The Business Case for PON

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Abstract: The need for upgrading the access network to PON is reviewed from technical and environmental perspectives, and an order-of-magnitude financial model is developed to estimate the costs, time-line, and return-on-investment.

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(060.4510) Optical Communications.

1. Introduction

The argument for PON is straightforward: more bandwidth than can be supplied by legacy access networks is needed for the new generation of IP-based services. These applications, viewed as key sources of revenue by many network operators, are driving the deployment of access fiber in many parts of the world. This paper reviews the case for retiring twisted pair- and coax-based networks and examines some of the financial implications of the transition to a PON-based access network.

2. Technical Drivers

The rapid and continuing increase in subscriber demand for bandwidth is well documented. Projections for the coming decade suggest that sustained bandwidth demands on the network will range from 10 to 50 times today's load [1,2], which very likely will require not only substantial new investment but also new approaches to network architecture [3,4]. The access network in particular will be challenged; for example, cloud-computing applications, which require the infrequent, rapid transfer of large files, are extremely sensitive to network delay due to the closed-loop nature of TCP/IP. For cloud computing to work properly, i.e., for the user experience to compare favorably with that of accessing programs and data stored locally on a PC, the disk-drive on the remote server must "look and feel" like a local disk-drive. In other words, a subscriber must be able to transfer large files (gigabytes in size) at high, sustained data-rates (hundreds of Mb/s) across the network, on-demand. There is little hope that today's access networks, based on twisted-pair and coax subscriber loops, can be "tweaked" to perform at this level, hence we must plan for a fundamental transformation of the outside plant.

For a variety of reasons systems that rely on fiber-fed, powered nodes in the outside plant will serve as stop-gap measures at best. Not only are there hard limits on how much bandwidth these platforms ultimately can support, they also are much more expensive to operate than passive networks [5], with the expense of powering the remote node being a particular problem. Finally, in terms of carbon footprint they are not competitive: for the same capacity per subscriber an HFC or xDSL system consumes almost twice the power of a modern PON system, while a WiMax system consumes almost three times the power [6-8]. The difference per subscriber can be as much as 50 W of continuous load on the power network; for a large network with tens of millions of subscribers, this translates into penalties of hundreds of megawatts of additional load on the power generation and transport infrastructure, the annual, additional combustion of millions of tons of coal, and the annual, additional release of millions of tons of CO_2. Given the magnitude of the difference between PON systems and powered-node approaches, the day is coming when environmental considerations will trump expediency in the design of access networks. In summary, although systems that rely on remote, powered nodes will see continuing deployment in the short term, their demise is certain and a passive, all-optical plant represents the future.

3. Financial Considerations

Replacing the cabling in the outside plant and all of the electronics in the access network is, of course, a huge undertaking. It is a once-in-a-century investment for a network operator that will require tens of billions of dollars and take decades. To estimate the broad outlines of the business case for such an undertaking, a simple model was constructed for four, hypothetical network operators of different sizes and with different starting conditions, modeled loosely on major North American companies (two telcos and two MSOs). Following are the key assumptions:

- The networks are converted completely from either coax or copper to PON. In other words, the existing coax- and twisted-pair networks are taken out of service;

- Each operator competes with one other operator in its territory;
- All operators begin conversion simultaneously;
- Both business and residential customers are served by a unified network;
- All residential customers are triple-play customers;
- Each operator ultimately captures 50% of the customers in its territory, both residential and commercial;
- Each operator converts its network at the maximum rate allowed by the size of its work force;
- All calculations are in constant, “Year-0” dollars and all financing costs are neglected;
- The model covers a 50-year period, chosen arbitrarily to represent the useful lifetime of the fiber plant.

Table 1 contains the detailed inputs for the model, while Table 2 and Figure 1show selected results.

Table 1: 50-year financial model assumptions.

Assumptions	Operator A	Operator B	Operator C	Operator D
Fixed-line business-unit employees	117,000	120,000	107,000	31,000
Number of residential subscribers in serving area	17,400,000	25,000,000	23,200,000	14,400,000
Number of commercial subscribers in serving area	2,700,000	3,900,000	3,700,000	2,300,000
Number of residential subscribers served by copper / coax, Year 0	13,600,000	25,000,000	23,200,000	14,400,000
Number of residential subscribers served by fiber, Year 0	3,800,000	0	0	0
Subscribers passed by FTTP, Year 0	15,900,000	0	0	0
Annual premises-pass rate (1)	4,000,000	4,100,000	3,600,000	1,200,000
Annual residential customer installation rate (1)	840,000	840,000	770,000	220,000
Annual commercial customer installation rate (1)	160,000	160,000	140,000	40,000
FTTP cost per subscriber -- "premises pass"	$2,000	$2,000	$2,000	$2,000
FTTP cost per residential subscriber -- installation	$1,000	$1,000	$1,000	$1,000
FTTP cost per commercial subscriber -- installation	$2,000	$2,000	$2,000	$2,000
Annual revenue per residential customer (triple-play)	$1,400	$1,400	$1,400	$1,400
Annual revenue per commerical customer	$16,400	$16,400	$16,400	$16,400
Margin on residential services	20%	20%	20%	20%
Margin on commercial services	80%	80%	80%	80%
Final number of FTTP residential customers (50% capture rate)	8,700,000	12,500,000	11,600,000	7,200,000
Final number of FTTP commercial customers (50% capture rate)	1,350,000	1,950,000	1,850,000	1,150,000

Note (1): Rate was estimated by using ratio of business-unit workforce sizes to scale reported actual rate.

Table 2: 50-year financial model results.

Modeling Results	Operator A	Operator B	Operator C	Operator D
Construction period (years)	9	15	16	33
Total capital expenditures ($ Billions)	16	74.2	69.1	42.9
Final annual revenue ($ Billions)	34.3	49.5	46.6	28.9
Final annual gross income ($ Billions) (1)	20.1	29.1	27.5	17.1
Total revenue ($ Billions)	1,588	2,124	1,983	996
Total gross income ($ Billions) (1)	919	1,258	1,177	597
ROI (total gross income / total capital expenditures)	5744%	1695%	1703%	1392%

Note (1): Gross income is calculated by multiplying the revenue by the marginal rate on a per-service basis.

4. Discussion

The most obvious outcome of this study is the prediction of an impressive return-on-investment for all cases, ranging from an annualized rate of 28% for Operator D to 115% for Operator A. A more complete modeling of the business case almost certainly would give different quantitative results, however, the qualitative finding is robust: by any measure PON is a sound investment.

Other differences among the predictions for the four operators deserve discussion. Operator A’s results are markedly better than those of the other operators, which can be traced to the fact that Operator A began with a large fraction of its outside plant already converted to PON. Although it was assumed for the sake of simplicity that each operator ultimately captures exactly 50% of the customers in its territory, it is most likely that any operator with a significant advantage in the rate of PON deployment will capture a major fraction of the customer base, hence this model probably underestimates Operator A’s results. Also, it should be noted that Operator D’s significantly longer construction period results from the relatively small size of its work force: ≈ 540 customer-premises per employee, versus ≈ 170-250 customer-premises per employee for the other three operators. The relatively slow rate of conversion has a significant, negative effect on Operator D’s financial outcome, and it is likely a more realistic study would include an expansion of the workforce to expedite the program.

Given the attractiveness of the business case, an explanation must be provided for the fact that the vast majority of network operators worldwide have yet to launch a PON conversion program. Figure 1 attempts to illustrate the most common explanation for this inactivity, namely the incursion of short-term debt to finance the initial construction phase. Although the top panels of Figure 1 show a compelling story over the 50-year lifetime of the network, the bottom panels of Figure 1 reveal that a network operator must be prepared for a negative annual cash-flow of several billion dollars associated with this project for the first few years, which likely will translate into the need to raise several tens of billions of dollars, either through stock issuance or the assumption of debt. While most North American and European network operators, sensitive to the financial community's current aversion to long-term investments, have been stymied by this challenge, it must be noted that some Asian operators have found ways to solve this problem and are rapidly converting to PON. A modern communications network is essential for any society that wishes to remain competitive, and in most developed countries the need for corporate, financial, and political leadership on this issue is abundantly clear and urgent.

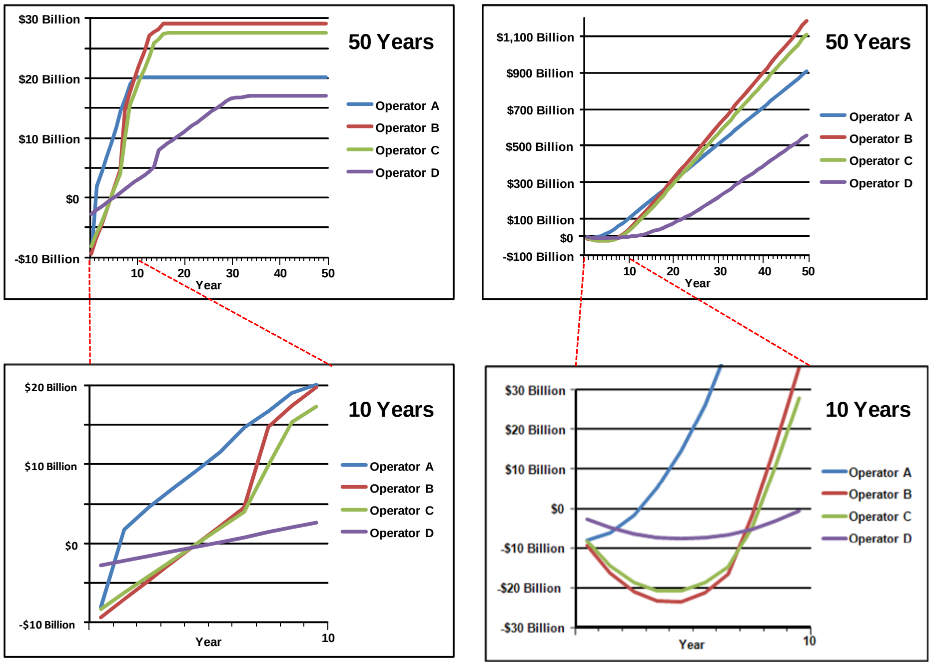

Figure 1: Annual gross income (left) and cumulative gross income (right).

5. References

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