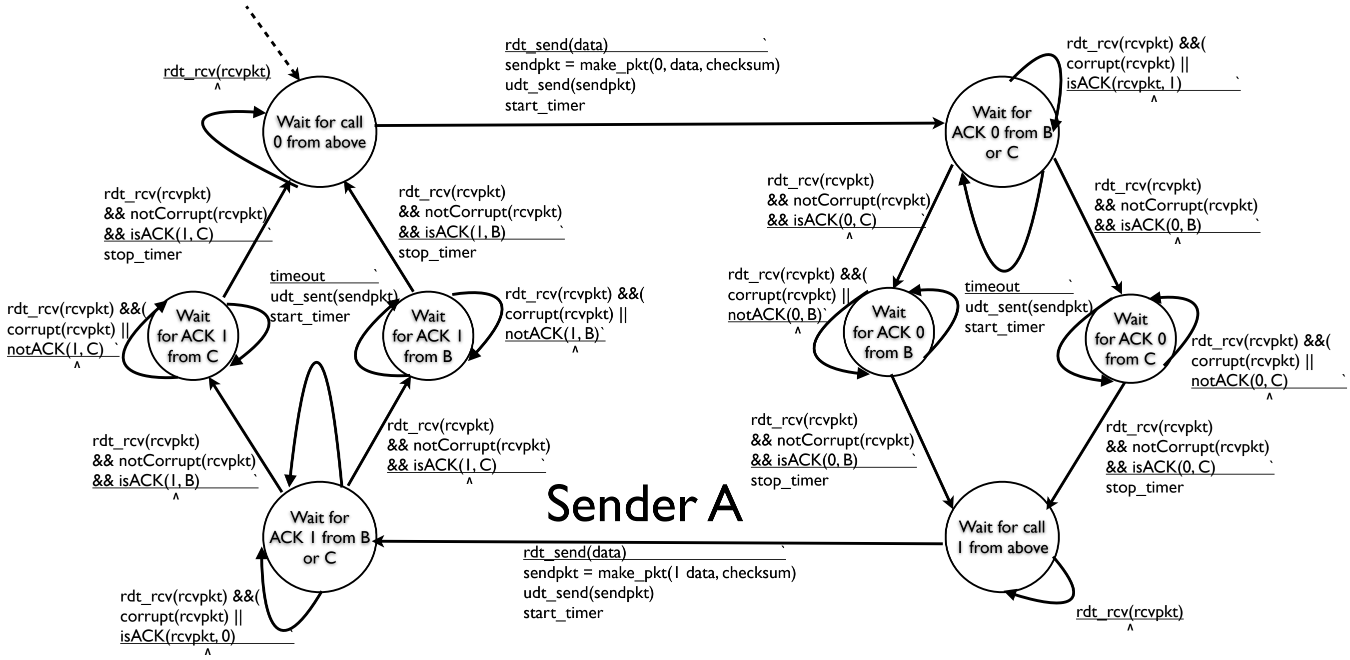
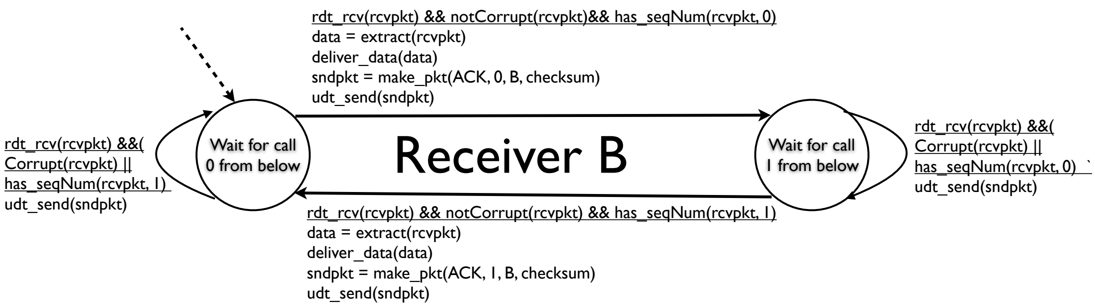
COMP431 Spring 2012 HW-6

Student Name: Duo Zhao PID: 720090360

1 Q1

The FSM of the Sender A and Receiver B (For C, C is equivalent and symmetric to B)



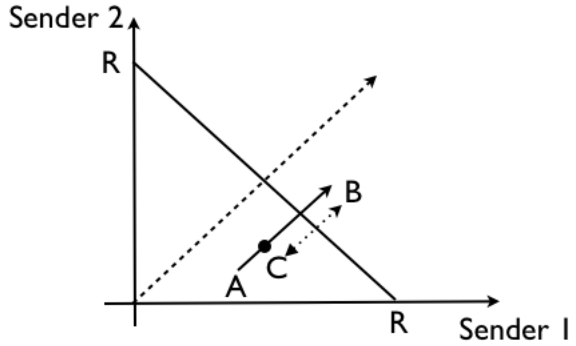


The FSM is a variation of rdt 3.0. The squence number of the sending package can still using the alternating bits (0 and 1). The major difference is that the sender must receive both ACKs from B and C before ready for listen to the next available package from its upper layer. Therefore, the "wait for ACK" state will become three separate states: wait for B or C, wait for B, wait for C, according to the order of the arrivals of ACKs. Each of the three states will ignore corrupted or out-of order ACKs. In addtion, ACKs from unanticipated receiver will also be discarded. Each of the three states waits for ACKs states will response to a time-out event, when the last made package is retransmitted.

The receiver side does not vary much from rdt 3.0 except that the package is supposed to include an identifier to distinguish sending from B or C.

2 Q2

The AIAD algorithm cannot guarantee the fairness between multiple senders. Consider the a simple case of two TCP connections sharing a single link with transmission rate R, as shown in the figure below. Make the same assumptions as the textbook "assume that the two connections have the same MSS and RTT, and therefore they have the same congestion window size and the same throughput, and they have a large amount of data to send, and that no other TCP connections or UDP datagrams traverse through this shared link. Also, ignore the slow-start phase of TCP and assume the TCP connections are operating in Congestion Avoidance mode at all times".



Suppose inititially the allocation point between the two links is at A. Since the bandwidth has not been fully utilized, with the equal MSS and RTT assumption, the two links will attempt to increase their window size almost at the same rate, and therefore, the allocation point will move along the 45 degree link towards the full bandwidth utilization line. At the first moment that the allocation point crosses the boundary line, according to the AIAD policy, each window size will be decrease by a constant. It means that the allocation point B will slide back to C along the same 45 degree line, and then moves towards the full utilization line, and so on to continue in an oscillatory way.

In this perspective, the trajectory will never deviate from the line AB, which is parallel to the equal bandwidth line. In conclusion, unless the initial allocation point resides on the equal bandwidth line, the bandwidth share will never be fair among senders.

3 Q3

3.1 a

The package total number of packages sent is from the window size of $w/2$ to w, since the window size is incremented by 1 each RTT. Therefore,

$$
\begin{aligned}
N_{sent} &= \frac{w}{2} + \left(\frac{w}{2} + 1\right) + \left(\frac{w}{2} + 2\right) + \cdots + w & (1)\\
&= \frac{1}{2}\left(w + \frac{w}{2}\right)\left(\frac{w}{2} + 1\right) & (2)\\
&= \frac{3}{8}w^2 + \frac{3}{4}w & (3)
\end{aligned}
$$

There the loss rate is given,

$$
L = \frac{1}{N_{sent}} = \frac{1}{\frac{3}{8}w^2 + \frac{3}{4}w} \tag{4}
$$

3.2 b

The data size of each window is MSS and each period contains the number of RTT equal to that from $\frac{w}{2}$ to w, therefore,

$$
\begin{aligned}
R &= \frac{MMS \cdot \left(\frac{w}{2} + \left(\frac{w}{2} + 1\right) + \left(\frac{w}{2} + 2\right) + \cdots + w\right)}{RTT \cdot \left(\frac{w}{2} + 1\right)} & (5)\\
&= \frac{3w}{4} \cdot \frac{MSS}{RTT} & (6)
\end{aligned}
$$

Given that $w^2 \gg w$,

$$
L \approx \frac{1}{\frac{3}{8}w^2} = \frac{8}{3w^2} \implies w = \sqrt{\frac{3}{8}}\frac{1}{\sqrt{L}} \tag{7}
$$

subtitute it back,

$$
R = \frac{3}{4}\sqrt{\frac{3}{8}}\frac{1}{\sqrt{L}} \approx \frac{1.22474 \cdot MSS}{RTT\sqrt{L}} \tag{8}
$$

4 Q4

for a) and b) the general formula of the response time for persistent HTTP connection is,

$$
\begin{aligned}
&T_{\text{persistent}}(RTT, R, BaseSize, ObjectSize) & (9)\\
&= RTT + \left(\frac{RTT}{2} + \frac{BaseSize}{R} + \frac{RTT}{2}\right) + M\left(\frac{RTT}{2} + \frac{ObjectSize}{R} + \frac{RTT}{2}\right) & (10)\\
&= (M+2)RTT + \frac{1}{R}\left(BaseSize + M \cdot ObjectSize\right) & (11)
\end{aligned}
$$

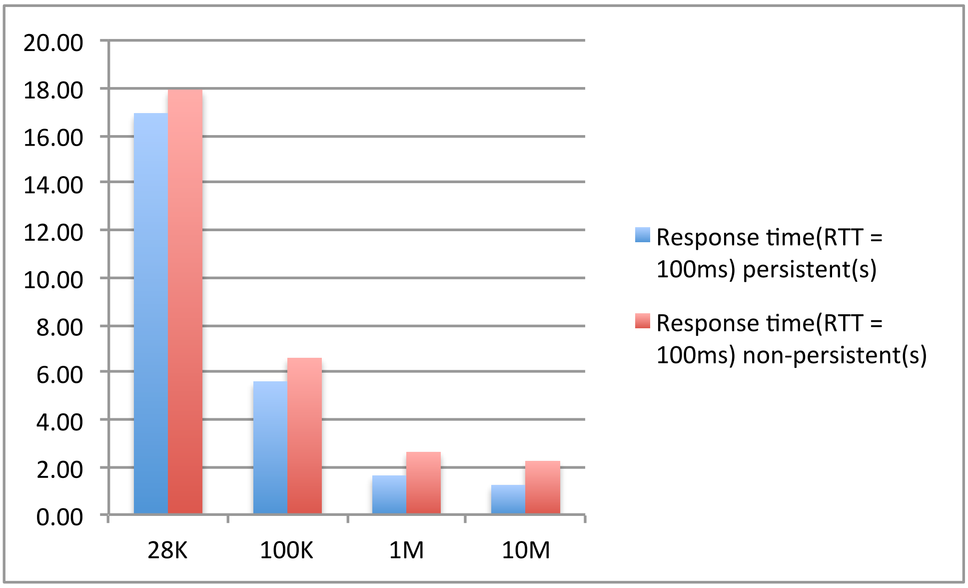
for non-persistent HTTP connection,

$$
\begin{aligned}
&T_{\text{non-persistent}}(RTT, R, BaseSize, ObjectSize) & (12)\\
&= \left(2RTT + \frac{BaseSize}{R}\right) + M \times \left(2RTT + \frac{ObjectSize}{R}\right) & (13)\\
&= 2(M+1)RTT + \frac{1}{R}\left(BaseSize + M \cdot ObjectSize\right) & (14)
\end{aligned}
$$

4.1 a

Resonse Time with RTT = 100 ms

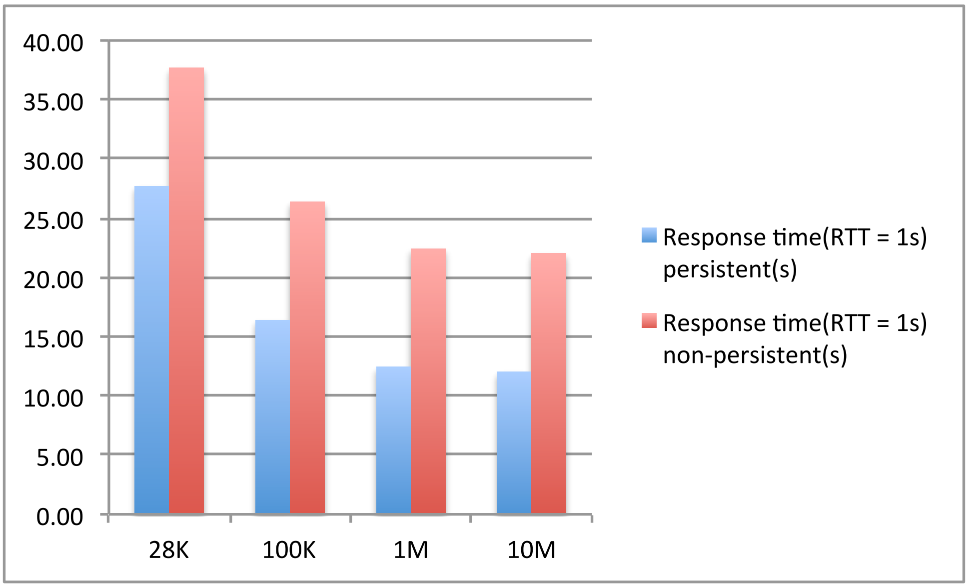
Bandwith	persistent(s)	non-persistent(s)
28K	16.91	17.91
100K	5.60	6.60
1M	1.64	2.64
10M	1.24	2.24



4.2 b

Response Time with RTT = 1 s

Bandwith	persistent(s)	non-persistent(s)
28K	27.71	37.71
100K	16.40	26.40
1M	12.44	22.44
10M	12.04	22.04



4.3 c

For fetching the base page (size=O)

$$T_1 = \frac{RTT}{2} \times 2 + \frac{O}{R} + \frac{RTT}{2} = 2RTT + \frac{O}{R} \tag{15}$$

For fecthing the objects, at each time point, up to x objects can be download simultaneously, when the downloading can be interleaving, and therefore there will $\frac{M}{x}$ sets of simultaneous connections, for each set, 2RTT will be added in addtion to nodal processing, therefore there will be

$$T_2 = \frac{M}{x} \times 2RTT + M \times \frac{O}{R} \tag{16}$$

Given the TCP SSL, the total time is

$$T = T_1 + T_2 + SSL \tag{17}$$

$$= (M+1)\frac{O}{R} + 2\left(\frac{M}{x} + 1\right) RTT + SSL \tag{18}$$

5 Q5

5.1 a

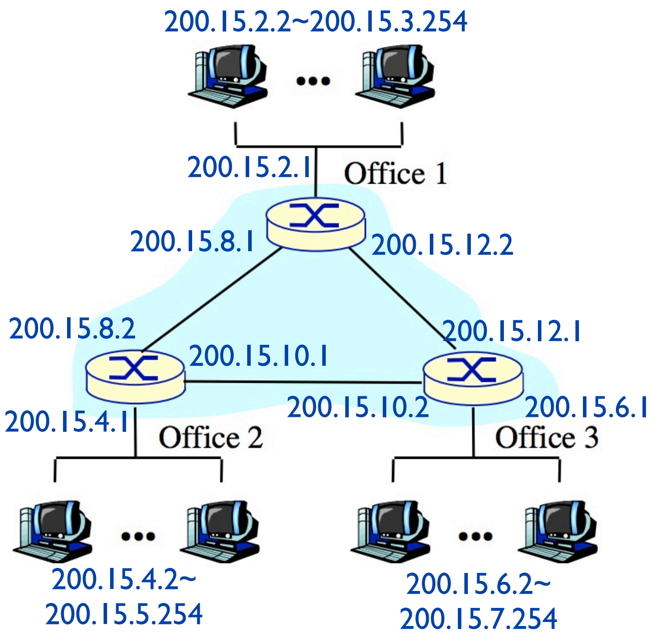
The binary-from IPv4 prefix that CIDR allocated is

$$200.15.0.0/20 \rightarrow 11001000.00001111.0000|0000.00000000 \tag{19}$$

Since there are six networks supposed to be designed, at least three bits ($2^3 = 8 > 6$) are needed to identify the six networks. The eight subset candidates are

$$200.15.0.0/23 \rightarrow 11001000.00001111.0000000|0.00000000 \tag{20}$$
$$200.15.2.0/23 \rightarrow 11001000.00001111.0000001|0.00000000 \tag{21}$$
$$200.15.4.0/23 \rightarrow 11001000.00001111.0000010|0.00000000 \tag{22}$$
$$200.15.6.0/23 \rightarrow 11001000.00001111.0000011|0.00000000 \tag{23}$$
$$200.15.8.0/23 \rightarrow 11001000.00001111.0000100|0.00000000 \tag{24}$$
$$200.15.10.0/23 \rightarrow 11001000.00001111.0000101|0.00000000 \tag{25}$$
$$200.15.12.0/23 \rightarrow 11001000.00001111.0000110|0.00000000 \tag{26}$$
$$200.15.14.0/23 \rightarrow 11001000.00001111.0000111|0.00000000 \tag{27}$$

One possible allocation is labeled in the following graph: (Here we're using the mid six ones and reserving the first/last one. It's valid to select any six distinct ones form the above eight subsets.)



For each of the three office locations, the total number capacity of hosts is

$$2^9 - 2 = 510 > 300 \tag{28}$$

5.2 b

Router in Office 1

Dest. Network	Next Router	Nhops	interface
200.15.2.0/23	-	1	200.15.2.1
200.15.4.0/23	200.15.8.2	2	200.15.8.1
200.15.6.0/23	200.15.12.1	2	200.15.12.2
200.15.8.0/23	-	1	200.15.12.1
200.15.10.1	200.15.8.2	2	200.15.8.1
200.15.10.2	200.15.12.1	2	200.15.12.2
200.15.12.0/23	-	1	200.15.12.2

Router in Office 2

Dest. Network	Next Router	Nhops	interface
200.15.2.0/23	200.15.8.1	2	200.15.8.2
200.15.4.0/23	-	1	200.15.4.1
200.15.6.0/23	200.15.10.2	2	200.15.10.1
200.15.8.0/23	-	1	200.15.8.2
200.15.10.0/23	-	1	200.15.10.1
200.15.12.1	200.15.10.2	2	200.15.10.1
200.15.12.2	200.15.8.1	2	200.15.8.2

Router in Office 3

Dest. Network	Next Router	Nhops	interface
200.15.2.0/23	200.15.12.2	2	200.15.12.1
200.15.4.0/23	200.15.10.1	2	200.15.10.2
200.15.6.0/23	-	1	200.15.6.1
200.15.8.1	200.15.12.2	2	200.15.12.1
200.15.8.2	200.15.10.1	2	200.15.10.2
200.15.10.0/23	-	1	200.15.10.2
200.15.12.0/23	-	1	200.15.12.1

5.3 c

A typical host in Office 1

Dest. Network	next router	Nhops
200.15.2.0/23	-	1
200.15.4.0/23	200.15.2.1	3
200.15.6.0/23	200.15.2.1	3
200.15.8.0/23	200.15.2.1	2
200.15.10.0/23	200.15.2.1	3
200.15.12.0/23	200.15.2.1	2
*(default)	200.15.2.1	*

A typical host in Office 2

Dest. Network	next router	Nhops
200.15.2.0/23	200.15.4.1	3
200.15.4.0/23	-	1
200.15.6.0/23	200.15.4.1	3
200.15.8.0/23	200.15.4.1	2
200.15.10.0/23	200.15.4.1	2
200.15.12.0/23	200.15.4.1	3
*(default)	200.15.4.1	*

A typical host in Office 3

Dest. Network	next router	Nhops
200.15.2.0/23	200.15.6.1	3
200.15.4.0/23	200.15.6.1	3
200.15.6.0/23	-	1
200.15.8.0/23	200.15.6.1	3
200.15.10.0/23	200.15.6.1	2
200.15.12.0/23	200.15.6.1	2
*(default)	200.15.6.1	*

6 Q6

Suppose each link cost is measured in time unit, then the message propagates as time unit steps. Let the time stamp for the original message is $t = 0$ for (1) Node C: $C \to D = \infty$ (2) Node D: $D \to C = \infty$.

6.1 a

The set of message that A received are

t	1	3	4	5	7
msg	$D \to C = \infty$	$C \to D = \infty$	$D \to C = \infty$	$C \to D = \infty, C \to D = \infty$	$D \to C = \infty$

6.2 b

The corresponding actions take by A:

t	Msg Received	Action
1	$D \to C = \infty$	update local data and forward
3	$C \to D = \infty$	update local data and forward
4	$D \to C = \infty$	ignore the message
5	$C \to D = \infty$	ignore the message
5	$C \to D = \infty$	ignore the message
7	$D \to C = \infty$	ignore the message

7 Q7

Let the topology of the network be a graph with finite nodes connected by finite undirectly-weighted edges.

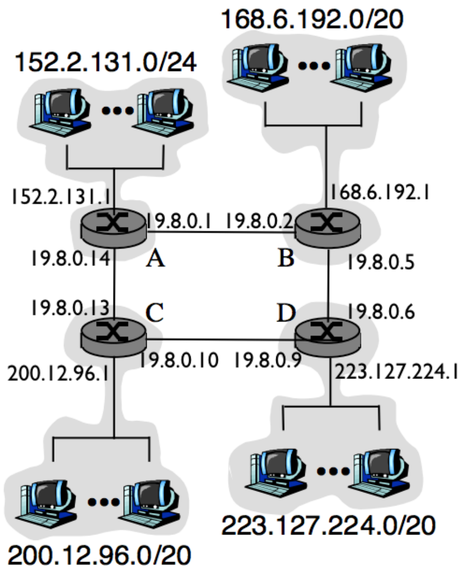
In the scenario of initially building the routing table, let L_{max_hops} be the longest possible path without a loop. The value obviously exists due the finite property of the graph. Measured in edge count without considering the edge weight, presumably $|L_{max\_hops}| <$ total number of edges. Since the question make the assumption of synchronous updates, suppose one period of iteration is each node delivers its distance vector to all its neighbours. Then after $|L_{max\_hops}| - 1$ iterations, all nodes will get the inforamtion the shortest path cost of up to $|L_{max\_hops}| - 1$ hops to all other nodes. Any path with $|L_{max\_hops}|$ more hops will result in loops, which is more costy than the loop-free path, therefore the algorithm will converge in at most $|L_{max\_hops}| - 1$ interations.

In the case of a link cost change, it may not guarantee the algorithm terminates in finite steps if some link cost increases to infinity (an edge breaks up). It's subject to the count-to-infinity problem, when the some distance will "converge to infinity" as the algorithm goes.

8 Q8

8.1 a

- Router A:
  - to B: 19.8.0.1/30
  - to C: 19.8.0.14/30
  - to intra: 152.2.131.1/24
- Router B:
  - to A: 19.8.0.2/30;
  - to D: 19.8.0.5/30;
  - to intra: 168.6.192.1/20
- Router C:
  - to A: 19.8.0.13/30;
  - to D: 19.8.0.10/30;
  - to intra: 200.12.96.1/20
- Router D:
  - to B: 19.8.0.6/30;
  - to C: 19.8.0.9/30;
  - to intra: 223.127.224.1/20



8.2 b

Router A

Dest. Network	Next Router	Nhops	interface
152.2.131.0/24	-	1	152.2.131.1
168.6.192.0/20	19.8.0.2	2	19.8.0.1
200.12.96.0/20	19.8.0.13	2	19.8.0.14
223.127.224.0/20	19.8.0.2	3	19.8.0.1
19.8.0.0/30	-	1	19.8.0.1
19.8.0.4/30	19.8.0.2	2	19.8.0.1
19.8.0.8/30	19.8.0.13	2	19.8.0.14
19.8.0.12/30	-	1	19.8.0.14

Router B

Dest. Network	Next Router	Nhops	interface
152.2.131.0/24	19.8.0.1	2	19.8.0.2
168.6.192.0/20	-	1	168.6.192.1
200.12.96.0/20	19.8.0.6	3	19.8.0.5
223.127.224.0/20	19.8.0.6	2	19.8.0.5
19.8.0.0/30	-	1	19.8.0.2
19.8.0.4/30	-	1	19.8.0.5
19.8.0.8/30	19.8.0.6	2	19.8.0.5
19.8.0.12/30	19.8.0.1	2	19.8.0.2

Router C

Dest. Network	Next Router	Nhops	interface
152.2.131.0/24	19.8.0.14	2	19.8.0.13
168.6.192.0/20	19.8.0.14	3	19.8.0.13
200.12.96.0/20	-	1	200.12.96.1
223.127.224.0/20	19.8.0.10	2	19.8.0.9
19.8.0.0/30	19.8.0.14	2	19.8.0.13
19.8.0.4/30	19.8.0.9	2	19.8.0.10
19.8.0.8/30	-	1	19.8.0.10
19.8.0.12/30	-	1	19.8.0.13

Router D

Dest. Network	Next Router	Nhops	interface
152.2.131.0/24	-	3	19.8.0.9
168.6.192.0/20	19.8.0.5	2	19.8.0.6
200.12.96.0/20	19.8.0.10	2	19.8.0.9
223.127.224.0/20	19.8.0.2	1	223.127.224.1
19.8.0.0/30	19.8.0.5	2	19.8.0.6
19.8.0.4/30	-	1	19.8.0.6
19.8.0.8/30	-	1	19.8.0.9
19.8.0.12/30	19.8.0.10	2	19.8.0.9

A Host in AS-A

Dest. Network	Next Router	Nhops
152.2.131.0/24	-	1
168.6.192.0/20	152.2.131.1	3
200.12.96.0/20	152.2.131.1	3
223.127.224.0/20	152.2.131.1	4
19.8.0.0/30	152.2.131.1	2
19.8.0.4/30	152.2.131.1	3
19.8.0.8/30	152.2.131.1	3
19.8.0.12/30	152.2.131.1	2
(*default)	152.2.131.1	*

A Host in AS-B

Dest. Network	Next Router	Nhops
152.2.131.0/24	168.6.192.1	3
168.6.192.0/20	-	1
200.12.96.0/20	168.6.192.1	4
223.127.224.0/20	168.6.192.1	3
19.8.0.0/30	168.6.192.1	2
19.8.0.4/30	168.6.192.1	2
19.8.0.8/30	168.6.192.1	3
19.8.0.12/30	168.6.192.1	3
(*default)	168.6.192.1	*

A Host in AS-C

Dest. Network	Next Router	Nhops
152.2.131.0/24	200.12.96.1	3
168.6.192.0/20	200.12.96.1	4
200.12.96.0/20	-	1
223.127.224.0/20	200.12.96.1	3
19.8.0.0/30	200.12.96.1	3
19.8.0.4/30	200.12.96.1	3
19.8.0.8/30	200.12.96.1	2
19.8.0.12/30	200.12.96.1	2
(*default)	200.12.96.1	*

A Host in AS-D

Dest. Network	Next Router	Nhops
152.2.131.0/24	223.127.224.1	4
168.6.192.0/20	223.127.224.1	3
200.12.96.0/20	223.127.224.1	3
223.127.224.0/20	-	1
19.8.0.0/30	223.127.224.1	3
19.8.0.4/30	223.127.224.1	2
19.8.0.8/30	223.127.224.1	2
19.8.0.12/30	223.127.224.1	3
(*default)	223.127.224.1	*

8.3 c

Suppose the four autonomous systems connected with the router A, B, C, D are labeled as AS-A(152.2.131.0/24), AS-B(168.6.192.0/20), AS-C(200.12.96.0/20), AS-D(223.127.224.0/20), respectively. Also the inter-router subnets are AB(19.8.0.0/30), BD(19.8.0.4/30), CD(19.8.0.8/30), AC(19.8.0.12/30). In the BGP session, it follows the following principle.

B advertises to D that it has no path to any other destination except for AS-B along with four inter-router networks. i.e. B will send to D an advertisement with entries - (prefix: 168.9.192.0/20; AS-PATH: AS-B; NEXT-HOP: 19.8.0.5), along with the inter-router netwroks AB, BD, CD, AC, which suggests to D is a gateway router only connected to a stub network (AS-B) and the four inter-router networks.

In a symmetric sense, D advertises to B that it has no path to a destination other than AS-D. i.e. B will send to D an advertisement with entries (prefix: 223.127.224.4/20; AS-PATH: AS-D; NEXT-HOP: 19.8.0.6), along with the four inter-router networks(AB, BD, CD, AC). Therefore, provided the information from D, B could infer router D only connects an stub network AS-D as well as inter-router networks. When B forwards datagram to A or C, it won't select D as a next-hop candidate, since it has no knowledge that AS-A or AS-C is reachable via D according to D's advertisement.