



**Fundusze Europejskie**  
Wiedza Edukacja Rozwój



**Rzeczpospolita  
Polska**

**Unia Europejska**  
Europejski Fundusz Społeczny



**Politechnika Śląska jako Centrum Nowoczesnego Kształcenia  
opartego o badania i innowacje**

**POWR.03.05.00-IP.08-00-PZ1/17**

**Projekt współfinansowany przez Unię Europejską ze środków Europejskiego Funduszu Społecznego**

# **Microprocessor and Embedded Systems**

**Faculty of Automatic Control, Electronics and Computer Science,  
Informatics, Bachelor Degree**

# Lecture 8

---

## PCI architecture

**Bartłomiej Zieliński, PhD, DSc**

# PCI architecture

---

Program:

- PCI configuration memory
  - Header structure
  - Access methods
  - Device classes
- PCI-X
- PCI Express

# PCI architecture

---

Program:

- PCI configuration memory
  - Header structure
  - Access methods
  - Device classes
- PCI-X
- PCI Express

# PCI architecture

- PCI configuration memory
  - Header format

Device ID		Vendor ID	
Status		Command	
Class		Class code Subclass	Interface
BIST	Header type	Latency timer	Version
Cache size			
Base address 0			
Base address 1			
Base address 2			
Base address 3			
Base address 4			
Base address 5			
Cardbus CIS pointer			
Suppl. Device ID		Suppl. Vendor ID	
ROM Base address			
			Capabilities list
Max. latency	Min. granted	Int	IRQ

# PCI devices...

---

- Field description
  - Vendor ID
    - Unique, defined by PCI SIG
    - FFFFh – forbidden, 8086h – Intel
  - Device ID
    - Defined by vendor
    - Vendor ID:Device ID → driver selection

# PCI devices...

---

- Field description

- Control

- Fast back to back: no wait between D and next A
    - System Error Enable
    - Wait Enable
    - Parity Error Enable
    - VGA Palette Snoop
    - Mem Write & Invalidate
    - Special Cycle (*monitor dual address cycle?*)
    - Master Enable (*initiator capability?*)
    - Memory Access (*decode Mem addresses?*)
    - IO Access (*decode IO addresses?*)

# PCI devices...

---

- Field description

- Status

- Parity Error (regardless of Command.PErr.Enable)
    - System Error
    - Received Master Abort: timeout in Target
    - Received Target Abort: transmission broken by Target
      - $\overline{\text{Stop}}$  or lack of  $\overline{\text{TRdy}}$  or  $\overline{\text{DevSel}}$
    - Signalled Target Abort: in Target who broke transfer
    - Device Select Timing: 0, 1 or 2 Clk to  $\overline{\text{DevSel}}$  active
    - Data Parity Reported:  $\overline{\text{PErr}}$  when Command.PErr.Enable
    - Fast Back to Back: can work in this mode
    - User Defined Features: requires user-def. Parameters
      - E.g., network card number
    - 66 MHz capable



# PCI devices...

---

- Field description
  - Class code
    - Class, subclass, interface
    - Class, e.g.
      - Bus interface
      - Network controllers
    - Subclass, e.g.
      - Host/PCI, PCI/PCI, PCI/ISA, PCI/Cardbus, etc.
      - Ethernet, Token Ring...
  - Interface
    - Not very often defined
    - Additional information about device class
    - E.g., IDE controller type, mode, ...

# PCI devices...

---

- Field description
  - Version
    - Defined by vendor
  - Header type
    - Normal
    - PCI/PCI
    - PCI/Cardbus (unofficial)
  - Min. transmission time
    - Shortest time needed for transmission
  - Cache size
    - number of DWORDs in cache line

# PCI devices...

---

- Field description
  - Base address
    - Up to 6 spaces + 1 ROM space
    - Device requirements for addressing space
      - Memory: in 16B-blocks
      - IO: in 4B-blocks
      - ROM: in 2KB-blocks
    - Addressing space assignment by OS
      1. Size detection
        1. Write FFFFFFFFh
        2. Read → size
      2. Address assignment

# PCI devices...

---

- Field description
  - Suppl. Vendor ID, Device ID
    - Additional information about device
    - Helps select drivers
  - Capabilities list
    - Additional information about device
    - E.g., helps recognise bus type (PCI, AGP, PCI Express, etc.)

# PCI devices...

---

- Field description
  - INT
    - Interrupt line in PCI BUS (A, B, C, D)
  - IRQ
    - Interrupt line in PC
    - Assigned by BIOS/OS
  - Min. latency
    - Average inter-request time,  $n \times 250$  ns
  - Max. granted
    - Average bus acquisition time,  $n \times 250$  ns

# PCI devices...

---

- Popular classes/subclasses
  - 00: pre-PCI 2.0 devices
  - 01: mass storage: SCSI, IDE, FDD, RAID, SATA...
  - 02: network: Ethernet, TokenRing, ATM, FDDI...
  - 03: display: VGA, 8514, XGA, 3D
  - 04: multimedia: video, audio, hi-def audio...
  - 05: memory: RAM, Flash...
  - 06: bridges: Host, ISA, EISA, MCA, PCI, PCMCIA, Cardbus, Infiniband...
  - 07: communication: serial, parallel, modem...

# PCI devices...

---

- Popular classes/subclasses
  - 08: system peripherals (interrupt, DMA, timer, RTC)
  - 09: input devices (kbd, mouse, digitizer)
  - 0A: docking stations
  - 0B: processors (386, 486, P5, P5 Pro, coproc)
  - 0C: serial: FireWire, USB, SMBus...
  - 0D: wireless: IrDA, UWB, BT, Wi-Fi, cellular...
  - 0E: Intelligent IO
  - 0F: satellite

→ <http://pci-ids.ucw.cz/read/PD/>

# PCI devices...

---

- Configuration memory access
  - 8-bit I/O registers (obsolete)
  - 32-bit I/O registers
  - PCI BIOS
    - Check for PCI BIOS presence
    - Read byte, word or double word from configuration memory



# PCI devices...

---

- Configuration memory access

- 8-bit I/O registers (obsolete)

- Out 0CFAh, bus8

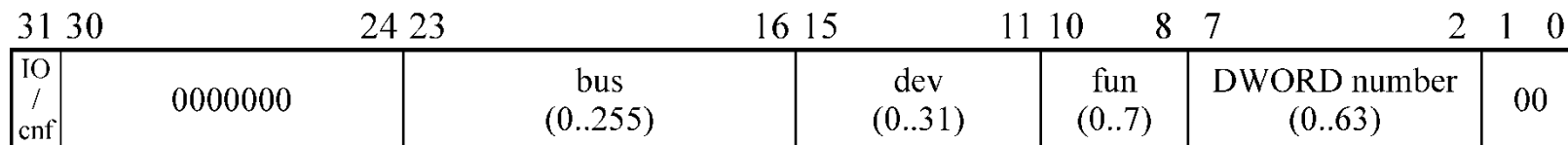
- Out 0CF8, fun8 SHL 1

- In Cx00..CxFF, byte; x=dev (0..15)

- 32-b I/O registers

- Out 0CF8, reg32; see below

- In reg32, 0CFC; DWORD from cnf. mem.



# PCI devices...

---

- Configuration memory access
  - PCI BIOS
    - Functions
      - Test PCI BIOS presence
      - Search for device by Vendor/Device
      - Search for device by Class code
      - PCI special cycle
      - Configuration memory read (BYTE, WORD, DWORD)
      - Configuration memory write (BYTE, WORD, DWORD)
      - Interrupt assignment options assignment
      - Interrupt assignment

# PCI devices...

---

- Configuration memory access

- PCI BIOS

- PCI BIOS presence test

- AX = B101h

- Int 1Ah

- EDX ← „PCI ”

- AH ← 0

- CF ← 0

- BX ← bus version (BCD)

- CH ← max\_bus

- AL ← configuration mechanism

# PCI devices...

---

- Configuration memory access

- PCI BIOS

- PCI BIOS byte read

- BH = bus

- BL = (dev SHL 3) OR fun

- DI = index

- AX = B108h

- Int 1Ah

- CL ← byte

# PCI devices...

---

- Configuration memory access

- Check PCI BIOS presence

- PCI presence, version
    - Max bus number

- Search for devices

```
for bus = 0 to max_bus
  for dev = 0 to 31
    for fun = 0 to 7
      get_hdr (bus, dev, fun);
      if VendorID=FFFFh
        skip_device;
      else
        write_device_info;
      end if
    end for
  end for
end for
```

# PCI devices...

---

- Example results – Asus EEE PC 1000HG

Commodore PC 10-III General Utility by BZiK Copyright (C) 1992, 2008 ver 3.2  
Checking system components...

Using PCI info access by PCI BIOS.

PCI BIOS ver. 3.00 found, max bus number: 05h, access mechanism: 01h.

Vendor	Device	BusDevFunction	Class	V	I	Ir	Fr	H	Description	
8086:1043	27AC:8340	0p 0 0	06.00.00	3	-	-	33	0	Host/PCI	
8086:1043	27AE:8340	0e 2 0	03.00.00	3	A	5	33	0	Graphics: VGA	
8086:1043	27A6:8340	0p 2 1	03.80.00	3	-	-	33	0	?Display	
8086:1043	27D8:831A	0e1B 0	04.03.00	2	A	5	33	0	Hi-def. audio	
8086:0000	27D0:0000	0e1C 0	06.04.00	2	A	5	33	1	PCI/PCI	00/04/04
8086:0000	27D2:0000	0e1C 1	06.04.00	2	B	10	33	1	PCI/PCI	00/03/03
8086:0000	27D6:0000	0e1C 3	06.04.00	2	D	11	33	1	PCI/PCI	00/01/02
8086:1043	27C8:830F	0p1D 0	0C.03.00	2	A	3	33	0	USB-UHCI	
8086:1043	27C9:830F	0p1D 1	0C.03.00	2	B	11	33	0	USB-UHCI	
8086:1043	27CA:830F	0p1D 2	0C.03.00	2	C	7	33	0	USB-UHCI	
8086:1043	27CB:830F	0p1D 3	0C.03.00	2	D	5	33	0	USB-UHCI	
8086:1043	27CC:830F	0p1D 7	0C.03.20	2	A	3	33	0	USB 2.0-EHCI	
8086:0000	2448:0000	0p1E 0	06.04.01	E2	-	-	33	1	PCI/PCI SubDec	00/05/05
8086:1043	27B9:830F	0p1F 0	06.01.00	2	-	-	33	0	PCI/ISA	
8086:1043	27C4:830F	0p1F 2	01.01.80	2	B	0	66	0	IDE	pISAsISA
14E4:1028	4328:0009	1e 0 0	02.80.00	1	A	11	33	0	?Network	
1969:1043	1026:8324	3e 0 0	02.00.00	B0	A	10	33	0	Ethernet	

# PCI devices...

---

- Example results – Asus EEE PC 1201K

Commodore PC 10-III General Utility by BZiK Copyright (C) 1992, 2008 ver 3.2  
Checking system components...

Using PCI info access by PCI BIOS.

PCI BIOS ver. 3.00 found, max bus number: 03h, access mechanism: 01h.

Vendor	Device	BusDevFunction	Class	V	I	Ir	Fr	H	Description	
1039:1043	0741:815C	0a 0 0	06.00.00	3	-	-	33	0	Host/PCI	
1039:0000	0003:0000	0p 1 0	06.04.00	0	-	-	66	1	PCI/PCI	00/01/01
1039:1043	0966:8204	0p 2 0	06.01.00	59	-	-	33	0	PCI/ISA	
1039:1043	7001:8204	0p 3 01	0C.03.10	F	A	5	33	0	USB-OHCI	
1039:1043	7002:8204	0p 3 3	0C.03.20	0	D	14	33	0	USB 2.0-EHCI	
1039:1043	0190:8204	0p 4 0	02.00.00	1	A	3	33	0	Ethernet	
1039:1043	1183:8204	0p 5 0	01.01.85	2	A	11	33	0	IDE	pPCIsPCI
1039:0000	000A:0000	0e 6 0	06.04.00	0	-	-	33	1	PCI/PCI	00/03/03
1039:1043	7502:83CE	0p F 0	04.03.00	0	A	7	33	0	Hi-def. audio	
1039:1043	6330:815C	1a 0 0	03.00.00	0	A	10	66	0	Graphics: VGA	
14E4:1028	4353:000E	2e 0 0	02.80.00	1	A	5	33	0	?Network	

# PCI devices...

---

- Example results – Samsung RC710

Commodore PC 10-III General Utility by BZiK Copyright (C) 1992, 2008 ver 3.2  
Checking system components...

Using PCI info access by PCI BIOS.

PCI BIOS ver. 3.00 found, max bus number: 07h, access mechanism: 01h.

Vendor	Device	BusDevFunction	Class	V	I	Ir	Fr	H	Description	
8086:144D	0044:C0A2	0p 0 0	06.00.00	2	-	-	33	0	Host/PCI	
8086:0000	0045:0000	0e 1 0	06.04.00	2	A	11	33	1	PCI/PCI	00/02/02
8086:144D	0046:C0A2	0e 2 0	03.00.00	2	A	11	33	0	Graphics: VGA	
8086:144D	3B64:C0A2	0e16 0	07.80.00	6	A	11	33	0	?Communication	
8086:144D	3B3C:C0A2	0p1A 0	0C.03.20	5	A	11	33	0	USB 2.0-EHCI	
8086:144D	3B56:C0A2	0e1B 0	04.03.00	5	A	7	33	0	Hi-def. audio	
8086:0000	3B42:0000	0e1C 0	06.04.00	5	A	10	33	1	PCI/PCI	00/03/04
8086:0000	3B48:0000	0e1C 3	06.04.00	5	D	5	33	1	PCI/PCI	00/05/06
8086:144D	3B34:C0A2	0p1D 0	0C.03.20	5	A	11	33	0	USB 2.0-EHCI	
8086:0000	2448:0000	0p1E 0	06.04.01	A5	-	-	33	1	PCI/PCI SubDec	00/07/07
8086:144D	3B09:C0A2	0p1F 0	06.01.00	5	-	-	33	0	PCI/ISA	
8086:144D	3B29:C0A2	0e1F 2	01.06.01	5	B	5	66	0	SATA/AHCI 1.0	
8086:144D	3B30:C0A2	0p1F 3	0C.05.00	5	C	10	33	0	SMBus	
8086:144D	3B32:C0A2	0e1F 6	11.80.00	5	C	10	33	0	?Signal proc.	
10DE:144D	0A7A:C0A2	2e 0 0	03.02.00	A2	A	11	33	0	Graphics: 3D	
168C:168C	0030:3116	3e 0 0	02.80.00	1	A	11	33	0	?Network	
10EC:144D	8168:C0A2	5e 0 0	02.00.00	6	A	5	33	0	Ethernet	



# PCI devices...

---

- Example results – Lenovo T540

Commodore PC 10-III General Utility by BZiK Copyright (C) 1992, 2008 ver 3.2  
Checking system components...

Using PCI info access by PCI BIOS.

PCI BIOS ver. 3.00 found, max bus number: 04h, access mechanism: 11h.

Vendor	Device	BusDevFunction	Class	V	I	Ir	Fr	H	Description	
8086:17AA	0C04:2210	0p 0 0	06.00.00	6	-	-	33	0	Host/PCI	
8086:0000	0C01:0000	0e 1 0	06.04.00	6	A	11	33	1	PCI/PCI	00/01/01
8086:0000	0416:0000	0e 2 0	03.00.00	6	A	11	33	0	Graphics: VGA	
8086:17AA	0C0C:2210	0e 3 0	04.03.00	6	A	11	33	0	Hi-def. audio	
8086:17AA	8C31:2210	0e14 0	0C.03.30	4	A	11	33	0	USB 3.0-XHCI	
8086:17AA	8C3A:2210	0e16 0	07.80.00	4	A	11	33	0	?Communication	
8086:17AA	153A:2210	0e19 0	02.00.00	4	A	11	33	0	Ethernet	
8086:17AA	8C20:2210	0e1B 0	04.03.00	4	A	10	33	0	Hi-def. audio	
8086:0000	8C10:0000	0e1C 0	06.04.00	D4	A	11	33	1	PCI/PCI	00/03/03
8086:0000	8C12:0000	0e1C 1	06.04.00	D4	B	10	33	1	PCI/PCI	00/04/04
8086:0000	8C14:0000	0e1C 2	06.04.00	D4	C	7	33	1	PCI/PCI	00/05/0C
8086:17AA	8C26:2210	0p1D 0	0C.03.20	4	A	9	33	0	USB 2.0-EHCI	
8086:17AA	8C4F:2210	0p1F 0	06.01.00	4	-	-	33	0	PCI/ISA	
8086:17AA	8C03:2210	0e1F 2	01.06.01	4	B	6	66	0	SATA/AHCI 1.0	
8086:17AA	8C22:2210	0p1F 3	0C.05.00	4	C	7	33	0	SMBus	
10DE:0000	1290:0000	1e 0 0	03.00.00	A1	A	11	33	0	Graphics: VGA	
10EC:17AA	5227:2210	3e 0 0	FF.00.00	1	A	11	33	0	??Unknown	
8086:8086	08B2:C270	4e 0 0	02.80.00	83	A	10	33	0	?Network	

# PCI devices...

- Example results – Lenovo T540

The screenshot shows the PCI-Z 2.0 utility interface. At the top, there's a title bar "PCI-Z 2.0 - PCI devices information utility x64" and a menu bar with icons for Verify, Update, Load, Refresh, Screenshot, Export, and About. Below the menu bar is a "System information" section containing the following details:

- Motherboard: LENOVO 20BES03R00 (BIOS version: GMET75WW (2.23 ))
- Processor: Intel(R) Core(TM) i5-4210M CPU @ 2.60GHz, 4 logical CPUs
- Available memory (MB): 7864
- Operating system: Microsoft Windows 7
- Computer name: N337-BZ03 User name: bzik

Below the system information is a table listing PCI devices. The table has six columns: Type, Vendor, Device, Subsystem, Subclass, and PCI device. The data is as follows:

Type	Vendor	Device	Subsystem	Subclass	PCI device
Bridge	Intel Corporation	Xeon E3-1200 v3/4th Gen Core Processor PCI Express x16 Controller		PCI bridge	8086:0C01 17AA:2210
Bridge	Intel Corporation	Xeon E3-1200 v3/4th Gen Core Processor DRAM Controller		Host bridge	8086:0C04 17AA:2210
Bridge	Intel Corporation	8 Series/C220 Series Chipset Family PCI Express Root Port #1		PCI bridge	8086:8C10 17AA:2210
Bridge	Intel Corporation	8 Series/C220 Series Chipset Family PCI Express Root Port #2		PCI bridge	8086:8C12 17AA:2210
Bridge	Intel Corporation	8 Series/C220 Series Chipset Family PCI Express Root Port #3		PCI bridge	8086:8C14 17AA:2210
Bridge	Intel Corporation	QM87 Express LPC Controller		ISA bridge	8086:8C4F 17AA:2210
Communication controller	Intel Corporation	8 Series/C220 Series Chipset Family MEI Controller #1		Communication controller	8086:8C3A 17AA:2210
Display controller	NVIDIA Corporation	GK208M [GeForce GT 730M]		VGA compatible controller	10DE:1290 17AA:2211
Display controller	Intel Corporation	4th Gen Core Processor Integrated Graphics Controller		VGA compatible controller	8086:0416 17AA:2211
Mass storage controller	Intel Corporation	8 Series/C220 Series Chipset Family 6-port SATA Controller 1 [AHCI mode]		SATA controller	8086:8C03 17AA:2210
Multimedia controller	Intel Corporation	8 Series/C220 Series Chipset High Definition Audio Controller		Audio device	8086:8C20 17AA:2210
Network controller	Intel Corporation	Wireless 7260	Dual Band Wireless-AC 7260	Network controller	8086:08B2 8086:C270
Network controller	Intel Corporation	Ethernet Connection I217-LM		Ethernet controller	8086:153A 17AA:2210
Serial bus controller	Intel Corporation	8 Series/C220 Series Chipset Family SMBus Controller		SMBus	8086:8C22 17AA:2210
Serial bus controller	Intel Corporation	8 Series/C220 Series Chipset Family USB EHCI #1		USB controller	8086:8C26 17AA:2210
Serial bus controller	Intel Corporation	8 Series/C220 Series Chipset Family USB xHCI		USB controller	8086:8C31 17AA:2210
Unassigned class	Realtek Semiconductor Co., Ltd.	RTS5227 PCI Express Card Reader			10EC:5227 17AA:2210

At the bottom left, it says "pci.ids version: 2017.07.01". At the bottom right, there is a note: "Right click on the list for options." with a double-slash icon.

# PCI devices...

---

- Example results – Gigabyte K8VT890  
– PCI bridges

```
PCI BIOS ver. 3.00 found, max bus number: 06h, access mechanism: 11h.
Vendor      Device      BusDevFunction Class      V I Ir Fr H Description
1106:1106 0238:0238 0a 0 0          06.00.00 0 - - 66 0 Host/PCI
1106:0000 1238:0000 0p 0 1          06.00.00 0 - - 33 0 Host/PCI
1106:0000 2238:0000 0p 0 2          06.00.00 0 - - 33 0 Host/PCI
1106:0000 3238:0000 0p 0 3          06.00.00 0 - - 33 0 Host/PCI
1106:0000 4238:0000 0p 0 4          06.00.00 0 - - 33 0 Host/PCI
1106:0000 5238:0000 0p 0 5          08.00.20 0 - - 33 0 ?Peripheral
1106:0000 7238:0000 0p 0 7          06.00.00 0 - - 33 0 Host/PCI
1106:0000 B999:0000 0p 1 0          06.04.00 0 - - 66 1 PCI/PCI      00/01/01
1106:0000 A238:0000 0e 2 0          06.04.00 0 A 10 33 1 PCI/PCI      00/02/02
1106:0000 C238:0000 0e 3 0          06.04.00 0 A 10 33 1 PCI/PCI      00/03/03
1106:0000 D238:0000 0e 3 1          06.04.00 0 B 10 33 1 PCI/PCI      00/04/04
1106:0000 E238:0000 0e 3 2          06.04.00 0 C 10 33 1 PCI/PCI      00/05/05
1106:0000 F238:0000 0e 3 3          06.04.00 0 D 10 33 1 PCI/PCI      00/06/06
```

# PCI devices...

---

- Example results – some PCI cards (1)

Vendor	Device	BusDevFunction	Class	V	I	Ir	Fr	H	Description	
10B7:10B7	9200:1000	0p 9 0	02.00.00	74	A	11	33	0	Ethernet	<i>3Com cards</i>
10B7:10B7	9055:9055	0p B 0	02.00.00	30	A	5	33	0	Ethernet	
8086:0E11	1229:B0D7	0p A 0	02.00.00	5	A	11	33	0	Ethernet	<i>Compaq NC3121</i>
8086:8086	1229:000E	0p A 0	02.00.00	5	A	11	33	0	Ethernet	<i>EtherExpress PRO/100+</i>
14F1:185B	8800:E000	0p 9 0	04.00.00	5	A	11	33	0	Video	<i>} TV tuner</i>
14F1:185B	8811:E000	0p 9 1	04.80.00	5	A	11	33	0	?Multimedia	
1106:1106	3044:3044	0p B 0	0C.00.10	80	A	11	33	0	FireWire-OHCI	
1106:0000	F238:0000	0e 3 3	06.04.00	0	D	10	33	1	PCI/PCI	<i>00/06/06</i>
1180:A000	0475:0000	0p 9 0	06.07.00	81	A	11	33	2	PCI/CardBus	<i>00/07/07</i>
14F1:14F1	2F00:2004	0p A 0	07.80.00	1	A	5	33	0	?Communication	<i>PCI modem</i>
1106:0000	F238:0000	0e 3 3	06.04.00	0	D	10	33	1	PCI/PCI	<i>00/06/06</i>
12D8:0000	E111:0000	0x 9 0	06.04.00	2	A	11	66	1	PCI/PCI	<i>00/07/07</i>
1415:1415	9521:0001	0p A 0	07.00.06	0	A	5	33	0	Serial-16950	<i>Moschip COM PCI</i>
9710:1000	9835:0002	0p B 0	07.00.02	1	A	11	33	0	Serial-16550	<i>Exsys COM PCI</i>
9710:A000	9900:1000	4e 0 01	07.00.02	0	A	10	33	0	Serial-16550	<i>Exsys COM PCIe</i>
11AB:1458	4362:E000	5e 0 0	02.00.00	19	A	10	33	0	Ethernet	<i>Exsys COM PCIe</i>
1912:1912	0015:0015	7e 0 0	0C.03.30	2	A	11	33	0	USB 3.0-XHCI	<i>PCI USB 3.0</i>

# PCI devices...

---

- Example results – some PCI cards (2)

104C:1186	9066:3B04	0p 9	01234567	02.80.00	0 A 11 33 0	?Network	<i>D-Link DWL-G520+</i>
168C:1186	0013:3A13	0p A 0		02.00.00	1 A 5 33 0	Ethernet	<i>D-Link DWL-G520</i>
168C:168C	FF96:EE96	0p A 1		07.00.02	1 A 0 33 0	Serial-16550	
0000:0000	0000:0000	0p A	234567	00.00.00	0 - - 33 0	Early Non-VGA	
9710:1000	9835:0012	0p B	01234567	07.80.00	1 A 11 33 0	?Communication	<i>LPT+COM</i>

# PCI devices...

---

- Example results – IDE/SATA controller

## IDE Mode

8086:1043	27B9:830F	0p1F	0	06.01.00	2	-	-	33	0	PCI/ISA	
8086:1043	27C4:830F	0p1F	2	01.01.80	2	B	0	66	0	IDE	pISAsISA

## SATA/Compatible Mode

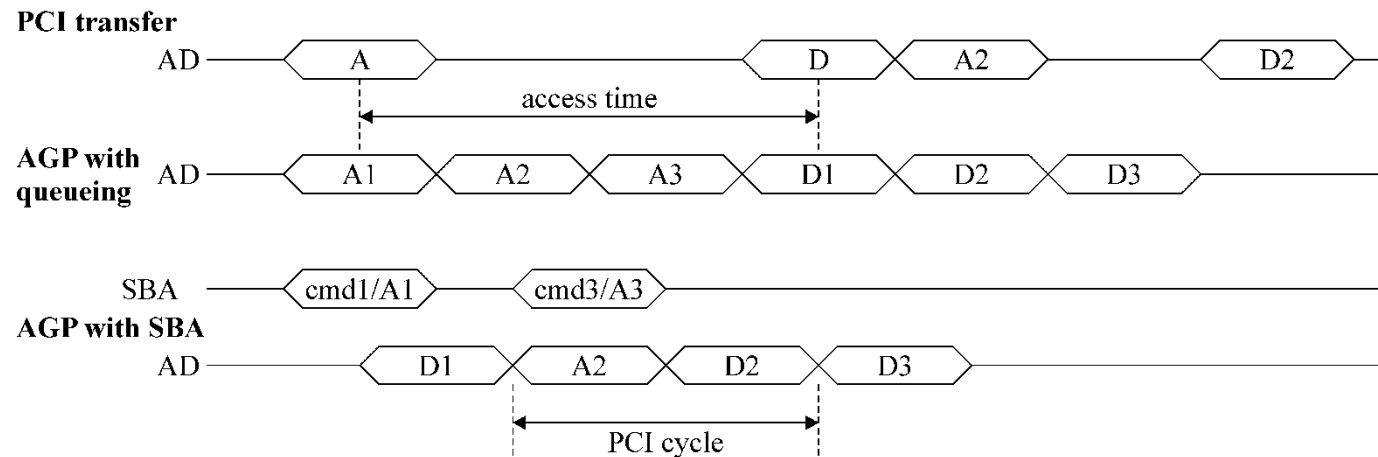
8086:1043	27B9:830F	0p1F	0	06.01.00	2	-	-	33	0	PCI/ISA	
8086:1043	27DF:830F	0p1F	1	01.01.8A	2	A	0	33	0	IDE	pP+IsP+I
8086:1043	27C4:830F	0p1F	2	01.01.8F	2	B	11	66	0	IDE	pP+IsP+I

## SATA/AHCI Mode

8086:1043	27B9:830F	0p1F	0	06.01.00	2	-	-	33	0	PCI/ISA	
8086:1043	27DF:830F	0p1F	1	01.01.8A	2	A	0	33	0	IDE	pP+IsP+I
8086:1043	27C5:830F	0e1F	2	01.06.01	2	B	11	66	0	SATA/AHCI 1.0	

# PCI devices...

- AGP
  - Accelerated Graphics Port
    - Only for graphics card
  - PCI extension
  - Clk=66 MHz
    - Too high for most PCI devices
      - All must support 66 MHz to enable higher frequency



# PCI devices...

---

- AGP signals
  - PCI signals

Signal	Comment
AD <sub>0..31</sub>	Like in PCI
C/ $\overline{\text{BE}}_{0..3}$	
PAR	
$\overline{\text{Frame}}$	Only in Fast Write
$\overline{\text{TRdy}}$	
$\overline{\text{IRdy}}$	
$\overline{\text{Stop}}$	Only in Fast Write
$\overline{\text{DevSel}}$	Only in Fast Write
IDSel	Unused
$\overline{\text{Req}}$	
$\overline{\text{Gnt}}$	
$\overline{\text{IntA}}.. \overline{\text{IntA}}$	Like in PCI
RST	
$\overline{\text{PErr}}$	Unused
$\overline{\text{SErr}}$	→ NMI



# PCI devices...

---

- AGP signals

- Flow control

Signal	Comment
$\overline{\text{RBF}}$	Read buffer full
$\overline{\text{WBF}}$	Write buffer full

- AGP requests

Signal	Comment
$\text{SBA}_{0..7}$	Sideband address (addr/cmd)
$\overline{\text{Pipe}}$	Requests serializing

- Status

Signal	Comment
$\text{ST}_{0..2}$	AGP exchange stage

- clock

Signal	Comment
CLK	
AdStb0	AGP 2x, 4x, $\text{AD}_{0..15}$
$\overline{\text{AdStb0}}$	AGP 4x, $\text{AD}_{0..15}$
AdStb1	AGP 2x, 4x, $\text{AD}_{16..31}$
$\overline{\text{AdStb1}}$	AGP 4x, $\text{AD}_{16..31}$
SbStb	AGP 2x, 4x, $\text{SBA}_{0..7}$
$\overline{\text{SbStb}}$	AGP 4x, $\text{SBA}_{0..7}$

# PCI devices...

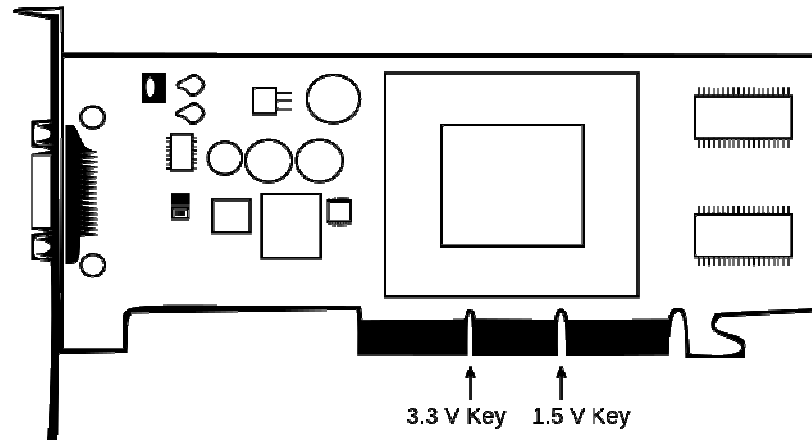
---

- AGP

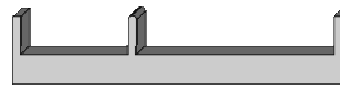
Spec.	Voltage	Clock	Speed	Transfers/clock	Rate (MB/s)
PCI	3.3/5 V	33 MHz	—	1	133
PCI 2.1	3.3/5 V	33/66 MHz	—	1	133/266
AGP 1.0	3.3 V	66 MHz	1×	1	266
AGP 1.0	3.3 V	66 MHz	2×	2	533
AGP 2.0	1.5 V	66 MHz	4×	4	1066
AGP 3.0	0.8 V	66 MHz	8×	8	2133
AGP 3.5*	0.8 V	66 MHz	8×	8	2133

# PCI devices...

- AGP



AGP 3.3 V



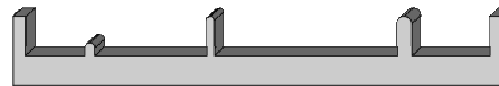
AGP 1.5 V



AGP Universal



AGP Pro 3.3 V



AGP Pro 1.5 V

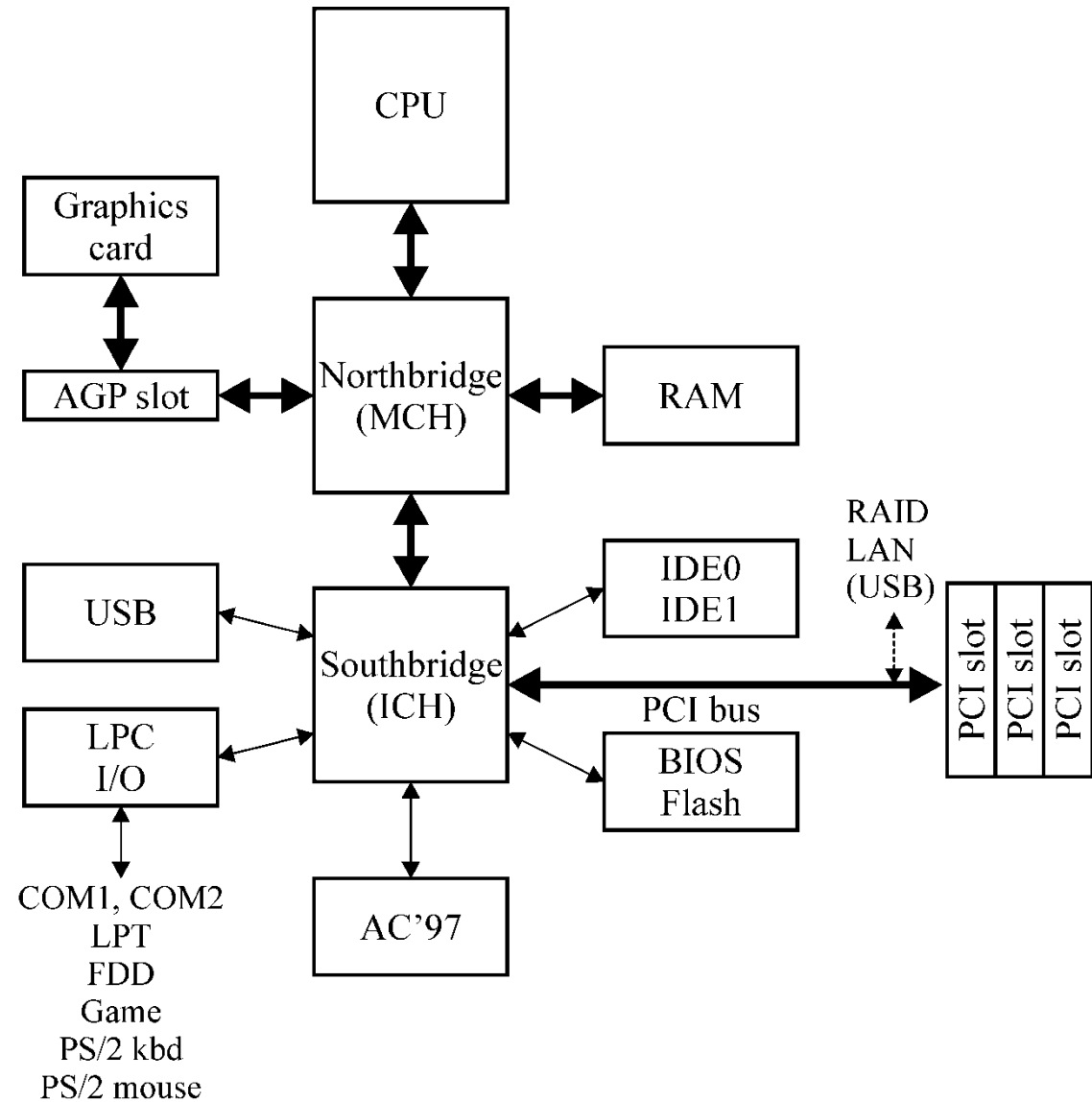


AGP Pro Universal



# PCI devices...

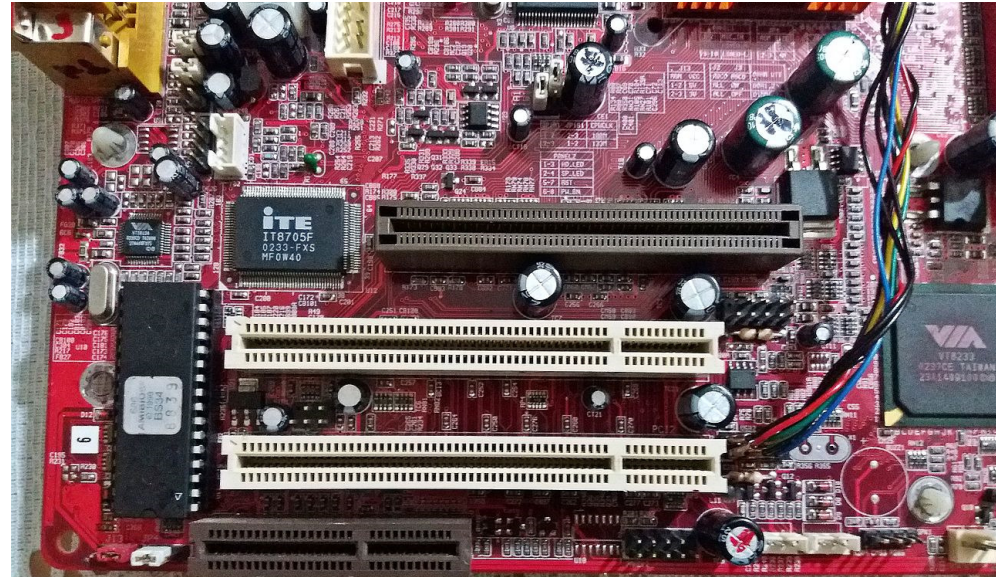
- AGP
  - PC architecture



# PCI devices...

---

- AGP examples



# PCI devices...

---

- PCI-X
  - $F_{\max}=133$  MHz (533 MHz)
  - Split-response transfers
  - Message-signalled interrupts
  - Fault tolerance
  - Transmission attribute phase

# PCI devices...

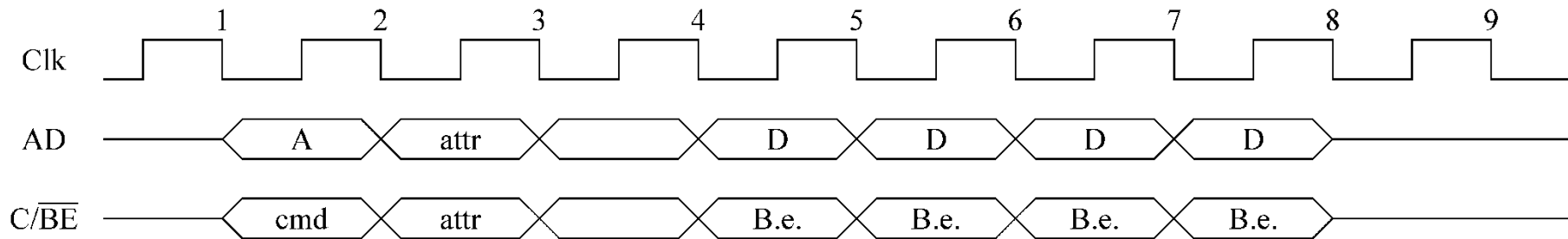
---

- PCI-X
  - Split-response transfers
    - When device not ready
      - PCI → wait-states inserted
      - PCI-X → bus released, transfer finished later
  - Message-signalled interrupts
    - Only 4 INT lines in PCI
      - PCI → interrupt sharing
      - PCI-X → MSI (memory write to a configured address)
  - Fault tolerance
    - Faulty card reinitialised or turned off

# PCI devices...

---

- PCI-X
  - Fault tolerance
    - Faulty card reinitialised or turned off
  - Transmission attribute phase

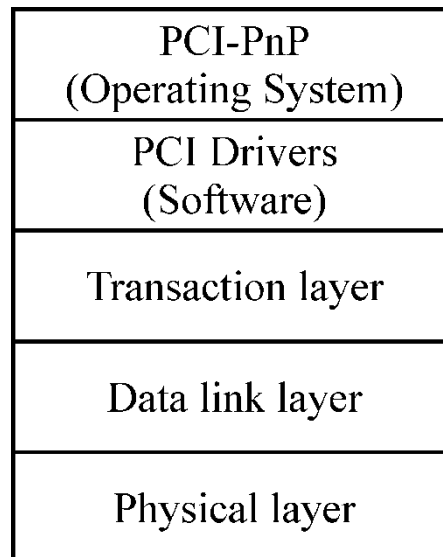




# PCI devices...

---

- PCI-Express (PCIe)
  - multi-layer architecture (like in computer networks)
  - Serial, full-duplex, point-to-point connections



# PCI devices...

---

- PCI-Express (PCIe)
  - Physical layer
    - 1 lane = 2 × (Low Voltage Differential signal pairs)
    - Link =  $n \times$  lane ( $n=1, 2, 4, 8, 12, 16, 32$ )
    - 8/10 encoding (better EM params)
    - Clock = 2GHz, encoded with data
    - Fiber optic possible
    - Information unit = packet (not a bit)
    - Card works in a slot of at least exact number of lanes
    - Large slot may have less lanes (but enough Gnd)

# PCI devices...

---

- PCI-Express (PCIe)

Ver.	Year	Encoding	Rate [GTps]	Throughput [Gbps]				
				x1	x2	x4	x8	x16
1.0	2003	8b/10b	2.5	0.250	0.500	1.000	2.000	4.000
2.0	2007	8b/10b	5.0	0.500	1.000	2.000	4.000	8.000
3.0	2010	128b/130b	8.0	0.985	1.969	3.938	7.877	15.754
4.0	2017	128b/130b	16.0	1.969	3.938	7.877	15.754	31.508
5.0	2019	128b/130b	32.0	3.938	7.877	15.754	31.508	63.015
6.0	2021	128b/130b	64.0	7.877	15.754	31.508	63.015	126.031

# PCI devices...

---

- PCI-Express (PCIe)
  - Data link layer
    - Transmission coherency
      - Labels with serial number and CRC
    - Protocol simplified
      - No collisions
        - » due to full-duplex, point-to-point
      - Packets transmitted on demand only
        - » No data rejection
      - Transmission errors → retransmission
    - Message signalled interrupts
      - Omit I/O APIC → faster than INT lines

# PCI devices...

---

- PCI-Express (PCIe)
  - Transaction layer
    - Split transactions
      - Other traffic possible while Target builds a response
    - Data amount never exceeds credit in a Target
    - Transfer robustness (CRC, Ack)
      - Long cont. Unidirectional transfer:  $\geq 95\%$  of lane data rate

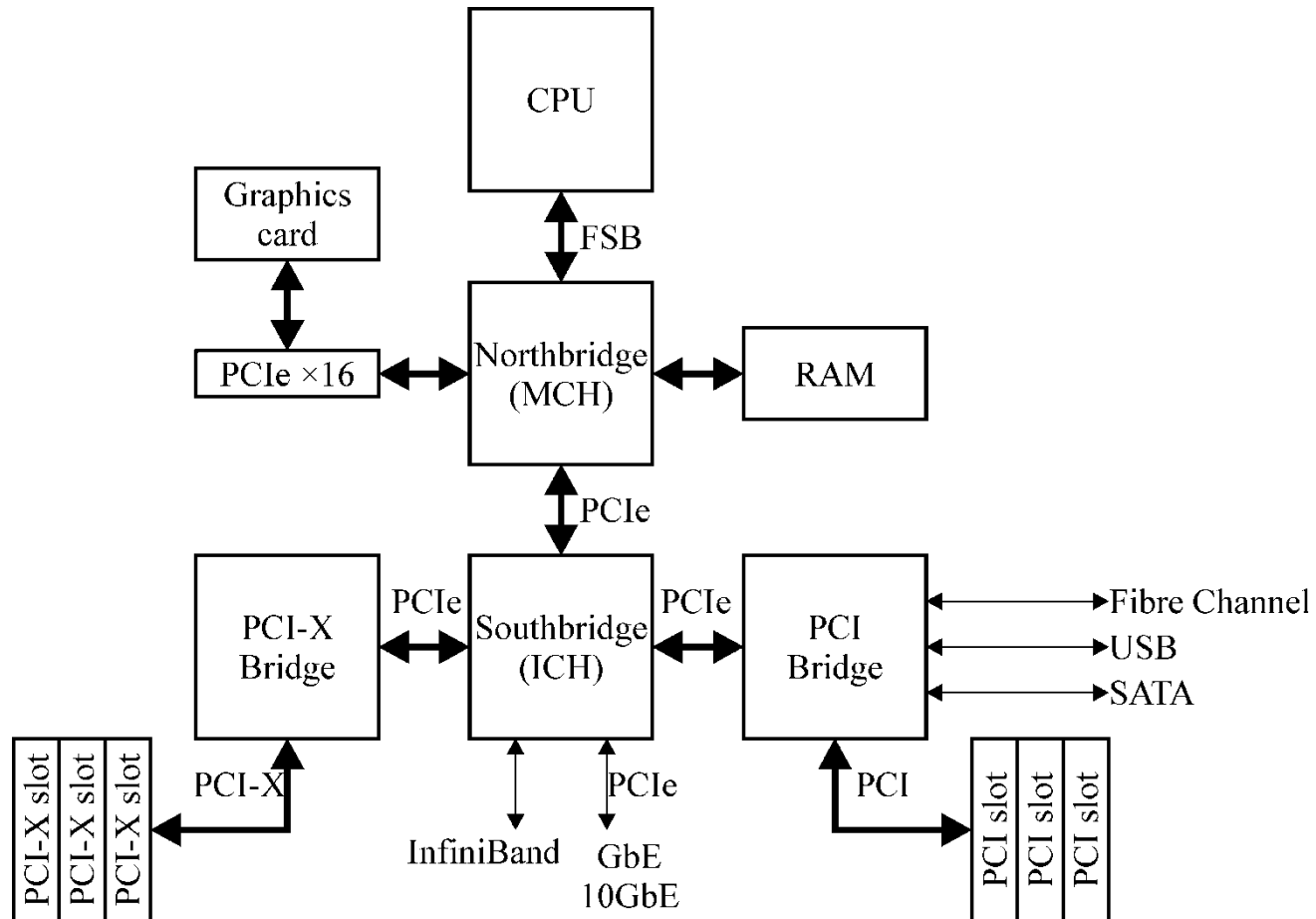
# PCI devices...

---

- PCI-Express (PCIe)
  - Software layers
    - PCI-compatible
      - Bus Enumeration
      - PCI Configuration Space
      - I/O Devices programming to optimally use system resources

# PCI devices...

- PCI-Express (PCIe)
  - System architecture



# PCI devices...

---

- PCI-Express (PCIe)
  - Example

