A Combined Effort of OptiCal & LUMOS NETWORKS

EE 290Q

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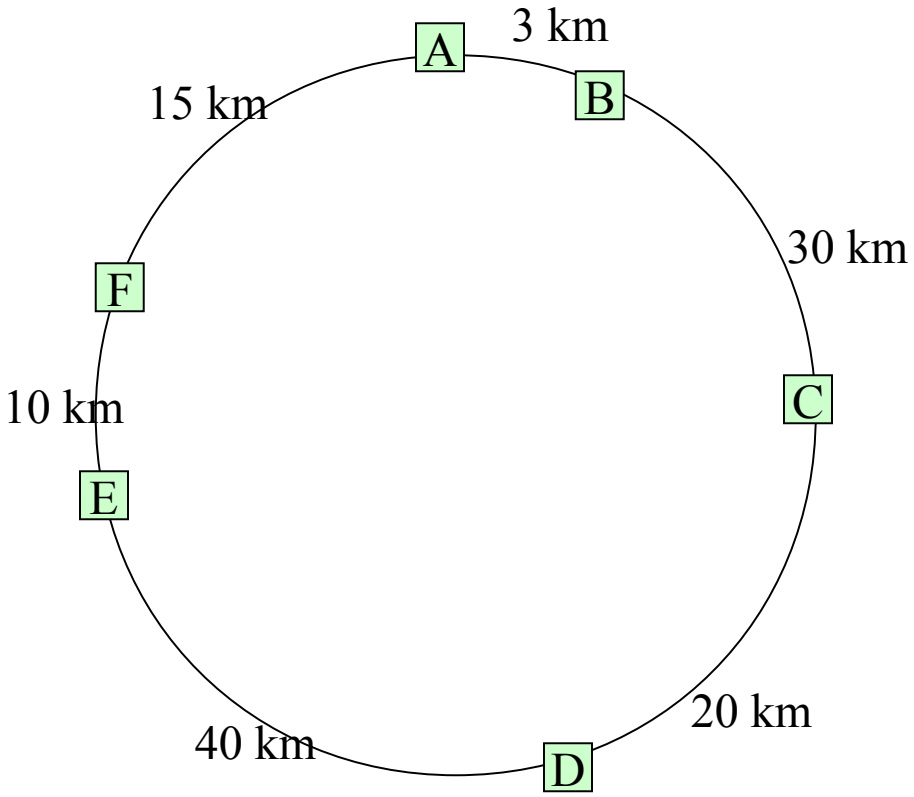
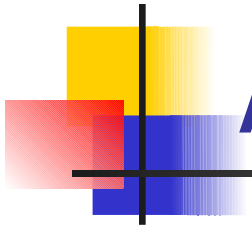
Metro Ring



Demand Set in OC48:

	A	B	C	D	E	F
A	x	8	25	0	0	0
B	x	x	5	15	1	1
C	x	x	x	5	10	10
D	x	x	x	x	5	5
E	x	x	x	x	x	15

- Fiber is standard Corning SMF-28 fiber (dispersion and loss info given in class and HW before)
- Total length = 118km
- Longest link = 115km
- Amplifier can be for 4 or limited number of channels at lower price (use linear scale)
- Free to use LumiPhase price list or ask for more



Advantage of STS-48

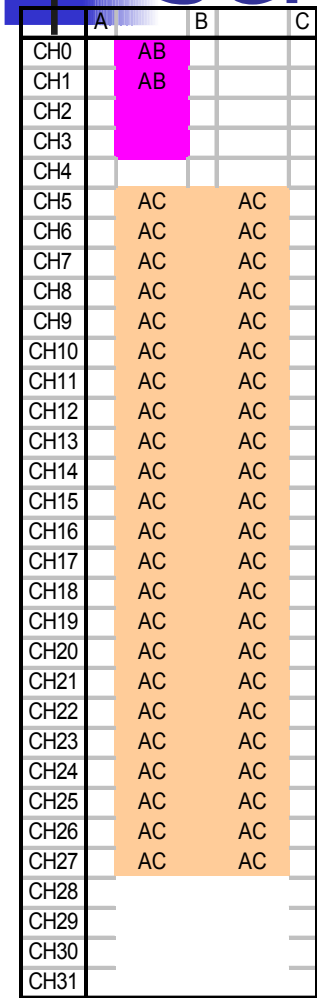
- Group velocity dispersion can be ignored:
  - Maximum eye closure = 0.09*238*115*0.02*2.5*0.01 = 0.123

    (for longest link of 115km)
- Increased minimum sensitivity of receiver made EDFA unnecessary.

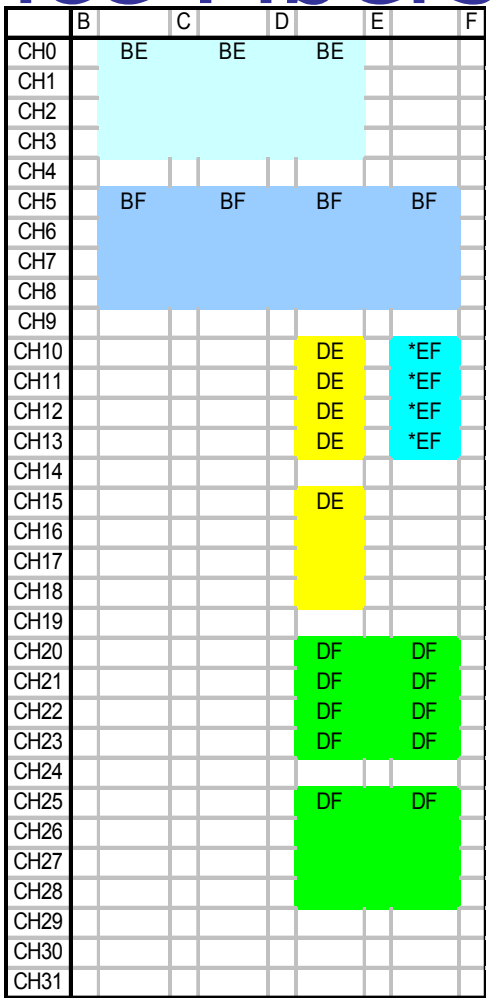
General Design Rule

- BLSR/4 is deployed.
- Traffic is routed on the shortest path between two nodes in the ring.
- Wavelength assignment is done according to maximum load principle.
- Power budget is carefully managed in order to maintain the SNR at the receiver.
- Span failure protection is realized by 1:1 line protection.

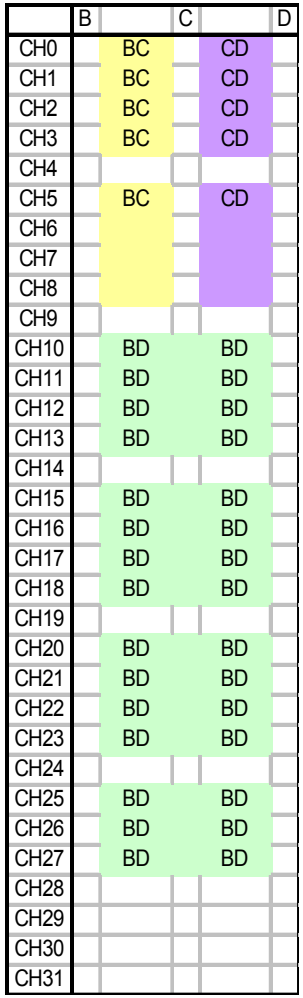
Wavelength Assignment for Service Fibers



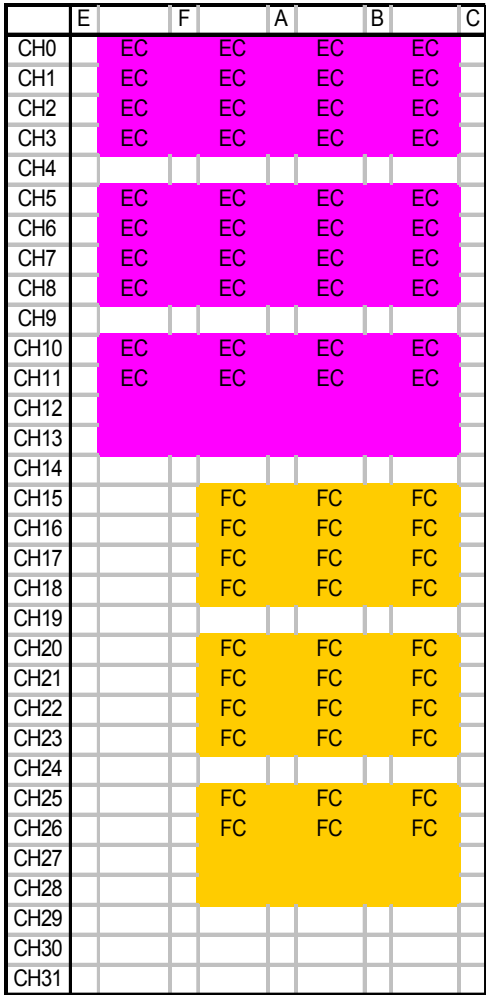
	A	B	C
CH0	AB		
CH1	AB		
CH2			
CH3			
CH4			
CH5	AC	AC	
CH6	AC	AC	
CH7	AC	AC	
CH8	AC	AC	
CH9	AC	AC	
CH10	AC	AC	
CH11	AC	AC	
CH12	AC	AC	
CH13	AC	AC	
CH14	AC	AC	
CH15	AC	AC	
CH16	AC	AC	
CH17	AC	AC	
CH18	AC	AC	
CH19	AC	AC	
CH20	AC	AC	
CH21	AC	AC	
CH22	AC	AC	
CH23	AC	AC	
CH24	AC	AC	
CH25	AC	AC	
CH26	AC	AC	
CH27	AC	AC	
CH28			
CH29			
CH30			
CH31			



	B	C	D	E	F
CH0	BE	BE	BE		
CH1					
CH2					
CH3					
CH4					
CH5	BF	BF	BF	BF	
CH6					
CH7					
CH8					
CH9					
CH10				DE	*EF
CH11				DE	*EF
CH12				DE	*EF
CH13				DE	*EF
CH14					
CH15				DE	
CH16					
CH17					
CH18					
CH19					
CH20				DF	DF
CH21				DF	DF
CH22				DF	DF
CH23				DF	DF
CH24					
CH25				DF	DF
CH26					
CH27					
CH28					
CH29					
CH30					
CH31					

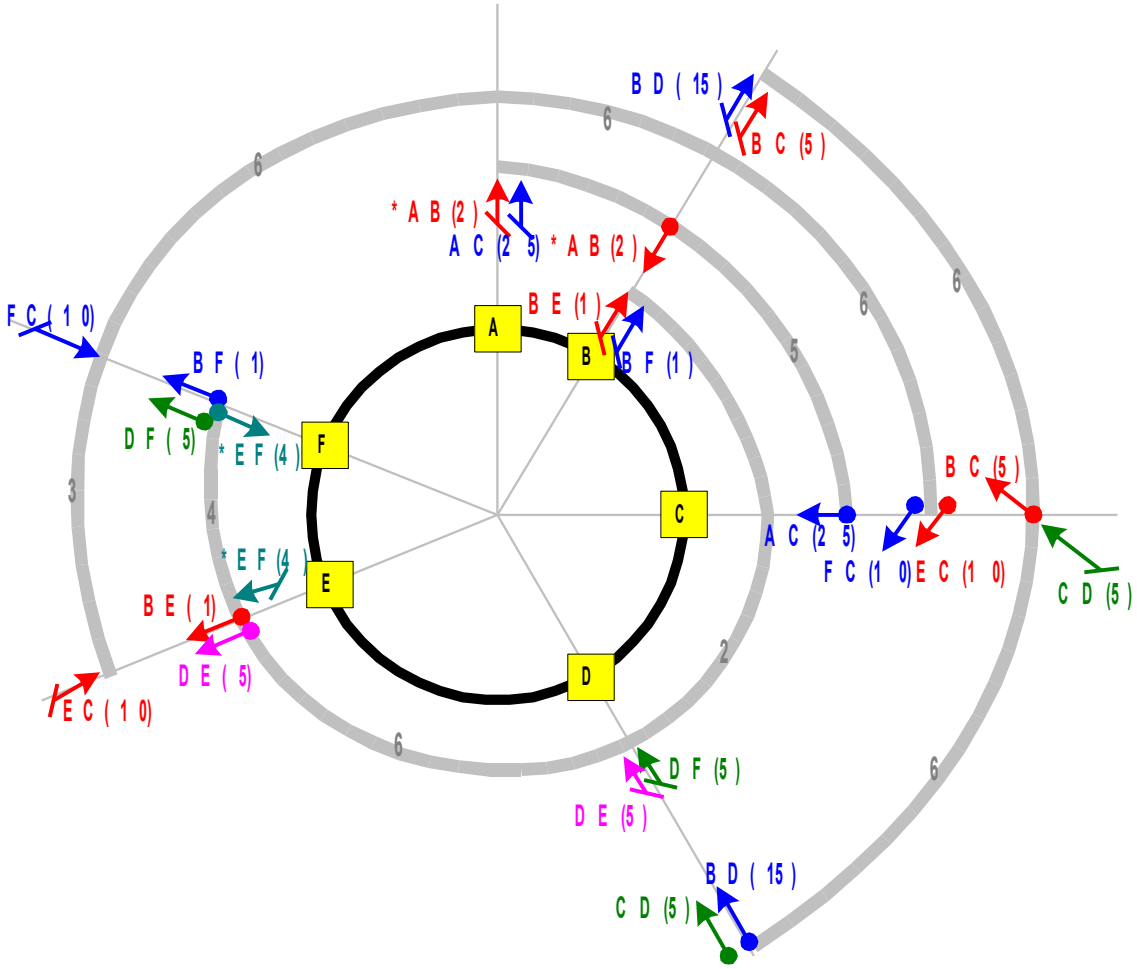


	B	C	D
CH0	BC	CD	
CH1	BC	CD	
CH2	BC	CD	
CH3	BC	CD	
CH4			
CH5	BC	CD	
CH6			
CH7			
CH8			
CH9			
CH10	BD	BD	
CH11	BD	BD	
CH12	BD	BD	
CH13	BD	BD	
CH14			
CH15	BD	BD	
CH16	BD	BD	
CH17	BD	BD	
CH18	BD	BD	
CH19			
CH20	BD	BD	
CH21	BD	BD	
CH22	BD	BD	
CH23	BD	BD	
CH24			
CH25	BD	BD	
CH26	BD	BD	
CH27	BD	BD	
CH28			
CH29			
CH30			
CH31			



	E	F	A	B	C
CH0	EC	EC	EC	EC	
CH1	EC	EC	EC	EC	
CH2	EC	EC	EC	EC	
CH3	EC	EC	EC	EC	
CH4					
CH5	EC	EC	EC	EC	
CH6	EC	EC	EC	EC	
CH7	EC	EC	EC	EC	
CH8	EC	EC	EC	EC	
CH9					
CH10	EC	EC	EC	EC	
CH11	EC	EC	EC	EC	
CH12					
CH13					
CH14					
CH15		FC	FC	FC	
CH16		FC	FC	FC	
CH17		FC	FC	FC	
CH18		FC	FC	FC	
CH19					
CH20		FC	FC	FC	
CH21		FC	FC	FC	
CH22		FC	FC	FC	
CH23		FC	FC	FC	
CH24					
CH25		FC	FC	FC	
CH26		FC	FC	FC	
CH27					
CH28					
CH29					
CH30					
CH31					

Graphic Illustration



Power Budget for Service Fibers

Fiber1		A	A-B	B	B-C	C
Band1	AB	-4	-4.6	-5.6		
Left Bands	AC(25)	-4	-4.6	-5.6	-11.6	-18.6

Fiber2		B	B-C	C	C-D	D	D-E	E	E-F	F
Band1	BE, EF	2	-4	-6	-10	-14	-22	-23	0	-1
Band2	BF	2	-4	-6	-10	-14	-22	-26	-28	-29
Band3	DE1					-1	-9	-11		
Band4	DE2					0	-8	-11		
Band5	DF1					1	-7	-11	-13	-14
Band6	DF2					2	-6	-10	-12	-13

Fiber3		E	E-F	F	F-A	A	A-B	B	B-C	C
Band1	EC1	2	0	-3	-6	-6	-6.6	-6.6	-12.6	-19.6
Band2	EC2	2	0	-3	-6	-6	-6.6	-6.6	-12.6	-19.6
Band3	EC3	2	0	-3	-6	-6	-6.6	-6.6	-12.6	-19.6
Band4	FC1			0	-3	-3	-3.6	-3.6	-9.6	-16.6
Band5	FC2			1	-2	-2	-2.6	-2.6	-8.6	-15.6
Band6	FC3			2	-1	-1	-1.6	-1.6	-7.6	-14.6

Fiber4		B	B-C	C	C-D	D
Band1	BC1,CD1	2	-4	-5	-3	-10
Band2	BC2,CD2	2	-4	-6	-2	-9
Band3	BD1	2	-4	-8	-12	-19
Band4	BD2	2	-4	-8	-12	-19
Band5	BD3	2	-4	-8	-12	-19
Band6	BD4	2	-4	-8	-12	-19

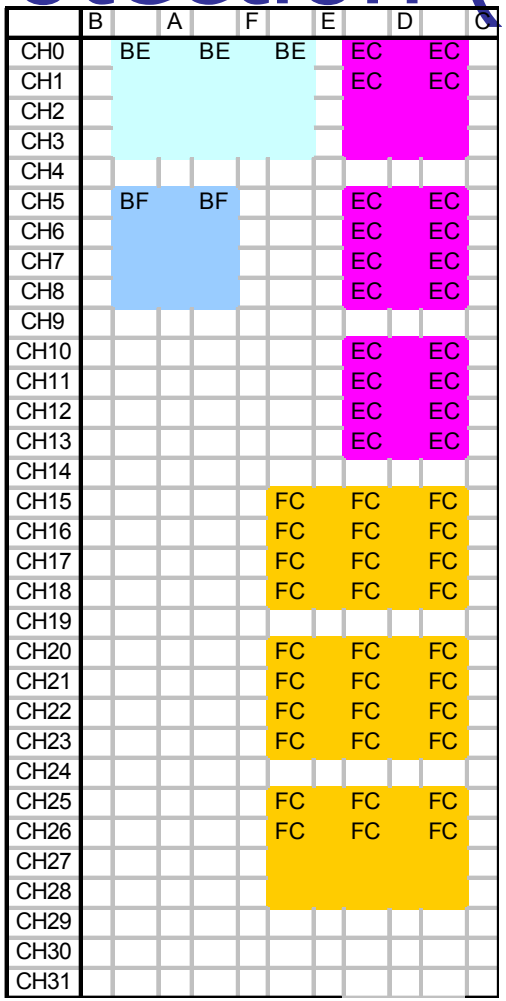
Wavelength Assignment of the Protection (I)

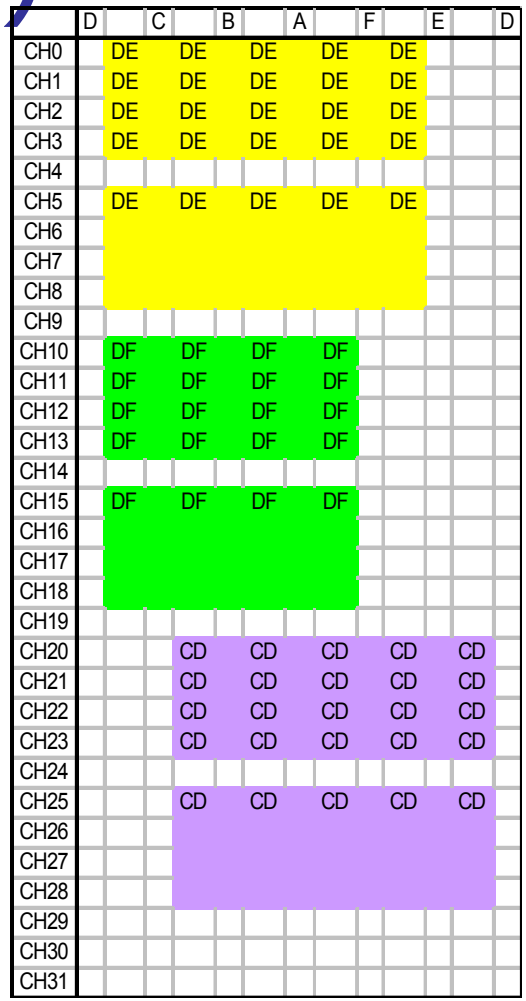
	A	F	E	D	C	B	A	F
CH0	AB	AB	AB	AB	AB			
CH1	AB	AB	AB	AB	AB			
CH2	AB	AB	AB	AB	AB			
CH3	AB	AB	AB	AB	AB			
CH4								
CH5	AB	AB	AB	AB	AB			
CH6	AB	AB	AB	AB	AB			
CH7	AB	AB	AB	AB	AB			
CH8	AB	AB	AB	AB	AB			
CH9								
CH10			EF	EF	EF	EF	EF	
CH11			EF	EF	EF	EF	EF	
CH12			EF	EF	EF	EF	EF	
CH13			EF	EF	EF	EF	EF	
CH14								
CH15			EF	EF	EF	EF	EF	
CH16			EF	EF	EF	EF	EF	
CH17			EF	EF	EF	EF	EF	
CH18			EF	EF	EF	EF	EF	
CH19								
CH20			EF	EF	EF	EF	EF	
CH21			EF	EF	EF	EF	EF	
CH22			EF	EF	EF	EF	EF	
CH23			EF	EF	EF	EF	EF	
CH24								
CH25			EF	EF	EF	EF	EF	
CH26			EF	EF	EF	EF	EF	
CH27			EF	EF	EF	EF	EF	
CH28								
CH29								
CH30								
CH31								

	A	F	E	D	C
CH0	AC	AC	AC	AC	
CH1	AC	AC	AC	AC	
CH2	AC	AC	AC	AC	
CH3	AC	AC	AC	AC	
CH4	AC	AC	AC	AC	
CH5	AC	AC	AC	AC	
CH6	AC	AC	AC	AC	
CH7	AC	AC	AC	AC	
CH8	AC	AC	AC	AC	
CH9	AC	AC	AC	AC	
CH10	AC	AC	AC	AC	
CH11	AC	AC	AC	AC	
CH12	AC	AC	AC	AC	
CH13	AC	AC	AC	AC	
CH14	AC	AC	AC	AC	
CH15	AC	AC	AC	AC	
CH16	AC	AC	AC	AC	
CH17	AC	AC	AC	AC	
CH18	AC	AC	AC	AC	
CH19	AC	AC	AC	AC	
CH20	AC	AC	AC	AC	
CH21	AC	AC	AC	AC	
CH22	AC	AC	AC	AC	
CH23	AC	AC	AC	AC	
CH24	AC	AC	AC	AC	
CH25					
CH26					
CH27					
CH28					
CH29					
CH30					
CH31					

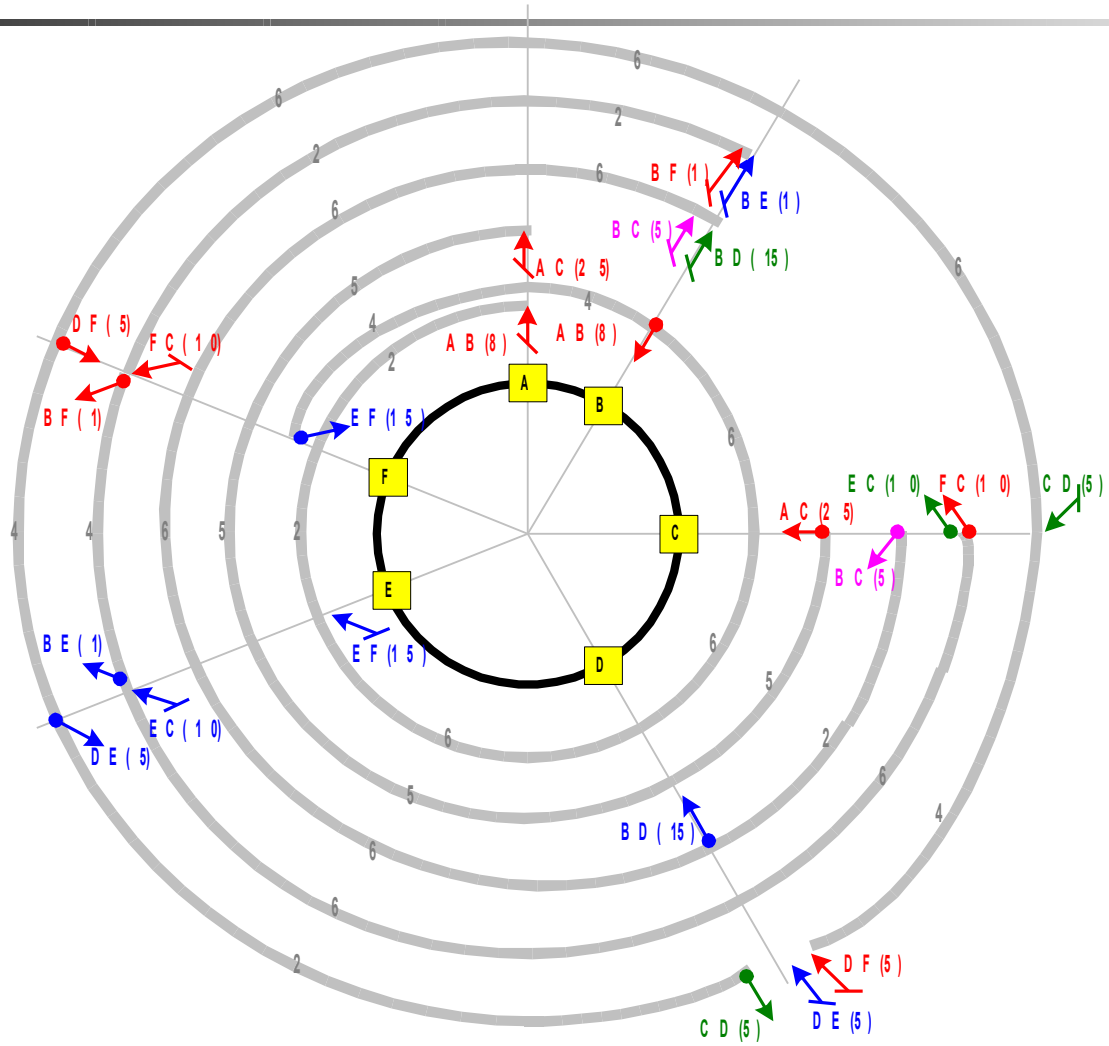
	B	A	F	E	D	C
CH0	BC	BC	BC	BC	BC	
CH1	BC	BC	BC	BC	BC	
CH2	BC	BC	BC	BC	BC	
CH3	BC	BC	BC	BC	BC	
CH4						
CH5	BC	BC	BC	BC	BC	
CH6						
CH7						
CH8						
CH9						
CH10	BD	BD				
CH11	BD	BD				
CH12	BD	BD				
CH13	BD	BD				
CH14						
CH15	BD	BD				
CH16	BD	BD				
CH17	BD	BD				
CH18	BD	BD				
CH19						
CH20	BD	BD				
CH21	BD	BD				
CH22	BD	BD				
CH23	BD	BD				
CH24						
CH25	BD	BD				
CH26	BD	BD				
CH27	BD	BD				
CH28						
CH29						
CH30						
CH31						

Wavelength Assignment of the Protection (II)





Protection Mechanism



Fiber1		A	A-F	F	F-E	E	E-B	B	B-A	A	A-F	F
Band1	AB1	2	-1	-1	-3	-7	-25	-26				
Band2	AB2	2	-1	-1	-3	-7	-25	-27				
Band3	EF1					-1	-19	-21	-21.6	-21.6	-24.6	-25.6
Band4	EF2					0	-18	-20	-20.6	-20.6	-23.6	-24.6
Band5	EF3					1	-17	-19	-19.6	-19.6	-22.6	-23.6
Band6	EF4					2	-16	-18	-18.6	-18.6	-21.6	-22.6

Fiber2		A	A-F	F	F-E	E	E-D	D	D-C	C
All Bands	AC(25)	2	-1	-1	-3	-7	-15	-15	-19	-26

Fiber3		B	B-A	A	A-F	F	F-E	E	E-D	D	D-C	C
Band1	BC1	2	1.4	1.4	-1.6	-1.6	-3.6	-7.6	-15.6	-15.6	-19.6	-26.6
Band2	BC2	2	1.4	1.4	-1.6	-1.6	-3.6	-7.6	-15.6	-15.6	-19.6	-26.6
Band3	BD1	2	1.4	1.4	-1.6	-1.6	-3.6	-7.6	-15.6	-16.6		
Band4	BD2	2	1.4	1.4	-1.6	-1.6	-3.6	-7.6	-15.6	-17.6		
Band5	BD3	2	1.4	1.4	-1.6	-1.6	-3.6	-7.6	-15.6	-18.6		
Band6	BD4	2	1.4	1.4	-1.6	-1.6	-3.6	-7.6	-15.6	-19.6		

Fiber4		B	B-A	A	A-F	F	F-E	E	E-D	D	D-C	C
Band1	BE, EC1	2	1.4	1.4	-1.6	-5.6	-7.6	-8.6	-8	-8	-12	-19
Band2	BF, EC2	2	1.4	1.4	-1.6	-2.6			-7	-7	-11	-18
Band3	EC3								-6	-6	-10	-17
Band4	FC1					0	-2	-6	-14	-14	-18	-25
Band5	FC2					1	-1	-5	-13	-13	-17	-24
Band6	FC3					2	0	-4	-12	-12	-16	-23

Fiber5		D	D-C	C	C-B	B	B-F	F	F-E	E	E-D	D
Band1	DE1	2	-2	-4	-10	-10	-13.6	-15.6	-17.6	-18.6		
Band2	DE2	2	-2	-4	-10	-10	-13.6	-15.6	-17.6	-19.6		
Band3	DF1	2	-2	-4	-10	-10	-13.6	-14.6				
Band4	DF2	2	-2	-4	-10	-10	-13.6	-15.6				
Band5	CD1			1	-5	-5	-8.6	-12.6	-14.6	-16.6	-24.6	-25.6
Band6	CD2			2	-4	-4	-7.6	-11.6	-13.6	-15.6	-23.6	-24.6

Cost Estimation for Service

Service	****2***			
	Description	Unit Cost (Thousand $)	Quality	Cost (Thousand $)
OC48to192	Electronic Mux	*30*	*8*	*240*
Mux/Demux	filter, awg	*48*	*4*	*192*
Linecard (192)	w/ transponder	*75*	*8*	*600*
Linecard (048)	w/ transponder	*30*	*77*	*2310*
C band Add-Drop		*1*	*11*	*11*
C band MUX		*4*	*11*	*44*
Laser (192)	CW10 + EXM01-192	*3.6*	*8*	*28.8*
Receiver (192)	APD-192	*2.5*	*8*	*20*
Laser (48)	CW10 + EXM01-048	*1.8*	*77*	*138.6*
Receiver (48)	APD-048	*1*	*77*	*77*
Fiber	proportional to length	*0.3*	*241*	*72.3*
Provisioning	4 fibers total	*2*	*85*	*190*
TOTAL (Eq)				*3923.7*

8.0 Million$

Cost Estimation for Protection

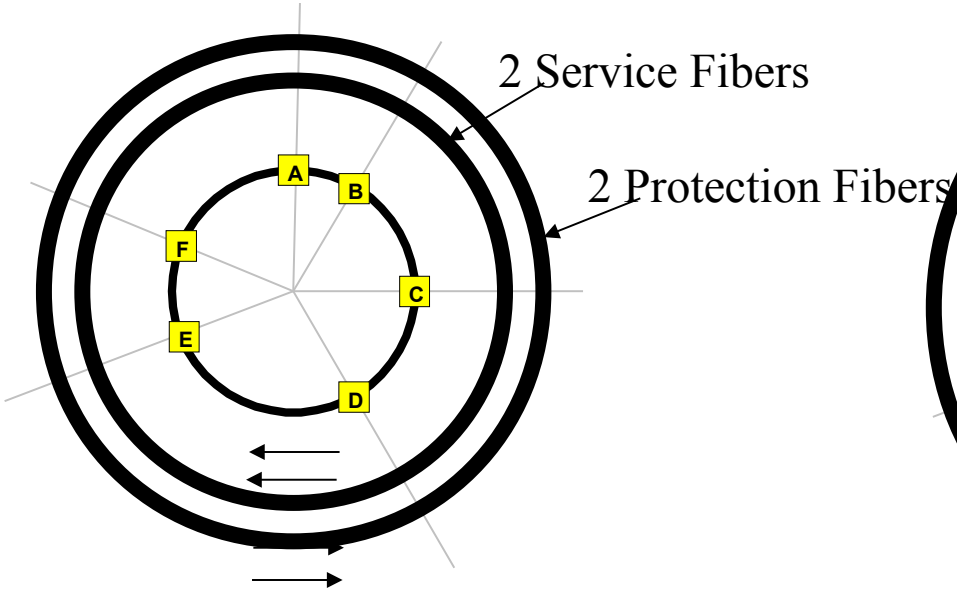
Protection	****2***			
	Description	Unit Cost (Thousand $)	Quality	Cost (Thousand $)
OC48to192	Electronic Mux	*30*	*0*	*0*
Mux/Demux	filter, filter	*64*	*5*	*320*
Linecard (192)	w/ transponder	*75*	*0*	*0*
Linecard (048)	w/ transponder	*30*	*105*	*3150*
C band Add-Drop		*1*	*17*	*17*
C band MUX		*4*	*17*	*68*
Laser (192)	CW10 + EXM01-192	*3.6*	*0*	*0*
Receiver (192)	APD-192	*2.5*	*0*	*0*
Laser (48)	CW10 + EXM01-048	*1.8*	*105*	*189*
Receiver (48)	APD-048	*1*	*105*	*105*
Fiber	proportional to length	*0.3*	*472*	*141.6*
Provisioning	5 fibers total	*2*	*100*	*225*
TOTAL (Eq)				*4215.6*

8.4 Million$

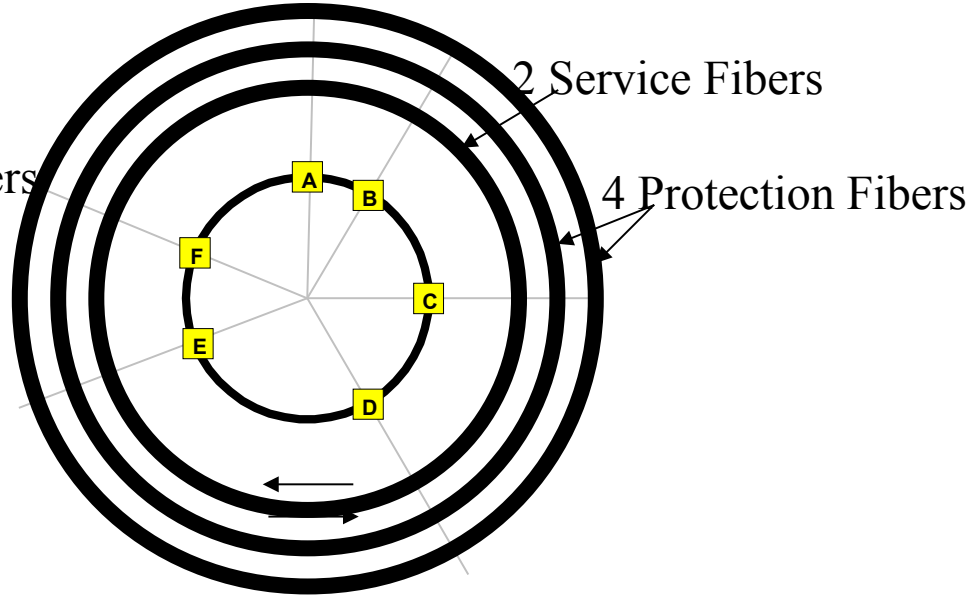
Total Cost

- Fiber baseline installation fee:
  - $20 k/km * 118 km = $2.36 Millions
- Service Cost:
  - $8.0 Millions
- Protection Cost:
  - $8.4 Millions
- Total Cost:
  - $2.36 + $8.0 + $8.4 = ***$18.8 Millions***

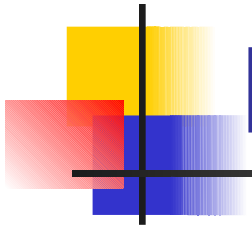
OC-192



2 Fiber Unidirectional
Path Switched Ring



4 Fiber Unidirectional
Path Switched Ring (6 physical)



Pros and Cons

- UPSR
  - 4 fibers
  - More fiber bandwidth efficient
  - Slightly cheaper (less components)
  - Typical for low speed networks (150Mb/s)
- BPSR
  - 6 fibers
  - Reciprocal paths (same delay)
  - Less components for service (more reliable)
  - Easier network management
  - Typical for high speed networks

Channel and Fiber Allocation for Service

	Service Fiber					
nm	AB	BC	CD	DE	EF	FA
1554.94	AB (4)	BC (4)	CD (4)	DE (4)	EF (4)	
1554.13	AB (4)	BC (1)	CD (1)	DE (1)	EF (4)	
1553.32					EF (4)	
1552.52					EF (3)	
1551.72						
1550.91	AC (4)	AC (4)	CE (4)	CE (4)		
1550.11	AC (4)	AC (4)	CE (4)	CE (4)		
1549.31	AC (4)	AC (4)	CE (1)	CE (1)		
1548.51	AC (4)	AC (4)	CE (1)	CE (1)		
1547.71						
1546.91	AC (4)	AC (4)		DF (4)	DF (4)	
1546.12	AC (4)	AC (4)		DF (1)	DF (1)	
1545.32	AC (1)	AC (1)				
1544.52						
1543.73						
1542.93		BD (4)	BD (4)			
1542.14		BD (4)	BD (4)			
1541.35		BD (4)	BD (4)			
1540.55	EB(1)	BD (3)	BD (3)		EB(1)	EB(1)
1539.76						
1538.97	FB (1)		CF (4)	CF (4)	CF (4)	FB (1)
1538.18			CF (4)	CF (4)	CF (4)	
1537.39			CF (1)	CF (1)	CF (1)	
1536.61			CF (1)	CF (1)	CF (1)	
1535.82						
1535.03						
1534.25						
1533.46						
1532.68						
1531.89						
1531.11						
1530.33						

Channel and Fiber Allocation for Protection:

AB cut

		Protection Fiber 1			CUT AB		
ITU THz	nm	AB	BC	CD	DE	EF	FA
192.8	1554.94		AB (4)	AB (4)	AB (4)	AB (4)	AB (4)
192.9	1554.13		AB (4)	AB (4)	AB (4)	AB (4)	AB (4)
193	1553.32						
193.1	1552.52						
193.2	1551.72						
193.3	1550.91			AC (4)	AC (4)	AC (4)	AC (4)
193.4	1550.11			AC (4)	AC (4)	AC (4)	AC (4)
193.5	1549.31			AC (4)	AC (4)	AC (4)	AC (4)
193.6	1548.51			AC (4)	AC (4)	AC (4)	AC (4)
193.7	1547.71						
193.8	1546.91			AC (4)	AC (4)	AC (4)	AC (4)
193.9	1546.12			AC (4)	AC (4)	AC (4)	AC (4)
194	1545.32			AC (1)	AC (1)	AC (1)	AC (1)
194.1	1544.52						
194.2	1543.73						
194.3	1542.93						
194.4	1542.14						
194.5	1541.35						
194.6	1540.55						
194.7	1539.76						
194.8	1538.97						
194.9	1538.18						
195	1537.39						
195.1	1536.61						
195.2	1535.82						
195.3	1535.03						
195.4	1534.25						
195.5	1533.46						
195.6	1532.68						
195.7	1531.89						
195.8	1531.11						
195.9	1530.33		BE	BE	BE		

Dispersion Analysis

Service fiber

	end	node A		node B		node C							
Dispersion		DCF-A	AB	DCF-B	BC	DCF-C	CD	DCF-D	DE	DCF-E	EF	DCF-F	FA
ps/nm		0	61.56	0	615.60	-800	410.40	-450	820.80	-900	205.20	0	307.80
start node:	A	x		61.56		-122.84		-162.44		-241.64		-36.44	
	B	209.80		x		-184.40		-224.00		-303.20		-98.00	
	C	394.20		455.76		x		-39.60		-118.80		86.40	
	D	433.80		495.36		310.96		x		-79.20		126.00	
	E	513.00		574.56		390.16		350.56		x		205.20	
	F	307.80		369.36		184.96		145.36		66.16		x	

- Spreadsheet calculates dispersion per fiber span, including DCFs
- Next adds up dispersion for each link.
- Allows us to tailor the location and amount of dispersion.

Dispersion Analysis

Service fiber, eye-closure:

	node A		node B		node C							
	DCF-A	AB	DCF-B	BC	DCF-C	CD	DCF-D	DE	DCF-E	EF	DCF-F	FA
A			0.049		0.098							
B					0.148		0.179					
C							0.032		0.095		0.069	
D									0.063		0.101	
E			0.06464								0.164	
F			0.04155									
							MAX		0.18			

- Eye closure is calculated based on 10 Gb/s external modulator, or 2.5 Gb/s (for links BE, BF)
- Varying the DCFs' locations and amount changes the eye closures.

Dispersion Analysis

Protection fiber, eye-closure:

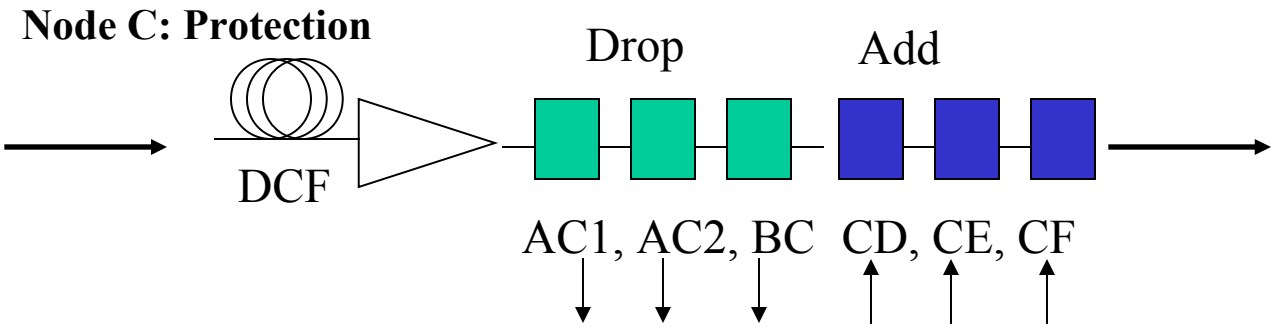
	node A		node B		node C							
	DCF-A	AB	DCF-B	BC	DCF-C	CD	DCF-D	DE	DCF-E	EF	DCF-F	FA
A												
B	0.291								0.019		0.005	
C	0.257		0.092									
D			0.125		0.159							
E					0.114		0.103					
F					0.057		0.275		0.229			
							MAX		0.291			

- Designed such that eye closure is < 0.3
- Gives 1 dB power penalty.

Power Budget- Service CW

		signal/	node A	link	node B	link	node C	link	node D	link	node E	link	node F	link
		band	EDFA-A	AB	EDFA-B	BC	EDFA-C	CD	EDFA-D	DE	EDFA-E	EF	EDFA-F	FA
Loss (dB) per link			0	0.60	0	6.00	0	2.00	0	8.00	0	2.00	0	3.00
number of adds			3		2		3		2		2		1	
number of drops			0		3		3		2		2		3	
	signal	AB	-1.0	-1.6	-4.6									
		AC1	0.0	-0.6	-5.6	-11.6	-12.6							
		AC2	1.0	0.4	-4.6	-10.6	-12.6							
		BC			0.0	-6.0	-9.0							
add		BD			1.0	-5.0	-11.0	-13.0	-14.0					
drop		CD					-1.0	-3.0	-5.0					
thru		CE					0.0	-2.0	-6.0	-14.0	-15.0			
		CF					1.0	-1.0	-5.0	-13.0	-17.0	-19.0	-20.0	
		DE							0.0	-8.0	-10.0			
		DF							1.0	-7.0	-11.0	-13.0	-15.0	
		EF									0.0	-2.0	-5.0	
		EB	-11.0	-11.6	-12.6						1.0	-1.0	-5.0	-8.0
		FB	-5.0	-5.6	-7.6								1.0	-2.0
									MAX	1.0				
									MIN	-20.0				

Device arrangement



Power Budget- Service CCW

		signal/ band	node A EDFA-A	link AB	node B EDFA-B	link BC	node C EDFA-C	link CD	node D EDFA-D	link DE	node E EDFA-E	link EF	node F EDFA-F	link FA
Loss (dB) per link			0.0	0.6	0.0	6.0	0.0	2.0	0.0	8.0	0.0	2.0	0.0	3.0
number of adds			0.0		3.0		3.0		2.0		2.0		3.0	
number of drops			3.0		2.0		3.0		2.0		2.0		1.0	
	signal	AB	-4.6	-1.6	-1.0									
		AC1	-12.6	-10.6	-10.0	-5.0	1.0							
		AC2	-12.6	-11.6	-11.0	-6.0	0.0							
		BC			-9.0	-7.0	-1.0							
add		BD			-14.0	-13.0	-7.0	-1.0	1.0					
drop		CD					-5.0	-2.0	0.0					
thru		CE					-15.0	-13.0	-11.0	-7.0	1.0			
		CF					-20.0	-19.0	-17.0	-13.0	-5.0	-1.0	1.0	
		DE							-10.0	-8.0	0.0			
		DF							-15.0	-14.0	-6.0	-2.0	0.0	
		EF									-5.0	-3.0	-1.0	
		EB	-2.6	0.4	1.0						-12.6	-11.6	-9.6	-5.6
		FB	-3.6	-0.6	0.0								-7.6	-6.6
									MAX	1				
									MIN	-20				

Power Budget- Protection CW (Protects Service CCW)

			node A	link	node B	link	node C	link	node D	link	node E	link	node F	link
			EDFA-A	AB	EDFA-B	BC	EDFA-C	CD	EDFA-D	DE	EDFA-E	EF	EDFA-F	FA
Loss (dB) per link			0	0.60	0	6.00	25	2.00	0	8.00	25	2.00	0	3.00
loss due to adds			3		2		3		2		2		1	
loss due to drops + DCF			0		3		3		2		2		3	
	signal	AB	-1.0		-5.6	-4.6	1.4	-17.6	-15.6	-11.6	-3.6	-10.0	-8.0	-4.0
		AC1	0.0				6.4	-17.6	-15.6	-11.6	-3.6	-9.0	-7.0	-3.0
		AC2	1.0				5.4	-17.6	-15.6	-11.6	-3.6	-8.0	-6.0	-2.0
		BC	-3.6	-0.6	0.0		6.4	-17.6	-15.6	-11.6	-3.6	-12.6	-10.6	-6.6
add		BD	-2.6	0.4	1.0				-13.6	-11.6	-3.6	-11.6	-9.6	-5.6
drop		CD	-15.6	-12.6	-12.0	-7.0	-1.0		-12.6	-11.6	-3.6	-24.6	-22.6	-18.6
thru		CE	-14.6	-11.6	-11.0	-6.0	0.0				-1.6	-23.6	-21.6	-17.6
		CF	-13.6	-10.6	-10.0	-5.0	1.0						-19.6	-16.6
		DE	-13.2	-10.2	-9.6	-4.6	1.4	-2.0	0.0		-0.6	-22.2	-20.2	-16.2
		DF	-13.2	-10.2	-9.6	-4.6	1.4	-1.0	1.0				-18.2	-16.2
		EF	-13.2	-10.2	-9.6	-4.6	1.4	-14.0	-12.0	-8.0	0.0		-17.2	-16.2
		EB			-7.6	-4.6	1.4	-13.0	-11.0	-7.0	1.0			
		FB			-6.6	-4.6	1.4	-17.6	-15.6	-11.6	-3.6	-1.0	1.0	
									MAX	6.4				
									MIN	-24.6				

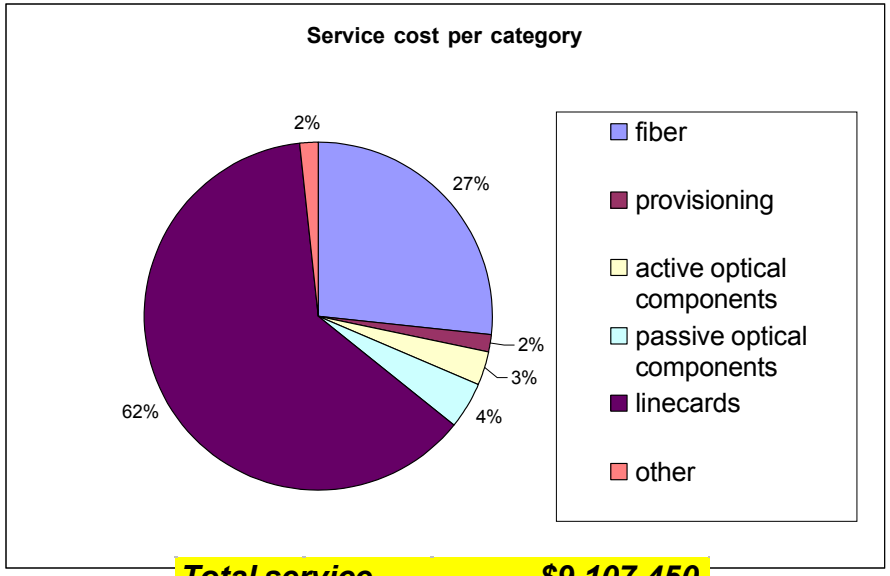
10 Gb/s Cost for Service

				parts for NORMAL service						
	nodes:									
Parts	A	B	C	D	E	F	totals			
Amplifiers							0	150.0	$0
C-Drop-100	3	5	6	4	4	4	26	1.0	$26,000
C-4-mux-100	3	5	6	4	4	4	26	4.0	$104,000
AWG-32	0	0	0	0	0	0	0	16.0	$0
Line-T-192	8	7	12	7	7	7	48	75.0	$3,600,000
Elec-Mux-048-4	8	7	12	7	7	7	48	30.0	$1,440,000
CW10	9	10	19	10	11	11	70	0.6	$42,000
EXM-048	1	3	7	3	4	4	22	1.2	$26,400
EXM-192	8	7	12	7	7	7	48	3.0	$144,000
PIN-192	8	7	11	7	7	6	46	1.3	$57,500
APD-192			1			1	2	2.5	$5,000
PIN-048	1	3	7	3	4	4	22	0.5	$11,000
Line-T-048	1	3	7	3	4	4	22	30.0	$660,000
bays	1	1	1	1	1	1	6	25.0	$150,000
DCF module (ps/nm)	$100k/80 km compensation						4300	0.1	$268,750
distances	3	30	20	40	10	15			
	link	link	link	link	link	link			
	AB	BC	CD	DE	EF	FA			
provisioning fiber	1	1	1	1	1	1	6	5	$30,000
prov. Additional	8	9	18	7	8	6	56	2.0	$112,000
fiber	$61,800	$618,000	$412,000	$824,000	$206,000	$309,000			$2,430,800
							Total service		$9,107,450

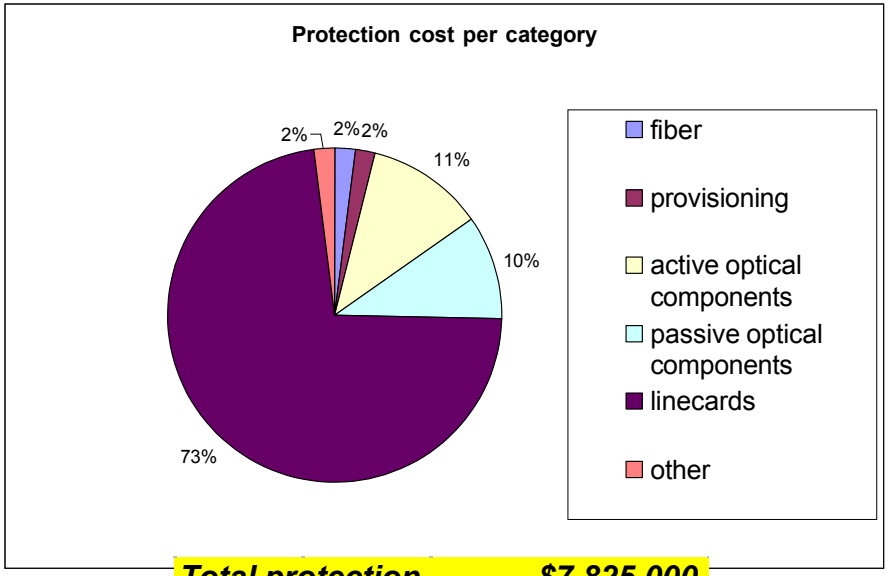
10 Gb/s Cost for Protection

				parts for PROTECTION service						
		nodes:								
Parts		A	B	C	D	E	F	totals		
Amplifiers				2		2		4	150.0	$600,000
C-Drop-100		3	5	6	4	4	4	26	1.0	$26,000
C-4-mux-100		3	5	6	4	4	4	26	4.0	$104,000
AWG-32		0	0	0	0	0	0	0	16.0	$0
Line-T-192		8	7	12	7	7	7	48	75.0	$3,600,000
Elec-Mux-048-4		8	7	12	7	7	7	48	30.0	$1,440,000
CW10		9	10	19	10	11	11	70	0.6	$42,000
EXM-048		1	3	7	3	4	4	22	1.2	$26,400
EXM-192		8	7	12	7	7	7	48	3.0	$144,000
PIN-192		8	7	11	7	7	0	40	1.3	$50,000
APD-192				1			7	8	2.5	$20,000
PIN-048		1	3	7	3	4	4	22	0.5	$11,000
Line-T-048		1	3	7	3	4	4	22	30.0	$660,000
bays		1	1	1	1	1	1	6	25.0	$150,000
DCF module (ps/nm)		$100k/80 km compensation						10400	0.1	$650,000
distances		3	30	20	40	10	15			
		link	link	link	link	link	link			
		AB	BC	CD	DE	EF	FA			
provisioning fiber		2	2	2	2	2	2	12	5.0	$60,000
prov. Additional		7	8	17	6	7	5	50	2.0	$100,000
fiber		$3,600	$36,000	$24,000	$48,000	$12,000	$18,000			$141,600
								Total protection		$7,825,000
								TOTAL		$16,932,450

Cost per category

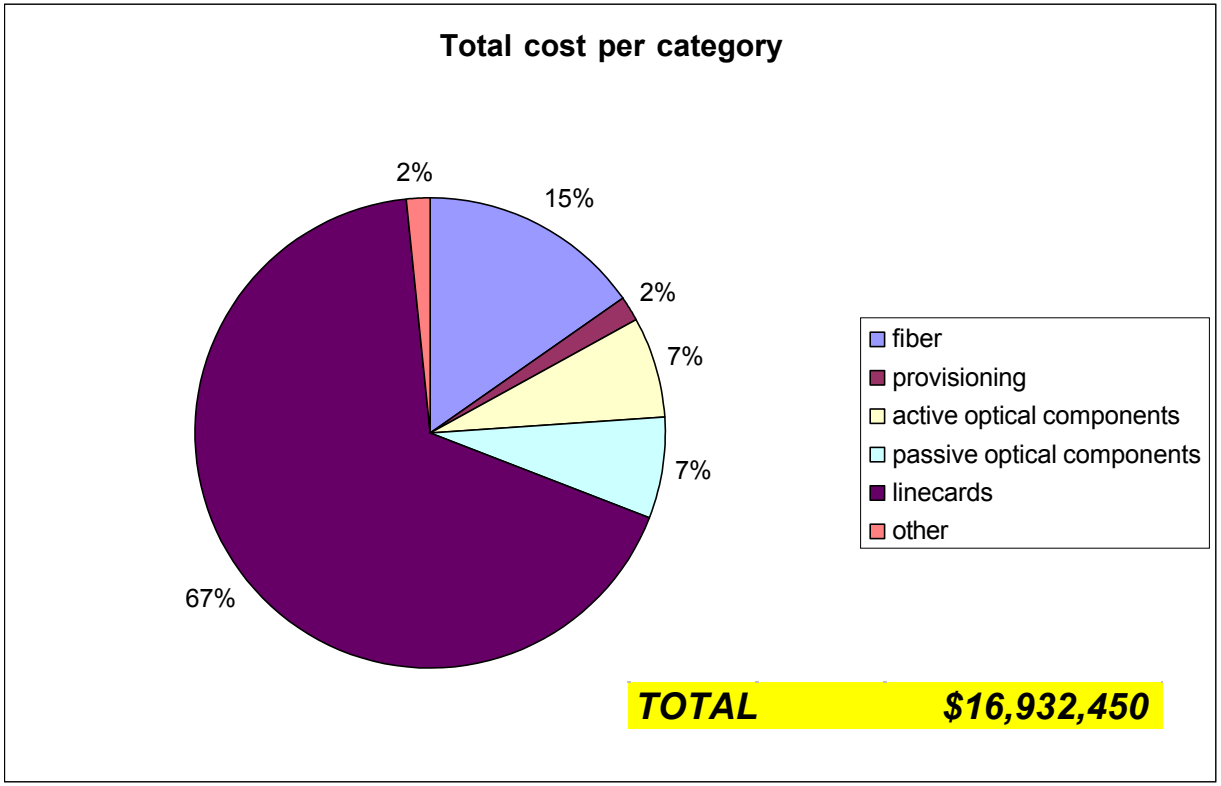


Total service $9,107,450

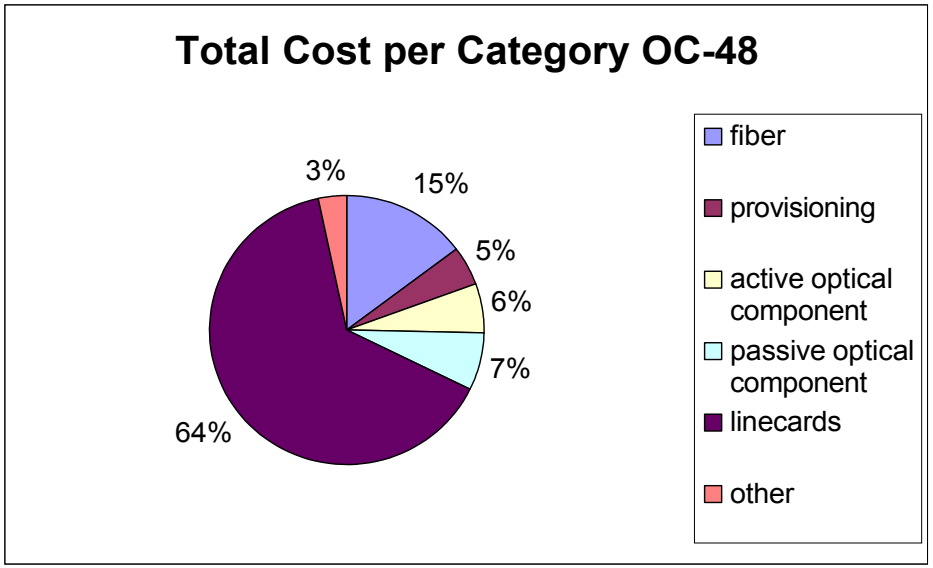


Total protection $7,825,000

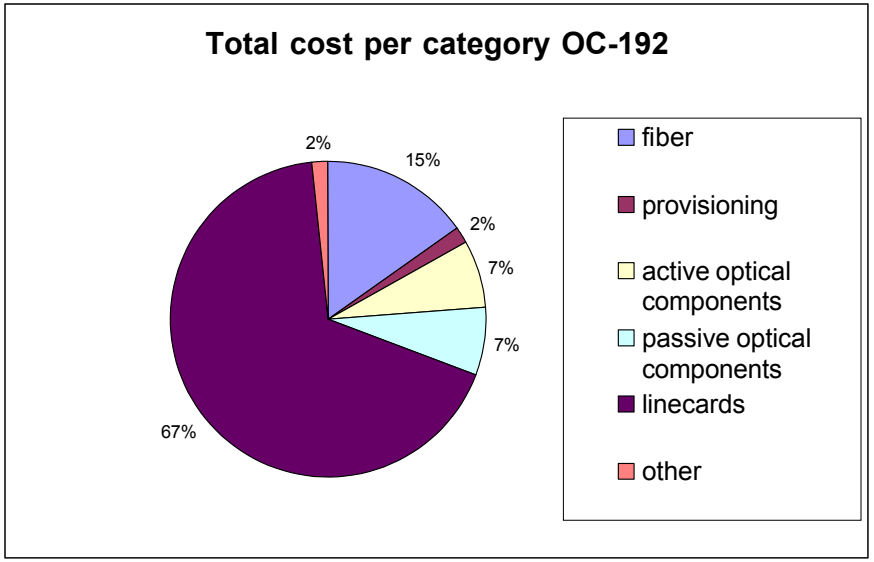
Total Cost per category



Cost comparison



TOTAL $18,800,000



TOTAL $16,932,450

Conclusion

- STS-48 solution costs more on provisioning while less on active optical component.
- There are more spare capacity in STS-192 solution than that of STS-48.
- STS-48 solution is not so scalable.
- STS-192 is easier to manage for both service and protection.