Simulation and Analysis of OSPFv2 DR Election Based on GNS

Xiaohua Li
School of Computer and Information Engineering
Beijing University of Agriculture
Beijing, China, 80796338
lixiaohuabj@gmail.com

Jian Xu*
School of Computer and Information Engineering
Beijing University of Agriculture
Beijing, China, 80796338

Juan Nie
School of Computer and Information Engineering
Beijing University of Agriculture
Beijing, China, 80796338

Chengkui Guo
School of Computer and Information Engineering
Beijing University of Agriculture
Beijing, China, 80796338

Xiangang Zhao
National Satellite Meteorological Center
China Meteorological Administration
Beijing, China, 68407473
zhaoxiangang@gmail.com

***Abstract*—Designated Router (DR) is the key for the quality of an Open Shortest Path First (OSPF) network and it enables a reduction in the number of adjacencies, which in turn reduces the amount of routing protocol traffic and the size of the Link State Database (LSDB). In this paper, we analyze the principle of OSPFv2's DR election algorithm and carry out the simulation based on GNS3. The simulation can provide a reference for building an OSPF network. In the simulations, we focus on two types of DR Election process: Normal DR Election and DR re-election. Experimental results show that the election of DR and BDR can reduce the amount of OSPF traffic and ensure an orderly transition from Backup Designated Router to Designated Router. However, through the simulation we also learn that lots of unnecessary DR election operations are executed, which consume the routers' CPU resource and occupy their processing time. To improve the election algorithm, we offer several modifications. We detach and subdivide the NeighborChange event that invokes the election algorithm into more specific granularity. Through these measures, the DR election algorithm is expected to dispense with the extra election, reduce network convergence speed, and thereby improve network performance.**

Keywords-OSPF; DR ; BDR; DR Election; GNS

I. INTRODUCTION

In order to release the pressure of full adjacency establishment/maintenance with every neighbor on every router, OSPF [1-4] (Open Shortest Path First) allows the routers on a LAN elect leaders among themselves to function as the Designated Router (DR) and Backup Designated Router (BDR). The DR[5-6] is responsible for updating all other OSPF routers when a change occurs. The BDR monitors the DR and takes over as DR when the current Designated Router fails. The other routers that are neither DR nor BDR consider themselves to be DROthers and they will establish full adjacency only with DR and BDR.

The DR election algorithm is the key for the quality of an Open Shortest Path First (OSPF) network and it enables a reduction in the number of adjacencies required on a multi-access network, which in turn reduces the amount of routing protocol traffic and the size of the Link State Database(LSDB). The election algorithm designed is complex and makes it very difficult to understand. Yet, understanding the election of DR and BDR is crucial for better operation and management of OSPF networks. So, in this paper, we focus on the GNS-based simulation and analysis of OSPF's DR election. The Designated Router election algorithm will be illustrated in section 2. Using GNS3, We carry out the simulation and analysis in section 3. Conclusions are given in section 4.

II. THE DESIGNATED ROUTER ELECTION ALGORITHM

The Designated Router election algorithm proceeds as follows: Call the router doing the calculation Router X. The list of neighbors attached to the network and having established bidirectional communication with Router X is examined. This list is precisely the collection of Router X's neighbors (on this network) whose state is greater than or equal to 2-Way. Router X itself is also considered to be on the list. Discard all routers from the list that are ineligible to become Designated Router. The following steps are then executed, considering only those routers that remain on the list:.

1) Note the current values for the network's Designated Router and Backup Designated Router.This is used later for comparison purposes.

2) Calculate the new Backup Designated Router for the network as follows. Only those routers on the list that have not declared themselves to be Designated Router are eligible to become Backup Designated Router. If one or more of these routers have declared themselves Backup Designated Router, the one having highest Router Priority is declared to be

This work is sponsored by the project of Beijing Committee of Education (KM201210020004). Jian Xu is the Corresponding Author.

Backup Designated Router. In case of a tie, the one having the highest Router ID is chosen. If no routers have declared themselves Backup Designated Router, choose the router having highest Router Priority, (again excluding those routers who have declared themselves Designated Router), and again use the Router ID to break ties.

3) Calculate the new Designated Router for the network as follows. If one or more of the routers have declared themselves Designated Router, the one having highest Router Priority is declared to be Designated Router. In case of a tie, the one having the highest Router ID is chosen. If no routers have declared themselves Designated Router, assign the Designated Router to be the same as the newly elected Backup Designated Router.

4) If Router X is now newly the Designated Router or newly the Backup Designated Router, or is now no longer the Designated Router or no longer the Backup Designated Router, repeat steps 2 and 3, and then proceed to step 5.

5) As a result of these calculations, the router itself may now be Designated Router or Backup Designated Router. The router's interface state should be set accordingly. If the router itself is now Designated Router, the new interface state is DR. If the router itself is now Backup Designated Router, the new interface state is Backup. Otherwise, the new interface state is DR Other.

6) If the above calculations have caused the identity of either the Designated Router or Backup Designated Router to change, the set of adjacencies associated with this interface will need to be modified. Some adjacencies may need to be formed, and others may need to be broken. To accomplish this, invoke the event AdjOK on all neighbors whose state is at least 2- Way. This will cause their eligibility for adjacency to be reexamined.

The DR election algorithm is invoked by the interface state machine of OSPFv2 when one of the following events takes place:

- *Wait timer fires.* This happens when the wait time duration is over since the coming up of the interface. The wait time duration is set to be same as the RouterDeadInterval, which is four times the hello interval. The wait time duration is sufficient to allow the new interface to establish bidirectional communication with all the other routers on the LAN before it does its first DR election.

- *BackupSeen event is generated.* This happens when the interface has detected the presence or absence of a BDR either on receiving a 2-way Hello claiming the BDRship for the sending router or receiving a 2-way Hello claiming DRship for the sending router with no router listed as BDR. The interface performs a DR election on emerging out of waiting state and transitions to DR/BDR/DROther state.

- *NeighborChange event is generated.* This event may be invoked when the bidirectional communication is established (or breaks down) with a neighbor on the LAN, or when a bidirectional neighbor newly declares (or is no longer declaring) itself as DR/BDR for the LAN, or when the Router Priority changes for a bidirectional router.

III. Simulations and Analysis

Based on GNS3, we designed a typical network topology and carry out the simulation and analysis of the process of DR election.

A. Network topology and configuration scheme

The network topology designed for DR election simulation is shown in Figure 1. Five C7200 routers connected by an Ethernet switch through fastEthernet connections compose a typical LAN network. The router ID and other corresponding configurations for each router are set and marked in the figure.

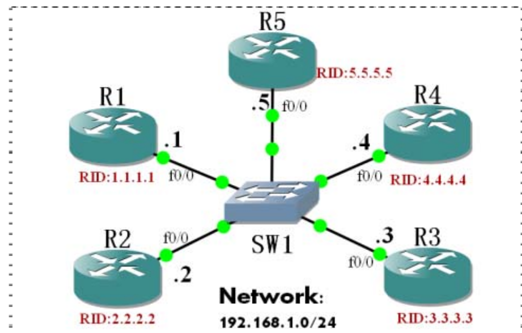

Figure 1. Network topology and configuration scheme.

B. Normal DR election

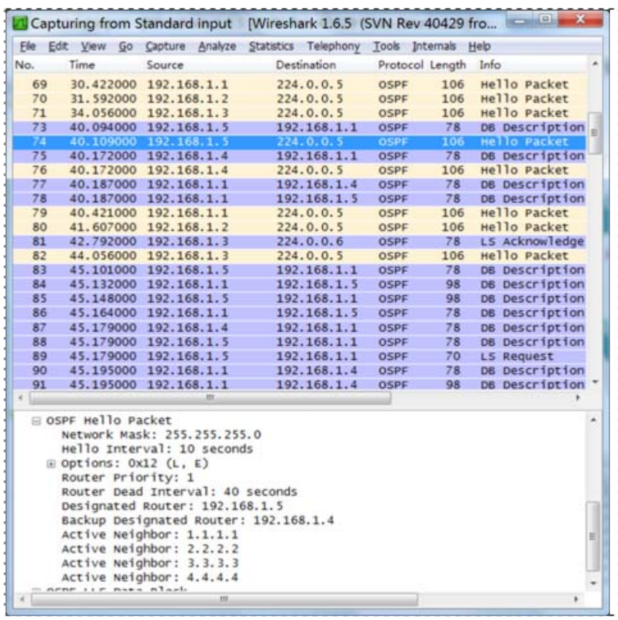

Figure 2. DR election results in normal election.

Since the routers used in the experiment are of the same type and their OSPF priorities are equal (defaults to 1 for all router interfaces), so if we start them in a very short period of time (all start before wait timer fires), the DR and BDR are determined by router ID. Thus, in our experiment, R5 and R4 will be elected as the DR and BDR respectively. The content written in Hello packets (captured in R1's f0/0 as shown in Figure 2) also verifies the election results.

When the leaders are elected, they will establish full adjacency with all the other routers. Packet series captured in R5's f0/0 (shown in Figure 3) telling us that R5 is establishing full adjacency and synchronizing with R1, R2, R3 and R4. The Packet series shown in Figure 3 is also a clear indication of the adjacency forming process between R5, R4 and R1.

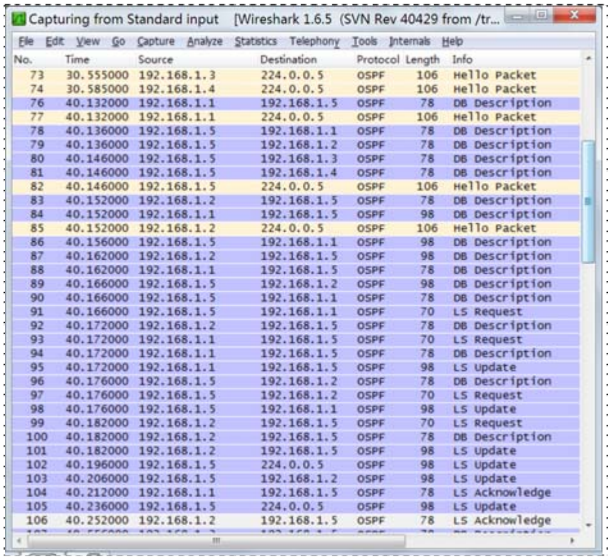

Figure 3. Database synchronization between DR and DROthers in normal DR election.

Examine the neighbor lists of the routers, we can see R1 keeps full adjacency with R5 (DR) and R4 (BDR), but only keeps 2way relationship with DROthers (R2 and R3), while R5 (DR) and R4 (BDR) keep full adjacency with all the other routers.

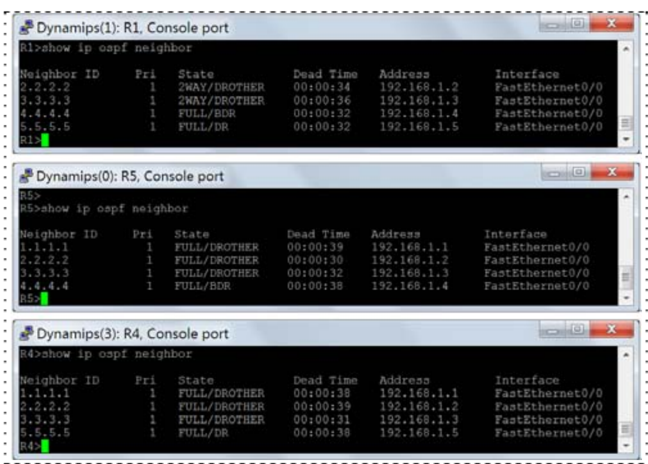

Figure 4. Neighbor lists of routers in normal DR election

C. *Leader replacement*

In this section, we perform two experiments to force the re-election of DR and test the leader replacement process.

1) *DR shutdown*

Shut down R5's f0/0, the network will be forced to elect a new DR. As R4 is the previous BDR, so, in this case, it will take over as the new DR and R3 will be elected to be the new BDR. The content written in Hello packet captured in R1's f0/0 verifies the new election results clearly (show in Figure5). The packet series in Figure 5 also illustrate the adjacency forming process between R1 and R3. As R4 has already established full adjacency and synchronized with all the others, we can see only the new adjacencies between the new BDR and all other routers have been formed, the leadership transition is smooth.

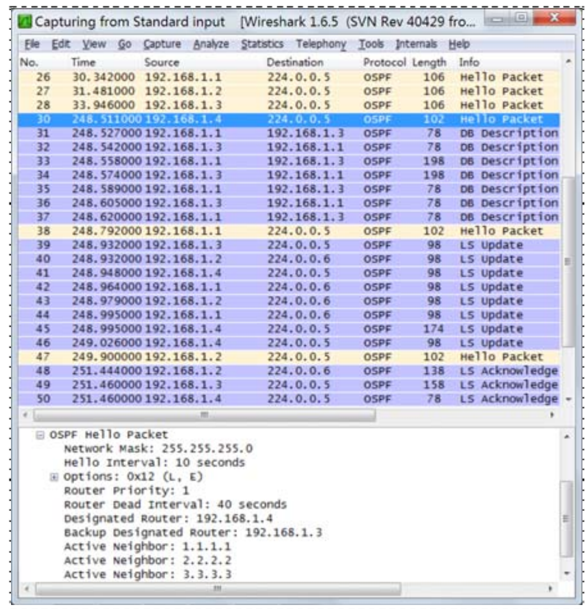

Figure 5. New election results when DR shut down.

2) *DR priority changes to 0*

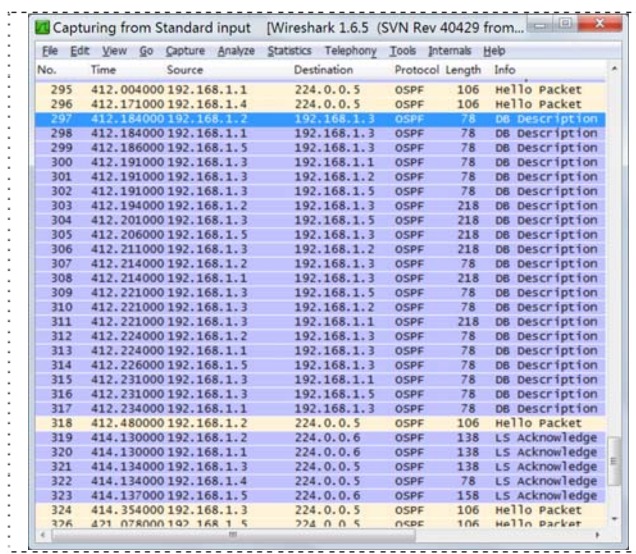

Figure 6. Adjacency forming process of new BDR when old DR becomes ineligible.

In this experiment, we change the router priority of R5 from 1 to 0. As the value of 0 makes R5 ineligible to be DR or BDR, DR election is forced to be executed. In this case, R4 will take over as the new DR and R3 is elected to be the new BDR. New adjacencies between the new BDR and all other routers attached to the network have to be formed. Part of the adjacency forming process is shown in Figure 6. The neighbor lists of the routers also verify this election results clearly (show in Figure 7).

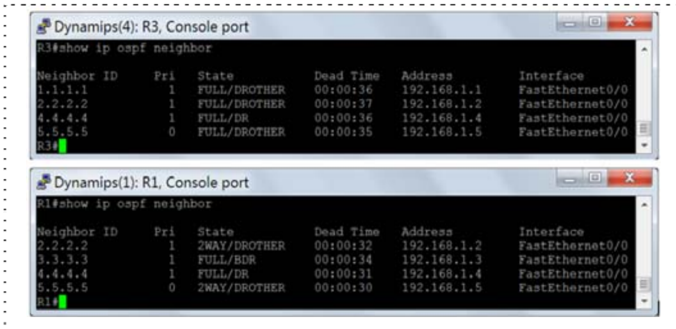

Figure 7. Neighbor list of the new BDR and DROTHER

D. Issues to be optimized and recommendations

Through simulation experiments, we also learn that lots of unnecessary DR election operations are executed and they consume the routers' CPU resource and occupy their processing time. The election algorithm has room to improve performance. Here, we offer several modifications. We detach and subdivide the NeighborChange event that invokes the DR election algorithm into more specific granularity, instead of mixing them together. According to our proposal, different event has its different corresponding processing operation, rather than simply a re-election.

- *New member joins in.* This event may be invoked when the bidirectional communication is established with a neighbor on the LAN, or when a bidirectional neighbor newly declares (or is no longer declaring) itself as DR/BDR for the LAN. When this events is generated, if the network has its own leaders (DR and BDR), just let the DR send a leader announcement to the newly joined member. All the members in the network do not have to conduct a re-election. If the network doesn't have its own leaders, all the members in the network execute the election operation.
- *Router Priority changes for a bidirectional router.* When this event is generated, we first have to determine whose priority has changed. If it is the DR or BDR, the network should have to conduct a re-election, otherwise, just note this message.
- *DR or BDR shuts down.* When this event is generated, the network should have to conduct a re-election.

IV. CONCLUSIONS

As the nature and demands of the routing infrastructures have changed over last several years, OSPF needs to make appropriate improvements to adapt to the new scenarios. So it is necessary and essential to re-evaluate the OSPF design and suggest protocol changes to improve its performance. In this paper we analyze the DR election algorithm. Based on GNS, simulation and analysis are carried out. Experimental results show that the election of DR and BDR can reduce the amount of OSPF traffic on multi-access networks. The current election algorithm can ensure an orderly transition from Backup Designated Router to Designated Router. The simulation can provide a reference for building an OSPF network. However, the simulation results also show that lots of unnecessary DR election operations are executed, which consume the routers' CPU resource and occupy their processing time. In large networks and complex routing domains, these operations are likely to make CPU overload in routers a real possibility; such failures may quickly snowball into a complete meltdown of routing functionality. To improve the leader election algorithm and reduce its time/processing requirements, we offer several modifications. We detach and subdivide the NeighborChange event that invokes the DR election algorithm into more specific granularity, instead of mixing them together. Through these measures, the DR election algorithm is expected to dispense with the extra election, reduce network convergence speed, and thereby improve network performance. To implement and modify the DR election algorithm, and carry out corresponding simulation and analysis are the focus of our future work.

ACKNOWLEDGMENT

We thank the authors involved in our reference for sharing data and beneficial inspirations with us. We also thank the peer review experts for their guidance and advice. Many references had to be deleted due to limited space, and we apologize to authors and readers for work that could not be cited.

REFERENCES

[1] M. Goyal, W. Xie, S. H. Hosseini, K. Vairavan, and D. Rohm 2006 Improving OSPF dynamics on a broadcast LAN Simulation 82 107 - 129.

[2] S. Huang, K. Kitayama, F. Cugini, F. Paolucci, A. Giorgetti, L. Valcarenghi, and P. Castoldi 2008 Network Architectures, Management, and Applications VI, October 27, 2008 - October 30, 2008 (Hangzhou, China, 2008)

[3] P. Li, S. - D. Wang, R. - C. Wang, and D. - Y. Zhang 2005 Research on security of OSPF routing protocol with digital signature Nanjing Youdian Xueyuan Xuebao/Journal of Nanjing Institute of Posts and Telecommunications 25 86 - 90.

[4] K. Manousakis and A. J. McAuley 2008 6th Intl. Symposium on Modeling and Optimization in Mobile, Ad Hoc, and Wireless Networks, Wiopt 2008, April 1, 2008 - April 3, 2008 (Berlin, Germany, 2008) pp 394 - 402

[5] Y. Yu, H. Wang, Y. Hua, and D. Zhou 2003 APOC 2003: Asia - Pacific Optical and Wireless Communications: Optical Transmission, Switching, and Subsystems, November 4, 2003 - November 6, 2003 (Wuhan, China, 2003) pp 653 - 661

[6] H. Lu, J. Zhiang, S. Yantai, and D. Linfang 2006 Next - Generation Communication and Sensor Networks 2006, October 2, 2006 - October 3, 2006 (Boston, MA, United states, 2006)