SA421 – Simulation Modeling
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Lesson 20. Trace, Streams, and Replications

1 Tracing your simulation

- How can we make sure our ProModel simulation is doing what we expect it to do?
- ProModel can generate a **trace**: a list of all the events and assignments made while running the simulation
- The ProModel file for today's lesson contains a simulation for the Fantastic Dan problem in Lesson 15
    - Note that streams for random variables are not specified
- The easiest and best way to generate a trace (in my opinion):
    - In Simulation → Options, check the Trace checkbox
    - Run the simulation to initiate a step-by-step trace
    - Left-click in the TRACE window to generate the next step of the simulation
    - Select Options → Trace Options → Trace Continuous to generate a trace without pausing
    - Saving the trace to a file:
        - Before starting the trace, select Options → Trace Options → Output to File
        - The output file (extension TRC) will be written to the folder named in Output Path in the Simulation → Options dialog box
- See Chapter 7.1 in Sanders for other ways of tracing your simulation

2 Streams

- Recall: the linear congruential method generates a **stream** of pseudo-random numbers $R_0, R_1, R_2, \ldots$ that are supposed to be uniformly distributed on $[0, 1]$:

$$\begin{aligned} X_0 &= \text{seed} \\ X_{i+1} &= (aX_i + b) \mod m \quad && \text{for } i = 1, 2, \ldots \\ R_i &= X_i/m && \text{for } i = 0, 1, 2, \ldots \end{aligned}$$

- ProModel can generate up to 100 streams simultaneously
- ProModel uses these streams to sample from distributions (e.g. inverse transform method)
- All streams use the same values of a, b, and m
- By default, stream 1 uses seed value $X_0 = 1$, stream 2 uses seed value $X_0 = 2$, etc.
- If a stream is not specified, any random sampling occurs with numbers from stream 1
- Note that the sequence of pseudo-random numbers $R_0, R_1, R_2, \ldots\ldots$ within a given stream are the same every time!

  ⇒ Running the same model over and over again in ProModel gives the same output

2.1 Managing streams for comparing alternative systems

- Why do we care about streams?
- First, let's simulate the first 5 arrival times of customers in our system
- If you run the simulation again, the first 5 arrival times should be the same
- Now, let's look at a modified system: change the service of a customer so that it is the sum of a Uniform$[7, 15]$ random variable and a Uniform$[2, 3]$ random variable
- Now, let's simulate the first 5 arrival times in our modified system
- They're different!
- Ideally, to compare these two systems, we should have identical arrival times so that the difference in behavior of these two systems is attributable to the modifications, not luck
- Let's modify the model so that the interarrival times and service times all use distinct streams
  - Use stream 2 for the interarrival time distribution, streams 3 and 4 for the service time distributions
  - Avoid stream 1, since it is the default stream
- Now, let's simulate the first 5 arrival times for both the original and modified systems
- Note that simulating the original system and the modified system now results in identical arrival times
- **Good practice: use a different stream for each stochastic element in the model**

3 Replications

- If running the same model over and over again gives the same output, how can we replicate the simulation to get better estimates of performance measures (e.g. observed sample mean and confidence intervals)?
- In Simulation → Options, enter the desired number of replications in Number of Replications
- ProModel will take care of the streams so that each replication is different
- Statistics over the multiple runs are available in the Output Viewer
  - For example: average, confidence intervals