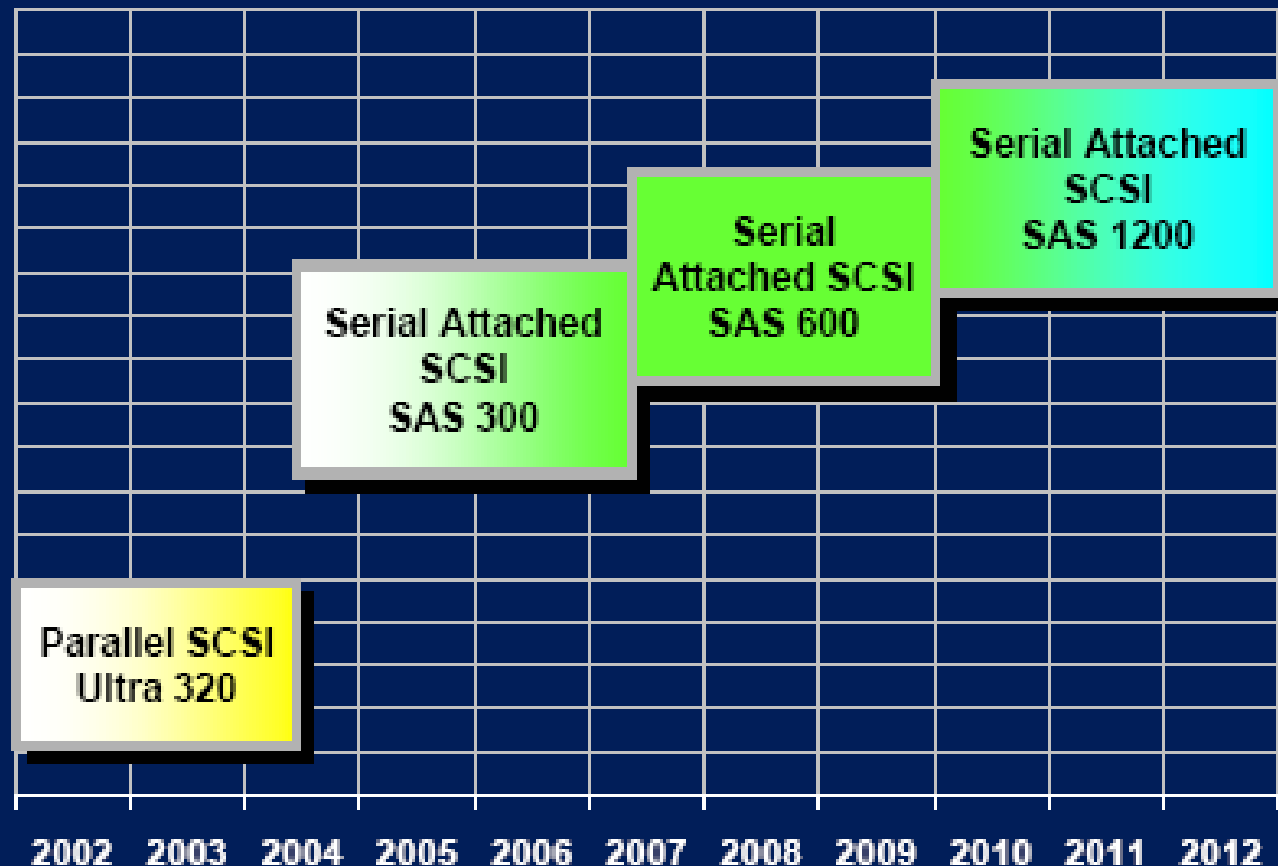


SAS

- **lower layer** borrowed from **SATA**
- **upper layers** borrowed from **FC**

SAS perspektive

SCSI Trade Association roadmap



Glavne komponente SAS

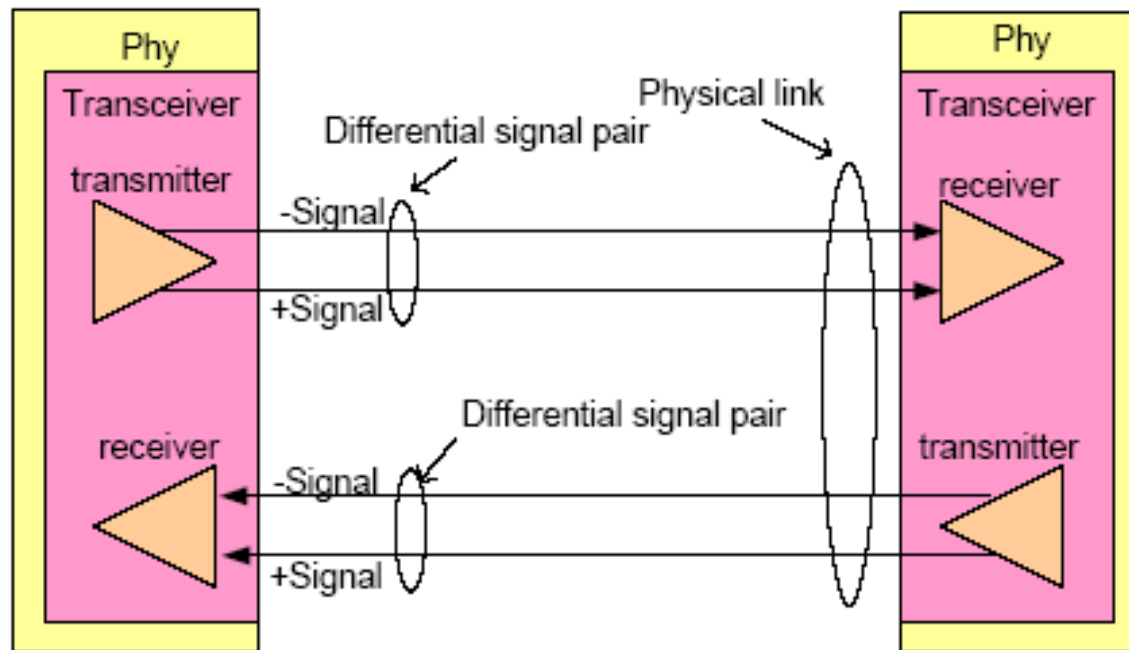
- Uređaj = {Inicijator – target- expander}
- svaki **SAS uređaj** ima **portove**
- **portovi** imaju **linkove** tj **phy devices**
- svaki **link** 300MB/s (in one way)
- **SAS/SATA compatibility**

Osnovni elementi SAS Arhitecture

Physical links and phys



- A phy contains one transceiver
- A physical link attaches two phys together

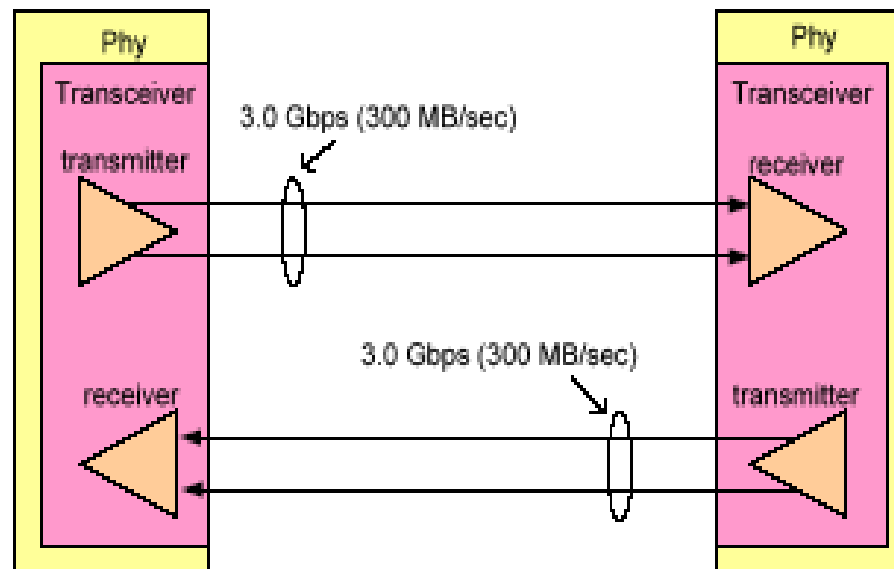


Brzine fizičkog linka

Physical link rate



- Each direction runs 1.5 Gbps or 3.0 Gbps (150 MB/sec or 300 MB/sec)
 - Both directions use the same physical link rate
- Dual simplex (full duplex) operation – 600 MB/sec total bandwidth
- Example: peak bandwidth needs of an HBA with 8 phys
 - 2400 MB/sec half duplex, 4800 MB/sec full duplex

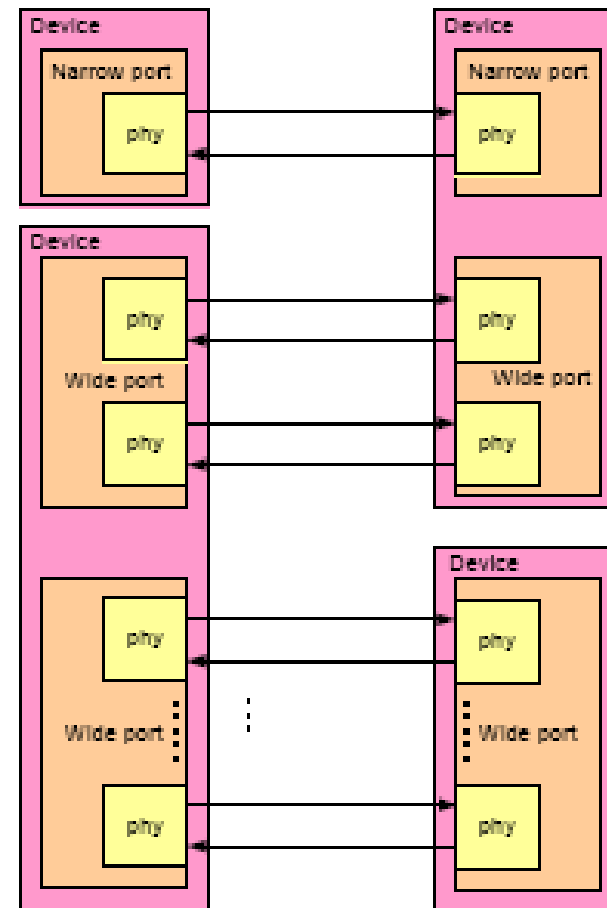


SAS uređaji i portovi



SAS devices and ports

- SAS devices contain ports
- Ports contain phys
- Ports are virtual constructs
 - Groups of phy with the same SAS address, attached to another group of phys with the same SAS address



SAS Uredaji

End devices



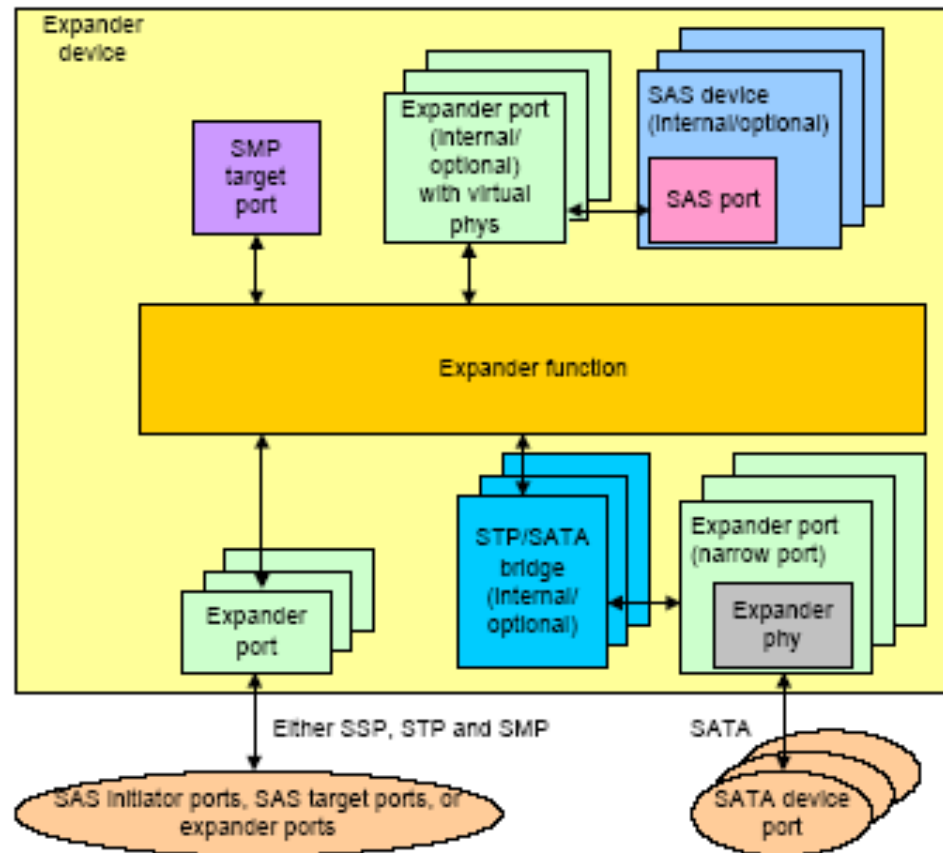
- End device is a SAS device that is not an expander device
- Sample end devices
 - HBA – 8 phys
 - One SAS address for all 8 phys
 - Potentially all one (very) wide port
 - One SAS address for 4 phys, another SAS address for 4 phys
 - Guarantees at least two ports
 - Good match for 4-wide connectors
 - Eight SAS addresses
 - Disk drive - 2 phys
 - Separate SAS address for each phy
 - Guarantees two ports
 - Never a wide port

Expander uređaji

Expander devices

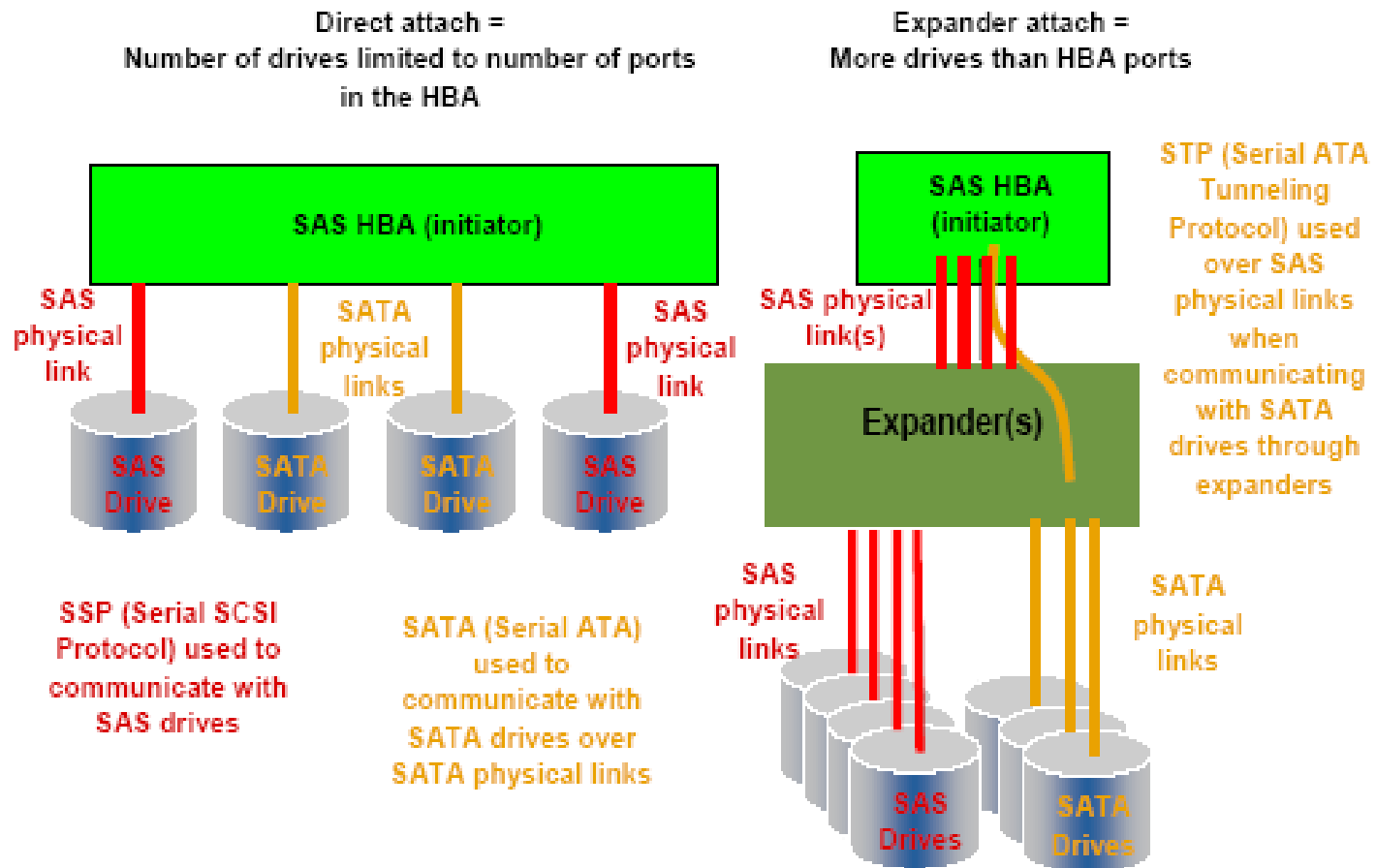


- Expander device contains expander ports
- May contain SAS devices too (e.g. for enclosure management)
- Each expander device has a SAS address
- Each expander phy has a phy identifier unique within that expander device

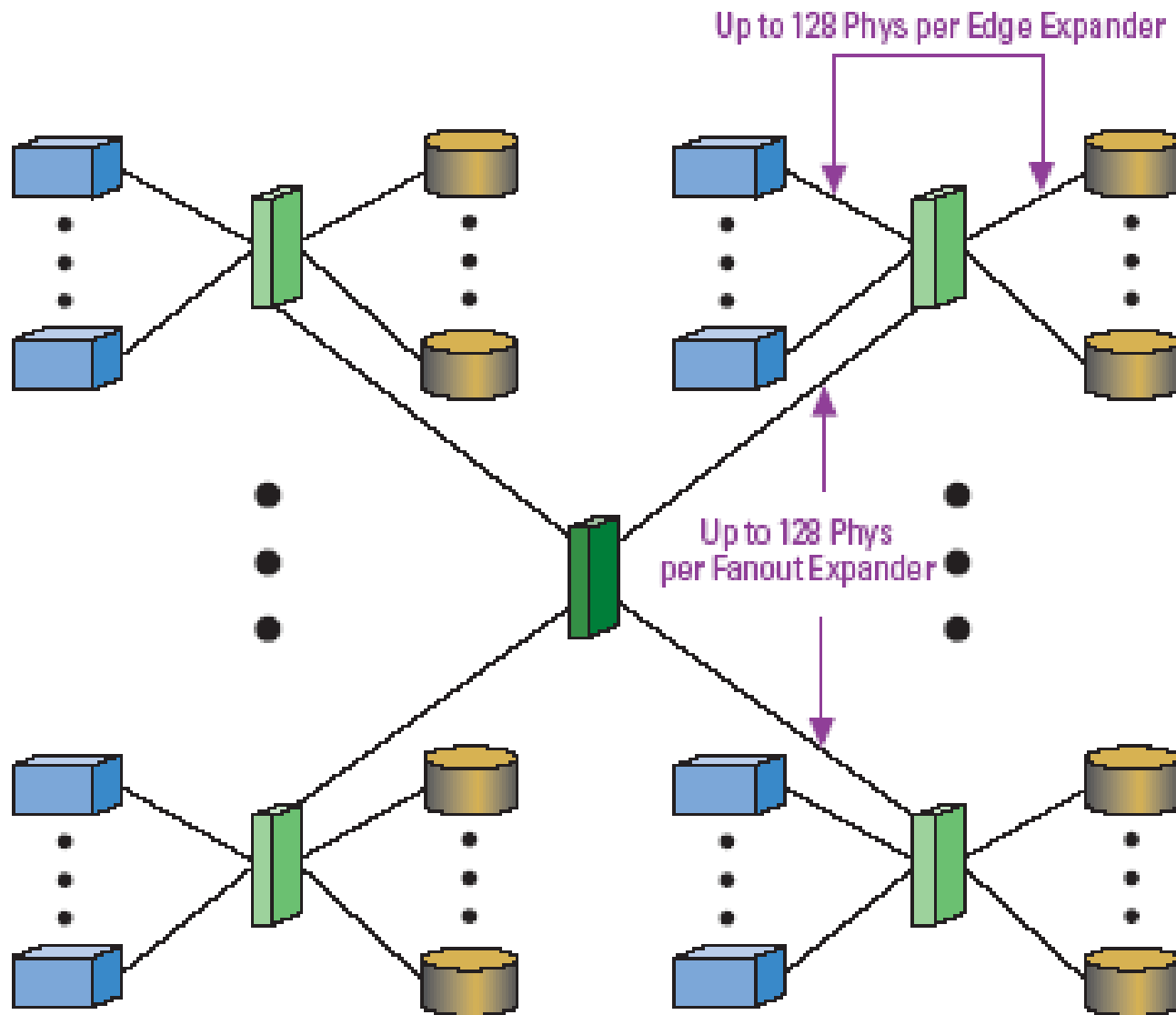


SAS priključenja-attachment

Direct attach and expander attach

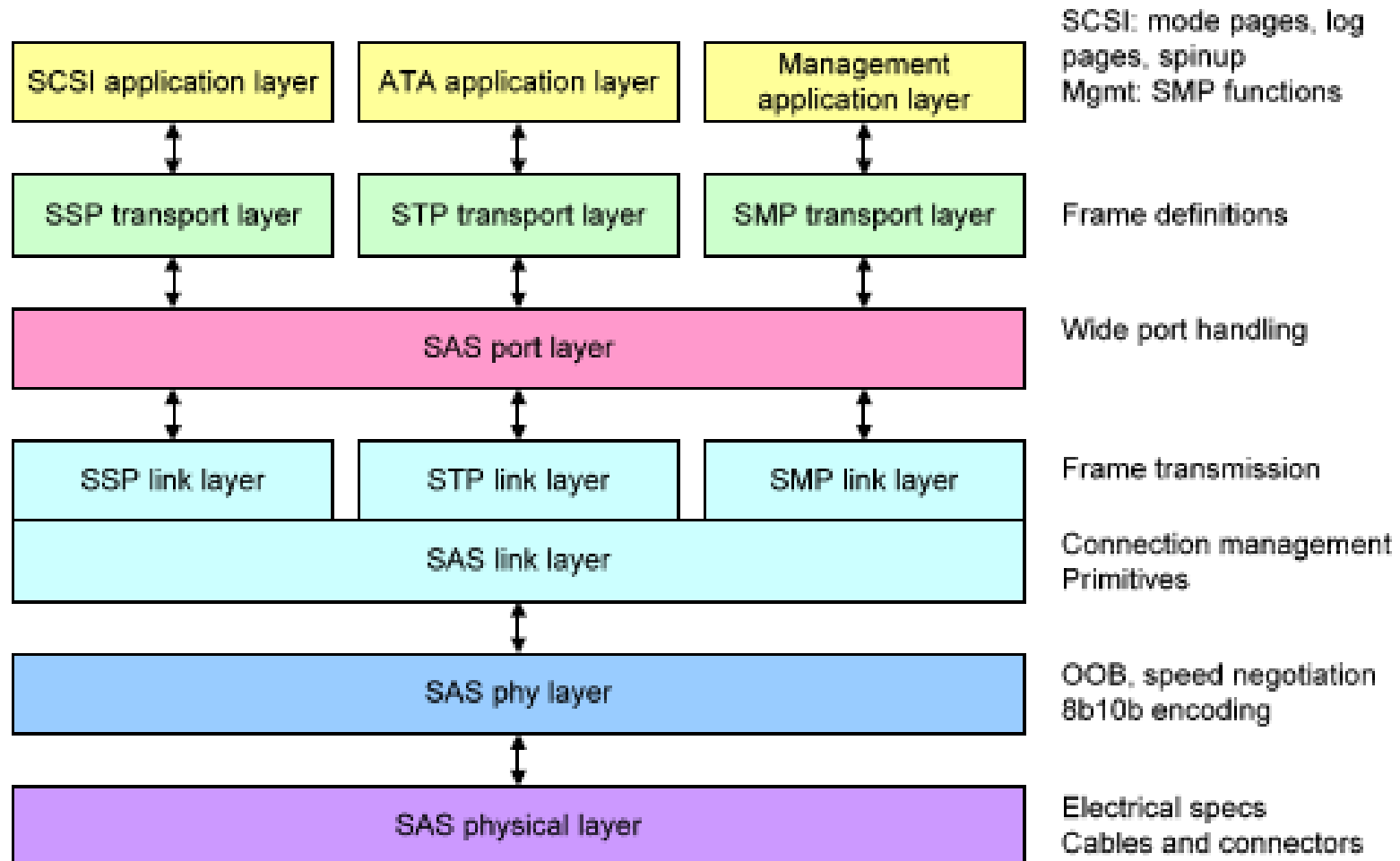


SAS Domain: 128 x 128



SAS layers

SAS standard layering

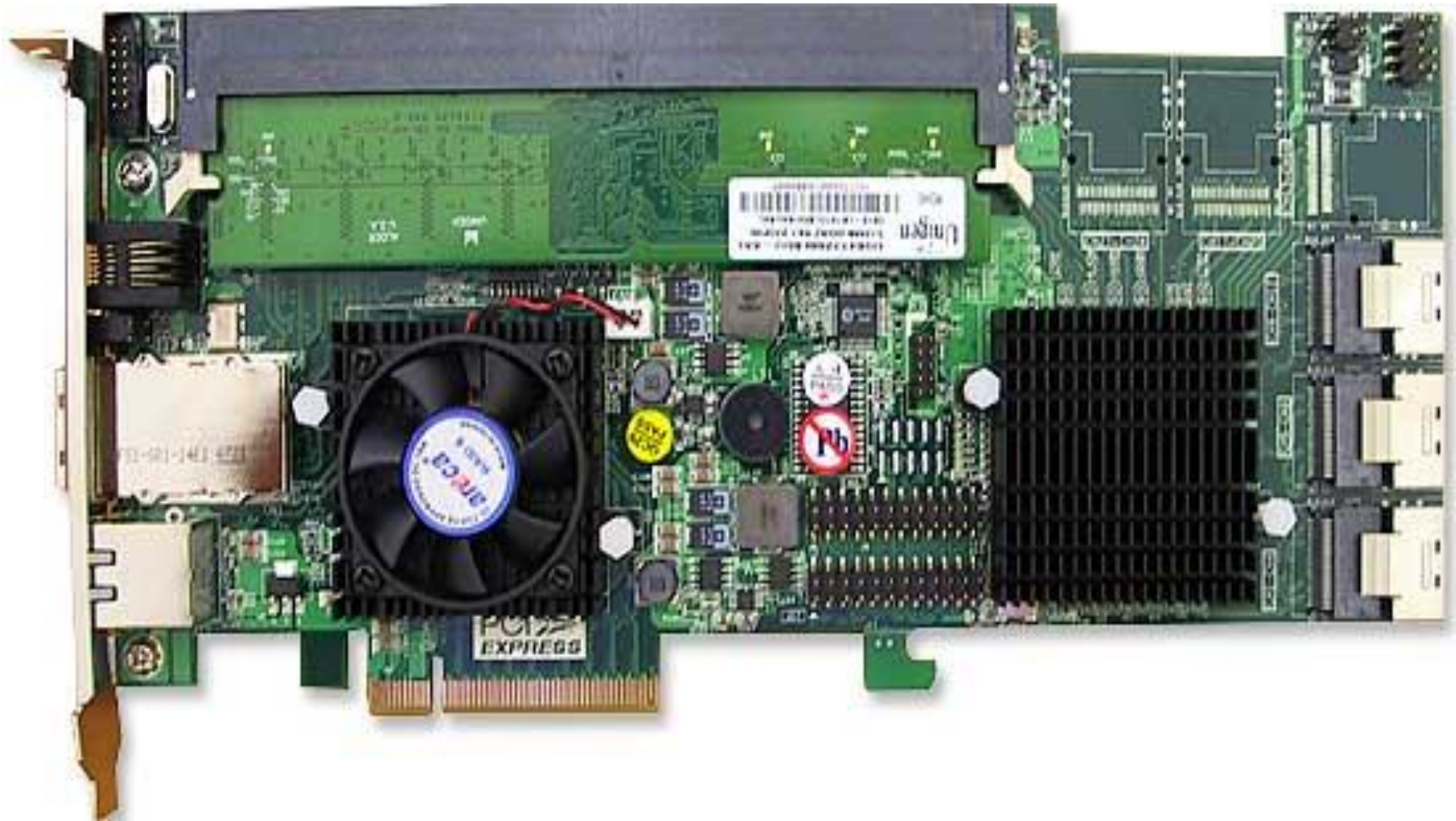


SATA, SAS, FC

	Serial ATA	Serial Attached SCSI	Fibre Channel AL
Performance	Half-duplex	Full-duplex with Link Aggregation (Wide ports)	Full Duplex
	1.5 Gb/sec (3.0 Gb/s announced)	3.0 Gb/sec (at intro.) (6.0 Gb/s planned)	2.0 Gb/sec (4 Gb/s announced)
Connectivity	1 m internal cable	>6m external cable	>15m external cable
	One device (fan-out devices demonstrated)	>128 decies Expanders (16k Phys. max)	127 decies Loop or loop switch
	SATA only	SAS and SATA	Fibre Channel only
Availability	Single port HDDs	Dual-port HDDs	Dual-port HDDs
	Single-host Point-to-point	Multi-initiator Point-to-point	Multi-initiator Shared media or point-to-point
Drive Model	Software transparent with Parallel ATA	Software transparent with SCSI	Software transparent with SCSI

Table 1 – Comparison of SATA, SAS, and FC features

SAS kontoleri

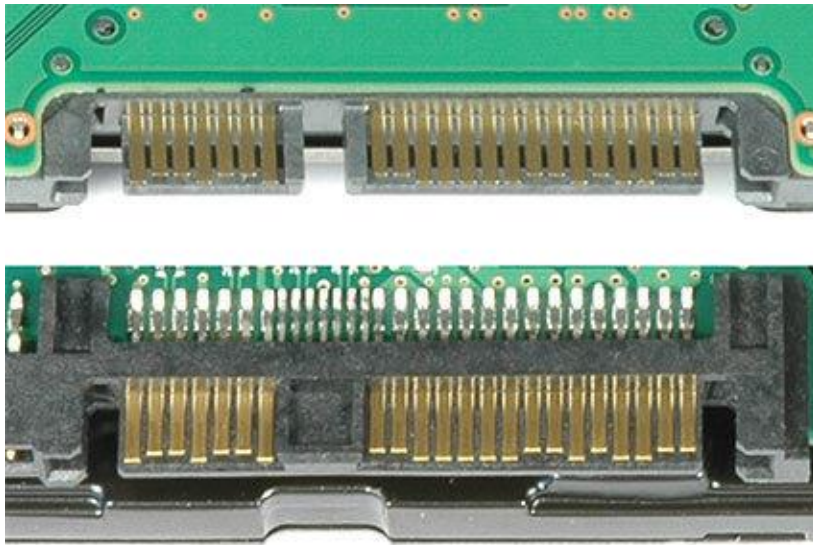


SAS kablovi 29 pin



Pin	Name	Description
S1	GND	GND for SAS Primary Port
S2	RP+	SAS Primary Port Receive (positive) signal
S3	RP-	SAS Primary Port Receive (negative) signal
S4	GND	GND for SAS Primary Port
S5	TP-	SAS Primary Port Transmit(negative) signal
S6	TP+	SAS Primary Port Transmit(positive) signal
S7	GND	GND for SAS Primary Port
S8	GND	GND for SAS Secondary Port
S9	RS+	SAS Secondary Port Receive(Positive) signal
S10	RS-	SAS Secondary Port Receive (negative) signal
S11	GND	GND for SAS Secondary Port
S12	TS-	SAS Secondary Port Receive (negative) signal
S13	TS+	SAS Secondary Port Receive (positive) signal
S14	GND	GND for SAS Secondary Port
P1	+3.3V	+3.3V power supply input
P2	+3.3V	+3.3V power supply input
P3	+3.3V	Pre-charge pin for +3.3V
P4	GND	Ground
P5	GND	Ground
P6	GND	Ground
P7	+5V-Charge	Pre-charge pin for +5V
P8	+5V	+5V power supply input
P9	+5V	+5V power supply input
P10	GND	Ground
P11	READY	LED READY LED output
P12	GND	Ground
P13	+12V-Ch	Pre-charge pin for +12V

SAS-SATA



SAS cables



Tipičan predstavnik SAS diskova



Specifications	146 GB ¹	73 GB ¹
Model Number	ST9146852SS ST9146752SS ²	ST973452SS ST973352SS ²
Capacity		
Formatted 512 Kbytes/Sector (GB)	146.8	73.4
External Transfer Rate (MB/s)		
3-Gb/s Serial Attached SCSI	300	300
6-Gb/s Serial Attached SCSI	600	600
Performance		
Spindle Speed (RPM)	15K	15K
Average Latency (ms)	2.0	2.0
Seek Time		
Average Read/Write (ms)	2.9/3.3	2.9/3.3
Track-to-Track Read/Write (ms)	0.2/0.4	0.2/0.4
Sustained Transfer Rate, Outer to Inner Diameter (MB/s)	160 to 122	160 to 122
Cache, Multisegmented (MB)	16	16
Configuration/Reliability		
Disks	2	1
Heads	4	2
Nonrecoverable Read Errors per Bits Read	1 sector per 10E16	1 sector per 10E16
Annualized Failure Rate (AFR)	0.55%	0.55%

Primeri za razumevanje

- PRIMER ZA VEŽBU BR. 1

- ☞ SAS diskovi

- PRIMER ZA VEŽBU BR. 2

- ☞ SAS taktovi i brzine prenosa

PRIMER BR. 1

< SAS diskovi >

- Date su karakteristike jednog realnog SAS diska.

disk Savvio® 15K.2	
maximum Capacity	73-146 GB
average seek time	3.3ms
rotational speed	15000 rpm
media speed	160MB/s
disk interface	SAS 2.0
maximum disk buffer throughput	6 GB/sec
disk buffer	32 MB

- U konfiguraciji računara imate 2 takva diska.
- Pristigla su 2 zahteva, za svaki disk po jedan
- **disk #1:** sa adrese (cilindar 15, head 0, sektor 13), pročitati 10 sektora
- **disk #2:** sa adrese (cilindar 940, head 2, sektor 1), pročitati 40 sektora
- odrediti ukupno vreme trajanja oba disk pristupa bez preklapanja media i interface faze

PRIMER BR. 1

< SAS diskovi >

- U slučaju SAS diskova, svaki disk radi nezavisno i to sa maksimalnom brzinom. Dva ili bilo koliko SAS diskova mogu obaviti N istovremenih operacija, po jednu na svakom disk pojedinačno.
- Oba diska su SAS
- i ovde se disk operacije preklapaju, obe se rade istovremeno
- **$T_{total} = \text{Max}(T_{access1}, T_{access2})$**
- disk #1: sa adrese (cilindar 15, head 0, sektor 13), pročitati 10 sektora
- $T_{access1} = T_{seek1} + T_{rotate1} + T_{media1} + T_{interface1}$
- $T_{seek1} = 1 \times \text{average seek time} = 3.3 \text{ msec}$
- $T_{rotate1} = T_{rotate_avg}(15000 \text{ rpm}) = 2 \text{ msec}$
- $T_{media1} = Q/V_{media} = 10 \times 0.5 \text{ KB} / 160 \text{ MB/s} = 0.03125 \text{ msec}$
- $T_{inteface1} = Q/V_{interface} = 10 \times 0.5 \text{ KB} / 600 \text{ MB/s} = 0.0083 \text{ msec}$
- **$T_{access1} = 5.3396 \text{ msec}$**

PRIMER BR. 1

< SAS diskovi >

- **disk #2: sa adrese (cilindar 940, head 2, sektor 1), pročitati 40 sektora**
- $T_{\text{access2}} = T_{\text{seek2}} + T_{\text{rotate2}} + T_{\text{media2}} + T_{\text{interface2}}$
- $T_{\text{seek2}} = 1 \times \text{average seek time} = 3.3 \text{ msec}$
- $T_{\text{rotate2}} = T_{\text{rotate_avg}}(15000 \text{ rpm}) = 2 \text{ msec}$
- $T_{\text{media2}} = Q/V_{\text{media}} = 40 \times 0.5 \text{ KB} / 160 \text{ MB/s} = 0.125 \text{ msec}$
- $T_{\text{inteface2}} = Q/V_{\text{interface}} = 40 \times 0.5 \text{ KB} / 600 \text{ MB/s} = 0.0333 \text{ msec}$
- $T_{\text{access2}} = 5.4583 \text{ msec}$
- $T_{\text{total}} = \text{Max}(5.3396, 5.4583) = 5.4583 \text{ msec}$

PRIMER BR. 2

<SAS taktovi i brzine prenosa >

- Zadatak 1.
- SAS-2 ima osnovni takt od 6GHz. Odrediti maksimalni transfer rate.
- **Rešenje:**
- odredićemo maksimalnu brzinu za SAS 2.0, poštujući osnovne činjenice
 - SAS prenosi podatke 1 bit u jednom taktu
 - SAS koristi šemu 8b/10b, za 8 data bitova, prenese ukupno 10 (80% efikasnosti)
- Na osnovu toga dolazimo do formule

- **SAS speed=**
- 6000MHz embedded clock
- x 1 bit per clock
- x 80% for 8b10b encoding
- / 8 bits per byte
- = 600 Mbytes/sec

- **Brzina transfera ovog SAS interfejsa je 600MB/s**