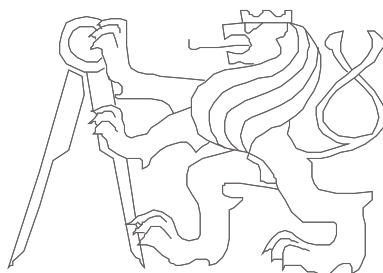


# Architektury počítačů

## PCI a PCI Express sběrnice a PCIe



České vysoké učení technické, Fakulta elektrotechnická

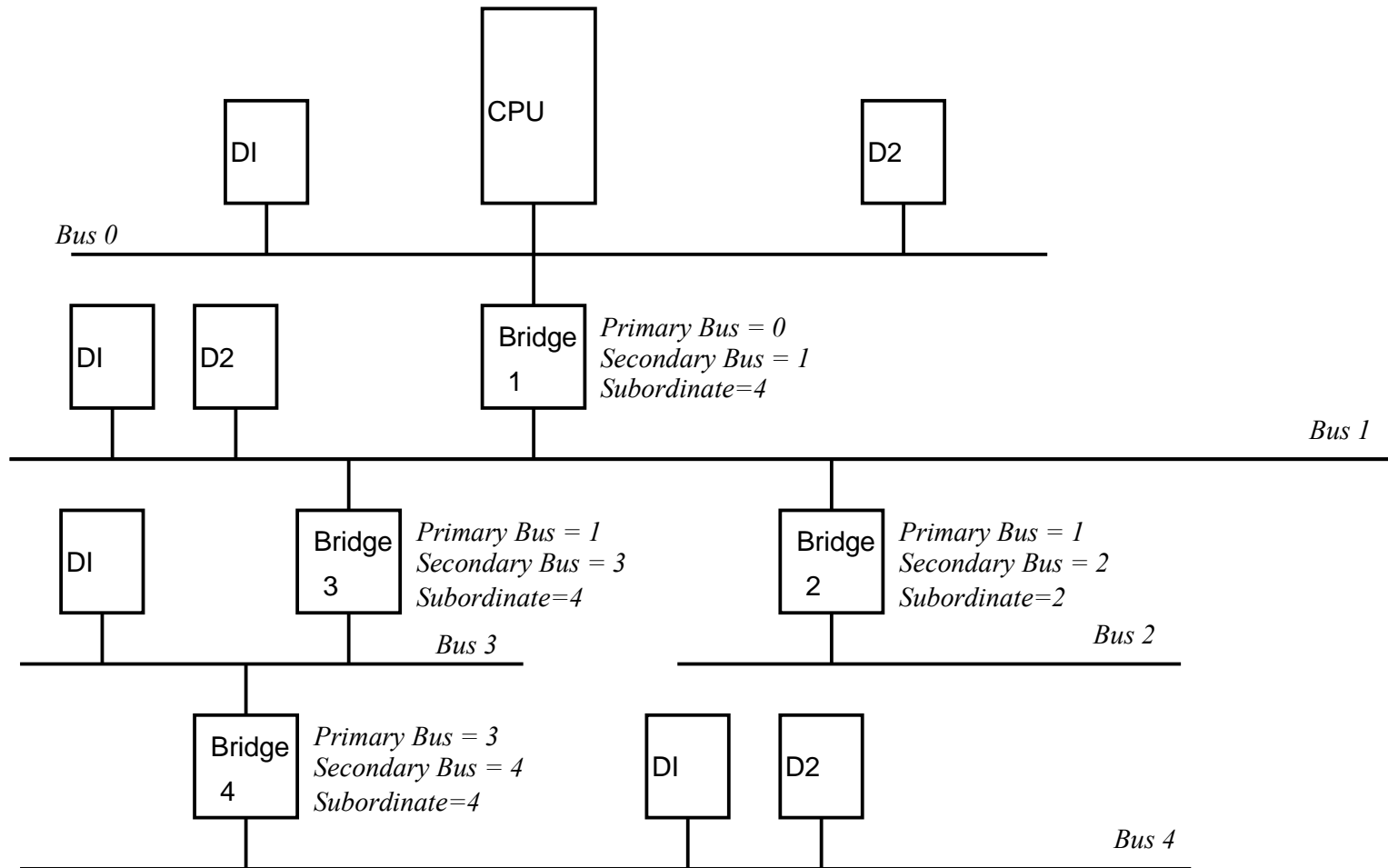
# PCI - Peripheral Component Interconnect

- PCI 1.0 - Intel (1992), PCI 2.0 (1993), PCI 2.1 (1995)
- původně 32-bit sběrnice, rozšíření na 64-bit
- multiplexovaná adresa a data na pinech AD0 až AD31
- při 64 bit adresaci možné dva cykly adresy na 32-bit verzi, jeden na 64 bit verzi
- v současné době nejrozšířenější sběrnice od PC přes pracovní stanice, servery a i průmyslové aplikace

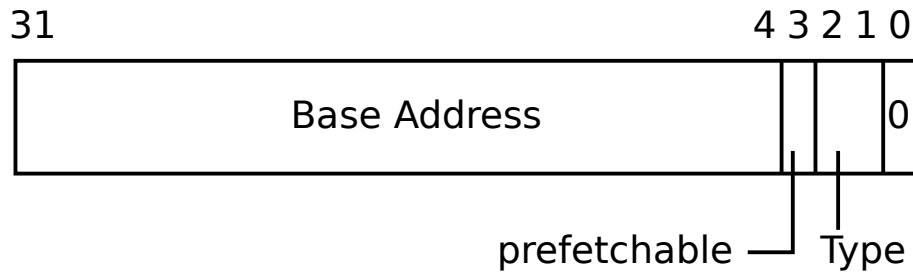
## PCI – frekvence a přenosová kapacita

PCI Bus Bandwidth [bits]	Bus Clock Frequency [MHz]	Bandwidth [MB/s]	Market
32	33	132	Desktop/Mobile
32	66	264	Server
64	33	264	Server
64	66	512	Server

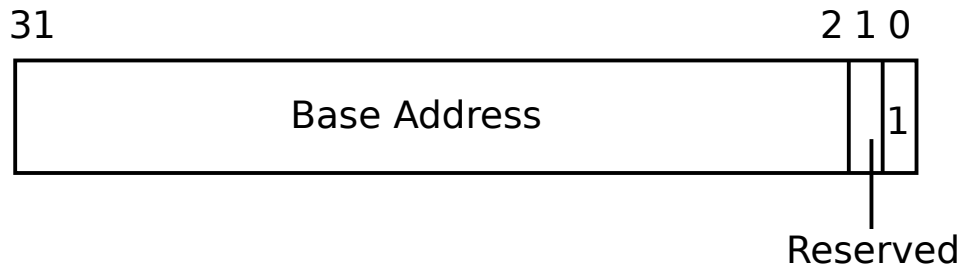
# Hierarchie PCI sběrnic



# Hlavička PCI Zařízení

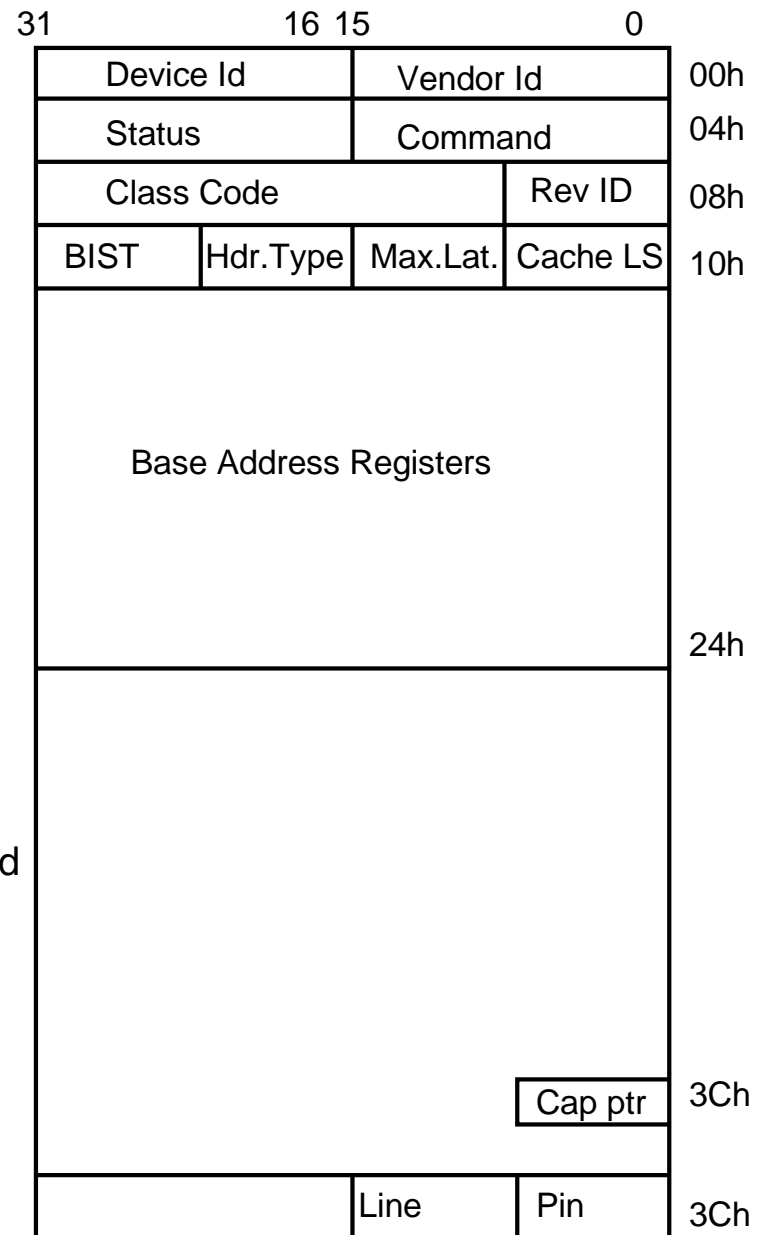


**Base Address for PCI Memory Space**



**Base Address for PCI I/O Space**

Hlavička PCI zařízení se nachází v řídicím adresním prostoru PCI sběrnice



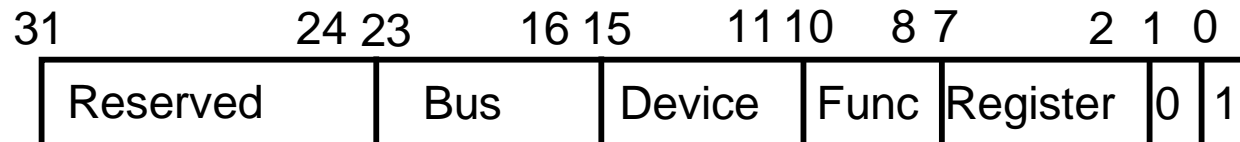
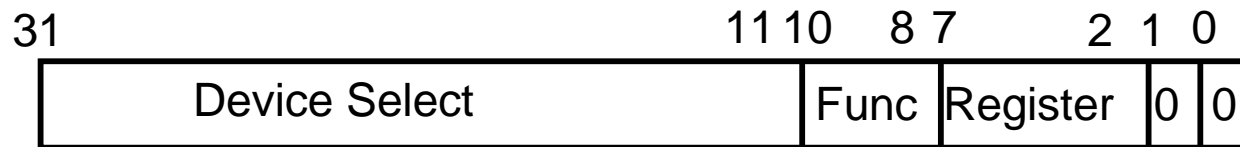
# PCI Device Header Type 0

				Byte Offset
Device ID		Vendor ID		00h
Status		Command		04h
Class Code			Revision ID	08h
BIST	Header Type	Master Lat. Timer	Cache Line Size	0Ch
Base Address Registers <sup>6</sup> max				10h
				14h
				18h
				1Ch
				20h
				24h
Cardbus CIS Pointer				28h
Subsystem ID		Subsystem vendor ID		2Ch
Expansion ROM Base Address				30h
Reserved			Capabilities Pointer	34h
Reserved				38h
Max_Lat	Min_Gnt	Interrupt Pin	Interrupt Line	3Ch

# PCI Device Header Type 1

				Byte Offset
Device ID		Vendor ID		00h
Status		Command		04h
Class Code			Revision ID	08h
BIST	Header Type	Master Lat. Timer	Cache Line Size	0Ch
Base Address Register 0				10h
Base Address Register 1				14h
Secondary Latency Timer	Subordinate Bus Number	Secondary Bus Number	Primary Bus Number	18h
Secondary Status		I/O Limit	I/O Base	1Ch
Memory Limit		Memory Base		20h
Prefetchable Memory Limit		Prefetchable Memory Base		24h
Prefetchable Base Upper 32 Bits				28h
Prefetchable Limit Upper 32 Bits				2Ch
I/O Limit Upper 16 Bits		I/O Limit Base Upper 16 Bits		30h
Reserved			Capabilities Pointer	34h
Expansion ROM Base Address				38h
Bridge Control		Interrupt Pin	Interrupt Line	3Ch

# Adresace PCI zařízení v řídicím prostoru





## PCI - Varianty

- PCI – původní specifikace 33 MHz
- PCI-X - 64 bitů @ 133MHz
- cPCI, Compact PCI – karty o VME rozměrech, 3U/6U, 2mm connectory
- PC104-Plus -PCI přidaná k PC104
- PISA - PCI přidaná s PCAT k ISA AT formátu
- P2CI - PCI na VME64 P2 konektoru
- PMC - PCI na Mezzanine Card, 'PMC'
- PXI - cPCI for měřicí přístroje (jak VXI)
- Card Bus - 32 bit PCI na PC Card (PCMCIA)

# PCI - signály

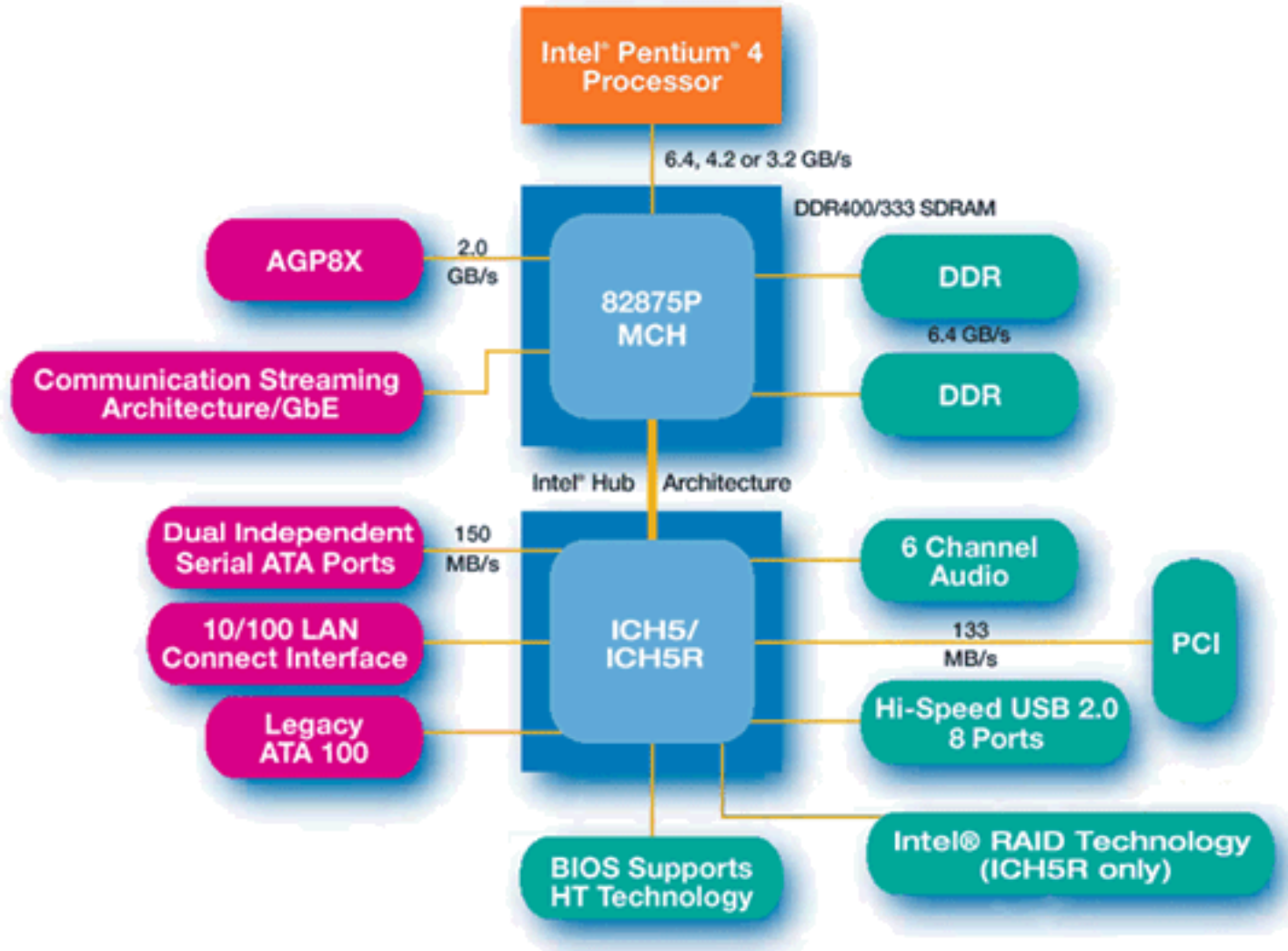
Pin #	Name	PCI Pin Description	Pin #	Name	PCI Pin Description
A1	TRST	Test Logic Reset	B1	-12V	-12 VDC
A2	+12V	+12 VDC	B2	TCK	Test Clock
A3	TMS	Test Mode Select	B3	GND	Ground
A4	TDI	Test Data Input	B4	TDO	Test Data Output
A5	+5V	+5 VDC	B5	+5V	+5 VDC
A6	INTA	Interrupt A	B6	+5V	+5 VDC
A7	INTC	Interrupt C	B7	INTB	Interrupt B
A8	+5V	+5 VDC	B8	INTD	Interrupt D
A9	-----	Reserved	B9	PRSNT1	Present
A10	+5V	Power (+5 V or +3.3 V)	B10	-----	Reserved
A11	-----	Reserved	B11	PRSNT2	Present
A12	GND03	Ground or Keyway for 3.3/Universal PWB	B12	GND	Ground or Keyway for 3.3/Universal PWB
A13	GND05		B13	GND	
A14	3.3Vaux	-----	B14	RES	Reserved
A15	RESET	Reset	B15	GND	Ground
A16	+5V	Power (+5 V or +3.3 V)	B16	CLK	Clock
A17	GNT	Grant PCI use	B17	GND	Ground
A18	GND08	Ground	B18	REQ	Request
A19	PME#	Power Management Event	B19	+5V	Power (+5 V or +3.3 V)
A20	AD30	Address/Data 30	B20	AD31	Address/Data 31
A21	+3.3V01	+3.3 VDC	B21	AD29	Address/Data 29
A22	AD28	Address/Data 28	B22	GND	Ground
A23	AD26	Address/Data 26	B23	AD27	Address/Data 27
A24	GND10	Ground	B24	AD25	Address/Data 25
A25	AD24	Address/Data 24	B25	+3.3V	+3.3VDC
A26	IDSEL	Initialization Device Select	B26	C/BE3	Command, Byte Enable 3
A27	+3.3V03	+3.3 VDC	B27	AD23	Address/Data 23
A28	AD22	Address/Data 22	B28	GND	Ground
A29	AD20	Address/Data 20	B29	AD21	Address/Data 21
A30	GND12	Ground	B30	AD19	Address/Data 19
A31	AD18	Address/Data 18	B31	+3.3V	+3.3 VDC

Pin #	Name	PCI Pin Description	Pin #	Name	PCI Pin Description
A32	AD16	Address/Data 16	B32	AD17	Address/Data 17
A33	+3.3V05	+3.3 VDC	B33	C/BE2	Command, Byte Enable 2
A34	FRAME	Address or Data phase	B34	GND13	Ground
A35	GND14	Ground	B35	IRDY#	Initiator Ready
A36	TRDY#	Target Ready	B36	+3.3V06	+3.3 VDC
A37	GND15	Ground	B37	DEVSEL	Device Select
A38	STOP	Stop Transfer Cycle	B38	GND16	Ground
A39	+3.3V07	+3.3 VDC	B39	LOCK#	Lock bus
A40	-----	Reserved	B40	PERR#	Parity Error
A41	-----	Reserved	B41	+3.3V08	+3.3 VDC
A42	GND17	Ground	B42	SERR#	System Error
A43	PAR	Parity	B43	+3.3V09	+3.3 VDC
A44	AD15	Address/Data 15	B44	C/BE1	Command, Byte Enable 1
A45	+3.3V10	+3.3 VDC	B45	AD14	Address/Data 14
A46	AD13	Address/Data 13	B46	GND18	Ground
A47	AD11	Address/Data 11	B47	AD12	Address/Data 12
A48	GND19	Ground	B48	AD10	Address/Data 10
A49	AD9	Address/Data 9	B49	GND20	Ground
A50	Keyway	Open or Ground for 3.3V PWB	B50	Keyway	Open or Ground for 3.3V PWB
A51	Keyway	Open or Ground for 3.3V PWB	B51	Keyway	Open or Ground for 3.3V PWB
A52	C/BE0	Command, Byte Enable 0	B52	AD8	Address/Data 8
A53	+3.3V11	+3.3 VDC	B53	AD7	Address/Data 7
A54	AD6	Address/Data 6	B54	+3.3V12	+3.3 VDC
A55	AD4	Address/Data 4	B55	AD5	Address/Data 5
A56	GND21	Ground	B56	AD3	Address/Data 3
A57	AD2	Address/Data 2	B57	GND22	Ground
A58	AD0	Address/Data 0	B58	AD1	Address/Data 1
A59	+5V	Power (+5 V or +3.3 V)	B59	VCC08	Power (+5 V or +3.3 V)
A60	REQ64	Request 64 bit	B60	ACK64	Acknowledge 64 bit
A61	VCC11	+5 VDC	B61	VCC10	+5 VDC
A62	VCC13	+5 VDC	B62	VCC12	+5 VDC

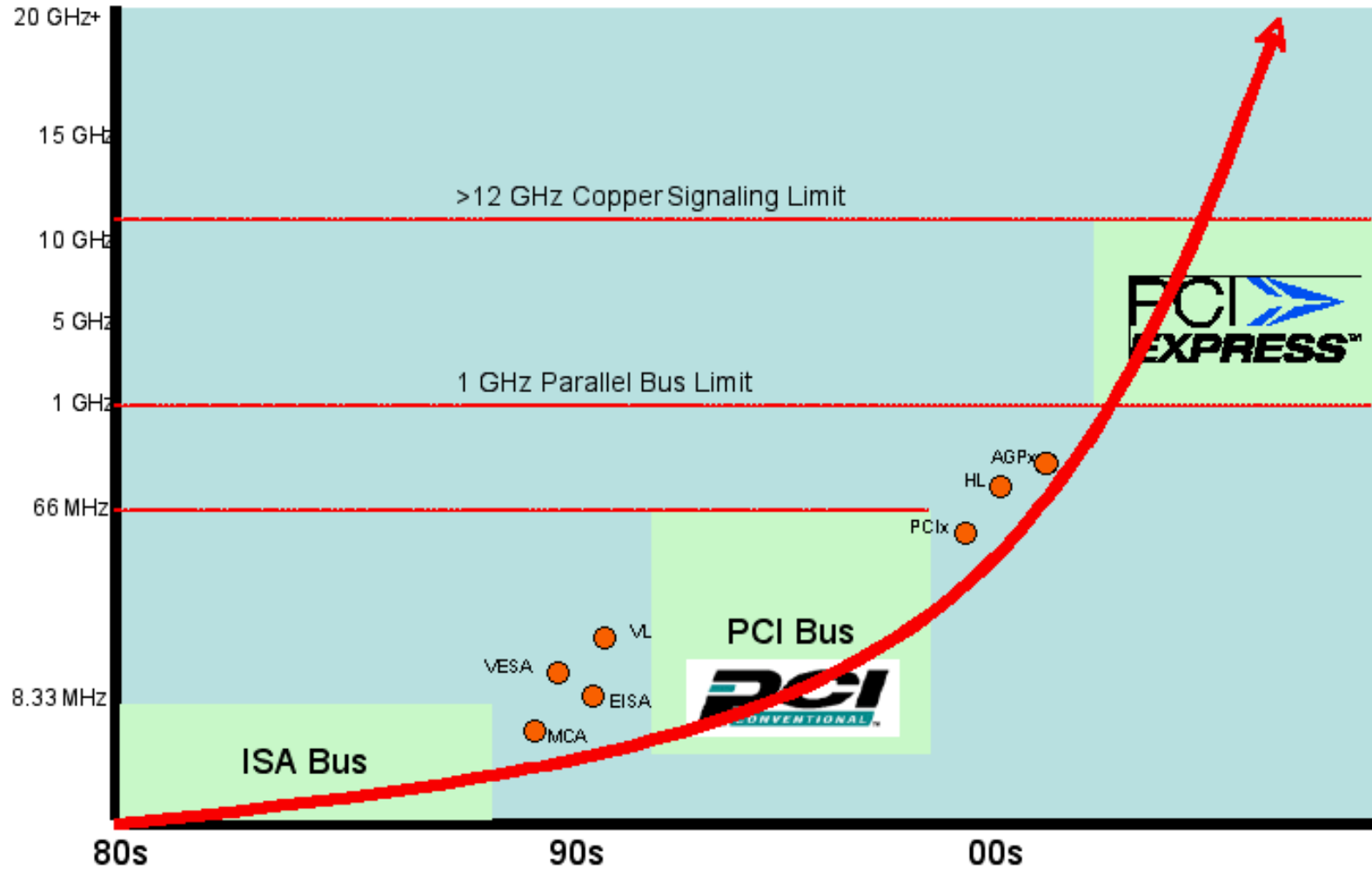
# PCI 64-bit

Pin #	Name	PCI Pin Description	Pin #	Name	PCI Pin Description
A63	GND	Ground	B63	RES	Reserved
A64	C/BE[7]#	Command, Byte Enable 7	B64	GND	Ground
A65	C/BE[5]#	Command, Byte Enable 5	B65	C/BE[6]#	Command, Byte Enable 6
A66	+5V	Power (+5 V or +3.3 V)	B66	C/BE[4]#	Command, Byte Enable 4
A67	PAR64	Parity 64	B67	GND	Ground
A68	AD62	Address/Data 62	B68	AD63	Address/Data 63
A69	GND	Ground	B69	AD61	Address/Data 61
A70	AD60	Address/Data 60	B70	+5V	Power (+5 V or +3.3 V)
A71	AD58	Address/Data 58	B71	AD59	Address/Data 59
A72	GND	Ground	B72	AD57	Address/Data 57
A73	AD56	Address/Data 56	B73	GND	Ground
A74	AD54	Address/Data 54	B74	AD55	Address/Data 55
A75	+5V	Power (+5 V or +3.3 V)	B75	AD53	Address/Data 53
A76	AD52	Address/Data 52	B76	GND	Ground
A77	AD50	Address/Data 50	B77	AD51	Address/Data 51
A78	GND	Ground	B78	AD49	Address/Data 49
A79	AD48	Address/Data 48	B79	+5V	Power (+5 V or +3.3 V)
A80	AD46	Address/Data 46	B80	AD47	Address/Data 47
A81	GND	Ground	B81	AD45	Address/Data 45
A82	AD44	Address/Data 44	B82	GND	Ground
A83	AD42	Address/Data 42	B83	AD43	Address/Data 43
A84	+5V	Power (+5 V or +3.3 V)	B84	AD41	Address/Data 41
A85	AD40	Address/Data 40	B85	GND	Ground
A86	AD38	Address/Data 38	B86	AD39	Address/Data 39
A87	GND	Ground	B87	AD37	Address/Data 37
A88	AD36	Address/Data 36	B88	+5V	Power (+5 V or +3.3 V)
A89	AD34	Address/Data 34	B89	AD35	Address/Data 35
A90	GND	Ground	B90	AD33	Address/Data 33
A91	AD32	Address/Data 32	B91	GND	Ground
A92	RES	Reserved	B92	RES	Reserved
A93	GND	Ground	B93	RES	Reserved
A94	RES	Reserved	B94	GND	Ground

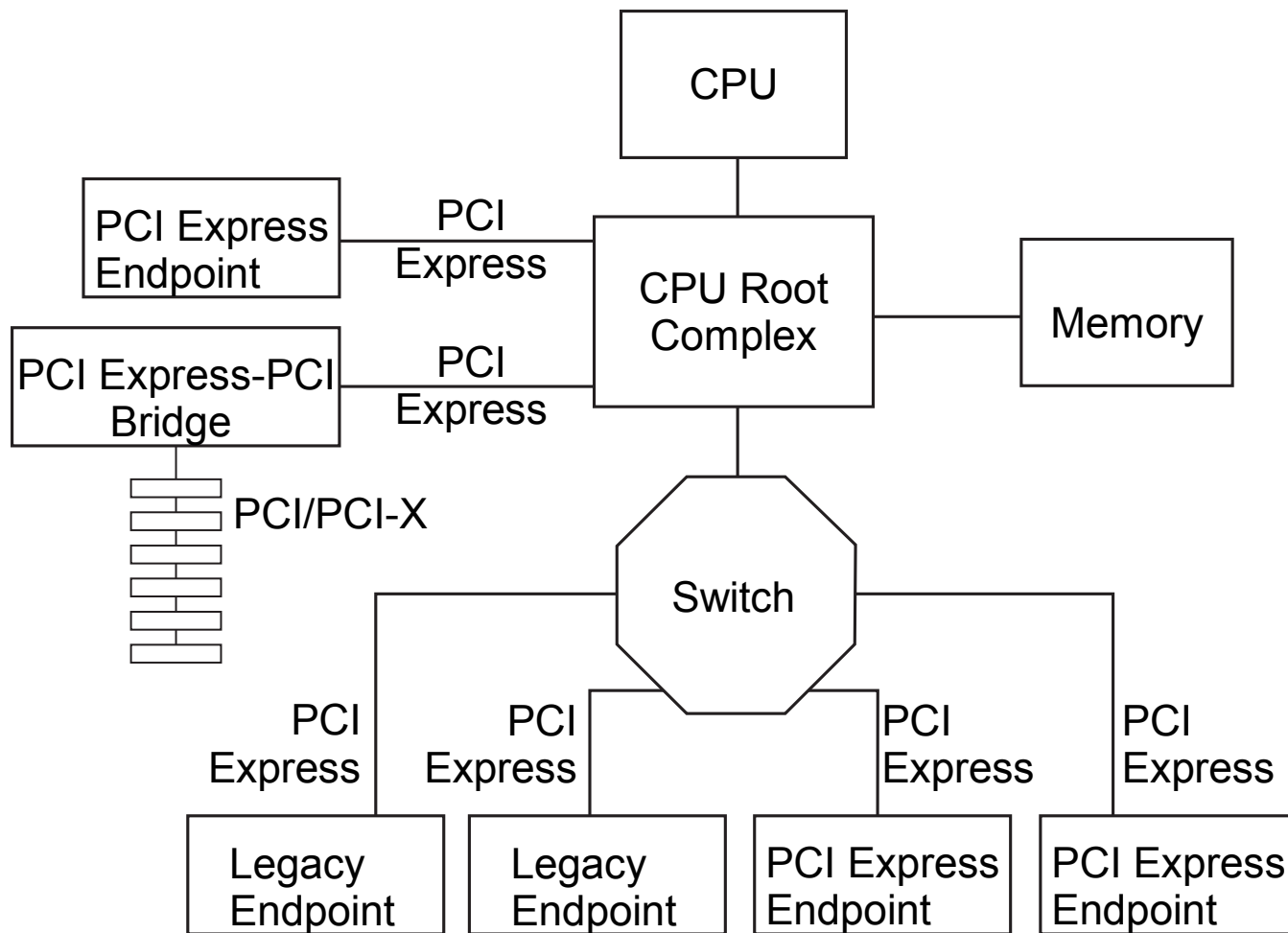
# PCI – typický systém (základová deska)



# Paralelní nebo sériová? Co je rychlejší?

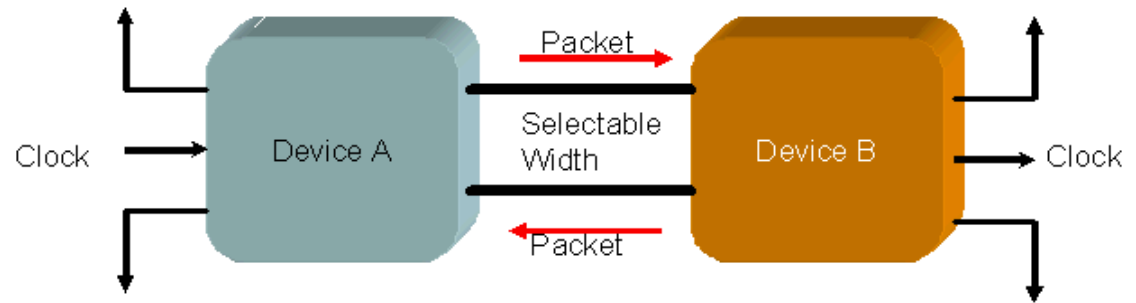


# Topologie sběrnice PCI Express

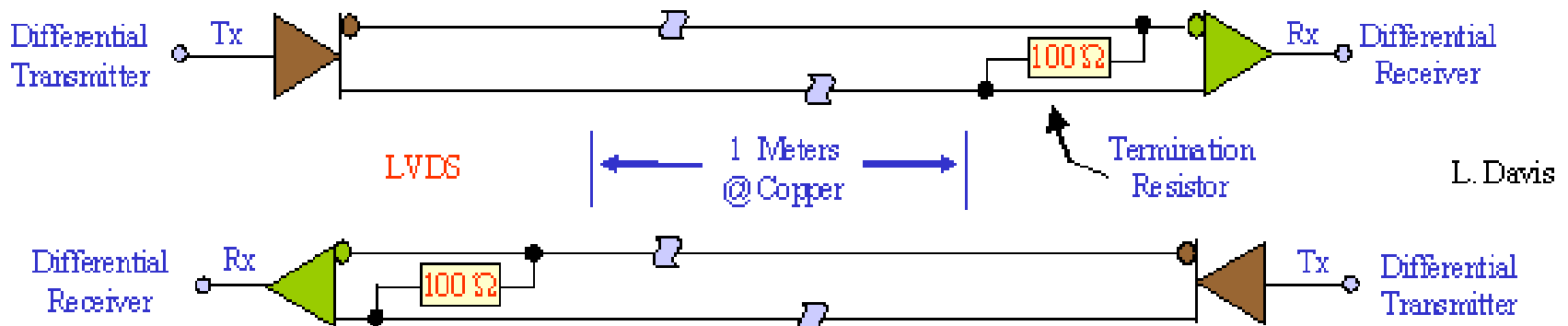


# PCI Express - fyzická vrstva

Diferenciální plně duplexní fyzická vrstva



Kódování 8b/10b zajišťuje dostatek hran pro obnovení hodin a shodný počet bitů 0 a 1 pro vyvážení stejnosměrné složky (DC) v střídavě (AC) vázaném systému



# Vodi4e PCI Express Sběrnice

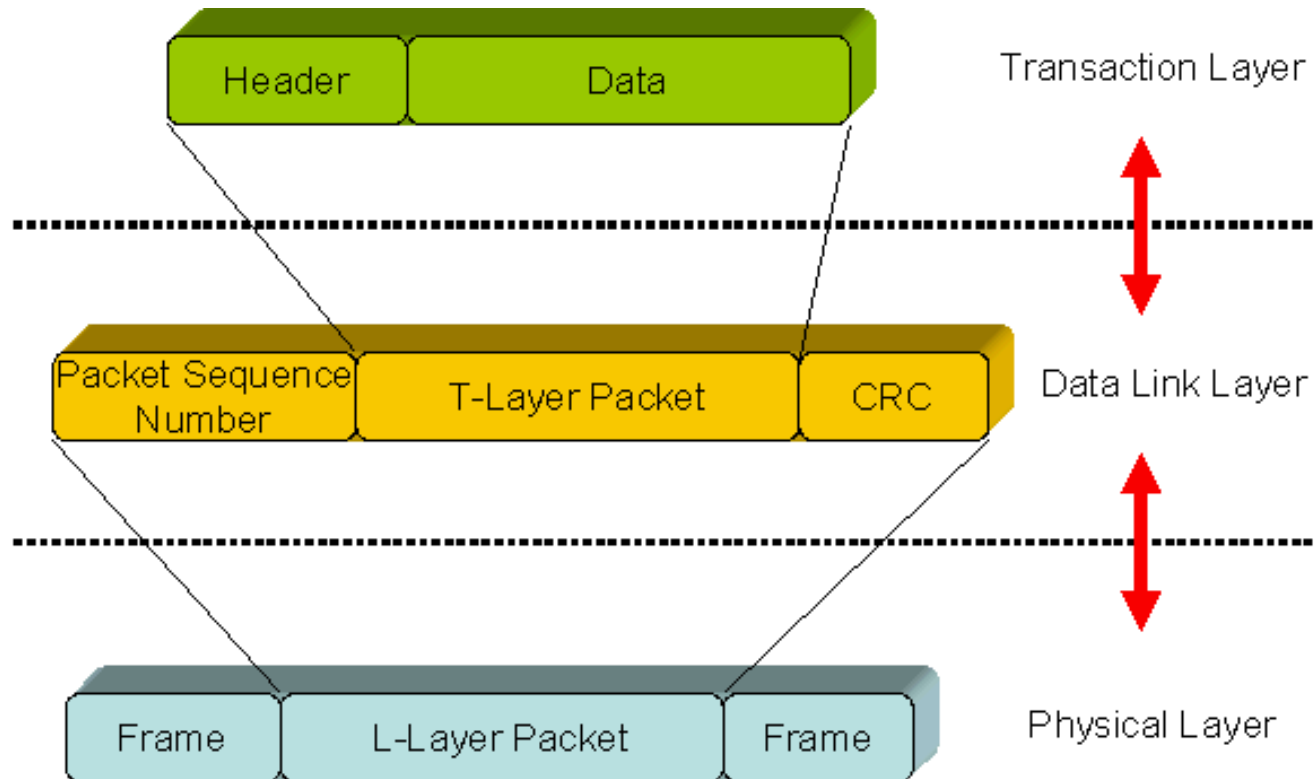
Pin #	Side B Connector		Side A Connector	
	Name	Description	Name	Description
1	+12v	+12 volt power	PRSNT#1	Hot plug presence detect
2	+12v	+12 volt power	+12v	+12 volt power
3	RSVD	Reserved	+12v	+12 volt power
4	GND	Ground	GND	Ground
5	SMCLK	SMBus clock	JTAG2	TCK
6	SMDAT	SMBus data	JTAG3	TDI
7	GND	Ground	JTAG4	TDO
8	+3.3v	+3.3 volt power	JTAG5	TMS
9	JTAG1	+TRST#	+3.3v	+3.3 volt power
10	3.3Vaux	3.3v volt power	+3.3v	+3.3 volt power
11	WAKE#	Link Reactivation	PWRGD	Power Good
<b>Mechanical Key</b>				
12	RSVD	Reserved	GND	Ground
13	GND	Ground	REFCLK+	Reference Clock
14	HSOp(0)	Transmitter Lane 0, Differential pair	REFCLK-	Differential pair
15	HSOn(0)		GND	Ground
16	GND	Ground	HSIp(0)	Receiver Lane 0, Differential pair
17	PRSNT#2	Hotplug detect	HSIn(0)	
18	GND	Ground	GND	Ground



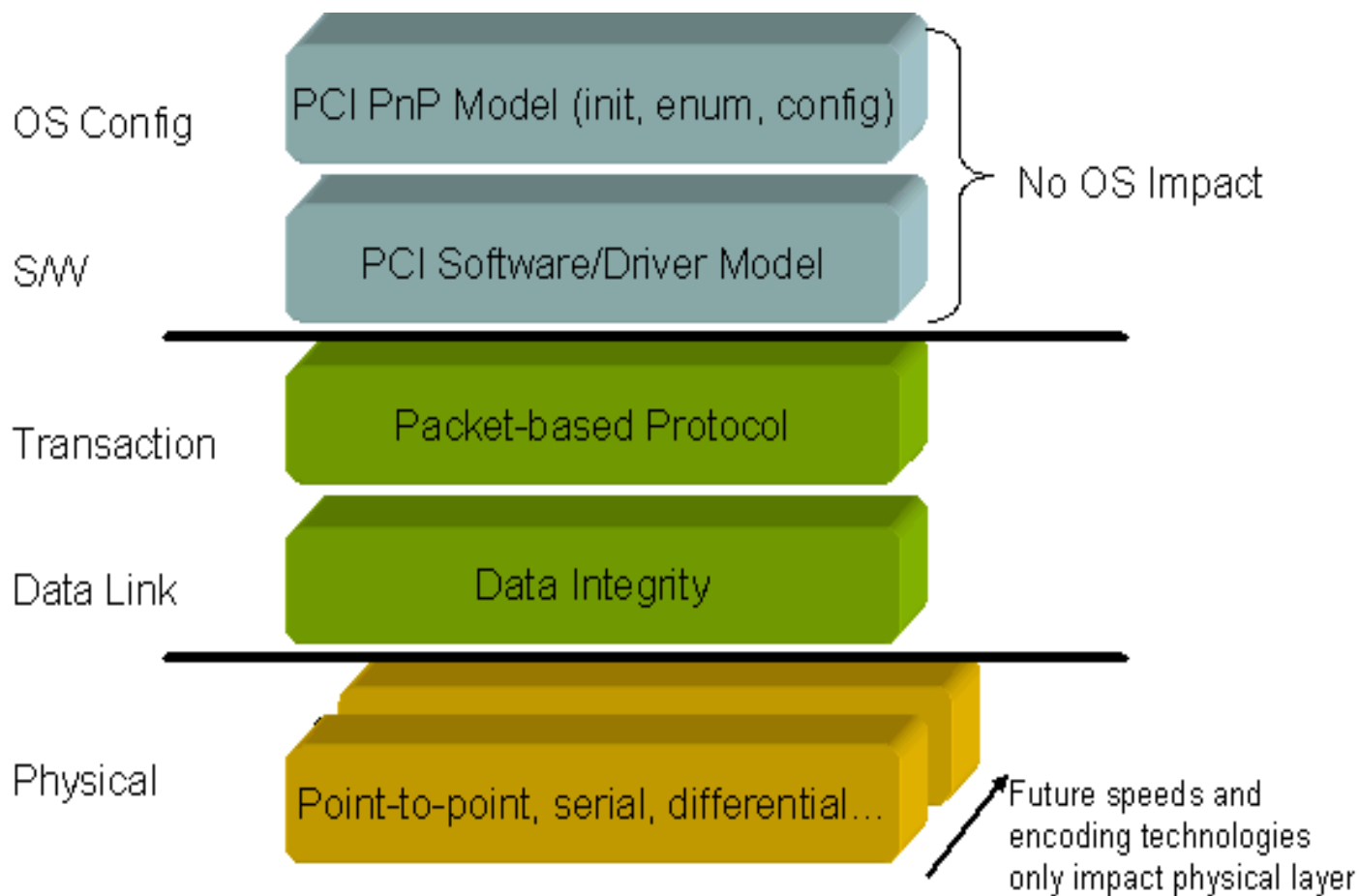
# PCI Express

- frekvence 2.5 Gb/s přenosová kapacita okolo 250 MB/s na jedné PCI Express trase (násobí se pro 2×, 4×, 8×)
- čistá užitečná kapacita okolo 200 MB/s to je 2× až 4× více než klasické PCI
- kapacita není sdílená, jedná se o sériové point to point kanály
- dva páry vodičů a diferenční úrovně
- kódování a synchronizace 8b/10b
- předpoklad až 10 Gb/s (pokrok technologie)
- PCI Express 2.x (2007) nabízí frekvenci 5 Gb/s
- PCI Express 3.x (základ listopad 2010) zvýší na 8 Gb/s
- přechod z 8b/10b (20% pásma na kódování) na "scrambling" a 128b/130b kódování (ubírá jen 1.5% pásma)

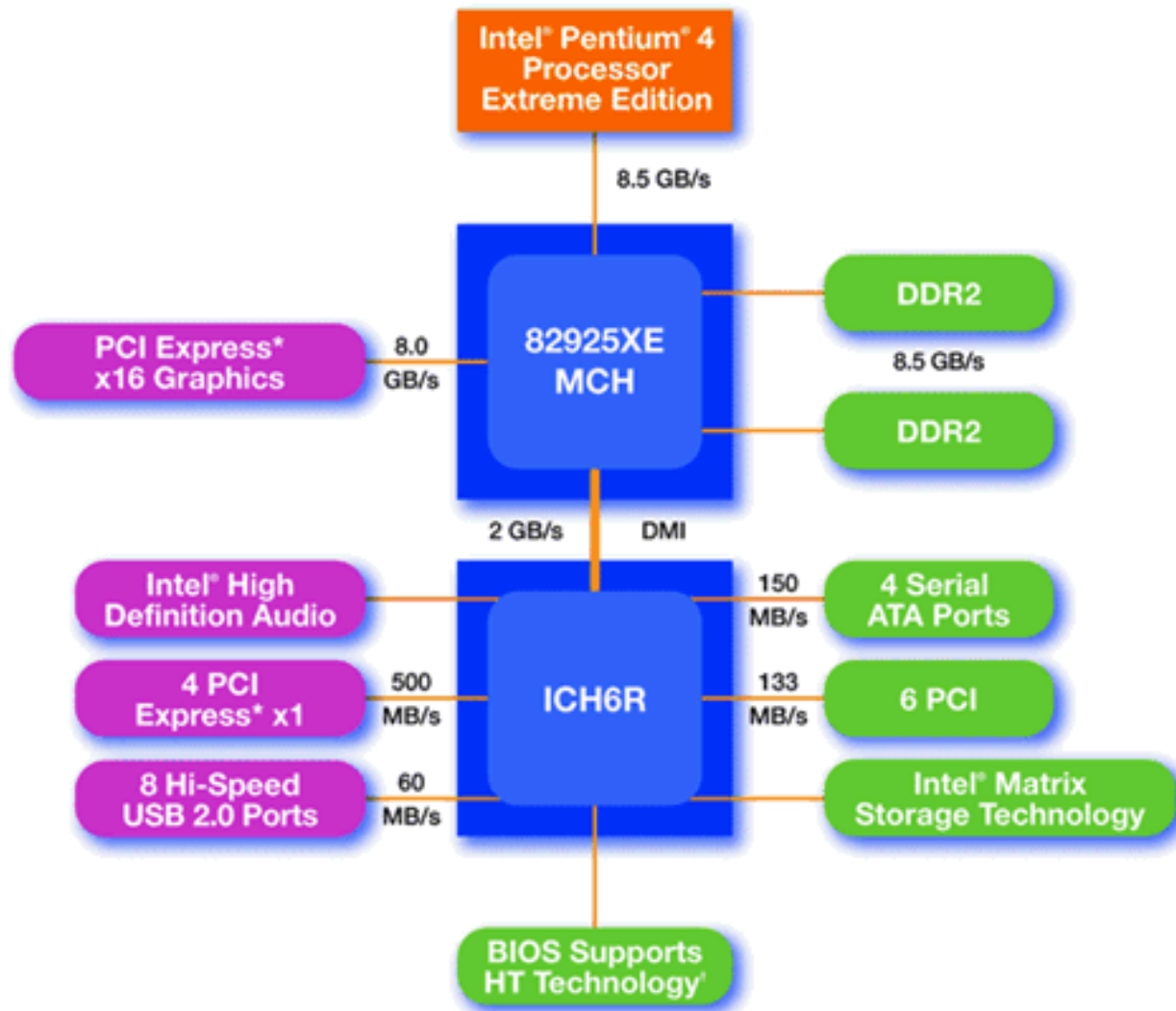
# PCI Express – paketový přenos dat



# PCI Express – kompatibilita s drivery



# PCI Express - typický systém (základová deska)



# PCI Express - konektory



Grafická karta PCIe 16x

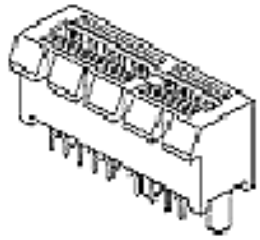


PCI-X

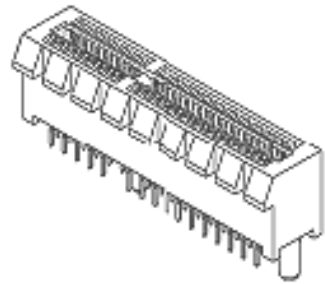
PCIe 8x

PCI

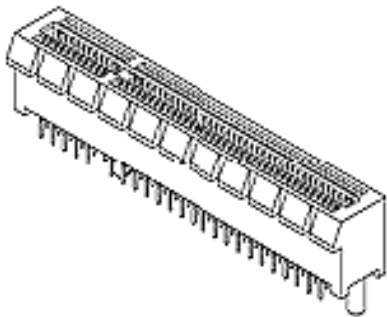
PCIe 16x



PCIe 1x



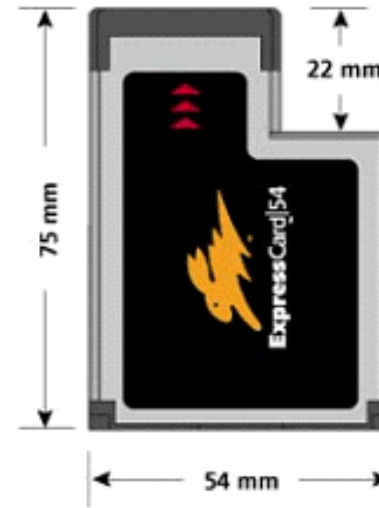
PCIe 4x



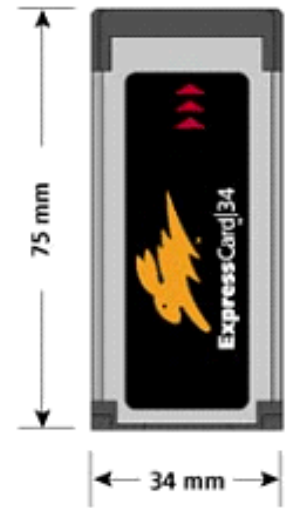
PCIe 8x



CardBus  
PCMCIA



ExpressCard/54



ExpressCard/34

PCIe 1x

## PCI Express - výhody

- velký výkon, i jen ve verzi x1 je dvakrát rychlejší než PCI a očekává se zrychlení
- zjednodušení V/V propojování, nahradí postupně AGP, PCI-X a HubLink což jednodušší složitost
- díky úrovňovému designu zajistí kompatibilitu se softwarem
- nové kvality, např. izochronní přenosy a QoS
- sjednotí i externí karty, hot-swap a hot-plug