

Packet Switching or Optical Switching

Lawrence G. Roberts

Packet Switching or Optical Switching?

One of history's main benefits is that it lets us detect trends that help predict the future. Over the past 30 years since the Internet started, many clear trends have emerged. This article very briefly examines the most critical of these trends, the one that led to the creation of the Internet--the packet switching cost trend.

Packet Network Cost Components

In the early seventies, as the Internet started to grow, I first examined the trends of the two components of packet network cost, switching and communications bandwidth,¹ illustrated in Figure 1. The computing cost to switch packets was decreasing by a factor of two every 20 months, a rate that has remained fairly constant ever since. The communications cost trend, however, was declining much slower, halving every 79 months.

Because of this difference in the rates of decline, the computer cost of switching crossed over in 1969 and became less than the communications cost for moving a terabit of data. This meant that the computing power needed for packet switching was no longer an inhibiting factor. Since the alternative to packet switching was circuit switching, and typical data interactions had a peak rate 15 times their average rate, the communications cost for sending just the packets of data was 15 times less than setting up a circuit at the peak rate. So after 1969, the Internet's first year, packet switching had a significant advantage (7:1, quickly growing to 15:1) over circuit switching for data.

Reversal to Optical Circuit Switching?

The cost trends continued unchanged until the early nineties, when dense wave division multiplexing (DWDM) started to alter the communications cost trend. Since 1992, DWDM has reduced the cost of fiber capacity by a factor of two every 12 months, so that the decrease in communications cost is now faster than that of the computing cost. At this new rate, by 2010 the cost of communications could drop to that of switching, and the curves could cross again. If this happens, a reversal could occur, so that it might become less expensive to use optical circuit switching instead of packet switching. Rather than lumping packets together to fill a pipe, opening a fat pipe for the duration of a call could become less expensive, even if the pipe was only 7 percent utilized.

Maximum Fiber Capacity

There is some controversy over the Shannon limit for the capacity of a fiber, but experts agree that there is a limit to the total bandwidth we will be able to achieve in a fiber, no matter how DWDM divides the channel. Current estimates of this limit range from 10 to 100 terabits per second (Tbps). This limit is expected to grow slowly with time, but probably no faster than the decline in computing cost. Thus, by 2008, when the DWDM density reaches 10,000 OC-192s per fiber (100 Tbps), we can expect the fast decline in communications cost to stop and revert to a trend like that for computing cost. At this point, the cost of the fiber component will still be 10 times the cost of packet switching, so there is no real possibility of a reversal to optical circuit switching in the foreseeable future.

Packet Switching Remains Least Expensive

Today, the time division multiplexing/circuit switching market is starting to decline, and packet switching is taking over voice as well as data. This trend is clearly going to continue. A change to optical circuit switching because of DWDM-driven reductions in communications cost appears unlikely, since computing will remain less expensive than fiber capacity. Thus, computing can optimize the fill of each fiber at less total cost than adding circuit-switched fibers, even if the circuit switching is free.

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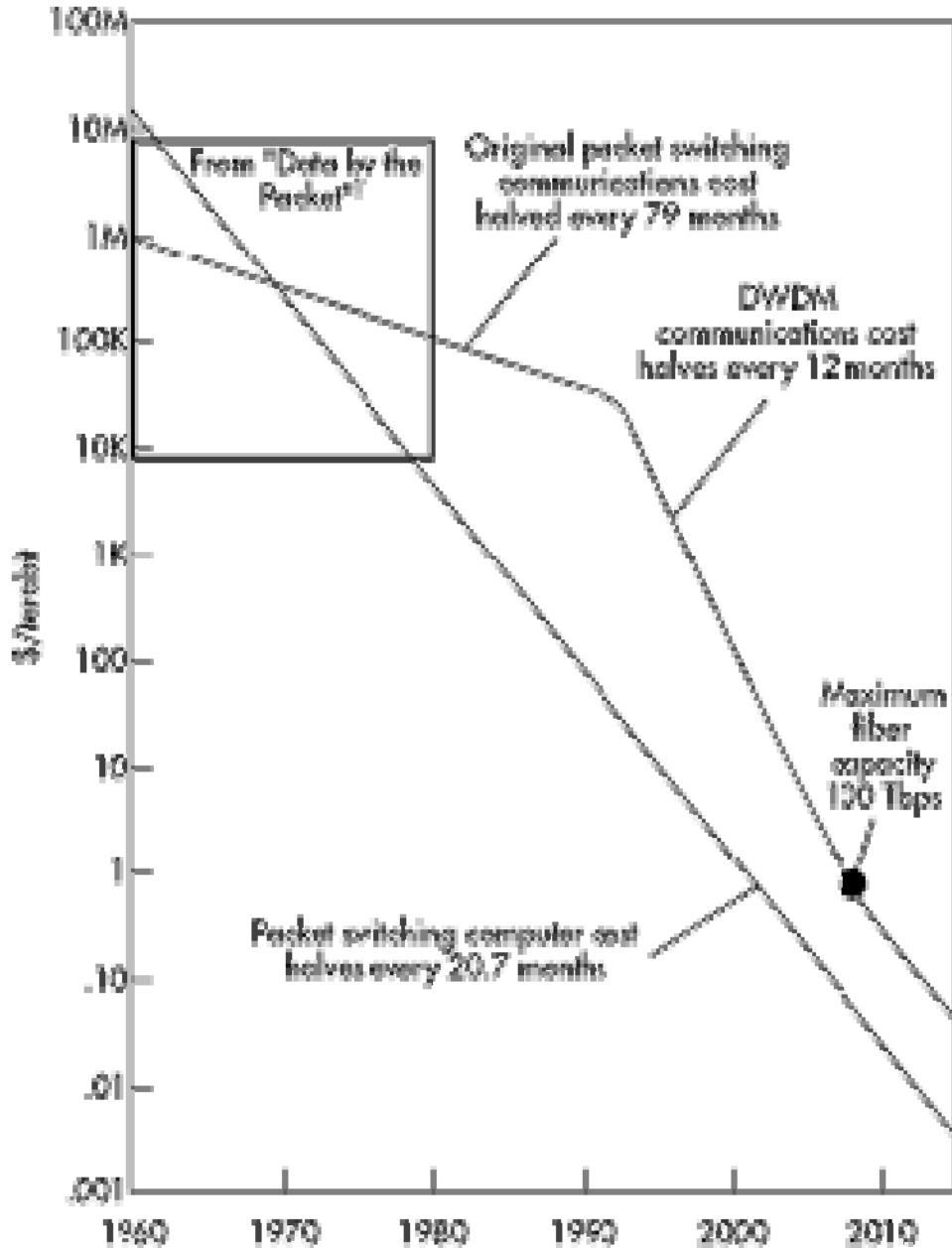


Figure 1. Trends in packet switching computer cost and communications cost.

REFERENCE

1. L.G. Roberts, "Data by the Packet," IEEE Spectrum, Vol. 11, No. 2, Feb. 1974, pp. 46-51.

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