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ABSTRACT

This paper presents results of measurement and test performance for integrated digital loop carrier (IDLC) technology. The study focuses on cable modem termination systems (CMTSs) that are reported on assortments of operating parameters to the end user based on upstream and downstream modes that are incorporated with statistical analysis approach. The study focuses on the statistical analytical measurement for noise margins on a particular type of loops – "white noise impairment."

Keywords: integrated digital loop carrier, DSL, broadband, interleaved mode

INTRODUCTION

Service providers in the past have extensively used digital loop carriers (DLC) in delivering reliable, robust and high quality voice service to end users. Recently, telecommunications network providers (TNP) improve and change their path in broadband technologies for better services and costs reduction to customers. As a result, they increased the number of lines with extended distances from Central Office (CO) with high quality of services in voice and data. From analog technology in plain old telephone services (POTs) to digital in DLC, TNP have made great stride and break through to service providers and end-users. Digital loop carrier (DLC) technology is based on digital techniques to provide large services to users via copper lines.

In today technologies, IDLC systems are broadly installed in delivering telecommunications services. Significant wiring and advantages of cost can be profited with IDLC at remote locations. In this work, the study illustrates the statistical analysis for the results of measurement of a test performance for integrated digital loop carrier (IDLC) type of white noise impairment.

This paper is arranged as follows: A review of literature provides an overview of voice over digital subscriber line (VoDSL), digital subscriber line (DSL), and carrier serving area (CSA). A description of the DLC and IDLC are then presented, with a discussion and network setup following. Regression analysis is then presented, with statistical analysis and hypothesis testing on the difference between the two means, of the noise margin, of the upstream and downstream cases in the interleaved mode setup completing the section. The paper is completed with a summary of the results and the conclusion.

LITERATURE REVIEW

Early studies showed that the first generation integrated access systems served as a platform for delivering voice, data and voice services over multiple T1/E1 lines and OC-3 fiber link. Later studies showed that the universal digital loop carrier system (UDLC), evolved into what are now known as the integrated digital loop carrier (Opara & Etnyre, 2010)

Musa, Akujuobi, & Mir (2007) indicated that when measuring call quality, three categories of study include listening quality, conversational quality and transmission quality. According to Musa et al., the objective of call quality measurement is to obtain a reliable estimate of one or more within the above categories using either subjective or objective testing methods.

A baseline test for the listening quality (LQ) using voice over digital subscriber line (VoDSL) access technology has been studied (Musa, Opara, Shayib, & El-Aasser, 2010). Researchers used voice/listening quality (V/LQ) transmission with voice compression while continuously downloading files. Indeed, those results enable the efficiency of the LQ and its statistical analysis based on a digital subscriber line (DSL) service at level 1.5M/384K for each American National Standards Institute (ANSI) and carrier serving area (CSA) loops.

Furthermore, based on the experimental VoDSL network architecture and the following DSL service levels 640K/ 640K, 1.5M / 384K, 3.0M/ 512K, and 1.5M/ 256K for each ANSI/CSA loops by using voice quality transmission testing with voice compression while continuously downloading files, it was found that on certain loops, all eight derived lines were not supported on IADs for VoDSL solution (Musa et al., 2007).

Additionally, the results of a traffic study undertaken to determine if a 64 kbit/s common signaling channel is sufficiently fast to meet the present and future call-processing needs of integrated digital loop carrier systems presented in (Jablecki, Misra, & Saniee, 1988). Bell Communications Research has proposed the use of such a 64 kbit/s common signaling channel in a requirements document, technical reference TR-TSY-000303, to satisfy call-processing needs across the IDLC generic interface, whenever out-of-band signaling is used. The authors characterize IDLC call-processing traffic on this message-oriented common signaling channel and examine associated design requirements in TR-303 under certain modeling assumptions (Poisson arrivals and exponential service time).

The study concluded that under a worst-case scenario, a critical message requiring a response within 100 ms would practically always meet that delay criterion. Further, critical messages requiring a response within 40 ms would fail once every ten busy hours. Since no specific signaling response requirement of 40 ms has been found, their study concludes that a 64 kbit/s common signaling channel for IDLC systems is sufficiently fast to achieve required signaling response times.

DESCRIPTION OF DIGITAL LOOP CARRIER AND INTEGRATED DLC TECHNOLOGIES

Digital loop carrier is a technology that uses digital techniques to customers via twisted-pair copper lines. DLC systems used for voice traffic only traditionally convert the telephone voice frequency signals into digital signals, and then transmit the digital signals between local digital switch in CO and remote digital terminals near the subscribers (Zhang, 1999).

DLC is remote terminal equipment used to transfer digital information between CO and the subscriber over copper or fiber cable (Andrews, 1991). The fiber/copper runs between the central office and the remote subscriber's terminal. Using the fiber will serve larger numbers of users than using copper. DLC is a remote-site box located on ground and is connected to CO through a fiber or copper distribution line. DLC is used to bundle out many channels of voice traffic to user areas and remotely expand CO capabilities without placing expensive new cables. DLC system used to provide telephone services for variety of POTS, digital data systems and integrated services digital network (ISDN) over T1 and SONET digital facilities (Khoe, Bolling, & Bhuyan, 1999). Indeed, the functional components of a DLC system are explained and discussed in (Arvidson, 1988).

The integrated digital loop carrier is required when a digital loop carrier system is integrated into a local digital link. In the other hand, the IDLC is capable of supporting broadband and POTS. IDLC can support a greater range of services and advanced access network technologies (Peck, Ruban, Marshman, & Carlson, 1991). IDLC system consists of a remote digital terminal and an integrated digital terminal interconnected via a digital facility (Jablecki et al., 1988). The functional components of an IDLC system are investigated in (Arvidson, 1988). IDLC can support both voice and high-speed data services. IDLC systems are the integration of the integrated digital terminal and remote digital terminal. The IDLC system moves some of the switching services from the local switches into remote digital terminals to increase the efficiency of communication lines between customers and the CO.

DISCUSSIONS AND RESULTS

Laboratory testing is measured to conform to industry standards and these uncovered many operational issues and problems, but cannot fully duplicate conditions experienced in the field. The study found that digital loop carrier technology made use of digital techniques to bring a wide range of services to users via twisted-pair copper telephone lines. This study further used the test setup methodology of the integrated digital loop carrier (IDLC) technology, based on upstream and downstream modes as demonstrated in Figure 1 for its analysis. The study also found that packetized voice, the transmission of telephone calls over a data network is now a reality.

Further, the study concluded that telephony on packet networks is growing exponentially in service revenue and is capturing more market share among of all telephony worldwide. The traffic generator located between the IDLC and the modem used to generate and receive the traffic, and the asymmetric digital subscriber loop wire line simulator (ADSL WLS) were used to simulate the loops and the impairments.

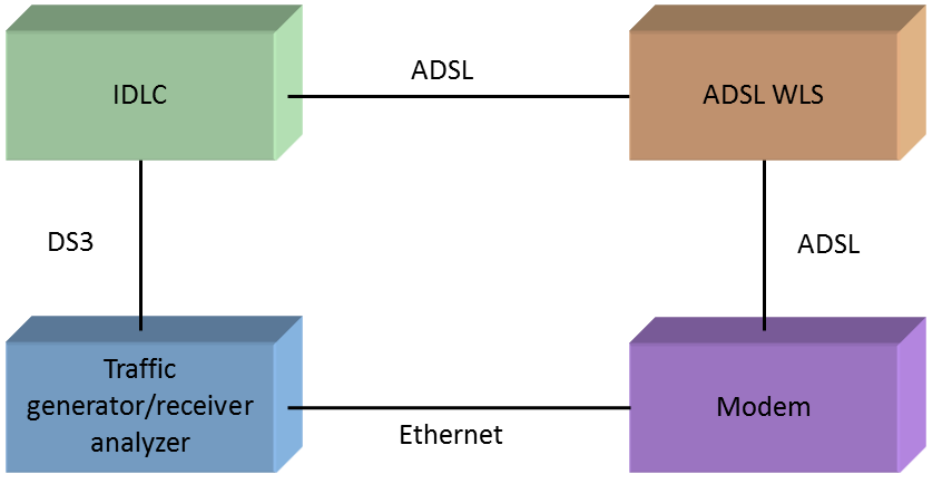

Figure 1. Test Setup for the Integrated Digital Loop Carrier for 24 HDSL, 24 DSL, and 5 T1 Adjacent Binder Impairments.

A digital loop carrier (DLC) as the study indicated is a system that uses digital transmission to prolong the array of the local loop farther than would be possible using twisted pair copper wires. A DLC digitizes and multiplexes the individual signals carried by the local loops onto a single data stream on the DLC segment. (Zhang, 1999).

Because of the explosion in acceptance of digital subscriber line (DSL) and the rewards provided by shorter metallic loops used with DLC systems, digital loop carriers are occasionally integrated with digital subscriber line access multiplexers (DSLAM), thereby providing a mechanism for both systems to take advantage of the digital transmission link from the DLC to the CO.

Customer premises equipment (CPE) modem is located at the subscriber. IDLC received voice and data and separated them by sending data to the network carrier and voice to the voice switch. Based on the above setup we found the following results using the measured value in kbps, and loop length in kft, 26 AWG: we used loop 26 AWG with noise impairment and AWGN at-140 dBm/Hz. The ADSL link has fast latency with 6 dB target noise margin. Table 1 shows the data for the upstream performance and the downstream performance of the white noise impairment, with the Fast mode. We observe in Table 1 that the only measured value for loop length 12 kft, 26 AWG at the downstream performance failed compared to the others. Table 2 shows the data for the upstream performance and the downstream performance of the white noise impairment, with the interleaved mode. We observed in Tables 1 and 2 that the all measured values are passed, for the upstream case, with the fast and interleaved modes.

The statistical analysis was based on regression analysis and hypotheses testing for the results of the measurement of the test performance of the IDLC one type of loop white noise impairment.

	Interleaved Mode Upstream Sync Rate (kbps)			Noise Margin, Actual (dB)		**Interleaved Mode** Downstream Sync Rate (kbps)			Noise Margin, Actual (dB)
LL	Expected	Actual	Pass/Fail			Expected	Actual	Pass/Fail	
0	800	800	P	8.5	0	7616	7616	P	17
1	800	800	P	8	1	7616	7616	P	17
2	800	800	P	8.5	2	7616	7616	P	19
3	800	800	P	8.5	3	7616	7616	P	18
4	800	800	P	8.5	4	7616	7616	P	17
5	800	800	P	9	5	7616	7616	P	15.5
6	800	800	P	8.5	6	7616	7616	P	12.5
7	800	800	P	8.5	7	7616	7616	P	9
8	800	800	P	9	8	7360	7616	P	9
9	800	800	P	9	9	6528	6976	P	6
10	800	800	P	8	10	5408	6112	P	6
11	800	800	P	6.5	11	4256	4768	P	5.5
12	800	800	P	5	12	3488	3616	P	6
13	736	736	P	5.5	13	2592	2496	F	6
14	640	640	P	5.5	14	1824	1664	F	6
15	576	576	P	5	15	1408	1088	F	6
16	480	480	P	5.5	16	960	736	F	6
17	384	416	P	5	17	608	416	F	7
17.5	384	384	P	5.5	17.5	480	352	F	5.5

Table 1. White Noise Impairment

REGRESSION ANALYSIS

For the data in Table 1, we like to check on the loop length against the noise margin for both cases, namely the upstream and the downstream for the interleaved mode. Since there is only one reading per the loop length setup, we will investigate the relationship between the loop length and the noise margin for the upstream and downstream separately. In addition to that, the data analysis will be carried on those setups that have data. For contrast, the three cases of regression (linear, quadratic, and cubic) will be calculated. In the three cases, the loop length will be taken as the explanatory variable, while the noise margin will be the response for that analysis.

The results of the analysis for the data in Table 1 are shown in Table 2 with the correlation coefficient of the relationship (R) between the loop length and the noise margin. R^2, expressed as a percentage, is the coefficient of determination that gives the percent of the variation in the noise margin that was explained by putting the loop length in the function.

It is clearly visible, see Table 2 above, that the linear relationship between the loop length and noise margin for the upstream and linear setup case is not as strong as in the quadratic case, as far as the percentage of variation explanation. This is in contrast with cubic that shows a stronger explanation of the variation due to the inclusion of loop length. On the other hand, for the downstream, the three relationships show a higher explanation of the variation than the upstream especially in the cubic case. The correlation between the two variables, in the downstream is higher, in value, than the upstream case.

Interleaved				
	Reg. Type	**Relation**	**R^2**	**R**
Up	Linear	$y = -0.2434x + 9.4215$	0.6976	-0.8352
	Quadratic	$y = -0.0169x^2 + 0.0585x + 8.5766$	0.7742	
	Cubic	$y = 0.0038x^3 - 0.1180x^2 + 0.75277x + 7.6992$	0.8554	
Down	Linear	$y = -1.2857x + 19.8297$	0.8834	-0.9399
	Quadratic	$y = -0.0350x^2 - 0.8661x + 19.0604$	0.8906	
	Cubic	$y = 0.0393x^3 - 0.7430x^2 + 2.3987x + 16.4643$	0.9841	

Table 2. Regression Analysis on Interleaved Mode.

In both cases, of the upstream and downstream and for the linear setup, the loop length and the noise margin are negatively correlated as shown in Table 2. In case we overlook the loop length setup for the upstream and downstream, for the interleaved mode data in Table 1, we see that the standard deviation in the noise margin for the downstream is more than 6 times than that in the upstream, based the data points in Table 1, and the calculations in Table 3.

STATISTICAL ANALYSIS AND HYPOTHESIS TESTING

Because of the small sizes in the sample for the data on the upstream and downstream, a T-test of statistical hypothesis will be carried on the equality of the means versus that they are different, where μ_1 is the mean on the data of the noise margin for upstream and μ_2 is the mean for downstream. Some restrictions will be taken into consideration, especially that the analysis was done for the data for the pass only, and on all the data as shown in the Table 1. Moreover, there will be no test on the equality of variances of up and down stream data. Hence, the test will be carried without pooling. That is, the two hypotheses that will be tested are the following, as shown in equation 1:

$$H_0 : \mu_1 - \mu_2 = 0 \ \ \textit{versus} \ \ H_1 : \mu_1 - \mu_2 \neq 0 \qquad (1)$$

Tables 3 and 4 show the t-test analysis of the results of Table 1, the interleaved mode case. The test was run with the assumption of unequal variances due to the big difference between the variances of upstream and downstream cases, displayed by the provided data. The test is carried out on the means of the noise margins for the downstream and upstream settings on those that were labeled as P only, and on all of the other values, respectively. The difference between the noise margin for the upstream and downstream is significant at the 0.05 level of significance, for both of the one-sided and two sided tests, as shown in Tables 3 and 4. In other words, there is a difference between the average noise margin levels of the upstream and downstream setup. The noise margin average and the variation are higher in the downstream case than the upstream.

t-Test: Two-Sample Assuming Unequal Variances Upstream vs Downstream, Interleaved, All Points

	Up Variable 1	Down Variable 2
Mean	7.237	10.211
Variance	2.649	27.287
Observations	19	19
Hypothesized Mean Difference	0.000	
Df	21	
t Stat	-2.369	
P(T<=t) one-tail	0.014	
t Critical one-tail	1.721	
P(T<=t) two-tail	0.027	
t Critical two-tail	2.080	

Table 3. t-Test Analysis for Interleaved, All Points

t-Test: Two-Sample Assuming Unequal Variances Upstream vs Downstream , Interleaved, Pass Points Only

	Up Variable 1	*Down Variable 2*
Mean	7.237	12.115
Variance	2.649	28.381
Observations	19	13
Hypothesized Mean Difference	0	
Df	14	
t Stat	-3.201	
P(T<=t) one-tail	0.003	
t Critical one-tail	1.761	
P(T<=t) two-tail	0.006	
t Critical two-tail	2.145	

Table 4. t -Test Analysis for Interleaved Mode, Pass Points

CONCLUSION

The measurements, as shown in Table 1, are the result of a test performed for IDLC technology based on upstream and downstream modes. Noise margins are measured in one type of loop white noise impairment, for comparing two cases on the interleaved mode, upstream and downstream. Furthermore, the passing and failing loops had been identified for this type. In the statistical analysis we found that, for the upstream of the interleaved mode, the values of R^2 are: 0.8554, 0.7742, and 0.6976 for the cubic, quadratic and linear regression respectively, while those values for the downstream are 0.9841, 0.8906, and 0.8834.The difference between the noise margin for the upstream and downstream is significant at the 0.05 level of significance, for both of the one-sided and two sided tests, whether the test was carried on all the pass data or all the data as shown in Tables 3 and 4.

REFERENCES

Andrews, F. T. (1991). The evolution of digital-loop carrier. *IEEE Communications Magazine, 29*(3), 31-35.

Arvidson, W. P. (1988). A generic operations system interface to support the next generation of digital loop carrier systems. *IEEE Journal on Selected Areas in Communications, 6*(4), 677-684.

Jablecki, H. M., Misra, R. B., & Saniee, I. (1988). A call-processing traffic study for integrated digital loop carrier applications. *IEEE Transactions on Communications, 36*(9), 1053-1061.

Khoe, H. -Y., Bolling, A. C., & Bhuyan, A. (1999). Digital loop carrier solutions for voice and data networks. *Bell Labs Technical Journal, 4*(2), 209-217.

Musa, S. M., Akujuobi, C. M., & Mir, N. F. (2007). VoDSL information management for broadband communication network access. *Journal of Computing and Information Technology, 15*(1), 17-24.

Musa, S. M., Opara, E. U., Shayib, M. A., & El-Aasser, M. A. (2010). Statistical analysis of VoDSL technology for the efficiency of listening quality of 640k/640k. *Journal of International Technology and Information Management, 19*(1), 97-110.

Opara, E. U., & Etnyre, V. (2010). Enterprise systems network: SecurID solutions, the authentication to global security systems. *Journal of International Technology and Information Management, 19*(4).

Peck, M., Ruban, J., Marshman, G., & Carlson, C. (1991). Evolution of integrated digital loop carrier. In *Globecom'91: Countdown to the New Millennium* (pp. 2092-2099). Phoenix, AZ.

Zhang, D. D. (1999). Use case modeling for real-time application. In *Proceedings of the Fourth International Workshop on Objective-Oriented Real-Time Dependable Systems* (pp. 56-64). Santa Barbara, CA.