The Network Layer

Computer Networking, A Top-Down Approach, 5th Edition

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End-of-chapter exercises

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Questions:

In the text we have used the term connection-oriented service to describe a transport-layer service and connection service for a network-layer service. Why the subtle shades in terminology?

Answer:

The subtle difference in terminology reflects the distinct roles and responsibilities of the transport and network layers:

- **Connection-oriented service (Transport Layer):**
  At the transport layer, a connection-oriented service (such as TCP) establishes, maintains, and terminates a logical end-to-end connection. This connection is defined **between two processes** on the end hosts (e.g., two TCP sockets). This service ensures reliable, ordered, and error-checked delivery of data across the entire network path, directly between the communicating applications.
- **Connection service (Network Layer):**
  At the network layer, a connection service (such as a virtual circuit) refers to the establishment of a logical path through the network, typically between routers or switches. This connection is defined **between two hosts** (and their intervening routers in the case of virtual-circuit networks). This path helps guide packets from source to destination but does not necessarily guarantee reliability or ordering. The focus here is on the route and forwarding of packets within the network infrastructure.

In summary:
The term “connection-oriented service” at the transport layer emphasizes end-to-end reliability and communication, while “connection service” at the network layer highlights the setup of a path through the network, without necessarily providing full end-to-end guarantees. The nuanced terminology helps clarify the different scopes and guarantees provided by each layer.

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Consider a datagram network using 32-bit host addresses. Suppose a router has four links, numbered 0 through 3, and packets are to be forwarded to the link interfaces as follows:

Destination Address Range	Link Interface
	0
	1
	2
	3

Questions and Answers:

a. Provide a forwarding table that has four entries, uses longest prefix matching, and forwards packets to the correct link interfaces.

Header	Link Interface(output)
11100000 00	0
11100000 01000000	1
1110000	2
otherwise	3

Explanation:
- Each entry uses the longest prefix that matches the given address range. - The router checks the destination address against each prefix, starting from the longest, and forwards the packet to the corresponding interface.

b. Describe how your forwarding table determines the appropriate link interface for datagrams with destination addresses:

11001000 10010001 01010001 01010101

11100001 01000000 11000011 00111100

11100001 10000000 00010001 01110111

1. **11001000 10010001 01010001 01010101**

- This address does **not** match any of the specified prefixes (does not start with 111⋯), so it is forwarded to **interface 3**.

2. **11100001 01000000 11000011 00111100**

   - This address matches the third entry:
     - Prefix: `1110000`
     - So, it is forwarded to **interface 2**.

3. **11100001 10000000 00010001 01110111**

   - This address matches the third entry:
     - Prefix: `1110000`
     - So, it is forwarded to **interface 2**.

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Consider a datagram network using 8-bit host addresses. Suppose a router uses longest-prefix matching and has the following forwarding table:

Prefix Match	Interface
00	0
010	1
011	2
10	2
11	3

Question and Answer:

For each of the four interfaces, give the associated range of destination host addresses and the number of addresses in the range.

Interface	Destination Address Range	Number of Addresses
0	00000000 - 00111111	64
1	01000000 - 01011111	32
2	01100000 - 0111111110000000 - 10111111	96
3	11000000 - 11111111	64

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Question and Answer:

Consider sending a 2400-byte datagram into a link that has an MTU of 700 bytes. Suppose the original datagram is stamped with the identification number 422. How many fragments are generated? What are the values in the various fields in the IP datagram(s) generated related to fragmentation?

According to IPv4 datagram format, each fragment includes a 20-bytes header.

先计算数据大小 $d = \lfloor \frac{700-20}{8} \rfloor \times 8 = 680$ bytes。

所以需要分成 $n = \lceil \frac{2400-20}{d} \rceil = 4$

主要变化在 `Offset` 和 `Flag`，所以：

Fragment	Datagram length	Offset	Flag
1	700	0	001
2	700	85	001
3	700	170	001
4	360	255	000

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Question and Answer:

Suppose datagrams are limited to 1,500 bytes (including header) between source Host A and destination Host B. Assuming a 20-byte IP header, how many datagrams would be required to send an MP3 consisting of 5 million bytes? Explain how you computed your answer.

MTU 为 1500 bytes，一个 datagram 的 data 大小为 $d = \lfloor \frac{1500-20}{8} \rfloor \times 8 = 1480$ bytes。

最终，datagram 的数目为 $n = \lceil \frac{5 \times 10^6}{d} \rceil = 3379$ 个。

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Consider the network setup in Figure 4.22. Suppose that the ISP instead assigns the router the address 24.34.112.235 and that the network address of the home network is 192.168.1/24.

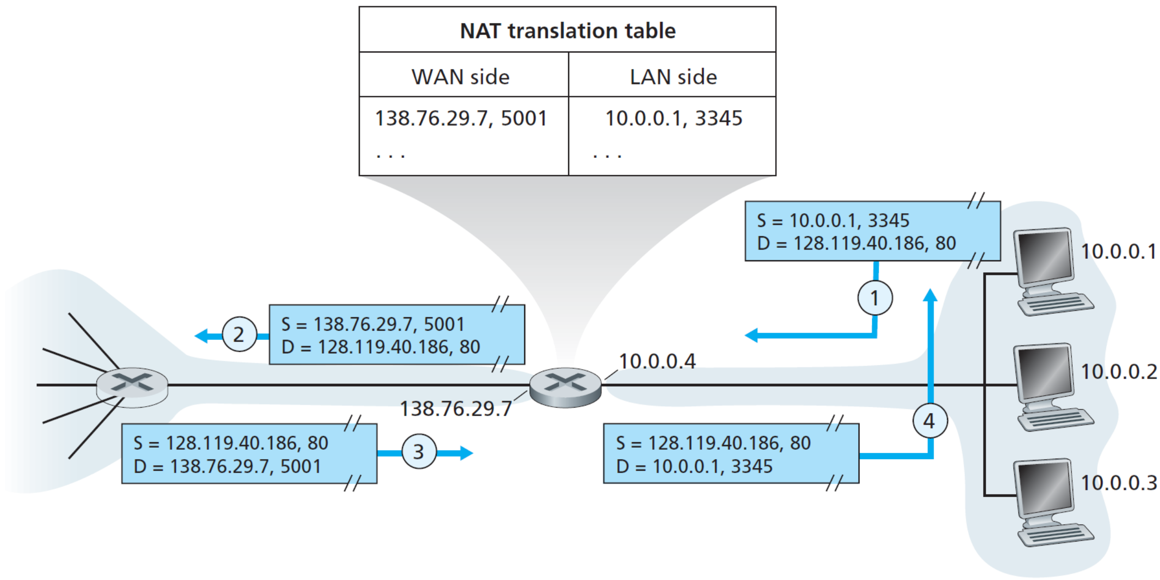

Figure 1: Network address translation

Questions and Answers:

a. Assign addresses to all interfaces in the home network.

也即是说，中间的 router WAN 的 IP address 是 `24.34.112.235`，LAN 的是 `192.168.1/24`，不妨和原图一样，设为 `192.168.1.4`。则右边的三个 host 的 LAN IP address 分别为：

- Host 1 address is 192.168.1.1

- Host 2 address is 192.168.1.2
- Host 3 address is 192.168.1.3

b. Suppose each host has two ongoing TCP connections, all to port 80 at host 128.119.40.86. Provide the six corresponding entries in the NAT translation table.

总共有 6 个 TCP connection，随便分几个端口号：

WAN side	LAN side
24.34.112.235, 50001	192.168.1.1, 3345
24.34.112.235, 50002	192.168.1.1, 3346
24.34.112.235, 50003	192.168.1.2, 3345
24.34.112.235, 50004	192.168.1.2, 3346
24.34.112.235, 50005	192.168.1.3, 3345
24.34.112.235, 50006	192.168.1.3, 3346

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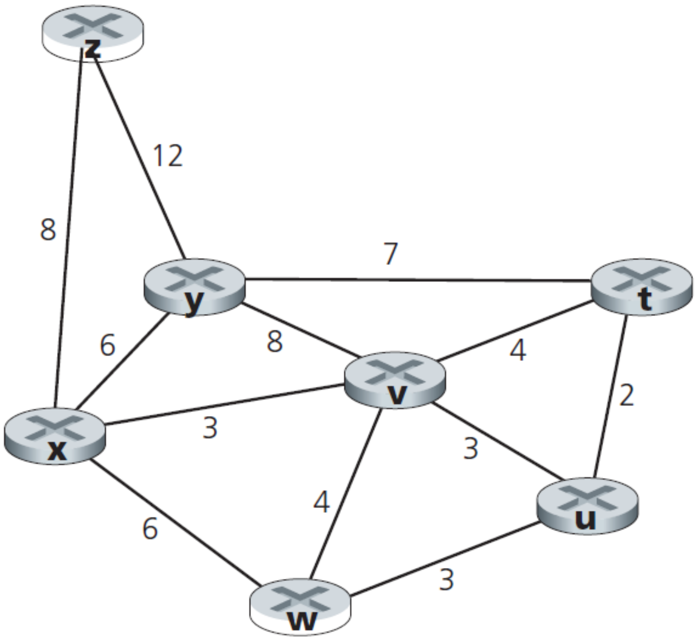

Figure 2: Graph P.24

Question:

Consider the following network. With the indicated link costs, use Dijkstra’s shortest-path algorithm to compute the shortest path from x to all network nodes. Show how the algorithm works by computing a table similar to Table 4.3.

Answer:

$N' = \{x\}$

step	$D(x)$ $P(x)$	$D(y)$ $P(y)$	$D(z)$ $P(z)$	$D(v)$ $P(v)$	$D(u)$ $P(u)$	$D(w)$ $P(w)$	$D(t)$ $P(t)$	N'
0	$0\ x$	$6\ x$	$8\ x$	$3\ x$	∞	$6\ x$	∞	x
1	$0\ x$	$6\ x$	$8\ x$	$3\ x$	$6\ v$	$6\ x$	$7\ v$	xv
2	$0\ x$	$6\ x$	$8\ x$	$3\ x$	$6\ v$	$6\ x$	$7\ v$	xvy

step	$D(x)$ $P(x)$	$D(y)$ $P(y)$	$D(z)$ $P(z)$	$D(v)$ $P(v)$	$D(u)$ $P(u)$	$D(w)$ $P(w)$	$D(t)$ $P(t)$	N'
3	$0\ x$	$6\ x$	$8\ x$	$3\ x$	$6\ v$	$6\ x$	$7\ v$	$xvyu$
4	$0\ x$	$6\ x$	$8\ x$	$3\ x$	$6\ v$	$6\ x$	$7\ v$	$xvyuw$
5	$0\ x$	$6\ x$	$8\ x$	$3\ x$	$6\ v$	$6\ x$	$7\ v$	$xvyuwt$
6	$0\ x$	$6\ x$	$8\ x$	$3\ x$	$6\ v$	$6\ x$	$7\ v$	$xvyuwtz$

So the shortest path from x to all nodes is follow.

Destination	Shortest Distance	Path
x	0	x
v	3	$x \to v$
y	6	$x \to y$
w	6	$x \to w$
u	6	$x \to v \to u$
t	7	$x \to v \to t$
z	8	$x \to z$

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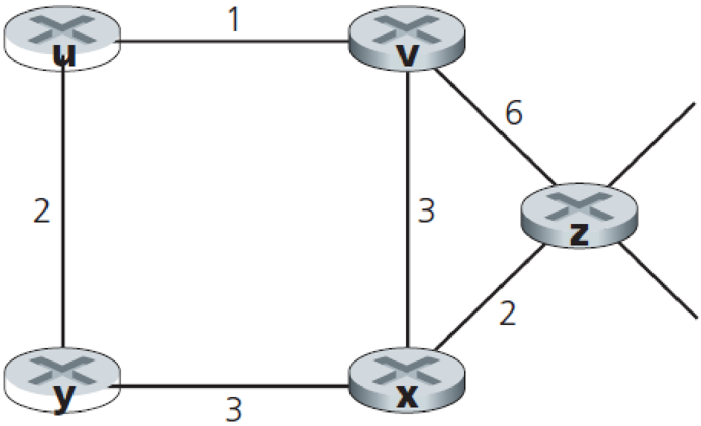

Figure 3: Graph P.26

Question:

Consider the network shown below, and assume that each node initially knows the costs to each of its neighbors. Consider the distance-vector algorithm and show the distance table entries at node z.

Answer:

Node z table:

First round

	cost to				
	x	y	z	u	v
from x	∞	∞	∞	∞	∞
from y	∞	∞	∞	∞	∞
from z	2	∞	0	∞	6
from u	∞	∞	∞	∞	∞

cost to					
from v	∞	∞	∞	∞	∞

Second round

cost to					
	x	y	z	u	v
from x	2	3	∞	∞	3
from y	3	∞	∞	2	∞
from z	2	5	0	7	5
from u	∞	2	∞	∞	2
from v	3	∞	6	1	∞

Because the question only asks to show the distance table entries at node z, we do not need to compute the full routing tables for all nodes. The Second round result about node z is also the finial result. 到这一步 from z to other 的 cost 表就收敛了，题目也只问了 node z。