# Appendix A

# Packet & Circuit Switches

In Chapter 1 we briefly touched on the internal structure of a typical circuit switch (Fig. 1.8), including input /output ports or linecards and a switching fabric. Depending on whether this fabric is digital or optical, there may be "Phy" chips on the linec-ards; and depending on whether it's a wavelength, time-slot or fiber switch, there may be another chip doing time-slot interchange or wavelength mux/demux. On the other hand, there are many more functions that are performed by packet switches. Table A.1 lists most of these functions.

|  | Fiber Switch | WDM Switch | TDM Switch | Packet Switch |
|---|---|---|---|---|
|  | Fabric | Mux/Demux<br>Fabric | Phy<br>TSI<br>Fabric | Phy<br>Parsing<br>Lookup<br>Modifications<br>Fabric<br>ACLs<br>Queuing<br>Policing<br>Policy Routing<br>Congestion Avoidance<br>QoS<br>Sampling & Mirroring<br>Hashing |

**Table A.1: Comparison of Packet and Circuit switching functions**

Comparing the switches side by side, it is reasonable to expect that since packet switches do much more, and they do it at a much smaller granularity and in much faster time scales than a circuit, it would come at the cost of power, size and price. When we compare real-world values, it matches our expectation quite well. Table A.2 lists four high capacity high-end switches – 3 circuit switches and 1 packet switch. It also lists their power consumption, volume and price. The price numbers are relative numbers derived from [82] - a good rule of thumb would be to multiply the numbers with $1000 to get absolute values.

|  | Fiber Switch | WDM Switch | TDM Switch | Packet Switch |
|---|---|---|---|---|
|  | Glimmerglass IOS600 | Fujitsu Flashwave 7500 | Ciena CoreDirector | Cisco CRS-1 |
| B/w | 1.92 Tbps | 1.6 Tbps | 640 Gbps | 640 Gbps |
| Power | 85 W | 360 W | 1440 W | 9630 W |
| Volume | 7" x 17" x 28" | 23" x 22" x 22" | 84" x 26" x 21" | 84" x 24" x 36" |
| Price | < 50 | 110.38 | 83.73 | 884.35 |

**Table A.2: Power consumption, Size and Price Comparison**

Price Calculations:

- IP router:  1 chassis (16.67) + 16 slot cards (9.17 x 16) + 32 10GELR port cards (4.20 x 32) + 32 OC192PoS (18.33 x 32) = 884.35; Normalized Price: 884.35/640 = 1.38 /Gbps

- TDM switch:   1 chassis (13.33) + 32 OC192 (1.67 x 32) + 32 10GE ( (0.7+2x0.18) x (32/2) ) =  83.73; Normalized Price: 83.73/640 = 0.13 /Gbps

- WDM switch:  1 chassis (2.5) + 12 degree, 40 channel ( 8.99 x 12 ) = 110.38; Normalized Price: 110.38/1600 = 0.069 / Gbps

- Fiber switch: 50/1920 = 0.026 / Gbps

It is more instructive to normalize each of these numbers with their switching bandwidth and then compare to the fiber switch (Table A.3). Clearly we see that there is a significant jump in going from optical to electrical switching fabrics. But even comparing the CRS-1 to a TDM switch which has a digital switching fabric, the former consumes 7 times the power and costs 10 times more.

As mentioned in Chapter 1, the objective of this exercise is not to say that the switches are equivalent because clearly they are not. They perform functions very differently. The objective is to say that there are some functions that circuits are exceedingly good at – like recovery, guarantees and on-demand-bandwidth; such that if we eliminate circuits and replace those functions with packets, we end up paying with higher operational and capital costs (as showed in Chapter 4).

|  | Fiber Switch | WDM Switch | TDM Switch | Packet Switch |
|---|---|---|---|---|
|  | Glimmerglass IOS600 | Fujitsu Flashwave 7500 | Ciena CoreDirector | Cisco CRS-1 |
| B/w | 1 | 1 | 1 | 1 |
| Power | 1 W/Gbps | 5 | 51 | 332 |
| Volume | 1 in$^3$/Gbps | 4 | 41 | 65 |
| Price | 1 $/Gbps | 3 | 5 | 53 |

**Table A.3: Normalized Values**