Assignment 2: Simulation of a Mobile Communication System

1 Introduction

In this assignment you will learn how to model and simulate a complex system. You will:

- Make a model of the problem
- Perform an input data modeling of given data collections
- Implement and simulate the model
- Verify and validate your model and implementation
- Perform an output data analysis of the results

1.1 Scenario

The telecommunication company XPhone is in charge of a mobile phone network covering a highway connecting two major cities. The company has been receiving complaints from its subscribers regarding interrupted calls. The company expects even more subscribers in the future and is consequently worried about the situation. Your job as a consultant is to model and simulate the mobile phone network, determine if the system meets the quality of service requirements and advise XPhone on possibly necessary changes in their network.

1.2 The network

A highway of a specified length is covered by base stations. The range of all base stations is equal and they do not overlap. Given the length of the highway and the number of base stations, the base station range will be equal to the length of the highway divided by the number of stations. Each base station has a fixed number of channels.
Users drive on the highway and make calls. XPhone has made measurements of the system and provides you with following information about the calls:

- Call initiation times
- Call durations
- Car speed
- Position of the car when a call is initiated

When a user initiates a call, a channel needs to be allocated in the base station that covers the piece of the highway that the user is currently on. The user proceeds to drive on the highway and a handover is necessary when he/she moves into the reach of a new base station: the allocated channel in the current base station is freed and a channel is allocated in the new base station. When the user hangs up, the channel allocated to this call is freed.

1.3 Quality of service Requirements

The users will not accept more than

b% blocked calls A call is blocked when there is no free channel available for a new call.

d% dropped calls A call is dropped when there is no free channel available in the new base station during a handover.

1.4 Channel allocation schemes

XPhone wants you to test different channel allocation schemes:

Fixed Channel Allocation (FCA) The number of channels in a base station is predefined and does not change with the load. New calls and handovers are allocated to all channels, without any differences.

FCA with Handover reservation scheme One or more channels in each base station are reserved for handovers. The handover channels can only be allocated to handovers. The non-handover channels can be allocated to new calls as well as to handovers.

1.5 Provided data

You can download data files containing specifications for your group from the course homepage. Following data is provided:

specification.txt contains information about the highway and the QoS requirements

initiation_time.txt is a sample of the initiation times of the calls. The times are given in seconds after 12:00.

position.txt gives the position of the cars at the moment a call has been initiated. This position is given relative to the start point of the highway in kilometres.

duration.txt gives the duration of the calls in seconds.

speed.txt gives the speed of the cars in km/h.

2 Tasks

2.1 Model the system

Describe your model of the problem. Which simplifications of the real-world problem are you applying? *Important:* Consider the boundary problem. Since the system is finite, the boundary base stations will be different from the base stations in the center and thus affect the overall statistics of the system. Try to devise a way to avoid this boundary problem, i.e. try to modify your model to avoid the boundary problem.
You are supposed to implement the model using the discrete event simulation algorithm used already in Assignment 1b. Define the state variables and events used in your algorithm.

2.2 Input data modeling

Use the data collections given to you to find the real underlying distributions of call initiation (as time between calls), call durations, car speeds and initiation position. Use the Chi-Square test to perform goodness-of-fit tests between the provided data and the chosen distributions.

2.3 Verification and validation

Change different parameters and see if the system works fine with other parameters. Make a stress-test to see if the system behaves as expected when the system is constrained, e.g. decrease call inter-arrival-times.

2.4 Output data analysis

Choose an appropriate simulation length. Perform an analysis of the necessary warm-up period (i.e. analyse at which point your system enters a steady state and decide on an appropriate warm-up period based on the results). Simulate the system and calculate the mean and confidence intervals of your results. Use your results to suggest answers to the following questions:

- Can the QoS requirements be fullfilled with the current number of channels when using the FCA scheme without handover reservation scheme?
- If not:
  - How many extra channels are needed to fullfill the QoS when using the FCA scheme without handover reservation scheme?
  - Can the system fulfill the QoS without extra channels when the handover reservation scheme is used? How many reserved channels are necessary?

3 Implementation and submission instructions

3.1 Implementation Requirements

Implement your model in either Java, C++ or Python. Your program may have a GUI, but it must be possible to execute it in text mode from a terminal. Name your executable *xphone*, then a typical run of your program must accept the following command line arguments, in exactly the given order as described below (analogously for C++/Python).

java xphone seed length replication warm-up channel reserved[debug]

- ***seed:*** is the single seed of the simulation. All required seeds for different streams of random numbers are derived from this seed. Given an input, different execution of your simulator should produce exactly the same output.
- ***length:*** is the time length of each replication of the simulation.
- ***replication:*** is the number of replications.
- ***warm-up:*** is the warm-up period in seconds.
- ***channel:*** is the number of channels in each base-station.
- ***reserved:*** is the number of reserved channels for handovers.

The last parameter ***debug*** is optional and may be used to provide extra meaningful outputs. If the debug option is not set the output of your program must exactly be the following.