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A Probabilistic and Dual Node failure Detection System in Mobile Wireless Networks

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Abstract

Detecting node failures in mobile wireless networks is incredibly challenging because the network topology can be highly dynamic, the network may not be always connected, and the resources are limited. In this paper, we take a probabilistic approach and propose two node failure detection schemes that systematically combine localized monitoring, location estimation and node collaboration. Extensive simulation results in both connected and disconnected networks demonstrate that our schemes achieve high failure detection rates (close to an upper bound) and low false positive rates and incur low communication overhead. Compared to approaches that use centralized monitoring, our approach has up to 80 percent lower communication overhead, and only slightly lower detection rates and slightly higher false positive rates. In addition, our approach has the advantage that it is applicable to both connected and disconnected networks while centralized monitoring is only applicable to connected networks. Compared to other approaches that use localized monitoring, our approach has similar failure detection rates, up to 57 percent lower communication overhead and much lower false positive rates (e.g., 0.01 versus 0.27 in some settings).

Keywords: *Wireless sensor networks, node estimation, two-node failure detection*

1. Introduction

Mobile wireless networks have been used for many mission critical applications, including search and rescue [17], environment monitoring [11], [20], disaster relief [25], and military operations [18]. Such mobile networks are typically formed in an ad-hoc manner, with either persistent or intermittent network connectivity. Nodes in such networks are vulnerable to failures due to battery drainage, hardware defects or a harsh environment. Detecting node failures is important for keeping tabs on the network. It is even more important when the mobile devices are carried by humans and are used as the main/only communication mechanism (see discussion in Section III). Node failure detection in mobile wireless networks is very challenging because the network topology can be highly dynamic due to node movements. Therefore, techniques that are designed for static networks are not applicable. Secondly, the network may not always be connected. Therefore, approaches that rely on network connectivity have limited applicability. Thirdly, the limited resources (computation, communication, and battery life) demand that node failure detection must be performed in a resource conserving manner. One approach adopted by many existing studies is based on centralized monitoring. It requires that each node send periodic “heartbeat” messages to a central monitor, which uses the lack of heartbeat messages from a node (after a certain timeout) as an indicator of node failure [5], [12], [19]. This approach assumes that there always

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exists a path from a node to the central monitor, and hence is only applicable to networks with persistent connectivity. In addition, since a node can be multiple hops away from the central monitor, this approach can lead to a large amount of network-wide traffic, in conflict with the constrained resources in mobile wireless networks. Another approach is based on localized monitoring, where nodes broadcast heartbeat messages to their one-hop neighbors and nodes in a neighborhood monitor each other through heartbeat messages. Localized monitoring only generates localized traffic and has been used successfully for node failure detection in static networks [15].

However, when being applied to mobile networks, this approach suffers from inherent ambiguities—when a node A stops hearing heartbeat messages from another node B, A cannot conclude that B has failed because the lack of heartbeat messages might be caused by node B having moved out of range instead of node failure. In this paper, we propose a novel probabilistic approach that judiciously combines localized monitoring, location estimation and node collaboration to detect node failures in mobile wireless networks. Specifically, we propose two schemes. In the first scheme, when a node A cannot hear from a neighboring node B, it uses its own information about B and binary feedback from its neighbors to decide whether B has failed or not. In the second scheme, A gathers information from its neighbors, and uses the information jointly to make the decision (see Section V for details). The first scheme incurs lower communication overhead than the second scheme. On the other hand, the second scheme fully utilizes information from the neighbors and can achieve better performance in failure detection and false positive rates. We have evaluated our schemes using extensive simulation in both connected and disconnected networks (i.e., networks that lack contemporaneous end-to-end paths). Simulation results demonstrate that both schemes achieve high failure detection rates, low false positive rates, and incur low centralized monitoring, while our approach may have slightly lower detection rates and slightly higher false positive rates, it has significantly lower communication overhead (up to 80% mlower). In addition, our approach has the advantage that it is applicable to both connected and disconnected networks. Compared to other approaches that use localized monitoring, our approach has similar failure detection rates, lower communication overhead (up to 57% lower) and much lower false positive rate (e.g., 0.01 versus 0.27 in some setting).

2. Existing System

Mobile wireless networks have been used for many mission critical applications, including search and rescue, environment monitoring, disaster relief, and military operations. Such mobile networks are typically formed in an ad-hoc manner, with either persistent or intermittent network connectivity. Nodes in such networks are vulnerable to failures due to battery drainage, hardware defects or a harsh environment. Detecting node failures is important for keeping tabs on the network. It is even more important when the mobile devices are carried by humans and are used as the main/only communication mechanism.

2.1. Disadvantages

1. Node failure detection in mobile wireless networks is very challenging because the network topology can be highly dynamic due to node movements. Therefore, techniques that are designed for static networks are not applicable.

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2. The network may not always be connected. Therefore, approaches that rely on network connectivity have limited applicability.
3. The limited resources (computation, communication, and battery life) demand that node failure detection must be performed in a resource conserving manner.

3. Proposed System

Our network model consists of a set of low-power radio frequency (RF) transceivers which move relative to each other across an irregular terrain subject to RF propagation impairments. The low transmitter power defines a radio coverage which limits the probability of intercept and the number of neighbors but optimizes frequency reuse. The combination of low power and propagation environment produces a network characterized by stochastic link failures.

We propose a novel scheme Link Scanner (LS) for monitoring wireless links at real time. LS issues one probe message in the network and collects hop counts of the received probe messages at sensor nodes. Based on the observation that faulty links can result in mismatch between the received hop counts and the network topology, we are able to deduce all links' status with a probabilistic model. A few distributed solutions have been proposed. In this paper for the detection of node replication attacks, We first analyze the desirable properties of a distributed mechanism. After that we show the solutions for the problem and later for detection of node replication attacks, we propose a self-healing RED protocol. Randomized, Efficient, and Distributed protocol and we see that it meets the requirements. Finally, it shows that our protocol is highly efficient in memory, communication and computation.

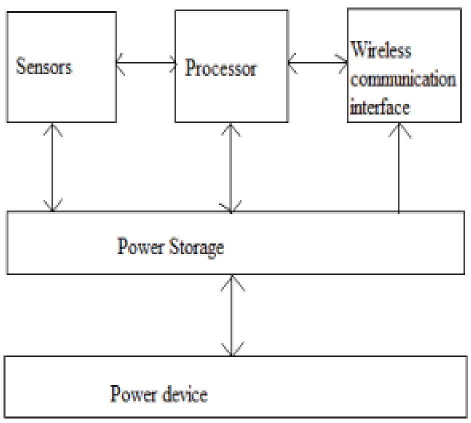

Figure. 1 Proposed network model.

3.1. Advantages

- We proposed a novel and low-cost link scanning scheme LS for faulty link detection. LS infers all links statuses on the basis of data collection from a prior probe flooding process in which we leverage hop count to reflect node in (or) out-going link performances.
- A distributed mechanism and shown the solution and later for detection of node replication attacks, to detect node replication attacks, a self-healing, efficient, and distributed protocol are proposed.

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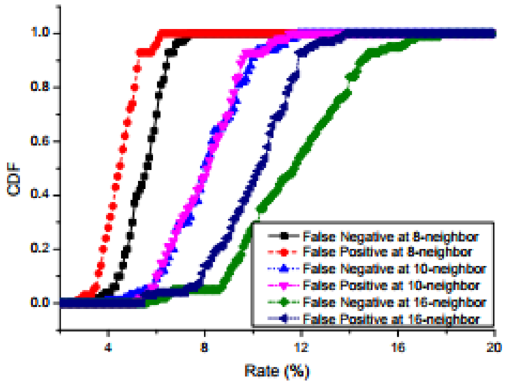
- We are investigating the efficiency and performance characteristics of survivable and adaptive network protocols with computer simulation techniques. Preliminary results will be reported on the evaluation of the algorithm in terms of message delay and acknowledgment overhead for different network sizes and routing restrictions.



Impact of network density: Network density can also significantly change the network topology. What is more, a dense network should suffer more channel collision and packet lost due to hidden terminal, thus may impact the probe flooding process and cover the real link performance. Here we define a network density in terms of average neighbor number. We show three densities in a 60-node network. Clearly, when the network is sparse LS can achieve a false negative rate about 5%, which means there is only one out of 20 normal links reported by LS is faulty in fact, while the false positive rate is only 4.8%. Following the network density increases, each node is expected to receive more probes with the same hop count number, since its neighbors are more centralized around itself. In DLV its corresponding group has a larger size, hence produces more possibilities once the number of probes mismatches the group size

4. Conclusion and Future Work

In this paper, we presented a probabilistic approach and designed two node failure detection schemes that combine localized monitoring, location estimation and node collaboration for mobile wireless networks. Extensive simulation results demonstrate that our schemes achieve high failure detection rates, low false positive rates, and low communication overhead. We further demonstrated the tradeoffs of the binary and non-binary feedback schemes.

As future work, we plan to evaluate our schemes using real world mobility traces and in scenarios with irregular transmission ranges. Our approach relies on location estimation and the usage of heartbeat messages for nodes to monitor each other. Therefore, it does not work when location information is not available or there is communication blackouts (e.g., due to weather conditions). Developing effective approaches for those scenarios is left as future work.

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