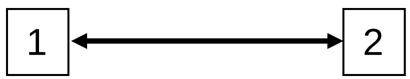
NETWORKS

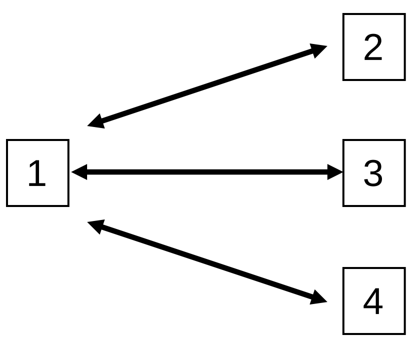
System architecture

Comparison Star and Bus Network

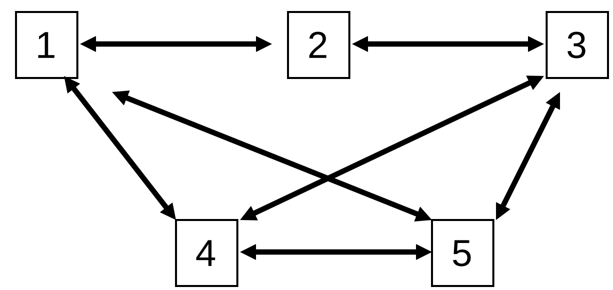
Three Basic Network Topologies



Link



Multipoint



Network

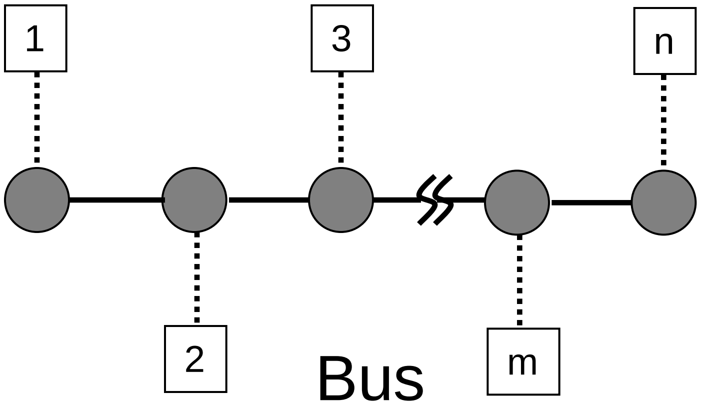
Fiber Optic Networks

WAN – Wide Area Network – connects users across a country
-Hubs/Nodes at major cities with (typically) electronic connection
Long link-length “Long haul” (1550nm with dispersion management), DWDM - stars and rings used

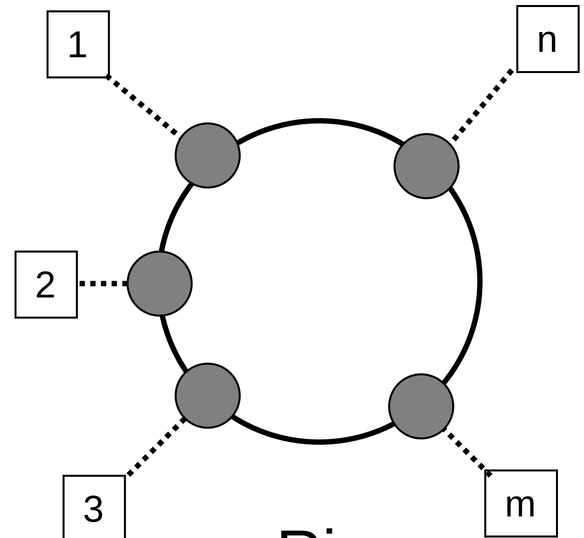
MAN – Metropolitan Area Network – within a city
-Typically rings connected to nodes on WAN
Intermediate link length (1550/1300nm)

LAN - Local Area Network – buildings, campus
-Star,Bus,Ring
Short Link Length (<10km) absorption/dispersion less important – bus topology matters (1300nm, 850nm)

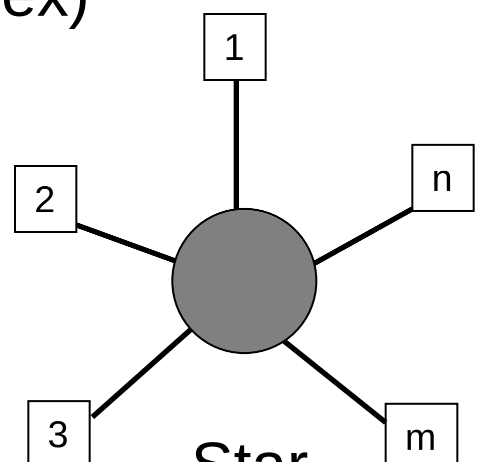
Topologies for Fiber Optic Networks



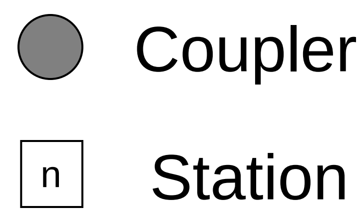
Bus
(Active or passive,
Simplex or Duplex)



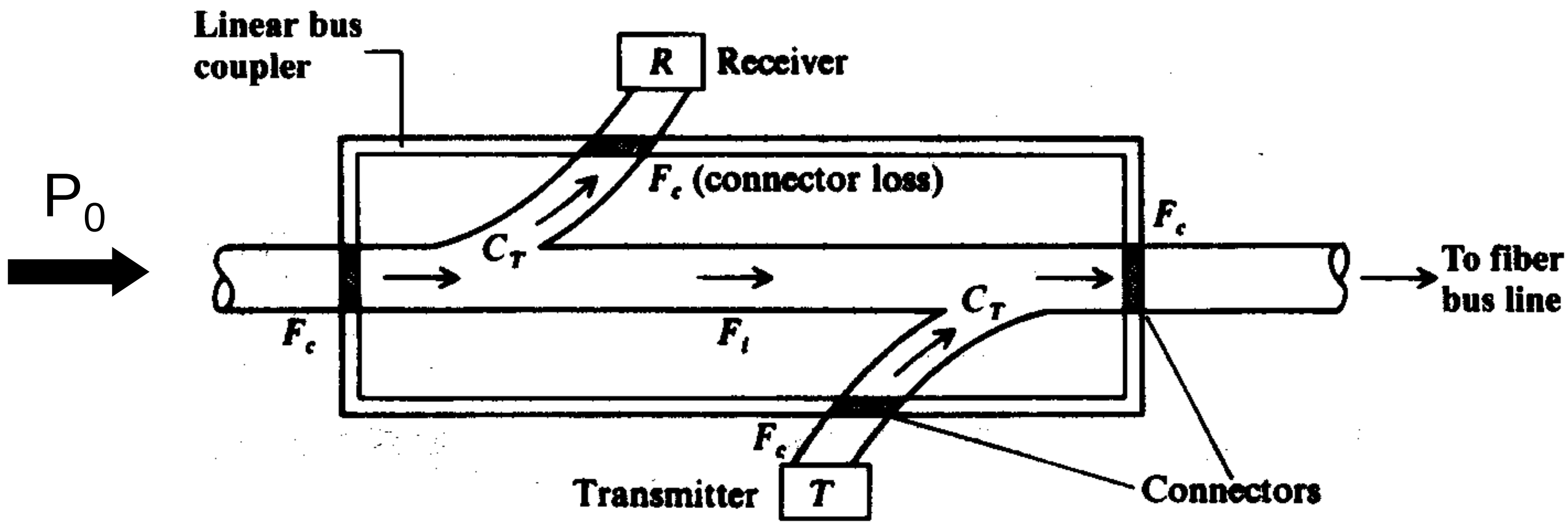
Ring
(active)



Star
(Active or passive)



Passive Coupler

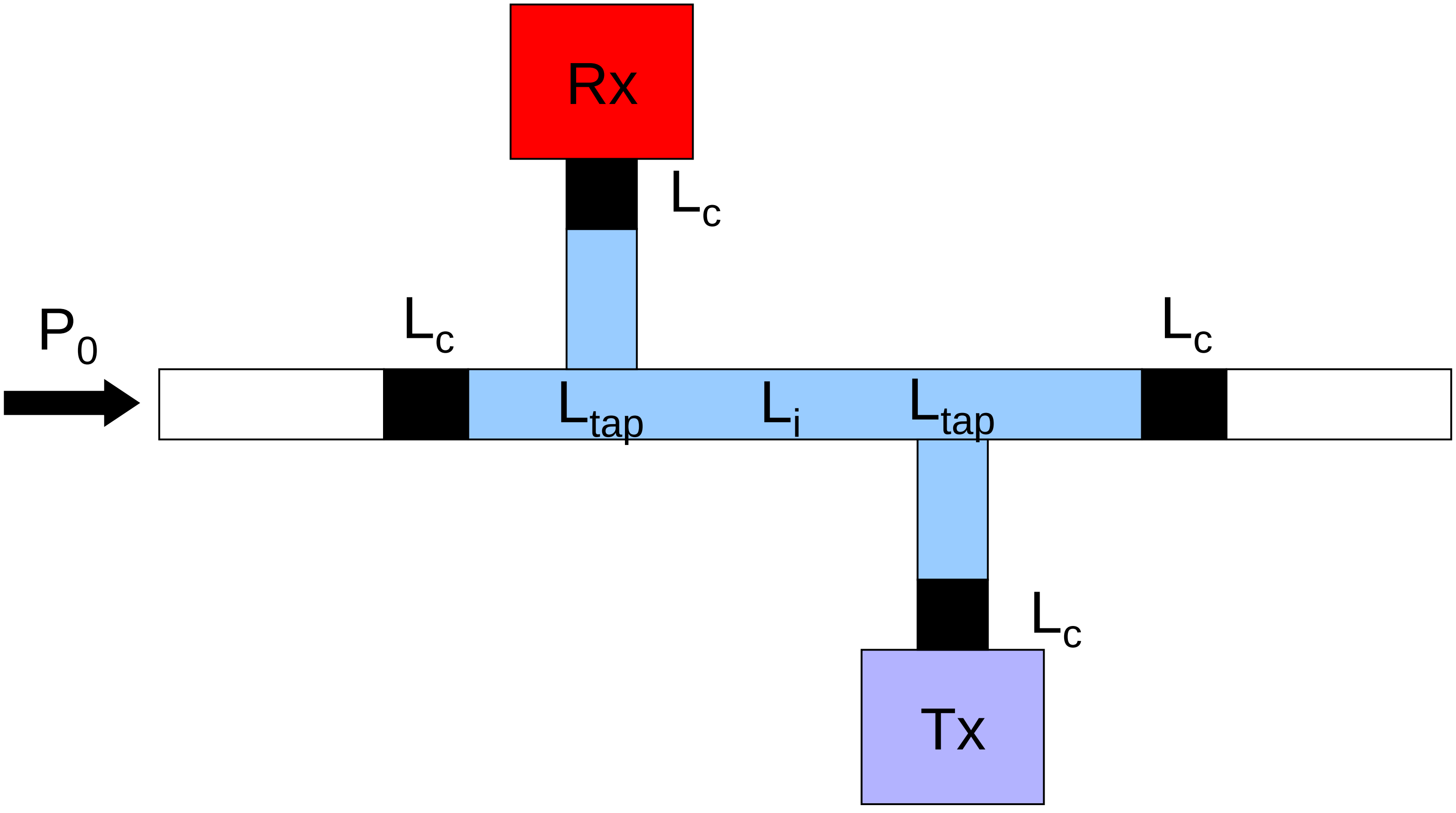


Connecting Loss L_c

Tap Loss (coupling) L_{tap} per tap, $L_{thru} = 1 – 1/L_{tap}$ (linear)

Intrinsic Transmission Loss L_i

Passive Coupler



Connecting Loss	L_c
Tap Loss	L_{tap} per tap
Transmission Loss	L_i

Passive coupler

Coupler actually made up of two directional couplers – 4 ports (one in each direction) but we only show two of the ports on previous slide – other pair unused.

C_T is the fraction of power removed from the bus and delivered to the detector port – power extracted from bus is called the tap loss and

$L_{tap} = -10 \log C_T$

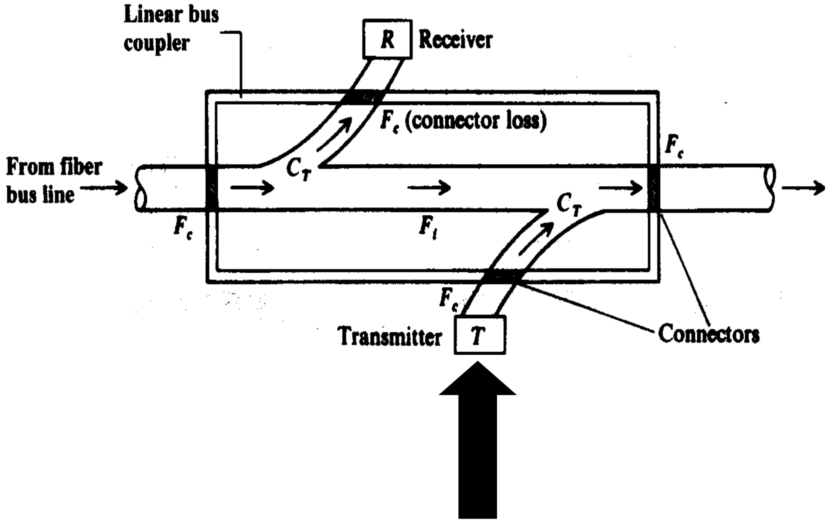
Now power passes over 2 tap points per coupler.

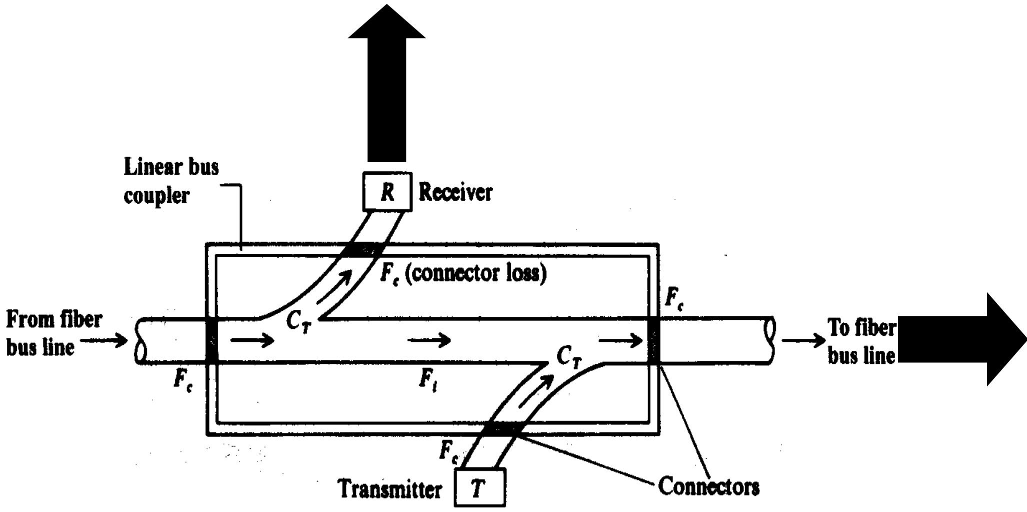
Hence the throughput power loss is

$L_{thru} = -10 \log (1-C_T)^2 = -20 \log(1-C_T)$

e.g. (10 dB coupler) $C_T = 0.1$, $L_{tap} = 10\text{dB} = 10$, $L_{thru} = 0.9\text{dB}$

Bus - Nearest Neighbour Power Budget

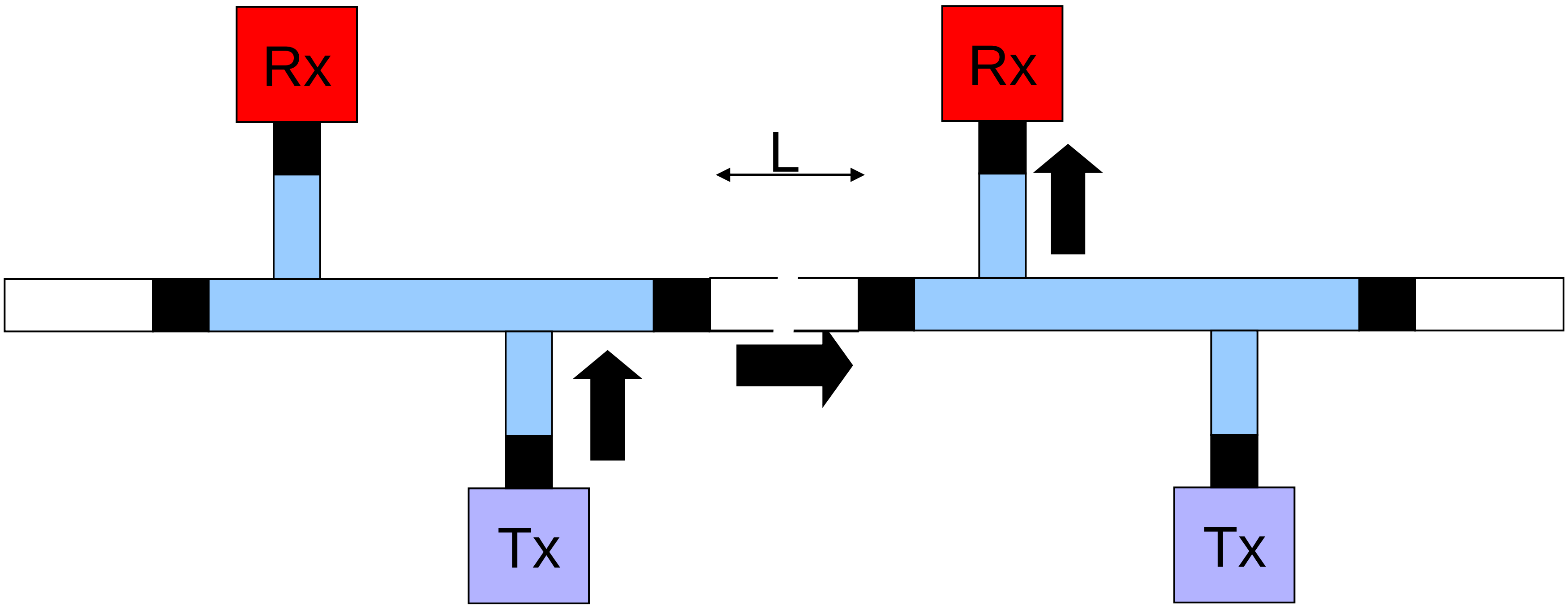




Loss Between Nearest Neighbours

$$= \alpha L + 2L_{tap} + 4L_c + 2L_i \quad \text{(equn A)}$$

Bus - Nearest Neighbour Power Budget



Loss Between Nearest Neighbours

$= \alpha L + 2L_{tap} + 4L_c + 2L_i$ (α L=fibre loss/m)

Bus – Longest Distance Power Budget

Loss Between station 1 and N

2 Connectors per station – intrinsic loss at each station

@ transmitting and detector ends– one tap loss

@ intermediate stations – one L_{thru} loss

Total Loss = $(N-1)\alpha L + 2NL_c + 2L_{tap} + (N-2)L_{thru} + NL_i$ (equn B)

Losses Linear with number of stations (p464 Keiser)

Bus – Dynamic Range

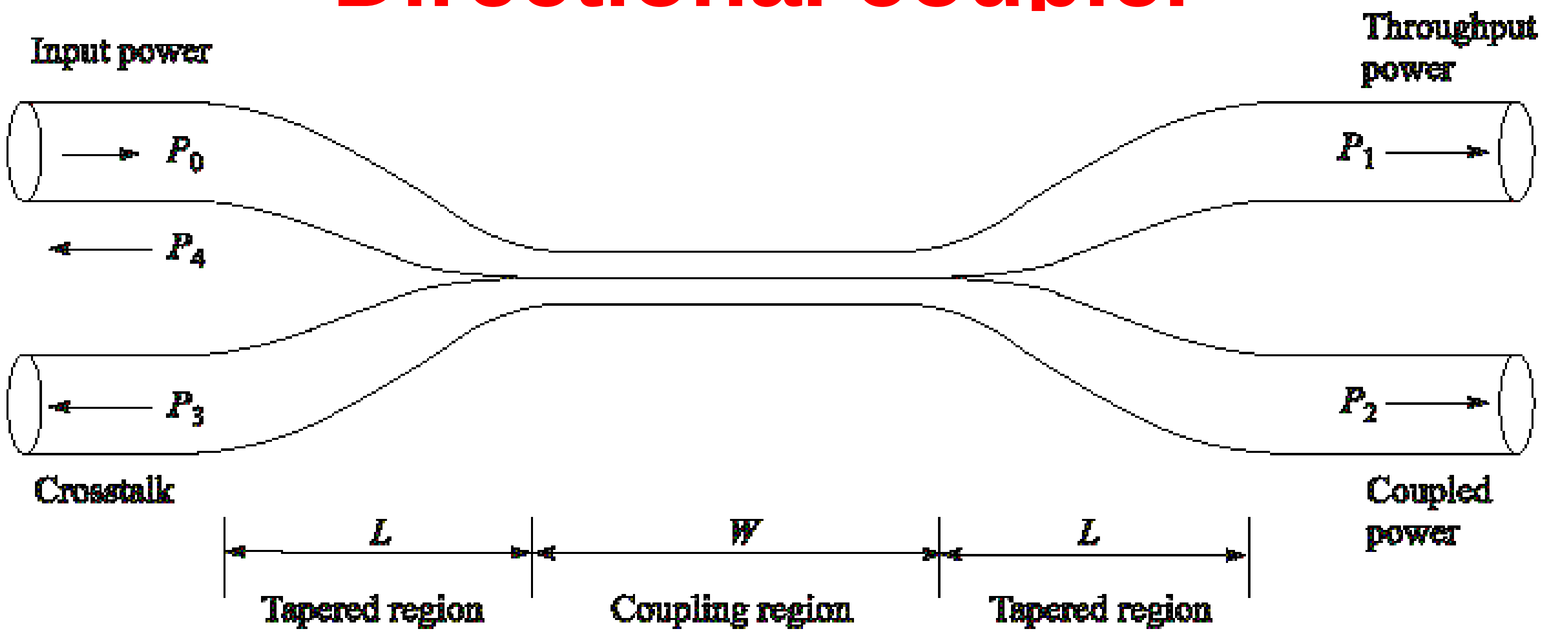
Detector used in Bus system will detect a larger power at station 1 than at station N

The Detector must have a dynamic range equal to that of the Bus system = ratio of power levels received at station 1 and station N

In dB = difference between nearest neighbour and longest length power budget (equn B – equn A)

Dynamic Range = $(N-2)(\alpha L + 2L_c + L_{thru} + L_i)$

Fused-Biconical coupler OR Directional coupler



- *P3, P4* extremely low (-70 dB below Po)
- Coupling / Splitting Ratio = *P2/(P1+P2)*
- If $P_1 = P_2$ → It is called 3-dB coupler

Fused Biconical Tapered Coupler

- Fabricated by twisting together, melting and pulling together two single mode fibers
- They get fused together over length *W;* tapered section of length *L;* total draw length = *L+W*
- Significant decrease in *V*-number in the coupling region; energy in the core leak out and gradually couples into the second fibre

Definitions

Splitting (Coupling) Ratio = $P_2/(P_1 + P_2)$

Excess Loss $= 10\ \mathrm{Log}[P_0/(P_1 + P_2)]$

Insertion Loss $= 10\ \mathrm{Log}[P_{in}/P_{out}]$

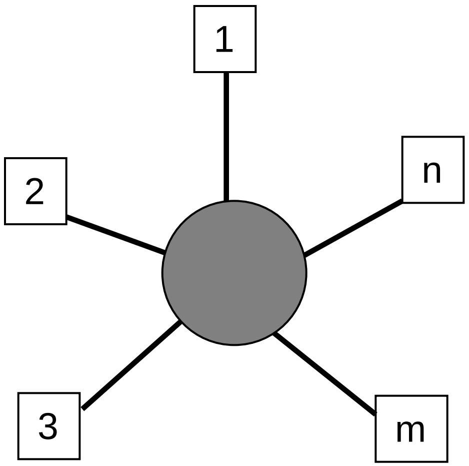
Crosstalk $= 10\ \mathrm{Log}(\mathrm{P}_3/\mathrm{P}_0)$

Coupler Characteristics

- power ratio between both output can be changed by adjusting the draw length of a simple fused fiber coupler

- It can be made a WDM de-multiplexer:
  - Example, 1300 nm will appear output 2 (p2) and 1550 nm will appear at output 1 (P1)
  - However, suitable only for few wavelengths that are far apart, not good for DWDM

Star Network – Losses and Power Budget



Star Coupler - Splitting Loss L_{split} = 10logN

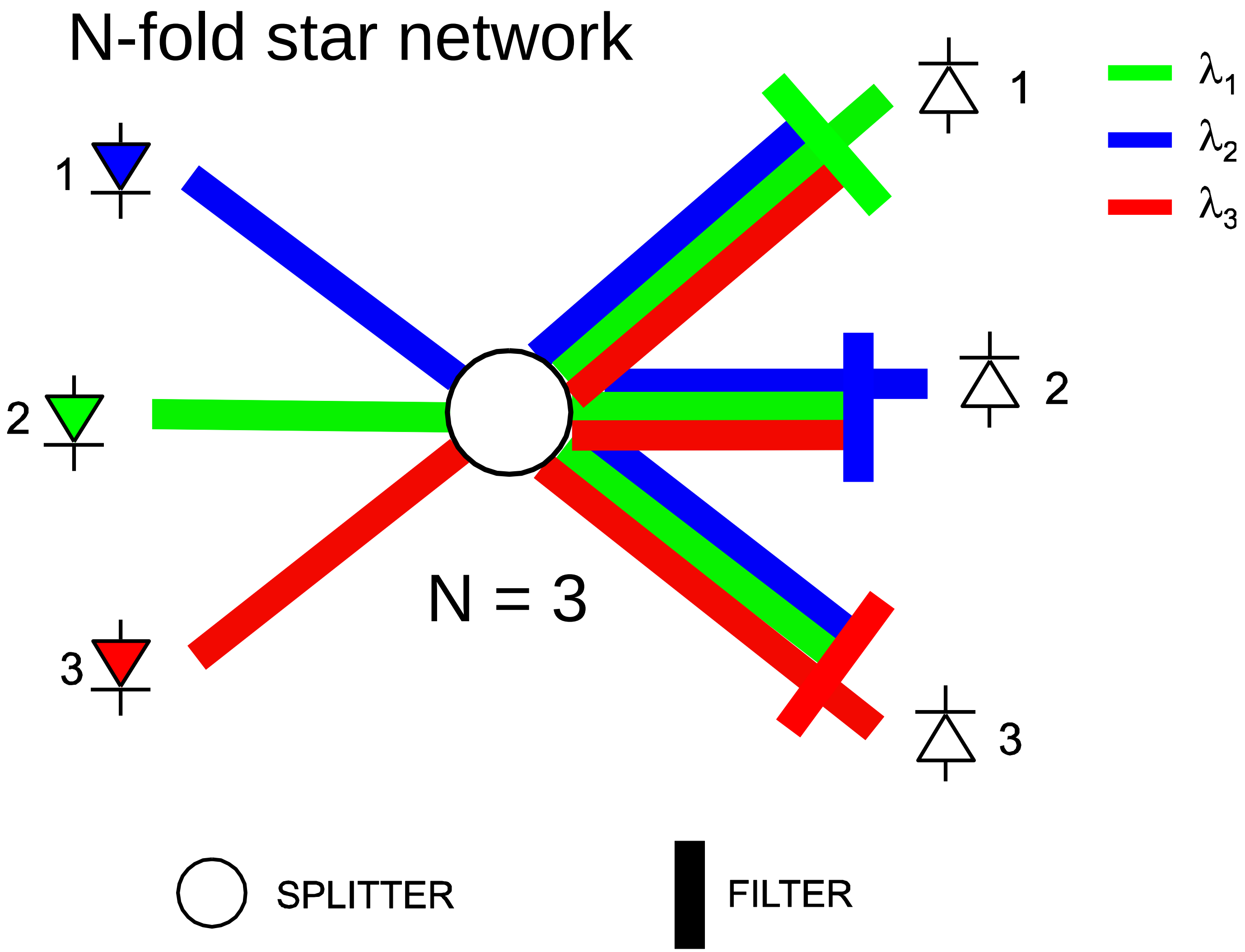
In doing so there is an excess loss L_{excess}

Connector at Transmitter and Receiver

All stations L km from Coupler

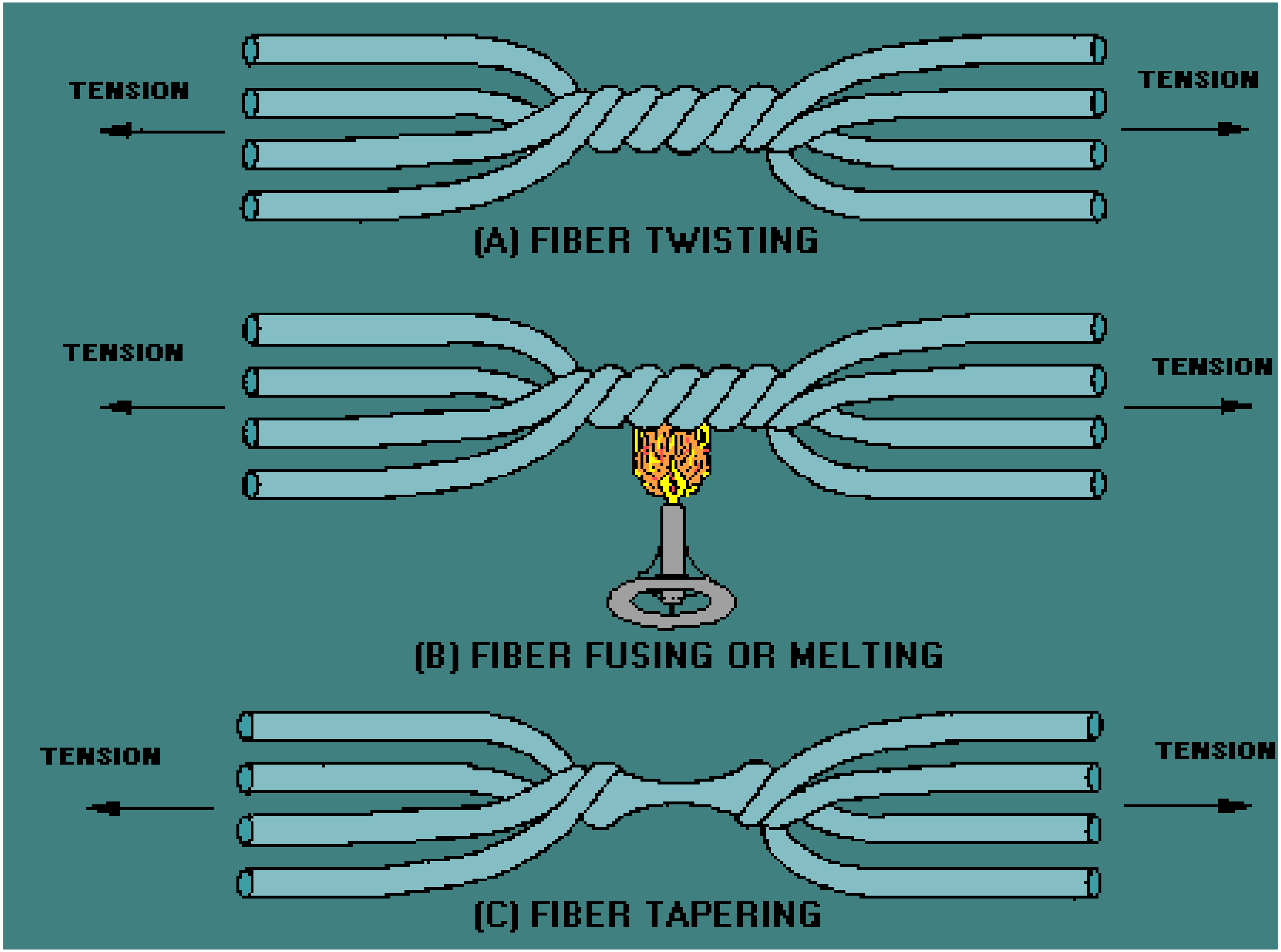
$$\text{Total Loss} = 2\alpha L + 2L_c + 10\text{Log}N + L_{excess}$$

Broadcast and select network

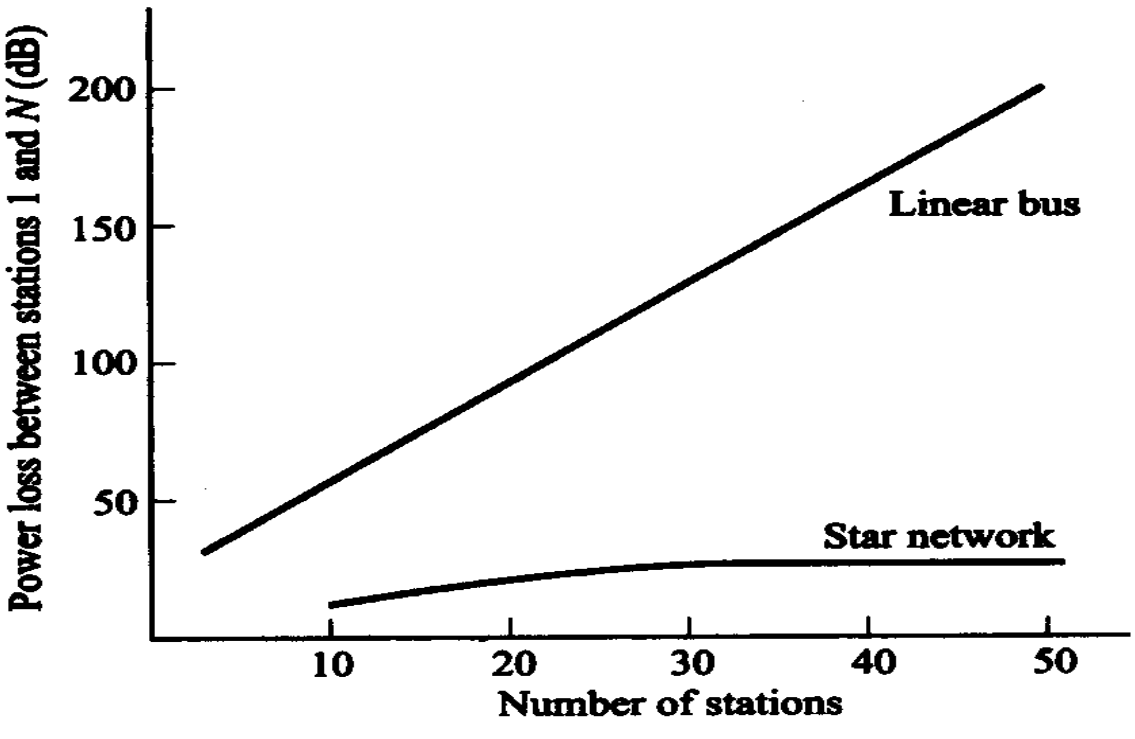


Splitting loss is 10 log N (waste of power)

Making A Star Coupler



Star and Linear Bus Losses



Summary – Network Architecture

So far only a link has been discussed (A to B).

In real applications networks of many links are formed.

Bus, Star, and Ring Networks are common

A comparison of passive bus and star networks shows a linear loss with node/station number for a bus but a logarithmic function for star networks.

Example – dynamic range

Determine the dynamic range of a network for N = 5 and 10 workstations if the stations are 1000m apart, the fibre loss = 0.3 dB/km, and the couplers have the following parameters:

Tap loss L_{tap} = 10 dB

Connector loss L_c = 1 dB

Intrinsic transmission loss L_i = 0.4 dB

Solution

Dynamic Range = $(N-2)(\alpha L + 2L_c + L_{thru} + L_i)$

Now Tap loss L_{tap} = 10 dB = 10, hence C_T = 0.1 and

$L_{thru} = -10 \log (1-C_T)^2 = -20 \log(1-C_T)$ dB = 0.9 dB

Connector loss L_c = 1 dB

Intrinsic transmission loss L_i = 0.4 dB

For 5 workstations

Dynamic range = (5-2) x (0.3x1 + 2x1 + 0.9 + 0.4) = 3 x 3.6 = 10.8 dB

For 10 workstations

Dynamic range = (10-2) x (0.3x1 + 2x1 + 0.9 + 0.4) = 8 x 3.6 = 28.8 dB