IO Introduction and Reliability

Lecture Objectives:

1) Draw a picture showing the connection between the processor and memory mapped IO devices.
2) Define the terms reliability, dependability, and availability
3) Compare and contrast MTTF and AFR.
4) Explain the relationship between MTTF, MTTR, MTBF, and availability.
5) Given MTTR and MTTF data, calculate availability.

Io Device Classifications

- Behavior
  - Input, output, storage
- Partner
  - Human / Machine
- Data Rate
  - The peak rate at which data can be transferred from one device to another.
  - Usually expressed in MBits per second.

Sound card: output device, human, 44.9 kBPS / 128 kBPS

slow, mid

Io Peripherals

60 Frames / Second

1024 x 768 pixel resolution

Each pixel is 3 bytes

1024 × 768 × 3 × 60 = 141,557,760 Bits

Discuss with your partner

- For each of the following devices, identify the partner, the behavior, and the data rate for the given device.
  - Keyboard — slow data rate
  - Scanner ← mid data rate
  - Video Card — very high

IO Device Diversity

Device	Behavior	Partner	Data rate (Mbit/sec)
Keyboard	Input	Human	0.0001
Mouse	Input	Human	0.0038
Voice input	Input	Human	0.2640
Sound input	Input	Machine	3.0000
Scanner	Input	Human	3.2000
Voice output	Output	Human	0.2640
Sound output	Output	Human	8.0000
Laser printer	Output	Human	3.2000
Graphics display	Output	Human	800.0000–8000.0000
Cable modem	Input or output	Machine	0.1280–6.0000
Network/LAN	Input or output	Machine	100.0000–10000.0000
Network/wireless LAN	Input or output	Machine	11.0000–54.0000
Optical disk	Storage	Machine	80.0000–220.0000
Magnetic tape	Storage	Machine	5.0000–120.0000
Flash memory	Storage	Machine	32.0000–200.0000
Magnetic disk	Storage	Machine	800.0000–3000.0000

Interrupts

Processor

Cache

Memory-I/O Interconnect

Main memory

I/O controller

I/O controller

I/O controller

Disk

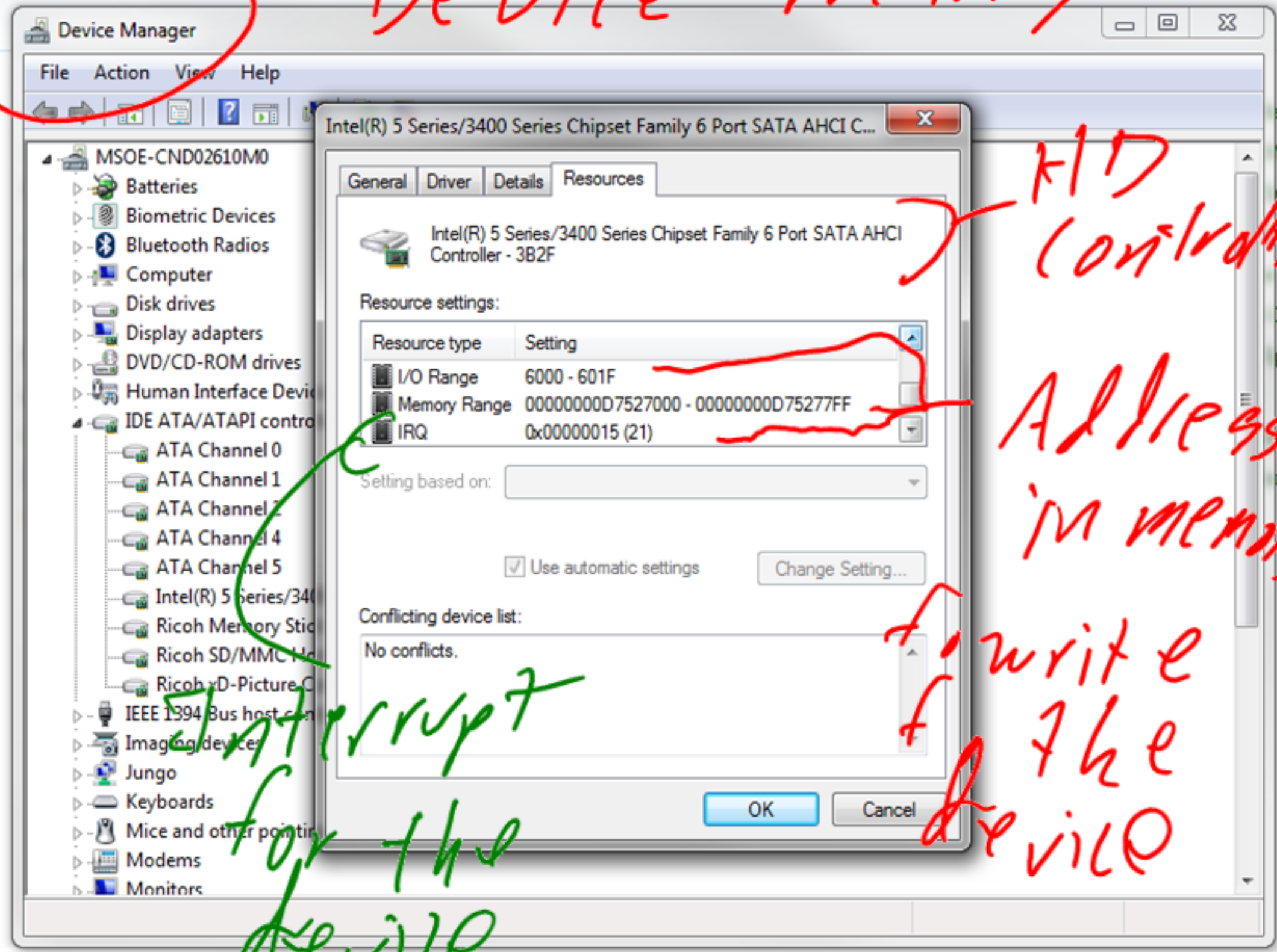
Disk

Graphics output

Network

Laptop device information

Device Manager



Device Manager

HD controller

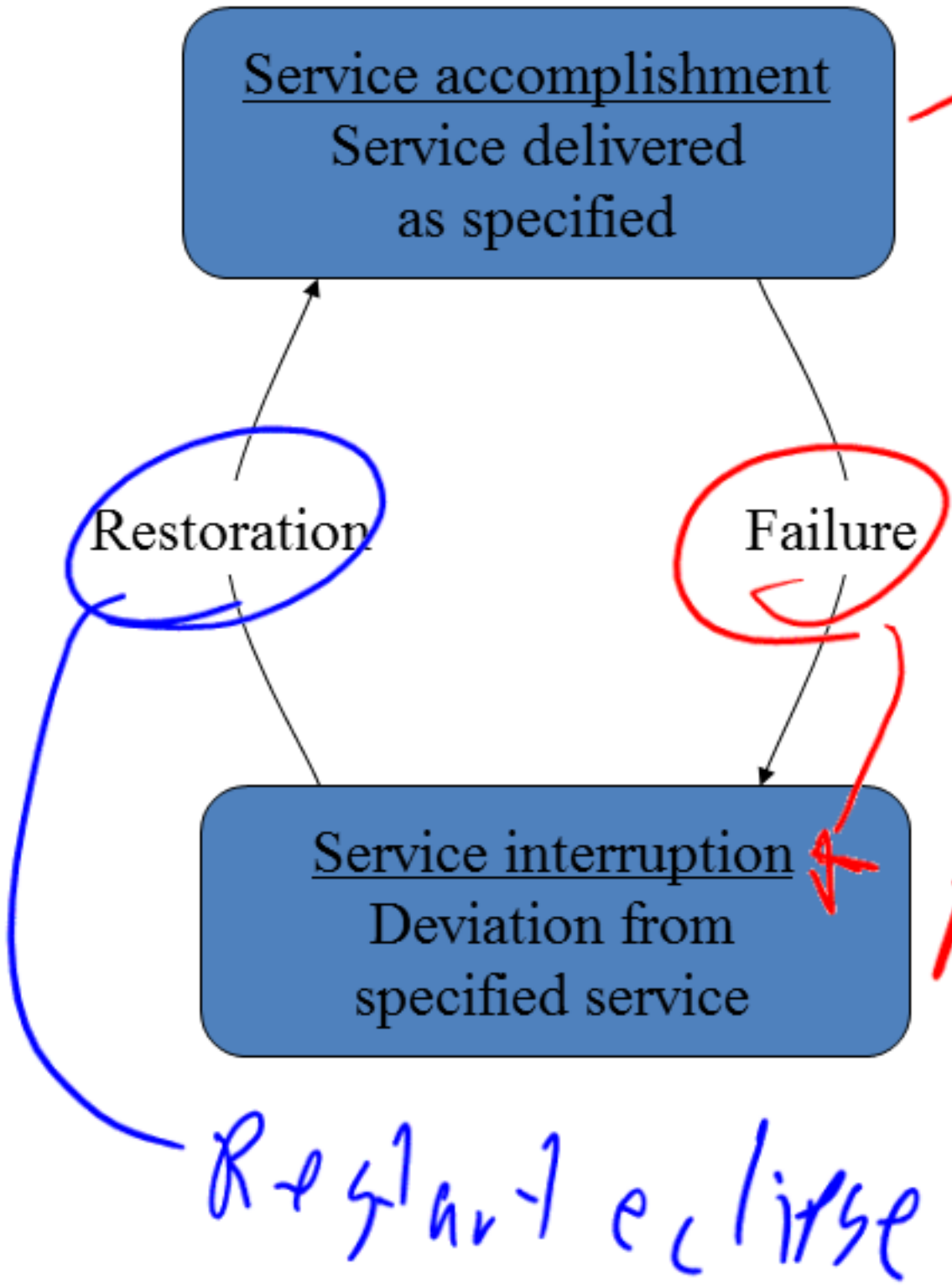
Address in memory to write to the device

Interrupt for the device.

Definitions

- Dependability
  - The quality of delivered service such that reliance can be justifiably be placed on this service
- Reliability
  - A measure of continuous service accomplishment, or the length of time to failure, from a given reference point
- Availability
  - A measure of service accomplishment with respect to the alternation between states of accomplishment and states of interruption

Dependability



- Fault: failure of a component
  - May or may not lead to system failure

Real World Examples

- Reliability
  - Unix server versus a windows PC server

Unix tends to up for longer periods of time

- Availability
  - Windows PC server versus Linux server

⇒ If a system is more reliable, it tends to be more available.

More Definitions

- Mean Time to Failure
  - The average time it takes for a system to fail once started
- Mean time to repair
  - The average time it takes to repair a failed system
- Mean time between failures
  - The average time between system failures

$$MTBF = MTTF + MTTR$$

Availability

$$Availability = \frac{MTTF}{(MTTF + MTTR)}$$

Problem

- Work with your partner to solve the following:
  - MSOE is looking to replace its e-mail system. Two systems are being considered. System 1 (Lookout) has a mean time to failure of 99 hours and a mean time to repair of 1 hour. System 2 (Woogle) has a mean time to failure of 980 hours and a mean time to repair of 20 hours. Which system is more available? Which system would be the better e-mail system?

Where does failure matter?

-Hard Drives

ata set	Type of	Duration	#Disk	# Servers	Disk	Disk	MTTF	Date of first	ARR
	cluster		events		Count	Parameters	(Mhours)	Deploym.	(%)
HPC1	HPC	08/01 - 05/06	474	765	2,318	18GB 10K SCSI	1.2	08/01	4.0
"	"	"	124	64	1,088	36GB 10K SCSI	1.2	"	2.2
HPC2	HPC	01/04 - 07/06	14	256	520	36GB 10K SCSI	1.2	12/01	1.1
HPC3	HPC	12/05 - 11/06	103	1,532	3,064	146GB 15K SCSI	1.5	08/05	3.7
"	HPC	12/05 - 11/06	4	N/A	144	73GB 15K SCSI	1.5	"	3.0
"	HPC	12/05 - 08/06	253	N/A	11,000	250GB 7.2K SATA	1.0	"	3.3
HPC4	Various	09/03 - 08/06	269	N/A	8,430	250GB SATA	1.0	09/03	2.2
"	HPC	11/05 - 08/06	7	N/A	2,030	500GB SATA	1.0	11/05	0.5
"	clusters	09/05 - 08/06	9	N/A	3,158	400GB SATA	1.0	09/05	0.8
COM1	Int. serv.	May 2006	84	N/A	26,734	10K SCSI	1.0	2001	2.8
COM2	Int. serv.	09/04 - 04/06	506	9,232	39,039	15K SCSI	1.2	2004	3.1
COM3	Int. serv.	01/05 - 12/05	2	N/A	56	10K FC	1.2	N/A	3.6
"	"	"	132	N/A	2,450	10K FC	1.2	N/A	5.4
"	"	"	108	N/A	796	10K FC	1.2	N/A	13.6
"	"	"	104	N/A	432	10K FC	1.2	1998	24.1

Bianca Schroeder, Garth Gibson. "Disk failures in the real world: What does an MTTF of 1,000,000 hours mean to you?" *5th Usenix Conference on File and Storage Technologies (FAST 2007).*

Failure Root Cause Analysis

Operator	Software	Hardware	System	Year data collected
42%	25%	18%	Datacenter (Tandem)	1985
15%	55%	14%	Datacenter (Tandem)	1989
18%	44%	39%	Datacenter (DEC VAX)	1985
50%	20%	30%	Datacenter (DEC VAX)	1993
50%	14%	19%	U.S. public telephone network	1996
54%	7%	30%	U.S. public telephone network	2000
60%	25%	15%	Internet services	2002