SF Drugs Network

Introduction

Armo is one of the biggest drug dealers in the San Francisco Bay Area. His drug network originates in Mexico and is transported North via land and sea routes to various locations in the Bay Area. Once in the Bay Area the drugs are shipped, distributed and sold throughout the various metropolitan areas. According to the police intelligence, the San Francisco police learn that Armo's network has three different categories of nodes in his Bay Area network. They are Transport Centers (land, sea, and air), Distributers, (responsible for organizing shipment and distribution within a specific metropolitan area) and Sellers (Street level dealers). Armo uses each Transport Center to receive drugs from Mexico and then ship drugs to each subarea. Each Transport Center can also transport drugs to surrounding local Distributers. Distributers allocate the drugs to each seller to satisfy their demands and they interact directly with their local Transporters.

San Francisco police want to minimize the Armo's ability to distribute drugs at the street level in San Francisco and have called on their fellow Bay Area cities to help interdict this drug operation. Their goal as a collective will be to maximize the amount of time it takes Armo to get drugs into San Francisco, with the intent to completely stop any distribution at the street level.

Model and Problems

In our model, the start node is a dummy node "Mexico" that represents the source of the supply chain and it will connect to two other dummy nodes which are the two methods that the drugs are being shipped from the border to the Bay Area ("Sea Route" and "Land Route). Each of those connect to various Transport Centers who receive the drugs and then begin shipping them around. The simplified network is provided at Figure 1.

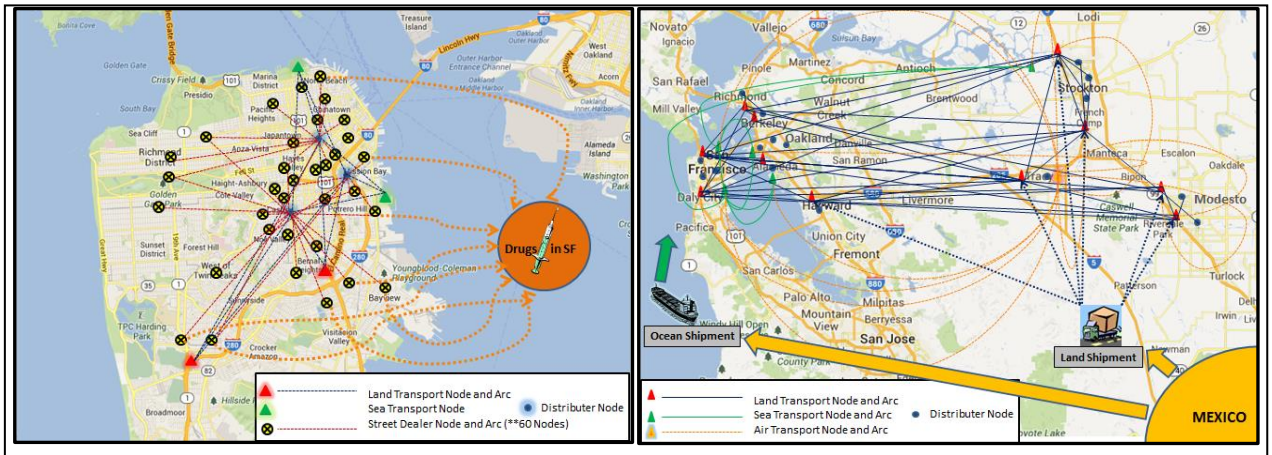

Figure 1. Simplified Transport Network at Bay Area

(1) Shortest Path with Interdiction Problem

We first define node "DrugInSF" as the end node. Then we find out Armo's best transport path (the shortest path) from Mexico to DrugInSF. Each edge is assigned a value as its cost according to its estimated time it takes for the drugs to be prepared and travel some distance by some mode of transportation. For instance, for a Distributor to distribute drugs to one of his local sellers it takes a

time of 1 unit, but for a Sea Transport Center to ship to another Sea Transport Center in a different city requires 8 units. According to the shortest path, we decide where to attack. Once an edge is attacked its cost increases. In this way, we attack as many edges as we can to maximize the cost of Armo's shortest path. In this problem, we will not restrict ourselves to a certain number of attacks so that we can discover the number of interdiction teams the Bay Area Police will need to come up with to stop drugs coming into SF. Once complete it is up to the Bay Area Police to decide if they have the resources to enact that plan or if they need to choose one of the optimal interdiction plans resulting from resource constraints.

(2) Max Flow with Interdiction Problem

Two kinds of attacks are designed in max flow problem. The first one is "Effective Attack" which means it can block the whole flow on an arc once the police attack that arc. The other one is "Attack Weak" which means it only blocks half flow on an attacked arc. Then we compare the effectiveness of both attacks. Capacities assigned to arcs depend on the level of an arc

(3) Interdiction Constraints

We assume each city has limited resources and they will need to pool their resources to interdict drugs into SF. However, each interdiction team that is based out of a specific city can only interdict edges that flow in and out of its own city. The purpose of this scenario is to maintain a degree of intercity department autonomy and discern if the drug network can be severed without using the State Legislative Branch to commandeer each cities police resources under a separate Northern California Police Task Force.

(4) Assumptions and Network Rules:

- Edges are not specific known roads. They are a path between the two nodes that consist of various roads and sea routes. The only way to interdict them is to put an interdiction team in constant over watch of those involved in the transportation over that edge and shipments will have to be followed from start to finish. This rules out putting a roadblock at a random intersection that is heavily used by civilians and drug dealers and catching the drugs. The drug dealers can spot randomly place roadblocks so it requires a dedicated team for that unique edge.
- Intra-City transportation is faster than Inter-City transportation.
- Land-Transport is faster than Sea Transport
- Air Transport is the fastest and has the ability to drop drug shipments in the ocean or on land for Sea and Land Transport centers to pick up.
- Water Transporters can only ship to Water Transporters and the same relationship for Land Transporters.
- Distributers are the only ones who can receive or send drugs to and from a transporter with in their city and are the only ones that can interact with "Sellers"
- For this problem the police cannot attack nodes because they constantly are in hiding, but they can attack the shipment if it has left hiding and is being moved.
- The arcs from Mexico to the Bay Area transporters are impossible to interdict due to lack of cooperation from the State Government and the Southern Municipalities.

Analysis of Results

(1) Shortest path with interdiction

- Transit increases quickly when Sea Transit has to be used.
- The airport is used only after SF Land Transport and Sea Transport nodes are cut from their Distributers.
- At 12 Interdiction Teams the Police pull all external teams and flood SF's internal network
- Resiliency curve is provided in Figure 2

(2) Modified Shortest Path with Interdiction

One SF Land Transporter to one SF Distributer is unknown to police and interdiction teams can not get the necessary intelligence to interdict.

- Initial success is derived from cutting Land Transporters in near cities off from SF.
- Airport Routes were not cut until 19 Interdiction Teams were Available.
- Sea Transporters were not used until 25 and 26 Interdiction Teams were available.
- Once 30 teams become available Police attack Sea Transporter to Distributer networks and then eliminate all Arcs that flow into Land Transporter Nodes
- Resiliency curve is provided in Figure 2

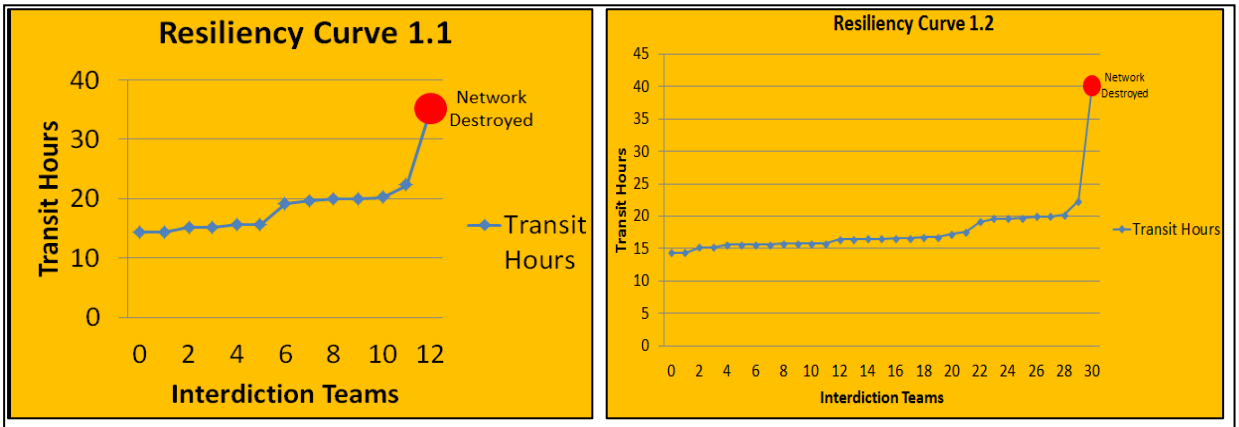

Figure2. Left is Standard Shortest Path with Interdiction; Right is Modified Shortest Path with Interdiction

(3) Max Flow with interdiction Problem

- Max flow without interdiction is 740 Kg
- Max flow under effective attack is cut off at 12 interdictions

- Under weak attack, max flow drops to 370 Kg at 12 interdictions and is cut off at 71 interdictions.
- SF police first attack arcs between distributers and transporters and finally need another 27 interdiction teams to attack arcs between sellers and DruginSF to cut the max flow off

- Resiliency curve under weak attack is provided in Figure 3

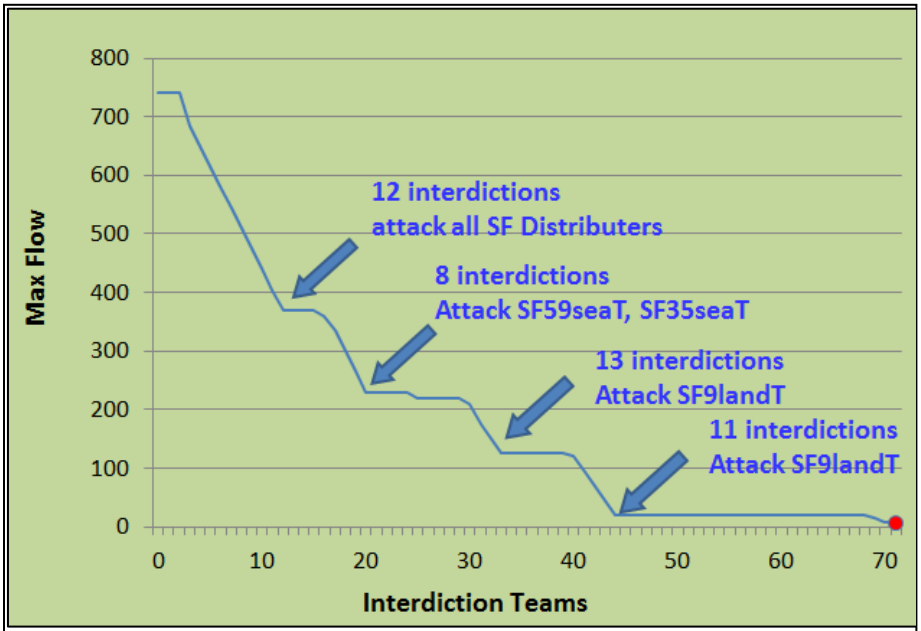

Figure 3. Resiliency curve under weak attack

Conclusion

- Weaknesses in intelligence will vastly increase the resource requirements.
- Land Based Drug Smuggling is likely to be used.
- Controlling Land Routes is essential to forcing Smugglers to use more costly means.
- Interdiction at the Street Dealer level is a sub-optimal use of resources.