

# Performance analysis of wireless ATM/AAL2 over a burst error channel

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## Abstract

Recent growth in cellular networks has motivated research on broadband access technologies for the support of diverse services over wireless networks. Wireless asynchronous transfer mode (WATM) has been proposed as a transport solution for next generation wireless and personal communication networks and ATM adaptation layer 2 (AAL2) has been identified suitable for the support of low data rate and delay sensitive voice traffic generated in cellular networks. In this paper, we study the performance of AAL2 over a burst error wireless channel. Analytical expressions for performance measures of interest are derived for the Gilbert–Elliott channel and numerical results are presented to demonstrate the effect of burst errors on the AAL2 frame structure and the AAL2 performance. © 2002 Elsevier Science B.V. All rights reserved.

*Keywords:* ATM adaptation layer 2 (AAL2); Burst errors; Gilbert–Elliott model; Wireless ATM

## 1. Introduction

Advances made in digital mobile technologies have increased the growth and applicability of cellular networks. Moreover, there has been an increased interest in research related to access technologies, and in particular broadband access technologies, for the support of services over wireless networks. Wireless asynchronous transfer mode (WATM) has been proposed as a transport solution for next generation broadband wireless and personal communication networks [1,2]. However, a number of technical issues must be resolved before ATM can be successfully deployed over the wireless medium. These issues are raised by the incompatibility of ATM technology (designed for fiber optic links) and the characteristics of the wireless medium. Typically, wireless links are characterized by high bit error rate (BER) caused by a variety of transmission impairments such as fading, interference and noise. In addition, some of these impairments exhibit a significant degree of correlation [3] resulting in burst errors. Wireless link errors can affect significantly the performance at the ATM and the ATM adaptation layers that inherently have very limited protection against errors. Another important

characteristic of wireless links is that bandwidth is usually limited, so its efficient use becomes of paramount importance.

The recently standardized ATM adaptation layer 2 (AAL2) has been identified as a suitable adaptation layer for the multiplexing of voice traffic generated by multiple sources in mobile networks [4,5]. AAL2, as defined by ITU-T standards, is designed to improve bandwidth utilization for low data rate and delay sensitive traffic by multiplexing data (AAL2 packets) from several sources within the payload of a single ATM cell. Various performance issues related to AAL2, such as multiplexing gain, overhead and transfer delay, have been addressed in the mobile telephony environment in Ref. [4]. In this paper, we are concerned with the effect of errors on the performance of AAL2 when AAL2 transport takes place over a wireless link. An example of a network topology using AAL2 over a wireless link is shown in Fig. 1. In this topology, a wireless subsystem (WSS) gains access to a wired ATM network at the access point (AP). A WSS consists of a group of wireless terminals (WTs) served by a base station (BS). User traffic from the WTs is multiplexed into AAL2 connections at the BS and is transmitted to the AP over a wireless link.

The existence of a wireless link between the BS and the AP is justified in those cases in which the physical terrain makes the installation of a wired link difficult and costly

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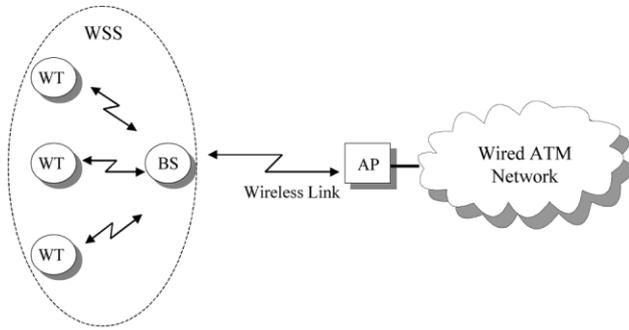


Fig. 1. ATM/AAL2 network topology.

or in which there is a need for flexibility with respect to mobility of the BS.

The effect of errors on the ATM/AAL2 transport over a wireless link is two-layered. At the lower layer, one of the key ATM functions susceptible to transmission errors is the *Header Error Control* mechanism, originally designed for low error rate fiber optic links. (The cell delineation process which relies strongly on the integrity of the ATM cell headers in order to maintain cell synchronization is also susceptible to errors but will not be considered in the context of this work). The ATM cell header is protected against errors by an error code with single bit error correcting capability only. Errors in the ATM cell header may result in the loss of ATM cells, due to the limited capability of the header error control mechanism. Clearly, the loss of an ATM cell results in the loss of the AAL2 packets in the ATM cell payload. At the AAL2 layer, a framing structure is imposed within the ATM cell payload that introduces its own header fields for the control and delineation of AAL2 packets. These header fields do not provide for any error correcting capability. In addition, AAL2 relies on the integrity of the header fields to maintain AAL2 packet delineation. Therefore, the AAL2 framing structure is also vulnerable to transmission errors. The effect of transmission errors on the performance of AAL2 is investigated in this work.

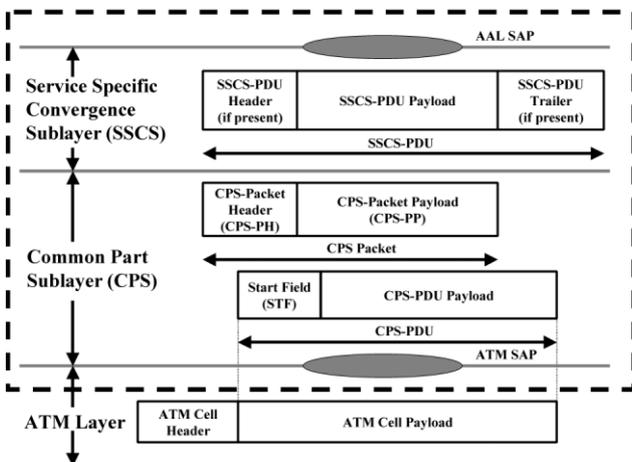


Fig. 2. AAL2 structure.

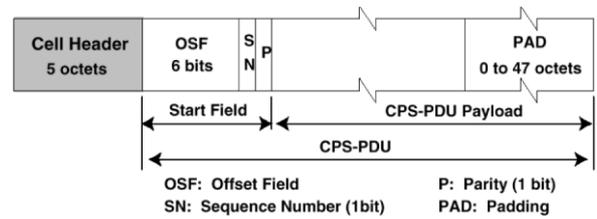


Fig. 3. Structure of the AAL2 CPS-PDU.

The paper is organized as follows. An overview of ATM Adaptation Layer 2, as defined by the ITU-T standard is presented in Section 2. Section 3 describes the Gilbert–Elliott channel model used to capture the burst error behavior of the wireless link. The analysis of ATM Adaptation Layer 2 over the Gilbert–Elliott channel is developed in Section 4 and performance measures of interest are derived in Section 5. Finally, numerical results to assess the effect of burst errors on the AAL2 structure are presented in Section 6, followed by conclusions in Section 7.

## 2. ATM adaptation layer 2

ATM adaptation layer 2 (AAL2) has been standardized recently by ITU-T [7] for the support of low bit rate and delay sensitive traffic over ATM networks.

AAL2 can provide significant improvement in bandwidth utilization that is not attainable by using other previously defined ATM Adaptation Layers such as AAL1, AAL3/4 or AAL5. The structure of AAL2, as defined by the ITU-T, is shown in Fig. 2. AAL2 is divided in two sublayers: the common part sublayer (CPS) and the service specific convergence sublayer (SSCS).

AAL2 achieves efficient bandwidth utilization by multiplexing data from different sources within the payload of the AAL2 common part sublayer protocol data unit (CPS-PDU). The structure of the AAL2 CPS-PDU is depicted in Fig. 3.

The CPS-PDU consists of the start field (STF) of size one byte and the CPS-PDU payload of size forty-seven bytes. The CPS-PDU payload is formed from a sequence of CPS packets (mini-cells<sup>1</sup>) originating from different sources. The Start Field STF includes a six-bit offset field (OSF) used to identify the position of the first CPS packet within the CPS-PDU payload. It should be noted that a CPS packet could be mapped across CPS-PDU payload boundaries. The structure of the CPS packet, which consists of the CPS packet header (CPS-PH) and the CPS packet payload (CPS-PP), is shown in Fig. 4.

The AAL2 CPS packet header is composed of four fields: the channel identifier (CID), the length indicator (LI), the user-to-user indication (UII) and the header error control (HEC).

<sup>1</sup> The terms CPS packet and mini-cell are used interchangeably throughout this document.

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