Computer Communications 35 (2012) 454–474

Contents lists available at SciVerse ScienceDirect

Computer Communications

journal homepage: www.elsevier.com/locate/comcom

Adaptive TCP congestion control and routing schemes using cross-layer information for mobile ad hoc networks ☆

Hsung-Pin Chang [a,*], Hui-Wen Kan [b], Ming-Hsin Ho [b]

[a] Department of Computer Science and Information Engineering, Institute of Networking and Multimedia, Taiwan
[b] Department of Computer Science and Information Engineering, National Chung Hsing University, Taichung 402, Taiwan

ARTICLE INFO

Article history:
Received 23 February 2011
Received in revised form 31 August 2011
Accepted 15 November 2011
Available online 25 November 2011

Keywords:
TCP
Routing protocol
Cross-layer design
Ad hoc network
Mobile ad hoc networks

ABSTRACT

Compared with traditional networks, ad hoc networks possess many unique characteristics. For example, ad hoc networks can drop a packet due to network events other than buffer overflow. Unfortunately, the current layered network architecture makes it impossible to pass the information specific to one layer to other layers. As a result, if a packet is lost due to reasons other than buffer overflow, TCP adversely invokes its congestion control procedure. Similarly, the routing algorithm may misinterpret that a path is broken and adversely invoke the route recovery procedure.

This study addresses the limitations of the current layered network architecture by adopting a cross-layer protocol design for TCP and routing algorithms in ad hoc networks. The objective of this approach is to enable the lower-layered ad hoc network to detect and differentiate all possible network events, including disconnections, channel errors, buffer overflow, and link-layer contention, that may cause packet loss. Using the information exploited by lower layers, the upper layer-3 routing algorithm, and the layer-4 TCP can take various actions according to the types of network events. Simulation results demonstrate that the combination of the cross-layer optimized TCP and routing algorithms can effectively improve the performance of TCP and DSR, regardless of whether it is in a stationary or a mobile ad hoc network.
© 2011 Elsevier B.V. All rights reserved.

1. Introduction

The TCP/IP protocol stack consists of a collection of layers. As Fig. 1(a) shows, these layers include the application programs, socket interface, transport layer, network layer, data-link layer, and the physical layer. Each layer defines a family of functions distinct from those of other layers, and communicates with its adjacent layers through a well-defined interface. The objective of this layered architecture is to allow modularity, which in turn facilitates the technological advancement of each layer, as each layer can be improved independent of other layers. This layered architecture works fine in the traditional network comprising of wired links and stationary hosts, since the traditional network is simple and stable. The information embedded in each layer is minimal, and each layer can work in an isolated manner.

1.1. The limitations of layered architectures and recent solutions in ad hoc networks

However, this layered architecture limits the performance improvement of ad hoc networks. To simplify discussion, this study uses MANETs to represent mobile ad hoc networks, SANETs to represent stationary ad hoc networks, and ad hoc networks to refer to both MANETs and SANETs [13]. Compared with traditional networks, ad hoc networks possess many new and unique characteristics. In addition to buffer overflow, ad hoc networks can drop a packet due to channel errors, node mobility, or link-layer contention. In other words, the lower physical and data-link layers in ad hoc networks embed lots of unique information that does not appear in traditional networks, and can be effectively exploited if available to the upper layers. However, current inflexible layered architecture and constrained interface definitions make it difficult to share this valuable information freely among each layer. Consequently, this study addresses the limitations of the traditional layered architecture via cross-layer protocol design. Specifically, this study focuses on utilizing lower layer to detect all possible network events in ad hoc networks, which in turn are used to improve the performance of upper layer TCP and routing protocols.

In fact, utilizing various network events to improve TCP performance has been shown in previous literature [4,22]. For example, the well known TCP-Feedback (TCP-F) [5] and TCP-Explicit Link Failure Notification (TCP-ELFN) [14] schemes try to identify packet loss caused by route failures. Likewise, Link Random Early Detection (LRED) [8] and TCP-Dynamic Adaptive Acknowledgment (TCP-DAA) [24] address the link-layer contention problem in static ad hoc networks. Ad Hoc-TCP (ADTCP) simultaneously considers

☆ This paper was partially supported by National Science Council under project NSC 97-2221-E-005-05.
* Corresponding author. Tel.: +886 4 22840497; fax: +886 4 22853869.
E-mail address: hpchang@cs.nchu.edu.tw (H.-P. Chang).

0140-3664/$ - see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.comcom.2011.11.008

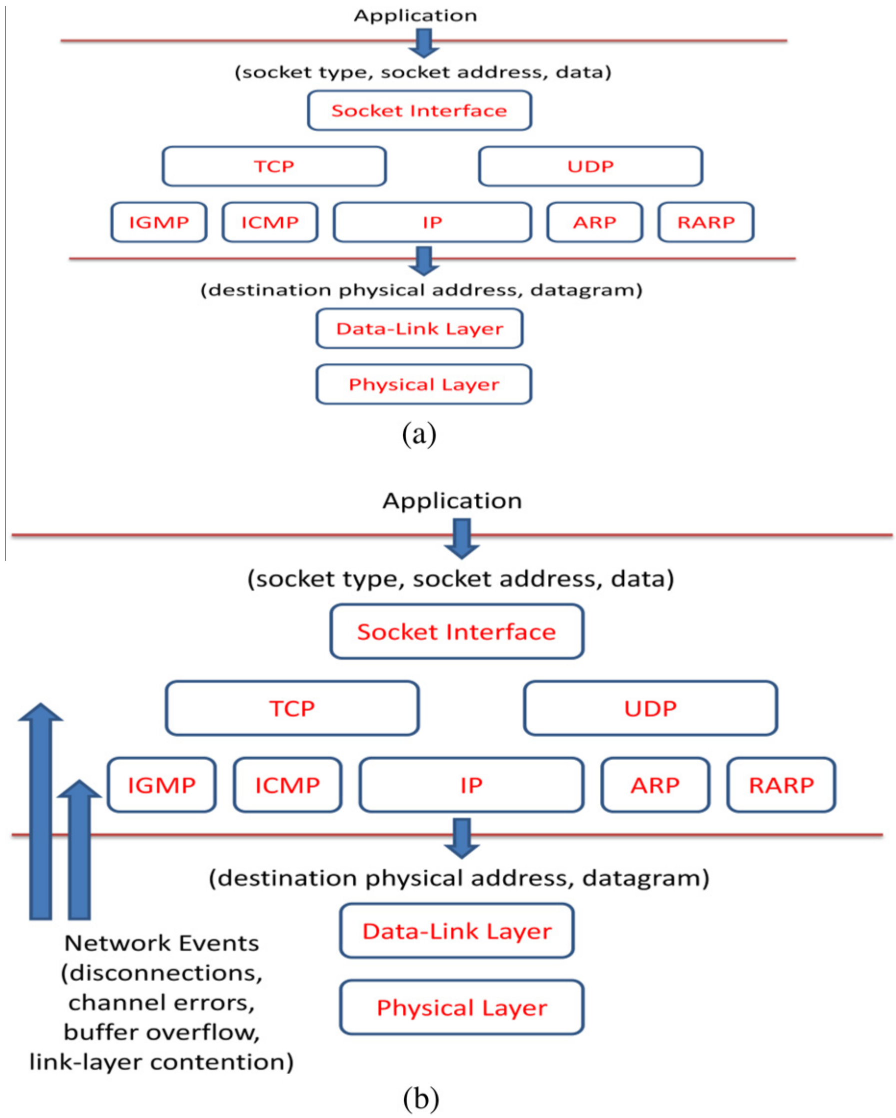

Fig. 1. (a) Interface between current network protocol stack, and (b) proposed cross-layer information sharing.

multiple network events, including buffer overflow, channel errors, and disconnection/route changes [9]. In addition to TCP, routing algorithms can be improved with underlying network information. For example, Goff et al. proposed a preemptive routing scheme that initiates path discovery procedure upon a path is likely to break [10]. However, previous approaches suffer severely from two major pathological cases. Firstly, previous approaches only propose solutions that identify a subset of the possible events that are occurred in ad hoc networks. For example, LRED and TCP-DAA assume that the network is a SANET and only identify link-layer contention. ADTCP is the one that detect multiple network events, including buffer overflow, channel errors, and disconnection/route changes, but does not consider the link-layer contention problem. As a result, previous schemes would misinterpret the packet losses caused by one event, which they do not consider and recognize, as due to other events and invoke inappropriate responses. Secondly, the event detection schemes in previous approaches may be inaccurate. For example, to detect network events, ADTCP utilizes only the information specific to its layer and do not consider cross-layer information. As a result, its identification scheme may suffer from noisy indicator measurements for certain network events, and might make an incorrect conclusion [9]. Even utilizing cross-layer information, previous event detection schemes might use the wrong layer's information and suffer from inaccuracy problems. For example, TCP-F and TCP-ELFN rely on the route failure information derived from the routing layer to detect packet losses due to route changes. Nevertheless, routing protocols might also incorrectly conclude the disruption of a route, for example, if packets are transmitted over a fading channel [23].

1.2. Contributions of this paper

On the basis of cross-layer design principle, as Fig. 1 (b) shows, this study utilizes physical and data-link layer information to efficiently and accurately identify and differentiate all possible network events that may cause packet loss in ad hoc networks. Using the events detected by the lower layers, the proposed approach improves the performance of both layer-4 transmission control protocol (TCP) and the layer-3 dynamic source routing (DSR) routing algorithm [16]. Specifically, this paper makes the following four contributions.

1. *A complete detection scheme for all network events* The proposed design identifies all possible network events that may cause packet loss in ad hoc networks. These events include buffer overflow, channel errors, disconnections, and link-layer conten-

Download English Version:

https://daneshyari.com/en/article/448700

Download Persian Version:

https://daneshyari.com/article/448700

Daneshyari.com