National University of Singapore
School of Computing
CS5229: Advanced Computer Networks
Semester I, 2021/2022

Lecture 8 Training
Mobile Ad Hoc Networks

In Lecture 8, we discussed various routing algorithms for mobile ad hoc networks where nodes communicate on wireless channels without centralized infrastructure and administration. We also discussed how location information can be exploited to achieve efficient routing using *geographic routing* algorithms. In this training, we will explore geographic routing in a modern context.

After taking CS5229 and graduating from NUS, you found yourself working for SpaceX under their Starlink project.

> "Starlink is a satellite internet constellation operated by SpaceX providing satellite Internet access to most of the Earth. The constellation consists of over 1600 satellites in mid-2021, and will eventually consist of many thousands of mass-produced small satellites in low Earth orbit (LEO), which communicate with designated ground transceivers. While the technical possibility of satellite internet service covers most of the global population, actual service can be delivered only in countries that have licensed SpaceX to provide service within any specific national jurisdiction. As of September 2021, the beta service offering is available in 17 countries." – Wikipedia

Understanding Local Minima

Your new boss asked you to evaluate the a proposal for a constellation of geo-stationary satellites[1] covering x longitudes and y latitudes. Basically, this constellation consists of xy satellites placed at the intersections of the longitudes and latitudes. You can assume that the intervals between the satellites are equal and uniform. You can assume that the satellites are equipped with radios that allow them to communicate with adjacent satellites along each latitude and also longitude (except the highest and lowest ones along each longitude, Figure 1). Basically, assume radio links do not extend across the north and south poles.

Given this information, which of the following statements is/are true:

Q1 Greedy forwarding between the satellites based on shortest distance along the circumference of the earth will be correct as long as there are no node failures.

Q2 Greedy forwarding between the satellites based on shortest distance along the circumference of the earth will be correct as long as there is at most one node failure.

Q3 Greedy forwarding between the satellites based on direct Cartesian distance will be correct as there are no node failures.

[1] Starlink uses Low-Earth Orbit (LEO) satellites instead of Geosynchronous Equatorial Orbit (GEO) satellites.

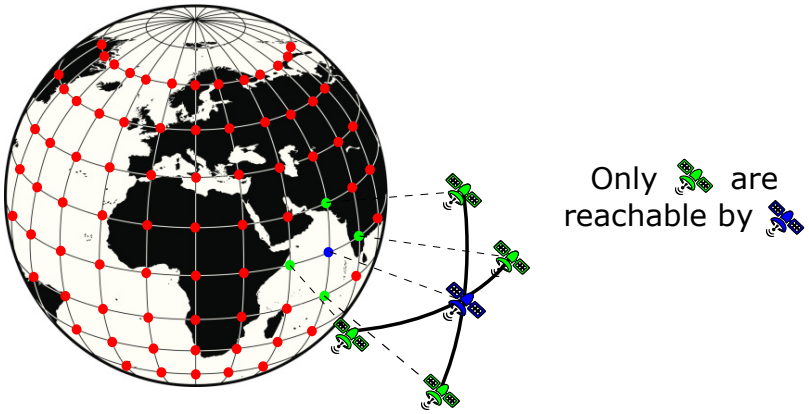

Figure 1: Organization of the geostationar satellites along the lattitudes and longitudes.

Recovering from Node Failures

Suppose greedy forwarding is adopted for the constellation of geo-stationary satellites and shortest distance along the circumference of the earth is used as the distance metric.

Q1 Propose what we should do if we experience one node failure, if we decide to stick with geographic routing.

Q2 Can we adopt the same strategy if there are more than one node failures? Explain. If not, proposal how we might be able to recover from the failure if we decide to stick with geographic routing.

GDSTR without Conflict Hulls

A key skill is to be able to analyze an algorithm and reason about how it works. We discussed GDSTR in lecture and mentioned briefly that *conflict hulls* will allow us to determine whether a packet is undeliverable more efficiently. It is quite difficult to explain this clearly in a lecture. In this question, your task is to reason about routing on a hull tree without conflict hulls. In particular, consider the scenario where you are running GDSTR with a single hull tree and the destination is invalid. In other words, none of the nodes in the network have a location that matches what is specified as the address. Explain how we would conclude that the packet is undeliverable.