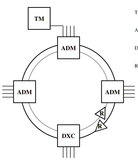
Optyczne sieci transportowe
OTN (G.709)

Trochę historii – sieci SDH

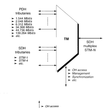


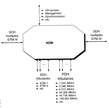
TM - Terminal multiplexer (konstrukcja końcowa)

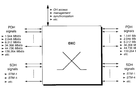
ADM – Add/drop multiplexer (konstrukcja transferowa)

DXC – Digital cross-connect (przełącznica cyfrowa)

R - regenerator



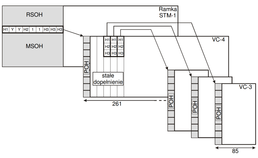




SDH (reszta świata)	Przepływność [Mb/s]	**SONET** (USA, Can. Jap.)
(STM-0)	**51,84**	STS-1 OC-1
STM-1	**155,52**	STS-3 OC-3
STM-4	**622,08**	STS-12 OC-12
STM-16	**2488,32**	OC-48
STM-64	**9953,28**	OC-192
STM-256	39813,12	

STM - Synchronous Transport Module, STS - Synchronous Transport Signal, OC – Optical Carrier

Poziomy hierarchii synchronicznej systemów SDH i SONET



OTN (G.709)

International Telecommunication Union

ITU-T

TELECOMMUNICATION STANDARDIZATION SECTOR OF ITU

G.709/Y.1331

(06/2016)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

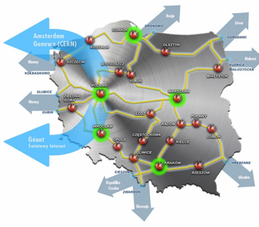
Digital terminal equipments – General

SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

Internet protocol aspects – Transport

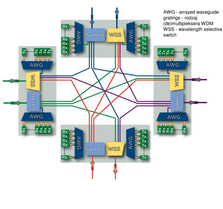
Interfaces for the optical transport network

Przykład – sieć akademicka PIONIER w tech. OTN



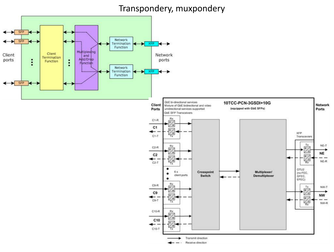
- Multiplikacja falowa (WDM) służy nie tylko do zwielokrotnienia danych w pojedynczym światłowodzie, ale do zestawiania ścieżek optycznych
- Sieć jest zasadniczo all-optical, czyli w zestawionej ścieżce sygnał optyczny nie jest zamieniany na elektryczny i nie jest przetwarzany
- Transmisja sygnału optycznego na odległość rzędu 3000 km możliwa dzięki:
  - Wzmacniacze EDFA i Ramana
  - Kompensacja dyspersji chromatycznej
  - FEC - Forward Error Correction

Kluczowa koncepcja: ROADM - *reconfigurable optical add-drop multiplexer*

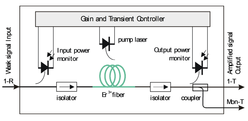


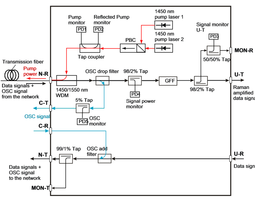
Rozwiązania komercyjne – modułowe platformy do „składania z klocków”

Transpondery, muxpondery

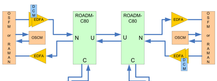


Wzmacniacze

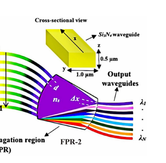




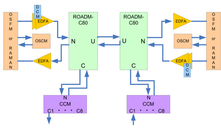
Moduły ROADM



ROADM Fixed Add/Drop

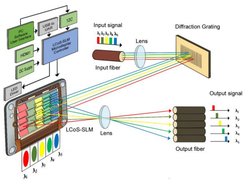


AWG

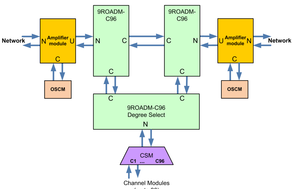


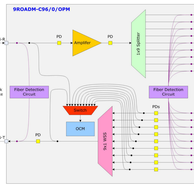
ROADM Colorless Add-Drop

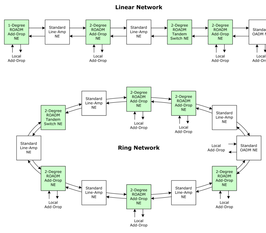
WSS

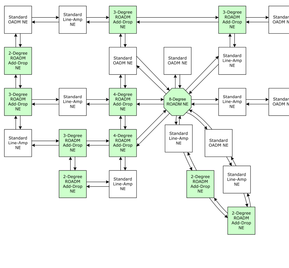


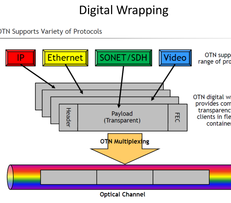
Directionless Add-Drop











Signal	Approximate data rate (Gb/s)	Optimized for
OTU1	2.66	SONET OC-48 or SDH STM-16 signal transport
OTU2	10.70	SONET OC-192 or SDH STM-64 or 10GbE Wide Area Network (WAN) physical layer (PHY) transport
OTU2e	11.09	10GbE Local Area Network (LAN) PHY transport (for IP/Ethernet switches/routers ports) at full line rate (10.3 Gb/s)
OTU3	43.01	SONET OC-768 or SDH STM-256 or 40GbE signal transport
OTU3e2	44.58	Transport of up to four OTU2e signals
ODU4	112	100GbE signal transport

5.1.1 Theoretical Description

G.709 FEC implements a Reed-Solomon RS(255,239) code. A Reed-Solomon code is specified as RS(n,k) with s-bit symbols where n is the total number of symbols per codeword, k is the number of information symbols, and s is the size of a symbol. A codeword consists of data and parity, also known as check symbols, added to the data. The check symbols are extra redundant bytes used to detect and correct errors in a signal so that the original data can be recovered.

For G.709:

s = Size of the symbol = 8 bits

n = Symbols per codeword = 255 bytes

k = Information symbols per codeword = 239 bytes

This means the encoder takes k information symbols of s bits, each, and adds check symbols to make an n-symbol codeword. There are n-k check symbols of s bits, each. A Reed-Solomon decoder can correct up to t symbols that contain errors in a codeword, where 2t = n-k.

The following Figure 3 shows a typical Reed-Solomon codeword:

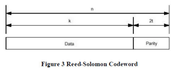
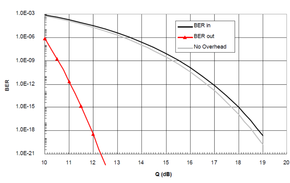


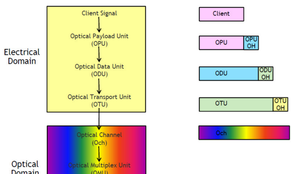
Figure 3 Reed-Solomon Codeword

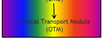
For the standard ITU recommended RS (255,239) code:

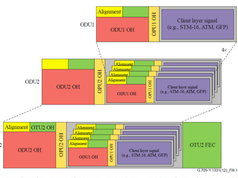
2t = n - k = 255 - 239 = 16

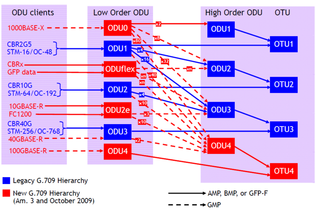
t = 8









NOTE – The ODU1 floats in a quarter of the OPU2 payload area. An ODU1 frame will cross multiple ODU2 frame boundaries. A complete ODU1 frame (15296 bytes) requires the bandwidth of (15296/3808) 4.017 ODU2 frames. This is not illustrated.

OTN Hierarchy