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HEURISTIC ALGORITHM FOR SPANNING TREE PROTOCOL ROOT BRIDGE DETERMINATION

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ABSTRACT

Techniques are presented to avoid requiring network administrators to have Spanning Tree Protocol (STP) domain specific knowledge while still achieving a stable and high performing Layer 2 (L2) topology in their Virtual Local Area Networks (VLANs). Configuring the STP is easily ignored since it is operable initially, but networks might run at a suboptimal efficiency as a result.

DETAILED DESCRIPTION

When Spanning Tree Protocol (STP) is not configured in a Layer 2 (L2) Virtual Local Area Network (VLAN), the root bridge becomes the switch with the lowest Media Access Control (MAC) address in the VLAN which might result in a suboptimal L2 topology. In the worst case, a simple access layer switch with minimum capabilities will become the root bridge. In this scenario, several problems might arise.

The first problem relates to a suboptimal topology. Here, frames take a non-optimal path to their destination (in terms of link bandwidth and/or hops), since the root of the STP tree is an access switch and hence core and distribution links are blocked. In some scenarios, the root bridge is responsible for communicating information towards all the switches in the VLAN (e.g., topology change in Institute of Electrical and Electronics Engineers (IEEE) 802.1D), so if the root bridge is inaccurately placed then this will take more time than necessary.

The second problem relates to an unstable topology. In particular, an access switch might be insufficient to handle large amounts of traffic and drop frames when the network is congested. Additionally if an edge, user facing, switch is elected then every time it is disconnected from the VLAN there will be disruptions due to STP recalculating the whole tree from scratch with a new root.

The third problem relates to a waste of resources. Core and distribution links, which can handle large amounts of traffic, can be blocked in favor of access links towards the root bridge. If a core or distribution switch was root, the VLAN would be able to handle larger amounts of traffic.

The problem is that STP usually works adequately out of the box, so network administrators might ignore the importance of configuring it. Also, it requires a considerably experienced network administrator to have the requisite knowledge to decide which switch is suitable to be a root bridge in the VLAN.

A good choice for a root bridge should satisfy the following characteristics. First, it should reside in the center of the VLAN (i.e., the cost of the (root) path taken from every switch to the root bridge should be as low as possible). Second, it should be equipped with multiple high speed links towards different nodes in the VLAN. Third, it should be a high end switch with high switching capacity.

These conditions can be captured using closeness centrality in graph theory, (i.e., how close a switch is to every other switch). Assuming the topology is known, the algorithm works as follows. First, set the cost of each link. In one example, the cost may be set according to a published standard table with the values. The selection of the values depends upon the version of STP that is currently being used on the network.

Second, a switch R in the VLAN is selected and it is assumed to be the root bridge. Assuming there are N other switches in the VLAN, a target switch T from the set of N switches is selected. Dijkstra's algorithm is applied to find the shortest path from R to T. The cost of this path is equivalent to the root path cost of T in any STP topology with R being the root bridge, since STP link costs are used. This is repeated for all N switches to obtain a set S of N root path costs. An average of S is taken which indicates the centrality of R.

Third, the second step is repeated for every switch in the VLAN to obtain the centrality score of each switch in the VLAN. Fourth, the set of switch(es) with the minimum score represents the optimized root bridge choice(s).

Figure 1 below illustrates an example topology for a first test case. In this scenario, both SW1 and SW2 are equally optimal for root bridges, but SW0 is clearly suboptimal because this choice will block a 1GB link in favor of a 100MB link.

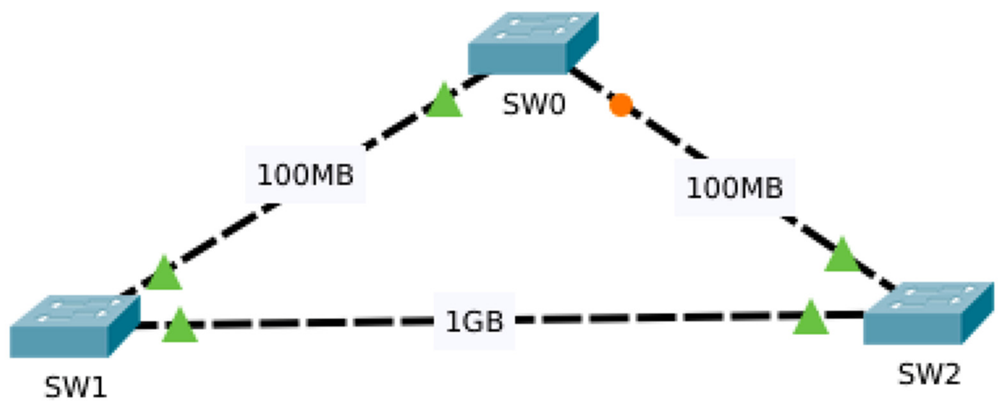

Figure 1

Table 1 below illustrates the link costs for the first test case.

Speed	100MB	1GB
Link Cost	4	19

Table 1

Table 2 below illustrates the shortest path distance for the first test case.

	SW0	**SW1**	**SW2**	**AVG**
SW0	0	19	19	*12.6*
SW1	19	0	4	*7.6*
SW2	19	4	0	*7.6*

Table 2

In the first test case, the algorithm identified both optimal choices correctly

Figure 2 below illustrates an example topology for a second test case. Here, SW2 is the optimal choice since it has a direct connection to every other switch and it is equipped with high speed links. SW0 is a bad choice for the same reason as in the first test case. SW3 is a bad choice because (1) it is not central and would therefore take more time contacting all switches in the case of a topology change than SW2 would need; and (2) it is an edge switch, making it more easily accessed by users which can cause instability of the topology if this switch is disconnected from the network, since STP would have to go through the whole process again. SW1 is a relatively bad choice because it is not as central as SW2, since it has fewer connections to other nodes.

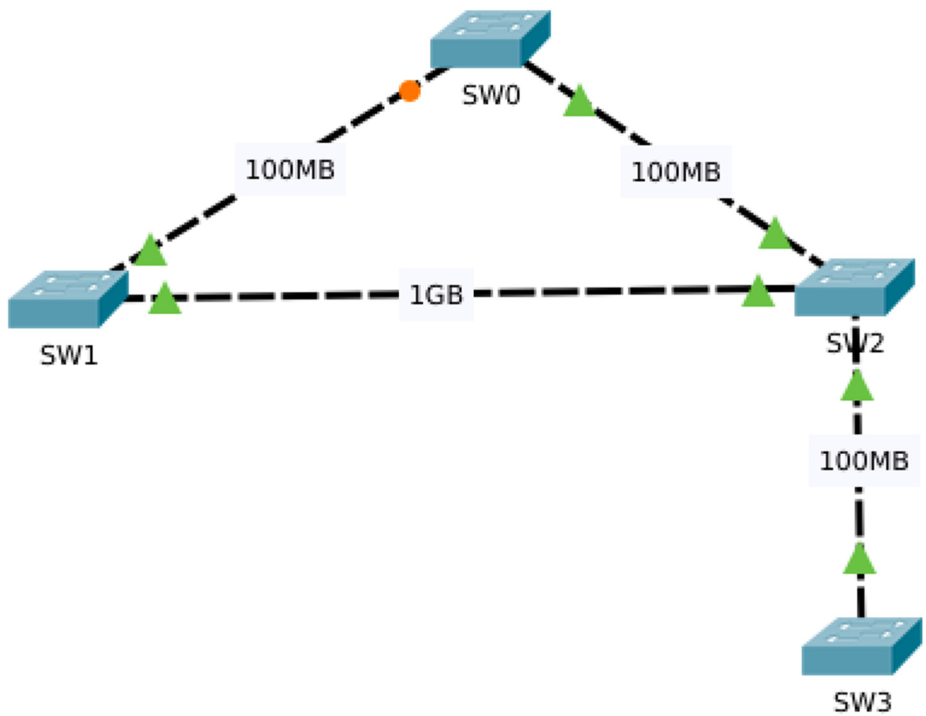

Figure 2

Table 3 below illustrates the link costs for the second test case.

Speed	100MB	1GB
Link Cost	4	19

Table 3

Table 4 below illustrates the shortest path distance for the second test case.

	SW0	**SW1**	**SW2**	**SW3**	**AVG**
SW0	0	19	19	38	*19*
SW1	19	0	4	23	*11.5*
SW2	19	4	0	19	*10.5*
SW3	38	23	19	0	*20*

Table 4

In the second test case, the algorithm determined the best choice.

Figure 3 below illustrates an example topology for a third test case. In the case of complicated topologies like this, there is no optimal choice but rather good and bad choices.

Initially, three switches appear to be good choices: Switch5, Switch6, and Switch10. Switch5 is central and equipped with multiple connections towards different nodes in the network. It has three 1GB and two 100MB links, more than any other switch in terms of number and speed. Also, it is at most two hops away from any other switch. Compared to Switch4 which is placed equally well in the physical topology, Switch5 has one more 1GB link than Switch4. Switch6 and Switch10 are also central. However, they have one less link than Switch4 and Switch5. They are also further away from the center than Switch4 and Switch5 since the furthest switch is three hops away.

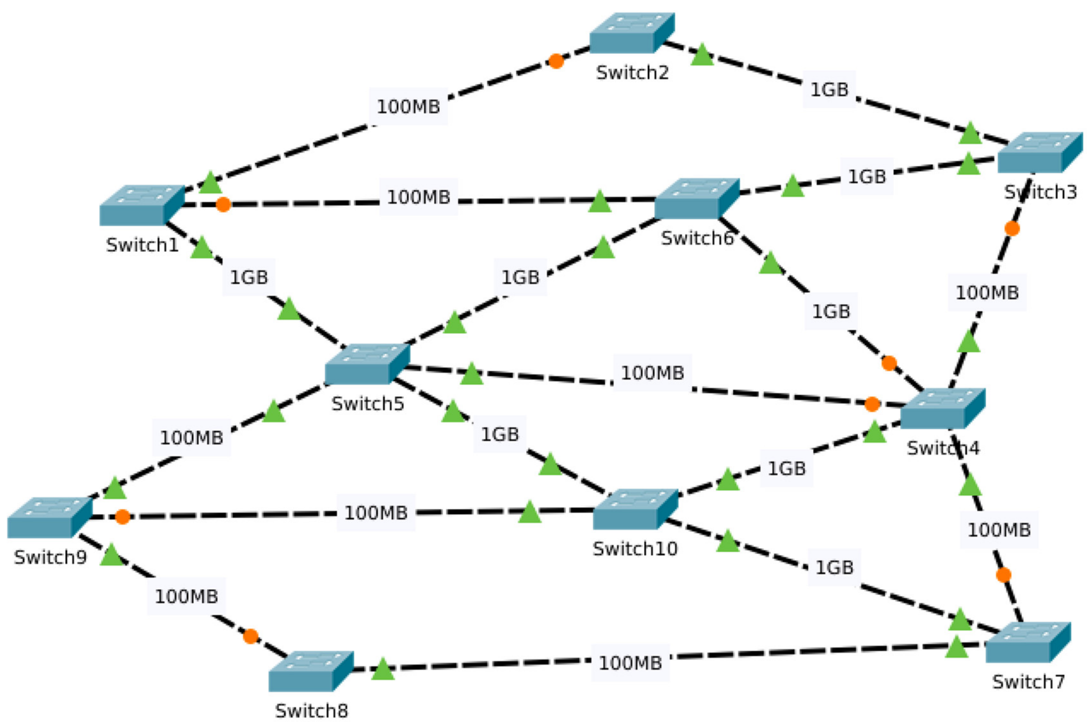

Figure 3

Table 5 below illustrates the link costs for the second test case.

Speed	100MB	1GB
Link Cost	4	19

Table 5

Table 6 below illustrates the shortest path distance for the second test case.

	SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8	SW9	SW10	AVG
SW1	0	16	12	12	4	8	12	31	23	8	*12.6*
SW2	16	0	4	12	12	8	20	39	31	16	*15.8*
SW3	12	4	0	8	8	4	16	35	27	12	*12.6*
SW4	12	12	8	0	8	4	8	27	23	4	*10.6*

SW5	4	12	8	8	0	4	8	27	19	4	*9.4*
SW6	8	8	4	4	4	0	12	31	23	8	*10.2*
SW7	12	20	16	8	8	12	0	19	23	4	*12.2*
SW8	31	39	35	27	27	31	19	0	19	23	*25.1*
SW9	23	31	27	23	19	23	23	19	0	19	*20.7*
SW10	8	16	12	4	4	8	4	23	19	0	*9.8*

Table 6

In the third test case, the algorithm determined the best choice.

Described is an algorithm to find a good root bridge choice. The algorithm provides the user with a set of optimized choices for the root bridge, and hence embodies an improved solution over the default random election. This way, the network administrator need not know what makes a good root bridge choice. It also allows better utilization of the network resources with minimal effort from the user side.

In summary, techniques are presented to avoid requiring network administrators to have STP domain specific knowledge while still achieving a stable and high performing L2 topology in their VLANs. Configuring the STP is easily ignored since it is operable initially, but networks might run at a sub-optimal efficiency as a result.