# Assignment 2: Simulation of a Mobile Communication System

The goal of this assignment is to help a phone company to test if their network meets the quality of service requirements (QoS) for dropped calls and blocked calls. Today the network consists of 20 base stations along a highway of 40km. The range of each base station is 2km and can hold up to 10 concurrent calls. If this setup isn´t enough to meet the QoS what changes to the network is needed to meet the requirements.

The limits defined as QoS:

* Percentage of blocked calls = 2.0%
* Percentage of dropped calls = 1.0%

## Model of the system

To simulate this, a model of the problem was developed. The range of all base stations is equal and where one station ends the next begins. The area of the range was simulated to be quadratic instead of circular. The highway was assumed to be oneway to make the simulation less complex. In the simulation the highway is 40km, the 20 base stations has a range of 2 km each.

To get rid of the boundary problem the road was implemented as a circular road. All cars driving past the 40km mark will be wrapped around and continue from the beginnning of the road.

* State variables
  + Total calls: Total started calls in the system, including dropped calls.
  + Dropped calls: Total active calls dropped by full base station at handover.
  + Blocked calls: Total call initiations blocked by full basestations.
* Events
  + Start call: A call is planned to start.
  + Handover: A call is planned to do a handover.
  + End call: A call will end.

When an event is created it´s placed in a future event list (FEL). All the events in FEL is sorted so the event with the lowest timestamp is always first. The simulation will handle one event at a time and then remove it from FEL when the event handler is done. The event handler is implemented like this:

If the event is of the type ”Start call”:

* A call is started at a position on the highway, if the current base station covering this position dont have any free channels the call is blocked. If there is a free channel its allocated and the call is started. Next step is to plan the next event, if the call will end inside the current base station an end event is created. If the call will end outside, a handover event is created.

If the event is of the type ”Handover”:

* Unallocate channel in current basestation. Next step is to plan the next event, if the call will end inside the next base station an end event is created. If the call will end outside, a handover event is created. But only if there is free channels in the next base station. Otherwise the call will be dropped.

If the event is of the type ”End call”:

* Unallocate channel in the base station connected to the call.

The handover process can be done in two ways.

FCA

- FCA with Handover reservation scheme

## Input data modeling

• Use the data collections given to you to find the real underlying distributions of call initiation, call durations, car speeds, initiation position

• For each of the data collections: ◦ Make histograms of the data to determine the distribution to use

May be necessary to test with different interval widths

◦ Estimate the parameters for the chosen distribution(λ, μ, σ, etc.)

Does the distribution fit? Use the Chi-Square test to perform goodness-of-fit test of the provided data and the chosen distribution

## Verification an Validation of model and implementation

We ran multiple simulations with different values of the seed, simulation time. The results got very similar each run except in the case of very short simulation time. This is expected because in the beginning is not many calls active on the road, later on when the simulation reaches a steady state the blocked and dropped % gets similar (see Table 1)

Seed 1, Replications 100, Warm-up 0, Channels 10, Reserved 0

|  |  |  |
| --- | --- | --- |
| Simulation time | Blocked calls % | Dropped calls % |
| 1000 | 0.2502 | 0.5996 |
| 10 000 | 0.4837 | 1.279 |
| 40 000 | 0.4854 | 1.299 |

Table 1.

## Output analysis

The warm-up time was estimated by running simulations with diffrent warm-up time trying too find the steady state. The parameters for all runs in Table 2 was: seed 1, simulation length 10000, replications 100, channels 10, reserved 0. From the test results steady state begins at approx. 800 sec but to be on the safe side we estimated it to 1000 sec. It´s better to have a value that’s a little too high than a too small value because the system will be in steady state.

|  |  |  |
| --- | --- | --- |
| Warm-up (sec) | Blocked (%) | Dropped (%) |
| 8000 | 0,51645 | 1,2809 |
| 7000 | 0,50619 | 1,3022 |
| 6000 | 0,50487 | 1,3256 |
| 5000 | 0,51572 | 1,3385 |
| 4000 | 0,51595 | 1,3502 |
| 3000 | 0,51673 | 1,3609 |
| 2000 | 0,51218 | 1,3495 |
| 1000 | 0,50916 | 1,3548 |
| 900 | 0,50769 | 1,3525 |
| 800 | 0,50559 | 1,3478 |
| 700 | 0,50377 | 1,342 |
| 600 | 0,50303 | 1,341 |
| 500 | 0,50264 | 1,3337 |
| 400 | 0,50065 | 1,3261 |
| 300 | 0,4982 | 1,3173 |
| 200 | 0,49349 | 1,3048 |
| 100 | 0,48855 | 1,2923 |
| 0 | 0,48369 | 1,2794 |

Table 2.

In following tests the seed was 1, simulation length 10 000 sec, replications 100 and warm-up lentgh 1000 sec.

• Simulate the system an adequate number of times (number of replications) and take the mean

• Calculate confidence interval for the obtained results

• Use results to suggest solutions to the problem