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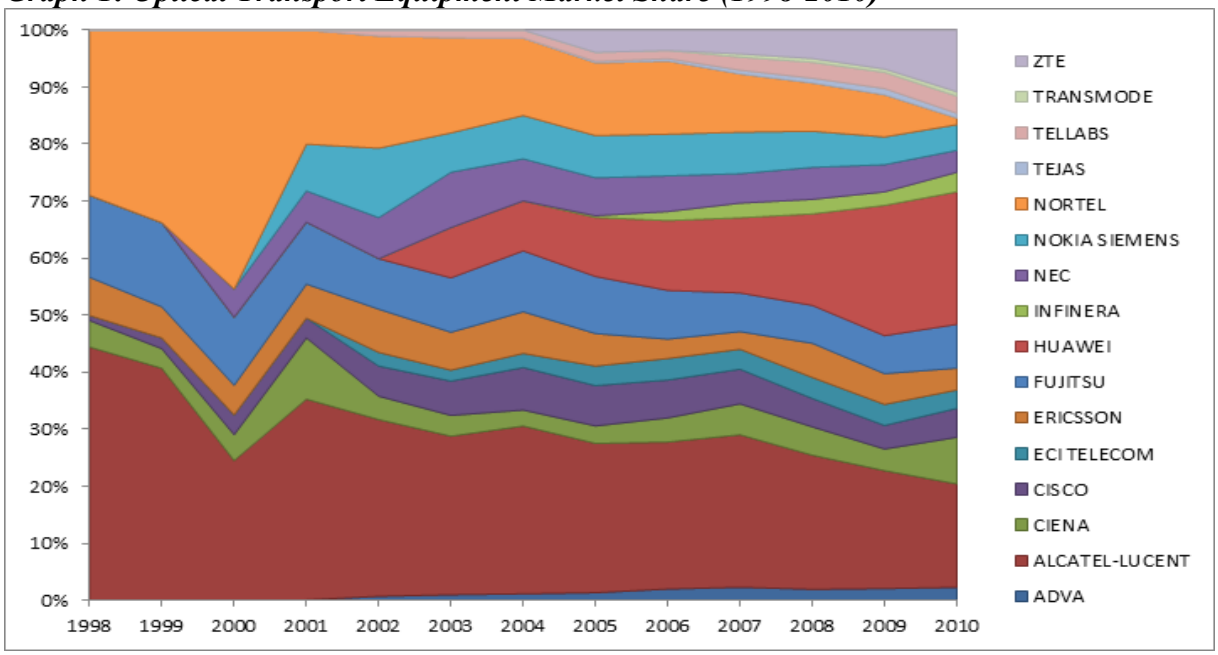
Cisco and optical networking

Announcing its acquisition of CoreOptics, a German firm headquartered in San José, for $99 million in May 2010, Cisco claimed that it "expands Cisco's optical presence in Europe, builds on its existing European operations in Monza, Italy, and will contribute to continued innovation in optical networking"[1]. A subsequent acquisition in the optical space in February 2012 – that of Lightwire, a Californian specialist in silicon photonics technology for $241 million – was announced as building on Cisco's "existing optical networking expertise"[2].

What is particularly striking about Cisco's performance in the optical networking segment of the telecommunications equipment market, however, is not its expertise or its innovative capabilities but its inability to build market share over the previous decade (Graph 1). During this same period, new entrants from China, Huawei and ZTE, have eaten into the dominance of Alcatel-Lucent and Nortel has literally disappeared. In 2010, other competitors from the west coast of the US, such as Ciena and Infinera also started to make gains as operators recover from the financial crisis and begin to roll out their next-generation networks. Cisco, on the other hand, appears only to be rediscovering in 2010, with the acquisition of CoreOptics, the necessity to develop competences in this key area of the telecom market.

Graph 1: Optical Transport Equipment Market Share (1998-2010)



*Source: Dell'Oro**exact referencing terms from Henrik?*

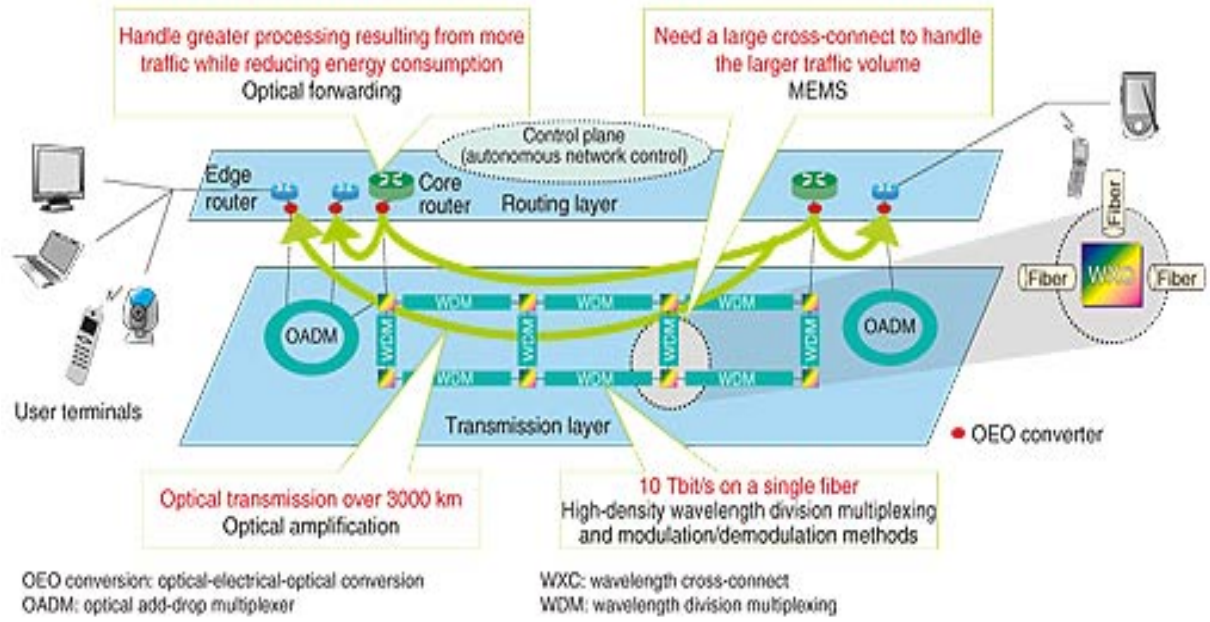
[1] Cisco Press Release, "Cisco Announces Agreement to Acquire CoreOptics", May 20, 2010.
[2] Cisco Press Release, "Cisco Announces Intent to Acquire Lightwire", February 24, 2012

This section will review the optical strategy of Cisco over the period 1998-2010 and examine in detail the acquisitions made and their subsequent performance. Cisco's difficulties with the service provider segment will be analysed and conclusions suggested about the company's difficulties in acquiring innovative capabilities in optical networking capabilities.

Cisco's entry into the optical networking segment

Optical networking "involves a network in which at least some of the operational steps in a network node take place in the optical realm, not just in the electrical realm" (Goralski, 2001: p.38). Dense Wavelength Division Multiplying (DWDM) technology, developed in the mid 1990s, made the use of fibre-optic cables more effective and efficient. The challenge since that time has been to develop and integrate the range of different technologies needed to maximise the use of optical equipment in the access, transmission and switching functions of a telecommunications network (Diagram 1).

Diagram 1: Optical technologies involved in a telecommunications network



Source: Takashi Hanazawa, "Evolving ICT and Challenges in R&D", NTT Technical Review, Vol. 5, No. 4, April 2007, p.8.

Cisco initially adopted optical networking technologies in its core routers for corporate networks. The enhanced features announced for the 7500 series in 1995 included support for asynchronous transfer mode (ATM) and wide area network (WAN) interfaces.[3] In 1998, Cisco announced that it was launching a five-phase optical networking strategy to be completed in one year. It involved[4]:

[3] Cisco Press Release, "Cisco 7500 Series Boosts Routing Muscle for Large, Evolving Corporate Networks", August 28, 1995.
[4] Cisco Press Release, "Cisco unveils five-phase optical internetworking technology strategy", ** April 1998.

1. The introduction of the 12000 series Gigabit Switch Routers and the Cisco 8000 WAN platform to leverage SONet/SDH infrastructures via IP and ATM optical interfaces as fast as 2.5Gbps.
2. Working with optical networking specialist, Ciena, on switches and routers that interface to the optical networking layer, enabling the 2.5Gbps bandwidth to act as one pipe.
3. Integrating SONet/SDH and optical capabilities with its switching and routing platforms tol expand optical internetworking into interoffice and metropolitan applications for phase four so businesses, campuses, and data centers can offer data services.
4. Rolling out Dynamic Packet Transport solutions to redefine metropolitan area network architectures to handle IP traffic and services, in a scalable, robust and cost-effective manner.
5. Extending optical internetworking to the edge of the infrastructure and add increased network capacity.

The dynamics underlying of the telecommunications bubble of the end of the 20th century were particularly intense in the optical networking segment. This is evident from the following extract from a report on Cisco by the equity research departement of Solomon Smith Barney, the equity research arm of Citygroup published on August 7 2000. The report explained that Cisco's three major growth segments would be optical, wireless and next generation telephony with revenue optical networking projected to grow from approximatly $500 million to $5.2 billion in 2002 – a tenfold increase. The report explained: "Data networking is going optical, and the forecast growth rates for optical equipment placement are staggering. According to Dell'Oro estimates, DWDM shipments should grow at 120% in 2000 and 90% in 2001, and we believe these are highly consertive forecasts"[5]. The report also forecast that the service provider segment would overtake the enterprise segment for Cisco in the two years to come.

Indeed, at the same period as Cisco was developing optical technologies spread from routers to the edge of the network, it was recognising the significant potential offered by the service provider segment of the market. In 1997, it re-organised its entire organisation into three segments: entreprise, small and medium sized-business and service provider.[6] Cisco's foray into the service provider segment, however, did not provide it with the same returns or margins that it was used to earning in the enterprise segment. In 2001, it announced the departure of the senior vice president of the service provider group, Brian Kennedy, who had been with the company for eight years, and the reorganization of the company into eleven technology groups, one of which was optical.[7] Ironically, Cisco's poor performance in the service provider segment proved to be a relative advantage as the "staggering" forecasts for growth in the telecommunications equipment sector proved illusory and the bubble burst (Carpenter et al, 2003).

Cisco's optical acquisitions

Cisco's success in using and Acquisition and Development (A&D) approch to technology development during the 1990s has been widely documented (Paulson, 2001; **). Its turnover grew during this decade from $0.69 to $20 billion, dominated 15 market segments and supplied

[5] B. Alexander Henderson and Timothy Anderson, "Telecommunications Equipment: United States. Cisco Sytstems Inc." Salamon Smith Barney, August 7, 2000, p.33.

[6] Cisco Press Release, "Cisco reorganizes, aligning its products and solutions into three customer segments: enterprise, small/medium business, and service provider", April **, 1997.

[7] Cisco Press Release, "**", August 24, 2001.

80% of the world's networking equipment (Donlon, 2000: 32). In the five year period between 1996 and 2001, Cisco acquired 66 firms. Eleven of these acquisitions involved firms with optical networking technologies. The total investment amounted to more $16 billion, albeit essentially covered by share transactions (table 1).

Table 1: Cisco's optical networking acquisitions, 1996-2001

Acquired company	***Date***	***$ (m)***	***Technology acquired***
Stratacom	April 1996	4,700	ATM & Frame Relay WAN
Skystone	June 1997	89	SONET/SDH transport
Pipelinks	December 1998	126	SONET/SDH router
StratumOne	June 1999	435	Optical/semiconductor design (silicon integration)
Cerent Corporation	August 1999	6,900	Optical transport
Monteray Networks	August 1999	500	Optical cross connect
Internet Engineering Group	December 1999	25	Optical networking software
Pirelli Optical Systems	December 1999	2,200	Optical/DWDM
Pentacom	April 2000	118	Optical/SRP technology
Qeyton Systems	May 2000	800	Optical, metro DWDM technology
AuroraNetics	July 2001	150	10 Gbps silicon for RPRs
Total	1996-2001	16,043	

Cerent – a successful optical acquisition for $6.9 billion

In fact, only one of these eleven optical acquisitions can be considered to be clearly successful – that of Cerent Corporation for $6.9 billion in August 1999. A year previously, Cisco had paid $13 million for a 9% stake in the company and at the time of purchase, Cerent had generated only $10 million in revenue from its intelligent add-drop multiplexers (ADMs) that lower the cost and increased the flexibility for the transport of all types of traffic over optical networks. Cerent's CEO, Carl Russo, became vice-president of Cisco's optical networking group and the majority of the engineering team was retained (Waters 2002:96, GALLAGHER 2004). The subsequent launch of Cisco's ONS 15454 helped the company increase its share from 0.5% to 9% in North America in 2000 and achieve global revenues in 2001 of $500 million.

Ironically, however, the initial success of this product may also be a contributing factor to Cisco's difficulties in the optical space. The ONS 15454 and its successors address the metro optical segment and Cisco has not managed to develop a successful long-haul product.[source**] In the longer term, also, Cisco did not manage to develop its market share in the growing multiservice SONET/SDH market beyond 6.3% in 2006 and certain commentators began to question whether even this acquisition could be considered "a $7 billion bust".[8]

The success of the other ten acquisitions in the optical networking space is even more questionable for a number of potential reasons: the integration and co-ordination of the numerous acquisitions, lack of competitive advantage of the technology acquired, Cisco's difficulties in

[8] Jim Duffy, "Cisco shutters Cerent HQ in Petaluma, CA. Spent $6.9 billion on optical transport company in 1999", *Network World*, November 5, 2009.

establishing itself as a supplier to service providers and the downturn that followed the explosion of the telecom bubble in 2001.

StrataCom – a less successful optical acquisition for $4.7 billion

StrataCom was the acquisition that most clearly suffered from problems of integration and co-ordination. Stratcom's customers were primarily long-distance carriers who use its switching equipment to provide data transmission services.[9] Its sales had grown from $154 million in 1994 to $332 million in 1995 and, in 1996, San Jose, Calif.-based StrataCom led in the frame relay and ATM markets (with 40 and 22 percent market share, respectively) (Bunnell and Brate 2000:80, Waters 2002:83).

In an effort to meet customers' increasing need for wide area networking (WAN) applications, Cisco began to make acquisitions in frame relay and asynchronous transfer mode (ATM) switch technologies.[10] Though Cisco already acquired and developed Fast Ethernet, this worked well for local area networking (LAN) but not WAN applications (Gawer and Cusumano 2002:174). Despite Cisco's own bias towards Internet Protocol (IP) – that is, to move data via routers - it embraced its technological agnosticism and expanded into ATM for incumbent phone companies and enterprise clients (Young 2001:180-193, Carpenter, Lazonick et al. 2003:984).[11]

Before StrataCom, Cisco acquired LightStream for its ATM products. Lightstream, acquired in 1994 for $120 million, increased its sales from $1.5 million to $45 million in 1995. However, it still trailed its competitors (StrataCom and Cascade) in the ATM market and only accommodated small and mid-sized corporate networks. With Cisco's customers increasingly requesting the ability to combine WAN with LAN-to-LAN requirements, there was a fear that the LightStream products could face obsolescence within 12-to-18 months. In light of the quickly changing market, Cisco turned to StrataCom (Rifkin 1997, Bunnell and Brate 2000:77-78).

In addition to the ATM technology, StrataCom could give Cisco a significant entry into the carrier market and a close relationship with the regional Bell holding companies (1996, Bunnell and Brate 2000:81).[12] StrataCom was no stranger to Cisco, as the two had worked together on a joint frame-relay forum back in 1989 and had a friendly corporate relationship and cultural chemistry. Reportedly, the $4.7 billion StrataCom deal was done in less than two weeks after John Chambers sat down to dinner with StrataCom CEO Dick Moley to inquire about his interest in being acquired (Waters 2002:82). Cisco instantly benefited from Stratacom's long-term

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[9] Lawrence M. Fisher, « Cisco Agrees to Acquire Stratacom In a Stock Swap Worth $4 billion", *The New York Times,* April 23 1996.

[10] The wide-area network market is the side of the networking industry that connects computers from remote locations to the Internet. Frame relay was a fast-emerging technology vital to connecting local networks that were physically separate from one another, and asynchronous transfer mode (ATM) was another high-speed switching technology that fused video, voice and data transmission through a single pipeline.

[11] Cisco avoids making "religion" out of technology and supposedly adopts technology according to the needs of its customers instead of its internal biases.

[12] At the time of the acquisition, Stratacom's had long-term agreements with AT&T to provide it a frame relay network, a deal estimated to be worth "hundreds of millions." Stratacom also reportedly provided frame relay for Concert, an international joint venture between MCI and British Telecom, and high-speed switching for CompuServe Inc. and Nation's Bank. Source: BRYANT, H. (1996). STRATACOM DEAL PUTS CISCO OVER THE TOP $4 BILLION BID: NETWORKING GIANT'S PLAN WOULD MAKE IT INDUSTRY LEADER. San Jose Mercury News (California)..

agreements with AT&T to provide it a frame relay network, which were reportedly worth "hundreds of millions" as well as other international market agreements (BRYANT 1996). It also helped the company move aggressively to pursue top positions in enterprise WAN and service provider ATM markets which could not be served by its LightStream products (Lach 1996).

However, the intregration of the StrataCom acquisition proved to be more challenging than the completion of the deal. First, there was the issue of integrating StrataCom's products into Cisco's LightStream ATM product line. It appeared that there was more overlap between the StrataCom and LightStream products than Cisco was willing to admit. Before the StrataCom acquisition, the LightStream 2020 (currently offered) and 2080 (under development) products were being pitched as ATM WAN switches in competition with products from StrataCom and Northern Telecom (Nortel). Meanwhile, StrataCom WAN switches were positioning to move into the campus level - the ATM market where LightStream successfully completed. However after Cisco acquired StrataCom, the LightStream 2020 ATM switch was repositioned as a campus backbone switch before being retired in favor of the StrataCom IGX platform. Additionally, the development of the LightStream 2080 (the 2020's replacement) was halted (1996, Greene and Duffy 1996, Higgins 1996, Wallace 1996). A few months following the acquisition, LightStream buyers were mad, and the LightStream division within Cisco stopped growing.[13] Some analysts claimed that the acquisition created confusion and initially hurt Cisco's ATM positioning (Bunnell and Brate 2000:83). Ultimately, LightStream was a false start for Cisco's entry into carrier-class ATM switches focus, and the StrataCom acquisition forced Cisco to pull the plug on its LightStream product family altogether (Lach 1996, Wallace 1996).

Second, there was the challenge of integrating StrataCom into the organizational structure of Cisco. Though Chambers preferred to acquire smaller firms, Cisco violated this policy by purchasing StrataCom with its approximately 1,400 employees. Chambers justified the acquisition as a way to rapidly enter the ATM space (Waters 2002:82-83, Mayer and Kenney 2004:319). But his reticence about doing larger acquisitions would unfortunately be confirmed. With such a large, public company, there would be a challenge in integrating the two corporate cultures (1996). There was the internal challenge of getting Cisco to embrace ATM technology and the ATM bias within StrataCom. "Despite Cisco's insistence on technological agnosticism, it had been emphatically biased toward IP" (Bunnell and Brate 2000:84). The StrataCom acquisition seemed to some as a sell-out to the original "IP everywhere" message that Cisco promoted and the divergent ATM and IP contingencies within Cisco were difficult to blend (Higgins 1996, Young 2001:186).[14]

Most notably, Cisco faced significant hurdles integrating the sales and marketing team from StrataCom. A few months following the StrataCom deal, approximately a third of the StrataCom sales team left after being put on lower compensation plans than the Cisco sales representatives and/or losing accounts altogether (Paulson 2001:199-200, Waters 2002:83, Mayer and Kenney

[13] The LightStream buyers were stuck with a discontinued product that Cisco previously assured would not overlap with the new StrataCom product families. Shortly following the acquisition, Cisco reportedly offered the full value of their discontinued switches toward new equipment, along with assistance and training.

[14] Some within Cisco that promoted IP thought that buying ATM, which they considered bad technology, for the sake of bolstering Cisco's sales portfolio was not a good idea. On the other side, StrataCom's CEO's was reportedly was **religiously** *devoted* to ATM to the exclusion of other technologies. Source: (Slater, 2003:224)

2004:319).[15] Another challenge was getting Cisco's native sales force to sell the StrataCom equipment which netted a significantly lower commission than Cisco's high-end routers. Finally, Cisco insistence that the StrataCom sales team shorten its sales cycle reportedly did not sit well with the sales account team (Higgins 1996, Bunnell and Brate 2000:85). Overall, Ed Kozel, former member of the Cisco board and onetime CTO characterizes StrataCom as a "neutral acquisition" in his "three bucket" typology of "painful failures", "neutral acquisitions", and "stunning successes." Neutral acquisitions are "Those which sort of worked but didn't hurt a lot; Cisco didn't get a lot of gain from them. This is a large bucket" (Slater 2003:224-225).

Pirelli – a failed optical acquisition for $2.2 billion

In December 1999, Cisco acquired Pirelli, S.p.A. as it sought to enter the Dense Wave Division Multiplexing (DWDM) market. DWDM enables the simultaneous transmission of multiple wavelengths of light, that is, packets of light data at the same time on the same fiber. This technology dramatically increases the capacity of broadband networks carrying a combination of phone, Internet, and video traffic. Cisco claimed the Milan, Italy-based company was the first to ship open standards-based 10-Gbps optical transport systems with customers such as France Telecom, Deutsche Telekom, Brazil Telecom, and Global Crossing. Cisco hoped this acquisition would help it extend the capacity of the fiber optic networks of large national carriers. The $2.2 billion was made in December 1999 for the business in a stock deal. That same month, Nortel acquired a rival start-up Qtera, with similar equipment, for $3.25 billion (1999, Anandalingam and Lucas 2004:112-113). Pirelli's 701 employees along with its plants in Italy, France, Germany and South Carolina were acquired (Carpenter, Lazonick et al. 2003:985).

The Pirelli acquisition was an unfortunate failure. James Richardson, Cisco's senior vice-president of enterprise and former head of Cisco Europe, claimed that distance, cultural differences and labor agreements[16] impeded the technology acquisition process (Avery 2000). Though Pirelli had big customers (i.e., France Telecom SA, Telecom Italia S.p.A. and Global Crossing Ltd), it was not a market leader when acquired by Cisco and its technology trailed that of Ciena, Lucent, and Nortel. In the long-haul market which doubled size for a year, Pirelli's share of the market declined from 5 percent in early 1999 to less than 1 percent in the beginning of 2000 (Mehta, Schlosser et al. 2001, Young 2001:184, Anandalingam and Lucas 2004:113). According to some analysts, Pirelli's equipment was difficult to mass produce whereas competitors like Ciena and Nortel were able to manufacture their gear in large quantities. To rectify the situation, Cisco outsourced the product manufacturing to Solectron in June 2000. In 2001, Cisco sold the South Carolina DWDM manufacturing facility to Solectron, and the press ultimately judged the Pirelli acquisition a failure (Carpenter, Lazonick et al. 2003:1021, Mayer and Kenney 2004:319-320). In August 2004, Cisco announced that it would cease selling the ONS 15808 (the product line inherited from Pirelli) from February 2005 (2010).

Monterey Networks and Quetyon Systems – optical acquisitions for $1.2 billion whose plants were closed

[15] The StrataCom CEO left soon after the acquisition as well.

[16] "At the time there was said to be a degree of paranoia among Cisco managers because the Pirelli operation was unionised - apparently the first time this had ever happened to Cisco", "Does Cisco want CoreOptics for internal use or to conquer the merchant market? (Part 1). *Optical Networks Daily, 1 June*.

With the pressure rising for Cisco to announce a viable optical product in 1997, Cisco decided to take a 10 percent minority investment in Monterey Networks (Paulson 2001:154-155). The advent of Wave Division Multiplexing (WDM) meant that the capacity of fiber optic networks could be increased 32-fold, thus allowing more traffic to be sent over existing lines. But this created a problem when phone carriers had to manually route traffic from one part of the fiber optic network to the other. Monterey's optical cross-connect technology automated this process (Bounds 1998). On the same day that Cerent was announced for acquisition, Cisco announced its acquisition of the Richardson, Texas-based Monterey Networks for approximately $500 million in stock (Mahoney 1999, Carpenter, Lazonick et al. 2003:985).

Unfortunately, the Monterey acquisition was plagued with problems. Just days following the acquisition, all three of Monterey's founders, including its engineering guru and chief systems architect, left Cisco. H. Michael Zadikian, a Monterey founder, said, "I came to the realization I wasn't going to have any meaningful impact on the product by staying." This was especially challenging for a company without revenue or customers, at least a year away from a completed product, and with considerable debt it had accrued since its founding in 1997 (Angell 2000, Bajaj 2001, Byrne and Elgin 2002). In Cisco's August 2000 earnings call, Chambers revealed that the Monterey optical cross-connect "… was delayed and wouldn't be generating revenue for another year" (Young 2001:184,249). Cisco announced several deployments and product trials of the Wavelength Router in 2000, but no contracts were signed (LaBarba 2001).

Cisco discontinued the Monterey optical cross-connect product 18 months after acquiring the company (Thurm 2001, Byrne and Elgin 2002). Cisco claimed that the Monterey product was a casualty of a bear market and a slowdown in capital spending by service providers (Bajaj 2001, Cope 2001, LaBarba 2001). However, market analysts thought that Cisco's product – and not the market – was the problem. Other products, like Ciena's optical switch and Tellium's Aurora optical cross-connect, were doing very well in the market. Cisco's competitors (i.e., Ciena, Lucent and Nortel Networks) with more experience in the telecom and optical market were closer to the market (Angell 2001, LaBarba 2001, Mehta, Schlosser et al. 2001). Though service provider capital expenditures slowed, Cisco's Wavelength Router lacked demand primarily because it did not provide the edge optical grooming switch functionality that was competitive in the market at that time (DUFFY 2001). By 2001, the entire operation was discontinued with plans in place to redeploy the engineering talent working on the router product into Cisco's metropolitan optical market (2001, Carpenter, Lazonick et al. 2003:1021, Mayer and Kenney 2004:320). Following this departure, Cisco decided to shift its attention from the core to the metropolitan optical market (LaBarba 2001).

In May 2000, Cisco announced the $800 million acquisition of Qeyton Systems, based in Stockholm, Sweden and a developer of Metropolitan Dense Wave Division Multiplexing (MDWDM) technology. Service provider networks were not designed for the Internet, and the Internet bandwidth explosion forced these service providers to add SONET rings to their networks. MDWDM technology uses more of the available capacity of fiber- optic strands to let existing networks carry more Internet, phone and video traffic, thus optimizing the performance and cost requirements of their metropolitan networks. Qeyton Systems technology was integrated into Cisco's ONS 15000 family of products while the 52 employees continued to remain in Stockholm (2000, ZIMMERMAN 2000). The challenge with the Qeyton acquisition is that as of

2001, it had yet to ship its products while some of its competitors, like ONI, were already selling DWDM systems linking end-users to long-distance carrier networks (Young 2001:184-185). By October 2002, Cisco closed the Swedish plant although it claimed that it would continue to sell the metro DWDM product (Harvey 2002).

Five optical acquisitions costing $825 million integrated into existing Cisco product lines

Pipelinks

Cisco acquired San Jose, California-based PipeLinks in December 1998 for $126 million in stock for its SONET/SDH router that cost-effectively combined traditional circuit-based traffic with IP traffic within a single device. PipeLinks was founded in 1996 and in 1997 had Cisco as a minority shareholder. Cisco hoped that the technology and the 73 employees in this acquisition would help the company target service providers that would continue to utilize their existing SONET/SDH infrastructure for leased line and voice transport while transitioning into new internet services (1998, Carpenter, Lazonick et al. 2003:985).

StratumOne

In June 1999, Cisco announced it acquisition of StratumOne for $435 million in stock. Founded in 1997, Silicon-Valley based StratumOne was a developer of highly integrated, high-performance semiconductor technology. Starting with a minority investment by Cisco in 1999, this acquisition brought StratumOne's experience in silicon integration to Cisco's technology development for 10 Gbit/sec (OC-192) next generation networks. Its 78 employees were integrated into the Optical Internetworking Business Unit within the Service Provider line of business (1999, 1999). Some industry observers considered the acquisition of StratumOne, with "virtually no revenues", a reactive move to a more competitive and acquisitive market. Lucent's recent acquisitions of Ascend Communications and Nexabit Networks as well as Tellabs' acquisition of NetCore products - a fast modem that was reported to have 10 times the capacity of Cisco's largest router – forced Cisco to bring some development in-house (ASCIERTO 1999). Though Cisco's traditionally outsourced its manufacturing operations, its desire to dominate the ultra high end of the communications equipment market (i.e., terabit routers) forced the company to remain in control of the entire production process, including silicon design. Additionally, because the terabit router market at that time was up for grabs, Cisco purchased StratumOne to remove a silicon player from the market that could have enabled a start-up or existing player to compete against it (Veerappan 1999).

Internet Engineering Group, LLC

In December 1999, Cisco announced its intent to acquire Ann Arbor, Michigan-based Internet Engineering Group, L.L.C. (IEng) for $25 million. The company developed software that resides in the core of service providers' networks. Cisco anticipated integrating IEng's software suite with their existing network software offering for optical internetworks for service providers. IEng's 13 employees became a part of Cisco's Optical Internetworking Business Unit within the Service Provider line of business (1999, 1999).

Pentacom

In April 2000, Cisco announced its acquisition of Pentacom, Ltd., based in Herzliya, Israel. The 48-employee firm, which was started in late 1998, implemented spatial reuse protocol (SRP) to develop optical networking products that give IP-based metropolitan area networks the same

protection and restoration capabilities of SONET-based networks with double the bandwidth efficiency. This technology addressed the challenges that service providers had in trying to maximize the service and capacity potential of both the network edge and core. The $118 million acquisition in cash and stock would add Pentacom's products, which were already being shipped to Sprint and Netnode, to Cisco's IP products and for use with its IP-based routers. Pentacom joined the Public Carrier IP Systems Group within Cisco's Service Provider Line of Business and relocated to Cisco's Herzliya development center (2000, LaBarba 2000, Sandler 2000).

AuroraNetics

In July 2001, Cisco broke a 7-month M&A hiatus with the announcement it would acquire AuroraNetics, Inc. of San Jose, California for $150 million in stock. The 52-employee firm, which was founded in 2000, developed resilient packet rings (RPR) for metropolitan area networks. RPRs help ensure that IP traffic travelling on fiber rings can be quickly restored in the event of a fiber cut, greatly reducing potential loss of service. AuroraNetics' silicon technology would potentially complement Cisco's existing RPR offering - Dynamic Packet Transport (DPT) – so that it could scale from 2.5Gbits/s to 10Gbits/s. AuroraNetics's employees joined Cisco's Public Carrier IP Services Group, Service Provider Line of Business (2001, 2001, Ristelhueber 2001).

Cisco and Service Provider Customers

Historically, Cisco interfaced with large enterprise customers, not telecommunications companies. The telephone companies bought switches from Nortel, Lucent, and other vendors, essentially ignoring Cisco until the mid-1990s. After telephone companies became interested in providing Internet access for their customers, Cisco began to attract their business for routers that could facilitate data transmission and telephony over the Internet. It also forged partnerships with telecommunications service and manufacturing companies in the early-to-mid 1990's to market itself to the phone companies (Gawer and Cusumano 2002:168). Cisco acquired StrataCom as a way to target telecommunications companies. And though it had some success with Internet service providers and emerging phone carriers, the traditional phone carriers continued to purchase those products from Nortel, Newbridge Networks, and Ascend Communications (which was acquired by Lucent in 1999) (Slater 2003:210). In 1997 and 1998, Cisco acquired a dozen other companies which would be of interest to telephone companies, including DSL equipment, multiservice equipment, and fiber-optic switching equipment (Gawer and Cusumano 2002:175). Cisco won a few major contracts in the carrier segment with Sprint (1998 and 2000) and Qwest (1999) as a result of this aggressive customer strategy (Tempest, Holloway et al. 1998:3, Bunnell and Brate 2000:192-194, Waters 2002:55-56).

However, Cisco ultimately did not win over the service provider segment to forge market leadership in the optical market. First, Cisco did not have the technology offerings or the previous relationships with the network operators to be attractive as an equipment vendor (Doheny, Glaspie et al. 2003:44). For example, Cisco conceded that the long-haul optical market was difficult for it to enter because its competitors' (Lucent and Nortel) relationships with telecom carriers were challenging to penetrate (Simon 2000). And as previously noted, Cisco's optical acquisitions did not necessarily lead its competitors in the market and/or technology.

Second, Cisco lacked an understanding of the service provider customer in terms of culture and expectations. Telecommunications carriers wanted carrier-class reliable equipment with high-quality connections while Cisco typically provided less-reliable but more flexible data networking equipment (Bunnell and Brate 2000:156, Cohen 2001). Cisco was not used to having a longer sales cycle, huge service and support staffs, or the ability to assist customers with financing their purchases (Higgins 1996, Bunnell and Brate 2000:xx).

Third, Cisco threatened its relationship with incumbent carriers by promoting revolutionary change in the telecommunications sector. At a gathering of approximately 100 service providers in Monterey, Calif. during the fall of 1998, John Chambers made his infamous statement that "voice would be free." Incumbent carriers became skeptical of Cisco's message that the future telephone networks would be delivered in data packets (via Cisco equipment) and that they should build new optical networks, forsaking their billion dollar century-old investments (DYRNESS 2000, Mehta, Schlosser et al. 2001). In contrast, Lucent and Nortel offered a "graceful evolution" into new-world packet-networks for the phone companies (e.g., promoting IP on ATM switches, SONET) (Bunnell and Brate 2000:188,190). For a company that prides itself on its customer service ethic, it is interesting that it failed to listen to and almost alienated a whole new breed of customers critical to garnering leadership in optical networking.

Fourth, Cisco bet on the wrong type of service provider – new telecommunications carriers. These upstarts, thought to be the next MCI, invested in "next generation" telecom equipment, failed in the early 2000's (Mehta, Schlosser et al. 2001). These companies were the bulk of Cisco's contracts in the service provider customer segment, thus affecting its optical market figures.

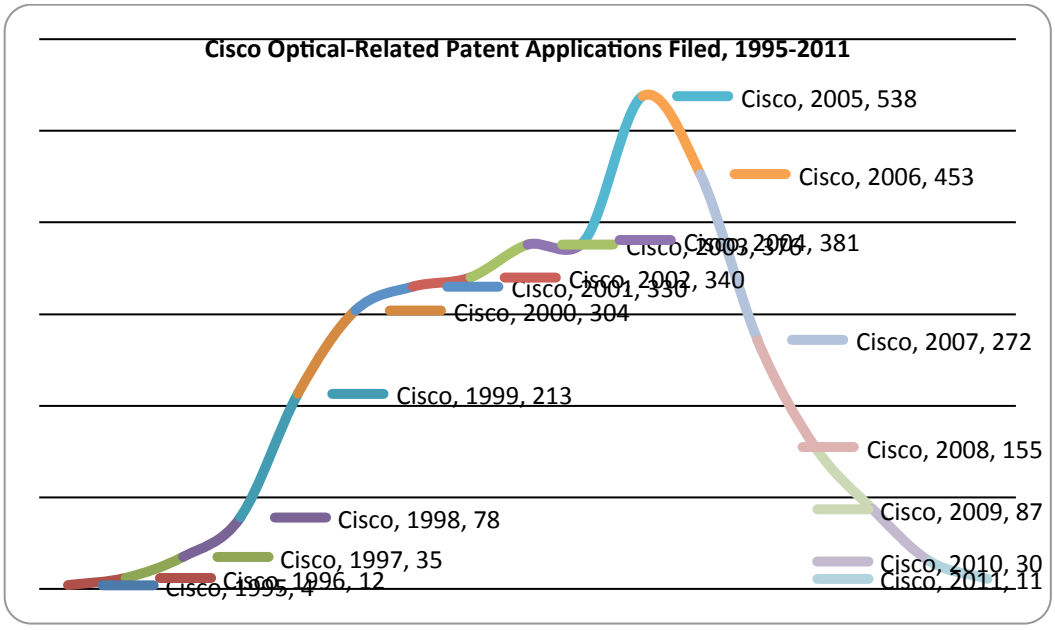
Ironically, it was partly this failure to develop a significant business in the operator segment that helped Cisco maintain growth in the years after the telecom bust. Cisco could continue to develop its enterprise business while its key competitors in the optical networking space: Alcatel, Nortel and Lucent, were faced with major revenue shrinkage. As one commentator explained: "much is made of Cisco's relative financial success versus its competitors, Lucent, Nortel and the European telecommunications giants, all of which are awash with debt. In a conference call announcing the company's [Q2 2006] quarterly results, CEO John Chambers proudly noted that Cisco grew an admittedly modest 7%, while its top competitors dropped a combined 43% in revenue. That success, however, was the lucky result of its failures to make headway in the service provider market. Between 1997 and 2001, Cisco's primary marketing focus was the service provider market, consisting of a global army of telecoms and Internet companies keen to build out their networks to drive the broadband revolution. But Cisco failed to break the incumbents' stranglehold, partly because it would not cede to carriers' demands for tailored solutions and partly because it was advocating a 'big-bang' equipment-replacement strategy, while service providers were committed to a more gradual migration approach. Having missed the telecoms spending boom of the late 1990s, Cisco was saved, ironically, by its very inability to become a leading supplier to the carriers."[17]

[17] "Cisco's softer side", *Information Age,* February 9 2006.

Diminishing optical focus in the downturn

After its eleven acquisitions in the 1990s, Cisco's activities in the optical space diminished considerably. It divested itself its Pirelli manufacturing facility in New Hampshire in 2001 and discontinued its DWDM products in 2004. The Monterey Networks products were abandoned in 2001 and Cisco closed the Queton Systems plant in Sweden in 2002. In 2005, eighty employees were moved from the optical group in San Jose, Richardson and Petaluma, where Cerent was based. A further 40 employees were moved in 2006 and, in 2009, Cisco finally closed the headquarters of its $7 billion optical acquisition, Cerent.[18]

In the first half of the 2000s, Cisco's applications of patents linked to the optical area soared to over 500 by 2005. However, the number of patents in the area for which Cisco applied subsequently fell dramatically to virtually none by the end of 2010. Despite making 68 acquisitions overall between 2001 and 2010, none were in optical networking.



Source: USPTO.
Search phrase (e.g., 2010): AN/cisco AND optic$ AND APD/1/1/2010->12/31/2010

Explaining the decision to pull discontinue a successful optical product, the wavelength router, in 2001, Cisco's Group Vice President of Optical Networking is clear that the time needed to recoup investments was viewed as too long: "it's a tough decision, but the bottom line is that in the curren economic environment, Cisco is focusing on business areas that provide immediate revenue growth. We fundamentally believe the future of service provider core networks is a meshed architecture, but service providers are not ready to deploy products like the ONS 15900 as rapidly as we originally anticipated".[19]

[18] Jim Duffy, "Cisco shutters Cerent HQ in Petaluma, CA. Spent $6.9 billion on optical transport company in 1999", *Network World*, November 5, 2009.
[19] Cisco Newsroom Feature, "Q&A : Cisco's Carl Russo discusses the Discontinuation of the ONS 15900 router", April 5, 2001.

Development of optical networking capabilites elsewhere

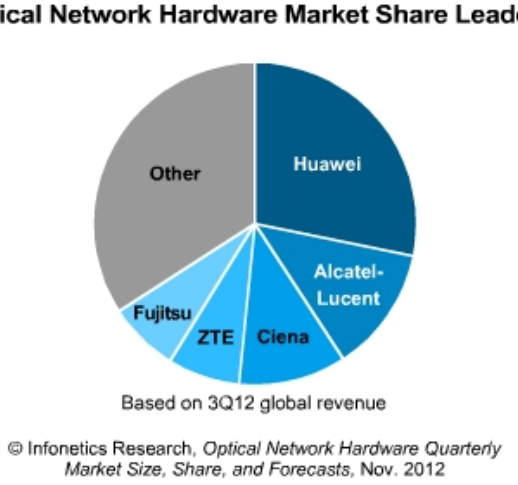
It is important to consider what what was happening with other companies during a similar time period, if we wish to understanding Cisco's inability to develop optical networking capabilities during the 15 years from 1995, when it integrated its first optical networking technology and 2010, when it relaunched its efforts to acquire such capabilites.

The company that has exhibited the most extraordinary growth in the area is the Chinese competitor, Huawei, that is currently leader in the segment, despite only having a marginal business in the US. Infinera is a Californian company that has specialised in the optical networking segment and that is only beginning to show returns on an investment and product development strategy begun in 2000. Both these companies exhibit an approche to the development of innovative capabilities that is strikingly different to Cisco's.

Huawei

The Chinese telecommunications giant, Huawei, has been leader in the global optical networking market since the third quarter of 2009. While Cisco had appeared in the pie-chart of optical network market shares compiled by market research firm, Informatics, in 2011, its share had declined enough by the third quarter of 2012 for it to disappear into the group with 'others' (graph 3).

Graph 3:



Source: http://www.infonetics.com/pr/2012/3Q12-Optical-Network-Hardware-Market-Highlights.asp, accessed November 22 2012.

Shenzhen-based Huawei was established in 1988 by Ren Zhenfei with a (seven-person) investment of $2,400 (RMB20,000) at the height of China's economic reforms.[20] It began by selling imported telephone call switches before developing its own space-division switching product (HJD-48) that would eventually sell at less than half of the cost of imported switches in the country. It used its revenues from these and other products that it designed and developed to invest in the R&D for the C&C08 switch, the key product that helped it dominate the Chinese telecom market (Low 2007:138, Athreye and Chen 2009:12). Because Huawei was birthed at the moment when the Chinese economy was liberalized, the global telecommunications multinationals flooded China, leaving Huawei to the markets where these corporate giants were not willing or able to go. In the early 1990's, Huawei focused on remote rural China, allowing it to build a base from which it could later penetrate larger cities and global markets (Li 2006:6-7, Athreye and Chen 2009:13).

Huawei's low-cost engineering - instead of low-cost manufacturing - is thought to be the secret behind its competitive advantage. In 2005, Huawei's research staff was 48.6 percent of the employee count, with 60 per cent of its employees holding master's or Ph.D. degrees. Even with this level of education and skill competence, many of the staff have salaries that are one-third to one-fifth those of their Silicon Valley counterparts, enabling the company a cost advantage in the marketplace (Normile 2005, Li 2006:7). Additionally, Huawei allocates at least 10 percent of revenue to research and development (R&D) by "company law." The company has R&D centers in Beijing, Shanghai, Nanjing, Hangzhou, Xi'an, and Chengdu in addition to its Shenzhen headquarters (Li 2006:7).

Huawei's internationalization process mimicked its process of expanding domestically throughout China. It began with less developed countries in South East Asia and South America, helping it develop an international base with which to expand into the Middle East and more developed markets like Europe and eventually North America (Li 2006:9, 2007:19). Huawei is known for waging price wars and selling at or below costs to either lock out competition or find a way into the market. For example, in the 1990 and throughout the 2000's, Huawei's products cost approximately 30% less than those produced by Cisco (Bian 2005:92,95). Huawei's move into price-sensitive emerging markets has also been bolstered by its low-cost workforce, assistance from the Chinese government in financing the purchase of telecommunications equipment overseas, and diplomatic governmental assistance as a tool for new 3G deals in emerging markets (2005).

Huawei's plans to move actively into the US market since 2001 received its first setback in 2003 with the filing of a lawsuit by Cisco accusing it of infringing its intellectual property rights. Cisco alleged that its patented technologies, sections of its company's user manuals, passages of source code, and even model numbers (making it easier for Cisco customers to switch vendors) among other things were copied by Huawei. In June 2003, the Texas Court issued an injunction halting Huawei from selling or distributing products containing the disputed IP. By July 2004,

[20] "Huawei's ownership is complicated and not transparent. It includes shares from the founder Ren Zhengfei (who amassed up to 5 percent of the shares) as well as joint-ventures or subsidiaries of Huawei, provincial telecom operators, and company employees (individually or collectively). Though company officials have indicated a public listing of Huawei was forthcoming since 2002, no IPO has yet occurred". Source: Larçon, J.-P. and G. Barré (2009). Technology-based competition and Chinese multinationals. Chinese multinationals. J.-P. Larçon. Singapore ; Hackensack, NJ, World Scientific**:** 127-149.

Cisco and Huawei resolved the matter out of court with Huawei making products changes to address Cisco's concerns without admitting guilt (Rhoads and Buckman, 2005; Sun, 2009: 146-148).

A further problem emerged for Huawei in the US market with the increasing mobilization of US lawmakers to fight the increasing success that Chinese equipment manufacturers were having over the decade in wooing Tier 1 carriers. The US House of Representatives' Intelligence Committee finally launched an investigation into the security threat posed by Huawei and ZTE, with one committee member stating explicitly: "The Chinese are aggressively hacking into our nation's networks, threatening our critical infrastructure and stealing secrets worth millions of dollars in intellectual property from American companies. This jeopardizes our national security and hurts U.S. competitiveness in the world market."[21]

The findings of the investigation, published in October 2012, offered little comfort to the Chinese equipment manufacturers hoping to develop their US business as this should be viewed "with suspicion", according to the authors of the report.[22] As a result, M&A activities should be blocked and government systems should exclude ZTE and Huawei. US network providers and systems developers were encouraged to seek other vendors, given the long-term security risks perceived with ZTE and Huawei. It was recommended that unfair trade practices involving financial support from China should be investigated, that Chinese companies become more transparent and that Congress should consider legislation to address the risks posed by such "telecommunications companies with nation-state ties or otherwise not clearly trusted to build critical infrastructure3.[23]

Huawei's Innovation in Optical Networking

Huawei continues to make innovative investments in its optical line of products. In 2003, Huawei acquired US-based Cognigine and Optimite, inheriting Cognigine's network processor as well as Optimite's Super Dense Wavelength Division Multiplexing (SWDWM) technologies (Low 2007:142). In 2003 and 2004, Huawei entered into strategic partnership agreements with LightPointe (USA) to sell its Flight ™ products, which are based on free space optic (FSO) technology, as part of Huawei's OptiX ™ line in China, Europe, and other emerging markets (2004, Low 2007:142)

In 2005, Huawei's ASON products and solutions were being used to construct intelligent transmission networks in China, Brazil, Russia, Romania, and Saudi Arabia. It has built over 400,000 km of DWDM backbone network with its super WDM technology that enables low-cost super-long-haul transmission. Huawei's GE-ADM technology and Metro WDM technology were being deployed in China and Europe as a Metro Ethernet service transmission solution and its OptiX BWS1600G DWDM system offered hybrid transmission rates 10Gbps and 40Gbps per wavelength (Huawei 2006:20). In that year, Huawei was selected by Frost & Sullivan as "Optical Vendor of the Year 2005," for its performance in the Asia Pacific market (Huawei 2006:3).

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[21] Ray Le Maistre, "Huawei, ZTE Probed by Intelligence Agency", *Heavy Reading*, 18 November 2011.

[22] Mike Rogers and Dutch Ruppersberger, "Investigative Report on the US National Security Issues Posed by Chinese Telecommunications Companies Huawei and ZTE", US House of Representatives, 112th Congress, October 8, 2012, p.vi. http://intelligence.house.gov/sites/intelligence.house.gov/files/documents/Huawei-ZTE%20Investigative%20Report%20(FINAL).pdf, accessed November 22 2012.

[23] *Ibid.,* p.vii.

In 2006, it continued to innovate with the rollout of SuperWDM+ technology (with enhanced transmission capability of long haul DWDM), an end-to-end WDM/OTN product and solution range of intelligent control platform, and an ASON/GMPLS intelligent optical network solution (Huawei 2007:18). In 2007, the company was awarded three InfoVision Awards 2007 by the International Engineering Consortium in recognition of its contributions to the global telecom industry in optical access, optical transport and resource control (Huawei 2008:27). In 2008, Huawei ranked first in WDM/OTN and launched the first 100G/100GE prototypes and the first T-bit OTN Product for both trial and commercial applications (Huawei 2009:20).
In 2009, Huawei launched the world's first end-to-end 100G solution from routers to the transmission system (Huawei 2010:3). That same year, the company also unveiled the OSN 8800 OTN solution (with 5.12 TBit/s cross-connect capability), allowing for the transmission of broadband services and the flexibility for operators to realize service grooming goals (2009). In 2010, this product was upgraded with the OSN8800 T16 next generation OTN, accommodating more bandwidth heavy services and forging ahead on Huawei's continued top position in the WDM/OTN market it held in 2009 (2010). In January 2010, Huawei announced its completion of a 100G long-haul transmission field trial with Spain's Telefónica over 1,022 km without electrical regeneration (based on OSN 6800 transport platform) (2010).

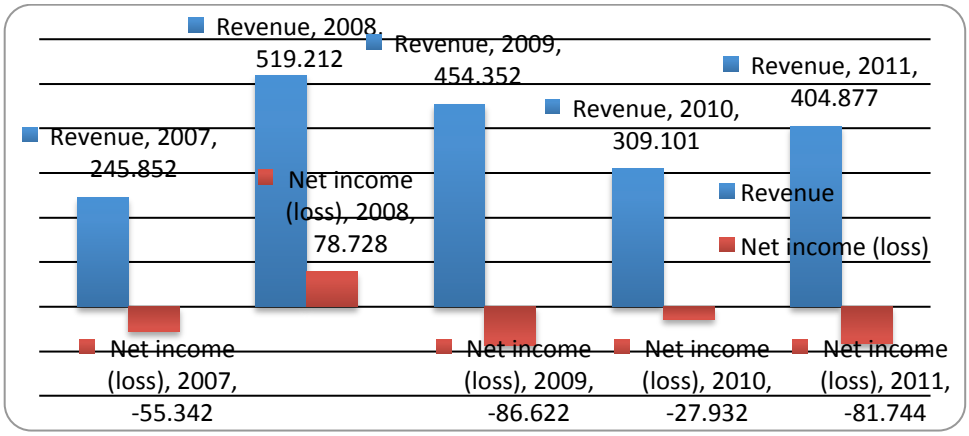
Infinera Corporation

Another SiliconValley company intent on revolutionizing optical networking, as Cisco had hoped to do, is Infinera Corporation. It was founded in 2000 and brought public in 2007 and has chosen to specialize in the upstream sector of integrated circuits. Infinera's Photonic Integrated Circuit, or PIC, combines dozens of optical components onto two tiny chips and are manufactured in its plants in California and Pennsylvania.
Infinera has developed a platform for optical transport and switching based on its PIC technology that will support 100 Gbps transmission with a 5 Tbps optical switch. From its inception, it has emphasized the importance of cross-functional interaction and manufacturing insights in the area of optical network design: "We began the design and manufacture of our PICs shortly after we were founded in December 2000. We employ a multi-disciplinary approach towards the development and manufacture of our PICs, with significant interaction between our manufacturing, system engineering and advanced technology groups. As a leader in the development of photonic integration, we have protected the intellectual property associated with our PIC manufacturing through a combination of trade secrets, patents and contractual protections. We believe that as a result of the combination of the multiple disciplines that were required to develop our PIC, together with the intellectual property protections that we have established, it will be difficult for others to duplicate the technology we have developed". [24]

In its fifth year as a traded company at the end of 2011, with revenues of $0.5 million, Infinera had made a loss of over $80,000 (Graph 4). Infinera raised $190 million in capital in its initial public offering in mid-2007 and a further $110 million in a second new public offering in October of the same year.[25]

Graph 4: Infinera revenues and income (loss), 2007-2011

[24] Infinera Corporation 2011 Annual Report on Form 10-K, p.6.
[25] Infinera Corporation 2007 Annual Report on Form 10-K, p.41.



Source: Infinera Corporation 2011 Annual Report on Form 10-K, p.40.

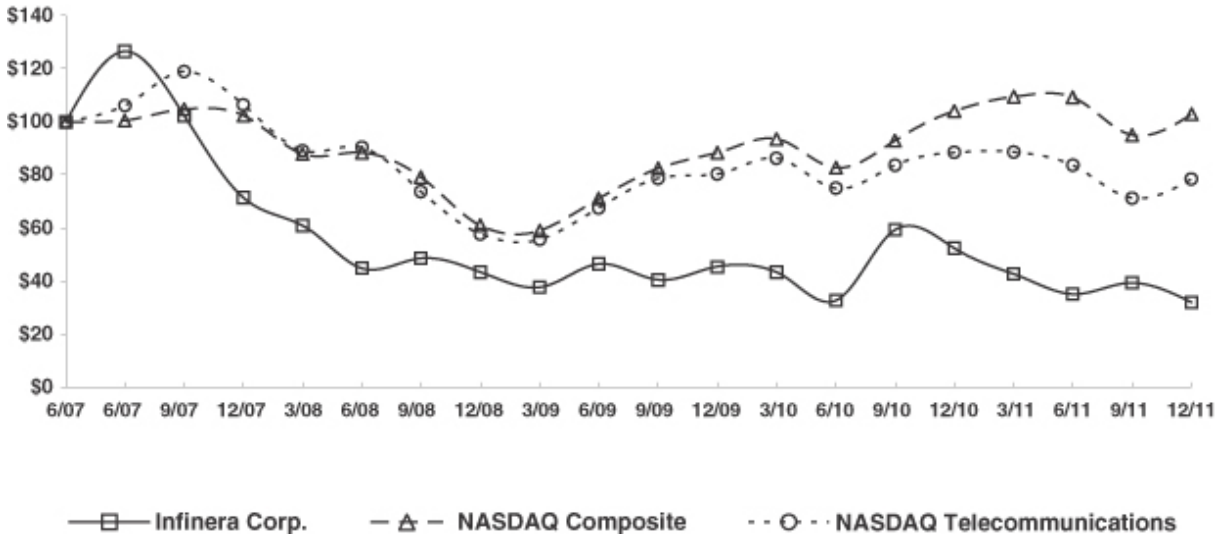
The company's share price has not performed favourably in comparison to the composite index of telecommunications company on the NASDAQ (graph 5). When Infinera's CEO, Tom Fallon, was asked "what is most important advice you can give for someone who wants to run a telecom company?", he replied: "My advice would be make sure you have a long view of the world. Investors can be shortsighted, and things can come along that are bright and shiny. The thing is to pick a technology path that is hard and big and that creates an opportunity for your customers to differentiate".[26]

Tom Fallon had been an operation manager at Cisco from 1993 until 2001 when he was made General Manager of Cisco's Optical Transport Business. In 2003, he became Cisco's Vice President of Engineering and Operations bit left to take up a position at Infinera in 2004 as Chief Operating Officer and Vice-President of Engineering and Operations. He became President and CEO of Infinera in 2010.

In 2011, Infinera had 1,181 employees, over one quarter of whom were located outside of the US, mainly in research facilities in India, China and Canada. Infinera invested 30% of its revenues in R&D and had 163 US patents, 3 international patents and had filed a further 178 US and 28 foreign patents.27 It continues to include manufacturing activities as a key part of its strategy however: "we believe that our vertical integration and manufacturing capabilities serve as a competitive advantage and intend to continue to invest in the manufacturing capabilities needed to produce new generations of PICs".[28]

Graph 5: Comparison of stock price, Infinera, NASDAQ Composite Index and NASDAQ Telecommunications Index, June 2007-December 2011

[26] Joe Baue, "CxO Download: Tom Fallon of Infinera", Light *Reading January 14 2011*
[27] Infinera Corporation 2011 Annual Report on Form 10-K, p.11.
[28] *Ibid.,* p.3.



Source: Infinera Corporation 2011 Annual Report on Form 10-K, p.39.

Conclusion

John Chambers, CEO of Cisco since 1995, regularly announces the company's priority growth areas in which the company expects to generate over $1 billion in revenues. Optical networking, as part of the Advanced Technologies Group, was still part of this list in 2004[29] and 2005[30]. Subsequently, in 2006, the key technologies mentioned in the advanced technologies group were security, storage, unified communications, and wireless.[31] Chambers is also believed to adhere to the Jack Welsh of General Electric's view that companies should only be in markets in which they can achieve a number one or number two position (Waters, 2003: ** - no direct quotation from Chambers on this point)

Despite consolidation in the optical networking market, the successful entry of Huawei and the acquisition of Nortel's optical capabilites by Ciena mean that there is little potential to move into a leading position via acquisitions in a short time period. It has also been noted that "if Cisco was serious about gaining a strong medium-term position in optical, the acquisition of Nortel's Metro Ethernet operations would have been a good opportunity to get most of the way there".[32] It is likely that what is more fundamentally problematic is the lack of margins in the optical networking segment: "let alone the kind of margin and net profitability to which Cisco is accustomed".[33]

One suggestion made for telecommunications equipment manufacturers to improve their margins and resist the price competiton imposed by new entrants from China is to build their own optical components, thus reversing the trend of the boom years, when manufacturing was outsourced to concentrate on more high value-added activities. Infinera is a clear example of such upward

[29] Cisco Annual Report 2004, p. 14.
[30] Cisco Annual Report 2005, p. 14.
[31] Cisco Annual Report 2006, p. 10.
[32] "Does Cisco want CoreOptics for internal use or to conquer the merchant market? (Part 2)", Optical Networks Daily, June 2, 2010.
[33] *Ibid.*

vertical integration, as the company's strategy from inception has been to develop its chip and build the optical system around it. Huawei has also developed capabilities in photonic chip manufacturing through its HiSilicon chip division and by acquiring, in January 2012, CIP Technologies, a British photonic integration specialist that was originally part of British Telecom's fibre optics division.[34]

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