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Detecting Node Failures in Mobile Wireless Networks: A Probabilistic Approach

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Abstract: - **Detecting node failures in mobile wireless networks is very challenging because the network topology can be highly dynamic 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— **Wireless Networks, Node Failure, Localize Monitoring and Estimation.**

I. INTRODUCTION

Mobile wireless networks have been used for many mission critical application, including search and rescue, monitoring environment, 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][9]. 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][10]. 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.

A. Heartbeating architectures

Heartbeat protocols are widely used for failure detection in network systems. In these protocols, a node periodically sends a heartbeat message (“I am alive”) to a detector node. If the time between consecutive heartbeat messages exceeds a timeout value, then the node is considered failed. Heartbeat architectures are used in many areas: system diagnosis, network protocols, reaching agreement, and fault detection in computer networks. Many variants of heartbeating architectures are found in the literature, depending on the network topology: centralized, all-to-all, ring-based, and cluster-based heartbeating.

1) Centralized heartbeating: A centralized entity senses the arriving heartbeat messages. Each node periodically sends a heartbeat message to the centralized entity. A node is declared failed if the centralized entity does not hear from it for a defined timeout. This variant is simple to implement. It is often used in devices that control servers to insure that they are running. When the devices miss a user-defined number of heartbeat intervals, they will reboot the servers. Unfortunately, the centralized entity presents a single point of failure and potential bottleneck when the network scales upwards. This architecture is not appropriate for MANETs since they are inherently fully decentralized.

2) All-to-all heartbeating: Every node in the network periodically sends heartbeat messages to every other node[5]. If a node does not receive a heartbeat message from a node after a certain period, it declares that node failed. This variant demands a high bandwidth and consequently it does not scale well.

3) Ring-based heartbeating: In this variant, the nodes are connected logically or physically in a ring. Each node sends a heartbeat message to its successor neighbor when it receives a heartbeat message from its previous neighbor. A node is determined failed if it does not receive a heartbeat message from its neighbor after a timeout. This variant was used in IBM SP-2 [6]. It presents a high detection delay and it is unpredictable for simultaneous multiple failures.

4) Cluster-based heartbeating: In this variant, the network is partitioned in clusters. Each cluster is maintained by a cluster-head. Different heartbeat styles can be applicable inside clusters and between cluster-heads. For example, it can be all-to-all heartbeating inside clusters and ring-based between cluster-heads. Cluster-based heartbeating is a compromise between centralized heartbeating and all-to-all heartbeating. By nature, it is decentralized and can be easily made scalable. Moreover, it minimizes the system throughput. Studies of cluster-based failure detection issues for MANET applications are still largely lacking. The work done in [7] presents a cluster-based failure detection service (FDS) for applications that are made up of large and dense populations of lightweight system resources. Applications are built over ad hoc wireless networks. The FDS exploits the message broadcasting in wireless networks to build a heartbeat failure-detection service. A cluster-head and the nodes in its range constitute a cluster. Nodes in the range of two clusters may act as gateways for inter-cluster failure forwarding. The heartbeat style is composed of three phases: heartbeat exchange, digest exchange and health-status-update diffusion. In the first phase, every node in the cluster broadcasts a heartbeat message to its cluster-head while the cluster-head broadcasts a heartbeat message to its members. In the second phase, every node in a cluster sends the cluster-head a digest message, which enumerates the nodes that it heard in the first phase. The cluster-head broadcasts its own digest messages to its members. Finally, in the third phase, the cluster-head analyzes the information collected in the two previous phases, identifies the failed nodes according to a set of failure detection rules and then diffuses an update message to all the nodes. A cluster-formation algorithm ensures the election of cluster-heads and connectivity between the clusters. It does not support routing stability when nodes move. In fact, the current cluster-based heartbeating solution is designed for stationary hosts and does not address node mobility at all, which is critical for MANETs. Consequently, the clusters will disappear once the nodes move. The FDS will then give unpredictable results since it relies on clusters that may no longer be there. Although the authors claim that their framework can be extended to accommodate host migration, we believe that the framework is still inappropriate for MANETs. First, the iterative cluster-formation algorithm is not designed for mobility since cluster-head election and gateways’ assignment for cluster connectivity are presumed stationary during the execution of the process. Second, when the cluster-heads move out of the range of their members during the heartbeat and digest phases, broadcasted messages will be lost and then failed nodes will be not detected until the stabilization of the clusters’ formation, which is very costly in time.

B. Pinging architectures

In this approach, a node sends a ping message (“Are you alive?”) to another node. The receiving node replies with an acknowledgement message (“I am alive”). Two strategies are used for detecting failed nodes. A node is considered failed if it does not send an acknowledgement within a timeout or fails to respond to a defined number of ping messages. Pinging architectures are more vulnerable to message loss than heartbeating architectures because of their acknowledgement feature, which increases message loss.

A variant of pinging architectures, randomized pinging, is described in [8]. Each node randomly picks another node to ping. If there is no response, k other nodes are randomly chosen to ping the suspected node. If an acknowledgement is received by one of the k nodes, the acknowledgement is forwarded to the original node. If no acknowledgement is received by the original node, the suspected node is considered failed. This variant considerably decreases the bandwidth but it presents a high detection delay.

C. Gossiping architectures

Gossiping architecture was presented for the first time in [9]. Subsequently, some new versions of gossiping architecture have been proposed [10]. In this architecture, each node in the network maintains a list of <M i , H i , T last > such that M i is the address of node i, H i is the heartbeat count and T last is the last time of the heartbeat increase. Every T gossip time, each node increments its heartbeat, selects a random target node (from its list) and sends to it a constant number of <M i , H i > entries. A node, upon receiving a gossip message, merges its list with the list received (taking the maximum of heartbeats). If the sum of T last of M i and a predefined T fail is less than that of the current system time, then node M i is considered as failed. These architectures are resilient against message loss but they use a large bandwidth because of message length.

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 Mfailure 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.

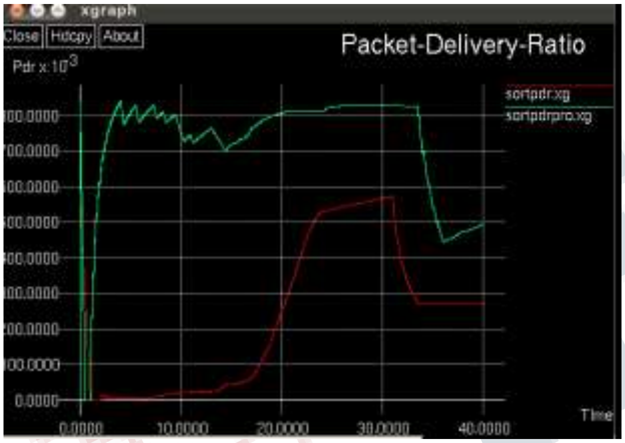
V. GRAPHS

Comparison between the Existing System and Proposed System

- Red Line indicates the Existing System.
- Green Line indicates the Proposed System

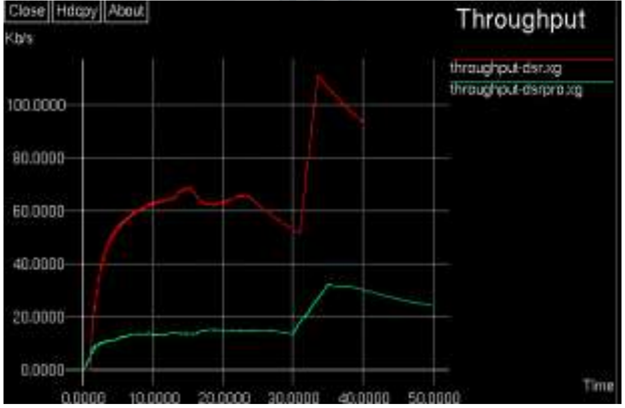
A. Packet-Deliver-Ratio

PDR is defined as the ratio between the received packets by the destination and the generated packets by the source.



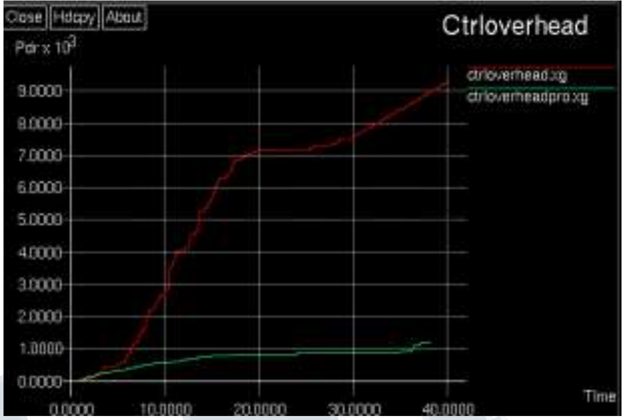
B. Throughput

Throughput is defined as the actual number of bits that flows through a network connection in a given period of time. Actually the no of bits that flows through a network connection in a given period of time is more compared with the existing system.



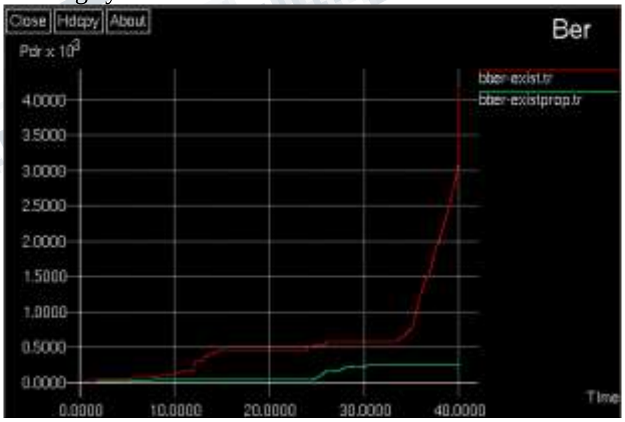
C. ControlOverhead:

Overhead is any combination of excess or indirect computation time, memory, bandwidth, or other resources that are required to perform a specific task Actually the consumption of time , memory and bandwidth that is very low compared with the existing system



D. BitErrorRate

BER is used to quantify a channel carrying data by counting the rate of errors in a data string. It is used in telecommunications, networks and radio systems. The no of error nodes are comparatively very low compared with existing system



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

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