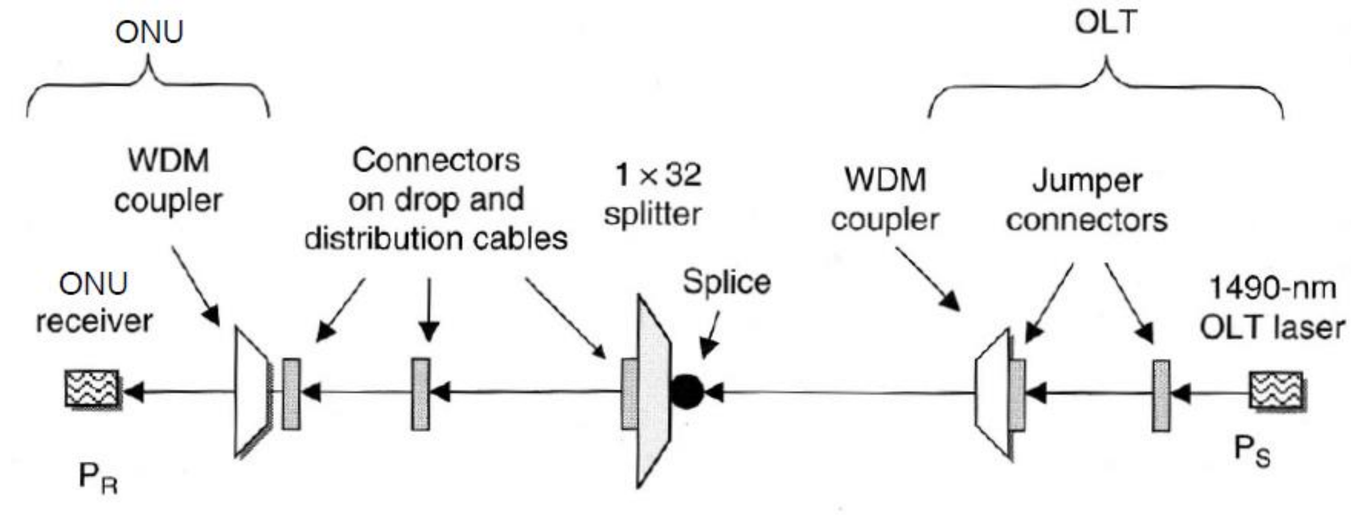
$S = \lambda \bar{X}$	S - throughput λ - in packets per second
$\bar{X} = \bar{L}/C$ $\bar{X} = 1/\mu$	$\bar{X}$ be average pacekt transmission time (srednje trajanje prostiranja signala) $\bar{L}$ be the average packet length in bits C in bits per second be the channel transmission rate
$\rho = \frac{D}{D+H} S$ $\rho = \lambda M \bar{X} = S$	**Channel utilization** is defined as the fraction of time a channel is busy transmitting packets. D is the number of data bits in the packet and *H* is the number of overhead bits in the packet.
$\rho < 1$	Uvjet stabilnosti sustava!
$p = \lambda/C$	Vjerojatnost ***p*** da je određeni bit zadnji u paketu
$\tau_{propagacije} = (duljina\, linka)/V$	**Propagacija** - srednje vrijeme trajanja slanja paketa
$\hat{T} = T/\bar{X}$	**Normalized average transfer** delay is defined as the average time from the arrival of the last bit of a packet into the sending station of a network until the last bit of this packet is delivered through the network to its receiving station. T be average transfer delay
LAN	
$t_v = m[1 + a(1 + 2e)]$	**Virtual transmission time**
$S = \rho = \lambda m = \bar{X}\lambda = \frac{1}{t_v} * m$ $m = \bar{X}$	**Prometna opterećenost**
$a = \frac{\tau_{propagacija}}{\bar{X}}$	
$\bar{L} = \frac{duljina\, linka * C}{V * a}$	**Prosječna duljina okvira**
FDMA	
$T = M\bar{X} + \frac{\rho M \bar{X}}{2(1-\rho)}$	T be **average transfer delay,** is equal to the sum of the packet transmission time and the average queueing delay at the station.
$\rho = \lambda M \bar{X}$	**Channel utilization**
$S = M \lambda \bar{X}$	**Throughput**

<table>
<tr><td>$$T = M\bar{X} + \frac{M\bar{X}S}{2(1-S)}$$
$$T = \frac{M\bar{X}}{2}\left[\frac{2-S}{1-S}\right]$$</td><td>jer je
$$S = \rho$$</td></tr>
<tr><td>$$\hat{T} = M + \frac{MS}{2(1-S)} = \frac{M(2-S)}{2(1-S)}$$</td><td>Normalized average transfer</td></tr>
<tr><td colspan="2">TDMA / STDM</td></tr>
<tr><td colspan="2">The length of a frame is $M\bar{X}$ seconds.</td></tr>
<tr><td colspan="2">$$T = \frac{M\bar{X}}{2} + \frac{MS\bar{X}}{2(1-S)} + \bar{X} = \frac{M\bar{X}}{2(1-S)} + \bar{X}$$
The average transfer delay T is the sum of the average synchronization delay, the average waiting time W in the buffer, and the packet transmission time.
$$T = \bar{X}\left[\frac{M}{2} + \frac{MS}{2(1-S)} + 1\right]$$</td></tr>
<tr><td>$M\bar{X}/2$</td><td>Average slot synchronization delay is one-half of the frame time.</td></tr>
<tr><td>$$W = \frac{\rho M\bar{X}}{2(1-\rho)}$$
$$S = \rho$$
$$W = \frac{SM\bar{X}}{2(1-S)}$$</td><td>Avarage delay in the buffer</td></tr>
<tr><td>$$\hat{T} = \frac{M}{2(1-S)} + 1$$</td><td>Normalized transfer delay</td></tr>
<tr><td>$$\hat{T}_{FDMA} = \hat{T}_{TDMA} + \frac{M}{2} - 1$$</td><td>$$\hat{T}_{FDMA} \geq \hat{T}_{TDMA}$$</td></tr>
<tr><td colspan="2">CDMA</td></tr>
</table>

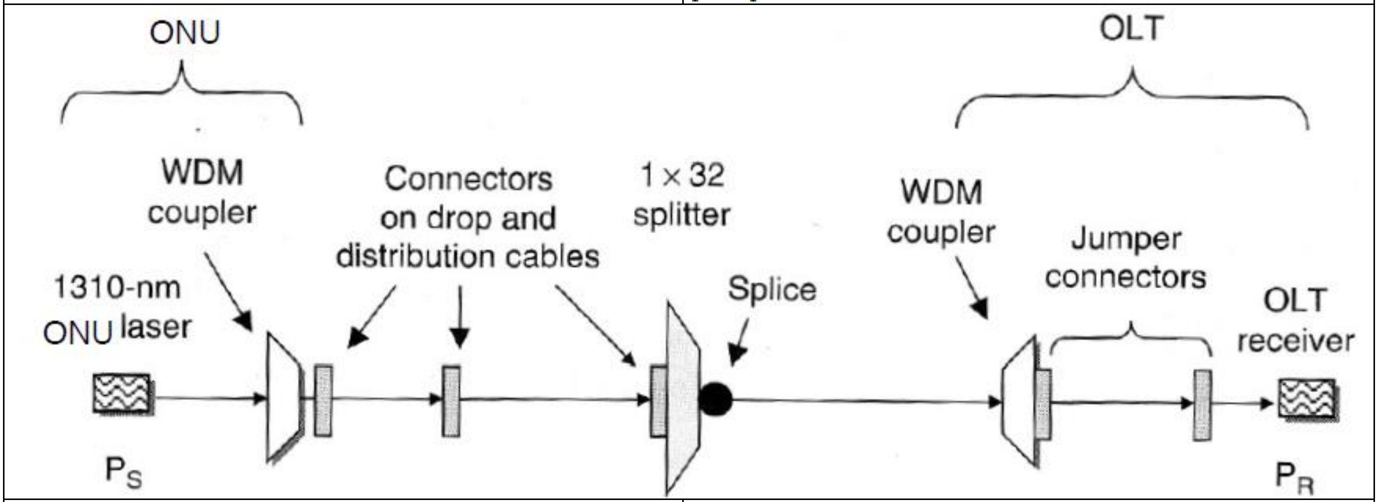
$$T = \frac{\rho M\bar{X}}{2(1-\rho)} + M\bar{X}$$ $$\rho = \lambda M\bar{X} = S$$ $$T = \frac{SM\bar{X}}{2(1-S)} + M\bar{X}$$	**Average packet transfer delay** can be written as the sum of the mean waiting time in the queue and the mean effective packet transmission time.
$$\hat{T} = \frac{SM}{2(1-S)} + M$$	**Normalized transfer delay**
$$\hat{T}_{CDMA} = \hat{T}_{TDMA} + \frac{M}{2} - 1$$	$\hat{T}_{CDMA} \geq \hat{T}_{TDMA}$
CENTRAL CONTROL ACCESS METHODS	
$$T = \bar{X} + \frac{\rho}{2(1-\rho)}\bar{X}$$ $$\rho = \lambda M\bar{X} = S$$ $$T = \bar{X} + \frac{S}{2(1-S)}\bar{X}$$	**Average transfer delay**
$\lambda\bar{X}$	**Prometno opterećenje po svakoj stanici**
$$\hat{T} = 1 + \frac{S}{2(1-S)} = \frac{2-S}{2(1-S)}$$	**Normalized transfer delay**
POLLING NETWORKS (Roll-call Polling)	
$$t_c = \sum_{i=1}^{N} w_i + \sum_{i=1}^{N} t_i$$	t_c be cycle time (scan time) w_i be station walk time t_i be station transmission time, time required to transmit packets on the line (vrijeme slanja poruke po svakoj stanici)
$$\bar{t}_c = \sum_{i=1}^{N} \bar{w}_i + \sum_{i=1}^{N} \bar{t}_i = L + \sum_{i=1}^{N} \bar{t}_i$$	**Average scan time** ***L*** be total walk time of the complete polling system. ***ρ*** be total traffic intensity.

$\bar{t}_c = L \Big/ \left(1 - \sum_{i=1}^{N} \rho_i\right)$ $= L/(1-\rho)$	
$\bar{m}_i = (\bar{\ell} + \ell')/C$	**Average frame lenght** (srednje vrijeme slanja paketa na link) in units of time. ***C*** be capacity of the channel, in bps. ***l*** be average lenght of packet, ***l'*** the number of overhead bits.
$\lambda_i \, \bar{t}_c$	Average number of packets (***N***) waiting to be transmitted when station *i* is polled.
$\bar{t}_i = \lambda_i \bar{t}_c \bar{m}_i = \rho_i \bar{t}_c$	t_i be station transmission time
$\rho_i \equiv \lambda_i \bar{m}_i$ $\rho \equiv \Sigma_{i=1} \rho_i = \Sigma_{i=1}^{N} \lambda_i \bar{m}_i$	**Traffic intensity** due to station *i*.
$L = \sum_{i=1}^{N} \bar{w}_i$	**Total system walk time**
$E(D) = \frac{\bar{t}_c}{2}\left(1 - \frac{\rho}{N}\right) + \frac{N\lambda \overline{m^2}}{2(1-\rho)}$ $= \frac{L}{2}\frac{(1-\rho/N)}{(1-\rho)} + \frac{N\lambda \overline{m^2}}{2(1-\rho)}$ $\rho = N\lambda \bar{m},$ $\overline{m^2} = 2(\bar{m})^2$ $E(D) = \frac{\bar{t}_c}{2}(1-\rho/N) + \frac{\rho \bar{m}}{(1-\rho)}$	**Average access delay** is the average time a apcket must wait at a station from the time it first arrives until the time transmission begins.
$L = Nt_P + Nt_S + \tau'$	**The walk time** is due to the polling-**message transmission time**, the necessary station **synchronization time (latency time)** and **propagation delay**.

$$\tau' = \frac{\tau}{2}(1+N)$$	***Total* propagation delay for entire N-station system**
$\tau = (2 * duljina\ linka)/V$	**τ** be round trip propagation delay
$t_p = L(duljina\ poruke\ prozivanja)/R$	**Poruka prozivanja**
$$\frac{\rho\bar{m}}{(1-\rho)}$$	**Wait time**
POLLING NETWORKS (Hub Polling)	
$\tau' = \tau$	Propagation time = round-trip delay (delay through a complete cycle)
$L_{hub} = \tau + Nt_s$	**Total walk time**
FTXX	
Point-to-point	Za ***N*** korisnika koji su udajeni ***L*** od centrale potrebno je ***2N*** primopredajnika a ukupna duljina niti je ***NL***.
Aktivna optička mreža	Ukupna duljina niti ***L***, primopredajnici su na ***2N+2***.
Pasivna optička mreža PON	Ukupna duljina niti ***L*** i broj primopredajnika ***(N+1)***.
$$\eta = 1 - \frac{N \cdot T_g}{T_{Cmax}}$$ $$\eta = \frac{T_C - NT_g}{T_c}$$	**Iskoristivost *upstream* kanala** T_g be guard time (zaštita vremena između transmisija) T_{Cmax} be implicitno maksimalno trajanje ciklusa
$L_{1G} = R_{1G} * T_C$ $L_{UK} = R(T_C - NT_g)$ $L_{BEuk} = L_{uk} - \sum L_{iG}$	$N_{BE} = N - 1$ $L_{BE} = L_{BEuk}/N_{BE}$
$10*\log_{10}(mW)$ [*dBm]*	W -> dBm
$10^{dB/10}$ [*W]*	dB -> W
Power margin = ONU (izlazna snaga laserske diode) [*dBm]* - OLT (osjetljivost fotodetektora) [*dBm]* = [*dB]*	
M, system margin	3.0 - 4.8 *dB*



$P_{OLT_{TX}\,[dBm]} - L_{uk\,[dB]} - M[dB] > P_{ONU_{TX}\,[dBm]}$	(downstream) 1490 nm



$P_{ONU_{TX[dBm]}} - L_{uk+burst[dB]} - M[dB] > P_{OLT_{RX[dBm]}}$	(upstream) 1310 nm

N_K = broj korisnika K_1 = kapacitet (broj niti) kabela 1 K_2 = kapacitet (broj niti) kabela 2 **Sve uzeti sa gornjim granicama!** $N_1 = N_K / K_1$ = broj velikih kabela (zjdč.) $N_2 = N_K / K_2$ = broj malih kabela (izrav.) N_{KAZETA} = broj spojnica niti / niti u kazeti	$C_1(l)=N_1 l(C_1 + C_{POLAGANJA}) + N_K(C_{IZRADE}+C_{ZAŠTITE}) + N_{SPOJNICA}(C_{SPOJNICE} + C_{POSTAVLJANJE\ SPOJNICE}) + N_{KAZETA}C_{KAZETE}$ $C_2(l)=N_2 l(C_2 + C_{POLAGANJA})$ $C_1 = C_2$ -> l=...