Trip to US (Dec 2023)

Meetings with stakeholders in San Francisco and Oakland

We met with people who work in the local homeless response system. We learnt many details about how the real-world homeless response system. Although we may well decide not to model these complexities, there were three key findings from a queueing point of view:

- **There is housing service and administrative service.** Before service in housing, customers also experience administrative service and bottlenecks can occur in the system due to lack of administrative human resources, even if housing servers downstream are available.
- **Mean service times increase as more time is spent queueing.** The queue for housing is a prioritised queue, where high priority is given to those in particularly difficult circumstances. High priority customers typically take longer to serve (both in administration and in housing). Low priority customers typically are quicker to serve, but as they wait, their situation deteriorates so when they reach the front of the queue, they are in a worse situation and require more service time.
- **Reneging from the queue occurs but resources are required to confirm when reneging has occurred.** Once someone has entered the unsheltered queue, unless they are served immediately, physically speaking their location is unknown. Once it is thought they have reached the end of the queue, it takes administrative service time to find them to give them service, but it might turn out that they may have reneged from the queue.

Research meetings with Dashi

Very productive meetings, discussing both the details of what I have been working on recently and future research directions. Some main points:

- My current breakdown of equations in my simple experiment needs some more thought. Summary printed below for reference. I think the equations at the bottom are wrong and I have been thinking a little more about what is appropriate here.

Housing or shelter? A simple experiment

Here we use our analytical model to test different solutions for building accommodation. We define our objective value as $\mathbb{E}[Y(x_{i,t,n})]$ where $Y(x_{i,t,n})$ is the mean size of the unsheltered queue over a 10 year model run for solution $x_{i,t,n}$ and:

i is the year in which we spend our budget (explained below),
t is the type of accommodation (housing or shelter) that we spend our budget on,
n is the amount of accommodation we can build with our budget.

All housing units have a service rate μ of 0.5/year. Arrival rate λ is constant at 100/year. We start with 40 houses and 15 shelters.

Baseline solution $x_{0,\text{-},0}$. Build 12 housing and 12 shelter units each year for 10 years.
Housing solutions $x_{i,\text{h},60}\ \forall\ i \in \{1,2,3,4\}$. As well as 12 housing and shelter units, build 60 extra housing units in the ith year.
Shelter solutions $x_{i,\text{s},n}\ \forall\ i \in \{1,2,3,4\}, n \in \{60,90,120,150,180\}$. As well as 12 housing and shelter units, build n extra shelter units in the ith year.

$$\begin{aligned}\mathbb{E}[Y(x_{i,\text{h},60})] = \quad & \mathbb{E}[Y(x_{0,\text{-},0})] \\ & - \mathbb{E}[\text{Mean extra space in system, due to } 60 \text{ houses built in year } i] \\ & - \mathbb{E}[\text{Mean service rate from } 60 \text{ houses built in year } i]\end{aligned}$$

$$\begin{aligned}\mathbb{E}[Y(x_{i,\text{s},n})] = \quad & \mathbb{E}[Y(x_{0,\text{-},0})] \\ & - \mathbb{E}[\text{Mean extra space in system, due to } 60 \text{ shelters built in year } i] \\ & - \mathbb{E}[\text{Mean extra space in system, due to } (n-60) \text{ shelters built in year } i]\end{aligned}$$

- The preliminary work on the analytical model is helpful to understand the mechanics of the system
- It is worth being strategic about what to spend time on in Jan/Feb before parental leave - may be smart to focus on the reading and constructive thinking of what direction we are going in, rather than specific coding tasks.
- One worthwhile task for Jan/Feb would be to make a list of specific tasks which I can do in late spring when I return to work (so I have some tangible tasks to do if/when I am sleep-deprived)
- Future directions could include:
    - SO with meta-modelling - agreed this is an interesting and relevant topic.
    - Formulation of problem as a sequential decision. Also considering 'shape' constraints - i.e. being aware of what shapes are feasible for decisions over time.
    - Bi objective SO - acknowledged this may involve heavy mathematical load
    - Analytical queueing models - e.g. diffusion models - acknowledged that new material in this area also involves heavy mathematical load
- Agreed that our ultimate direction of research should consider plans for post-PhD - ideally to keep doors open for jobs in academia and industry.

<u>Comments from different people following seminar given at NPS</u>

- Suggestion to consider that in reality the feasible solution space may be discrete and relatively small - if so an MDP formulation and a routine to learn optimal policies could be most suitable approach.
- From a queueing perspective, when considering slong-run behaviour, surely it is better to simply build/acquire as many houses as possible, rather than shelter units which do not provide service.
- Suggestion to consider in the modelling those reneging from the queue.
- Could think about the costs and benefits (to the system controller and to the customers) of being in each state (unsheltered, sheltered, housed).
- Idea to consider this like an epidemiological model with transition probabilities of moving between different states.

<u>Summary of my experience at Winter Simulation Conference</u>

Lots of interesting talks attended. Particularly enjoyed the simulation optimisation track and analysis methodology track. Some relevant talks/posters include:

- Segmentation approach for SO with Gaussian Markov random fields in high dimensions
- Training 'Dynamic Bayesian networks' as meta models when simulating queueing systems
- Sampling strategies for SO with multi-fidelity meta models (with an M/M/s queue example)
- Theory and practical applications of Multi Objective SO
- Discussion of assessing 'how feasible / how infeasible' solutions are in SO with stochastic constraints

I also attended an introduction to meta-modelling tutorial with Russell Barton which was v interesting, including linear/quadratic regression models, Gaussian process regression and neural networks. This motivated me to (at some point) experiment with different meta-models of our simulation model.

It was good to meet some other PhD students from the 'PhD colloquium' who made presentations and presented posters - they were all a bit further along in the PhD than me. PhD colloquium is open to applicants within 2 years of finishing PhD. You can only attend PhD colloquium once. I think it could be good to aim to attend PhD colloquium at Winter Sim in future.