

POSSIBILITY OF USING NETWORK SIMULATOR (NS-2) FOR MODELING SATELLITE NETWORKS

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SUMMARY

This paper answers to the question if is possible to simulate satellite networks in Network Simulator (NS-2). We describe its functionality such as types of nodes, kinds of satellite links and handoffs. Also are presented two real satellite networks, Iridium and Teledesic, compared their parameters and simulation results. Numerical and graphical outputs are presented to show how satellite networks work.

Keywords: satellite network, Iridium, Teledesic, NS-2, node, links

1. INTRODUCTION

The efficient modelling of communication networks has been a standard requirement for years within the communications systems world. Simulation and analysis are very important to create satellite networks.

Network simulator (NS-2) is a powerful tool which offers simulation of networks, modelling of nodes, links, protocols and other facilities of a real traffic. It can be also a solution, how we can do simulation of a satellites networks, because it enable exact simulation with a detailed modelling of radio frequency characteristics (interference, fading), protocol interactions (e.g., interactions of residual burst errors on the link with error checking codes), and second-order orbital effects (precession, gravitational anomalies, etc.).

2. DESCRIPTION OF THE SIMULATOR

2.1. Types of satellite nodes

There are three types of nodes for satellite networks, which can be used to modelling:

- Geostationary
- Non-geostationary
- Terminal

Geostationary nodes are used to create GEO networks, which are at an altitude of 36.000 kilometers above the equator. There is possibility to define two kinds of these satellites, processing and “bent-pipe” satellites. For both it is necessary to specify longitude (from range -180° to 180°) [1].

Polar satellites (LEO or MEO) can be also simulated in NS-2. Basic definition of these nodes includes five parameters: altitude (specified in kilometers above the Earth’s surface), inclination (0° to 180°), longitude of ascending node (-180° to 180°), alpha (define the initial position of the satellite along the orbit, and has range from 0° to 360°) and plane (depending on type of satellite network).

Terminal nodes are placed on the Earth’s surface. They are specified by their latitude (from range -90° to 90°) and longitude (from range -180° to 180°).

2.2. Composition of satellite nodes

Each satellite node has one or more satellite network interface stacks, to which channels are connected to the physical layer object in the stack. Fig. 1 illustrates the major components. The Radio Propagation Model is a place, where more detailed error models can be used. LL represent link layer, IFq describes a queue type with the main parameter of its length, MAC layer with two existing types (with and without collision detection) and primary parameters of bandwidth and size of packet header. Physical layer is divided into two classes (transmitting and receiving) [2], [3].

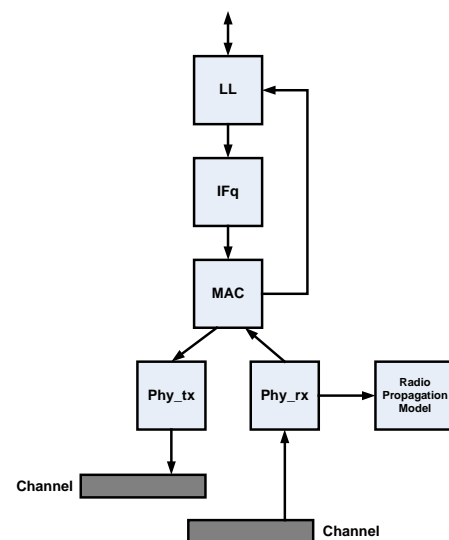


Fig. 1 Main components of satellite network interface

Following types of satellite links can be defined. To create connection from a terminal to a satellite (uplink), link can be indicated as geo or polar. On

the other hand, for connection from satellite to terminal (downlink), gsl and gsl-repeater links were defined. Because in satellite networks it is necessary to create connections between satellites in the same plane and also between other planes, intraplanes, interplanes and crossseam links can be employ.

2.3. Handoffs

Satellite handoff modelling is a key component of LEO satellite network simulations. There are two types of links that must be handed off: GSLs to satellites, and crossseam ISLs. A third type of link, interplane ISLs, are not handed off but are deactivated at high latitudes (for example above 60 degrees in our simulation). Each terminal connected to a satellite runs a timer that, upon expiry, causes the Handoff Manager to check whether the current satellite has fallen below the elevation mask of the terminal. If so, the handoff manager disconnect the terminal from that satellite's interface, and searches through the linked list of satellite nodes for another possible satellite. If it finds a suitable satellite, it connects its network interfaces to that satellite's uplink and downlink channels, and restarts the handoff timer. If it does not find a suitable satellite, it restarts the timer and tries again later. If any link changes occur, the routing agent is notified.

3. SIMULATIONS OF IRIDIUM AND TELEDEISC

The Network simulator is created in C++ and Otel program language. It can be used under Unix and Unix-like systems, as FreeBSD, Linux, Sun Solaris. Also can be used in Windows platform (95/98/NT). In our work we made tcl (tool command language) script and so we simulated two of possible satellite

network models – Iridium and Teledesic. Next table shows differences between them [4] [5].

	Iridium	Teledesic
Altitude	780 km	1375 km
Planes	6	12
Satellites per plane	11	24
Inclination (deg)	86.4	84.7
Interplane separation (deg)	31.6	15
Seam separation (deg)	22	15
Elevation mask (deg)	8.2	40
Intrplane phasing	Yes	Yes
Interplane phasing	Yes	No
ISLs per satellite	4	8
ISL bandwidth	25 Mb/s	155 Mb/s
Up/downlink bandwidth	1.5 Mb/s	1.5 Mb/s
Cross-seam ISLs	No	Yes
ISL latitude threshold (deg)	60	60
Queue length	50	50

As a output of simulation we can obtain a text file, where are described single nodes with their positions, links and delays. These delays rise during transmission of a packet. Below is shown a part of this file, where receive event is indicated by “r”, + mean enqueue operation, - deque operation. Letter “d” describes a dropped packet. The second column shows time from the beginning of the simulation. Next are the numbers of nodes, between them link was created. As you can see from this example, node 19 receive packet from node 30. In this simulation was decreased length of the queue to 2 to ensure a drop event will occur. CBR describe a traffic. Next numbers are source (69) and destination terminals (66). Because in the same time also other nodes create traffic, next column describes the number of packets transmitted from the terminal 69 and the

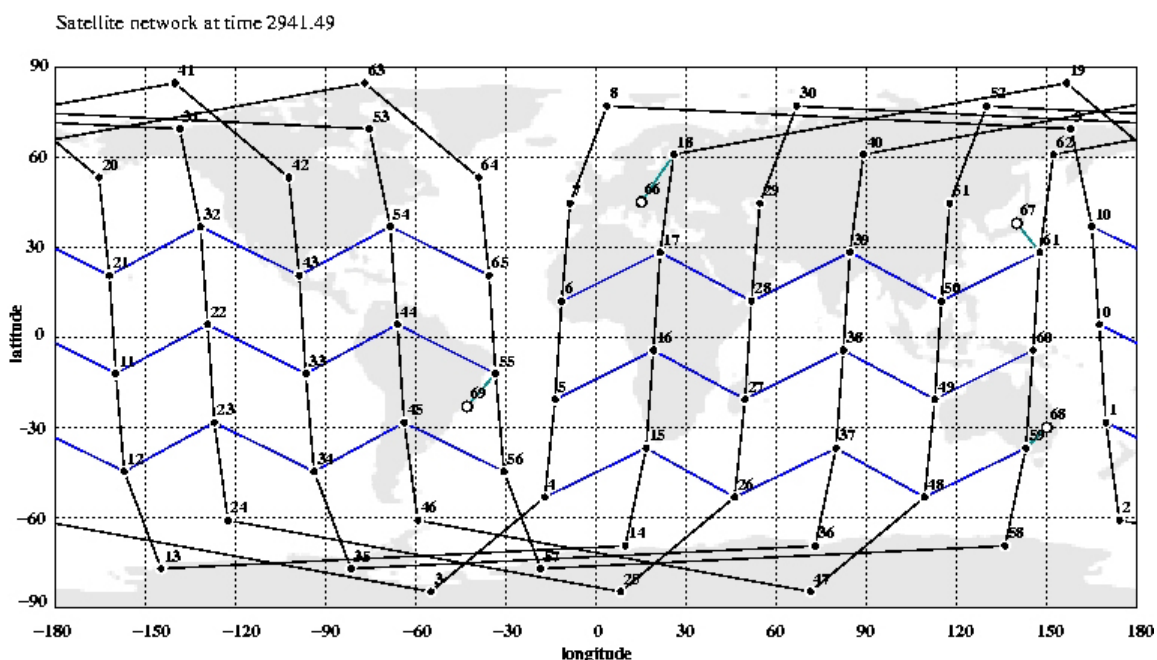


Fig. 2 Iridium satellite network

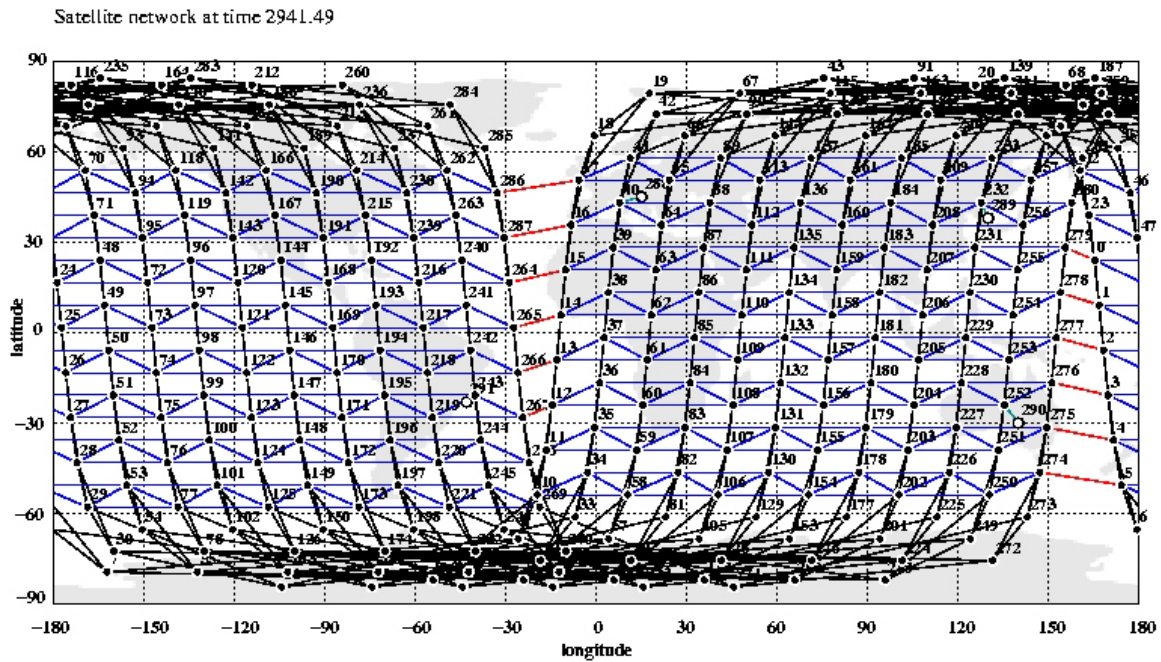


Fig. 3 Teledesic satellite network

second shows how many packets were transmitted through the network to the current time. Next there is longitude and latitude of the source and destination. Also it is possible to create own error model. One of them was used in this experiment. Error models can be set to cause packets to be errored according to various probability distributions. These error models are simple and don't necessarily correspond to what would be experienced on an actual satellite channel (particularly a LEO channel).

```
r 2161.4427 30 19 cbr 210 ---- 0 69.0 66.1 36 147 30.86 56.32 47.16 26.46
+ 2161.4427 19 66 cbr 210 ---- 0 69.0 66.1 36 147 47.16 26.46 45.10 15.00
d 2161.4427 19 66 cbr 210 ---- 0 69.0 66.1 36 147 47.16 26.46 45.10 15.00
- 2161.4430 19 66 cbr 210 ---- 0 68.0 66.1 36 146 47.16 26.46 45.10 15.00
```

Also it is possible to create dump file. This file contains numbers of nodes, their positions and planes. With these information and with using ns-sat-plot program (which uses Xfig program), we can do a graphic presentation of network in selected time. In our simulation we used four terminals located in Košice (node 66), Tokyo (node 67), Sydney (node 68) and Rio De Janeiro (node 69). In the Figure 2 you can see links and positions of 66 Iridium satellites, 4 terminals and links between them at time 2941 seconds from the beginning of the simulation. Similar figure (Fig. 3) was created with designing of Teledesic network, where terrestrial nodes remain the same and 288 satellites are shown.

From results of simulations, next tables were generated. In next table, there are total delays and paths through satellites from Košice (node 66) to Rio De Janeiro (node 69) in Iridium satellite network and also in Teledesic satellite network (node 288 represents Košice and node 291 Rio De Janeiro).

Iridium			Teledesic		
Node	Plane	Delay [ms]	Node	Plane	Delay [ms]
66	Terminal	122.7	288	Terminal	51.4
18	2		40	2	
19	2		16	1	
20	2		14	1	
21	2		12	1	
32	3		267	12	
43	4		243	11	
54	5		291	Terminal	
65	6				
55	6				
69	Terminal				

A similar feature has next table, where path from Tokyo to Sydney is shown.

Iridium			Teledesic		
Node	Plane	Delay [ms]	Node	Plane	Delay [ms]
67	Terminal	39.1	289	Terminal	45.6
61	6		232	10	
60	6		256	11	
59	6		254	11	
68	Terminal		252	11	
			290	Terminal	

4. CONCLUSION

In this paper was briefly described a simulation possibilities of satellite networks in Network simulator. We found out, it is possible to simulate satellite networks (LEO and GEO). As was

described above, we created error model for each of these simulations. We also created two types of outputs, a text file and graphical representation of network. From results we know to determine delays between two terminals and locate a route of a packet in selected time. Also is possible to compute Quality of Service. Disadvantage of NS-2 is that it is impossible to create NAM file for satellite networks, which is a typical graphical output for classical wired network. We overcame this fact with using ns-sat-plot program. The next restriction is that the current status of routing in satellite networks is incomplete.

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BIOGRAPHY

Stanislav Marchevský received the M.Sc. in electrical engineering at the Faculty of Electrical Engineering, Czech Technical University in Prague, in 1976 and PhD. degree in radioelectronics at the Technical University of Košice in 1985. Currently he is a Professor of Electronics and Multimedia Communications Department of Faculty of Electrical Engineering and Informatics of Technical University of Košice. He teaching interests include switching theory, digital television technology, and satellite communications. His research interests include image nonlinear filtering, neural networks, genetic algorithms, and multiuser detection, spacetime communication, diversity communication over fading channel, and power and bandwidth-efficient multiuser communications.

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