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EE384A: Network Protocols and Standards
Homework #2 - Solutions
Multicast and GMRP

Problem 1: LAN Multicast

a) *The maximum number of channels is 2 since every channel will have to be broadcast on all segments and 10 Mbps segment can not handle more than 2 4-Mbps channels. The number of channels does not depend on the location of sources since multicast traffic is broadcast on the whole LAN.*

b)

1. *The maximum number of channels is 250. It is limited to what the backbone 1-Gbps segment can handle since all source multicasts are transmitted on it.*

2. *K <= 2 as in a). KN <= 25, limited by the wing bridge's 100Mbps uplink segment. KNM can be unlimited since the limit on the number of channels available (250) implies that the floor bridge's 1-Gbps uplink segment capacity is never exceeded. L can be as large as needed.*

c)

1. *Since this topology eliminates the shared 1_Gbps segment bottleneck, an unlimited number of channels can now be offered.*

2. *K <=2, KN <= 25 and KNM <=250 as before. However, if we want to achieve the above-stated goal, then the total number of users KNML is limited to 250, the backbone segment's capacity.*

d)

1. *Since there is no limit on the number of ports, then an unlimited number of video sources can be attached to the switch (note that in this question, all switches are considered to be GMRP-aware).*

2. *K <= 2, KN <= 25 and KNM <= 250 are still valid. However, L and thus the total number of users KMNL is unlimited.*

e)

Backbone Switch (GB/s)	**Floor Switches (100 MB/s)**	**Wing Switches (10 MB/s)**
GMRP Unaware	GMRP Unaware	GMRP Unaware
GMRP Aware	GMRP Aware	GMRP Aware
GMRP Unaware	GMRP Aware	GMRP Aware
GMRP Unaware	GMRP Unaware	GMRP Aware
GMRP Aware	GMRP Aware	GMRP Unaware
GMRP Aware	GMRP Unaware	GMRP Unaware
GMRP Aware	GMRP Unaware	GMRP Aware
GMRP Unaware	GMRP Aware	GMRP Unaware

Table 1.1

Note that case number 1 corresponds to a) (having a shared segment or a switch as a backbone does not make a difference in this case) and case number 2 corresponds to d).

Case 1: 1) The maximum number of channels that can be offered is 2.
2) k<=2, KN <=2, KNM <= 2, KNML <=2

Case 2: 1) The maximum number of channels that can be offered is unlimited.
2) k<=2, KN <=25, KNM <= 250, KNML unlimited

Case 3: 1) The maximum number of channels that can be offered is 250.
2) k<=2, KN <=25, KNM unlimited, KNML unlimited

Notice that KNM is unlimited because we know that no more than 250 channels are available and thus no more than 250 different channels can be requested at the same time which satisfies the constraint on the 1Gbps link usage. Similar reasoning applies to other cases below.

Case 4: 1) The maximum number of channels that can be offered is 25.
2) k<=2, KN unlimited, KNM unlimited, KNML unlimited

Case 5: 1) The maximum number of channels that can be offered is unlimited.
2) k<=2, KN <=2, KNM <= 250, KNML unlimited

Case 6: 1) The maximum number of channels that can be offered is unlimited.
2) k<=2, KN <=2, KNM <= 2, KNML unlimited

Case 7: 1) The maximum number of channels that can be offered is unlimited.
2) k<=2, KN <=25, KNM <= 25, KNML unlimited

Case 8: 1) The maximum number of channels that can be offered is 250.
2) k<=2, KN <=2, KNM <= unlimited, KNML is unlimited

Comments:

We use the following notation in the discussion below: for a bridge, N stands for non GMRP-aware, and Y stands for GMRP-aware. For example, the 3 letters NYY mean that the 1Gbps bridge is N, the 100Mbps and the 10Mbps switches are Y (left to right).

To comment on the effect of the placement of bridges in the tree, we compare first the cases where at most one bridge level is Y. In terms of total number of channels offered, we get:

YNN (case 6) gives an unlimited number of channels that can be offered.
NYN (case 8) gives a maximum of 250 channels that can be offered.
NNY (case 4) gives a maximum of 25 channels that can be offered.
NNN gives a maximum of 2 channels that can be offered.

It is clear that putting the GMRP aware level closer to the root of the tree gives a larger selection of different channels. This is due to the fact that a GMRP-aware bridge shields lower bandwidth segments from unnecessary multicasts.

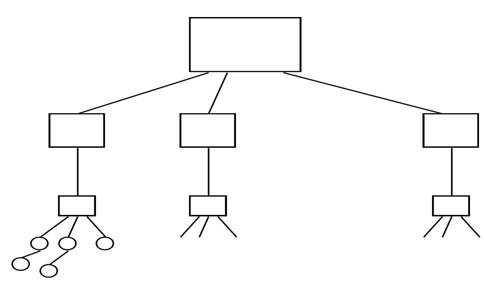
Moreover, in order to be able to offer an unlimited number of different movies or channels, the Gbps switch must be GMRP-aware (this corresponds to a Y- -placement, where – means that the bridge may be N or Y). The placements NY- and NNY give respectively a maximum of 250 and 25 channels.
Now if we look a the constraints placed on the number of users at different levels we see that:

> *YNN gives KN <= 2, KNM <= 2, KNML unlimited*
> *NYN gives KN <= 2, KNM unlimited, KNML unlimited*
> *NNY gives KN unlimited, KNM unlimited , KNML unlimited*

These results show that we can support more users per port by placing the GMRP-aware bridges closer to the leaves, the best placement in terms of port usage being NNY. YNN limits the number of users per 1Gbps port to 2, while NYN limits the number of users per 100Mbps port to 2.
The number of users per port translates to a total number of 100Mbps and Gbps ports for the hotel. Since the cost of the network is directly related to the price per port[1] and the total number of ports, it is imperative that this total be minimized. Therefore, we will give preference to the solution that gives better port usage figures.
We conclude that if a 25 channel selection is acceptable, then the GMRP functionality should be implemented in the 10Mbps switches (the level closest to the leaves). Note that this case corresponds to an unlimited number of 10Mbps switches sharing a 100Mbps backbone segment (in other words, the Gbps and the 100Mbps switches are not needed).
Otherwise, if more than 25 channels are needed, an additional level must be GMRP-aware. In order for us to decide which level it should be, we have to compare the cases where two levels are Y. Then:

> *YYN (case 5) gives an unlimited number of channels.*
> *YNY (case 7) gives an unlimited number of channels.*
> *NYY (case 3) gives a maximum of 250 channels.*

However, the port utilization figures are:



> *YYN gives KN <= 2, KNM <= 250, KNML unlimited*
> *YNY gives KN <= 25, KNM <= 25, KNML unlimited*
> *NYY gives KN <= 25, KNM unlimited, KNML unlimited.*

This shows that, compared to NNY, adding a GMRP-aware bridge at the 100Mbps level helps us increase the number of channels that can be offered to 250. The port usage for the NYY case is clearly the best. YYN gives 2 users per 100Mbps port only, while YNY reduces the 100Mbps

[1] As you might expect, higher bandwidth ports cost much more than lower bandwidth ones

switches to serving as down-converters (1Gbps to 100Mbps links – see figure above) since they don't help in increasing the number of users that can be supported.

If a selection of more than 250 channels is needed, then the configuration to use is YYY (all bridges GMRP-aware) in order to achieve acceptable port usage numbers.

Problem 2: GARP/GMRP

a.) *See Table 2.1*

b.) *See Figure 2.2*

c.) *See Table 2.2*

d.) *See Figure 2.3*

We assumed that stations marked by an X are sources of O1 and O2 traffic. If you chose other stations or assumed that all stations connected to these bridges are sources of O1 and O2 traffic it is acceptable as long as your solution is consistent with your choice.

e.) See Table 2.3

f.) *See Figure 2.4*

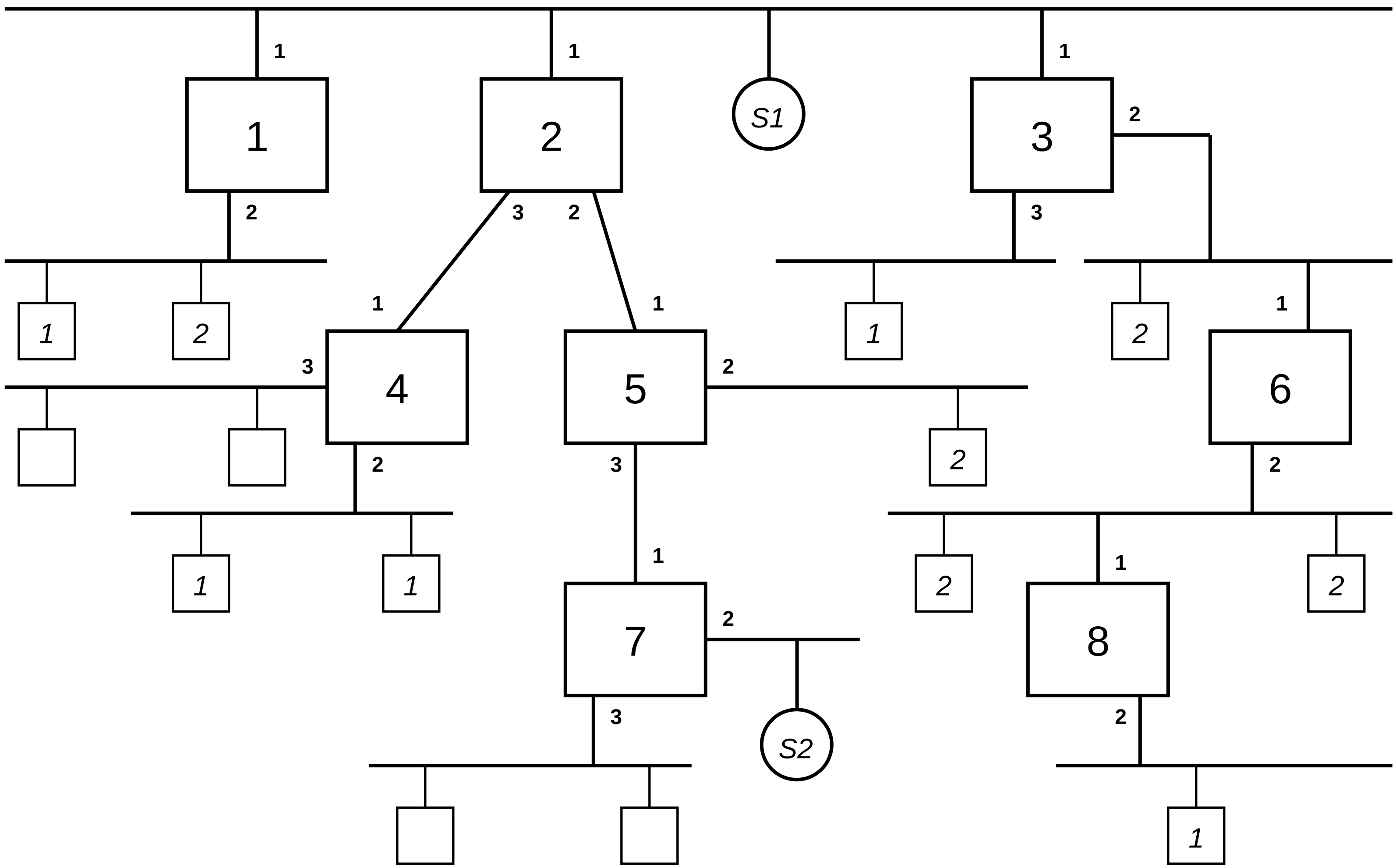


Figure 2.1

Bridge #	Multicast Addr.	Port 1	Port 2	Port3
1	M1	FD	FD	-
1	M2	FD	FD	-
2	M1	FD	FT	FD
2	M2	FD	FD	FT
3	M1	FD	FD	FD
3	M2	FD	FD	FT
4	M1	FD	FD	FT
4	M2	FD	FT	FT
5	M1	FD	FT	FT
5	M2	FD	FD	FT
6	M1	FD	FD	-
6	M2	FD	FD	-
7	M1	FD	FT	FT
7	M2	FD	FT	FT
8	M1	FD	FD	-
8	M2	FD	FT	-

Table 2.1 – Question 2a.)

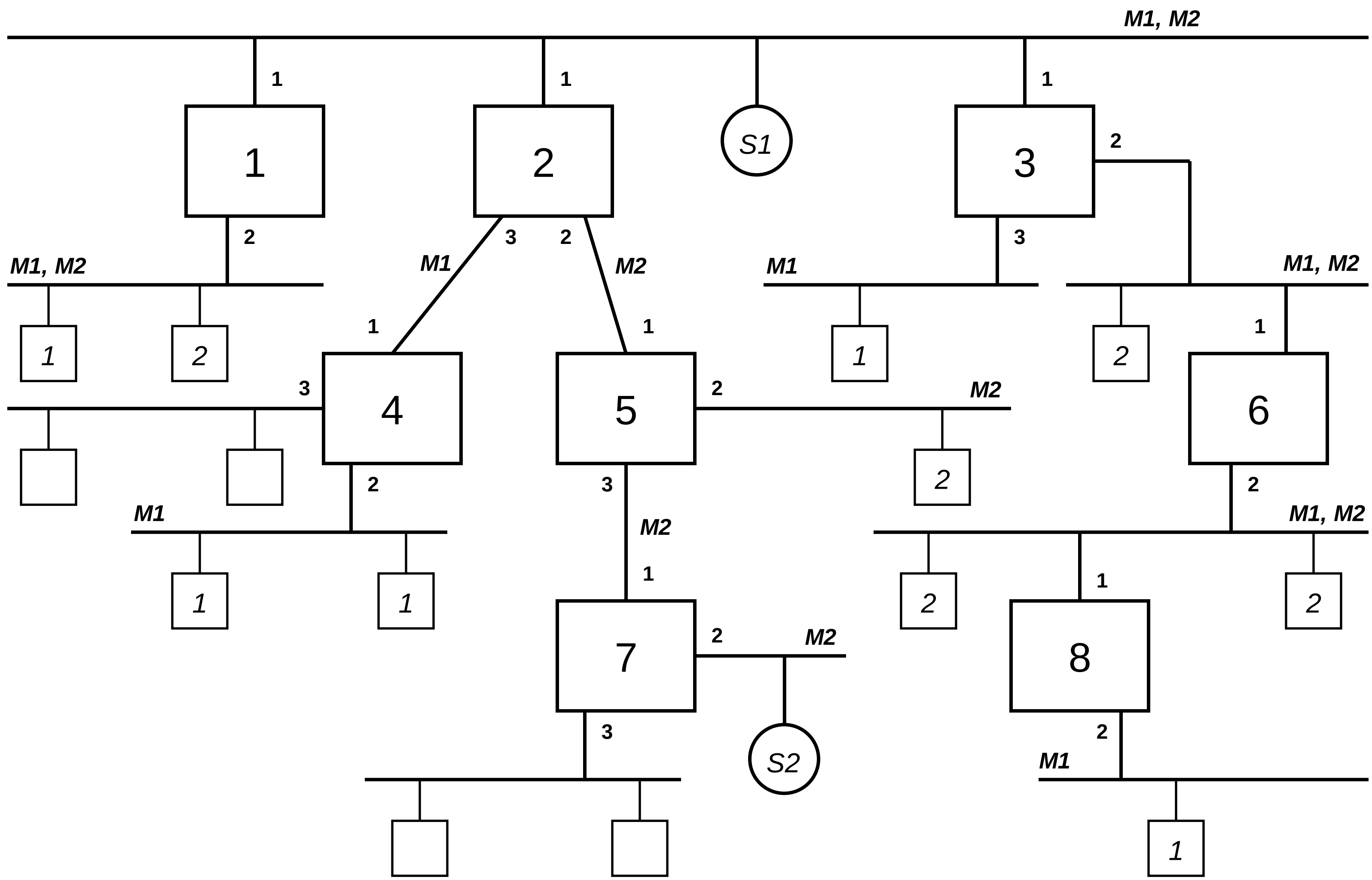


Figure 2.2 – Question 2b.)

Bridge #	Multicast Addr.	Port 1	Port 2	Port3
1	M1	FD	FD	-
1	M2	FD	FD	-
1	AG	FD	FT	-
2	M1	FD	FT	FD
2	M2	FD	FD	FT
2	AG	FT	FD	FT
3	M1	FD	FD	FD
3	M2	FD	FD	FT
3	AG	FD	FT	FT
4	M1	FD	FD	FT
4	M2	FD	FT	FT
4	AG	FD	FT	FT
5	M1	FD	FT	FT
5	M2	FD	FD	FT
5	AG	FT	FT	FD
6	M1	FD	FD	-
6	M2	FD	FD	-
6	AG	FD	FT	-
7	M1	FD	FT	FT
7	M2	FD	FT	FT
7	AG	FT	FT	FD
8	M1	FD	FD	-
8	M2	FD	FT	-
8	AG	FD	FT	-

Table 2.2 – Question 2c.)

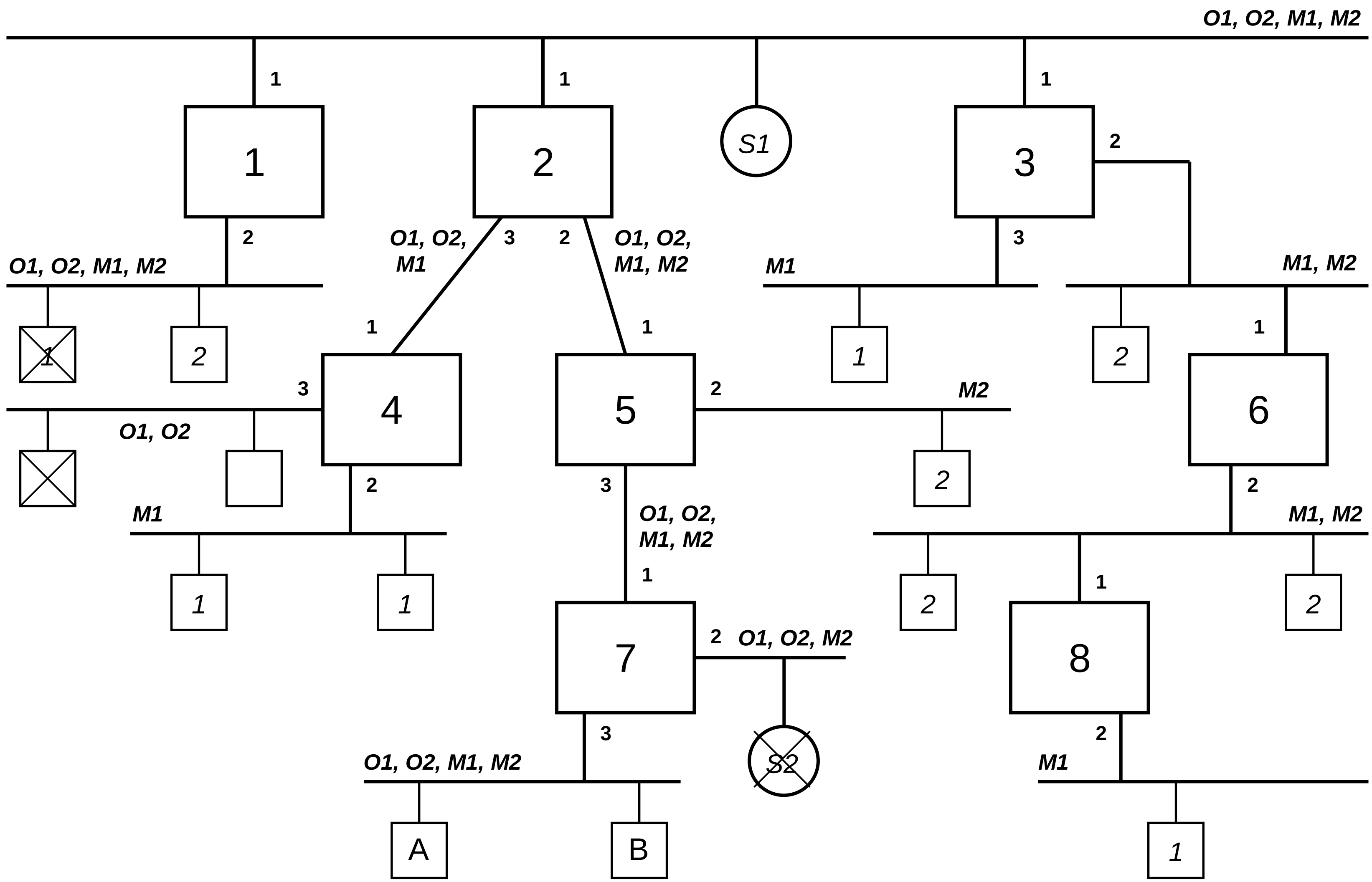


Figure 2.3 – Question 2d.)

Bridge #	Multicast Addr.	Port 1	Port 2	Port3
1	M1	FD	FD	-
1	M2	FD	FD	-
1	UG	FD	FT	-
2	M1	FD	FT	FD
2	M2	FD	FD	FT
2	UG	FT	FD	FT
3	M1	FD	FD	FD
3	M2	FD	FD	FT
3	UG	FD	FT	FT
4	M1	FD	FD	FT
4	M2	FD	FT	FT
4	UG	FD	FT	FT
5	M1	FD	FT	FT
5	M2	FD	FD	FT
5	UG	FT	FT	FD
6	M1	FD	FD	-
6	M2	FD	FD	-
6	UG	FD	FT	-
7	M1	FD	FT	FT
7	M2	FD	FT	FT
7	UG	FT	FT	FD
8	M1	FD	FD	-
8	M2	FD	FT	-
8	UG	FD	FT	-

Table 2.3 – Question 2e.)

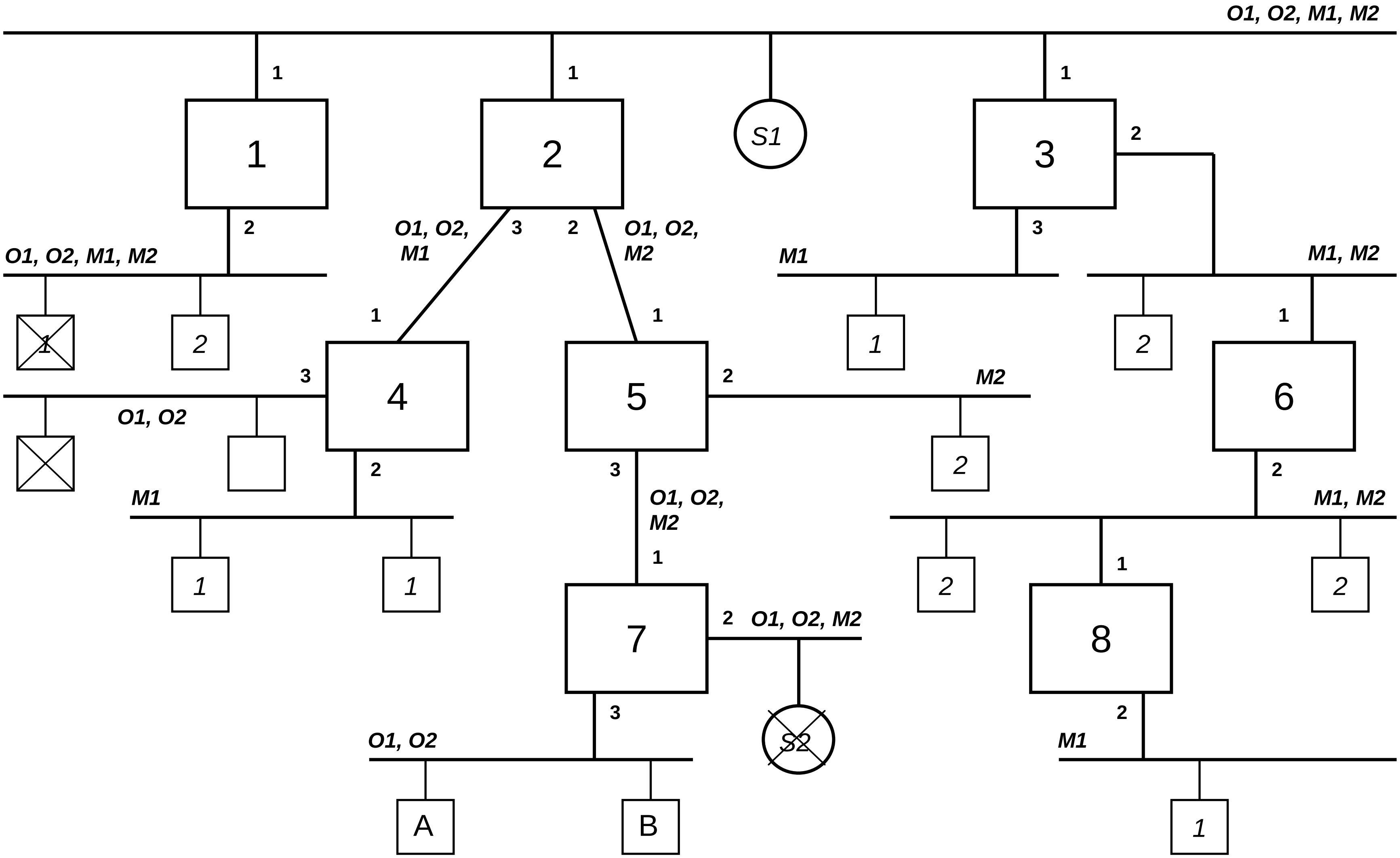


Figure 2.4 – Question 2f.)