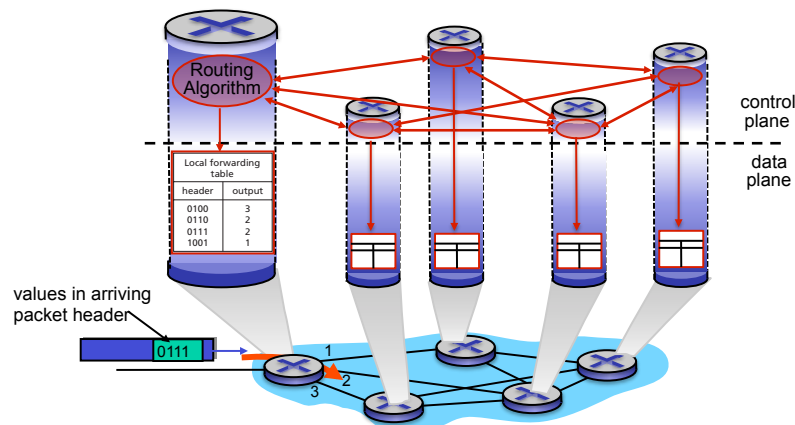


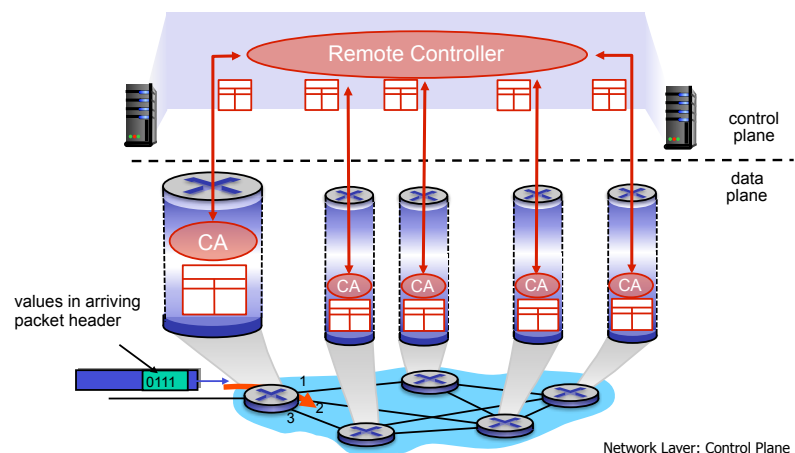
Network Layer (I)

Network-layer Functions, Data Plane and Control Plane

- **Forwarding:**
 - Task of the **data plane**
 - Data plane: **move** packets **from router's input to** appropriate router **output**
- **Routing:**
 - Task of the **control plane**
 - Control plane: **determine route** taken by packets from source to destination
- *Two approaches* to structuring network control plane:
 - **per-router control** (traditional)
 - Individual routing algorithm components in **each and every router** interact in the control plane



- **logically centralized control** (software defined networking)
 - A distinct (typically remote) controller interacts with local control agents (CAs)
 - The routing path is computed by the remote controller



Network Layer General Functions

- Addressing: IP address
 - Error control: rerouting, ICMP (Internet Control Message Protocol)
 - QoS: TOS (Type of Service) field and Differentiated Services
-

ICMP

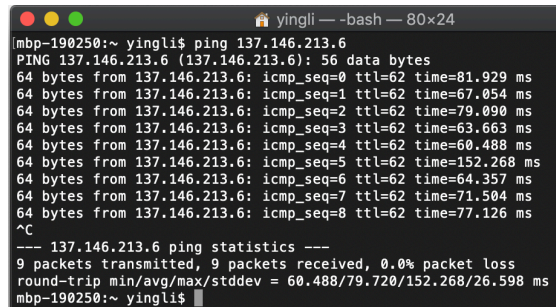
- Internet Control Message Protocol

- used by hosts & routers to communicate network-level information
- typically used for diagnostic/control purpose/generated in response to errors in IP
- Runs on top of IP but still within the network layer
- **Examples:**
 - ping (**Echo Request/Reply**)
 - uses ICMP to send requests to the destination and replies to the source
 - traceroute (**Time-to-live Exceeded, Destination Unreachable**)
 - every node on the path sends three responses to measure the RTT using ICMP or to tell the destination is unreachable.
 - "TTL is 0" (**Packet Drop**)
 - a router uses ICMP packet to indicate the source of a packet that the lifetime exceeded and the packet is dropped.
- ICMP messages use its **type** and **code** fields to specify its purposes. These values are well defined in the protocol. The list below shows a subset of the values as an example.

<u>Type</u>	<u>Code</u>	<u>description</u>
0	0	echo reply (ping)
3	0	dest. network unreachable
3	1	dest host unreachable
3	2	dest protocol unreachable
3	3	dest port unreachable
3	6	dest network unknown
3	7	dest host unknown
4	0	source quench (congestion control - not used)
8	0	echo request (ping)
9	0	route advertisement
10	0	router discovery
11	0	TTL expired
12	0	bad IP header

Ping

- ping 137.146.213.6 and open Wireshark filter on ip.src == 137.146.103.160 && icmp

A terminal window titled 'yingli -bash - 80x24' showing the output of a ping command. The user has entered 'ping 137.146.213.6'. The output shows 9 successful pings with varying round-trip times (RTT) ranging from approximately 60.488 ms to 152.268 ms. The user has pressed Ctrl-C to stop the command. The terminal then displays ping statistics: 9 packets transmitted, 9 packets received, 0.0% packet loss, and round-trip statistics: min/avg/max/stddev = 60.488/79.720/152.268/26.598 ms.

```
mbp-190250:~ yingli$ ping 137.146.213.6
PING 137.146.213.6 (137.146.213.6): 56 data bytes
64 bytes from 137.146.213.6: icmp_seq=0 ttl=62 time=81.929 ms
64 bytes from 137.146.213.6: icmp_seq=1 ttl=62 time=67.054 ms
64 bytes from 137.146.213.6: icmp_seq=2 ttl=62 time=79.090 ms
64 bytes from 137.146.213.6: icmp_seq=3 ttl=62 time=63.663 ms
64 bytes from 137.146.213.6: icmp_seq=4 ttl=62 time=60.488 ms
64 bytes from 137.146.213.6: icmp_seq=5 ttl=62 time=152.268 ms
64 bytes from 137.146.213.6: icmp_seq=6 ttl=62 time=64.357 ms
64 bytes from 137.146.213.6: icmp_seq=7 ttl=62 time=71.504 ms
64 bytes from 137.146.213.6: icmp_seq=8 ttl=62 time=77.126 ms
^C
--- 137.146.213.6 ping statistics ---
9 packets transmitted, 9 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 60.488/79.720/152.268/26.598 ms
mbp-190250:~ yingli$
```

- ping is a network tool to check the status of the network
- It uses ICMP and the client-server model
- The client sends an ICMP request (type 0 code 0), and the server sends an ICMP response (type 8 code 0) back to the client after receiving the request.
- The ping program calculates the RRT for each ping packet based on the request and response messages
- After ctrl-c, the ping program calculates the statistics based on the RTT of all ping packets
- Then, we can use the statistics to tell the status of the network. (packet loss and RRT).

Disclaimer: Notes adapted from the textbook and online resources.