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# A ROBUSTNESS OPTIMIZATION SCHEME FOR LOCATION-ASSISTED ON-DEMAND ROUTING PROTOCOL

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## Introduction

In this paper, an optimization scheme is proposed to streng then the robustness of LAOR. It adopts another method to c alculate the request area. The optimized request area ensure s that a single node failure will not lead to routing failure, a nd in the case of multiple node malfunctions, the optimizati on scheme achieves a lower probability of routing failure. A t the same time, it reduces routing costs by cutting down the number of Route Request (RREQ) packets.

## LAOR

The routing procedure of LAOR is as follows: when the source satellite initiates a routing procedure, it first calculates the request area and generates RREQ packet, sends it to all its neighboring satellites in the request area, and all the intermediate satellites in the area also forward the RREQ packets to their neighboring satellites. Until the RREQ packet is forwarded to the destination satellite, it generates the Route Reply (RREP) packet and sends it back to the source satellite along the shortest delay path built by RREQ flooding, and updates the routing table of all satellites on the path, the routing procedure is finished.

## Analysis of LAOR

The design objective of the request area is to guarantee the existence of at least one available path in the request area and this does not take robustness into account. In the three cases shown in Fig. 1, the failure or congestion of only one specific satellite is enough to leave no available path between the source and destination satellites.

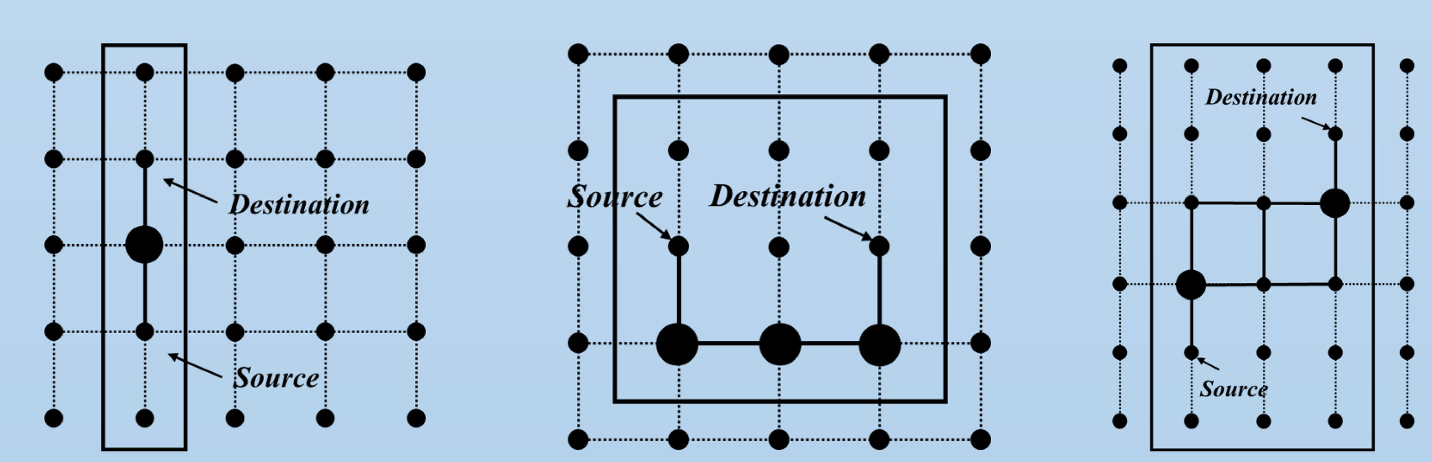


Fig.1. Satellite failures causes routing failures(

In Fig. 1 (a), the source and the destination satellite are in the same orbit, and the failure of any satellite between them will block the only path. In Fig. 1 (b), $y_{src}=y_{dst}$ and they are in one (South or North) polar region, the parameter $w_{min}$ allows the path to bypass the polar region, but the malfunction of any satellite marked as a larger point will lead to a routing failure. In Fig. 1 (c), the source and destination satellites are respectively located in two polar regions, and the satellites marked as larger points in the figure are their entry satellites into the non-polar region; if either one fails, the source and destination satellites cannot be routed to each other.

## Optimization Scheme

To address the above features, the optimization sc heme is proposed by changing the calculation meth od of the request area. Instead of using parameter $w_{min}$, another method to guarantee connectivity is a dopted. First, calculate the request area according t o (1) where $w_{min}$ is set to zero. In particular, if $x_{src}=x_{dst}$, $S_y$ is expanded to the whole orbit; if $y_{src}=y_{dst}$, $S_y$ is expanded to $[y_{src}, y_{src}+1]$ (Particularly, when $y_{src}=y_{src}=M$, $S_y$ is expanded to $\{1, M\}$). After that, if the source or destination satellite is located in the polar region, $S_y$ should be expanded from it to the ‘first non-polar satellite’ in two directions to guarantee each satellite in the polar region has two entrances to the non-polar region.

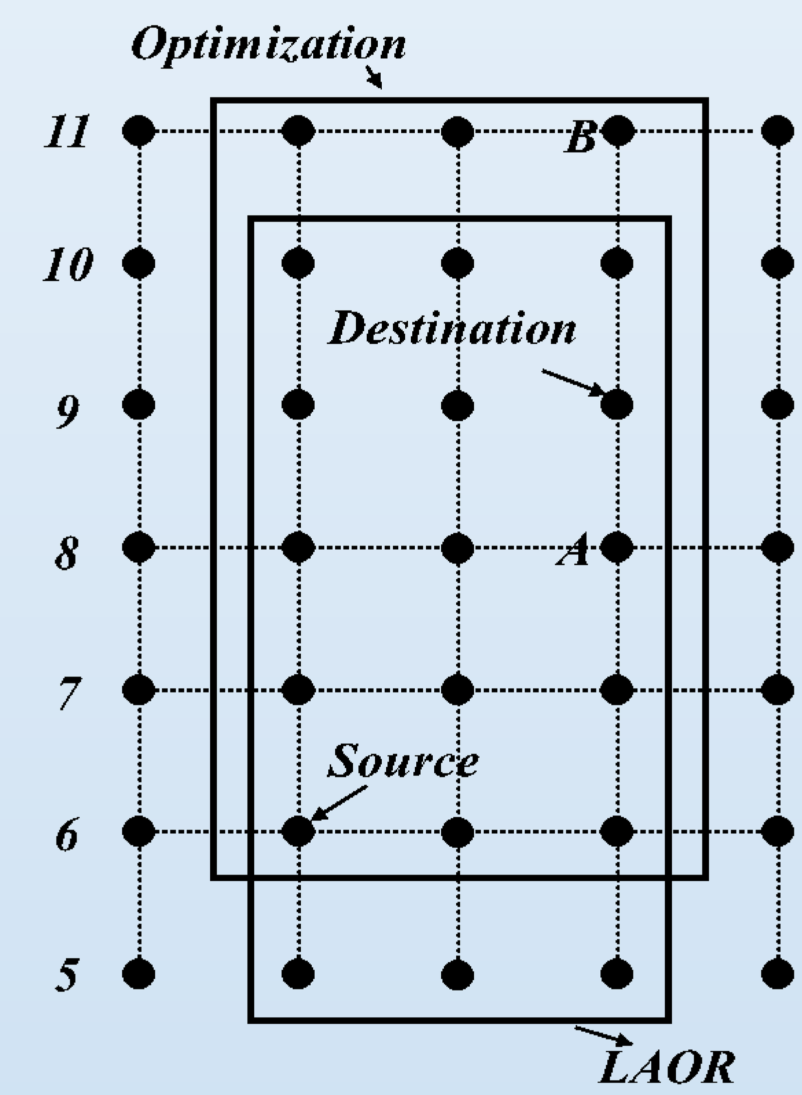


Fig.2. Request area in optimaizatio n scheme and original LAOR

## Simulation

We randomly select the source satellite and the destination satellite, and randomly make certain numbers of other satellites or links fail, check whether the routing fails under suc h a failure situation. 1000 experiments for each number of failures are performed. The av erage routing failure rate of the two schemes is shown in Fig. 3 and Fig. 4.

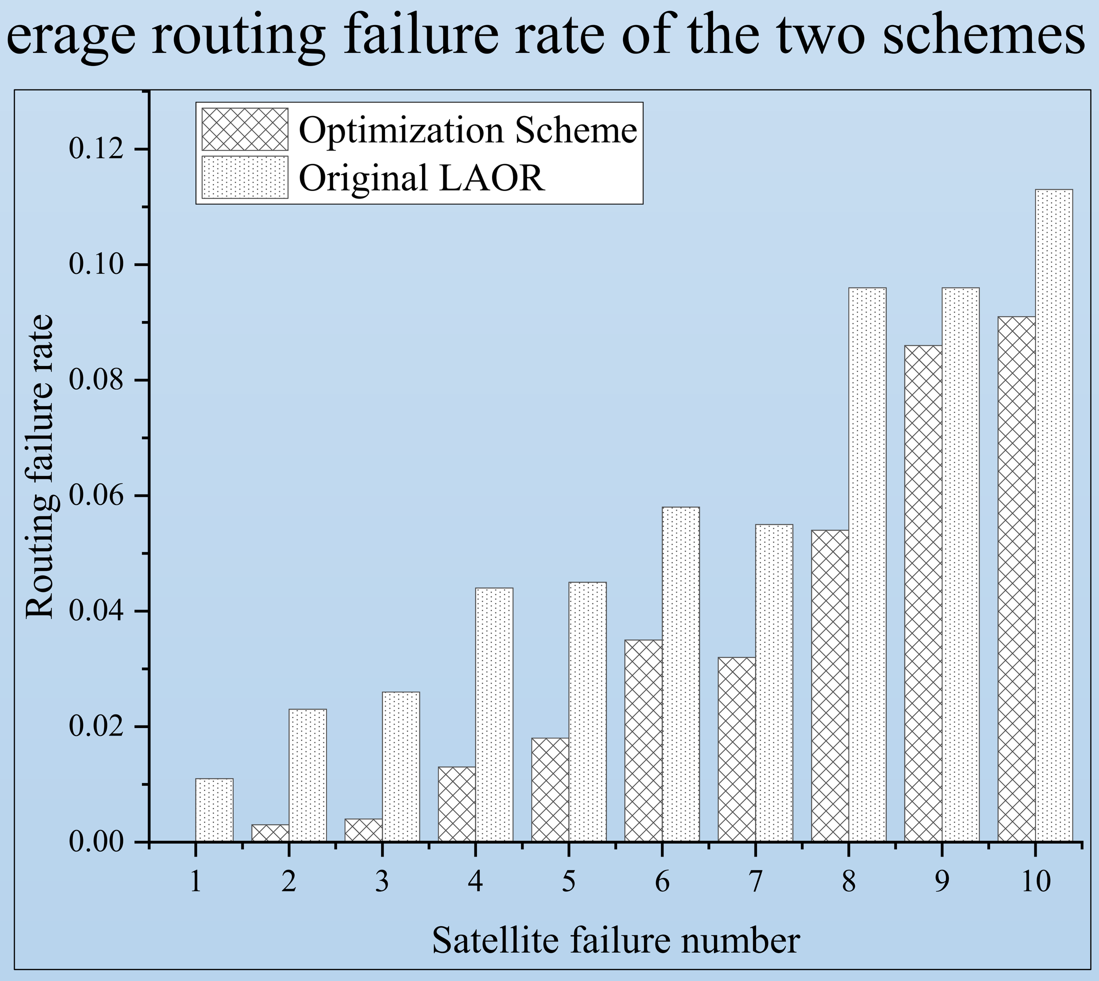


Fig.3. Routing failure rate under satellite failures

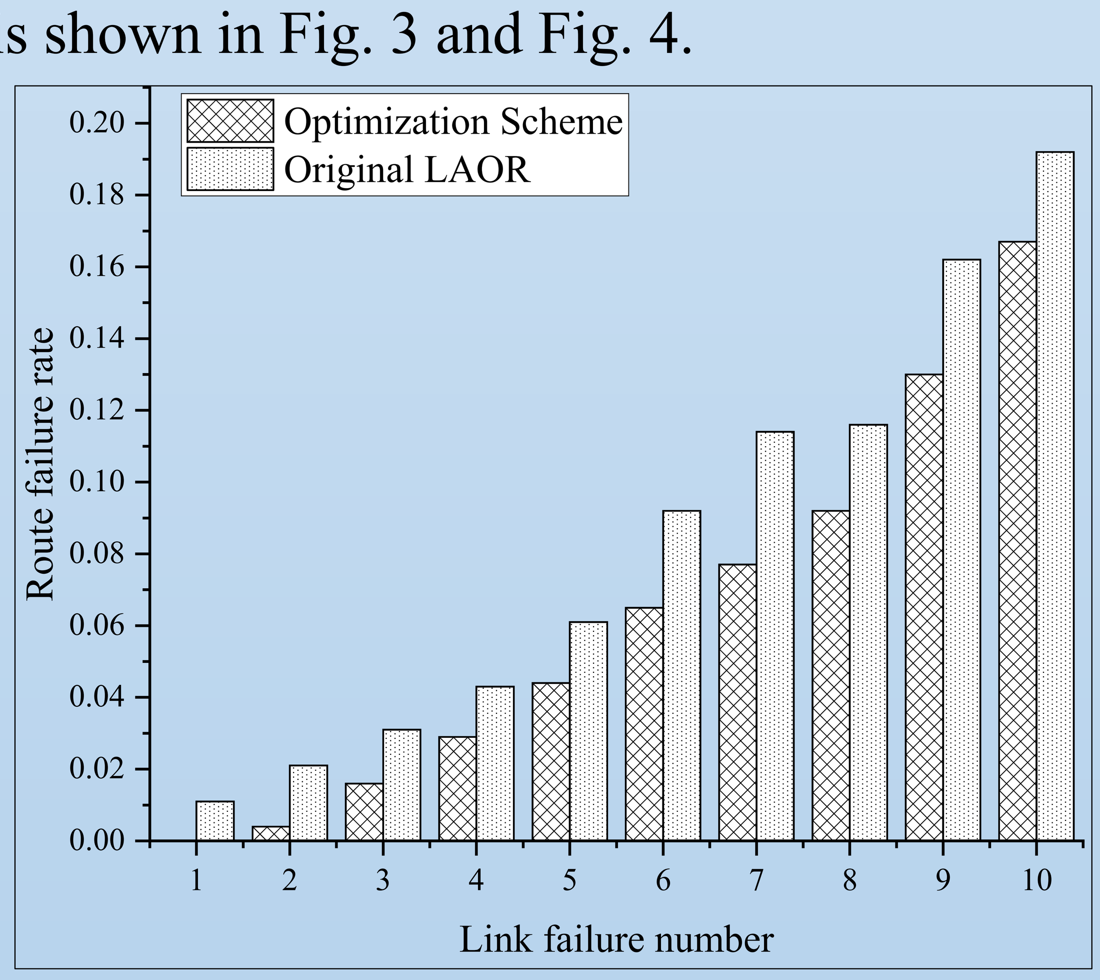


Fig.4. Routing failure rate under link failures

The results in Fig. 3 and Fig. 4 show that in the case of one satellite or link failure, the r outing failure rate of optimization scheme is zero, which is consistent with our expectatio n. Moreover, the routing failure rate of the optimization scheme is always lower than that of original LAOR when the number of failures increases, confirming that the robustness of optimization scheme is higher than that of original LAOR.

## Summary

This paper first introduces the workflow of the LAOR protocol, analyzes its features in terms of routing cost and robustness: the redundant area decreased the network efficiency, and some specific satellite failures lead to routing failure. To address these features, an optimization scheme is proposed. It changed the original method of calculating the request area without extra complex steps.

The simulation results show that the optimization scheme achieves higher robustness and lower routing cost than the original LAOR at the same time. The optimization scheme can be implemented in the LEO routing system in the context of the increasing importance of robustness of satellite networks.

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