The Design and Development of Simulation System for Broad Band Wireless Communication

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Abstract: Based on the analysis of the broad band wireless communication, we design a wireless terrain network with some different subnet of satellite, microwave, LTE, and so on. OPNET provides a virtual network environment, through the modeling of the network. We give the simulation flow of the wireless communication. It designs the station node and satellite node, and builds a simulation system for the broad band wireless communication by OPNET. According the wireless communication topology, it realizes the network simulation system with six zone subnets which contain six single users and two communication vehicles. It contains the communication satellites which use the transparent transponders. The simulation system can display the dynamic route by the simulation system. It also can analyze the performance and efficiency of the wireless system with the parameters, such as: throughput, delay, processing delay, Packet Loss Ratio. It can use “Failure Recovery” module in the simulation system and set the parameters and analyze the communication system influence.

1. Introduction
With the development of the communication technology, wireless communication is used widely and widely with great virtue. We can use network simulation technology in system evaluation, in order to research the wireless communication systems.

Network simulation is widely used in communication network performance analysis [1]. The simulation system of the broad band wireless communication is built by the network simulation tool, which can simulate the wireless communication system [2]. It can build the network equipment, link and protocol model and simulate the transfers of the network flow by network simulation [3, 4]. The simulation system can be used to analyze the performance of the communication system and provide the theory support [5–9]. It can collect the network data for network design and make the network as perfect or effective as possible.

2. Design of the Simulation System
OPNET provides a virtual network environment, through the modeling of the network [6,10]. The user can analyze the network performance more effectively. OPNET can meet the simulation needs of the great complex network with 3 layers models, which can correspond with protocol layer, equipment layer, network layer. OPNET can completely reflect the network characteristics.

1) Process model
Process model can simulate the protocol and depict the protocol by finite state machine (FSM).

2) Node model
Node model can simulate the equipment and be made of corresponding protocol model.

3) Network model

Network model can simulate the network and be made of corresponding node model.

OPNET wireless module can provide wireless modeling environment and simulate wireless transmission performance, such as: terrain diffraction, fading, path loss because of atmosphere. It can simulate the influence of the network performance by the node moving and the connection with the other communication system. The simulation flow includes the process of wireless communication protocol modeling, node module modeling, network topology construction, traffic load deployment, statistic selection and simulation analysis and so on, which is showed as figure 1. It can build the wireless communication simulation system by OPNET, which can realize the model modeling, performance evaluation, network layout [6-8].

The broadband wireless communication can analyze the performance of the wireless communication system, and put forward some suggestions for the layout and development of the system. The wireless communication system contains six wireless zone subnets, such as: Beijing, Xi’an, Xichang, Taiyuan, Jiuquan, Xiamen, which can cover the area with 50 kilometers * 50 kilometers. The subnets have some simulation objects, such as: base station, individual user, communication vehicle, which are connected with optical fiber, satellite, microwave, ultrashort wave, wireless Mesh, LTE. It can use the terrain data in the zone subnets’ simulation, which can make the simulation system better reflect the true wireless communication and better analyze the performance of the communication.

Figure 1. sketch map of the simulation flow

Then it needs to define application and deploy traffic flow. The applications contain FTP, HTTP, Email. It can connect the source node and object node with ip_traffic_flow and deploy the traffic flow with ip_traffic_flow module.

3. Simulation System and Key Node Models

3.1. Simulation System Realization
According the wireless communication topology, it realizes the network simulation system with six zone subnets which contain six single users and two communication vehicles [5], showed as Figure 2. The terrain model can be used in the simulation system, which can support to load the true terrain data. It can simulate the environment influence, such as terrain factor, the refraction of earth’s surface. It can analyze the signal attenuation because of the terrain factors, then well and truly reflect the performance of the wireless communication system. The terrain model contains Free Space Transmission Model, Longley-Rice Model, HATA Model, TIREM Model and so on. It can choose different transmission model and collocate the parameters according to the real terrain in order to reflect the wireless communication system’s efficiency in different terrain.

The simulation system can realize the function, such as: model development, terrain simulation, statistic analysis.

1) Model development
The simulation system contains the equipment model from OPNET, such as: router, switch. There are some other equipments, such as: satellite node, ground station, microwave relay node, which need to develop modeling simulation.

2) Terrain simulation
The simulation system can import terrain data by the terrain data interface and use the transmission model in order to well analyze the performance of wireless communication system.

3) Statistic analysis
According to the real evaluation requirement, it can choose the corresponding statistics by Project Editor in the simulation system, such as: point-to-point utilization, point-to-point throughput, in packet jitter, in packet ETE delay, Traffic Receive, Traffic sent, and so on. Then it can collect the simulation data by running the simulation system, which can analyze the system’s performance and evaluate the system’s efficiency.

3.2. Satellite Model
The satellite nodes in the simulation system need to develop by program. The other nodes can use the models from OPNET, such as: router, switch, microwave node, LTE base station. Which can modify the configuration according to the real equipments.
Communication satellites almost are in Geostationary Earth Orbit (GEO), which use the transparent transponders. It can realize the frequency conversion and data transmission after receiving data without the function of onboard switching and onboard processing on satellites. So the satellite node only needs to realize the function of data transmission with the models of relay module, module of Radio Frequency transmitters and receivers, antenna module. The satellite node model and relay module are showed as figure 3. It uses omni-directional antennas with 14dB plus.

The work flow of satellite node is as following:
1) The “antenna” model receives the signal, which can increase 14dB gain;
2) “rr_0” Radio Frequency receiver model receives the signal;
3) “relay” model can choose appropriate frequency to transmit the signal;
4) “rt_0” Radio Frequency transmitter model can transmit the signal.

The “relay” model can realize the repeater’s frequency choice as the core of the satellite node. It can realize the function with four process modules, such as: “INIT”, “INS_TAIL”, “Wait”, “SEND_HEAD”.

**INIT:** Process initializes and goes into “Wait” state;

**Wait:** “Wait” state is ready to be activated by data stream, then turns into “INS_TAIL” state;

**INS_TAIL:** It inserts received data packet in queue, then changes the state from "self interrupt" into “SEND_HEAD” state by activation;

**SEND_HEAD:** It can confirm the suitable frequency in order to transmit satellite signal by “CI” binding in the packet. Then it can acquire the number of the “rt_0” Radio Frequency transmitters and receivers by “confirm_tx_chann_num” function. It can choose suitable channel to transmit the packet by “confirm_transmitter_frequency” function, which can realize the data forwarding.

4. Application of Simulation System
The simulation system of wireless communication can simulate communication process and route choice between different users in different terrain. It also can well display the IP flux route between different users. It can analyze the end-to-end performance, evaluate wireless network efficiency, layout and deployment of the wireless network, the evaluation for network invulnerability [10].

1) End-to-End Performance Analysis
It can set parameters according with real wireless network, such as: network topology, traffic flow, protocol. Then it can collect the simulation data in order to analyze the End-to-End Performance of the wireless communication system.

2) Evaluation of Wireless Network Efficiency and QoS (Quality of Service)

It can evaluate the wireless network efficiency by different evaluation index. It also can compare the different QoS of the network after adding new wireless service.

| Name | Time (seconds) | Status |
|------|----------------|--------|
| taiyuan<->beijing | 800 | Fail |
| taiyuan<->beijing | 420 | Recover |
| taiyuan<->xian | 400 | Fail |
| taiyuan<->xian | 540 | Recover |
| beijing<->xiamen | 200 | Fail |
| beijing<->xiamen | 240 | Recover |

Figure 4. Link Failure and Recovery

3) Layout and Deployment of the Wireless Network

It can evaluate the network efficiency after new layout and deployment, analyze the influence of terrain factors for network deployment.

4) Network Invulnerability Evaluation

It can analyze the influence of the wireless communication system after some key nodes are trouble by changing some simulation parameters. So it can evaluate the network invulnerability viability after being attacked in wartime.

It can use “Failure Recovery” module in the simulation system and set the parameters according to Figure 4. The link between Beijing and Xiamen is failure in 200 second and resume in 240 second. The link between Taiyuan and Beijing is failure in 300 second and resume in 420 second. The link between Taiyuan and Xian is failure in 480 second and resume in 540 second. When the link is failure, the route is interrupt. It needs to choose a new route to continue the data transmission, which can make some packet lost, showed as Figure 5. Once the route is built, it will be work well and have no influence for the communication.

In order to evaluate the system performance, it needs to choose different indices according to different objects. It can choose indices, such as: throughput, delay, processing delay, Packet Loss Ratio for performance analysis of the equipment. It can choose indices, such as: global load, throughput, delay, for performance analysis of the network. It can choose service throughput, delay, delay jitter for performance analysis of the service statistics. It can collect the simulation results by different methods, such as: global statistics results, node statistics results, link statistics results, flux statistics results.
5. Conclusions

It designs the simulation system for the broad band wireless communication, which can simulate the wireless communication network under different environment. The simulation system can well reflect the performance of the wireless communication network and evaluate the system efficiency. It can provide theory support for the system development and ensure the wireless communication network with the performance of security, reliable, high effective, real-time.

References

[1] ZHU Chen, DONG Yin-hu. Network Simulation Technology and Its Application Based on OPNET [J]. Radio Engineering, 2013, 43(3): 12-15,61.
[2] Zhang Shuqiao. OPNET Simulation Test for Multiple Wireless Communication Modes [J]. Digital Communication World, 2014, 10: 63-65.
[3] YE Libang, WANG Manxi, ZHANG Yuling, GENG Hongfeng. Research on multi-connection modes based topology model of wireless communication network [J]. Modern Electronics Technique, 2016, 39(7): 1-4,9.
[4] GUO Pengfei;ZHANG Jie;LV Ming;BO Yuming. Modeling for wireless communication network and fault propagation[J]. Computer Engineering and Applications, 2015, 51(3): 1~5.
[5] XU Heng-jie, LIN Tao, ZHANG Kun, ZHANG Li. Research on Distributed Scene Simulation System Based on WCN [J]. Video Engineering ,2010,34(7): 111~114.
[6] LIU Min, GAO Ming-xia, LU Si-yu, QIAO Hui-dong. Research on OPNET-based simulation of field communication network[J]. Electronic Design Engineering, 2012, 20(4): 120-124.
[7] ZHOU Hua;LIU Zhuang;HAN Wei;HUANG Weifang Design of distributed parallel wireless communication simulation platform based on 5G[J]. Computer Engineering and Applications, 2016, 52(22): 15~21,85.
[8] PEI Xiao-dong, WANG Lin, LIU Wei. Simulation Design of Dynamic Spectrum Access System[J]. Journal of China Academy of Electronics and Information Technology, 2017, 12(4): 414~419.
[9] CHEN Hai-bin. Wireless Network Communication Information Transmission Efficiency Optimization Simulation [J]. Computer Simulation, 2017, 34(10): 159~162.
[10] ZHU Chen, DONG Yin-hu. Network Simulation Technology and Its Application Based on OPNET[J]. Radio Engineering, 2013, 43(3): 12-15,61.