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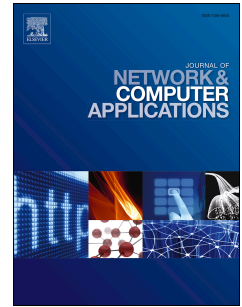
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Hybrid Covert Channel in LTE-A: Modeling and Analysis

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Abstract

As a major approach to information leakage, covert channels are rapidly gaining popularity with the exponentially growing of cloud computing and network resources. Long Term Evolution Advance (LTE-A) has dominated the 4th generation (4G) of mobile telecommunication networks, however, this brings an elevation of the risk of covert channels. This paper constructs a Covert Channel in LTE-A circumstance which can ensure the accuracy and effectiveness of the covert communication. Delayed Packet One Indicator (DPOI) is a Covert Timing Channel (CTC) model evolved from classic network CTC. Firstly, we use High-level Petri Nets (HLPN) to model the structure and behavior of the DPOI, especially the process of encoding/decoding and synchronization, according to which, we perform formal verification of the model's major shortcomings. Secondly, we propose HYBRID DPOI, an improved hybrid covert channel model which introduced Covert Storage Channel (CSC) in MAC layer for synchronizing. Moreover, we model the structure and behavior of the HYBRID DPOI using the HLPN to demonstrate the accuracy and effectiveness of our proposed model. At last, we analyze and evaluate the HYBRID DPOI. The results show that the proposed model in LTE-A circumstance is reliable and effective, which provides a new idea for covert channel construction.

Keywords: Covert channel, High-level Petri Nets, LTE-A, Modeling, Reliability.

1. Introduction

Establishing a pathway over an overt network resources to conceal secret data transmission is known as covert communication. The term “covert channels” was first coined by Lampson (1973) and defined as the channels “not intended for information transfer at all”. In the Orange Book (Qiu et al., 1985), published by the U.S. Department of Defense, a covert channel is defined as “any communication channel that can be exploited by a process to transfer information in a manner that violates the system’s security policy”. Covert channels can be constructed using a variety of shared media. For example, utilizing network resources, covert channels can transfer information hidden from network security features, such as firewalls. Since they embed covert message bits in innocuous communications, the fact that the transition of secret information is taking place hidden from overt channels and unsuspecting wardens.

As an illustration of the practical meaning of the covert channel consider the famous prisoners’ problem described by Simmons (1984). The problem is as follows: two prisoners need to communicate to escape, but all the messages should pass through the warden who can detect any encrypted messages. They must find some technique of hiding their secret messages in an innocent-looking communication.

Cloud computing provides diverse services through various networks. The proliferation of smartphone and portable devices with a wireless network access, is accelerating the development

of mobile-cloud computing. Mobile commerce, mobile health-care and mobile learning are some of the areas in which the mobile-cloud computing can be utilized (Kirui, 2014). As a most advanced mobile cellular network, LTE-A is one of the network support platform for the cloud computing applications, especially for the mobile-cloud computing. Extensive availability and development of cloud computing and mobile network open up the opportunity for abusing network resources to distribute malicious data and leak sensitive information. Numerous researches (Wu et al., 2015; Enck et al., 2009; Wang et al., 2010; Shen et al., 2015b; Mazurczyk et al., 2013) have demonstrated that covert channels are a great threat to the information security of networks, cloud computing and mobile computing. Wu et al. (2015) designed a memory bus-based covert channel in the cloud, a pure timing-based data transmission scheme using the bus locking mechanism. Based on the natural behaviors of browsers, Shen et al. (2015b) designed a covert channel aiming at HTTP. Mazurczyk et al. (2013) discussed the methods of utilizing prevalent internet applications and sharing services such as Skype and BitTorrent to distribute secret data. This type of covert channels are rapidly gaining popularity as the growing of cloud computing and mobile applications.

Including CSC and CTC, various covert channels for TCP/IP network are presented in literatures. However, to the best of our knowledge, very little research on the topic of covert channel for LTE-A has been published so far, more importantly, most of which just discussed the protocol vulnerabilities may be used by covert communication, there are no modeling analysis aiming at the feasibility and reliability of the proposed LTE-A covert channel scheme.

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