Midterm Examination

Open Book, Open Notes
Time Allowed = 2 hours (16/10/2004)

“I certify that I have neither received nor given unpermitted aid on this examination and that I have reported all such incidents observed by me in which unpermitted aid is given.”

Signature _______________________

Name ___________________________ Student ID ____________________________

Problem 1 ____________ [40]
Problem 2 ____________ [30]
Problem 3 ____________ [40]
Problem 4 ____________ [40]
Problem 5 ____________ [50]

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TOTAL ________________ [200]
Problem 1: Basic Virtual LANs [40pts] An extended LAN architecture is shown in the figure. Bridges are shown as squares while end stations are shown as circles. Bridge and station IDs are written within. Segment numbers are also indicated in the figure.

- Default PVID = 1 for all ports of all bridges.
- Ingress filtering is disabled at all ports of all bridges.
- Bridge 1 forbids registration of VLAN2 on port 1.
- Following stations register for VLAN2: A, B, C, D
- Following stations register for VLAN3: A, D, E, F
- Bridge 1 uses a shared filtering database with a FID consisting of VLANs 2 and 3. Other bridges use independent learning.

(a) [6points] What stations can station A send packets to on the following VLANs:
- VLAN 1:
- VLAN 2:
- VLAN 3:

(b) [6points] What stations can station C send packets to on the following VLANs:
- VLAN 1:
- VLAN 2:
- VLAN 3:

(c) [9points] What stations can station E send packets to on the following VLANs:
- VLAN 1:
- VLAN 2:
- VLAN 3:
(d) [9points] The following events occur in sequence.

Event 1: Station A sends a packet to station D on VLAN 3
Event 2: Station C sends a packet to station A on VLAN 2
Event 3: Station B sends a packet to station D on VLAN 3

Fill out the corresponding tables indicating only those segments a packet travels on and corresponding VLAN tag.

<table>
<thead>
<tr>
<th>SEG. #</th>
<th>VLAN TAG</th>
<th>SEG. #</th>
<th>VLAN TAG</th>
<th>SEG. #</th>
<th>VLAN TAG</th>
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</table>

Table for Event 1  
Table for Event 2  
Table for Event 3

(e) [10points] Now consider that a network manager enables ingress filtering at all ports of all bridges. Everything else remains as in previous parts. Fill in the following table to indicate which stations are reachable from station E on VLAN2 and VLAN3. Just use Y or N. If a station can not be reached from station E, also indicate in the table where (which bridge, which port) the frame is filtered.

<table>
<thead>
<tr>
<th>Target Station</th>
<th>On VLAN2</th>
<th>On VLAN3</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Reachable?</td>
<td>If No, filtered at:</td>
</tr>
<tr>
<td></td>
<td>Y/N</td>
<td>Bridge</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
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<tr>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Stations reachable by E on VLAN2 and VLAN3
Problem 2: Multicast Traffic Forwarding [30pts] Consider the topology of an extended LAN shown in the following figure. All bridges are GMRP-aware and IEEE 802.1D compliant with bridge IDs also indicated in the figure. There are stations in the network as shown. We use $M$ for the stations who are interested in receiving traffic for a multicast group $M$. Some other stations are interested in receiving traffic for another multicast group $G$, and some stations are interested in neither. Ports of bridges will either forward or filter traffic for the multicast groups $M$ and $G$. We are interested in the state of each port (either forwarding or filtering) in the network. For each port, put a star (⋆) next to it if the port will forward traffic for group $M$ on the associated segment. For each port, put a circle (○) next to it if the port will forward traffic for group $G$ on the associated segment.

Figure 2: Extended LAN for Problem 2
Problem 3: GARP Join Messages [40pts] Consider the topology shown in the following figure. The topology includes two bridges B1 and B2, two stations A and B, and three LAN segments.

![Figure 3: Extended LAN for Problem 3](image)

Both the bridges are IEEE 802.1D compliant and are GMRP-aware. Both stations are also GMRP-aware with simple applicants. Assume the both the stations get interested in receiving traffic for a multicast group G. Assume that a GARP monitoring alien is monitoring GARP messages on all the three segments.

(a) [6points] Draw circles on ports which will forward traffic for multicast group G onto attached segment.

(b) [6points] In steady state, what is the maximum number of GARP Join messages the alien would have seen on each segment? (Hint: Make sure you have considered the fact that a JoinEmpty message will force an applicant into “Very Anxious” state)

- Segment 1:
- Segment 2:
- Segment 3:

(c) [6points] In steady state, what is the minimum number of GARP Join messages the alien would have seen on each segment?

- Segment 1:
- Segment 2:
- Segment 3:

(d) [6points] If stations A and B get interested in receiving the traffic for group G at EXACTLY the same time, what are the chances that station A will send the first Join message ever seen by the alien?
For the rest of the question, focus on Segment 2 and assume no packets are lost. Assume that both stations transmit their first *Join* message at EXACTLY the same time. As a result, bridges will get interested in propagating this information at EXACTLY the same time onto Segment 2.

(e) [12points] What are the chances (in %age) that the alien will see the maximum possible number of *Join* messages on segment 2. Note that this maximum number was found in part(b) above.

(f) [4points] What are the chances that the alien will see the minimum possible number of *Join* messages on segment 2. Note that this minimum number was found in part(c) above.
Problem 4: GARP [40points] A video multicast system and a video conference system are deployed on a bridged Ethernet LAN whose topology is shown in the figure. All bridges are IEEE 802.1D compliant and GMRP-aware.

There are three TV channels that are multicast on the system, ABC, CNN, and FOX. The corresponding sources are explicitly identified in the figure by the acronym in capital letters (e.g., ABC). Stations that are interested in receiving a given channel are marked with the channel acronym in lower case (e.g., abc). Stations which are not marked with any channel acronym have no interest in receiving any of the TV channels. The network manager at station $S_7$ subscribes to the All Unregistered Groups service identified by the acronym AUG.

The stations labelled VC are taking part in a video conference: they are all sources of video multicast traffic and each of them registers for the multicast address VC in order to receive multicast traffic sent to this address.

The ethernet multicast addresses are represented as follows: We use the TV channel acronym to represent the Ethernet multicast address used for that channel (e.g., ABC) and we represent the All Unregistered Groups service by the acronym AUG. The multicast address is VC for the video conference users.

The CNN source has a full-applicant GARP state machine and the ABC source has an applicant-only state machine. All other stations have the simple-applicant state machine. Every source that is capable of source pruning uses it.

(a) [14points] Indicate, for the GARP participants at the ports or stations specified in the figure, the applicants and the registrars that are present, and the state that each of these is in, after steady state has been reached (i.e., ignore the transient states associated with the LeaveAll messages). To indicate the state, use the acronyms given in the lecture notes. If there is a situation when a member can be passive or active, indicate so by using the acronym A/P. Use a dash when an attribute is present but a registrar or applicant is not.

(b) [6points] Indicate on the figure the LAN segments on which traffic corresponding to each of the multicast addresses flows by marking the segments by the address acronym. Be precise, and clearly write the acronym next to the segment.

(c) [6points] Now assume that station $S_4$ registers for CNN. Once again mark each segment by the address acronym of the multicast group for which the traffic will flow onto corresponding segment. Use the figure for this part (two pages later).

(d) [14points] Under the condition of part (c), show the applicant and registrar states for the indicated ports. Use the figure for this part (two pages later).
Figure 4: For problem 4(a)
Figure 5: For problem 4(d)
Problem 5: Bridging in an ISP Network [50points] The following figure represents a topology deployed by a typical ISP to serve a metropolitan area. An effort has been made to provide some redundancy in this architecture such that all bridges can access any other bridge through multiple paths. This is usually done in extended LANs to guarantee that users can still be served when links fail.

Further note that the topology consists of links of different speeds as indicated by dark and thin lines. The path costs of the links are assigned the recommended values provided in the IEEE 802.1D standard as shown in the associated table (taken from Table 8-5 of the standard). Bridges are IEEE 802.1D compliant running the spanning tree algorithm and are indicated by squares with bridge IDs written in the center and port numbers as indicated.

Assume that all the bridges use the default timer values recommended in the standard and reproduced in the table shown. Further assume that the time it takes to generate, transmit, and process BPDUs are all negligible.

It is considered in this problem that the message age increment used by all bridges is set to 1 s. Note that the message age increment is the value by which the age of a BPDU received on the root port is incremented before transmitting it on the designated port(s). We further note that according to the standard, there is no age associated with the configuration message stored at a designated port.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Link Speed</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Path Cost</td>
<td>10 Mbps</td>
<td>100</td>
</tr>
<tr>
<td>Path Cost</td>
<td>100 Gbps</td>
<td>19</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FDB Ageing Timer</td>
<td>300</td>
</tr>
<tr>
<td>Hello Time</td>
<td>2</td>
</tr>
<tr>
<td>Max Age</td>
<td>20</td>
</tr>
<tr>
<td>Forward Delay</td>
<td>15</td>
</tr>
</tbody>
</table>

(a) [5points] What is the maximum number of links that you may allow to fail still ensuring that all the users are served? Which links are they?

(b) [5points] Assuming there are users on all the links, what is the minimum number of links failing which will cause disruption of service to some users? Which links are they? (Note: Disruption of service really means that you have a disconnected topology!)
(c) [10 points] We are interested in finding the active topology (i.e., spanning tree) reached at steady state. This can be easily done by indicating the status of all ports.

Assume that steady state has reached. On the following figure, use the boxes provided next to each port to indicate whether the ports are designated port (DP), root port (RP), or blocked port (BP); use the small square box to indicate this. Also indicate the BPDU transmitted, if any, on each port in the rectangular boxes in the form `<Root> . <CostToRoot> . <TransmittingBridgeID> . <TransmittingPortID>`. Place a “dash” if no BPDU is transmitted on a port. Do not leave it blank. For example, an entry in the figure might appear as `DP 2.0.2.2`
(d) [10points] Now assume that the link connecting bridges 0 and 2 is physically cut resulting a failure. Repeat part (c) in this case. That is, fill in the boxes representing port states and BPDUs transmitted after a new steady state is achieved. Once again, place a “dash” if no BPDU is transmitted on a port.
For the rest of the problem, let \( t = 0 \) be the time at which link was cut. We assume that this failure has occurred immediately following the successful transmission of a BPDU by root bridge (bridge with ID 0) on that link.

**e)** [10points] Consider bridge with ID 3 at time \( t = 17 \). For each port, show in the figure below its state as well as the configuration message stored on that port along with its corresponding age.
(f) [10points] Consider bridge with ID 3 at time $t = 18.5$. For each port, show in the figure below its state as well as the configuration message stored on that port along with its corresponding age.