Homework 3 Suggested Solutions

Q1

Part a

How many fragments are generated?

Let the total transport-layer data to be sent be denoted by d
Let the max transport-layer data that can be sent in a single packet over this MTU be p_{max}

$$d = 1600 - 20 = 1580$$
$$p_{max} = 500 - 20 = 480$$
$$n_{fragments} = \left\lceil \frac{d}{p_{max}} \right\rceil = \left\lceil \frac{1580}{480} \right\rceil = 4$$

What are the values in the fragmentation fields?

Identification number, offset, and More Fragments (MF) flag.

Fragment	Identification Number	Offset (octets)	MF Flag
1	291	0	1
2		60	
3		120	
4		180	0

Part b

There are two possible interpretations to this question that results in slightly different answers for the offset. The first answer assumes that the receiver router immediately starts to forward the fragmented packets without reassembly; the second answer assumes the receiver router waits to reassemble all fragments before fragmenting again.

No reassembly

$$p_{max} = 300 - 20 = 280$$
$$n_{sub_{fragments}} = \left\lceil \frac{480}{280} \right\rceil * 3 + \left\lceil \frac{1580 - (180 * 8)}{280} \right\rceil = 6 + \left\lceil \frac{140}{240} \right\rceil = 7$$

Each fragment in part a gets fragmented again into two unequal fragments. The first sub fragment carries 280 bytes of transport layer data (35 octets), the second sub fragment carries $480 - 280 = 200$ bytes of transport layer data (25 octets). Fragment 4 from above is already smaller than the MTU (this can be calculated).

Fragment	Identification Number	Offset (octets)	MF Flag
1	291	0	1
2		35	
3		60	
4		95	
5		120	
6		155	
7		180	0

Question 2

Count the number of unique sequences of identifiers.

For every new packet that comes in, compare against a set of numbers containing previous identifier numbers. If there is a matching number that is difference of 1 (or more depending on tolerance), replace that number in the set. The length of the set is the number of hosts.

If the numbers are random then no information is available to guess the number of hosts.

Question 3

Note: $D(X), p(X)$ has been omitted for brevity

Step	S	Q	$D(U),$	$D(V), p(V)$	$D(W), p(W)$	$D(Y), p(Y)$	$D(Z), p(Z)$
0	$\emptyset$	$\{X, U, V, W, Y, Z\}$	∞	∞	∞	∞	∞
1	$\{X\}$	$\{U, Y, W, V, Z\}$	$1, X$	$6, X$	$5, X$	$4, X$	∞
2	$\{X, U\}$	$\{Y, W, V, Z\}$	$1, X$	$5, U$	$5, X$	$4, X$	$2, U$
3	$\{X, U, Z\}$	$\{Y, W, V\}$	$1, X$	$5, U$	$5, X$	$3, Z$	$2, U$
4	$\{X, U, Z, Y\}$	$\{W, V\}$	$1, X$	$5, U$	$4, Y$	$3, Z$	$2, U$
5	$\{X, U, Z, Y, W\}$	$\{V\}$	$1, X$	$5, U$	$4, Y$	$3, Z$	$2, U$
6	$\{X, U, Z, Y, W, V\}$	$\emptyset$	$1, X$	$5, U$	$4, Y$	$3, Z$	$2, U$

Question 4

Part a

Router Z	Informs W, $D_z(x) = \infty$	Z's current best route is already through W. If we learn of a route through a neighbor, we do not propagate said route back to the same neighbor.
	Informs Y, $D_z(x) = 6$	Z's current best route is through W with a cost of 5, and its own link cost to W is 1. Hence it informs Y of the best cost of 6.
Router W	Informs Y, $D_w(x) = \infty$	W's current best route is already through Y. If we learn of a route through a neighbor, we do not propagate said route back to the same neighbor.
	Informs Z, $D_w(x) = 5$	W's current best route is through Y with a cost of 4, and its own link cost to Y is 1. Hence it informs Z of the best cost of 5.
Router Y	Informs W, $D_y(x) = 4$	There are only two edges from X and Y has the best edge.
	Informs Z, $D_y(x) = 4$	

Part b

Yellow highlight indicates use of poisoned reverse. $\rightarrow Z$: means send message to Z. Added T4 for extra clarity.

<table>
<tr><th></th><th>T1</th><th>T2</th><th>T3</th><th>T4</th></tr>
<tr>
<td>Z</td>
<td><table><tr><td>Via</td><td>Cost</td></tr><tr><td>Y</td><td>7</td></tr><tr><td>W</td><td>6</td></tr></table></td>
<td>Receive poisoned reverse message.<table><tr><td>Via</td><td>Cost</td></tr><tr><td>Y</td><td>∞</td></tr><tr><td>W</td><td>6</td></tr></table></td>
<td>Receive update from W.<table><tr><td>Via</td><td>Cost</td></tr><tr><td>Y</td><td>∞</td></tr><tr><td>W</td><td>10</td></tr></table>Route to X via Y has been poisoned. Only can route through W.
$\rightarrow Y$:
$D_Z(x) = D_W(x) + c(z, w) = 10 + 1 = 11$

$\rightarrow W$:
$D_Z(x) = \infty$</td>
<td></td>
</tr>
<tr>
<td>W</td>
<td></td>
<td>Receive update from Y. Its current best route is through Y.
$\rightarrow Z$:
$D_W(x) = D_Y(x) + c(w, y) = 9 + 1 = 10$

$\rightarrow Y$:
$D_W(x) = \infty$</td>
<td></td>
<td>Receive poisoned reverse message.<table><tr><td>Via</td><td>Cost</td></tr><tr><td>Z</td><td>∞</td></tr><tr><td>Y</td><td>10</td></tr></table>Its best route is still through Y.</td>
</tr>
<tr>
<td>Y</td>
<td>Y detects link cost to X changes to 60.

$D_y(x) = \min(D_z(x) + c(y, z), c(y, x)) = \min(9, 60) = 9$

$\rightarrow W$:
$D_y(x) = 9$
$\rightarrow Z$:
$D_y(x) = \infty$

Its current best route is now through Z.</td>
<td></td>
<td>Receive poisoned reverse message.<table><tr><td>Via</td><td>Cost</td></tr><tr><td>Z</td><td>9</td></tr><tr><td>W</td><td>∞</td></tr><tr><td>Y</td><td>60</td></tr></table>Its best route is still through Z.</td>
<td>Receive update from Z.<table><tr><td>Via</td><td>Cost</td></tr><tr><td>Z</td><td>14</td></tr><tr><td>W</td><td>∞</td></tr><tr><td>Y</td><td>60</td></tr></table>Its best route is still through Z, but it has increased, so it needs to inform its neighbors.
$\rightarrow W$:
$D_y(x) = 14$
$\rightarrow Z$:
$D_y(x) = \infty$</td>
</tr>
</table>

Here we can see a routing loop start to form (the last events that happens is the bottom-rightmost corner of the table). Y's best route to X is through Z. Z's best route to X is through W. W's best route to X is through Y. This triangular route will continue to propagate until Z realizes that its 50-cost direct link to Z is better than through Y or W, at round 29.