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Review

Ambient noise in wireless mesh networks: Evaluation and proposal of an adaptive algorithm to mitigate link removal

Jesús Friginal [a,*], Juan-Carlos Ruiz [b], David de Andrés [b], Antonio Bustos [b]

[a] LAAS-CNRS, 7 Avenue du Colonel Roche, 31077 Toulouse Cedex, France
[b] STF-ITACA Universitat Politècnica de València, Campus de Vera s/n, 46022, Spain

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ABSTRACT

Ambient noise is one of the major problems in Wireless Mesh Networks (WMNs). It is responsible for adverse effects on communications such as packet dropping, which dramatically affects the behaviour of ad hoc routing protocols, a key element of these networks. This issue is of prime importance for WMNs since the loss of communication links experienced by nodes may strongly increase the convergence time of the network. Furthermore, the dynamic nature of this problem makes it difficult to address with traditional techniques. The contribution of this paper goes in the direction of (i) exploring this problem by assessing the behaviour of three state-of-the-art routing protocols in the presence of *ambient noise* (OLSR, B.A.T.M.A.N and Babel) and (ii) improving the resilience capabilities of these protocols against *ambient noise* by proposing an algorithm for the link quality-based adaptive replication of packets, named LARK. The goal of LARK is to avoid the loss of communication links in the presence of high levels of *ambient noise*. The effectiveness of the proposal is experimentally assessed, thus establishing a new method to reduce the impact of *ambient noise* on WMNs.

Contents

* Corresponding author.
E-mail addresses: jesus.friginal@laas.fr (J. Friginal), jcruizg@disca.upv.es (J.-C. Ruiz), ddandres@disca.upv.es (D. de Andrés), anbusrod@alumni.upv.es (A. Bustos).

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1. Introduction

The progressive interest (and dependence) of our society on mobiquitous (mobile and ubiquitous) systems explains why incorporating new added-value services into modern devices is not an option but a demand requirement. Ad hoc networks enable the rapid and spontaneous creation of low-cost data networks without the need of any pre-existing communication infrastructure. Wireless Mesh Networks (WMN) follow this paradigm to offer self-managed networking solutions, which are currently exploited by (i) some city councils to democratise the free wireless Internet access to their citizens; and (ii) private companies to provide affordable Internet access to isolated populations (such as Meraki[1] and TerraNet[2]).

In mainstream WMNs, routing protocols are responsible for the efficient creation of multi-hop wireless communication routes among distant nodes. Most of the routing protocols used in WMNs are proactive, which means that they periodically exchange topology control messages with other nodes in order to maintain updated routes towards Internet gateway nodes. Unfortunately, signal propagation and environment saturation problems may affect the reception of control messages exchanged by routing protocols. This issue, known as *ambient noise*, might lead to excessive loss rates or packet delays (Raya et al., 2004).

In such scenarios, a simple recovery action that can be adopted by a proactive routing protocol is to force the two nodes concerning the affected link to switch to a different channel with less spectrum activity. This technique may eventually have a very negative impact over the network convergence time, since it may require a large portion of the rest of mesh nodes to switch channels so the network topology stays connected. If degradation of communication links induced by noise does not partition the network, an alternative approach adopted by most mesh routing protocols consists in repairing affected paths by automatically choosing other alternative links to maximise some quality link metrics of the protocol (Ni et al., 2008). Today, most of existing WMN routing protocol implementations incorporate mechanisms to react against *ambient noise*. Overly agile protocol reactions may lead to route flapping (Ramachandran et al., 2007) and must be avoided. In fact, they may increase the network overhead by flooding the route repair control messages without gaining much throughput. One possible way to counter this effect is to use flap damping. The goal is to limit the global impact of unstable routes by temporarily suppressing routes with rapid changes over short time periods. However this technique may cause persistent oscillation in the network due to the adverse interactions between flap damping and route convergence (Geibig and Bradler, 2010). On the other hand, if the reaction of the protocol against noise is too slow it may entail the loss of existing communication links in the network. The main consequence is the activation of the self-configuration capabilities provided by the routing protocols to establish new communication routes among affected nodes. When many links result affected, the convergence time increases, which reduces the network steadiness and availability (Feng et al., 2009).

It seems thus reasonable to keep communication links alive as long as possible in case of being subjected to *ambient noise*. This can be done by simply tuning routing protocols in order to increase the lifetime of their links, thus reducing the issues related to the network converge time. What must be carefully considered is the overhead derived from such a tuning and the pertinence of the resulting configuration along the time. In Tcholtchev and Chaparadza (2010), for instance, authors propose an automatic approach to manage link communication faults in WMNs by inferring suitable configurations from network model simulations. Facing dynamic perturbations, such as *ambient noise*, asks for more dynamic strategies to adapt at runtime the level of link protection against *ambient noise* in WMNs.

Following this trend, this paper proposes to explore the effect of *ambient noise* in well-known state-of-the-art proactive routing protocols named OLSR (Clausen and Jacquet, 2003), Babel (Chroboczek, 2011) and B.A.T.M.A.N (OpenMesh, 2011), as a first step to propose an adaptive strategy to prevent nodes from losing their communication links in the presence of high rates of *ambient noise*. By introducing this algorithm within routing protocols we are able to reduce the convergence time of routes while improving their availability in a dynamic way.

Figure 1 can assist the reader to understand the motivation that leads us to carry out every step we take towards this goal. The paper is consequently structured in this fashion. So, firstly, Section 2 describes the innate capabilities of such protocols to *ambient noise* adaptation. Section 3 identifies the various parameters affecting the behaviour exhibited by the protocols, and experimentally assesses such a behaviour under similar experimental conditions. Results show that under similar conditions, differences between protocols mainly rely on the overhead they induce in the network rather than in their protection capabilities. However, it seems clear that it is neither desirable nor affordable to suffer from such an overhead when noise does not exist or it is very low. The alternative that is introduced in Section 4 focuses on the feasibility of adapting the level of protection provided by existing link-quality-based mechanisms, and thus the level of induced overhead, to the level of noise experienced at each moment, in each network node, by each communication link. The idea is to keep links alive (i) by replicating control messages when the network is exposed to high levels of noise and (ii) by dynamically incrementing or reducing the level of replication attending to the evolution of such a noise. The approach is deployed and assessed on the three considered routing protocols, thus showing the feasibility of the approach and its generality. Section 5 places this study with respect to related works. Finally, Section 6 concludes the paper.

2. Proactive routing and noise adaptation

This section provides an overall view of what is a proactive routing protocol. Then, the notion of *ambient noise* and how it can impact on routing is introduced. Finally, the viability of link-quality-based techniques to face this problem is discussed.

2.1. Proactive routing protocols

Proactive routing protocols provide facilities for discovering, establishing and maintaining communication links among 1-hop neighbour nodes. Depending on the strategy considered to compute such routes, proactive routing protocols can be link-state or

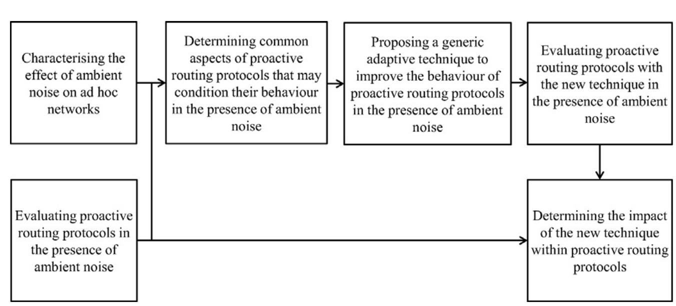

Fig. 1. Paper's roadmap.

[1] http://meraki.com.
[2] http://terranet.se.