Simulation and Traffic Routing for Efficient Allocation and Management

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Abstract

STREAM - Simulation and Traffic Routing for Efficient Allocation and Management is a simple simulation tool that I have developed as a part of my project work over the summer. It is intended to locate the importance of Braess's Paradox in effectively allocating resources over networks where there is a flow of traffic. It is just a simple tool to analyse if there is any extraneous edge in the network and whether the functioning efficiency of the entire network would improve if it is not present.

Braess's Paradox

"Braess's paradox is the observation that adding one or more roads to a road network can slow down overall traffic flow through it. The paradox was first discovered by Arthur Pigou in 1920."

A very important discovery in the domain of game theory, it provides a practical problem that is posed to networks with high traffic flow and limited resources or components. It gives an outlook towards the design of such networks and provides intuition on how more efficiency can be achieved in the overall network. Our common belief and intuition tells us that addition of more components in a network would generally tend to ease the pressure on them and make it more efficient overall, but that doesn't seem to hold true in all cases. It is observed that in quite a few places, removal/ reduction of certain components in the network tend to lead to greater overall efficiency in the network.

The concept of Nash Equilibrium helps us to understand the counter intuitive behaviour of networks. Braess's Paradox is considered to be a game with a pure strategy Nash Equilibrium. This can be described in the following way,

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This is a tool that simulates the Braess's paradox on simple networks and analyses to check if the efficiency of the network given a traffic profile is most suitable in the network. The main idea is to perturb a flow network with a single user, and then check if Braess's paradox is followed or not. First the network is set up with the given map and initial flow values. The weights to the edges are set up in such a way that they are affected by the number of users on that particular edge. Here, only a linear dependence is assumed to be followed for each edge. This can be proven to be a suitable assumption as Braess's paradox can be shown to work in any case where there is a functional dependence on the number of people on that particular edge in the network.

Since we are unsure of which of the edges in the network cause the paradoxical behaviour, this tool loops through each of the directed edge in the network and does the following things in the analysis:

- Remove/ restrict the given edge and then find the shortest path for the trip using Dijkstra's algorithm.
- Add a non weighted edge between two points and then simulate the shortest path after redistribution of the traffic on the other edges.