Project Executive Summary

Backstory:

In any operation area, there has to be a robust communication network, for ease of any kind of operation. And as technology increases our information flow from field units (sensors), we have to expand and improve these network systems constantly. This problem leads to think about a real problem on operation area; a communication network with dynamic entities in real time. But since the scope of this problem is beyond this project, it's simplified to static clients and one dynamic server.

Introduction:

This project aims to design a combat communication network system. This system has N nodes, each node as a client computer (which can be an armored unit or a marine platoon or even a helicopter) and one server (HQ or main Comm. unit). For sake of simplicity, client computers are geographically stabilized, but the server is mobilized. The arcs are the messages sent from client I to client J. There can be many messages from one node to many other nodes. But the point is, each message should visit server. This means that if a message is sent from client I to a neighbor client J, it first has to go to server and then come back to client J. Assuming that each message transfer takes " 1 " time, our objective is to find the best possible place for the server in order to minimize the total time.

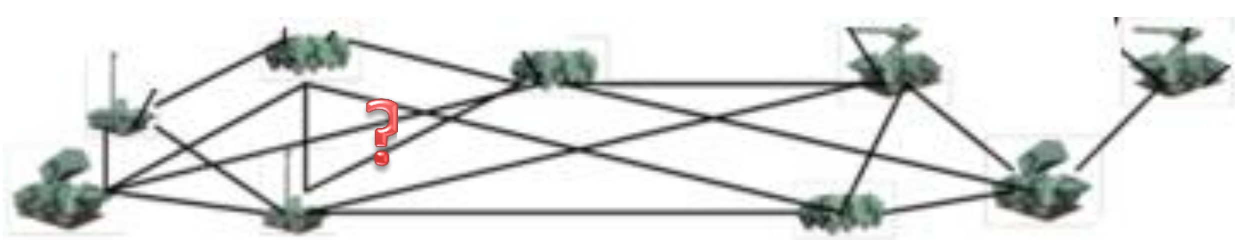


Figure – 1 : A simplified combat communications network

Since this is a communication network design project, it does not have a real map, but there will be some artificially generated maps for visualization of the problem.

There are some constraints and assumptions. The first server constraint is connection capacity. The server can only connect number of Cs clients directly, so messages may have to come through other clients. The second server constraint is distance limitation. The server cannot connect clients further than distance Ds (this constraint can be omitted). The assumptions are, the network has constant speed at anywhere and anytime, and the process time is related to number of transfers (not distances).

## Modeling:

This is a network design problem, but unlike network reliability, it aims to minimize the sum of time. So the problem will be a shortest path problem (on many iterations) and the objective function is ;

$$\min \ \left( \sum_{i,\exists\ arc\ (i,j)}^{N} \mathrm{T(i,s)} + \sum_{j,\exists\ arc\ (i,j)}^{N} \mathrm{T(s,j)} \right)$$

With defining T(k,l) = # of nodes from node k to node l * unit-time (1)

Though the solution was modeled as a shortest path problem, this can be converted to a flow problem, too. After taking first step as a SP, the next step is to re-model the solution according to different size of message loads. In that case, shortest path will not be enough, and a max-flow approach will be needed.

## Follow-up Study:

This problem solves a static layer of operation area ( and it looks like it’s far away being realistic), but one can convert it to a dynamic model with a few changes. Time- layering is the first option. As we modeled the ship according to the weather, we can use the same concept to convert this static model to a dynamic combat communication network. Changing the message load will also contribute the model to be more realistic. And other constraints can be added later, such as different clent types, different capacities, communication quality (as cost).