# Modeling smuggler network as electrical circuit:

source

target

10000

**Approach:**

This approach adopts a **global** method of calculating path probabilities by using node/edge features to calculate **myopic** estimates for edge attractiveness.   
This approach does **not** need graph to be directed. This approach does **not** rely on features to capture non-local information about future nodes in graph/other targets etc.

1. First step is to estimate the attractiveness value for every transition (edge ‘e’) in a purely myopic fashion (attractiveness is equivalent to resistance/conductance of a component). The values in the graph above denote attractiveness values of the corresponding edges. *Here it would also be ok to have a super attractive edge even though it may lead to a dead end, as shown above.*
   1. This could be done using node features of adjoining nodes/edge features of the edge under consideration.
   2. Pass these features through a GCN 🡪 NN 🡪 bounded rationale equation🡪 spew out some positive real number corresponding to attractiveness value.
2. Next, we consider the set of all **simple** paths (no loops) from source🡪 target. This will always be a finite set.
   1. For every path belonging to this set: calculate the effective attractiveness (like effective resistance). One of the ways to do this could be:

Of course, could be computed as a simple sum of the constituent )’s, but computing it like this, fits the electrical network model. It also fits the CTMC model (explained below), which is a lot similar to electrical network model and a lot different from the DTMC model.

1. Once is computed for all paths , the probability of each path is just proportional to . Thus,
2. Probability of an edge can be computed by summing up probabilities of paths which include that edge. In contrast to earlier approach, here prob of edge is computed from prob of path, rather than vice versa.

**Appendix:**   
  
1. What’s the point of GCN here if it anyway predicts local characteristics?   
The objective of GCN here is not to try to predict whether the node can lead to other more attractive nodes and eventually to the target. In some cases, the ease of transition from Node\_a🡪 Node\_b might depend on some qualities of neighbors of node A and node B, for whatever reason. The GCN only allows us to take into account these qualities, of nodes which may not even be part of the path under consideration.

2. CTMC model:  
  
This is a Markovian model that assumes that the state moves from a current state, to one of its neighboring state after a transition time that is modeled as an exponential random variable. The t is unique for every edge. The transition time for every edge is defined as the expected value of this random variable. The rate of that edge is defined as the inverse of the transition time.   
  
Intuitively this model fits the problem at hand, because we can assume the transition time of the CTMC to be inversely related to the attractiveness of an edge. Further this model provides for methods to compute the probability of a path in CTMC. The solution given by this takes the same form as the electrical network model described above.