Reliable Routing in Unreliable Networks

1. Background

Modern communication networks such as wireless sensor networks, mobile ad-hoc networks, IoT systems, and satellite communication networks operate in environments where communication links are often unreliable.Link failures may occur due to interference, noise, congestion, mobility, or hardware limitations.

Despite this, many traditional routing algorithms assume that all network links are reliable and available at all times. This assumption simplifies routing decisions but does not accurately reflect real-world network behavior.As a result, routes selected using conventional shortest-path algorithms may fail frequently when deployed in unreliable environments.

2. Motivation

In real-world networks, packet delivery over a link is not guaranteed.
Each communication link has a certain probability of successful transmission, which can vary based on environmental and network conditions.Ignoring link reliability during routing can lead to:

- Increased packet loss
- Frequent route failures
- Reduced overall network performance

Therefore, there is a need for routing strategies that explicitly consider link reliability while selecting paths between nodes.

3. Problem Description

The network is modeled as a graph where:

- Nodes represent communication devices or routers.
- Edges represent communication links between nodes.
- Each edge is associated with a success probability representing the likelihood of successful data transmission over that link.

Given a source node and a destination node, the problem is to determine a routing path that maximizes the probability of successful end-to-end communication.The end-to-end success

probability of a path is defined as the product of the success probabilities of all links along that path.

4. Challenges

The primary challenge in this problem arises from the multiplicative nature of link probabilities. Unlike traditional shortest-path problems that involve additive costs, probabilistic routing requires maximizing a product of probabilities.Additionally:

- Links may fail dynamically
- Multiple paths may exist with different reliability characteristics
- A shorter path may not always be the most reliable one.

These factors make direct application of standard routing algorithms insufficient without modification.

5. Objective of the Project

The objective of this project is to design and implement a routing strategy that:

- Incorporates link success probabilities into routing decisions.
- Identifies the most reliable path between a given source and destination.
- Evaluates the robustness of the routing strategy under random link failures.

The project aims to demonstrate that reliability-aware routing can significantly improve end-to-end communication success in unreliable network environments.

6. Scope and Applications

The proposed approach is applicable to:

- Wireless sensor networks.
- IoT communication systems.
- Satellite and space communication networks
- Mobile and ad-hoc networks.

By considering probabilistic link behavior, the routing strategy better aligns with real-world network conditions.