**CSCE 654 Project**

**Part IV (10%) – Due:**  15, 22 May



**Problem Description:** Your group has been tasked to develop a communications system model for 5 geographically separated transmission nodes as shown in Figure 1 above. Your proposal can include the use of STS-3 lines, leased T-3 links, leased or installed “bent-pipe” geostationary links, and “intelligent” geostationary satellites, capable of routing between each other. In addition to developing this model, you must provide a cost/delay performance analysis of the proposed communications system. The customer is very concerned with cost as well as the average and worst-case end-to-end delay of network traffic. Your task is to review the system specifications, make appropriate operating assumptions, model and simulate the system, and report your findings via formal documentation following the prescribed schedule:

**1. Report Schedule**

1. 15 May 2019 – Initial analysis
   1. Turn in a topology of the system (hand-drawn is fine)
   2. Provisioning, location, and distance information (consider using a spreadsheet)
   3. Analytical analysis of expected performance
2. 22 May 2019 – Written Report. Overall performance analysis of system due including:
   1. Table of contents
   2. List of figures
   3. OMNet++ node models
   4. Narrative of design decisions and supporting rationale
   5. Data analysis
   6. Recommendations

**2. System Specification** This system comprises 5 geographically separated sites. These sites are shown in Figure 1. The system shall be designed to support digital data communications excluding voice communications. Transmission for the proposed system is full-duplex, with node-to-node traffic breakdown as shown in Table 2 (below).

Table 2. Mean packet rate (pkts/sec) between network nodes.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **SOURCE** | **DESTINATION** | | | | |
|  | **Hickam** | **Cheyenne Mt** | **Qatar** | **Langley** | **Ramstein** |
| Hickam | -- | 200 | 2500 | 1000 | 250 |
| Cheyenne | 250 | -- | 500 | 250 | 50 |
| Qatar | 250 | 500 | -- | 500 | 250 |
| Langley | 250 | 500 | 500 | -- | 250 |
| Ramstein | 250 | 200 | 250 | 1000 | -- |

For the purpose of modeling, the following **assumptions** can be made:

1. For simulations, each node has infinite transmitting and receiving buffer capacities. However, a recommendation on buffer size at each node is required. Justification must be provided by addressing probable packet loss at each loading level.
2. Each link is considered to be errorless (i.e., no need for ACK or retransmissions).
3. The 654SS Server service delay (processing and routing decision time) is negligible (to simplify analysis and simulation design). Transmission time depends on packet length (exponential with mean 20000 bits) and link bandwidth. Both must be accounted for.
4. Compute satellite distances using geostationary orbits at 0 degrees latitude and the longitude of your choosing, except that satellite elevation look angles must be greater than 15 degrees. Because of the customized placement, satellite distances are not provided.
5. For “bent-pipe” satellites, ignore processing time at the satellite.
6. For “intelligent” satellites, node processing time must be considered for all links (up, down, cross). Intelligent satellites support up to 4 up/down link pairs, and up to 3 cross link pairs.
7. Geostationary satellites can be placed at any desired longitude, and zero degrees latitude.
8. For modeling purposes, node pairs requiring multiple links can be built in OMNet with a single link and an aggregate bandwidth (as opposed to building every individual link).
9. Additional justified operating assumptions.

**3. Items to consider in modeling and reporting.**

1. Did system bottlenecks exist (if so, where were they and how would you alleviate them)?
2. Model verification: how did you verify the correct operation of your model?
3. Model validation: how did you (can you) validate that the model accurately reflects “real-world” operations?
4. Cost and performance of network (cost information shall be for ten years to include installation and monthly operational costs. )

**4. System Modeling Tool:**  The tool to be used in this analysis is OMNeT*++*. Because of the extensive time required for Part IV, the first three parts are due within the first four weeks of class. Do not wait until the last minute to start Part IV of the project.

**5. Costs:**  Determining the ten year cost for the system involves numerous factors. Link costs are detailed as follows.

1. For land lines, costs include trenching, plus wire costs. Table 1 identifies the wire costs per type of land link. Trenching costs are a flat $10k/km, whether on land or in the ocean. (If dual links are used, trenching costs can be shared, but because the links are co-located, they are assumed to fail together, e.g., it only takes one backhoe.)
2. For owned satellites, installation costs are one-time costs. Monthly costs cover the cost of maintaining the ground stations.
3. Although you may choose how many to use, you must use the CSCE 654 Standard Server (654SS) for routing and processing at a cost of $20,000. A server is required for every outbound link (not including bent-pipe satellites which have no queueing or routing.)
4. Two military owned Intelligent Geostationary satellites are available for free if you wish to use them (i.e., no installation cost, but the ground station cost is still required). They are located at 100W and 21W degrees longitude respectively. Each satellite has 4 transceivers (XCVR), cross links require use of transceivers as well.

Table 1. Link types and associated costs

|  |  |  |  |
| --- | --- | --- | --- |
| Link Type | Data Rate | Installation Cost | Monthly cost |
| Intelligent (4 XCVR)  Geo satellite | 20 Mbps  up/down/cross | $60M | $8K per earth station  (Max 4) |
| “Bent-pipe”  Geo satellite | 20 Mbps up/down | $40M | $8K per earth station  (Max 4) |
| Leased “Bent-pipe” Geo satellite | 5 Mbps up/down | none | $500K per link |
| STS-3 | 15.52 Mbps | $4K per km | $5K per link |
| Leased STS-3 | 15.52 Mbps | none | $700K per link |
| T-3 | 4.4736 Mbps | $2K per km | $5K per link |
| Leased T-3 | 4.4736 Mbps | none | $500k per link |

**6. Evaluation:** Your results will be evaluated according to the following value (cost) function, analyzed initially, then computed using the simulation results.

1. total 10 year cost / $6M
2. (k-connectedness) ( 1=100, 2=50, 3=20, 4=0 )
3. weighted sum of average end to end delays (milliseconds) \*0.1

Appendix

Table 1. Location coordinates for network nodes.

|  |  |  |
| --- | --- | --- |
| Hickam | 21° 20' N | 157° 55' W |
| Cheyenne | 38° 49' N | 104° 43' W |
| Qatar | 25° 18' N | 51° 31' E |
| Langley | 36° 54' N | 76° 12' W |
| Ramstein | 49° 34' N | 8° 28' E |

Table 2. Ground distance (as the crow flies) between network nodes.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **SOURCE** | **DESTINATION** | | | | |
|  | **Hickam** | **Cheyenne Mt** | **Qatar** | **Langley** | **Ramstein** |
| Hickam | 0 | 5400 km | 14000 km | 7900 km | 12000 km |
| Cheyenne | 5400 km | 0 | 12500 km | 2500 km | 8200 km |
| Qatar | 14000 km | 12500 km | 0 | 11200 km | 4600 km |
| Langley | 7900 km | 2500 km | 11200 km | 0 | 6600 km |
| Ramstein | 12000 km | 8200 km | 4600 km | 6600 km | 0 |

To obtain the distance from a ground station to a satellite, you may use any aids you wish. I found this site very useful <http://web.nmsu.edu/~jbeasley/Satellite>.

As the crow flies distances can be determined using the excel spreadsheet co-located with the course notes on the L: drive.

To obtain the distance from one geostationary satellite to another, use simple trigonometry with the orbital radius (distance from center of the earth to the geostationary orbit) of 42164km.