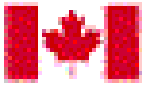

Industry Canada Industrie Canada

Canadian School Board Investments in Private Fiber Optic Networks

An assessment of the cost and benefits of building high speed fiber optic networks to link schools in Canada

SECOR

June 2000

Canadian School Board Investments in Private Fiber Optic Networks

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1. Introduction

The Continuous Growth of a Knowledge Economy

The world economy is in profound transformation towards knowledge intensive economies

- **A new economic order**
  - increased international economic activity;
  - new competitive advantages;
  - displacement of international trade;
  - new growth opportunities.

- **A country's wealth and the quality of life of its inhabitants are determined by its capacity to innovate and disseminate knowledge.**

- **Developing human resources is fundamental to any winning competitive strategy in the new economy.**

North American Education is in Transition

A paradigm shift from “Teaching to Learning”

Objective: prepare children to succeed in the new economy

- **Technology is viewed as a tool to support pedagogical activities (not a replacement for classroom lectures).**
  - Nonetheless, there is an ongoing debate about the role of technology in education.

- **Numerous Canadian initiatives underway that aim at enhancing technology in learning activities*:**
  - Alberta has announced massive investment in high speed telecommunication services to schools;
  - Toronto, Ottawa and Sudburry's school boards are getting fiber optic access to the WWW;
  - 40% of Quebec's schools will be connected through private fiber optic networks by the end of 2000;
  - Office of learning technologies promotes online learning;
  - TeleLearning Network of Centres of Excellence stimulates and tracks telelearning research;
  - Inforoute du Savoir, a Bell CGI project to develop an educational portal for schools;
  - Projet Carrefour, TéléQuébec (online video library).

Note: This list is not exhaustive. These initiatives are enumerated to illustrate the growing importance of technology in education.

CANARIE and Industry Canada are Playing a Role

Part of the federal Government's strategy to better compete in the new economy is to speed up the country's access to Internet.

- **A strategy to improve our ability to compete and protect our standard of living:**
  - Better access to information will improve productivity in all areas of the economy;
  - Better access to technology improves the education sector's performance;
    - *An investment in skills and productivity for the future.*

The potential of information and communications technology to improve the teacher's ability to prepare students coincides with both CANARIE's and IC's mandates

Quebec School Boards Are Advanced in the Drive for High Speed Connectivity

Today 26 Quebec school boards are planning the installation of private fiber networks interconnecting their schools.

- **Among these school boards, five are presently in the process of building networks, the rest are selecting the best solution available to them.**
- **Perceived benefits of a proprietary high speed network are:**
  - Immediately available benefits:
    - *lower cost for high speed connection and networking;*
    - *decrease network operating costs;*
  - Long term potential benefits:
    - *unlimited bandwidth for teaching purposes;*
    - *telephone service to the classroom.*
- **CANARIE and Industry Canada asked SECOR to examine the business case behind a typical school board's decision to install its own high speed network.**
  - What are the costs and benefits of this approach?
  - How do they compare with alternative means of connecting?

2. La Commission Scolaire des Affluents

A Case Study of a Typical School Board's Situation

Network Needs & Constraints
Solution Selected
Why?
How?

Des Affluents serves 40,000 students in 10 municipalities

Was recently formed from the merging of two school boards: des Manoirs and Le Gardeur

- **There are 75 education centers*:**
  - 54 primary schools
  - 15 secondary schools
  - 2 adult centers
  - 2 professional schools
  - 2 administrative centers.
- **The technological equipment is composed of:**
  - 3,000 personal computers
    - *80% for teaching purposes*
    - *20% for administration.*
- **One optical fiber access point between an administrative complex and a school (Notre-Dame).**
- **A microwave antenna network linking a couple of the schools.**
  - Moreover, the installed network links schools in the western part of the territory, formerly the CS des Manoirs
  - Creating inequalities in the services offered to each schools.

**: 75 education centers housed in 70 buildings.*

Amalgamation Motivated Network Investment

The primary objective of the network was to link the two former school boards into one network and to link the two administration buildings

- **Administrative requirements:**
  - Link all the schools to the administration network
  - Provide an electronic mail system throughout the school board
  - Fulfill the human resources management applications' need
  - Computerize the school bus network management system
  - Improve the daycare management system
- **Pedagogical requirements:**
  - Internet access for all the schools
  - Software and database sharing
  - Online access to the pedagogical software and applications

Technical Requirements

In addition to the administrative and pedagogical requirements, the Board's has four technical network requirements to fulfill:

- **Support of multiple transmission type (video, voice, data…)**
  - Online video libraries
  - Online pedagogical content
  - Online teaching through video conferencing.
- **High bandwidth (> 10 Mbps) for the support of distributed video transmission**
- **Multiple physical connections support:**
  - LAN on twisted pair (access level);
  - Distribution optical fiber.
- **Easy upgradability**
  - Education applications require a network that will support rapidly increasing throughput.

These ensemble of requirements had to be balanced with tight budgets. In this sense, the problem facing Des Affluents' board is typical of school boards across Canada

Solution Selected

The Board Selected Fast Ethernet on Fiber Optic

Achieving a balance of technical and financial requirements drove the decision taken by the des Affluents Board

- **First, optical fiber is the only medium that will support increasing traffic at high speed.**
  - Alternative physical mediums have capacity limitations
    - *ADSL on copper wire: Speed attenuation at distances over 4 Km*
    - *Coaxial cable: Speed attenuation at distances over 1 Km*
    - *Antennas: Slower and expensive where line-of-site is problematic*

- **Second, Fast Ethernet on optical fiber is the least expensive technology in terms of maintenance and upgradability.**
  - Risks of transmission quality due to the transport of multiple data types is limited when fiber optic strands are dedicated to a single user group

A cost-benefit analysis is not meant to challenge or refute the Board's decision, rather it will broaden the decision criteria to include a wider array of benefits and expenses

The proposed Architecture Includes Three Levels:

The *access* level: provides users with a connection to the network

- This is the end-point of the network where classroom access is provided
- All schools would have access to the network at at least 10 Mbps.

The *distribution* level: handles the segmentation of the broadcast domains with the use of virtual networks (VLAN)

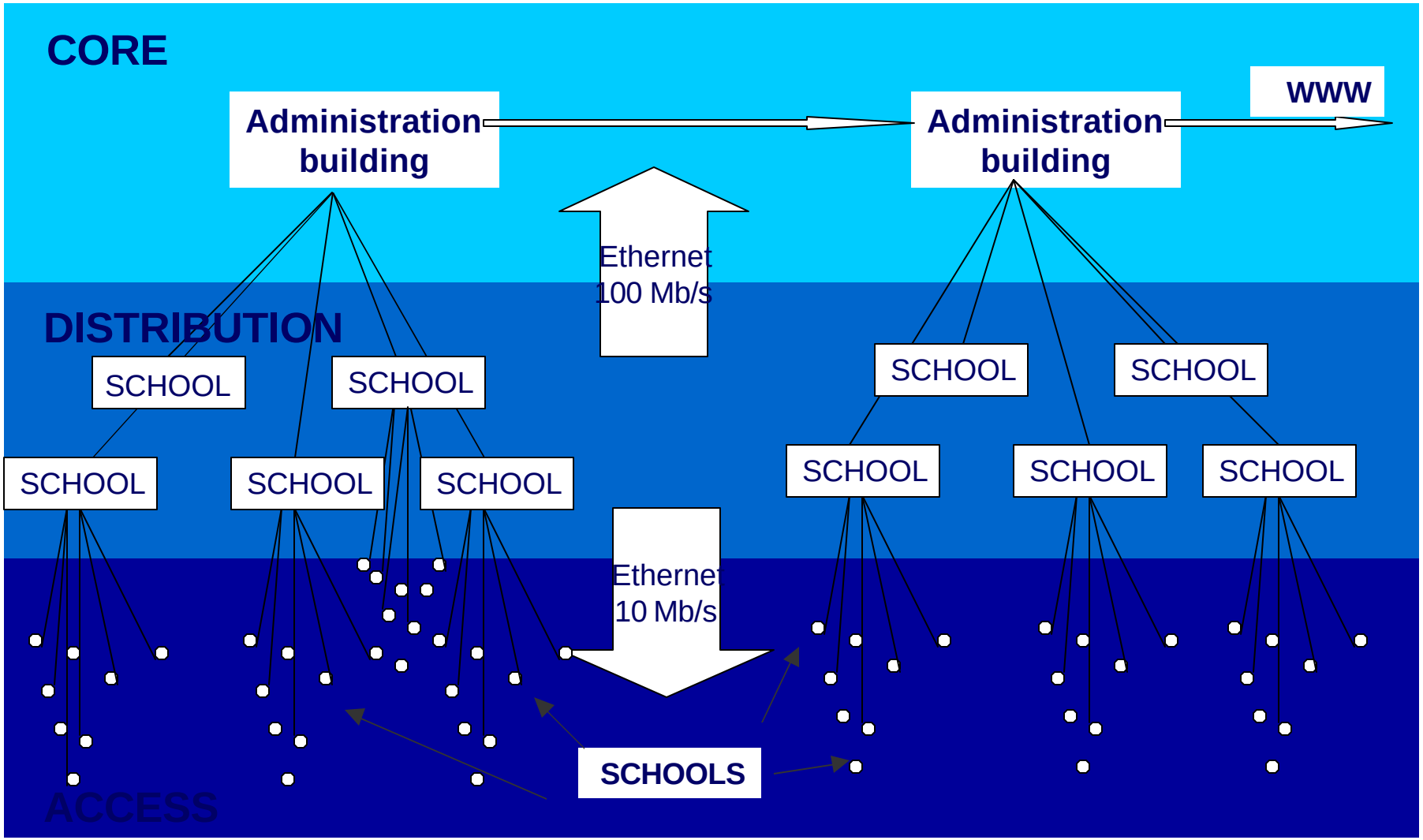
- This level houses the switches responsible for allowing effective availability of bandwidth for each network user.
- Selected schools within the board would serve as distribution centers.

The *core* level: responsible for sending information to the different virtual networks and providing the link to the World Wide Web

- Exchanges between the core and the distribution levels will be at 100 Mpbs
- The core will have 1 Gbps access to the WWW.

Solution Selected

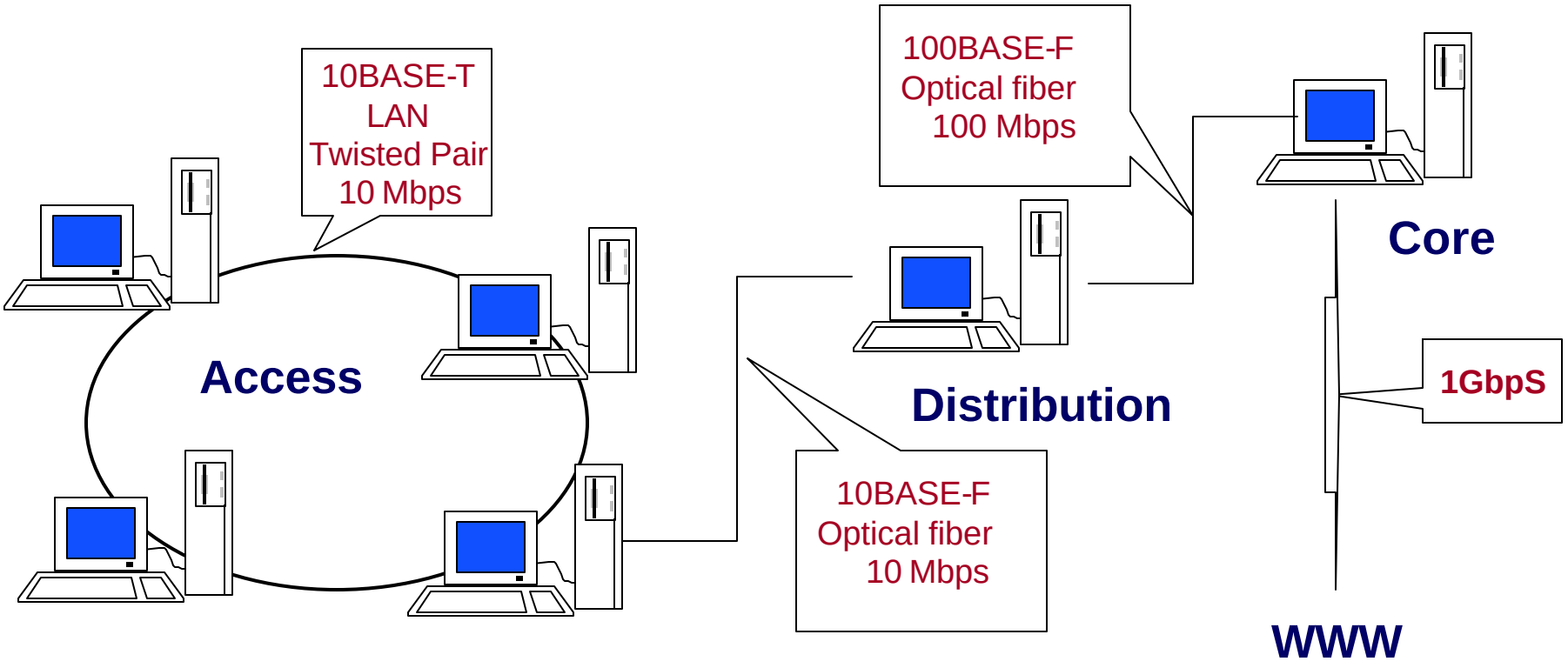
Logical Architecture



Solution Selected

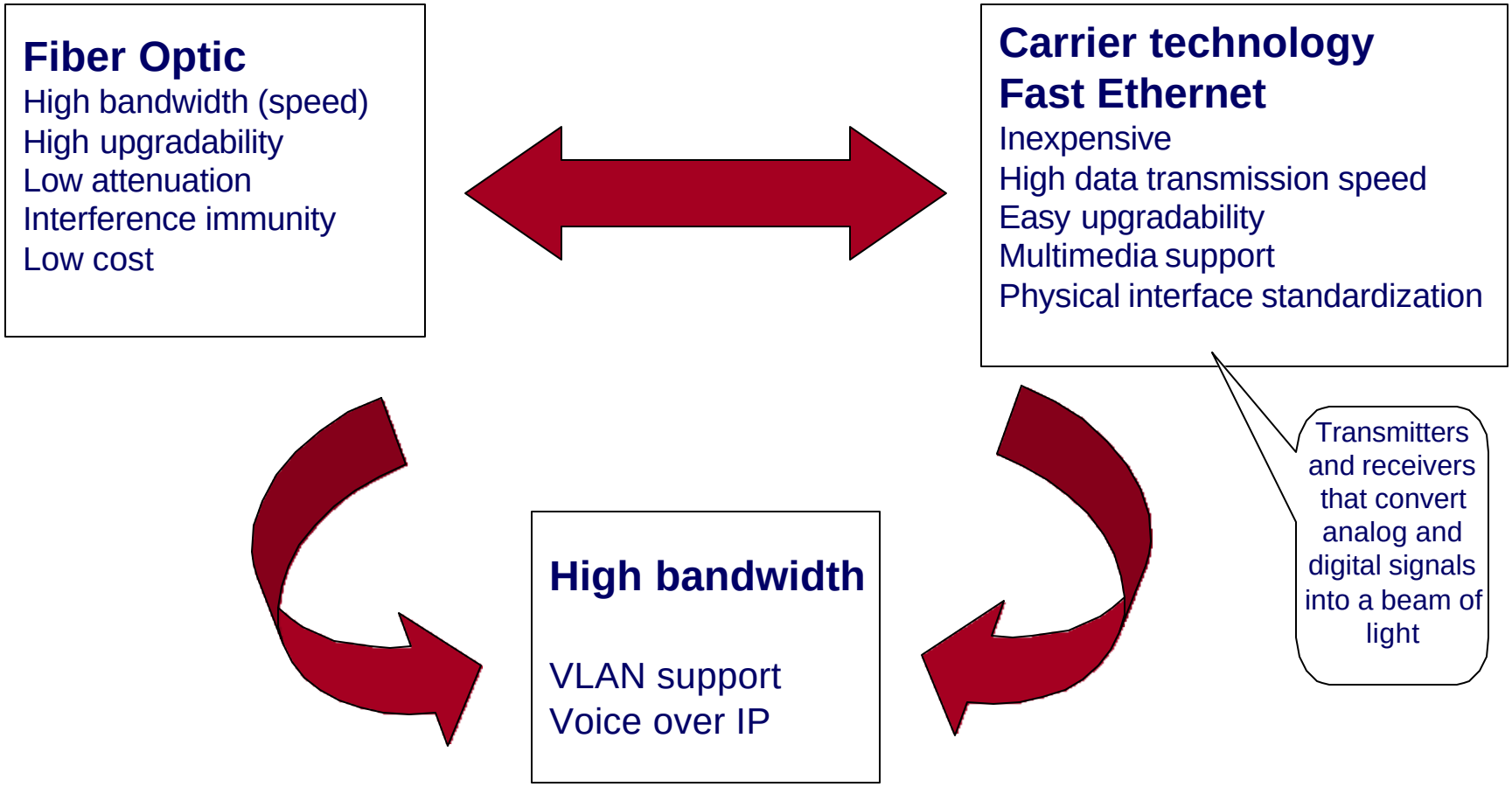
Critical Path

- **Externally:**
  - 179 Km of fiber optic (6 strands) linking 70 schools
  - 80% of the fiber installed on poles (aerial structure)
  - 20% underground.
- **Internally:**
  - Copper twisted pair within the schools and administration buildings.



Why the Solution was Chosen

Fiber Optic + Fast Ethernet = High Bandwidth



**: The functions and capabilities of the network are detailed in Appendix.*

Benefits: A technology that supports high bandwidth permits functions like VLAN support and Voice over IP

What Benefits Come from the High Bandwidth?

1. High speed networking supports VLANs

- **Virtual Local Area Networks (VLAN) provide the functions and savings of a compact network over a very large area**
  - simplified network management;
  - application sharing among many sites;
  - costs sharing with other institutions.

- **For a school board with many sites, VLANs can generate significant savings.**

2. Voice over IP: inexpensive telephone services within the school board

- **The Board could use the network to reduce the number of phone lines it rents while expanding the number of phone extensions it uses.**
  - Conceivably, an entire school board could be serviced with one line with an IP based PBX.
  - Moreover, the bandwidth of the selected network would be sufficient to introduce outside telephone lines into each house.

- **However, for safety and security reasons multiple phone lines will be retained.**
  - If a system with one phone line for 75 schools should ever lose that one line, then all schools would be without a line.

Partnerships with other Public Sector Network Users

Sharing portions of the network construction costs significantly reduced the burden on the board's resources.

- Estimated savings of 9% on the capital costs alone were realized through partnerships.

Des Affluents Board had three partners:

- Ville de Terrebone
- Ville de Repentigny
- Cégep Régional de Lanaudière.

For shared network elements;

- Costs were apportioned according to fiber strand demand by each partner.

Each partner assumed the full costs of elements dedicated to their needs;

- e.g. the cost of connecting each school to the core network.

The economies of partnering were threefold:

- The construction costs of the main network can be divided among the partners without compromising the quality of service or capacity provided to each partner;
- There is the possibility to share the costs of the data transmission equipment;
- Internet access from the network can be shared among the partners.

The Use of a Network Consultant was Essential

- **IMS provided the Board assistance with:**
  - Cost estimates;
  - Selection of the technical solution;
  - Structure of the partnership deal;
  - Construction of the network.

- **IMS has been involved in most of Quebec's school board network projects**
  - Commission scolaire des Bois-Francs
  - Commission scolaire de Laval
  - Commission scolaire Seigneurie des Mille-Îles
  - Commission scolaire des Samares
  - Commission scolaire des Trois-Lacs
  - Commission scolaire de l'Amiante
  - Commission scolaire de la Capitale
  - Commission scolaire Sir Wilfrid Laurier
  - Commission scolaire Première Seigneurie
  - Commission scolaire de Sherbrooke
  - Commission scolaire des Seigneuries
  - Commission scolaire des Draveurs
  - Commission scolaire de St-Hyacinthe
  - Commission scolaire Chemin-du-Roy

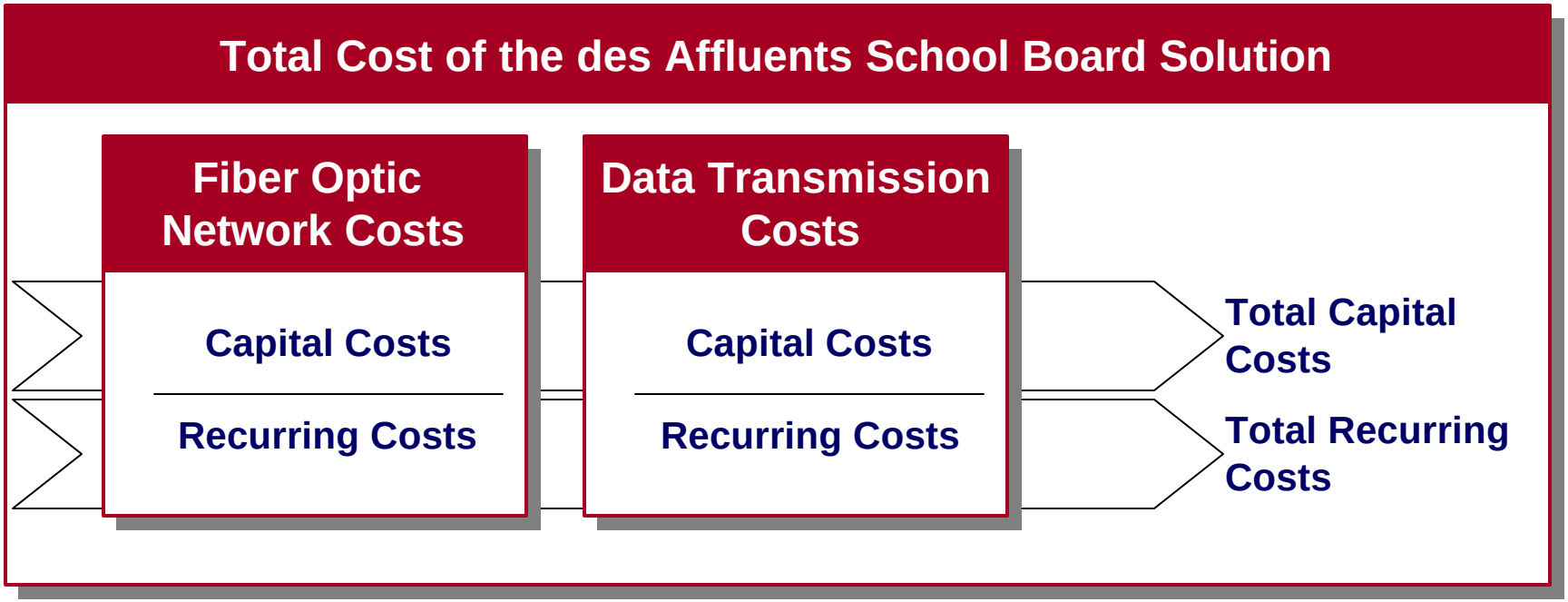
3. The Costs Incurred by the Commission Scolaire des Affluents

Actual Capital and Recurring Expenses Associated with the Network

Cost Structure of the Project

The cost of the project involves:

- **Installation and maintenance of the fiber optic network**
  - The Board managed to find three partners to share this cost.
- **The acquisition, installation and maintenance of data transmission equipment.**



Source: Commission Scolaire des Affluents

Des Affluents School Board Network Cost

Fiber optic network cost

	DESCRIPTION	AVERAGE COST/KM	TOTAL COSTS
CAPITAL COSTS			
Engineering / Construction	Consulting Engineering Construction Permits Fiber optic cables Cable fusion Distribution panels 179 Km	$7,000	**$1,253,000**
ANNUAL RECURRING COSTS			
Right of way	Aerial (on 149 Km)	$520	$77,480
Right of way	Underground (on 30 Km)	$900	$27,000
Maintenance	On 179 Km	$50	$26,850
Total recurring costs (annually)			**$131,330**

Source: IMS Consulting and the Affluent school board

These costs are based on the sharing of the construction cost between 4 partners. Without the partnership both capital and recurring costs would be nearly 10% higher

Des Affluents School Board Network Cost

Data transmission cost

DATA TRANSMISSION EQUIPMENT AT THE CORE LEVEL

QTY	DESCRIPTION	$
CAPITAL COSTS		
2	Fast Ethernet Switch 10/100 Mbps, Layer 3, IP/IPX	$30,000
24	Transceivers 100 Mbps/SMF (LR and SR)	$52,800
1	Network management system	$15,000
	Installation	$9,780
Total Capital Costs		**$107,580**
RECURRING COSTS		
Annual maintenance cost (12%)		$12,910

DATA TRANSMISSION EQUIPMENT AT THE DISTRIBUTION LEVEL

QTY	DESCRIPTION	$
CAPITAL COSTS		
13	Fast Ethernet Switch 10/100 Mbps, Layer 2, VLAN support	$78,000
30	Transceivers 10 Mbps/SMF (SR)	$54,000
30	Transceivers 100 Mbps/SMF (SR)	$21,000
	Installation	$15,300
Total Capital Costs		**$168,300**
RECURRING COSTS		
Annual maintenance cost (12%)		$20,196

Note: Transceivers and switches at the access level are assumed to be in place already and are not accounted in the new systems costs as they are sunk costs.

Source: IMS Consulting and the Commission Scolaire des Affluents

Des Affluents school board Network Cost

Total network cost

TOTAL NETWORK COSTS

DESCRIPTION	COSTS IN $
CAPITAL COSTS	
Fibre optic network costs	$1,253,000
Data transmission equipment /core level	$107,580
Data transmission equipment /distribution level	$168,300
Total capital costs	**$1,528,880**
RECURRING COSTS (ANNUALLY)	
Optical-fibre network costs	$131,330
Data transmission equipment /core level	$12,910
Data transmission equipment /distribution level	$20,196
Internet access charge (one shared T3 line)	$50,000
VLAN & Data Transmision Technicians* (32 jobs @ 35,000)	$1,120,000
Total annual recurring costs	**$1,334,436**

Source: IMS Consulting and Des Affluents school board

* The Board employed 40 technicians, 1 per 1,000 students, before it moved to a fiber optic solution. Much of their efforts were dedicated to LAN support . With a single VLAN the number of technicians needed fell dramatically but the savings is somewhat offset by the new data transmission requirements. The Board estimated the Net effect was a 20% reduction in technician costs.

4. Setting up for a Cost and Benefit Analysis of the Fiber Optic Investment

Validating the Fiber Optic Option

Overview of CBA
The CBA Framework
The Frame of Reference for the Decision
Describing the Alternative Paths:
- The Best Available Alternative Technology
- Wait and Switch

Cost-Benefit Analysis (CBA) is a Decision-making Aid

CBA provides a framework for sorting information about the impact of alternative investments

- **In the public sector context, it guides decisions so as to deliver the most public good given the spending choices available.**
  - The CBA framework gives us a consistent means of defining *most public good* and in selecting relevant choices.
- **CBA is only an aid to decision makers, it does not tell us what to do.**
  - The framework is a means of standardizing and organizing the available information so fair comparisons can be made.
  - However, information about future benefits and costs is always incomplete so even at its best CBA can only provide a partial analysis.

The CBA Framework

① Defining the analysis frame of reference

- Whose benefits and whose costs are we working with?

② Identifying the alternative projects

- The proposed project versus other uses for the resources.

③ Standardization of the alternatives for the purpose of comparison

- Adjustments have to be made for differences in time frame, financial structure and impacted community.

④ Dealing with uncertainty and intangible costs and benefits

- Employ methods for monetization of intangibles and uncertainty, or
- Subjectively assess the impact of them, or
- Net as many of them out of the comparisons as possible.

⑤ Criteria for a decision recommendation

- Absolute best alternative;
- Highest net benefit;
- Breakeven point.

SECOR's Sources for CBA

Even though CBA has to be somewhat flexible to account for the nuances of each decision analyzed, quality models are available

- **Treasury Board of Canada Secretariat** (*Benefit-Cost Analysis Guide*, Draft July 1998)
  - The standard for Federal Government CBAs.
- **The United States Office of Management and Budget** *(Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs,* Circular A-94, October 1992)
  - A comprehensive series of guides on CBA and CBA issues from the US government point of view.
- **National Institutes of Health Chief Information Officer** (*Cost-Benefit Analysis Guide for NIH IT Projects*, May 1999)
  - A CBA process that accounts for the unique challenges associated with information technology projects:
    - *Rapid depreciation of assets (rapid onset of obsolescence);*
    - *Extreme uncertainty as to the state-of-the-art technology;*
      - Revolutionary versus evolutionary changes in state-of-the-art IT
    - *Uncertain future prices.*

The Decision Frame of Reference

Des Affluents school board's frame of reference was determined by its role as an educational organization and an administrative center

Benefits of the Solution ⟷ **Structure of the Solution** ⟷ **Cost of the Solution**

Administrative requirements

Link all the schools to the administration network
Provide an electronic mail system throughout the school board
Fulfill the human resources management applications' need
Computerize the school bus network management system
Improve the daycare management system

Technical requirements

Support of multiple transmission type (video, voice, data…)
- Online video libraries, online pedagogical content, online teaching through video conferencing

High bandwidth (> 10 Mbps)
Multiple physical connections support:
- LAN on twisted pair (access level);

Easy upgradability

Target of the benefits

Pedagogical requirements

Internet access for all the schools
Software and database sharing
Online access to the pedagogical software and applications

The School Board's Cost Constraint

Alternative Solutions

Des Affluents Board committed $1.5 million to network capital and $1.3 million a year in operating costs. What were the alternatives?

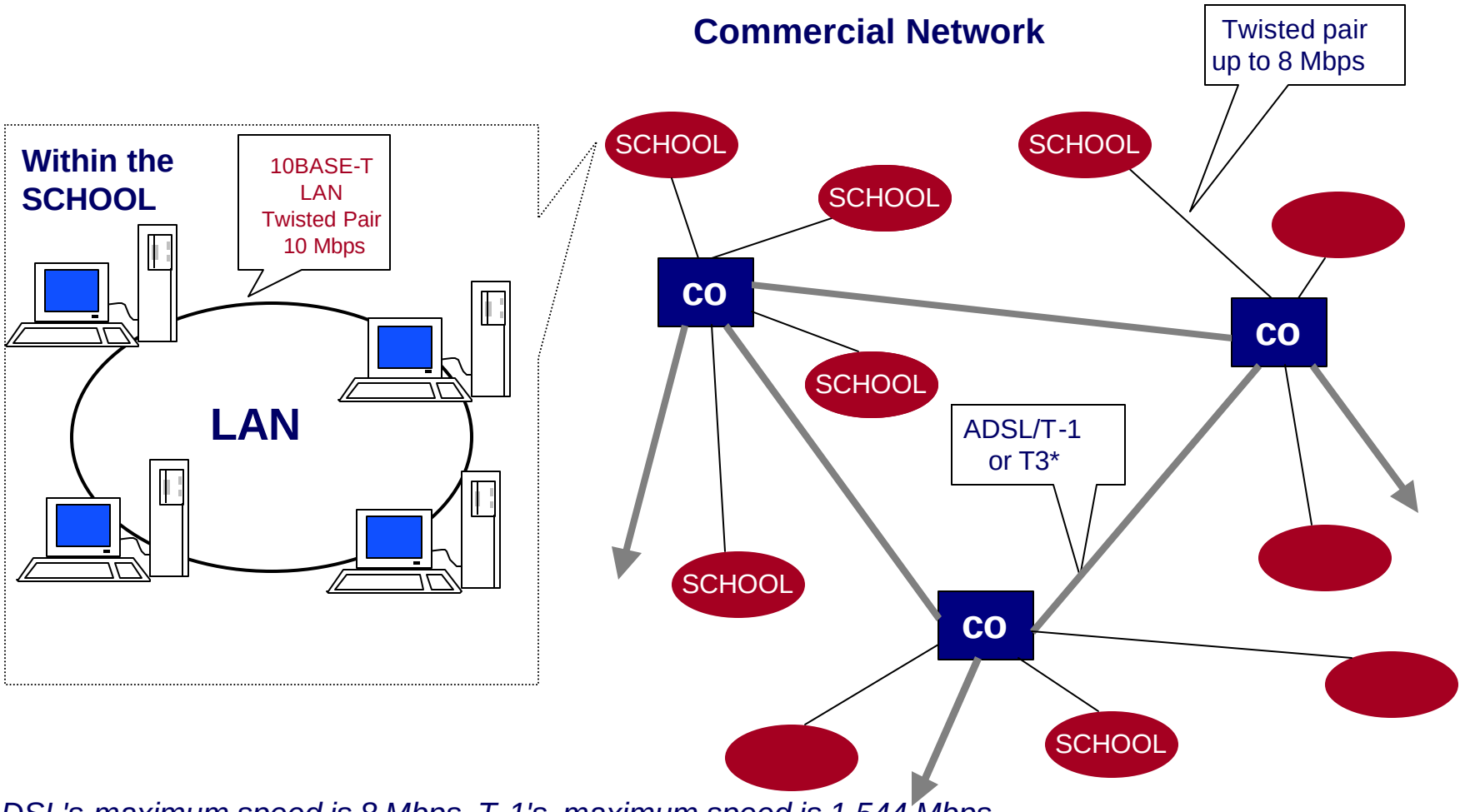
- **Another network based on the best available alternative technology (BAAT) to fiber optic but deployed over the same time frame**
  - ADSL over twisted base pair copper wire was selected as the BAAT.
- **An alternative time frame for deploying the fiber optic solution**
  - This “wait and switch” strategy is based on waiting for either superior technology or better price or both in the provision of carrier based fiber optic services.
- **Some interesting alternatives were not analyzed because they fell outside the frame of reference;**
  - Investing the resources in other tools (teachers and their salaries, books and bricks and mortar infrastructure;
    - *A valid alternative from the point of view of the Province or society as a whole*
  - However, the Board was not free to reassign the IT funds to other projects
    - *Therefore it is outside the relevant frame of reference.*

Characteristics of the BAAT

A network based ADSL over twisted base pair copper wire where the connection of the various sites is purchased from a telcom carrier.

- **Maximum speed:**
  - up the line: up to 8 Mbps
  - down the line: up to 2 Mbps
  - however, these speeds drop to 640 Kbps without repeaters at distances over 4 Km.
- **Point-to-point World Wide Web access**
  - Each key site in the Board's system will have their own Internet connection.
- **The critical path on a commercial network** (illustrated on the next page)
  - Each school communicates at 10 Mbps on LAN within the school;
  - Services throughout school boards are often mixed depending on technology availability on a specific route.

Critical Path of the Alternative Solution



**ADSL's maximum speed is 8 Mbps, T-1's maximum speed is 1.544 Mbps.*

***CO**: Central office*

Source: Robert Proulx - IMS et SECOR

All the Cost of the BAAT are Recurring Annual Costs

The BAAT solution is more simple to cost than the fiber optic option because there would be no new capital costs associated with it.

- **There is no network or data transmission system to install and finance**
  - The carrier would assume these costs in exchange for a recurring access fee.
- **The LAN system costs in each school, though a capital component, were already in place when the Board made its decision.**
  - Therefore, as with the fiber optic solution, the transceivers and switches at the access (school) level are assumed to be in place and are not accounted in the new system's costs since they are already sunk costs.
- **The recurring annual costs are twofold:**
  - Carrier network access charges;
  - LAN support within each of the sites in the Board.

Carrier Network Access Charges

Carriers price structure depends on services availability in the area and on the nature of land difficulties.

- Rural networks tend to encounter less land difficulties (rivers, highways, buildings…) but the costs are spread among a lower number of customers;
- Urban networks require more complex installations to compensate for land difficulties but the costs are spread among a wider customer base.

QUOTED PRICES FOR COMMERCIAL POINT-TO-POINT BROADBAND INTERNET SERVICES

MAXIMUM SPEED	SERVICES	LOCATION	PRICE / MONTH / INSTITUTION
120 Kbps	ISDN	Rural	$400
7 Mbps	ADSL	Urban	$400
10 Mbps	Mixed	Mixed	$500 to $600

Sources: Richard Lampron - CS Trois Rivières, Bernard Lemonnier - CS des Affluents, Dennis Nicholson - Alberta Innovation and Science, Robert Proulx - IMS

The Price Quoted by Bell was Consistent

Bell's offer to the des Affluents was around $400 per month per site, including network access, data transmission and Internet access

- With 75 sites the network access costs total $360 thousand per year.

The average Bell access price was consistent in two ways:

- **across the Board's territory in both urban and rural areas**
  - Although commercial services are based on:
    - *regional services available;*
    - *services required - traffic;*
    - *the presence of competition;*
    - *required investments;*
    - *cost structure of the carrier;*
  - Prices tend to be approximately the same for commercial services on carrier twisted pair networks in rural or urban centers.

- **when compared with projects outside Quebec**
  - In a network study prepared for Alberta Innovation and Sciences, carrier network charges were consistent across the province and similar to Quebec.

The Local Area Network Costs

Though the LAN capital costs are already sunk, operating the LANs adds to the recurring costs

- **The des Affluents Board employed 1 technician per 1,000 students**
  - A total of 40 technicians supporting the LANs in the 75 sites;
  - Each technician is paid on average $35,000 a year including benefits;
  - Total support costs: $1,400,000 per year.

- **Equipment costs associated with maintaining the LANs**
  - The maintenance costs for the 75 LANs in the des Affluents system would be $70,000 per year
    - *Based on a conservative 6.2% of an average $15,000 LAN equipment cost (not including cable).*

Summary of BAAT Costs

TOTAL BAAT SOLUTION COSTS

DESCRIPTION	COST
CAPITAL COSTS	
No new capital employed	0
Total capital costs	**0**
RECURRING COSTS (ANNUALLY)	
Carrier network access charges	$360,000
Data transmission equipment included	0
Internet access charge included	0
LAN equipment maintainance	$70,000
LAN Technicians (40 jobs @ $35,000)	$1,400,000
Total annual recurring costs	**$1,830,000**

Source: SECOR

Functions and Capabilities of the Alternative Solution

The most important advantage of ADSN networks is to provide high speed access using existing infrastructure.

- **The majority of fiber optic networks' functionality is available on high bandwidth twisted pair networks but at the expense of speed, quality and reliability. For example:**
  - VLAN support is not media dependent but speed dependent. On highly utilized networks, telecommunications speed would not be practical for a VLAN. The alternative is to build independent LANs at each site.
  - Voice over IP would also not be practical at speeds below 10 Mbps.
- **On the school boards' side the extra expenses consist of:**
  - Servers, server software and applications are required at the school level;
  - Higher technical support is required to manage all these servers;
  - Video transmission would require multiple line access to prevent bottlenecks.

Basic Advantages and Compromises of the BAAT

- **In a point-to-point solution, the data transmission network responsibilities are handled by the carrier**
  - ***Strategic advantage:*** the Board is relieved of the technology cost and risk associated with data transmission infrastructure.
  - ***Strategic drawback:*** the boards will lose control over key requirements such as easy upgradability, multimedia support, multiple physical connection support.
- **Broadband services are not consistently available in all regions**
  - Many communities still cannot get full T-1 or ADSL services.
  - A geographically dispersed Board must consider if this will create inequalities within the system.
- **Because twisted pair networks were originally conceived to transport voice, its transformation to support high traffic is prohibitively expensive and limited which explains the carriers' resistance to diminish their costs.**

Characteristics of the Wait & Switch Approach

The Wait & Switch strategy is a conservative approach that assumes competition among carriers will eventually lead to affordable access to commercial fiber optic networks or equivalent quality wireless networks.

- **Future access provided on a fixed fee per period or bandwidth use**
  - Regardless of pricing model, the carrier would provide all data transmission services as part of the network access costs.
- **The "Wait" component**
  - In the interim, the Board would either use a network solution similar to the BAAT solution (ADSL or Microwave based) or forego an integrated network entirely.
- **The "Switch" component**
  - Criteria for switching would have to be established based on
    - *Commercial fiber availability*
    - *The relative cost of the fiber versus ADSL access*
    - *The relative gap between the benefits of the fiber solution and the ADSL solution.*
- **The cost of this solution would be near the ADSL solution until the switch point is reached**
  - The post-switch costs are indeterminate since affordable fiber is not yet available.

The Advantages of Being Conservative

Minimizing risk exposure is the main reason to employ a cautious network strategy

- **At $1.5 million, there is a large fixed cost component to the fiber optic solution**
  - Incurring these costs reduces the Board's flexibility to take advantage of carrier-provided solutions that will be available in the future.

- **The capital investment in the data transmission network and the responsibility of operating and maintaining it can be avoided**
  - If carriers provide access to fiber networks for a fixed fee then the carriers will assume the cost and technology risks of the data transmission system.
  - Reduces the chances that the Board's data transmission will become obsolete with time.

5. Cost and Benefit Analysis

Decision Criteria and Interpretation

Comparing the Costs and Benefits of the Options

The appropriate criteria for CBA depend on the relative size and nature of the costs and benefits of each option

Highest net benefit method

- Used when a cost and benefit trade-off is evident in comparing two options
  - *i.e. comparing a high-cost/high-benefit option to a low-cost/low-benefit option.*

The absolute best method

- Used when one option clearly gives more for less
  - *i.e. when one option is both higher benefit and lower cost than the other.*
  - *This situation is encountered in comparing the fiber optic solution with the BAAT.*

The breakeven point method

- Used to compare capital intensive options with others when there is a high degree of uncertainty about future costs and technology.
  - *This is suited for the comparison of the fiber and the wait & switch options.*
- Locates the point in time where the amortized costs of the capital intensive solution are equal to the costs of the alternative solution and after which the high capital solution begins to pay off.
- A value judgement is then made on whether the breakeven point is within a reasonable time horizon.

Fiber Optic Solution versus the BAAT Solution

Cost comparison

Standardization adjustments required

- The capital costs of the fiber optic solution have to be annualized at 9.08%* discount rate so that the cost comparison is made in the same time framework
  - *The useful life of the fiber network is assumed to be 20 years*

TOTAL FIBER NETWORK COSTS

DESCRIPTION	COSTS
COSTS (ANNUALLY)	
Annaulized capital costs (9.08% for 20 years)	$165,250
Fibre optic network costs	$131,330
Data transmission equipment/core level	$12,910
Data transmission equipment/distribution level	$20,200
Internet access charge (one shared T3 line)	$50,000
VLAN & Data Transmision Technicians (32 jobs @ $35,000)	$1,120,000
Total annual recurring costs	**$1,499,690**

TOTAL BAAT SOLUTION COSTS

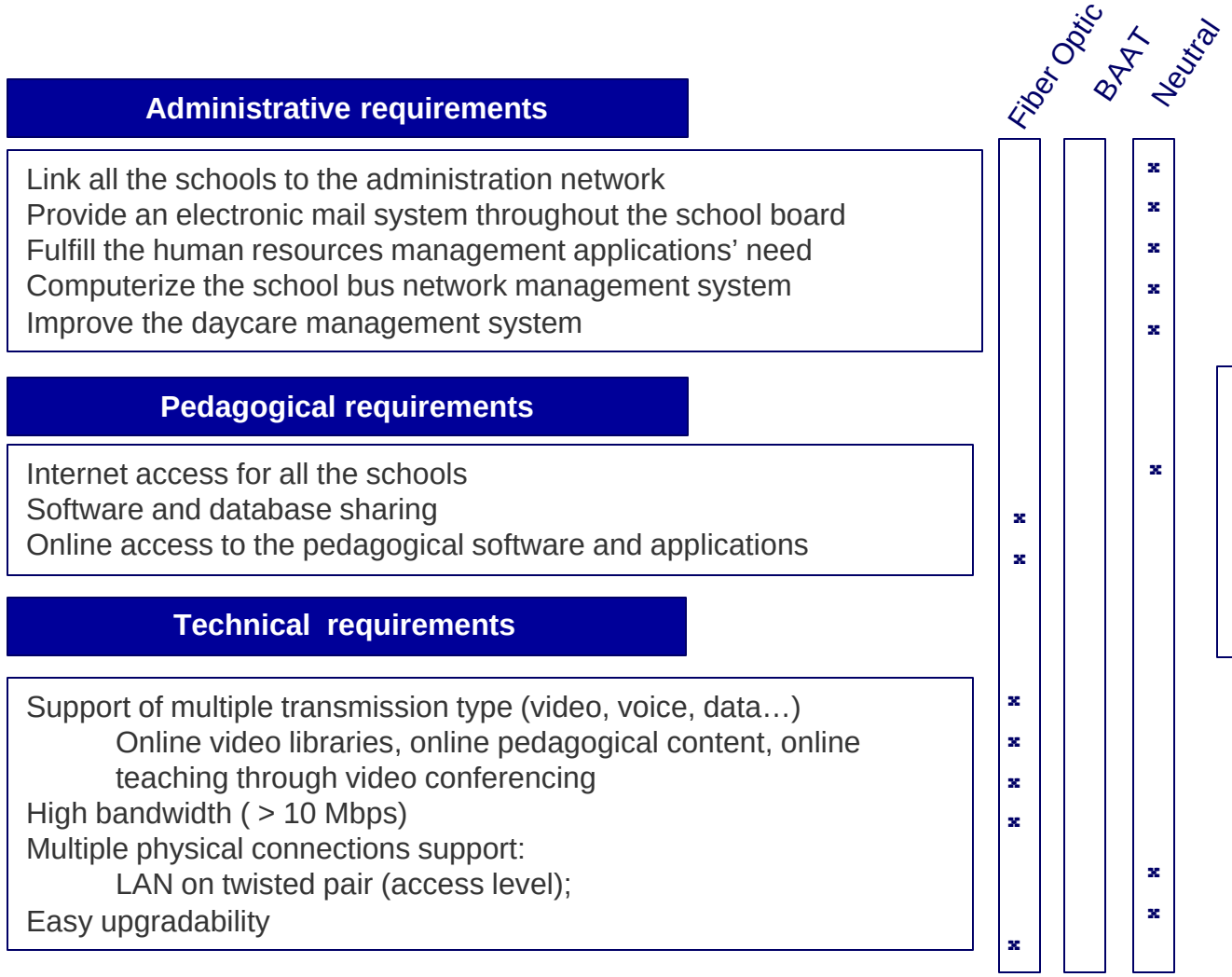
DESCRIPTION	COST
COSTS (ANNUALLY)	
Carrier network access charges	$360,000
Data transmission equipment included	0
Internet access charge included	0
LAN equipment maintainance	$70,000
LAN Technicians (40 jobs @ $35,000)	$1,400,000
Total annual recurring costs	**$1,830,000**

$ 330,000 per year cost advantage for the fiber optic solution

* average 1999 federal debt servicing costs

Fiber Optic Solution versus the BAAT Solution

In meeting des Affluent Board's base requirements there is no category in which the BAAT has an advantage



The fiber optic solution has an absolute benefit advantage over the BAAT

Applying the CBA criteria

The fiber optic solution is the absolute best option when compared to the BAAT

- It is lower cost on an annualized basis and delivers more benefits.

However, there are caveats to consider due to uncertainties:

- How comfortable are we in assigning a useful life of 20 years to an IT solution?
  - *With the glass wire the assumption is probably safe but not with the data transmission systems.*
- How durable is ADSL as a best available alternative technology?
  - *ADSL will eventually fade out as fiber or wireless technologies become more prevalent and cheaper.*
    - Similar to the current trend facing Internet over POTS and Modem versus alternatives such as ADSL itself and Cable.

To fully consider the uncertainties, we need to calculate the breakeven point for undertaking the fiber investment

- In other words we need to assess the Wait & Switch strategy.

Assessing the Wait & Switch Strategy

Three questions need to be addressed:

① **If we do not wait, when will we break even?**

- At what point will the operational savings from investing fiber pay for the additional capital costs?

② **Is the breakeven point within a stable technology time horizon?**

- Is there likely to be a technological “revolution” before we reach the breakeven point?
  - *Are the rules of the game likely to change so as to eliminate either the operational cost advantage or the additional benefits of a fiber network?*

③ **If we do wait, can we afford to forgo the benefits of the fiber solution for the period leading up to the breakeven point?**

Assessing the Wait & Switch Strategy

The fiber optic solution breaks even after three years and 8 months

- **If we wait, we pay for an ADSL type solution until it is prudent to switch.**
  - Implicitly this means we will incur annual network costs of $1,830,000 (see page 37).
- **If we do not wait we will have the fiber optic solution but...**
  - Our annual operating costs will drop to $1,334,440 (see page 24)
  - Savings of $495,560.
- **However, for the lower cost structure we must pay $1,528,880 in capital costs (see page 24).**
  - If we channel all the operational savings into financing the capital debt, how long before we pay off the capital (a.k.a. break even)?
- **The answer: just under 44 months**
  - The point where the net present value discounted at 9.08% of monthly payments of $41,300 (the annual savings divided by 12) just exceeds $1,528,880 million.
- **The wait & switch strategy is preferable if we believe that the rules of the game will change before August 2003.**

Interpretation & Conclusion

Private fiber optic networks have higher net benefits over the next best alternative solution and over a conservative wait & switch strategy.

- **The fiber optic solution has an absolute advantage over the ADSL solution**
  - It provides both lower cost and higher benefits
- **In comparison to a wait & switch strategy, the breakeven point of the fiber investment is 44 months.**
- **The advantage of paying up front capital costs depends on the value of the intangibles to the board:**
  - The value to the educators accessing the best solution sooner rather than later;
  - Speed of transmission;
  - Quality of transmission;
  - Security;
  - Video support;
  - The possibility to support large increases in traffic.
- **If carriers offer cheap optical fiber network services before the breakeven point, than the tangible costs of getting the private network ahead of time is the value of the unpaid loan for capital at that time**
  - After 44 months the private fiber solution is paid up in full.

Appendices

Functions and Capabilities of the Fiber Optic Network

Fiber optic characteristics:

1. Fiber optic will support technology with the highest speed (research is now being carried on 1,000 Gbps networks).

2. Fiber conducts laser light over great distances without losing its intensity.

3. Fiber carries a laser light signal and therefore is not susceptible to electric interference and gives off no emissions. These characteristics increase telecommunications' quality and security when compared to wired communications.

4. Compared to copper wire, fiber optic requires much less physical room and strands to carry the same amount of information, resulting in a lower cost solution.

Functions and Capabilities of the Network...

Fast Ethernet technology characteristics:

1. Supports high data transmission speed (from 100 Mbps);

2. Easy upgradability. Allows increasing network speed capacity at low cost (from 100 Mbps to 1 Gbps);

3. Fast Ethernet supports the transmission of a variety of media: Voice data, fax, graphics, images and video;

4. Ethernet offers the possibility to standardize physical interfaces on switches at the distribution level (a variety of media transports the Fast Ethernet signal: 100BaseT, 100BaseF multimode, and 100BaseF multimode).

Bandwidth Support Comparisons

PHYSICAL MEDIUM	SPEED RANGE	ADVANTAGES	DISADVANTAGES
Copper Wire (ADSL)	Up to 8 Mbps	â Expands the bandwith of existing networks	â Asynchronous mode of communication: speed down is 2 Mbps â Network's speed is distance sensitive: down to 640Kbps at distance > 4 Km
Coaxial cable	1,5 Mbps to 8 Mbps	â Capitalizes on existing cable co's network	â High attenuation restricts its use to distances < 1Km
Fiber optic	1.5 Mbps to 100 Gbps	â Maintains high quality of transmission over long distances (transmitters at 30 Km) â Interference immunity â Secure (cannot be tapped) â Low cost • Less physical space • Easier maintenance	â Not available outside urban centers
Antennas	400 Kbps to 2 Mbps	â Low infrastructure required (Last mile technology)	â Subject to interference â Limited frequence availability â Expensive when line of sight is problematic

Source: IMS and West Virginia University's College of Engineering

Data Transmission Architecture Comparisons

- **Ethernet architecture** widens the effective available bandwidth for each network user. Wider bandwidth permits multiple traffic types: voice, data and video.
- **ATM** is layered, allowing multiple services like voice data or video to be mixed over a network while guarantying high quality of transmission.

ARCHITECTURE	ADVANTAGES	DISADVANTAGES
ETHERNET	• Provides a single network for all traffic • Investment protection- Adaptable to existing ethernet standard network (LAN at access level)	• Transmission quality not guarantied when transmitting multiple traffic types
ATM	• Provides a single network for all traffic • High quality traffic management • Not based on physical transport: compatible with twisted pair, coax and fiber • Long architecture lifetime	• Requires an interface to the existing network • Complex network management when two architectures are supported

Source: IMS and West Virginia University's College of Engineering

Fast Ethernet was chosen in CS des Affluents because it was less expensive while quality issues represent little risk on dedicated fiber optic strands.

Physical Medium Description

PHYSICAL MEDIUM	SPEED RANGE	CARRIER TECHNOLOGY	APPLICATION
TWISTED PAIR	Up to 56 Kbps	Regular telephone service (POTS)	Home and small business
	64 to 128 Kbps	BRI : ISDN	Faster home and small business access
	1.544 Mbps	DS1/T-1	Large company to ISP
	512 Kbps to 8 Mbps	DSL	Home, small business and enterprise using existing copper lines
	10 Mbps	Ethernet 10BASE-T	Local Area Network
	100 Mbps	Fast Ethernet (100 BASE-T)	Workstations with a 10 Mbps Ethernet card can plug into a Fast Ethernet LAN

Note : The information included in this table is not intended to be exhaustive.

Physical Medium Description

PHYSICAL MEDIUM	SPEED RANGE	CARRIER TECHNOLOGY	APPLICATION
COAXIAL CABLE	1.544 Mbps	DS1/T-1	Large company to ISP
	512 Kbps to 8 Mbps	DSL	Home, small business and enterprise using existing copper lines
	10 Mbps	Ethernet 10BASE-T	Local Area Network
OPTICAL FIBRE	1.544 Mbps	DS1/T-1	Large company to ISP
	10 Mbps	Ethernet 10BASE-T	Local Area Network
	100 Mbps	Fast Ethernet (100 BASE-T)	Workstations with a 10 Mbps Ethernet card can plug into a Fast Ethernet LAN
	1 Gbps	Gigabit Ethernet	Workstations with a 10/100 Mbps Ethernet card can plug into a Gigabit Ethernet switches
	100 Mbps and up	ATM	Multimedia telecommunications
WIRELESS	400 Kbps	Satellite/Antennas	Faster home and small enteprise access

Note : The information included in this table is not intended to be exhaustive.

Financial Models

Based on the existence (or not) of fiber optic in the region

	OPTIONS
EXISTING FIBER OPTIC IN THE REGION	1. Dark fiber leasing 2. Spectrum or band leasing
FIBER OPTIC NOT INSTALLED	3. Carrier installation and strand leasing 4. Condominium network/telco partnership/CS installation

1. Dark fiber leasing:

- Carrier has strands of fiber that are not utilized
- Carrier is willing to lease exclusive use of 2 strands for a predetermined period of time

2. Band leasing:

- Carrier is willing to lease exclusive use of 2 bands for a predetermined period of time

Financial Models

3. Carrier installation and strand leasing

- Carrier installs a fiber optic network
- and leases exclusive use of 2 strands for a predetermined period of time.

4. Condominium network

- **CS finds partners in the region that are willing to share the cost of installing and maintaining a fiber optic network;**
- **CS finds an interested CRTC approved carrier to enter a partnership where the carrier becomes the owner of the fiber in exchange of[1]**
  - an exclusive right of utilization of 6 strands for the partners
  - maintenance costs are established at Cost + 5%
  - maintenance costs fall to zero when telco starts selling services on the network to other parties.

Note 1: a partnership agreement with a CRTC registered telecommunication company is required for the right to operate a fiber optic network that runs through public infrastructures.