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   STATEMENT OF THE PROBLEM

   OBJECTIVES

   HYPOTHESES

   RESEARCH METHODOLOGY

   RESULTS & DISCUSSION

   FINDINGS

   RECOMMENDATIONS/SUGGESTIONS

   CONCLUSIONS

   SCOPE FOR FURTHER RESEARCH

   ACKNOWLEDGMENTS

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FAULT DETECTION IN NETWORKS BASED ON DYNAMIC INTERVAL BASED ACTIVE PROBING

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ABSTRACT

Increase in the network usage for more and more performance critical applications has caused a demand for systems that can monitor network health with minimum management overhead. Active probing is widely used to provide effective tools for end-to-end monitoring and fault diagnosis over a network. Adaptive probing based algorithms use probing messages to diagnose the state of the nodes in the network. The fault nodes are identified and reported. But the tricky part of probing is to localize faults in the network by sending less probes so that the network load does not get severely increased. In this paper we present a dynamic probing interval selection that keeps the amount of probing under control. Using the reliability and failure rate metric of the nodes as the based, we calculate the probing frequency that will be varying and according to the network's vulnerability to node failures. Our assessment of the proposed method gives satisfactory result and we are realized that this approach provides better performance than approaches, which probe for fixed frequencies.

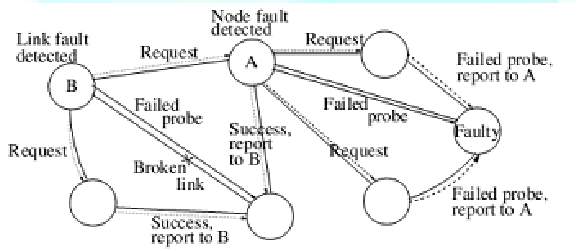
KEYWORDS
fault management, fault detection, probing, networks.

INTRODUCTION
Fault detection is the process of detecting a node failure and localizing the cause of the failure from observed failure indications. With the widespread usage of computer networks in performance critical applications, fault diagnosis has become a vital task for network administrators. Furthermore, increasing advances in developing performance critical applications, increasing importance on quality of service, and growth of large and complex systems make quick detection and isolation of faults essential for robustness, reliability, and system accessibility.

Broadly there are two approaches to fault detection, active and passive detection. Active detection is an active, effective, and adaptive network detection technique, which can detect and localize the faults in the network as soon as possible by sending out probing packets, which include some measurement parameters, into the network. In contrast, passive detection only analyzes the messages already present to infer the existence of network faults without sending out additional probing packets. In this study, we mainly discuss active detection.

Probing is based on actively sending out probes in the network to infer the health of network components. Probes are test messages whose response depends on the health of the probed network components. Probing is typically used to obtain end-to-end statistics such as latency, throughput, loss, and route availability. For instance, a probe could be a ping to collect information about connectivity of nodes. Probe tests are performed in each node to test the availability of adjacent nodes and links. If a probe test on a connection fails, a symptom of a network fault has been detected and a fault-localization process based on node collaboration is initiated (see Figure 1).

FIG 1: EXAMPLE OF ALGORITHM FUNCTIONALITY



There are two main problems to address while developing probing-based monitoring solutions namely probe station selection and probe selection. The probe station selection problem addresses the problem of selecting nodes in the network where the probe stations should be placed. The probe stations are the nodes that send probes into the network and analyze probe results. The probe station nodes should be selected such that the required diagnosis capability can be achieved through probes. Furthermore, as the probe station selection involves an additional instrumentation cost, the number of probe stations need to be minimized. Once the probe stations are identified, the probe selection problem addresses the task of selecting appropriate probes such that the failure can be detected and localized. As the probes involve an additional traffic overhead, the number of probes should be minimized. At the same time, the probes should be selected such that the detection and localization time is minimal. In this paper we address the problem of selecting the ideal probing interval in order to keep the additional load due to probing under control and at the same time ensuring proper failure detection.

REVIEW OF LITERATURE
In this section, we review the related works in the area of fault detection and recovery in computer networks. Many techniques have been proposed for fault detection, fault tolerance and repair in computer networks. In a paper by Yu et al., one of the main risks of centralized approaches identified is increased link load, close to the central collection point [2]. Further, the authors point out that neighbor-coordination for fault-detection reduces communication overhead. Different strategies for fault-detection have been investigated by Zhuang et al. [3]. The authors divide fault-detection into passive and active methods. Passive approaches eavesdrop on packets for monitoring the status of other nodes, whereas active monitoring methods are based on end-to-end transactions between nodes. One such probing method is based on logical trees for determining a candidate node for probing [4];

In another approach, the authors solve the NP-hard problem of computing a minimal set of probe messages to be transmitted by the stations for fault-isolation and latency measurements, applying a polynomial-time greedy approximation algorithm [5]. Other techniques for active probing are based on statistics and information-theoretic approaches; for example probabilistic reasoning is performed to select the most informative probe test [6]. Tang et al. propose a combination of passive and active methods for isolating faults via probing, involving heuristic fault-reasoning and fidelity measures for decision making [7]. Andersen et al. describes a method [8], in which two different probing frequencies are applied and used for outage detection. Their probing approach is based on fixed time intervals applied to all connections in the network. In contrast, probing intervals in our approach relates to the reliability of the nodes in the network and are not based on any fixed time.

DYNAMIC PROBING INTERVAL SELECTION

Usually a network won't have any faulty nodes in the initial several rounds of usage. Thus, the probe stations that send probing packets during each probing session, but will not receive any useful feedback messages until the first fault node has appeared. In other words, all the probing work is useless during the period from the beginning to the time when the first fault nodes appear. A way to considerably reduce this useless probing is to not send out the first probing packet until there is a failure in the network, this depends on the reliability of the nodes in the network.
The following notations are used in our discussion.

NOTATIONS

Si	–	Sensor node
S	–	set of sensor nodes
Ri(t)	–	reliability of si in time t
Fi(t)	–	fault probability of Si in time t
Ti	–	average life time
α	–	fault rate of sensor
w	–	time interval of sensing probing packets
fre	–	probing frequency

In general, a node's failure probability will change with time, and the longer the time a node works the higher failure probability it will have. We can define the reliability R_i (t) of a node S_i as the probability of not having a failure within the time interval (0,t).

$$Ri(t) = e^{-at}$$

where α is the failure rate of node Si. The fault probability of node Si in time t is Fi (t):

$$F_i(t) = 1 - R_i(t)$$

It is easy to see that the probability Ri(t) means the probability of lifetime is larger than t_0. Then, the average lifetime of the nodes is Ti:

$$T_i = \int_0^\infty R_i(t)dt = \int_0^\infty e^{-at}dt = \frac{1}{\alpha}$$

The reliability of the entire network is R:

$$R_i = \prod_1^{|s|} R_i(t)$$

Since the nodes of the networks have the same α, the average lifetime (T) of the entire network must be:

$$R = \prod_1^{|s|} R_i(t)dt = \int_0^\infty e^{-|s|at}dt = \frac{1}{|s|\alpha}$$

where | S | is the number of nodes in the network. We can trust that there is no faulty node before T in the network. Thus we can reduce the probing packets until T , and cut down the number of useless probing packets.
In this study, we decrease the probing interval through dynamic adjustment of the probing frequency to reduce useless probing. A simple rule is described to show how to determine probing frequency:

$$fre = \begin{cases} 1 & |Sd| \geq 1 \\ 1/w & other \end{cases}$$

In this way, we can reduce the useless probe traffic using the above rule, but the problem of missing faults must be considered when reducing the probing frequency. Because the probing packets are sent out every round, any faults occurring during the interval between these probing packets and the next probing packets may be missed. For convenience we call this interval the probing interval. In this study, we adopt two measures to avoid this disadvantage:

- In any cases, the probe station nodes broadcast the probing packets to their one-hop neighbors. If the probe station node doesn't receive feedback messages from one neighbor, this one could be the fault node, so even when the fault nodes occur in the time with no probing packets, they can still be detected out by the later probing packets. This however will result in some delay.
- Any node of the network can store the messages of all fault nodes, and once a new fault node was detected out, the probe station broadcast the messages of this fault node to the neighbors. This way we could avoid broadcasting the repeat fault messages.

RESULTS & DISCUSSION

Our proposed approach will keep the frequency of probing or the probing interval to be minimal when there are no faults reported, and would increase the frequency as faults begin to occur. An important factor we should consider when studying fault detection problems is the FDR (Fault Detection Rate). FDR is the proportions of faults have been detected by probe stations. We can get the FDR by dividing the number of nodes that have been detected by the total number of fault nodes. According to our assessment, the FDR rate for our approach would be relatively lower. Because, If the probe station nodes happen to fail in the round they should send out probing packets, the faults will be detected at least two rounds later. This will lead to two more rounds of delay, and the faults would be missed. In extreme cases, the earlier several faults would be missed because of the successively failed probe stations. The probing frequency is not adjusted to the normal value until one fault is detected. As a result, the FDR of this approach will be low in certain cases, but it ill be acceptable in most general cases.

CONCLUSION AND FUTURE WORK

In this paper we analyze the problem of active probing based fault detection of nodes in a network. We find that the frequency of probing has a profound impact on the overall network traffic. As the network traffic increases, this results in congestion, packet loss and eventually drops in QOS. It also results in wastage of bandwidth. So it is important to avoid unnecessary probing. We have proposed a strategy that will decrease the probing frequency through dynamic adjustment of the probing frequency to reduce useless probing. As part of the future work, we aim to work on addressing Quality of Service (QoS) failures.

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