1 Network Layer

1.1 Data Plane

- local, per-router function
- determines how datagram arriving on router input port is forwarded to router output port
- forwarding function

1.2 Control Plane

- network-wide logic
- determines how datagram is routed among routers along end-end path from source host to destination host

2 Inside a Router

2.1 Routing Processor

performs control and management plane functions

- maintains routing table
- attaches link state information to routing table
- computes forwarding table
- in SDN, it is also responsible for the communication and event handling with the 'controller'
- performs network management functions (e.g. packet counting stats, etc.)

2.2 Input port functions

Line termination - physical layer functions = bit-level reception Link Layer Protocol - Data link layer functions = ethernet interoperation Lookup, forwarding, queueing - decentralized switching = lookup functions

2.3 How much to buffer?

$B = RTT * C$

RTT - round trip time (e.g. 250 ms)
C - Link Capacity (e.g. 10 Gbps)
New eq: $B = \frac{RTT * C}{\sqrt{N}}$
N - # of flows

3 Internet Protocol

3.1 Why does IP have a checksum?

1. IP does not have to run over TCP/UDP
2. TCP/UDP checksum entire package, IP only header
3. Note that checksum has to be recomputed at every router since the TTL changes

3.2 IPv4 Addressing

IP Address: 32-bit identifier for host, router interface
Interface: connection between host/router and physical link

- router's typically have multiple interfaces
- host typically has one or two interfaces (wired Ethernet, wireless 802.11)

CIDR - Classless InterDomain Routing

- subnet portion of address of arbitrary length
- address format: a.b.c.d/x where x is the # of bits in the subnet portion of the address

4 Generalized Forward and SDN