Red Team Modeling Project 3: Deliverables and Guidance

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1 Deliverables

The deliverables for the project are as follows.

1. **A 21 minute in-class presentation** followed by 4 minutes of questions and discussion. We will do these presentations the last five days of class.

2. **PowerPoint slides** for your presentation.

3. **A 3 page executive summary** of the project and results.

4. **GAMS files, and data/csv files** for your project. . . essentially, everything required to rederive and rerun the results listed in your presentation and summary.

I'll hand out more instructions on submitting the deliverables as the presentations get closer.

2 Guidance

You have completed the drug smuggler example project. Your class project is somewhat similar in makeup to that sequence of homework assignments, except the problem you are analyzing is different and thus the mathematical models will be different.

The basic steps of the project, some of which you are familiar with, are:

1. **Create a back-story.** In other words, create a short story or scenario to motivate yourself and the people listening to your presentation why the problem you are analyzing is important. In other words, at a high-level, what is your real-world network, and why is someone attacking it?

2. **Mathematically model your network operations.** For this step, you have to abstract the real-world into a set of nodes and edges. What are your nodes? What are your edges? What data is associated with a node or edge? What kinds of flows / movement is happening across the edges? What is special about your network vs. other networks? Also, very importantly, what is a single real-number-valued *measure of effectiveness* for your network operations? The answers to all these questions should help you create a network-flow-type LP to model your network operations.

3. **Create the data for your network.** Using the real-world data you found in Project 0, create the CSV files required to populate your LP.

4. **Code a GAMS model for your network.** Turn the LP you created into something you can solve using a computer, so you can tell you how your network operates.

5. **Mathematically model attacks on your network / design of your network.** Using your back-story, what does an attack on your network mean? Use the attack meaning to

create a "min-max" or "max-min" MIP that solves for the best attacks on your network. Use the dual-trick to turn that into something you can solve with a solver.

If you are modeling design of your network, the design variables and the network operator variables have the same objective. So, you don't have to do the dual-trick, because the original problem you write down will already be a MIP you can put into GAMS. This is not easier or harder than modeling attacks, its just different.

You can model both design and attacks, but that is slightly more difficult.

6. **Code a GAMS model for finding attacks on your network / design of your network.** Turn the MIP from the dual trick into GAMS code, so you can solve for attack locations. Or, for design, write your design MIP into GAMS to solve for a good network design.

7. **Analyze!** Now that you have a fully-working model, use it to analyze your network. What are the best attack plans? How does the network's operation change if attacked? How fragile is your network? What is its operator resilience curve? If someone could invest into protecting just a few edges or nodes, what would be those key places to protect? You can take this part of the project to many directions, but be sure that the direction you go is coherent, important, and interesting.

Besides myself, ask the optimization faculty in the department for help with your models and analysis. Most of them have written papers and helped masters students doing exactly this kind of analysis on exactly the kinds of networks you are considering. Some people to think about talking to are: Javier Salmeron, Emily Craparo, Matt Carlyle, Dave Alderson, Johannes Royset, Jerry Brown, Rob Dell.

When you graduate from NPS you'll be in a unique position because you'll both have to produce analysis, and evaluate other people's analysis. That is why as part of the project, we'll do some peer evaluation. Specifically, before the presentation time, each of you will receive a pre-print of two other team's projects. You'll write some feedback and evaluation for those projects, to help the other teams improve their analysis for presentation time.

3   Timeline

Previous network projects have been quite impressive... and you have almost a month to work on them! Be sure to do something interesting, and meaningful that you can educate the class about. Here is a rough timeline you might follow:

Monday, May 21: Have working GAMS code for a meaningful attack/design analysis.

Wednesday, May 23: Write preliminary 3-page executive summary of analysis for feedback.

Friday, May 25: Give feedback on pre-prints you've received.

May 21 – May 31: Expand model to feature new aspects of reality. Edit analysis and writeup based on feedback.

June 4 – June 11: Project presentations.

I'll pass out some more specific guidance on the deliverables as we continue to work on the projects.