PROBABILISTIC APPROACH FOR DETECTING NODE FAILURES IN MOBILE WIRELESS NETWORKS

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Abstract: Detecting node failures in mobile wireless networks is very 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% 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.

Keywords: Mobile Wireless Networks,NodeFailure,Localize Monitoring and Estimation

I. INTRODUCTION

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. Node failure detection in mobile wireless networks is very challenging because the network topology can be highly dynamic due to node movements [1]. 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 [2]. Node failure detection in mobile wireless networks assumes network connectivity. Many schemes adopt probe-and-ACK (i.e., ping) or heartbeat based techniques that are commonly used in distributed computing. Probe-and-ACK based techniques require a central monitor to send probe messages to other nodes. When a node does not reply within a timeout interval, the central monitor regards the node as failed. Heartbeat based techniques differ from probe-and-ACK based techniques in that they eliminate the probing phase to reduce the amount of messages. Several existing studies adopt gossip based protocols, where a node, upon receiving a gossip message on node failure information, merges its information with the information received, and then broadcasts the combined information [3]. A common drawback of probe-and-ACK, heartbeat and gossip based techniques is that they are only applicable to networks that are connected. In addition, they lead to a large amount of network-wide monitoring traffic. In contrast, our approach only generates localized monitoring traffic and is applicable to both connected and disconnected networks.

II. RELATED WORK

Most existing studies on node failure detection in mobile wireless networks assume network connectivity. Many schemes adopt probe-and-ACK (i.e., ping) or heartbeat based techniques that are commonly used in distributed computing. Probe-and-ACK based techniques require a central monitor to send probe messages to other nodes [4]. When a node does not reply within a timeout interval, the central monitor regards the node as failed. Heartbeat based techniques differ from probe-and-ACK based techniques in that they eliminate the probing phase to reduce the amount of messages. Several existing studies adopt gossip based protocols, where a node, upon receiving a gossip message on node failure information, merges its information with the information received, and then broadcasts the combined information [5]. A common drawback of probe-and- ACK, heartbeat and gossip based techniques is that they are only applicable to networks that are connected. In addition, they lead to a large amount of network-wide monitoring traffic. In contrast, our approach only generates localized monitoring traffic and is applicable to both connected and disconnected networks.

Calculating Failure Probability: In the basic case, a node sends a single heartbeat packet at each time. When node A cannot hear from B, one of the following conditions must hold: node B has failed; node B is not failed but A is out of the transmission range of B; or node B has not failed and A is in the transmission range of B, but the packet sent from B is lost. Let R denote the event that A is in the transmission range of B at time t + 1.

Upper Bound of Failure Detection Rate: Consider an arbitrary node, A, that fails at time t +1. When using our approach, a necessary condition for the failure of A to be detected is that there exists at least one live node in the transmission range of A at time t (so that there exists a node that hears A at t but no longer hears from A at t +1). Let M be a random variable that denotes the number of nodes that are in A's transmission range at time t. Then the probability that the failure of node A is detected successfully is no more than Pr(M > 0).

III. PROBLEM STATEMENT

Existing Model : This approach assumes that there always 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.

- 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.

Proposed System: 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 wire-less 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.

Advantages :

- 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.

IV. METHODOLOGY

We have 3 main Modules.

Localized Monitoring: Localized monitoring only generates localized traffic and has been used successfully for node failure detection in static networks.

Location Estimation: By localized monitoring, Node only knows that it can no longer hear from other neighbor nodes, but does not know whether the lack of messages is due to node failure or node moving out of the transmission range. Location estimation is helpful to resolve this ambiguity.

Node Collaboration: Through this module, we can improve the decisions which are taken during Location estimation module.

Algorithm

Algorithm1 Non-binary feedback scheme (sending query)

```
suppose A hears from B at t but not t + 1
A calculates p, the probability that B fails, using (4)
if (p ≥ θ) then
    A starts a timer with a random timeout value
    if A has not heard a query about B when the timer
    times out then
        A broadcasts an inquiry about B
        if A receives at least one response of 0 then
            A does nothing (B is alive)
        else
            A updates p based on the feedbacks using (17)
            if (p ≥ θ) then
                A sends a failure alarm about B to the manager
                node
            end if
        end if
    end if
end if
```

Algorithm2 Non-binary feedback scheme (receiving query)

```
suppose C receives a query message about B
if C has just heard from B then
    C responds with 0
else
    C responds with the probability that all K messages
    from B to C are lost and the probability that C is in
    B's transmission range
end if
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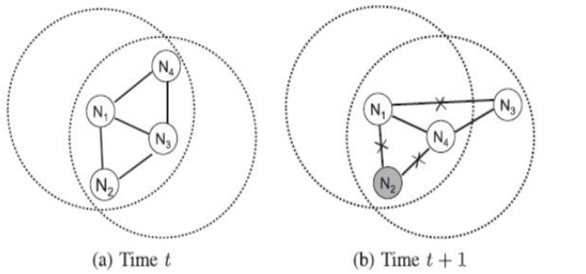

Figure 1: System Architecture

An illustrating example, where a failed node is shaded and a link with a cross means that the link is down.

V. PERFORMANCE EVALUATION

We evaluate the performance of our schemes through extensive simulations using a purpose-built imulator. The simulator is built using Matlab. The main reason for using the purposebuilt simulator instead of other simulators (e.g., ns3) is because it provides much more flexibility in implementing the node failure detection algorithms that are proposed in the paper. We use the example in Fig. 1 to motivate our approach. In this example, for simplicity, we assume no packet losses and that each node has the same circular transmission range. At time t, all the nodes are alive, and node N1 can hear heartbeat messages from N2 and N3 (see Fig. 1(a)). At time t+1, node N2 fails and N3 moves out of N1's transmission range (see Fig. 1(b)). By localized monitoring, N1 only knows that it can no longer hear from N2 and N3, but does not know whether the lack of messages is due to node failure or node moving out of the transmission range.

Location estimation is helpful to resolve this ambiguity: based on location estimation, N1 obtains the probability that N2 is within its transmission range, finds that the probability is high, and hence conjectures that the absence of messages from N2 is likely due to N2's failure; similarly, N1 obtains the probability that N3 is within its transmission range, finds that the probability is low, and hence conjectures that the absence of messages from N3 is likely because N3 is out of the transmission range. The above decision can be improved through node collaboration. For instance, N1 can broadcast an inquiry about N2 to its one-hop neighbors at time t + 1, and use the response from N4 to either confirm or correct its conjecture about N2. The above example indicates that it is important to systematically combine localized monitoring, location estimation and node collaboration, which is the fundamental of our approach.

VI.CONCLUSION

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. The Rates, low false positive rates, and low communication overhead. We further demonstrated the tradeoffs of the binary and non-binary feedback schemes.

VII.REFERENCES

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