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Briefing paper

Big Pipes, Big Dreams or Little Nightmares: bandwidth capacity in Hong Kong

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Bandwidth Galore?

Trying to map the number of submarine telecommunications cables criss-crossing the Asia Pacific region is like trying to sketch a bowl of noodles. But this is changing as existing pipes are being progressively replaced by a small number of very high capacity cables landing on coastlines and being lit-up. (See Appendix 1) The change is not just technological, although advances in optical technology, especially in dense wave divisional multiplexing or DWDM, the so-called 'rainbow' fibre technology, [1] have been crucially important. The coming of these cables represents a fundamental shift in the economics of the industry, spurred by the liberalization of the international telecommunications sector. In Asia this began in Australia and New Zealand, and has spread by degrees to Hong Kong, Japan, Malaysia, South Korea, and Singapore. Taiwan and even mainland China have begun the process, while Thailand and Indonesia are planning similar moves.

Just how large an increase in bandwidth is coming to Hong Kong can be measured by comparing the capacity before liberalization to the cable landings planned for completion by April 2002. According to OFTA's website, in September 2000 less than 10 Gbps was available by land and sea cable – mostly over the Asia Pacific Cable Network (APCN) - with an additional 1.1 Gbps by satellite. Twenty per cent of the cable capacity was on the US route, with 9 per cent going to Japan, 7 per cent to Singapore and another 7 per cent to China. Hong Kong's cable capacity doubled over night when the EAC system landed in March 2001. The four new cables due to be lit by 2002 are listed in the table below.

The capacity shown is shared between the countries in which the cable lands, [2] and initially only a fraction of the potential capacity will be lit. The table shows initial and potential capacities.

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[1] So-called because each wavelength in the spectrum represents a colour in a rainbow.

[2] Typically a submarine cable completes a ring. Traffic is directed along the 'working path' of the ring, but the opposite directional path, the so-called 'protected' path, is also kept open in case of breakdown. Unlike wireline communications, traffic 'lights' can be directed simultaneously along both paths of an optical fibre cable, but redundancy requirements place an operational constraint on doing so. According to a Goldman Sachs report (*Telecom Services: Global Broadband Infrastructure*, May 2001) adding additional rings for data traffic over certain routes can reduce the idle capital involved by up to 30 per cent.

Table 1
Cable Systems serving Hong Kong and South East and East Asia

Cable System	Capacity potential	Countries
New Systems reaching Hong Kong		
APCN2 (includes Reach and other 'national' carriers)	80 Gbps ⇨ 2.56 Tbps	Asia-Pacific region
C2C (including SingTel)	160 Gbps ⇨ 7.5 Tbps	Singapore, Malaysia, Philippines, China, HK, Taiwan, Korea, Japan
EAC - East Asia Crossing (Global Crossing)	80 Gbps ⇨ 2.56 Tbps	Singapore, Malaysia, Philippines, HK, Taiwan, Korea, Japan
FLAG Tiger System (including Level 3)	160 Gbps ⇨ 3.84 Tbps	HK – Taiwan- Korea – Japan
Existing System serving Hong Kong		
APCN (A-P 'national' carriers)	10 Gbps ⇨ 20 Gbps	Thailand, Vietnam, Malaysia, Singapore, Indonesia, Philippines, HK, Taiwan, Korea, Japan
Pre-APCN: Hontai-2 linking with Taiwan, H-J-K linking with Japan and Korea, T-V-H linking with Thailand and Vietnam, APC linking with Japan, Taiwan, Singapore and Malaysia. See J.Ure (1995, 1997) *Telecommunications in Asia*, pp.130-131, with map		
New Systems serving Asia-USA		
Pacific Crossing, China-US, Southern Cross, Japan-US, Southern Cross Cable Network, FLAG Pacific, TyCom Trans-Pacific		380 Gbps ⇨ 9.5 Tbps
New Systems serving Asia-Europe		
SE-ME-WE-3, FLAG FEA, SAT-3/WASC/SAFE		150Gbps ⇨ 320 Gbps

Measuring Bandwidth

Using data from Level 3's example of the FLAG system - submarine cables typically have 6-8 fibres - the following formula is the measure of capacity of a submarine cable using 'rainbow' DWDM.[3] That is, using current technology each fibre can be divided into 64 or more different wavelengths each of which transmits up to10Gbps.

6 fibres x 64 ë x 10 Gbps per wave length = 384 Gbps

As a recent Goldman Sachs report (*Telecom Services: Global Bandwidth Infrastructure* May 2001) points out, each colour (ë) can have a bandwidth up to 10 Gbps (as in the

[3] For future systems DWDM also permits a wider spacing of repeaters on the ocean floor than the 60-80 kilometres at present. Optical switching is another coming technology that promises much greater flexibility in system routing and configuration.

FLAG example) which implies 64 x 155 Mbps circuits (OC-3/STM-1 circuits) = 9,920 Mbps (OC-192/STM-64). Current rates of OC (optical carrier = payload speed) or STM (synchronous transport mode = signaling rate; also known in Europe as Digital Span, or DS) are given follows:

- OC-3/STM-1/DS1 = 155.5 Mbps
- OC-12/STM-4/DS2 = 622.1 Mbps
- OC-48/STM-16/DS3 = 2,488 Mbps (2.5 Gbps)
- OC-192/STM-64/DS4 = 9,953 Mbps (10 Gbps)

Currently spacing between bands is typically 100–200 GHz, but according to Telegeography's report *International Bandwidth 2001*, new technologies may well reduce these to 50 or even 25 GHz and push ë up to 340, a five fold capacity increase. With such capacity potential, and with the downturn in the global economy and the collapse of the dot.com bubble, the perennial question arises: is there a glut of bandwidth, and if so for how long and with what consequences? Before addressing other aspects of this question, one of the consequences will be a reduced need for satellite transponder space for telecommunications. Or will it?

Satellites

Telecommunications satellites will continue to serve remote areas not served by cables, such as the many islands of Indonesia, the Philippines, the Pacific islands as well as remote landlocked regions, and will continue to provide redundant capacity. But the principal future non-military use of satellites probably lies in four areas. First, in television and related applications, such as the delivery of health services and distance learning, and possibly in fast Internet and streaming video services. Second, in digital radio applications, such as location and monitoring services to vehicles. Third, in surveillance, such as monitoring weather patterns, disaster zones, and prospecting agricultural, forestry and mineral resources. Fourth, the continued use of Vsats for private commercial communications is likely, but growth around the Asia Pacific has been rather under expectations to date.

Economic Fundamentals Have Changed

The driving force behind liberalization has been the market, principally the by-pass of official tariff structures. Market arbitrage whittled away resistance. Callback, refile and voice-over-IP have subverted the old cartel or 'club' of national 'international' carriers. Gone, or fast disappearing, is the international accounting rate system. Gone, or fast disappearing, is the ownership of 'half-circuits' by telcos, bought through their investment in cable consortiums of international carriers which confer 'indefeasible rights of usage' or IRUs to the investing carriers. The 'half-circuit' concept – which measures ownership to a notional half-way point between countries – was appropriate to a time when national 'international' carriers did not seek to market their services outside their own jurisdictions. But as their customers, such as banks and airlines, became increasingly 'multi-national' so did they. They had little choice anyway once their 'corresponding administrations' overseas begun entering their market, for example with calling cards that route overseas calls and the billing to a customer's 'home' carrier. AT&T, itself in

competition at home from MCI/Worldcom and US Sprint, was one of the first to offer this service in Hong Kong in the 1990s. “If you can’t beat ‘em, join ‘em” was the inevitable reaction.

Today international carriers compete by offering end-to-end capacity and services, and wherever possible, local delivery to central business districts (CBDs) as well. The 1990s saw new players enter the ‘big pipes’ scene, companies like Global Crossing, Level 3, Qwest, Sprint, TyCom, Williams, Worldcom, 360 Networks, alongside traditional players like AT&T, BT, Cable & Wireless, Deutsche Telekom, France Telecom, KDD, Teleglobe, Telstra, and so on. New, but often shifting alliances were forged and fell apart again.[4] The basis of these alliances was not altogether clear. Were they marketing alliances, trying to exploit the geographical synergies between different networks, taking advantage of economies of scope in network services, or were they trying to reduce duplication and cost? Each fell foul of the competing interests of their members and to the changing structure of ownership within the industry. As far as cable investment was concerned companies could choose their strategy between the conventional consortium approach and going it alone, using IPO financing and venture capital. The recent economic downturn then had its impact. Project Oxygen went bankrupt. Earlier this year, 360 Networks filed for bankruptcy. [5] In the past month Qwest and Worldcom have both announced major investment cutbacks. Level 3 is buying back debt. Tycom recently pulled out of a new FLAG Japan-US cable project but appears to be pushing ahead with a system of its own serving East Asia. But the real impact on the economics of the industry is in the way intermediate and end-users can now secure bandwidth.

From an end user’s perspective, more bandwidth means more competition and choice of carrier, not least for redundancy purposes, lower prices and, when prices eventually bottom out, competitive quality and service level agreements. From a carrier’s perspective, it means a much more flexible marketing mechanism for wholesale capacity. No longer will smaller regional carriers or domestic new entrants looking for international bandwidth be forced into the highly expensive purchase of IRUs, assuming IRUs are made available from existing consortiums.[6] A variety of leasing arrangements are now becoming normal, and at much more competitive prices, especially where pre-sale takes place. This is where a carrier commits itself to buying a given level of capacity for so many years ahead of the cable landing and being lit. Discounting by volume and duration of contract is rife, knocking any real meaning out of posted tariff rates. (For tariffs, see Appendix 2)

Wholesale Pricing

The same can be said for the prices offered to other commercial carriers and large corporate users. For example, larger ISPs and data centres and companies running

[4] Such as Concert (AT&T/BT) and Global One (FT, DT, Sprint) and UniSource (PTT Netherlands, Telia, Swiss PTT, Sprint) and the Financial Network Association (Telstra, Belgacom, DT, FT, HKT, ItalCable, KDD, MCI, Mercury, SingTel, Stentor and Telefonica).

[5] This raises an issue: what risk is now attached to presale or to the purchase of an IRU in a future system?

[6] The ‘club’ mentality was both exclusive and highly secretive – even discovering who were the members of a consortium was a task of major detective work.

international call centres all have need for bandwidth, albeit on a basis that expands incrementally with business. Purchase arrangements which guarantee bandwidth on demand as and when the traffic requires it involve intensive discounting as the fight for market share accompanies the coming online of the new bandwidth carriers. The losers are without doubt the incumbent national carriers, but their loss is not terminal.

In many ways the region's national carriers are in a strong position to migrate their customer base to IP networks, e-business applications and managed networks services. Regional alliances will strengthen this trend. In all likelihood, the real challenge lies less in state of the market – intra-Asian traffic is forecast to grow strongly over the coming decade - or in competition from US and European international carriers, and more in the difficulty of finding common ground and a basis of partnership with other players in the region. But there is no doubt that international bandwidth prices, which have remained much higher across Asia than in Europe or the USA, where the pace of liberalization has been much faster, are due to collapse. According to the Goldman Sachs report *(Telecom Services: Global Bandwidth Infrastructure*, 1 May 2001) bandwidth prices fell globally an average of 42 per cent 1999-2000, with cross-Atlantic prices leading them down by 66 per cent. Across Asia the report foresees STM-1 prices coming down by nearly 40 per cent annually 2001-2004. Other reports, such as Jardine Fleming (*Hong Kong telecoms/Internet – PCCW*, September 2000) cite industry sources expecting costs on the Hong Kong – Japan route to fall by 85 per cent during 2001 and maybe 50 per cent again in 2002. A general view in Hong Kong seems to be that bandwidth prices have come down maybe 50 per cent on average during 2001 and will fall a further 45 per cent next year.

These price reductions reflect cost reductions as well as increased supply. The Goldman Sachs report estimates the cost per Gbps per kilometer of building a cable system has fallen from US$4,000 Gbps/Km to US$450 Gbps/Km, and the incremental cost of lighting a new fibre – typically 10-15 per cent of the capacity is lit upon landing a cable – has come down from US$100m to US$60-75m.

Bandwidth and Minutes Exchange

Market mechanisms to under-cut tariffed prices abound. We noted above that commercial agreements invariably include sizable discounts according to volume, duration of contract, the significance of the customer and so on. For example, some carriers will offer to buy-out long-term contracts that potential customers have entered into with other carriers, such is the competition for market share.

Another market mechanism is the exchange system.[7] For domestic Internet traffic the HKIX (based at the Chinese University of Hong Kong) offers capacity. For international Band-X appears to be the only player currently in the market, at least two others having closed shop over the past year. Until now ISPs have entered into contracts, typically one year, with one or other of the major carriers for trans-Pacific connectivity. Companies

[7] 'The biggest benefit offered by bandwidth exchanges is greater pricing transparency, which helps buyers to identify the "going rate" for a specific type of circuit on a particular route.' (TeleGeography, *International Bandwidth 2001*, p.19).

like Band-X offer shorter tie-in contracts of typically one month and thereafter-daily transactions if required. In a period of rapidly falling prices there will be advantages for some ISPs in this approach, others will undoubtedly be offer attractive alternatives by the big pipe providers, and in many cases the major ISPs will be affiliated to a big carrier. For example, Netvigator is part of the PCCW group, HKNet part of the NTT group. The other major market is in the trading of traffic minutes. Again carriers will sell minutes available on particular routes and buyers using the exchange platform - which in the case of Band-X physically links the pipes of the buyer and seller - will bid for them. Minutes going to the buyer at the lowest offer price will absorb the minutes they require, the next lowest buyer will absorb their requirement, and so on until 100 per cent of minutes have been sold. Prices will adjust according to minutes unsold. (See Appendix 2 for an example of bandwidth trading prices.)

At one time it was speculated that exchanges could break through the cartel arrangements that dominated international bandwidth pricing. That has not happened. Exchanges provide the arbitrage machine with oil, but the real determinant of prices are the enormous bandwidths now beginning to come online in Asia, and the pricing is steered by big pipe operators who are out to capture market share. This is a volume business at a moment when growth in demand, however certain long term, is currently uncertain.

Demand for Bandwidth

Demand, as we saw earlier, falls into three categories: primary carrier's demand, demand from secondary carriers such as smaller national networks and ISPs, and end-user demand, principally from large corporate users. As more SME's gain access to local broadband connections there will be a growing demand for direct international access from this source, especially those companies that are involved in electronic commerce on any significant scale. However it is most likely that local national carriers and ISPs will be their first line of service provider rather than the operators of big oceanic pipes. Finally, various big pipe operators are building their business by moving up the value chain to provide a range of services from co-location and data centre management, to IP transit and routing, to switched minutes of voice and data traffic, to VPN facilities and services, including 'last mile' facilities, and even to content distribution. Different operators have different strategies and, especially following the downturn of the US and global economies, are re-focusing on markets by segment and by geography.

The prognosis for demand in the short-medium term is anyone's guess, although most observers believe strongly in the longer-term demand for bandwidth. For example, on his webpage, bandwidth's guru (no technology is complete without one) George Gilder [8] remains unmoved by the recent downturn. According to Ovum Research (cited in CSFB *PCCW-Reach*, 3 April 2001) the Asia Pacific region will see an 86 per cent CAGR in voice and data traffic combined 1999-2005. The following table summarises Ovum's forecast.

[8] In 1997 Gilder forecast ('Fiber Keeps its Promise', *Forbes ASAP*, February) that total bandwidth will triple every year for the next 25 years. This was then declared to be Gilder's Law.

Table 2

Forecast Peak Load Traffic Demand for Asia-Pacific (Mbps)			
	1999	2000	2005(e)
Voice traffic	1,586	1,756	7,174
Corporate data traffic	11,386	19,227	188,369
Internet (daytime)	10,527	32,328	1,615,084
Internet (evening)	2,689	8,834	633,560

Ovum Research

Rather the scrabble around for a range of forecasts, it is worth quoting a passage from Teleography's *International Bandwidth 2001* report:

> is there, or will there be, a capacity glut? Resolving this quandary requires an accurate gauge of bandwidth demand. Most efforts have focused on bottom-up [9] approaches to modeling demand: gather a wide range of statistics on end-user traffic (e.g., number of users, peak user flows, bandwidth per application), then run them through a set of assumptions to see how much bandwidth to provision. To test the accuracy of this approach, the results of the predictive models are measured against TeleGeography's historical inventory of actual network deployment. A comparison suggests that most models chronically overestimate the capacity actually deployed in networks. In particular, Internet bandwidth has historically been far smaller than most models have predicted.
>
> Even more troubling- at least at first glance- is a comparison of projected network deployment against the future supply of lit, available bandwidth. Not a single model predicts that bandwidth provisioned in networks will amount to even half of the lit capacity across the Atlantic and Pacific … This huge gap provides a clue that projections based on network provisioning requirements tell only half the story; purchased but unused capacity also figures strongly in the bandwidth demand equation. Service providers tend to purchase excess capacity for a range of reasons, including network redundancy and long provisioning times. This excess buying behavior is bad news for models that focus strictly on network traffic requirements to predict future bandwidth demand. For investors of companies that depend on bandwidth sales, though, it is a most welcome phenomenon. (Executive Summary, p.18)

Policy Issues

A major consequence of falling international retail (IDD) and now wholesale prices (IPLCs) has, of course, been the impact upon cross-subsidization of the local loop and the

[9] The Goldman Sachs report uses a top-down approach (p.15) arriving at a less optimistic forecast – JU.

universal service obligation, or USO. In Hong Kong's case the ending of the exclusive international telecommunications licence of HKTI and the subsequent introduction in January 1999 of international simple resale (ISR) simply knocked the bottom out of the cross subsidy. [10] Local loop tariffs have been rebalanced to reflect cost, and for the moment the USO is being met by a fee levied on all international service providers, which offers some financial relief. But clearly national 'international' carriers have to become regional players, if only to aggregate sufficient traffic through their hub. Going regional is not an option, it is a necessity, and it will involve new alliances that are typically shifting alliances in the telecommunications business. [11] But it is the notion of 'hub' that stands out.

Is a hub still a relevant concept in a world of the Internet and IP? If it is, and there is perhaps little doubt that corporate business centres, data centres and the like will continue to act as nodes within the architecture that supports the expansion of regional traffic for the foreseeable future, then there remains a strong national interest in the routing behaviour and patterns of the regional carriers.[12] A liberalized and light-handed regulatory regime clearly offers more incentive to hub through a territory than the reverse, but how far is hubbing determined by proximity to markets? In principle, the 'death of distance' should leave network operators indifferent to the geographic location of their hubs, but has the 'death of distance' been over-stated?

In Hong Kong's case the continuing presence of so many multinational company regional headquarters indicates that for the time being at least Hong Kong remains the location of choice for south east and east Asia. China's entry into the WTO is likely to have a dual effect of countervailing forces. On the one hand more companies will shift their regional headquarters to Beijing and Shanghai to deal directly with mainland business issues and representation. As China's telecommunications reforms deepen, and the quality and range of services improve to match falling prices China will itself develop economies of aggregation in this area. On the other hand, insofar as Hong Kong continues to benefit from being China's major entrepôt and centre for business and financial services, and trade and marketing activities, Hong Kong will remain the premier hub of the region.

The really challenging issue for Hong Kong is none of the above, but whether Hong Kong reverses recent trends and strikes out to reassert a regional presence in its own right. Has it the strength of vision as well as the orientation in services to do so? Can it

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[10] For an analysis of the impact of ISR on HKTI's revenues, which finds a 70 per cent decline if applied to the 1995 data, see J.Ure (2000) 'The era of international simple resale: not waving but drowning?' *Telecommunications Policy*, v.23.2, February, pp.9-30. (Also at www.trp.hku.hk.) It became immediately apparent why C&W plc could want to sell its ownership of HKTI, although other strategic factors also drove the decision.

[11] The regional ambitions of HKTI, now Reach – jointly owned by PCCW and Telstra - and SingTel, are examples of this, but others are bound to follow. KDDI of Japan is one candidate, but NTT of Japan is only just moving into the international market. Korean Telecom is another candidate, as is Malaysia Telekom and Indosat and PT Telekom of Indonesia. The CAT and possibly the TOT, of Thailand are candidates for the future.

[12] So economic rather than 'security' issues may be more relevant to the debates over foreign ownership of national carriers.

move its business services sector further up the value chain and across a wider region. The problem is that many of Hong Kong's most successful service enterprises thrive by ring-fencing their commercial activities, and for sure this no longer works in the communications sector. But creating barriers to entry has been an important business strategy since commerce began. Where this differs from the business of providing international bandwidth is that barriers to entry in the latter case arise from the huge upfront costs of building and laying a submarine optical fibre cable, whereas the incremental cost of providing service is low and falling. The industry is now entering an era where bandwidth becomes a commodity. It has happened in the USA and it has happened on the cross-Atlantic routes. It is beginning to happen within Europe and it is now about to happen in Asia, at least where the sector has been open to competitive entry. [13]

Weak Link in the Chain

There is one link in the chain that has yet to be established before genuine end-to-end international bandwidth at cost plus becomes the norm. That is the 'last mile'. New entrants can land cable, but they then have to connect that landing station to their point-of- presence, or POP, within the territory. This backhaul link will remain the first bottleneck in Hong Kong until 2003 at least, after which new entrants may be allowed to build their own. Currently, only the four FTNS licence holders – or five, if we include the rights extended to Reach to connect their international gateway switch to the SAR's territorial border – have the right of way to lay cables. But having reached their POP a second bottleneck arises for new entrants, namely reaching their customers. To achieve this they are required to lease private circuits from an FTNS provider, and here the prices are high. In some cases it seems the price can add on as much as 30-40 per cent to the overall cost of the international connection. [14]

This would prove unsustainable if the local FTNS market were opened further to competitive entry, but clearly there is no enthusiasm for yet more street digging in Hong Kong, so at least two options seem appealing. First, FTNS licensing with rights of way restricted to serving certain areas and with mandatory sharing of ducts and other bottleneck facilities. Second, FTNS licences for utility companies and other organizations that have ducts, tunnels, bridges, etc through which fibre cables can be laid. These licences could be class licences that endorse certain commercial activities, such as wholesaling or reselling. Then, and only then, will Hong Kong achieve a fully competitive market in international telecommunications.

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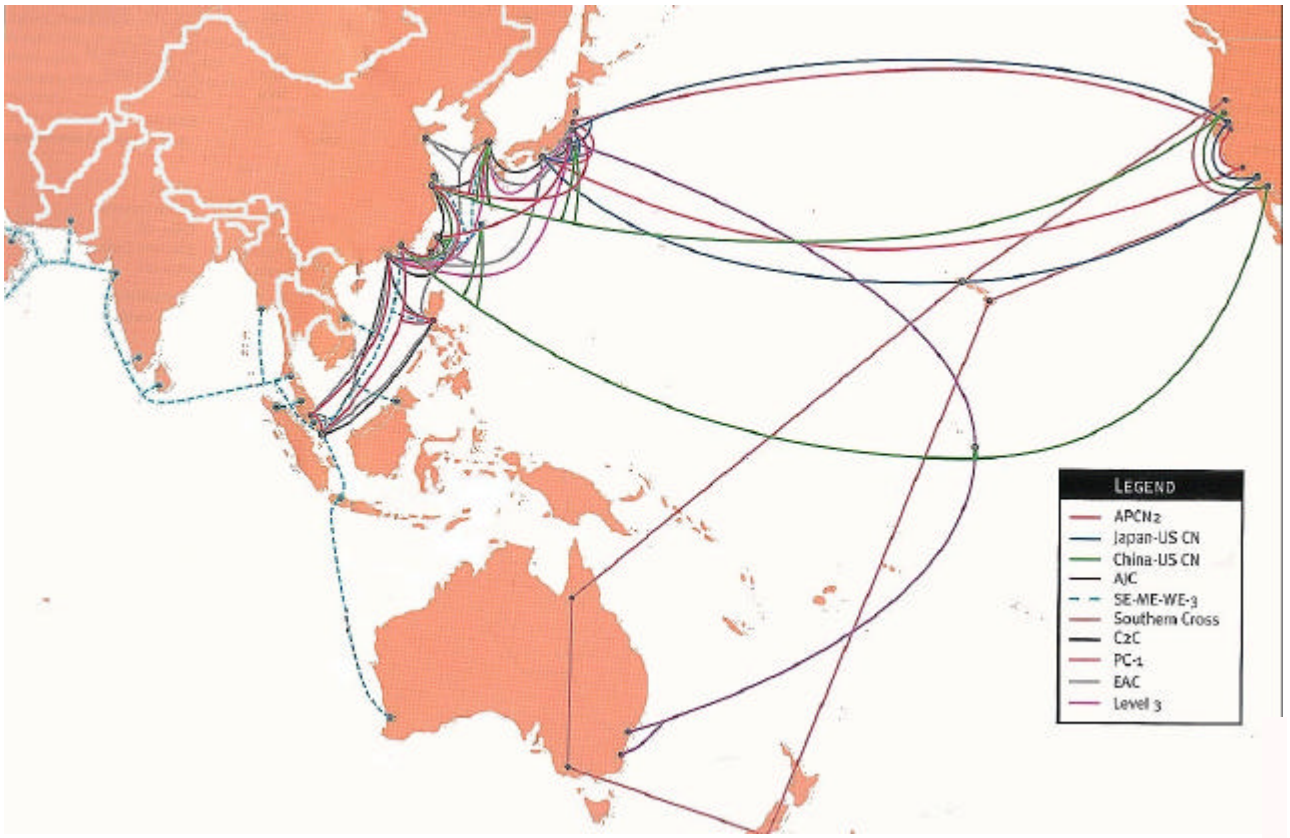
[13] Becoming a commodity, but not yet a commodity. The system of bandwidth wholesale remains opaque, while substantial and non-regular deviations of price from standard contract terms typify the industry across the Asia Pacific. (See, for example, TeleGeography, 2001, *International Bandwidth*)

[14] 'A straw poll on recent long-haul network bids suggests that last mile connections add about 30 per cent to the cost of an end-to-end connection.' (TeleGeography, *International Bandwidth 2001*, p.18). Japan seems to be tackling this problem where, according to *Total Telecom* 13 Sept. 2001, SingTel's C2C network has won a Type 1 facilities licence.

APPENDIX 1

Asia Cable Capacity



Jardine Fleming Research, September 2000

Appendix 2

Bandwidth Pricing

Growing bandwidth capacity is fuelling competition among carriers within the Asia-Pacific region and providing opportunities for bandwidth resellers and capacity exchanges. In Hong Kong, Reach (formerly Hongkong Telecom International) is still considered a dominant player in the provision of IPLCs and therefore its prices are tariffed only with the approval of the Telecommunications Authority. Two sets of tariffs are approved, the Basic Rate (which has remained virtually unchanged since 1998 when the market was liberalised) and Reach's discount plans. These plans include further discounts according to the capacity ordered, commitments to future orders and length of contract. For most buyers these rates are for reference only as non-dominant players, who are rapidly growing in number, are free to offer any discounts they like, including buying out the long term contracts of Reach's customers. In terms of circuit provisioning it is difficult to see Reach's status as a dominant player remaining for long.

The following tables illustrate the IPLC tariffs of Reach and these are followed by an example of bandwidth capacity exchange prices, randomly selected from a web search that accessed the site of US-based Bandwidth Market Ltd.

1. Reach (PCCW/Telstra): data in HK$

Reach's Pre-Discount Tariffed Wholesale Rates for IPLCs (Satellite and/or Terrestrial Duplex)

Reach's Pre-Discount Basic Rate (Note: tariffed rate for reference only) - HK$							
Zones/Speeds	**56/64**	**128**	**256**	**512**	**1.024**	**T1**	**E1**
China (South) & Macau	20,000	31,000	50,000	77,500	122,500	160,000	187,500
China (Rest), Taiwan & Philippines	32,000	49,600	80,000	124,000	196,000	256,000	300,000
S.E.Asia & Pacific	32,000	49,600	80,000	124,000	196,000	256,000	300,000
USA & Canada	40,000	62,000	100,000	155,000	245,000	320,000	375,000
Rest of World	40,000	62,000	100,000	155,000	245,000	320,000	375,000

Reach's OFTA-Approved Wholesale Discount Rates (Plan B) for IPLCs

IPLC Wholesale Discount Plan (B) for Terrestrial Duplex						
Minimum Commitment Period – 1 Year						
Speed	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5**	**Zone 6**
64 Kbps	83.87%	80.27%	72.75%	87.40%	85.89%	76.32%
128 Kbps	80.30%	78.24%	68.44%	87.69%	86.21%	73.88%
256 Kbps	77.60%	76.38%	65.75%	87.63%	86.15%	71.66%
512 Kbps	72.32%	74.28%	62.70%	87.01%	85.45%	69.13%
1.024 Mbps	75.27%	75.14%	63.95%	87.50%	86.01%	70.16%
T1	80.13%	77.22%	66.96%	88.46%	87.07%	72.66%
E1	81.70%	78.95%	69.48%	89.25%	87.96%	74.74%
T3	92.63%	90.98%	86.92%	95.39%	94.84%	89.17%
STM-1	95.08%	93.99%	91.28%	96.93%	96.56%	92.78%
STM-4	95.70%	94.74%	92.37%	97.31%	96.99%	93.68%

Zones: (1) China, Macau (2) Taiwan, Singapore, Malaysia, Philippines, Korea (3) Australia, Thailand, Indonesia, other S.E.Asian countries (4) Japan (5) North America (6) Rest of World.

2. Bandwidth Trading: data in US$

Cost of VoIP Wholesale Minutes to China from the USA
www.bandwidthmarket.com, 14 September 2001

City in China	**T** ¢ p/m	**E** ¢ p/m	**P** ¢ p/m	**D** ¢ p/m	**D + P** ¢ p/m
VoIP					
Beijing	2.5	2.8	3.2	3.5	4.0
Shanghai	2.2	2.5	2.8	3.0	3.5
All others	4.5	4.8	5.0	5.5	6.0
Cell phone	5.0	5.3	5.5	6.0	6.5
International	56.0				
PSTN					
International	56.0				
PSTN in China	8.5				

T = guaranteed 99.9% no cut off; connection rate to wire phone more than 50%; connection rate to wireless phone more than 30%
E = T + provider responsible for minutes termination and equipment in China
P = E + provider also responsible for public Internet access (but no quality guarantee)
D = E + provider also responsible for whole dedicated leased circuit from LA to China

Cost of PSTN Wholesale Minutes to China from the USA
www.bandwidthmarket.com, 14 September 2001

Call type to:-	**US$ per minute**
China wire phone	$0.042 per minute
China cell phone	$0.0445 per minute

Dedicated Whole International Private Leased Circuits (IPLCs)
from www.bandwidthmarket.com, 14 September 2001

Circuits	**L.A. - China (IPLCs) US$ per month**	**China access US$ per month**	**Installation fee US$ for 1st month**
64 kbps	1,500	400	3,000
128 kbps	3,000	600	3,000
256 kbps	5,000	800	3,000
512 kbps	8,000	1,000	3,000
1 Mbps	12,000	1,200	5,000
1.5 Mbps (T1)	15,000	1,200	2,800
2 Mbps (E1)	20,000	1,200	3,400
45 Mbps (T3)	28,000	10,000	5,000

Appendix 3

Companies with External FTNS Licences and Selected Companies Providing International Services from Hong Kong

Company	**External FTNS**	**Satellite EFTNS**	**Services**
APT Telecom (SingTel and APT Sat.)		✓	
Asia Global Crossing (in HGC JV)	✓		
AT&T/BT (Concert)			✓
Cable & Wireless			✓
China Digital satNet		✓	
China Netcom Corporation (CNC)	✓		
China Unicom	✓		
CLP Telecom	✓		
CTI International		✓	
Deutsche Telekom			✓
Equant (France Telecom IP services)			✓
ET Network Services			✓
FLAG Telecom Asia	✓		
France Telecom			✓
Galaxy Satellite Broadcasting		✓	
GB21 (SingTel)	✓		
Japan Telecom			✓
KDDI			✓
Korea Telecom			✓
Level 3	✓		
New T&T			✓
New World			✓
NTT	✓		
Origin			✓
Qwest			✓
Pacific Century Matrix (PCG)		✓	
Reach (PCCW/Telstra)	✓		
Sky Citi-Link International Telecom		✓	
Smartone		✓	
Telecoms Technology Investments Ltd		✓	
Teleglobe		✓	
Telhope Information Development		✓	
TMI (Telemedia – Telecom Italia)			✓
Worldcom			✓