A comparative Performance Evaluation of the ADSL2+ and ADSL Technologies

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Abstract. Recent advances in broadband technology have resulted in the emergence of a new DSL standard, the ADSL2+. This new technology is designed to offer almost three times the downstream rate offered by the current ADSL technology, accompanied by a substantially increased upstream rate, at the same time providing backward compatibility with existing Customer Premises Equipment (CPE). In this article, we present a comparative evaluation of the ADSL2+ against its predecessor technology. The evaluation of these two alternatives is based on their respective performance at the physical layer, according to increasing subscriber loop length. The measured bit rates and corresponding SNR levels determine the actual capabilities of this new technology.

1 Introduction

Over the past few years, the Asymmetrical Digital Subscriber Line (ADSL) technology, described in the ITU-T G.992.1 recommendation [1], has become the dominant broadband access technology, deployed on a large scale, most usually in order to address the needs of the majority of residential end users. Enhancements made to the ADSL technology produced ADSL2 as its immediate successor, described in the ITU-T G.992.3 recommendation [2]. The ADSL2 offers higher bit rates in both the downstream and upstream directions by using a more efficient G.DMT-based [3] modulation mechanism, applied to the same set of sub-carrier frequencies in the bandwidth range up to 1,1MHz (as per the original ADSL standard). Further improvements on the original have resulted in the next successor standard. Referred to as ADSL2+ and described in the ITU-T G.992.5 recommendation [4] (with extensive reference to the G.992.3 ADSL2 standard), this technology is specifically designed to further improve the bit rates and extend the reach of the original technology (a concept also part of the G.992.3 standard). In order to achieve this goal, ADSL2+ employs a dual approach. By adopting the improved modulation mechanism, first introduced in the ADSL2 standard, it improves the bit carrying efficiency per sub-carrier frequency. At the same time, by doubling the downstream spectrum bandwidth of the original ADSL and ADSL2 specifications, reaching 2,2MHz instead of 1,1MHz (in the case of the older technologies), it effectively doubles the bit rate it can offer, without sacrificing backward compatibility. The new standard holds much promise, especially in view of the move to new bandwidth demanding multimedia-based services targeted at to the residential users market. It is therefore necessary to evaluate this technology in order to prove that it can deliver on its promises. This article will compare the physical layer performance of ADSL2+ against its predecessor ADSL technology, with respect to bit rates offered in both the downstream and upstream directions, as well as corresponding SNR values, according to increasing subscriber loop length. To do this, we measured the performance of ATU-R/ATU-C tranceiver pairs for both ADSL2+ and ADSL, using a copper line emulator and crosschecking the results on real 0.4mm (equiv. 26AWG) copper cable lines, without the presence of noise.

2 Experimental Results

All measurements were performed in-lab, using a Globespan-based ADSL2+-compliant Digital Subscriber Line Access Multiplexer (DSLAM) and two CPEs; a Broadcom chipset ADSL2+-compliant CPE (Thomson 536) and a Globespan Virata chipset standard ADSL CPE (Lancom 821). We therefore tested two combinations; an {ADSL2+ ATU-R/ATU-C} (ADSL2+) link and an {ADSL ATU-R/ADSL2+ ATU-C} (ADSL) link. We used a Telebyte Inc. 458-LM-HDE 0.4mm copper line emulator to observe the behavior of our ADSL2+ and ADSL test links according to increasing subscriber loop lengths, ranging from 300m up to 6600m in steps of 300m. For each individual loop length, the corresponding bit rate and SNR values, for both the downstream and the upstream directions of both the ADSL2+ and ADSL links, were recorded. These measurements were then crosschecked for validity, by performing a second set of measurements on real 0.4mm copper line lengths. In all measurement cases (ADSL2+/ADSL), the ATU-R/ATU-C training had a target SNR of 6dB (DSLAM equipment default), representing a minimum threshold for ensuring a low communication Bit Error Rate (BER) on the DSL access link.
The results of this measurement process are presented in the three following figures, documenting the values acquired from the line emulator measurements, corroborated by the values acquired from measurements on the real 0.4mm copper loops (max divergence ~5%). Figures 1 and 2 show the decrease of downstream and upstream bit rates according to increasing loop length respectively, for both the

just before completely failing at 6000m. This is evidently caused by the ADSL2+ link attempting to achieve its target SNR in that range by lowering the line rate, indicating a preference for communication quality over speed.

Another interesting result, drawn from our upstream measurements, reveals that by connecting a standard ADSL ATU-R to an ADSL2+-compliant ATU-C port, the upstream link capacity clearly exceeds the theoretical upper limit of ~800Kbps of the ADSL standard. In fact, we found out that the upstream bit rate remained consistently above 900Kbps at loop lengths up to 3300m, achieving a ~32% increase over a standard ADSL ATU-R/ATU-C combination [5]. This implies that it might be possible for suitable G.DMT carrier frequencies (in the low frequency range) to be used more efficiently, allowing more symbols to be transmitted. This is however subject to decisions made during the initial transceiver training phase.

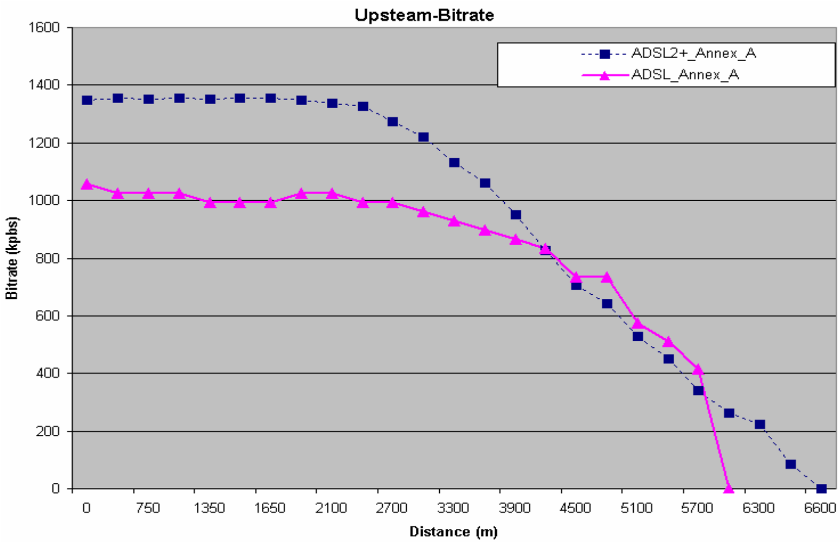

Fig. 2. Upstream Bit-rates

Observing the SNR results (Figure 3), we have to point out that the ADSL2+ demonstrates a very stable behavior, maintaining compliance to the target SNR (when necessary at the expense of bit rate), for both the downstream and upstream directions, across the range of tested loop lengths. This certainly makes for a guaranteed quality link.

The ADSL case however displays a remarkable but uneven SNR performance. The downstream SNR exceeds by far the set target even at long loop lengths (7.5dB at 5700m), indicating that more bits per second could be carried on the link. Yet the upstream SNR fluctuates from lower-than-the-target values, at very short loop lengths, to better-than-the-target values, at longer loop lengths. This rather erratic behavior indicates a preference for speed over communication quality.

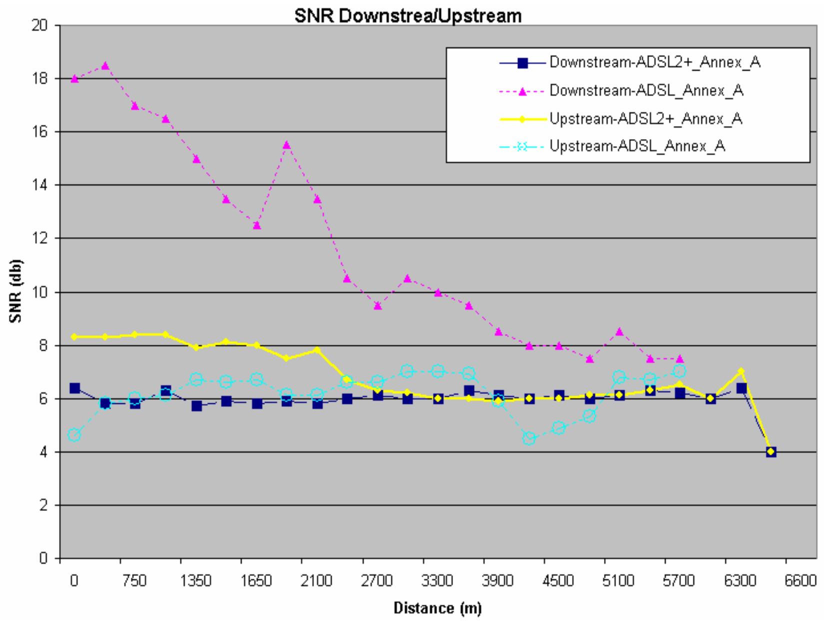

Fig. 3. SNR Downstream/Upstream

4 Conclusion

In this article we examined the performance of the new ADSL2+ technology and how it compares against the older ADSL technology. We conducted a measurement-based evaluation, measuring the bit rates and SNR offered at increasing loop lengths without the presence of noise. The comparison of the results we acquired proved that ADSL2+ not only offers higher information rates, but also maintains a constant quality link, evenly lowering the rates, at increasing subscriber loop lengths. However, the ADSL2+ connection is extremely asymmetric, at a 26:1 ratio for downstream/upstream rates. This makes the ADSL2+ an ideal technology for highly asymmetric bandwidth-intense multimedia services, such as high quality video streaming.

As vendors are already marketing products implementing the G992.3/G992.5 standards in a single chipset, rendering the deployment of pure ADSL2 solutions disadvantageous, it is expected that ADSL2+ will soon displace ADSL2. In view of this, the ADSL2+ is seen as the next dominant access technology for the residential market, pending the standardization and rollout of the new VDSL2 technology.

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