

OptiCal Inc.

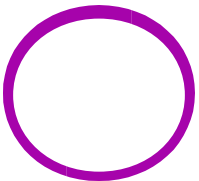
Kwest Proposal

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Tal Lavian

The Light at the end of the Tunnel



OptiCal Outline

- Design
- Link Analysis
- Financing

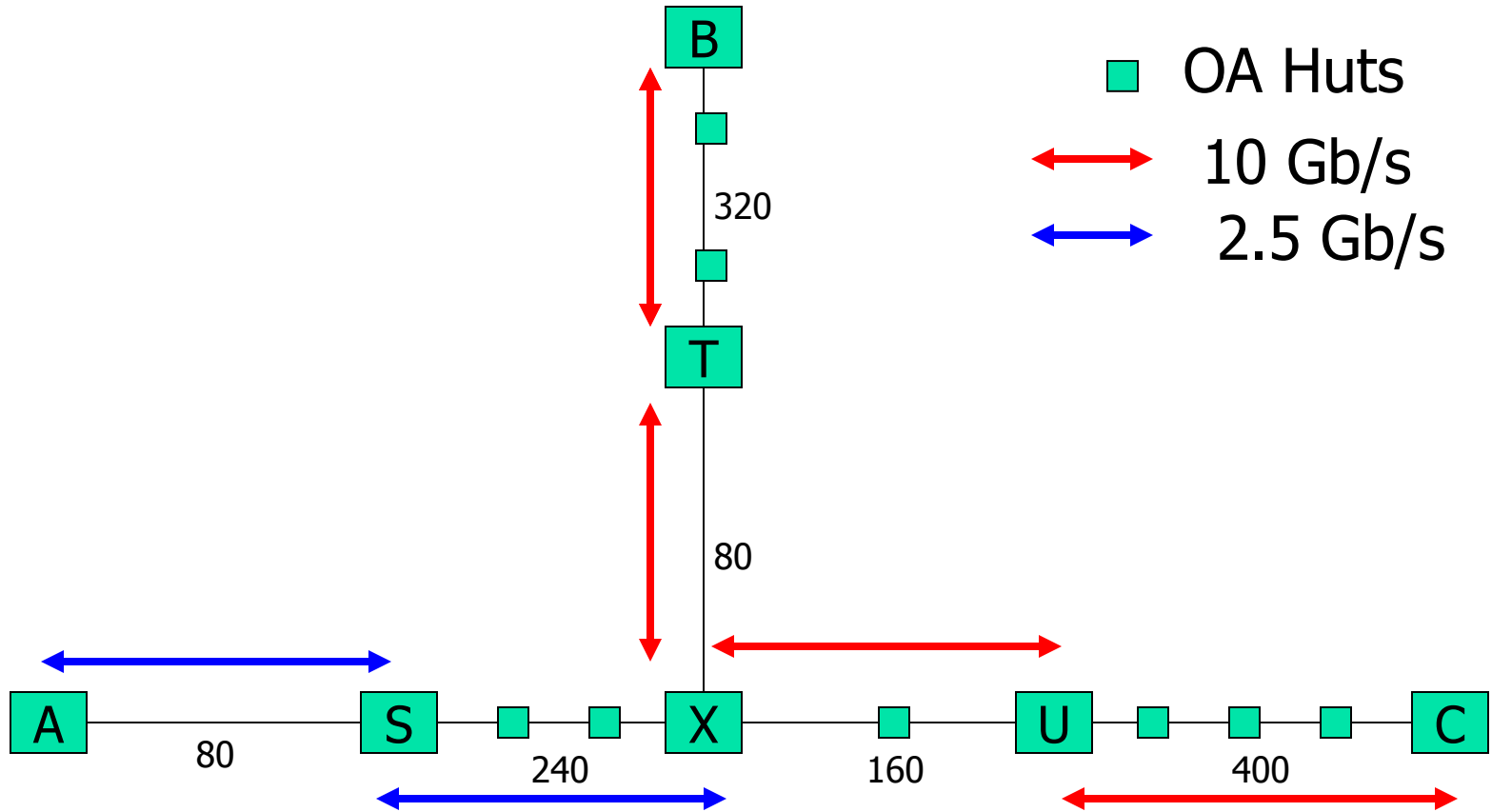


Goal

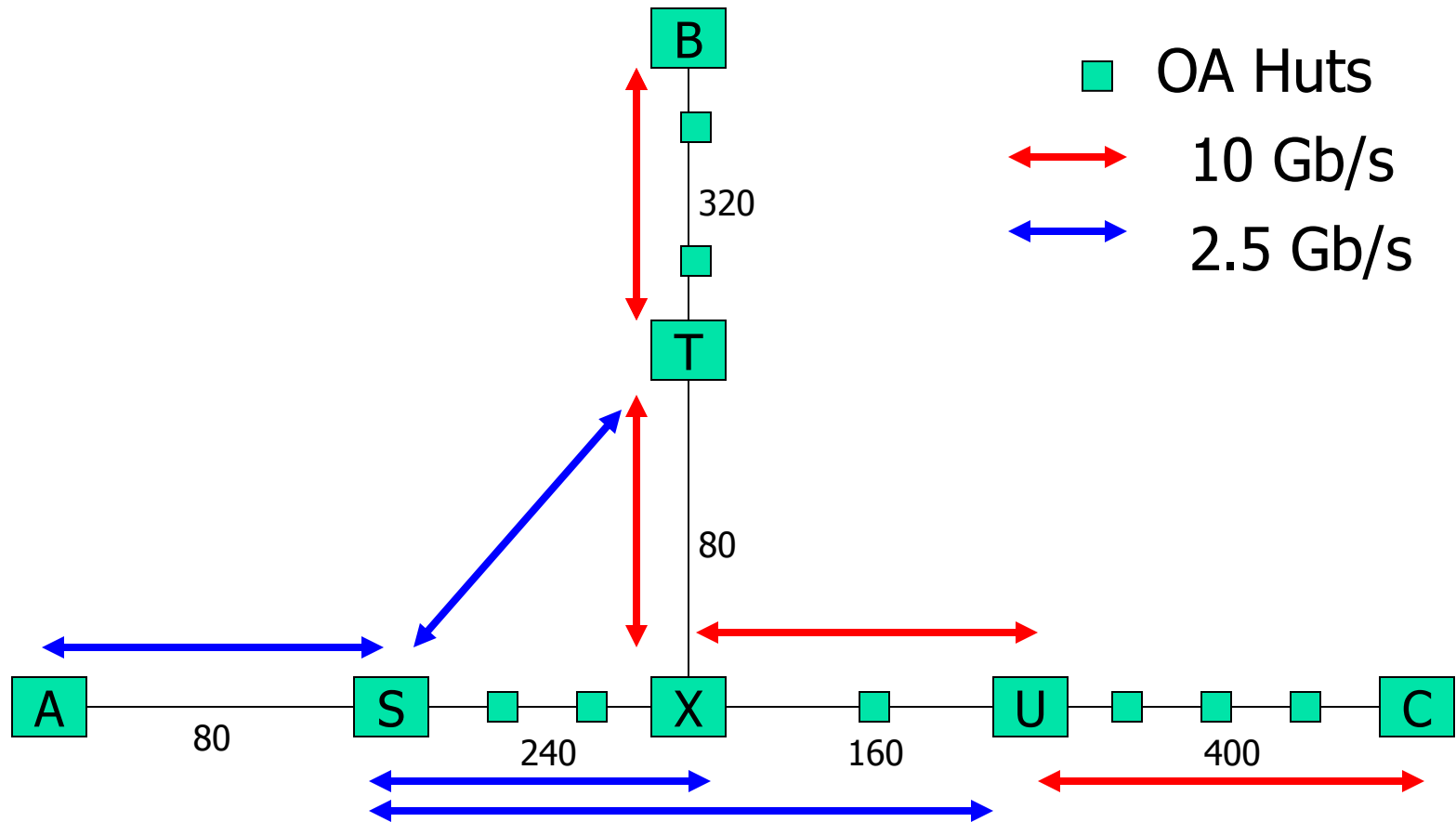
- Design OADM network.
- Compare purchasing this network all at once, vs. purchasing the regeneration-based network all at once.



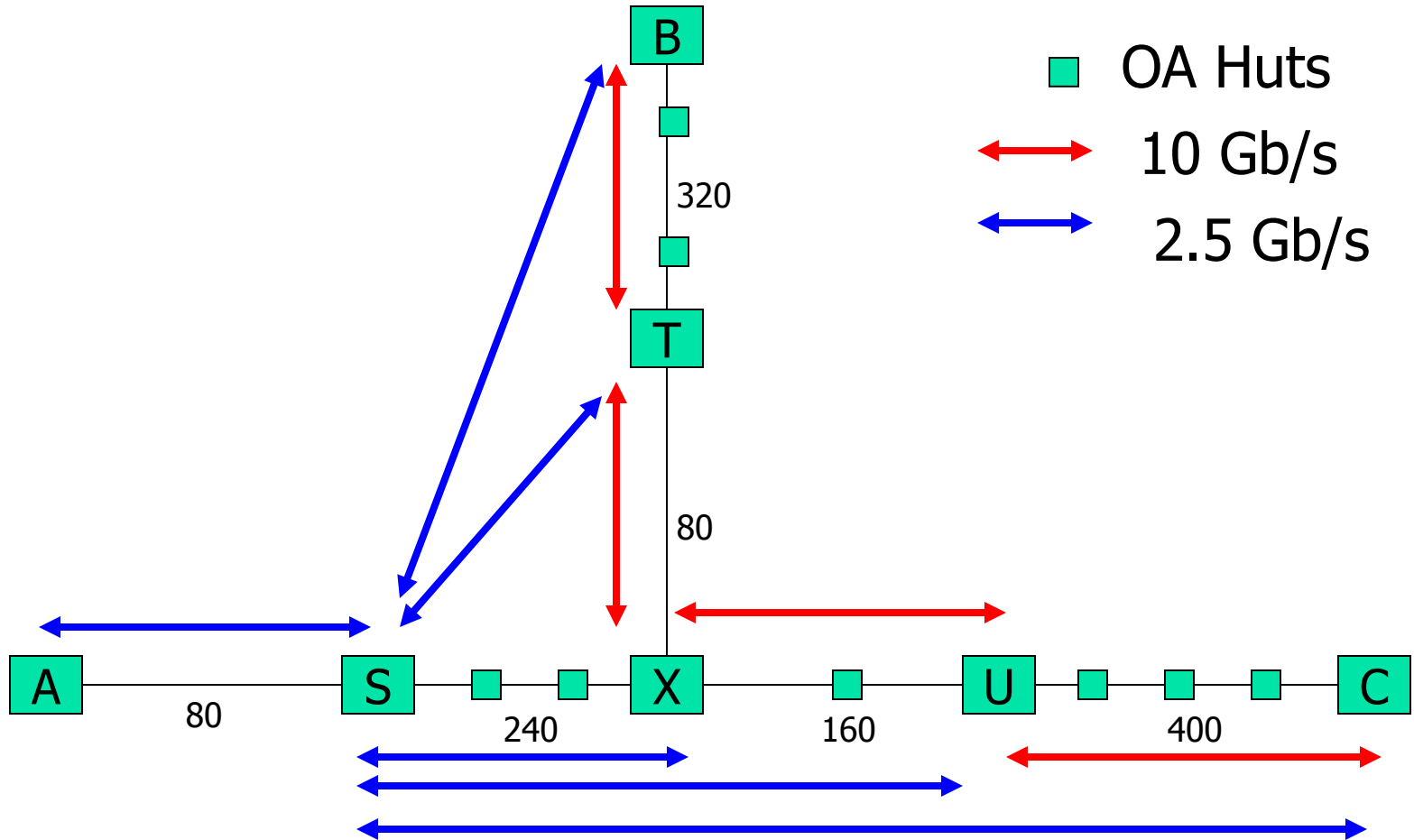
Network Diagram 1st year



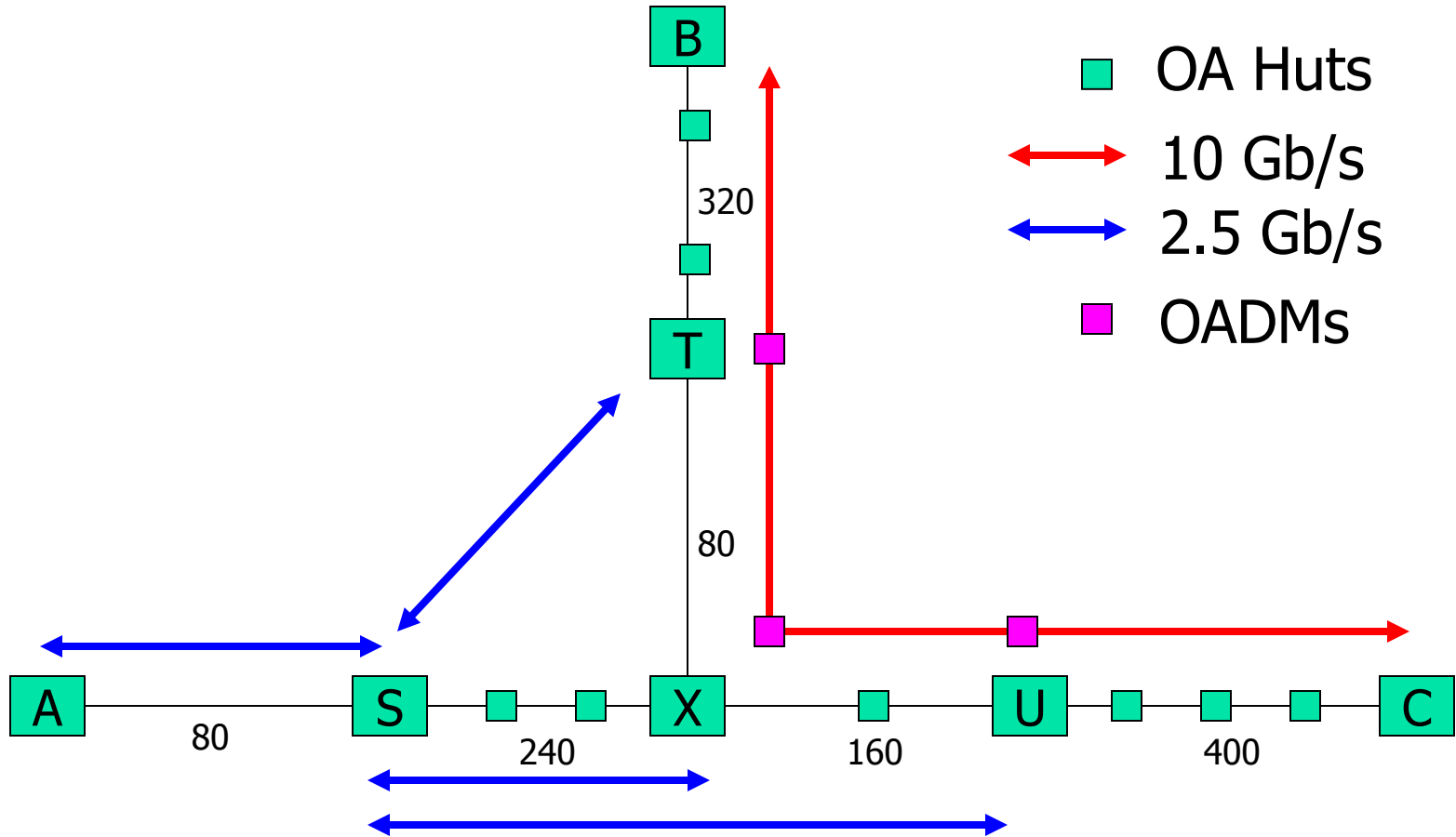
Network Diagram 2nd year



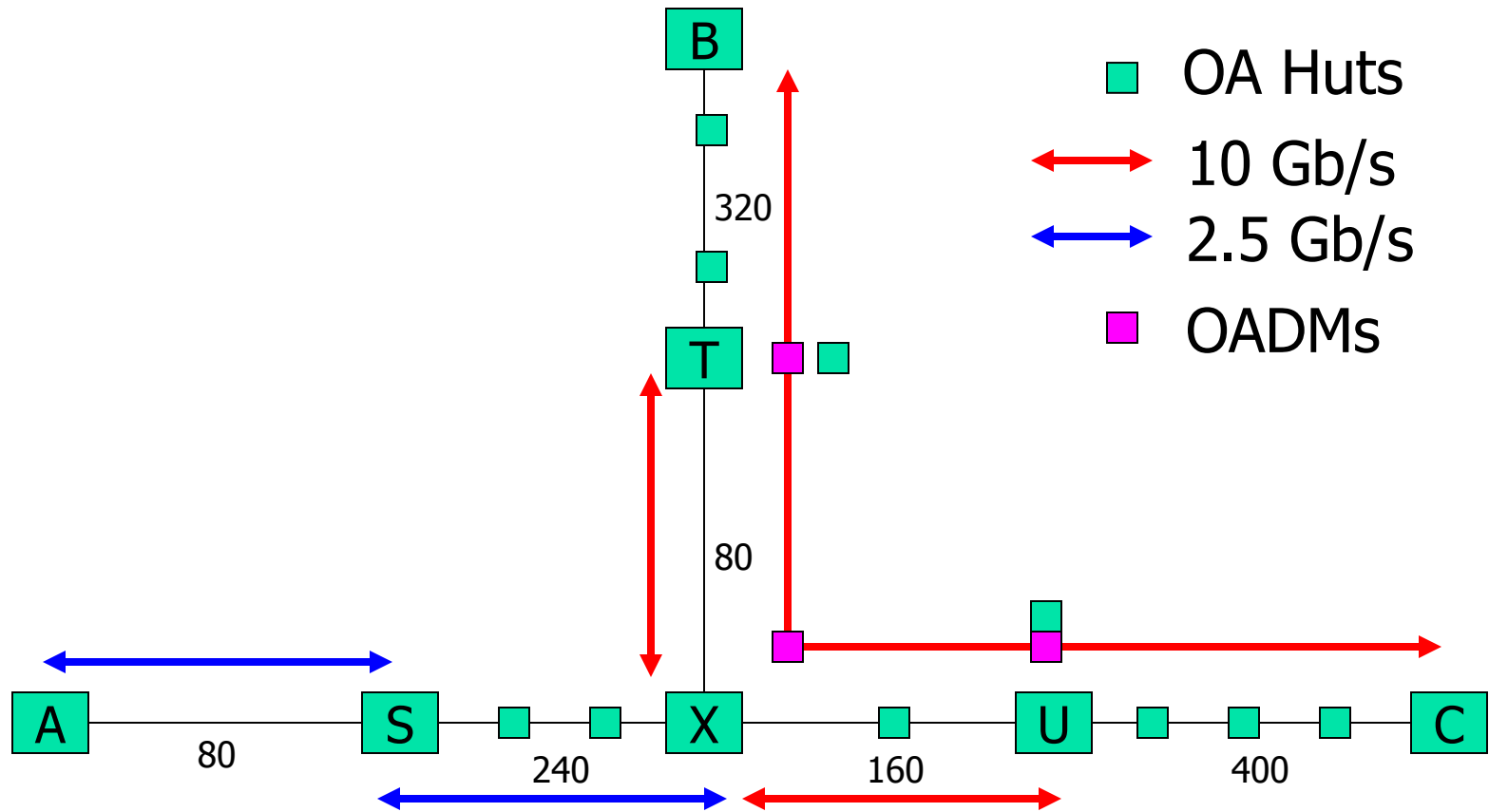
Network Diagram 3rd year



Network Diagram 3rd year /w OADM's (a)



Network Diagram 3rd year /w OADM's (b)



Link SX comparison

	(a)	(b)
EDFAs	3 extra	
OC48-192	0 extra (12)	12 extra (24)
2.5 lasers	Same	same
10 laser/det		12 extra
	CHEAPER!	



Electrical Regeneration

- Don't need to use transponders. Use cheaper line cards (***Line-O-192***)
 - 2.5 – 10 conversion (both 2.5 and 10 line cards)
 - From A,S through X: 5+5
 - 2.5-10 at nodes T,U: 2+2
 - Data from B-C: 3



OADM Restrictions

- Choose wavelength based on minimum dispersion (1530, 1550 nm)
- Eye closure < 0.3
- Dispersion restrictions:
 - BC: too much dispersion.
 - BU: $1548.5 < \lambda < 1550.5$
 - CX: $\lambda < 1539$
 - BX: $1538 < \lambda < 1561$
 - TC: $\lambda < 1536$
 - TU: $\lambda < 1552$



From Node S

194.25	1543.33	SX	SX link	SU link	ST link
194.3	1542.93	AC3	SX1	AU1	AT1
194.35	1542.54	AC3	SX1	AU1	AT1
194.4	1542.14	AC3	SX1	AU1	AT1
194.45	1541.74	AC3	AX1	AU2	AT2
194.5	1541.35	SC1	AX1	AU2	AT2
194.55	1540.95	SC1	AX1	AU2	AT2
194.6	1540.55	SC1	AX2	AU3	AT3
194.65	1540.16	SC2	AX2	AU3	AT3
194.7	1539.76	SC2	AX2	AU3	AT3
194.75	1539.37	SC2	SX2	AU3	AT3
194.8	1538.97	SC3	SX2	AU3	AT3
194.85	1538.58	SC3	SX2	AU3	AT3
194.9	1538.18	SC3	AX3	SU1	ST1
194.95	1537.79	SC3	AX3	SU1	ST1
195	1537.39	SC3	AX3	SU1	ST1
195.05	1537	SC3	AX3	SU2	ST2
195.1	1536.61	AB3	AX3	SU2	ST2
195.15	1536.21	AB3	AX3	SU2	ST2
195.2	1535.82	AB3	SX3	SU3	ST3
195.25	1535.42	AB3	SX3	SU3	ST3
195.3	1535.03	SB1	SX3	SU3	ST3
195.35	1534.64	SB1	SX3	SU3	ST3
195.4	1534.25	SB1	SX3	SU3	ST3
195.45	1533.85	SB2	SX3	SU3	ST3
195.5	1533.46	SB2	AB1	AC1	AB1
195.55	1533.07	SB2	AB1	AC1	
195.6	1532.68	SB3	AB2	AC1	
195.65	1532.29	SB3	AB3	AC2	
195.7	1531.89	SB3	AC2		AB2
195.75	1531.5	SB3	AC2		AB2
195.8	1531.11	SB3	AC3		
195.85	1530.72	SB3	AC3		AB3



Link TX

192.8	1554.94	AT1	CB1	CB1	CB1	CB3
192.9	1554.13	AT1	CB2	CB2	CB2	CB3
193	1553.32	AT1	CB3	CB3	CB3	CB3
193.1	1552.52	AT2				
193.2	1551.72	AT2				
193.3	1550.91	AT2				
193.4	1550.11	AT3	UB3	UB3	UB3	UB3
193.5	1549.31	AT3	UB3	UB3	UB2	UB2
193.6	1548.51	AT3	UB1	UB1	UB1	UB2
193.7	1547.71	AT3				
193.8	1546.91	AT3	TX1	TX1	TX1	TX3
193.9	1546.12	AT3	TX2	TX2	TX2	TX3
194	1545.32	ST1	TX3	TX3	TX3	TX3
194.1	1544.52	ST1				
194.2	1543.73	ST1	AB3	AB3	SB1	AB3
194.3	1542.93	ST2	SB3	SB2	SB1	AB3
194.4	1542.14	ST2	SB3	SB2	SB2	SB1
194.5	1541.35	ST2	SB3	SB3	SB3	SB3
194.6	1540.55	ST3				
194.7	1539.76	ST3	BX3	BX3	BX3	BX3
194.8	1538.97	ST3	BX2	BX2	BX2	BX3
194.9	1538.18	ST3	BX1	BX1	BX1	BX3
195	1537.39	ST3	AB1	AB1	AB2	AB3
195.1	1536.61	ST3				
195.2	1535.82					
195.3	1535.03		CT3	CT3	CT3	CT3
195.4	1534.25	AB1	CT2	CT2	CT2	CT3
195.5	1533.46	AB2	CT1	CT1	CT1	CT3
195.6	1532.68	AB2				
195.7	1531.89	AB3	TU3	TU3	TU3	TU3
195.8	1531.11		TU1	TU1	TU1	TU3
195.9	1530.33		TU2	TU2	TU2	TU3



Link BT

192.8	1554.936	CB1	CB1	CB1	CB3
192.9	1554.13	CB2	CB2	CB2	CB3
193	1553.325	CB3	CB3	CB3	CB3
193.1	1552.52				
193.2	1551.717				
193.3	1550.914				
193.4	1550.112	UB3	UB3	UB3	UB3
193.5	1549.311	UB3	UB3	UB2	UB2
193.6	1548.511	UB1	UB1	UB1	UB2
193.7	1547.711				
193.8	1546.913				
193.9	1546.115				
194	1545.318				
194.1	1544.522				
194.2	1543.727	AB3	AB3	SB1	AB3
194.3	1542.932	SB3	SB2	SB1	AB3
194.4	1542.138	SB3	SB2	SB2	SB1
194.5	1541.346	SB3	SB3	SB3	SB3
194.6	1540.553				
194.7	1539.762	BX3	BX3	BX3	BX3
194.8	1538.972	BX2	BX2	BX2	BX3
194.9	1538.182	BX1	BX1	BX1	BX3
195	1537.393	AB1	AB1	AB2	AB3
195.1	1536.605				
195.2	1535.818	AB1	AB2	AB2	AB3
195.3	1535.032	BT1	BT1	BT1	BT3
195.4	1534.246	BT2	BT2	BT2	BT3
195.5	1533.461	BT3	BT3	BT3	BT3
195.6	1532.677				
195.7	1531.894				
195.8	1531.112				
195.9	1530.33				



Link XU

192.8	1554.936203	AU1	SC2	SC2	SC3	SC3
192.9	1554.130119	AU1	SC1	SC1	SC1	SC2
193	1553.32487	AU1	AC3	AC3	AC3	AC3
193.1	1552.520456	AU2	SC3	SC3	SC3	SC3
193.2	1551.716874	AU2				
193.3	1550.914123	AU2				
193.4	1550.112203	AU3	UB3	UB3	UB3	UB3
193.5	1549.311111	AU3	UB3	UB3	UB2	UB2
193.6	1548.510847	AU3	UB1	UB1	UB1	UB2
193.7	1547.711409	AU3				
193.8	1546.912797	AU3	TU3	TU3	TU3	TU3
193.9	1546.115008	AU3	TU1	TU1	TU1	TU3
194	1545.318041	SU1	TU2	TU2	TU2	TU3
194.1	1544.521896	SU1				
194.2	1543.726571	SU1	XU1	XU1	XU1	XU3
194.3	1542.932064	SU2	XU2	XU2	XU2	XU3
194.4	1542.138374	SU2	XU3	XU3	XU3	XU3
194.5	1541.345501	SU2				
194.6	1540.553443	SU3	BC3	BC3	BC3	BC3
194.7	1539.762198	SU3	BC2	BC2	BC2	BC3
194.8	1538.971766	SU3	BC1	BC1	BC1	BC3
194.9	1538.182145	SU3				
195	1537.393333	SU3				
195.1	1536.605331	SU3				
195.2	1535.818135	AC1	CT3	CT3	CT3	CT3
195.3	1535.031746	AC1	CT2	CT2	CT2	CT3
195.4	1534.246162	AC1	CT1	CT1	CT1	CT3
195.5	1533.461381	AC2				
195.6	1532.677403		AC2	AC2	AC3	AC3
195.7	1531.894226		XC1	XC1	XC1	XC3
195.8	1531.111849		XC2	XC2	XC2	XC3
195.9	1530.330271		XC3	XC3	XC3	XC3



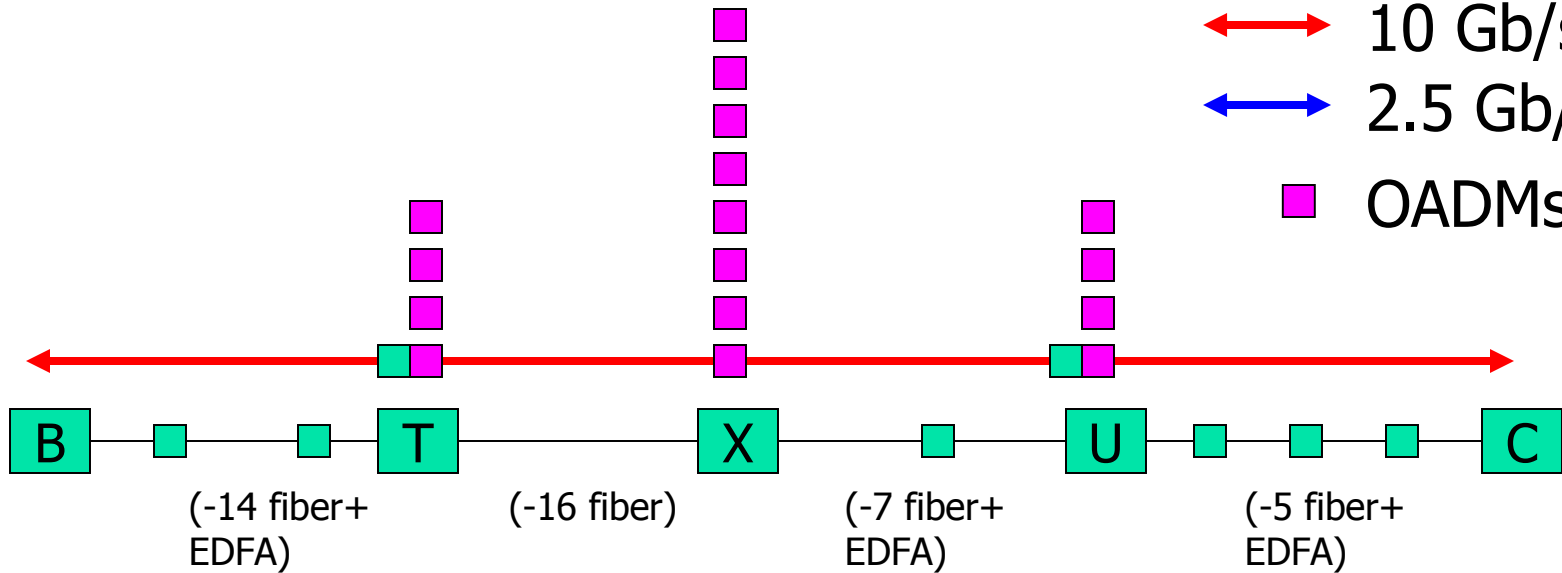
Link UC

192.8	1554.936	SC2	SC2	SC3	SC3
192.9	1554.13	SC1	SC1	SC1	SC2
193	1553.325	AC3	AC3	AC3	AC3
193.1	1552.52	SC3	SC3	SC3	SC3
193.2	1551.717				
193.3	1550.914				
193.4	1550.112				
193.5	1549.311				
193.6	1548.511				
193.7	1547.711				
193.8	1546.913				
193.9	1546.115				
194	1545.318				
194.1	1544.522	AC1	AC1	AC1	AC2
194.2	1543.727	UC3	UC3	UC3	UC3
194.3	1542.932	UC1	UC1	UC1	UC3
194.4	1542.138	UC2	UC2	UC2	UC3
194.5	1541.346				
194.6	1540.553	BC2	BC1	BC1	BC1
194.7	1539.762	BC2	BC2	BC3	BC3
194.8	1538.972	BC3	BC3	BC3	BC3
194.9	1538.182				
195	1537.393				
195.1	1536.605				
195.2	1535.818	CT3	CT3	CT3	CT3
195.3	1535.032	CT2	CT2	CT2	CT3
195.4	1534.246	CT1	CT1	CT1	CT3
195.5	1533.461				
195.6	1532.677	AC2	AC2	AC3	AC3
195.7	1531.894	XC1	XC1	XC1	XC3
195.8	1531.112	XC2	XC2	XC2	XC3
195.9	1530.33	XC3	XC3	XC3	XC3



Link B-T-X-U-C Power Budget

- OA Huts
- ↔ 10 Gb/s
- ↔ 2.5 Gb/s
- OADMs



+3 (modulated),
-4 (muxed)

-18 (input),
-22 (after OADM)
+3 (amplified)

-13 (input),
-21 (after OADM)

-28 (input),
-3 (amplified),
-7 (after OADM)

-12 (input),
-19 (after mux)

-12 (input),
-19 (after mux)

-19 (input),
-23 (after OADM)
+2 (amplified)

+5 (input),
-3 (after OADM)

-9 (input),
-13 (after OADM),
+12 (amplified)



+3 (modulated),
-4 (muxed)



EDFAs, Channel Spacing

- System uses only EDFA-32 C-Band
- Channel spacing 100 Ghz.
 - Chosen to allow 10 Gb/s transmission.
- System is symmetric for easier bi-directionality.



Equipment Needed

		1st Year	2nd Year	3rd Year
Component	Price	Units	Units	Units
CW01	300.00	0	48	0
CW10	600.00	148	92	240
DM01-025	1,000.00	0	0	0
EML01-025	2,000.00	0	0	0
EML01-192	5,000.00	10	8	12
EXM-048	1,200.00	96	12	192
EXM-192	3,000.00	42	12	36
PIN-048	500.00	96	60	192
PIN-192	1,250.00	26	16	30
APD-048	1,000.00	36	84	72
APD-192	2,500.00	52	20	48
EDFA-32	150,000.00	7	5	11
EDFA-64	375,000.00	0	0	0
AWG-32	16,000.00	0	0	0
AWG-64	32,000.00	0	0	0
OC48-192	30,000.00	52	20	48
Linecard /w transp. 048	15,000.00	96	72	120
Linecard /w transp. 192	37,500.00	52	20	48
Bay	25,000.00	7	1	1
Provisioning Fibers	5,000.00	23	18	36
Provisioning additional	2,000.00	51	16	30
Disconnect	4,000.00	0	30	30
OA Hut	10,000.00	8	0	0
Workers	200,000.00	1	0	0



Finance (updated 3 year Solution)

Component	Price	1st Year		2nd Year		Units
		Units	Total	Units	Total	
<i>CW01</i>	300.00	60	18,000.00	12	2,376.00	0
<i>CW10</i>	600.00	88	52,800.00	164	64,944.00	276
<i>EML01-192</i>	5,000.00	0	0.00	0	0.00	0
<i>EXM-048</i>	1,200.00	96	115,200.00	144	114,048.00	240
<i>EXM-192</i>	3,000.00	52	156,000.00	68	134,640.00	60
<i>PIN-048</i>	500.00	96	48,000.00	84	27,720.00	192
<i>PIN-192</i>	1,250.00	26	32,500.00	16	13,200.00	30
<i>APD-048</i>	1,000.00	0	0.00	48	31,680.00	24
<i>APD-192</i>	2,500.00	26	65,000.00	26	42,900.00	48
<i>EDFA-32</i>	150,000.00	7	1,050,000.00	5	495,000.00	11
<i>AWG-32</i>	16,000.00	10	160,000.00	4	42,240.00	4
<i>OC48-192</i>	30,000.00	36	1,080,000.00	32	633,600.00	60
<i>Linecard /w transp. 048</i>	30,000.00	96	2,880,000.00	108	2,138,400.00	240
<i>Linecard /w transp. 192</i>	75,000.00	52	3,900,000.00	32	1,584,000.00	48
<i>Bay</i>	25,000.00	7	175,000.00	1	16,500.00	1
<i>Provisioning Fibers</i>	5,000.00	23	115,000.00	20	66,000.00	38
<i>Provisioning additional</i>	2,000.00	51	102,000.00	68	89,760.00	91
<i>Disconnect</i>	4,000.00	0	0.00	30	79,200.00	30
<i>OA Hut</i>	10,000.00	8	80,000.00	0	0.00	0
<i>Workers</i>	200,000.00	1	200,000.00	0	0.00	0
Total			10,229,500.00		5,576,208.00	

*** note: O-E-O conversion doesn't require transponders.
Actual total line card cost should be lower.



Finances for one-time purchase

Component	Price		
CW01	300.00	60	18,000.00
CW10	600.00	456	273,600.00
EXM-048	1,200.00	384	460,800.00
EXM-192	3,000.00	120	360,000.00
PIN-048	500.00	336	168,000.00
PIN-192	1,250.00	60	75,000.00
APD-048	1,000.00	48	48,000.00
APD-192	2,500.00	60	150,000.00
EDFA-32	150,000.00	23	3,450,000.00
AWG-32	16,000.00	18	288,000.00
OC48-192	30,000.00	126	3,780,000.00
Linecard /w transp. 048	30,000.00	384	11,520,000.00
Linecard /w transp. 192	75,000.00	120	9,000,000.00
Bay	25,000.00	7	175,000.00
Provisioning Fibers	5,000.00	81	405,000.00
Provisioning additional	2,000.00	171	342,000.00
Disconnect	4,000.00		
OA Hut	10,000.00	8	80,000.00
\$1M bonus: LC, CM, TL	1,000,000.00	3	300000
Total			33,593,400.00

*** note: O-E-O conversion doesn't require transponders.
Actual total line card cost should be lower.



Cost Distribution?

- Over 60% is for line cards - 😞
- Line card w/ transp048 \$11.5M
- Line card w/ transp192 \$9M
- OC-48-192 \$3.7
- EDFA-32 \$3.5M
- Bonus - 😊 \$3M



OADM Solution

	<i>link</i>	<i>links</i>	<i>nodes:</i>							
<i>Parts</i>	<i>AS</i>	<i>S+</i>	<i>X</i>	<i>T</i>	<i>B</i>	<i>U</i>	<i>C</i>	<i>totals</i>		
Amplifiers								18	\$150	\$2,700,000
<i>C-Drop-100</i>			8	4		4		16	\$1	\$16,000
<i>C-4-mux-100</i>			8	4		4		16	\$4	\$64,000
<i>AWG-32</i>		8			2		2	12	\$16	\$192,000
<i>Line-O-192</i>			13	2		2		17	\$38	\$637,500
Line-T-192			12	11	18	11	18	70	\$75	\$5,250,000
Line-T-048	144	192						336	\$30	\$10,080,000
<i>Line-O-048</i>		48						48	\$15	\$720,000
Elec-Mux-048-4			28	13	18	13	18	90	\$30	\$2,700,000
<i>CW10</i>	144	112	28	13	18	13	18	346	\$1	\$207,600
<i>CW1</i>		128						128	\$0	\$38,400
<i>EXM-192</i>			28	13	18	13	18	90	\$3	\$270,000
EXM-048	144	240						384	\$1	\$460,800
<i>PIN-192</i>			28	13	18	13	18	90	\$1	\$112,500
PIN-048	144	184						328	\$1	\$164,000
<i>APD-048</i>		56						56	\$1	\$56,000
<i>bays</i>	1	1	1	1	1	1	1	7	\$25	\$175,000
<i>prov. fiber</i>	72	4		1	1	1	1	80	\$5	\$400,000
<i>prov. add.</i>	0	115	35					150	\$2	\$300,000
								Total:	\$24,543,800	

*** note: \$1.4M more if we used only Line-T-xxx

Total:

\$24,543,800

Cost Distribution?

- Over 80% is for:
- Line-T-048 \$10M
- Line-T-192 \$5.2M
- Elec-Mux-048-4 \$2.7M
- Amplifiers \$2.7M



Questions

- Provision costs for OADM?



Price Summary

Solution	Price
3 Year Plan (incl. depreciation)	\$23,038,264
One time purchase (with regeneration)	\$33,593,400
One time purchase (OADM Solution)	\$24,543,800

