

Nanyang Technological University

School of Computer Engineering

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**Report on CE749 Project 2:**

**A Mobile Communication System**

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1. **Design**
   1. Federates

The system consists of two kinds of federate: Source Federate and Base station (BS) Federate. A Source Federate is responsible for creating federation and generating calls based on the input data. Each BS Federate simulates four contiguous base stations; therefore, we have 5 federates of this kind. These BS Federates receive call initiation events from the Source Federate and handle events happening during the simulation process.

All federates are time-managed and each of them performs event-driven time advancement via API call *NextEventRequest*. The Source Federate is time regulating federate; the BS Federates are both time regulating and time constraint federates.

* 1. Interaction

Communication between federates are done via Interaction. There are two types of Interaction in the system: Interaction between Source Federate and BS Federate and Interaction between BS Federates. By using Interaction, the Source Federate sends newly-initiated call events to BS Federates. While processing events, BS Federates send information of Handover calls to the next BS. We also use Data Distribution Management (DDM) when implementing Interaction.

The information sent in a Call initiation Interaction is: timestamp when the call starts, duration of the call, the position where the call is initiated and the speed of the car. The Handover Interaction transfers the information including: timestamp of the Handover event, the remaining duration of the call, the next station and the speed of the car.

1. **Implementation**
   1. Generating calls

At the start of the program, the Source Federate creates the Federation and reads all call records from the input file. Then it sends these Call initiation events, whose timestamp is when the call begins, to BS federates. As all BS federates are time-constraint, these events need not to be sent in timestamp order and all of them can be sent at once at the beginning of simulation process (logical time = 0.0).

* 1. Handling events in BS Federates

Each BS Federate maintains its own internal event list which contains events occurring in that federate in the future. The BS Federate processes each event in its list in the timestamp order until the list is empty. When handling an event (the event has the smallest timestamp) the federate may receive or schedule a new event in the future. If this event is in the same federate, this federate inserts it to its own event list. Otherwise, the BS Federate sends this event to another BS Federate which is interested in it.

There are 3 types of events: Call initiation, Call termination, Call handover. The BS Federates receive the Call initiation events from the Source Federate and Call handover events from the previous BS Federate. When dealing with these events, the BS Federate may schedule the next event based on the status of the current base station (the number of free channel of base station). If there is not any free channel, the call cannot be initiated (blocked) or transferred to the next station (dropped); therefore, there will not be any more events generated by this call. If there is still one or more free channel in the base station, this call will consume one channel (hence, the number of free channel decrease by 1) and the BS Federate calculate the next event of this call which is Call handover to the next station or Call termination. If the next event is Call handover and the next station belongs to another BS Federate, the current BS Federate sends a Call handover Interaction to the next BS Federate.

This is the flowchart of the event handling process:



When advancing to the next event (by calling NextEventRequest), the BS Federate may receive an event which is Call Initiation from Source Federate or Call Handover from other BS Federate. In that case, the *receiveInteraction* callback function is triggered by the RTI and what this function does is inserting this event to the event list.

* 1. Data distribution management (DDM)

There are two types of Interaction in the system: Interaction between Source Federate and BS Federate for call initialization and Interaction between BS Federates for call handover. When a federate generates information and send it through Interaction, e.g., Source Federate initials a call or BS Federate handovers a call to the next, we hope only the federate who are interested in receives the information. Hence, we employ data distribution management in our simulation project.

For both interactions, we bind them to the same 1-dimensional routing space *TestSpace*. Each BS Federate is assigned to a specific range within *TestSpace*, which is stated when it subscribes to the Interaction with *subscribeInteractionClassWithRegion* function. In our system, BS Federate i, which simulates base station 4i to base station 4i+3, subscribes to both interactions with region [2i,2i+1]. After stating the interest of each federate, the Federation is able to deliver the information to a specific destination, rather than broadcasting to every federate.

Two examples about how DDM works in our system. When the Source Federate initials a call at base station 1, which is managed by BS federate 0, it sends the information to *Call\_init* interaction class with *sendInteractionWithRegion* function and set the argument Region to [0,1]. The federation will route this interaction to BS Federate 0 only, since it is the only federate subscribed to region [0,1]. And if BS Federate 0 wants to handover a call to BS Federate 1 through *Handover* interaction class, it must send the interaction with Region [2, 3].

1. **Communication**

As a distributed simulation project, we aim to run federates in different machines. The communication part of Portico project is configured in RID file, which provides configurations of *jgroups*. We use the *portico.jgroups.udp.bindAddress* configuration to set up a networked simulation project. For each federate, the value of bindAddress is set to the ip addresss of the host machine. We find out that there is no need to explicitly set the ip address of the machine hosting the Federation, which indicates that the federate running in remote machine find the Federation via broadcasting.

1. **Test and Experiment**

The input is based on the given input trace and a randomized position within the range. At the beginning, the simulation system will warm up tw seconds, where tw is an argument passed in when we start the BS federate. During this period, we will not count the call initiation, call handover, call drop and so on. Only after the federation reaches tw or larger than tw will the system begin to do the statistics work. We run our system on 5 different machines, since after the source federate finishes sending the events, it can be terminated; we only need to run different BS federates on different machines. First we run the experiment with no warm up time. The experiment is repeated 3 times and the average is taken. The following table demonstrates the experiment results.

Table : 0 seconds warm up time

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| BS Federate | Call initiation | Call handover | Call handover from other feds | Call blocked | Block ratio (%) | Call dropped | Drop ratio (%) |
| 1 | 2001 | 1667 | 0 | 0.33 | 0.01 | 0 | 0 |
| 2 | 1991 | 3175 | 787 | 4 | 0.20 | 8 | 0.25 |
| 3 | 1966 | 3239 | 836 | 4 | 0.20 | 6.67 | 0.21 |
| 4 | 2005 | 3272 | 786 | 5.67 | 0.28 | 9 | 0.27 |
| 5 | 2037 | 3331 | 832 | 6.67 | 0.33 | 8 | 0.24 |

We can see that the blocked call ratio is less than 2% and drop ratio is less than 1%. The warm up time will affect the block ratio and drop ratio. Without warm up time, the block ratio and drop ratio will be smaller than expected in most cases. That’s because at the beginning, the channel is almost free and will not cause block or drop. So we set tw =400(this value is tuned by us, later we will see the comparison with other warm up time) seconds (federation time) and repeat the experiment 3 times and take the average. The following table demonstrates the experiment results.

Table 2: 400 seconds warm-up time

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| BS Federate | Call initiation | Call handover | Call handover from other feds | Call blocked | Block ratio (%) | Call dropped | Drop ratio (%) |
| 1 | 1939 | 1611 | 0 | 0.33 | 0.01 | 0.33 | 0.02 |
| 2 | 1928 | 3102 | 763 | 3 | 0.16 | 5 | 0.16 |
| 3 | 1913 | 3151 | 800 | 4.33 | 0.23 | 6.67 | 0.21 |
| 4 | 1941 | 3218 | 785 | 6 | 0.31 | 10 | 0.31 |
| 5 | 1986 | 3256 | 808 | 6.67 | 0.34 | 10 | 0.31 |

The experiment has proved our statement: without warm up time, the block ratio and drop ratio will be smaller than expected in most cases. As we can see from Table 1 and Table 2, the block ratio and drop ratio of BS federate 3, 4, and 5 in Table 1 are less than the corresponding ratio in Table 2.

However, choosing too large warm up period is also not necessary. Hence, we want to choose the proper warm up time and conducted the experiment as below. We set the warm-up time to 200 seconds and 800 seconds respectively (federation time) and still repeat the experiment 3 times and take the average. The following tables demonstrate the experiment results.

Table : 200 seconds warm up time

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| BS Federate | Call initiation | Call handover | Call handover from other feds | Call blocked | Block ratio (%) | Call dropped | Drop ratio (%) |
| 1 | 1967 | 1640 | 0 | 0.33 | 0.02 | 0.33 | 0.02 |
| 2 | 1956 | 3145 | 764 | 4.33 | 0.22 | 4.67 | 0.15 |
| 3 | 1947 | 3187 | 811 | 4.67 | 0.24 | 11 | 0.35 |
| 4 | 1971 | 3266 | 789 | 6.33 | 0.32 | 5.33 | 0.16 |
| 5 | 2010 | 3298 | 826 | 6 | 0.30 | 9 | 0.27 |

Table : 800 seconds warm up time

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| BS Federate | Call initiation | Call handover | Call handover from other feds | Call blocked | Block ratio (%) | Call dropped | Drop ratio (%) |
| 1 | 1893 | 1556 | 0 | 0.00 | 0 | 0 | 0 |
| 2 | 1866 | 3016 | 746 | 1.67 | 0.01 | 3 | 0.01 |
| 3 | 1864 | 3058 | 774 | 3.33 | 0.18 | 6.67 | 0.22 |
| 4 | 1890 | 3116 | 759 | 10 | 0.53 | 8.67 | 0.28 |
| 5 | 1923 | 3135 | 787 | 5 | 0.26 | 9.33 | 0.30 |

For 200 seconds and 800 seconds warm up, we can see that there’s too less warm time, which contribute still less block/drop ratio or too large block/drop ratio. Hence we choose the warm up time to be 400 seconds. The experiment results have demonstrates that with all kind of setting, the mobile system has less than 2% block ratio and 1% drop ratio. Hence, the mobile system can guarantee the QoS based on our simulation.