



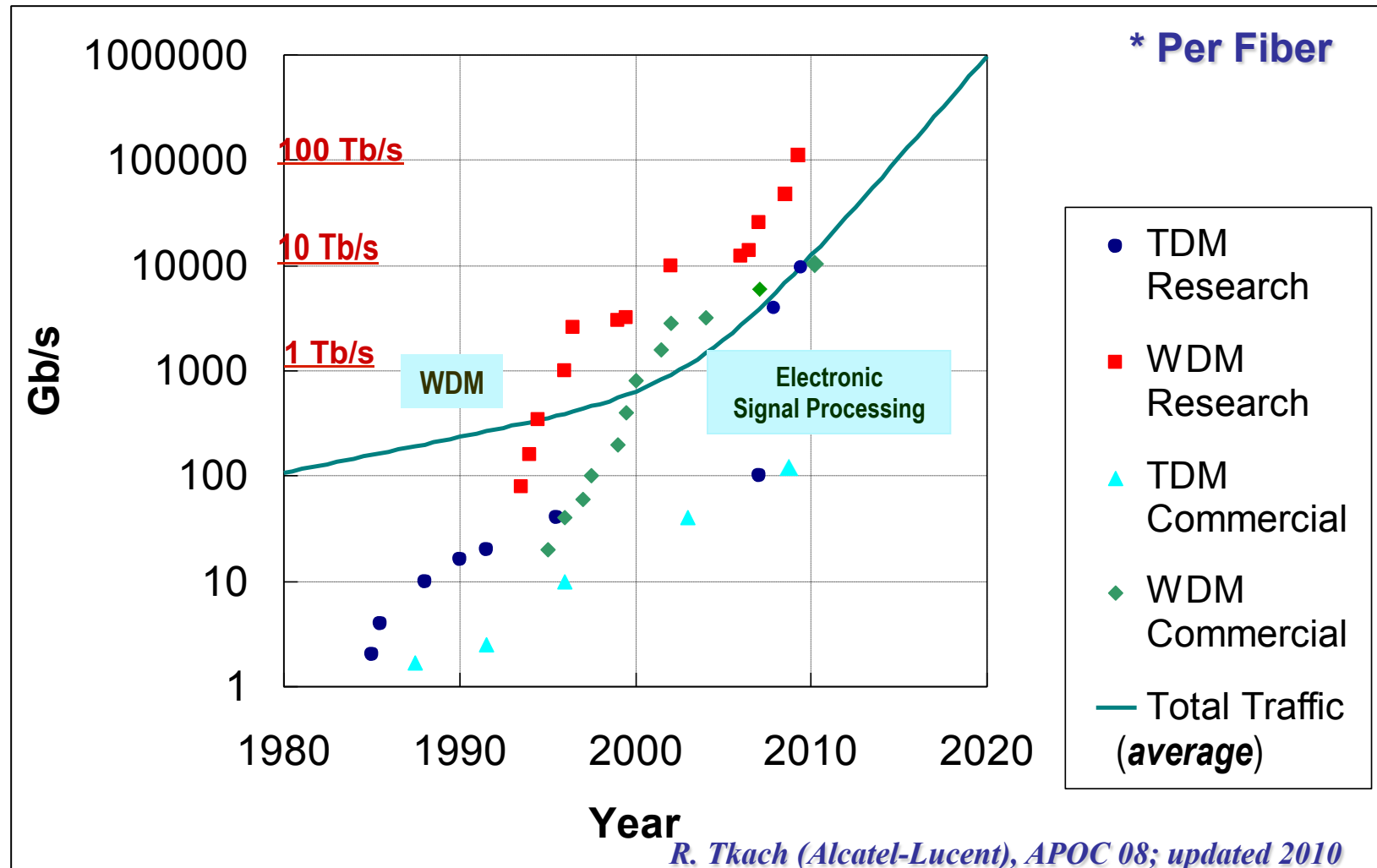
A future of Abundance

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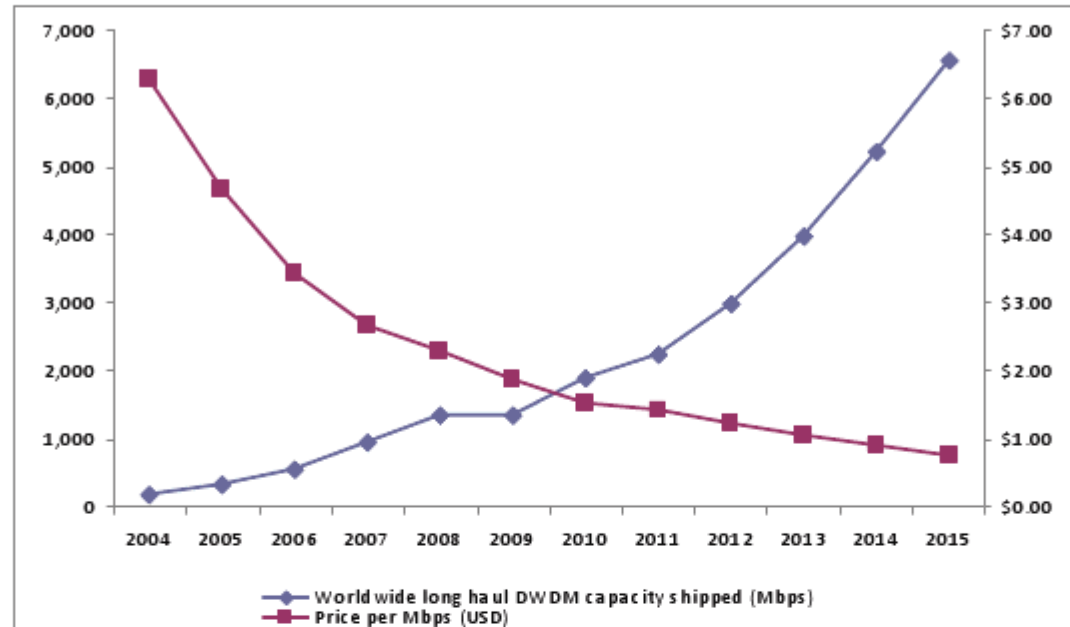
Progress of Optical Fiber Communications

System Capacity* and Network Traffic



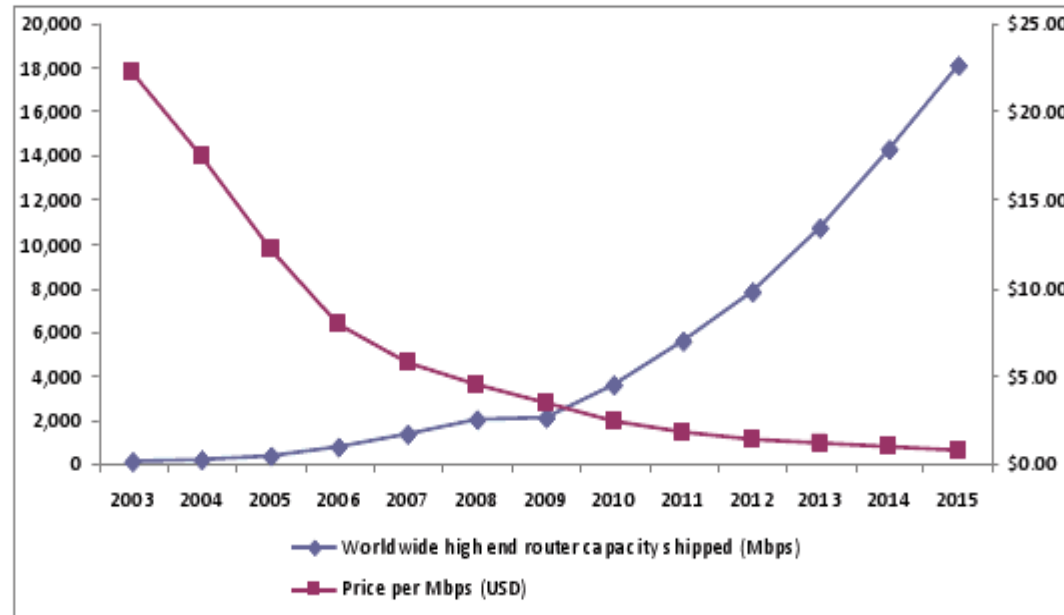
Over a period of 25 years, the system capacity has increased by almost 5 orders of magnitude!

Large increases in optical capacity at flat cost



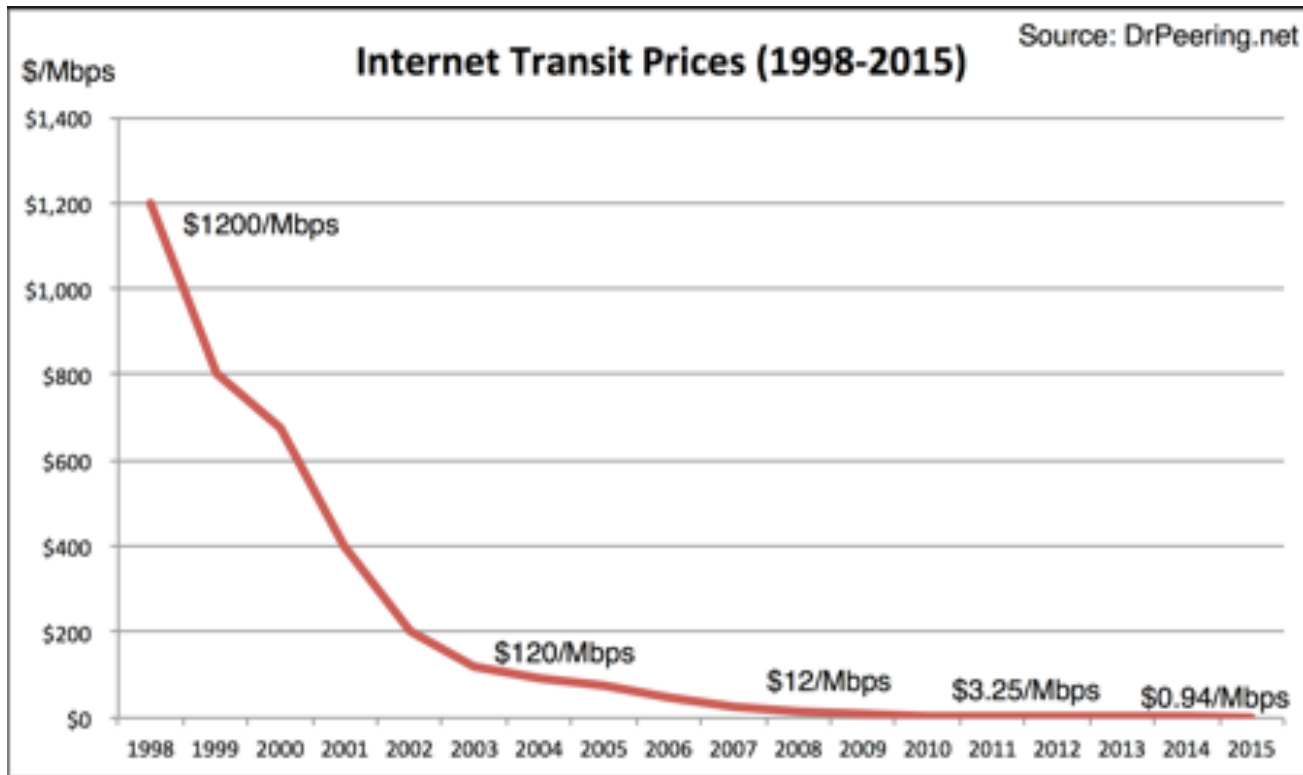
Source: Dell'Oro data,¹⁹ WIK calculations

Large increases in routing capacity at flat cost

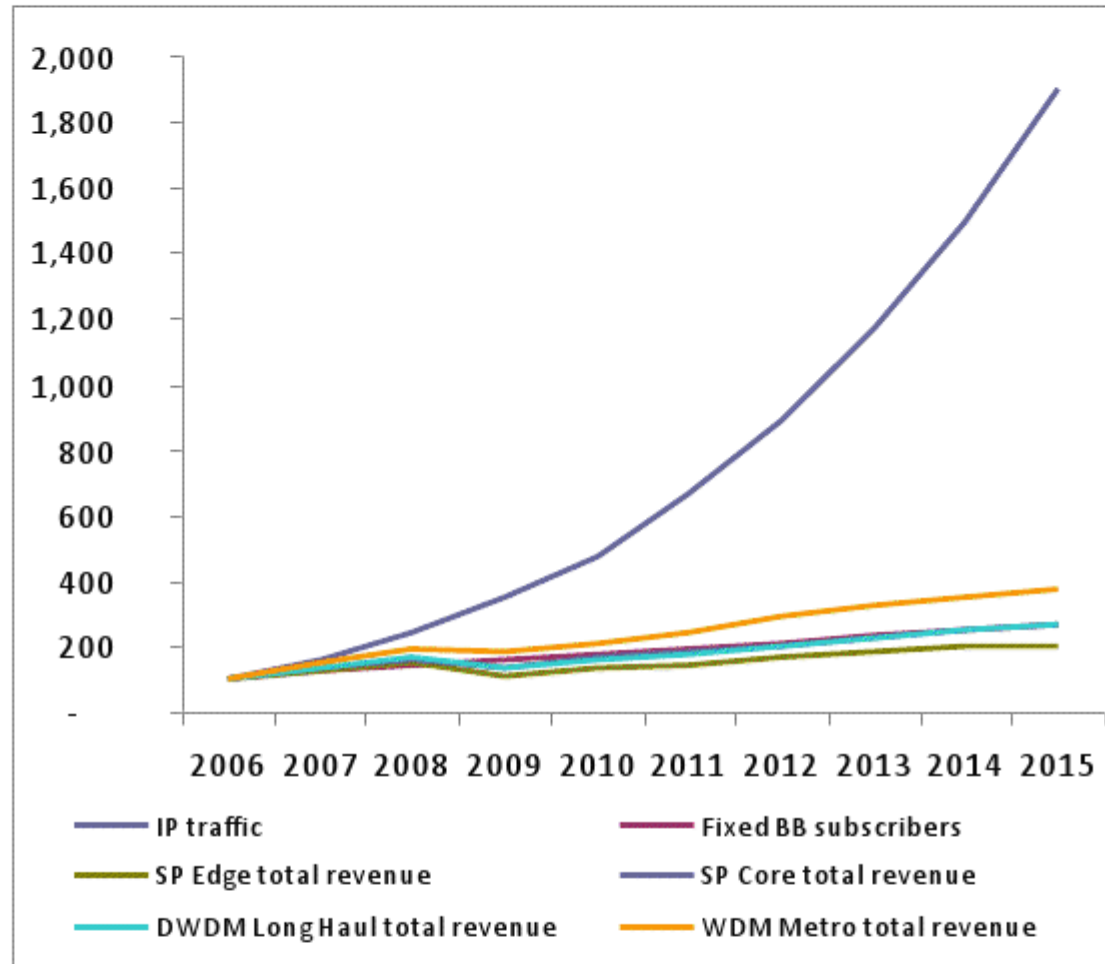


Source: Dell'Oro data,¹⁸ WIK calculations

With a resulting decline in Internet Transit pricing



Costs and revenues are flat despite significant traffic growth



Wireless can follow this curve as well

- **Cellular access is not following the wireline curve despite progress**
 - We now are moving to OFDMA based technologies that allow much higher capacity using wider swathes of spectrum
 - Beamforming and other active antenna technologies are improving spectral efficiency
 - Small cells will allow much faster growth in capacity than adding spectrum in macrocells
 - the future of cellular will look like wifi today
- **But spectrum continues to be a major constraint**
 - This is odd, because most spectrum is unutilized – we have an allocation problem
 - The FCC and Government cannot clear spectrum as in the old days – a new paradigm is required
 - Shared spectrum technologies will allow us to transcend this limit
 - Newer more band agile radios will empower new types spectrum use and industry will move in this direction if new vistas of spectrum are accessible with it
 - We can get wireless back on the wireline curve if we can opportunistically share much more spectrum which is possible in smaller cells

“Potterville”

- **An alternate view of the future is possible**
- **Aggressive usage based pricing has the potential to retard bandwidth growth significantly**
- **By rationing access to capacity, carriers may move Internet transport to a much more static bandwidth expansion**
- **It's easier to not have to innovate and invest, if competition doesn't force that investment**