

Lecture 17: Router Design

CSE 123: Computer Networks
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Lecture 17 Overview



- BGP relationships
- Router internals
 - ◆ Buffering
 - ◆ Scheduling



Espresso Prize



Business Relationships



- Neighboring ASes have business contracts
 - ◆ How much traffic to carry
 - ◆ Which destinations to reach
 - ◆ How much money to pay
- Common business relationships
 - ◆ Customer-provider
 - » E.g., Princeton is a customer of USLEC
 - » E.g., MIT is a customer of Level3
 - ◆ Peer-peer
 - » E.g., UUNET is a peer of Sprint
 - » E.g., Harvard is a peer of Harvard Business School

A History of Settlement



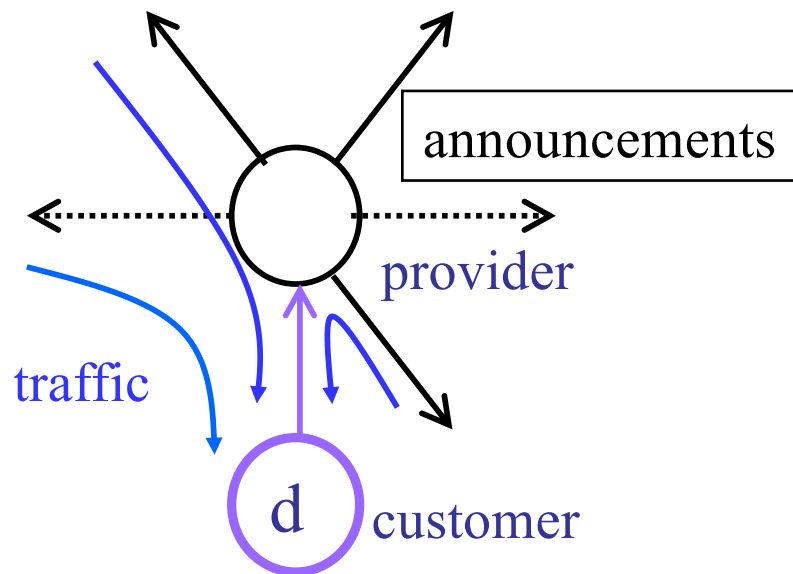
- The telephone world
 - ◆ LECs (local exchange carriers) (e.g., PacBell, NYNEX)
 - ◆ IXC (inter-exchange carriers) (e.g., Sprint, AT&T)
- LECs MUST provide IXCs access to customers
 - ◆ This is enforced by laws and regulation
- When a call goes from one phone company to another:
 - ◆ Call billed to the caller
 - ◆ The money is split up among the phone systems – this is called “settlement”



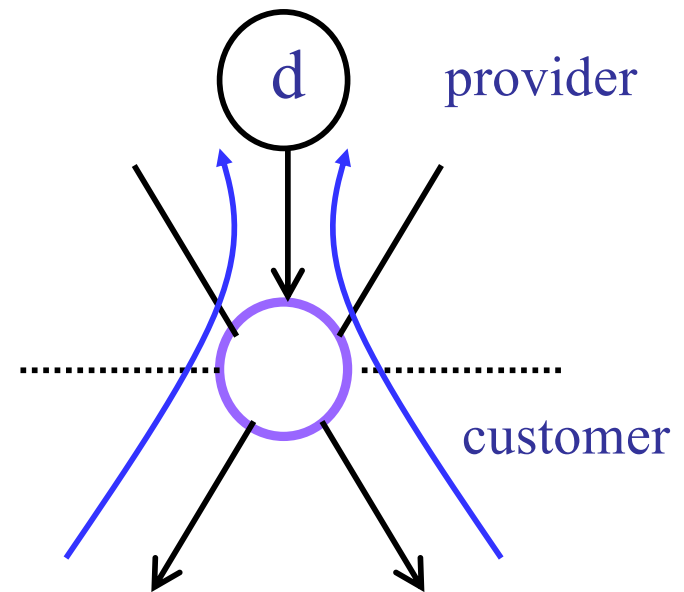
Customer/Provider

- Customer needs to be reachable from everyone
 - ◆ Provider tells all neighbors how to reach the customer
- Customer does not want to provide transit service
 - ◆ Customer does not let its providers route through it

Traffic **to** the customer



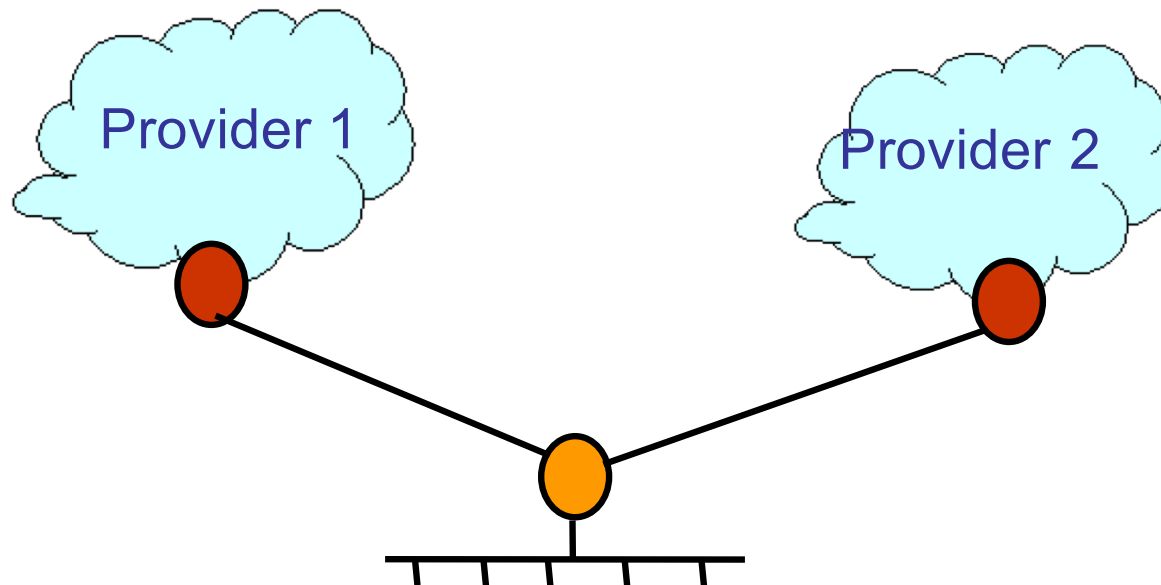
Traffic **from** the customer



Multi-Homing



- Customers may have more than one provider
 - ◆ Extra reliability, survive single ISP failure
 - ◆ Financial leverage through competition
 - ◆ Better performance by selecting better path
 - ◆ Gaming the 95th-percentile billing model

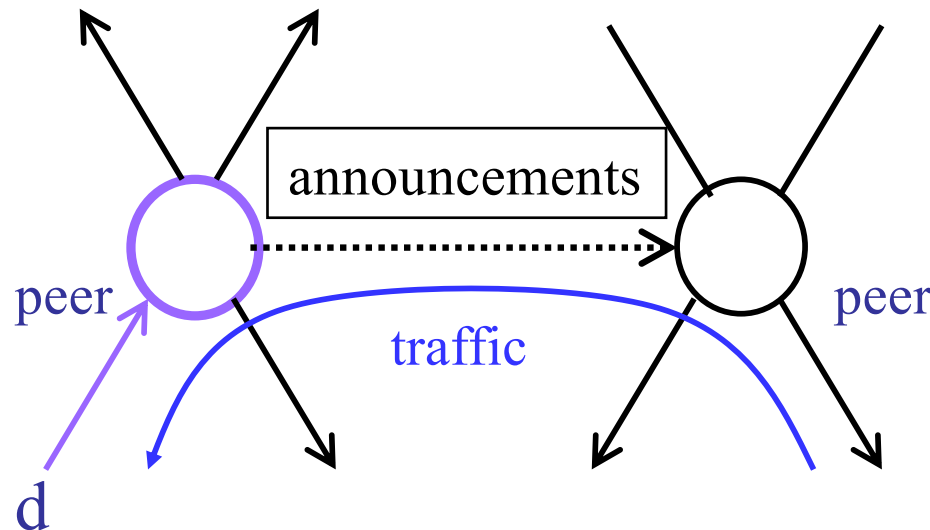


Peer-to-Peer Relationship



- Peers exchange traffic between customers
 - ◆ AS exports *only* customer routes to a peer
 - ◆ AS exports a peer's routes *only* to its customers
 - ◆ Often the relationship is settlement-free (i.e., no \$\$\$)

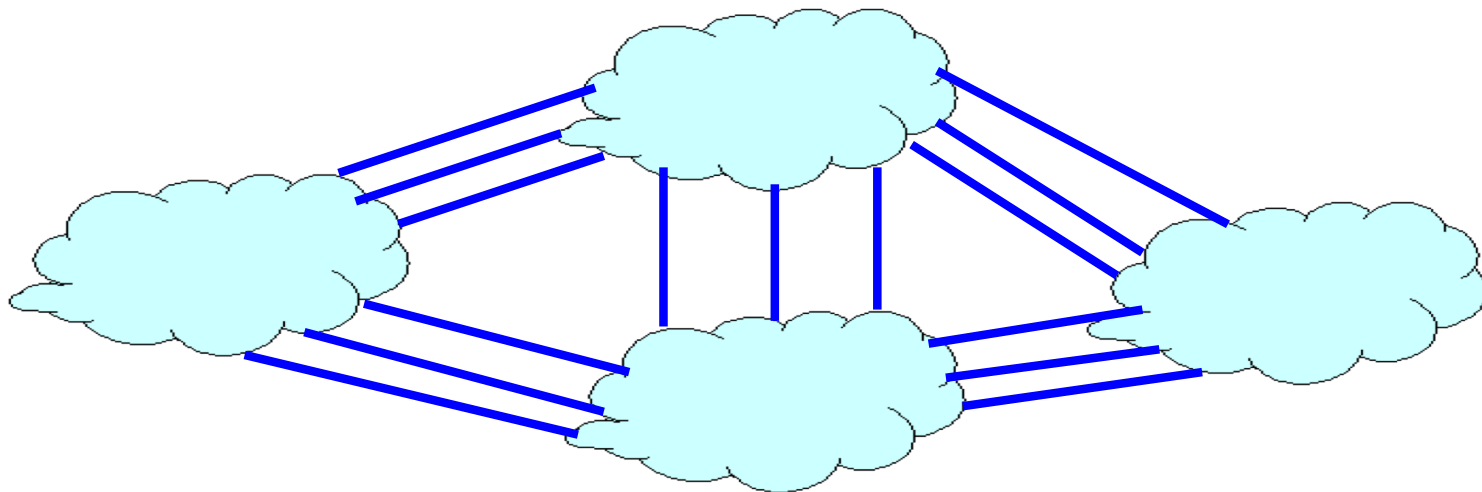
Traffic to/from the peer and its customers



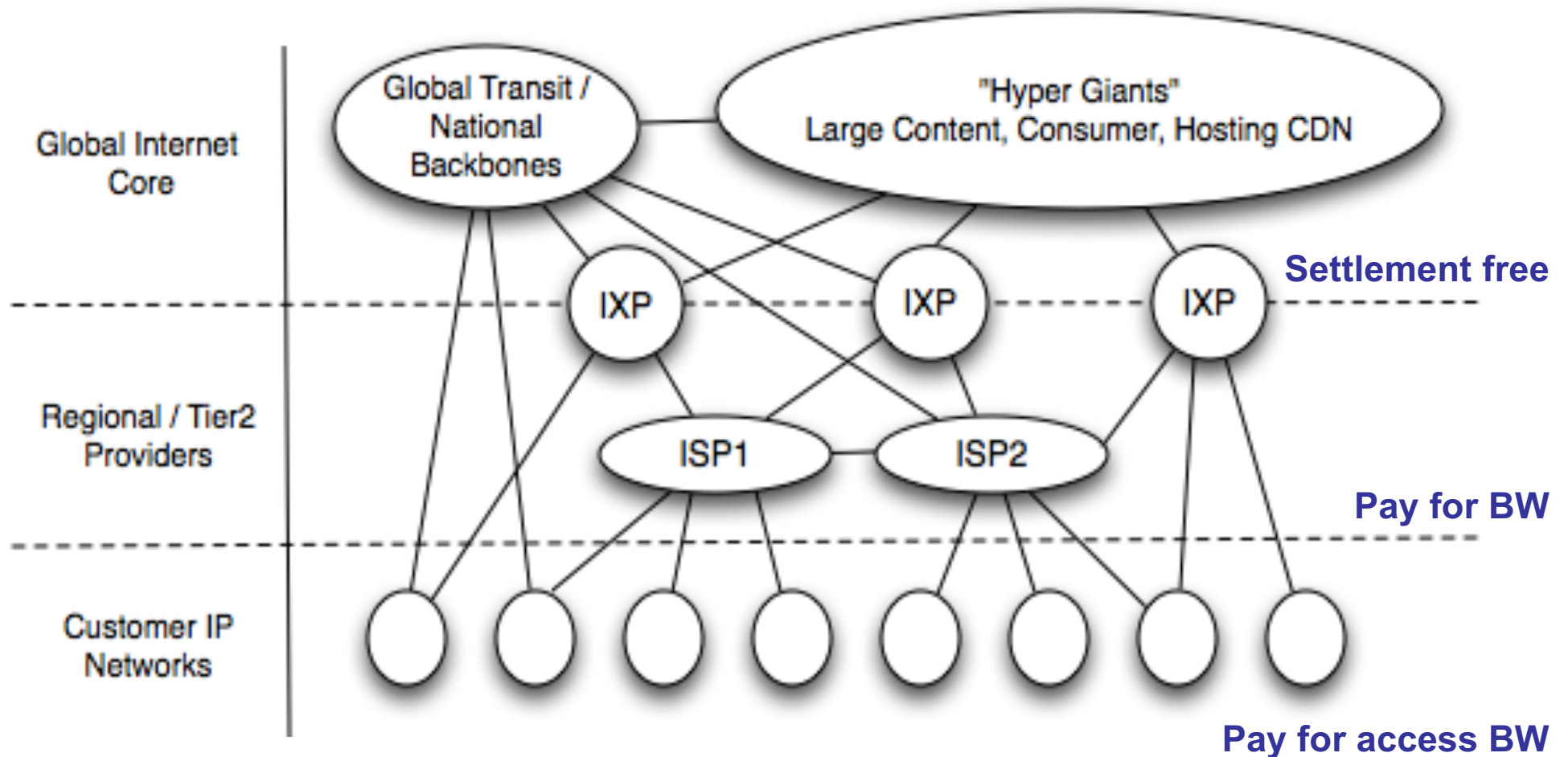


Tier-1 Providers

- Make up the “core” of the Internet
 - ◆ Has no upstream provider of its own
 - ◆ Typically has a national or international backbone
- Top of the Internet hierarchy of ~10-20 ASes
 - ◆ E.g., AT&T, Level 3 (Global Crossing), NTT/Verio, Century Link (formerly Qwest), Sprint, Verizon
 - ◆ Full peer-peer connections between tier-1 providers



The Internet Hierarchy



BGP Summary



- Interdomain-routing
 - ◆ Exchange reachability information (plus hints)
 - ◆ BGP is based on path vector routing
 - ◆ Local policy to decide which path to follow
- Traffic exchange policies are a big issue \$\$\$
 - ◆ Complicated by lack of compelling economic model (who creates value?)
 - ◆ Can have significant impact on performance



What's in a Router?

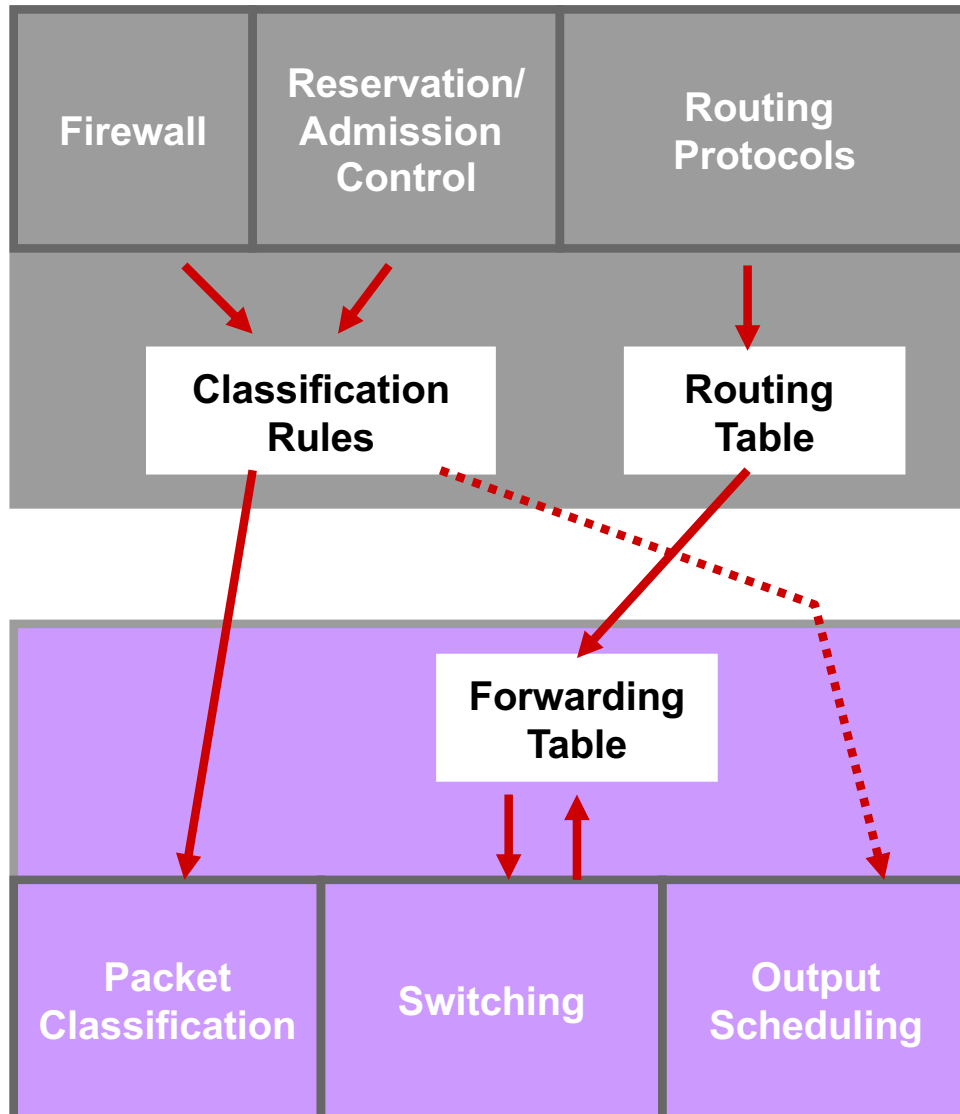
- Physical components
 - ◆ One or more **input interfaces** that receive packets
 - ◆ One or more **output interfaces** that transmit packets
 - ◆ A chassis (box + power) to hold it all
- Functions
 - ◆ **Forward** packets
 - ◆ **Drop** packets (congestion, security, QoS)
 - ◆ **Delay** packets (QoS)
 - ◆ **Transform** packets? (Encapsulation, Tunneling)

Router Functions



1. Receive incoming packet from link input interface
2. Lookup packet destination in forwarding table
(destination, output port(s))
3. Validate checksum, decrement ttl, update checksum
4. Buffer packet in input queue
5. Send packet to output interface (interfaces?)
6. Buffer packet in output queue
7. Send packet to output interface link

Functional architecture



Control Plane

- Complex
- Per-control action
- May be slow

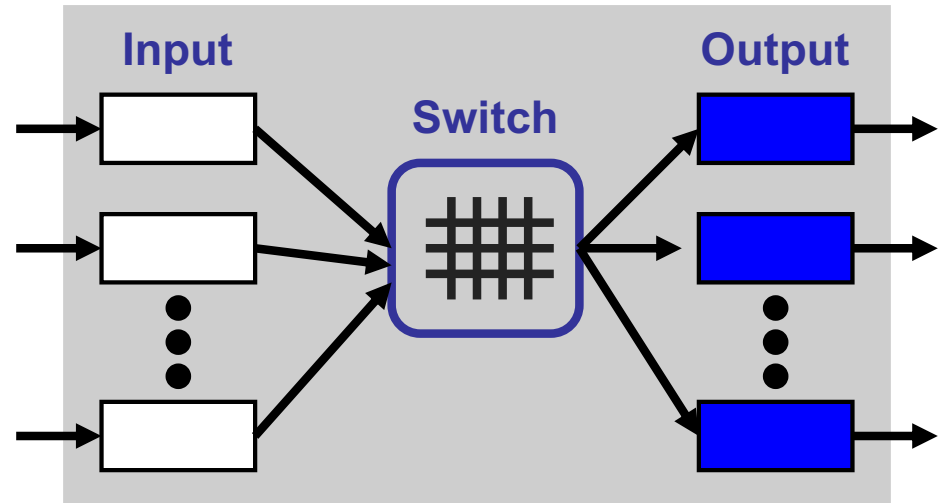
Data plane

- Simple
- Per-packet
- Must be fast

Interconnect architecture

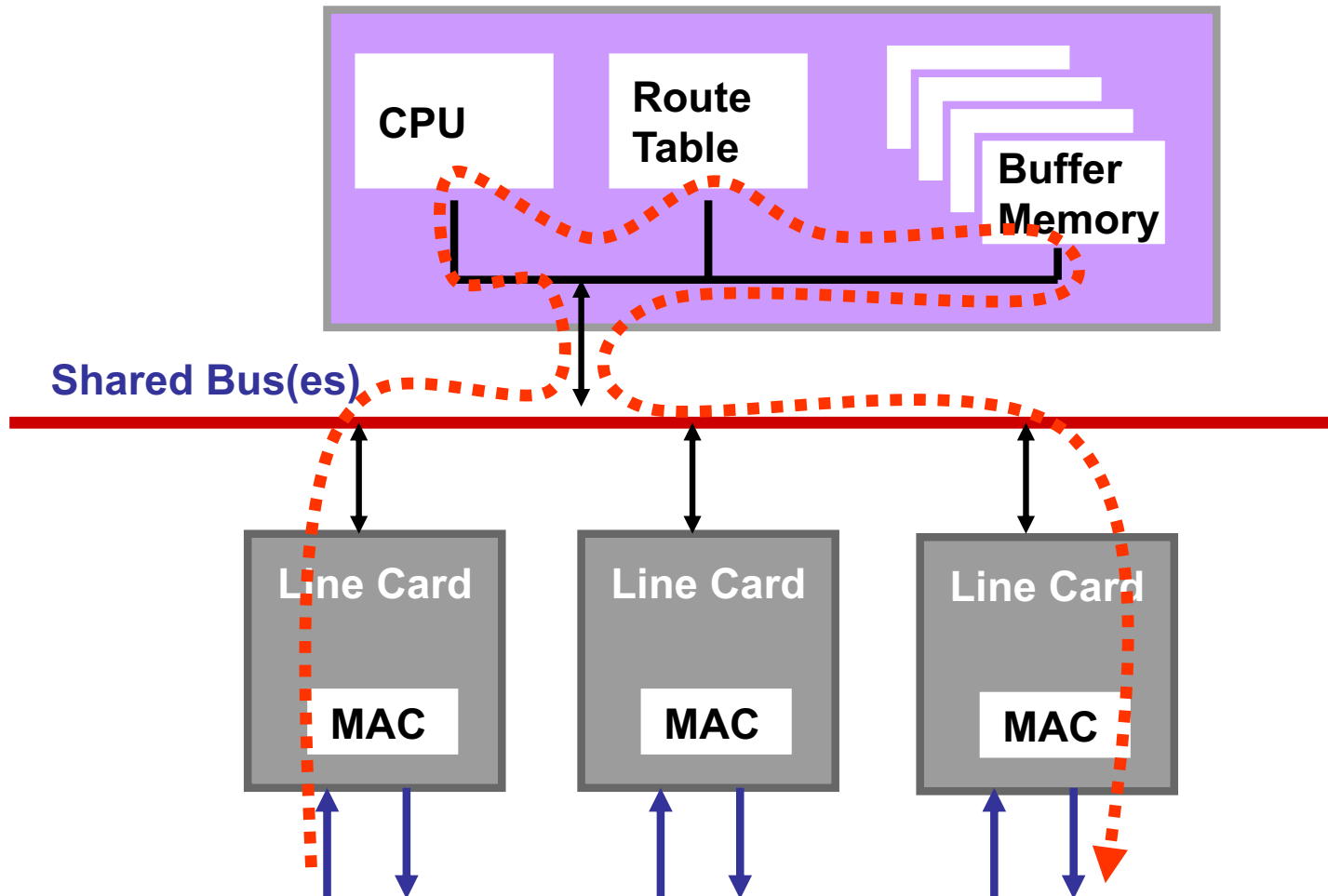


- Input & output connected via switch fabric
- Kinds of switch fabric
 - ◆ Shared Memory
 - ◆ Bus
 - ◆ Crossbar
- How to deal with transient contention?
 - ◆ Input queuing
 - ◆ Output queuing





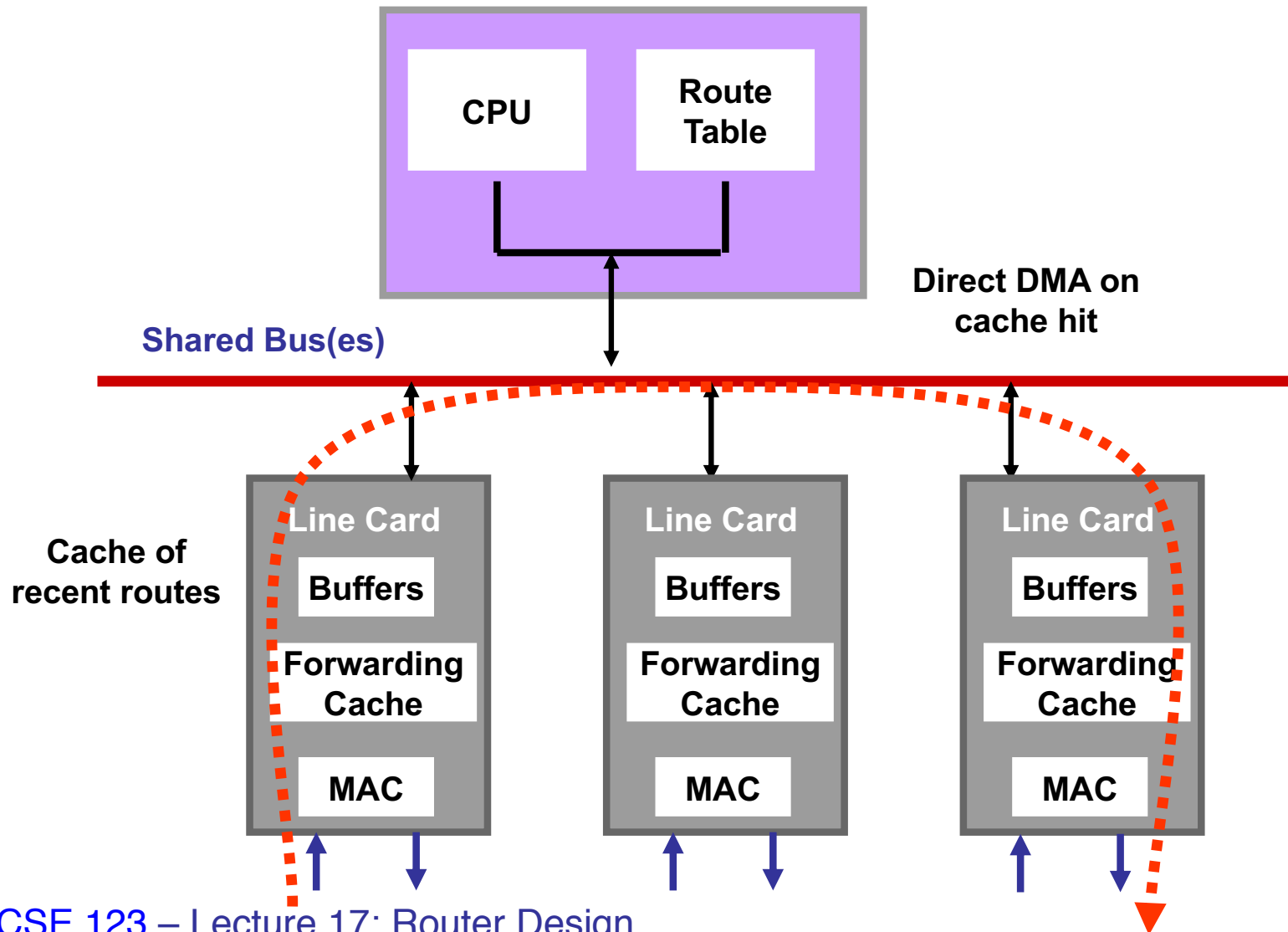
First Generation Routers



Single CPU and shared memory;

All classification by main CPU

Second Generation Routers



For Next Time



- Read P&D 6.2
- Get started on P2 initial tasks
- Homework 3 out Friday