Router Architectures

An overview of router architectures.

Introduction
What is a Packet Switch?

• Basic Architectural Components
• Some Example Packet Switches
• The Evolution of IP Routers
Router Components

- Hardware components of a router:
  - Network interfaces
  - Interconnection network
  - Processor with a memory and CPU

- PC router:
  - Interconnection network is the (PCI) bus and interface cards are NICs
  - All forwarding and routing is done on central processor

- Commercial routers:
  - Interconnection network and interface cards are sophisticated
  - Processor is only responsible for control functions (route processor)
  - Almost all forwarding is done on interface cards

Functional Components

- Control
- Datapath: per-packet processing
Routing and Forwarding

Routing functions include:
- route calculation
- maintenance of the routing table
- execution of routing protocols

- On commercial routers handled by a single general purpose processor, called *route processor*

IP forwarding is per-packet processing
- On high-end commercial routers, IP forwarding is distributed
- Most work is done on the interface cards

Basic Architectural Components

*Per-packet processing*

```
+-----------------+             +-----------------+
| Routing Table  |             | Output Scheduling|
+-----------------+             +-----------------+
| Routing Decision|
+-----------------+             +-----------------+
| Routing Table   |             | Output Scheduling|
+-----------------+             +-----------------+
| Forwarding Decision|
+-----------------+             +-----------------+
| Routing Table   |             +-----------------+
+-----------------+             +-----------------+
| Forwarding Decision|
+-----------------+             +-----------------+
```

Switch Fabric
Router Components

- **On a PC router:**
  - Interconnection network is the (PCI) bus
  - Interface cards are NICs (e.g., Ethernet cards)
  - All forwarding and routing is done on central processor

- **On Commercial routers:**
  - Interconnection network and interface cards can be sophisticated
  - Central processor is the route processor (only responsible for control functions)

Slotted Chassis

- Large routers are built as a slotted chassis
  - Interface cards are inserted in the slots
  - Route processor is also inserted as a slot

- This simplifies repairs and upgrades of components
Evolution of Router Architectures

- Early routers were essentially general purpose computers
- Today, high-performance routers resemble supercomputers
  - Exploit parallelism
  - Special hardware components

- Until 1980s (1st generation): standard computer
- Early 1990s (2nd generation): delegate to interfaces
- Late 1990s (3rd generation): Distributed architecture
- Today: Distributed over multiple racks

1st Generation Routers

- This architecture is still used in low end routers
- Arriving packets are copied to main memory via direct memory access (DMA)
- Interconnection network is a backplane (shared bus)
- All IP forwarding functions are performed in the central processor.
- Routing cache at processor can accelerate the routing table lookup.

- Drawbacks:
  – Forwarding Performance is limited by CPU
  – Capacity of shared bus limits the number of interface cards that can be connected
**Generation Routers**

- Keeps shared bus architecture, but offloads most IP forwarding to interface cards.
- Interface cards have local route cache and processing elements.

**Fast path:**
- If routing entry is found in local cache, forward packet directly to outgoing interface.

**Slow path:**
- If routing table entry is not in cache, packet must be handled by central CPU.

**Drawbacks:** Shared bus is still a bottleneck.

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**Another Generation Architecture**

- IP forwarding is done by separate components (Forwarding Engines).

**Forwarding operations:**

1. Packet received on interface:
   - Store the packet in local memory.
   - Extracts IP header and sent to one forwarding engine.

2. Forwarding engine does lookup, updates IP header, and sends it back to incoming interface.

3. Packet is reconstructed and sent to outgoing interface.
3rd Generation Architecture

- Interconnection network is a switch fabric (e.g., a crossbar switch)

- **Distributed architecture:**
  - Interface cards operate independent of each other
  - No centralized processing for IP forwarding

- These routers can be scaled to many hundred interface cards and to aggregate capacity of > 1 Terabit per second