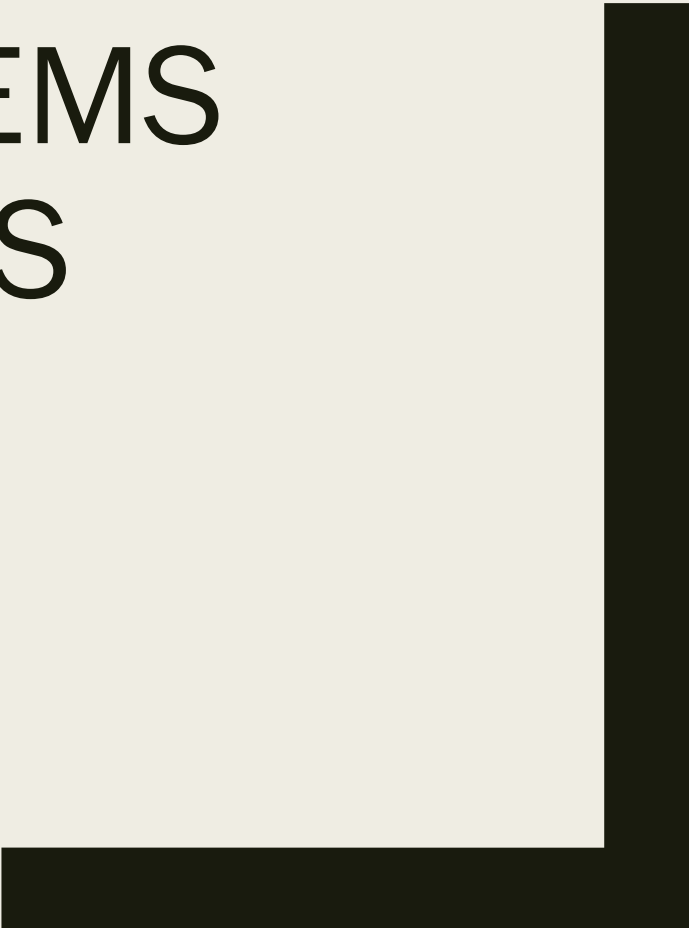# COMPUTER SYSTEMS FUNDAMENTALS
(4COSC009C)

Contact details

■ Module Leader:
  – *Rathesan Sivagnanalingam*
  – *Email :rathesan.s@iit.ac.lk*
  – *See BlackBoard site for further contact details*
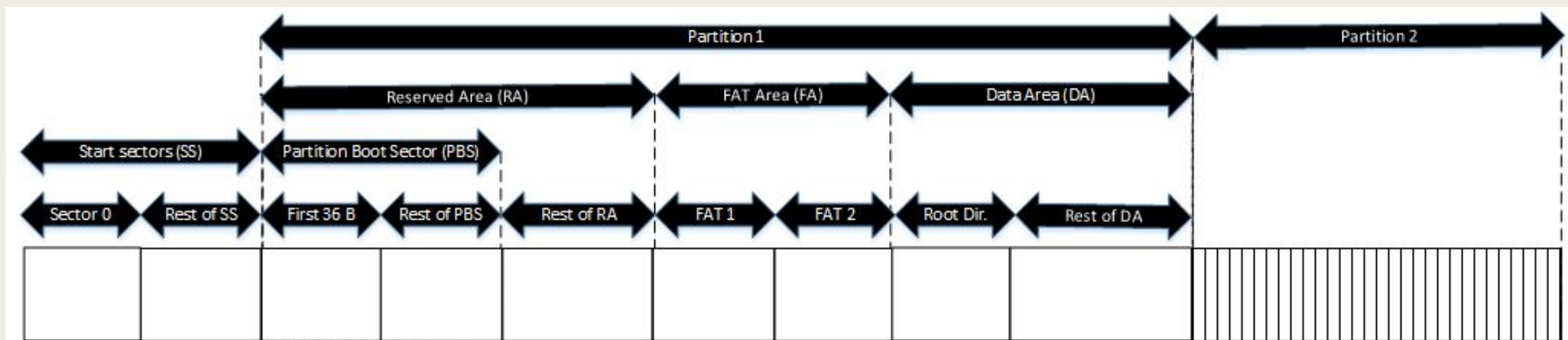
In File Systems part b:

- ■ FAT File Systems
  - – *FAT structure*
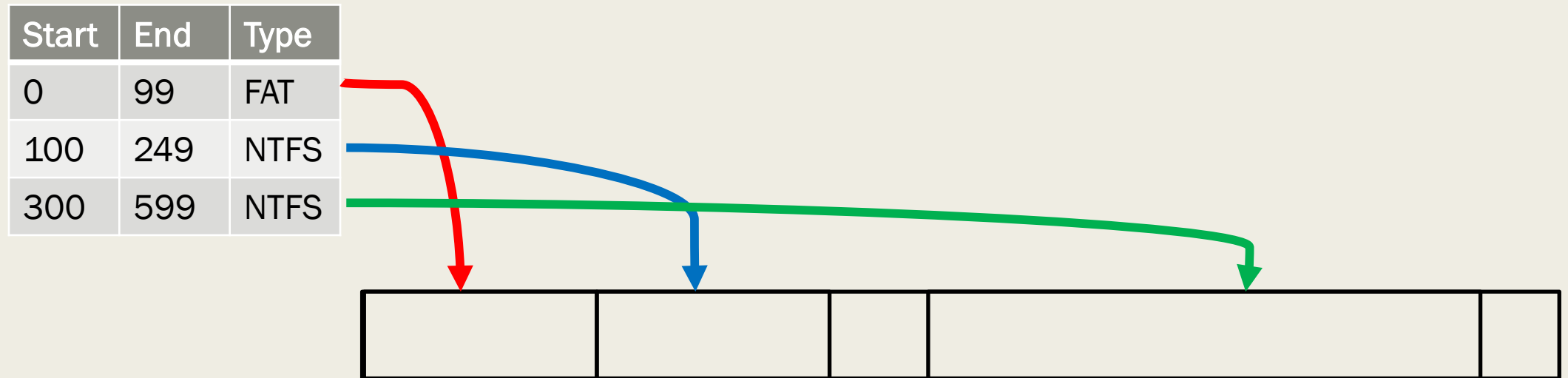 - – *FAT Boot Sector*

FILE SYSTEMS part b.1

In this lecture we will cover:

- Partition Sector Zero
  - *FAT16*
  - *Reading & understanding*

Schematic view of a Disk

Disk formatting

Start	End	Type
0	99	FAT
100	249	NTFS
300	599	NTFS

Endianness

- Byte ordering for the representation of data
  - *IA32 based system*

- **Big Endian**
  - *Most significant Byte first*
  - *10 25 03 is written as 10 25 03*

- **Little Endian**
  - *Least significant Byte first*
  - *10 25 03 is written as 03 25 10*

- So knowing the endianness used by a particular computer, we can read the information stored in it.

File System at Sector 80325

Start of sector 80325 (or byte 41126400)

Contents in Hexadecimal

NTFS File System

Contents in ASCII

Signature value

FAT File Systems

- Arrived with DOS
  - *Used to be widely used in many operating systems and devices*
  - *FAT12/16*
  - *FAT32*
- NTFS (New Technology File System) is more common today

FAT Structure

Reserved Area	FAT Area	Root Directory	Data Area

- FAT12/16, Reserved Area is only 2 sectors.
  - *FAT32 can have several sectors in RA*

- FAT Area contains the File Allocation Tables
  - *Generally 2 FATs*

- Root Directory falls in Data Area
  - *FAT12/16, always at the beginning*
  - *FAT32, can be anywhere*

FAT Boot Sector

FAT Partition – Details of the First 36 Bytes in the FAT Partition Boot Sector	
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32 - 35	32–bit value of number of sectors in file system. Either this value or the 16–bit value above must be 0

FAT Boot Sector

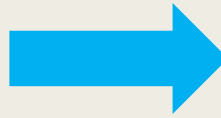| FAT Partition – Details of the First 36 Bytes in the FAT Partition Boot Sector	
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00016352	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
00016368	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
00016384	EB	3C	90	4D	53	44	4F	53	35	2E	30	00	02	20	02	00	ë< MSDOS5.0
00016400	02	00	02	00	00	F8	EF	00	3F	00	FF	00	20	00	00	00	øï ? ÿ
00016416	E0	DF	1D	00	00	00	29	5E	95	C6	48	4E	4F	20	4E	41	àß)^•ÆHNO NA
00016432	4D	45	20	20	20	20	46	41	54	31	36	20	20	20	33	C9	ME FAT16 3É
00016448	76	46	E2	39	60	5C	B0	15	74	A9	E3	07	BA	DF	56	3F	vFâ9`\° t©ã °ßV?
00016464	6A	05	9A	50	E2	6F	A6	5F	35	C7	EB	2D	A6	9A	2B	FC	j šPâo¦_5Çë–¦š+ü
00016480	99	42	C2	B3	C5	FF	53	E2	AE	AA	FB	7E	C0	51	81	70	™BÂ³ÅÿSâ®ªû~ÀQ p

FAT Boot Sector
Bytes per sector
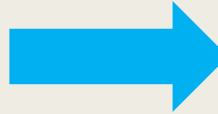
Bytes 11-12: Bytes per sector

Little-Endian: 00   02

Big-Endian: 02   00

Value: 0x0200

$2 \times 256 =$ **512** Bytes per Sector

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00016368	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
00016384	EB	3C	90	4D	53	44	4F	53	35	2E	30	00	02	20	02	00	ë< MSDOS5.0
00016400	02	00	02	00	00	F8	EF	00	3F	00	FF	00	20	00	00	00	øï ? ÿ
00016416	E0	DF	1D	00	00	00	29	5E	95	C6	48	4E	4F	20	4E	41	àß)^•ÆHNO NA
00016432	4D	45	20	20	20	20	46	41	54	31	36	20	20	20	33	C9	ME FAT16 3É
00016448	76	46	E2	39	60	5C	B0	15	74	A9	E3	07	BA	DF	56	3F	vFâ9`\° t©ã °ßV?
00016464	6A	05	9A	50	E2	6F	A6	5F	35	C7	EB	2D	A6	9A	2B	FC	j šPâo¦_5Çë–¦š+ü
00016480	99	42	C2	B3	C5	FF	53	F2	AE	AA	FB	7E	C0	51	81	70	™BÂ³ÅÿSò®ªû~ÀQ p

FAT Boot Sector
Sectors per cluster

Byte 13: Sectors per cluster

Little-Endian: 20

Big-Endian: 20

Value: 0x20

$2 \times 16 = $ **32 Sector per cluster**

Byte Range:	Description:
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00016416	E0	DF	1D	00	00	00	29	5E	95	C6	48	4E	4F	20	4E	41	àß)^•ÆHNO NA
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00016480	99	42	C2	B3	C5	FF	53	E2	AE	AA	FB	7E	C0	51	81	70	™BÂ³ÅÿSâ®ªû~ÀQ p

FAT Boot Sector
Size of RA

Byte 14-15: Size of RA in Sectors

Little-Endian: 02   00

Big-Endian: 00   02
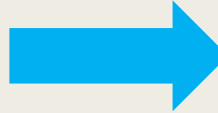
Value: 0x0002

Reserved Area is 2 Sectors large

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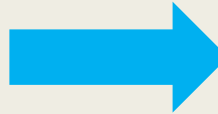| Offset	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
00016352	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
00016368	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
00016384	EB	3C	90	4D	53	44	4F	53	35	2E	30	00	02	20	02	00	ë< MSDOS5.0
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00016480	99	42	C2	B3	C5	FF	53	E2	AE	AA	FB	7E	C0	51	81	70	™BÂ³ÅÿSâ®ªû~ÀQ p

FAT Boot Sector
Number of FATs

Byte 16: Number of FATs

Little-Endian: 02

Big-Endian: 02

Value: 0x02

2 FATs

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```
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00016352   00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
00016368   00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
00016384   EB 3C 90 4D 53 44 4F 53  35 2E 30 00 02 20 02 00   ë< MSDOS5.0
00016400   02 00 02 00 00 F8 EF 00  3F 00 FF 00 20 00 00 00       øï ? ÿ
00016416   E0 DF 1D 00 00 00 29 5E  95 C6 48 4E 4F 20 4E 41   àß    )^•ÆHNO NA
00016432   4D 45 20 20 20 20 46 41  54 31 36 20 20 20 33 C9   ME    FAT16   3É
00016448   76 46 E2 39 60 5C B0 15  74 A9 E3 07 BA DF 56 3F   vFâ9`\° t©ã °ßV?
00016464   6A 05 9A 50 E2 6F A6 5F  35 C7 EB 2D A6 9A 2B FC   j šPâo¦_5Çë-¦š+ü
00016480   99 42 C2 B3 C5 FF 53 F2  AE AA FB 7E C0 51 81 70   ™BÂ³ÅÿSò®ªû~ÀQ n
```

FAT Boot Sector
Max files in Root Dir

Byte 17-18: Max. files in Root Dir.

Little-Endian: 00   02

Big-Endian: 02   00

Value: 0x0200

$$2 \times 256 = 512 \; files$$

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00016480	99	42	C2	B3	C5	FF	53	E2	AE	AA	FB	7E	C0	51	81	70	™BÂ³ÅÿSâ®ªû~ÀQ p

FAT Boot Sector
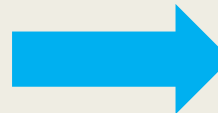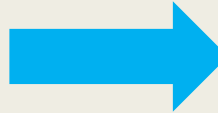## Sectors in partition

Bytes 19-21: 16-bit value

Little-Endian: 00   00

Bytes 32-35: 32-bit value

Little-Endian: E0   DF   1D   00

Big-Endian: 00   1D   DF   E0

Value: 0x001DDFE0

Byte Range:	Description:
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00016368	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
00016384	EB	3C	90	4D	53	44	4F	53	35	2E	30	00	02	20	02	00	ë< MSDOS5.0
00016400	02	00	02	00	00	F8	EF	00	3F	00	FF	00	20	00	00	00	øï ? ÿ
00016416	E0	DF	1D	00	00	00	29	5E	95	C6	48	4E	4F	20	4E	41	àß)^•ÆHNO NA
00016432	4D	45	20	20	20	20	46	41	54	31	36	20	20	20	33	C9	ME FAT16 3É
00016448	76	46	E2	39	60	5C	B0	15	74	A9	E3	07	BA	DF	56	3F	vFâ9`\° t©ã °ßV?
00016464	6A	05	9A	50	E2	6F	A6	5F	35	C7	EB	2D	A6	9A	2B	FC	j šPâo¦_5Çë–¦š+ü
00016480	99	42	C2	B3	C5	FF	53	E2	AE	AA	FB	7E	C0	51	81	70	™RÂ³ÅÿSâ®ªû~ÀQ p

FAT Boot Sector
Media type

Bytes 21: Media type

Value: 0xF8

Ie. Fixed disk

Byte Range:	Description:
FAT Partition – Details of the First 36 Bytes in the FAT Partition Boot Sector	
0 – 2	Assembly instruction to jump to boot code needed to boot the operating system
3 – 10	OEM Name in ASCII
11 – 12	Bytes per sector. Allowed values are 512, 1024, 2048 and 4096
13 – 13	Sector per cluster (data unit). Allowed values are powers of 2
14 – 15	Size in sectors of the reserved area
16 – 16	Number of FATs. Typically 2 for redundancy
17 – 18	Maximum number of files in the root directory for FAT12 and FAT16. This is 0 for FAT32 and typically 512 for FAT16.
19 – 20	16-bit value of number of sectors in the file system. If the number of sectors is larger than can be represented in this 2-byte value, a 4- byte value exists later in the data structure and this value should be 0 in that case
21 – 21	Media type. For fixed disks, value is 0xF8, for removable value is 0xF0
22 – 23	16-bit size in sectors of each FAT for FAT12 and FAT16. For FAT32, this field is 0
24 – 25	Sectors per track of storage device
26 – 27	Number of heads in storage device
28 – 31	Number of sectors before the start of partition
32 - 35	32-bit value of number of sectors in file system. Either this value or the 16-bit value above must be 0

```
Offset    0  1  2  3  4  5  6  7   8  9 10 11 12 13 14 15
00016352  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
00016368  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
00016384  EB 3C 90 4D 53 44 4F 53  35 2E 30 00 02 20 02 00    ë< MSDOS5.0
00016400  02 00 02 00 00 F8 EF 00  3F 00 FF 00 20 00 00 00        øï ? ÿ
00016416  E0 DF 1D 00 00 00 29 5E  95 C6 48 4E 4F 20 4E 41    àß    )^•ÆHNO NA
00016432  4D 45 20 20 20 20 46 41  54 31 36 20 20 20 33 C9    ME    FAT16   3É
00016448  76 46 E2 39 60 5C B0 15  74 A9 E3 07 BA DF 56 3F    vFâ9`\° t©ã °ßV?
00016464  6A 05 9A 50 E2 6F A6 5F  35 C7 EB 2D A6 9A 2B FC    j šPâo¦_5Çë-¦š+ü
00016480  99 42 C2 B3 C5 FF 53 F2  AE AA FB 7E C0 51 81 70    ™RÂ³Å÷Sò®ªû~ÀQ p
```
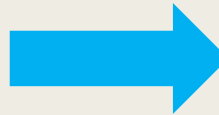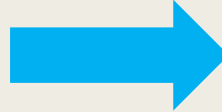
FAT Boot Sector
Size of each FAT

Bytes 22-23: Size of each FAT in sectors

Little-Endian: EF 00

Big-Endian: 00 EF

Value: 0x00EF

$$224 + 15 = 239 \ sectors$$

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Offset	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
00016352	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
00016368	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
00016384	EB	3C	90	4D	53	44	4F	53	35	2E	30	00	02	20	02	00	ë< MSDOS5.0
00016400	02	00	02	00	00	F8	EF	00	3F	00	FF	00	20	00	00	00	øï ? ÿ
00016416	E0	DF	1D	00	00	00	29	5E	95	C6	48	4E	4F	20	4E	41	àß)^•ÆHNO NA
00016432	4D	45	20	20	20	20	46	41	54	31	36	20	20	20	33	C9	ME FAT16 3É
00016448	76	46	E2	39	60	5C	B0	15	74	A9	E3	07	BA	DF	56	3F	vFâ9`\° t©ã °ßV?
00016464	6A	05	9A	50	E2	6F	A6	5F	35	C7	EB	2D	A6	9A	2B	FC	j šPâo¦_5Çë–¦š+ü
00016480	99	42	C2	B3	C5	FF	53	E2	AE	AA	FB	7E	C0	51	81	70	™BÂ³ÅÿSâ®ªû~ÀQ p

FAT Boot Sector
Sectors per track

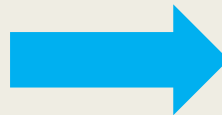Byte 24-25: Number of sectors per track

Little-Endian: 3F 00

Big-Endian: 00 3F

Value: 0x003F

$$48 + 15 = 63 \; sectors$$

Byte Range:	Description:
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```
Offset      0  1  2  3  4  5  6  7   8  9  10 11 12 13 14 15
00016352   00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
00016368   00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
00016384   EB 3C 90 4D 53 44 4F 53  35 2E 30 00 02 20 02 00    ë< MSDOS5.0
00016400   02 00 02 00 00 F8 EF 00  3F 00 FF 00 20 00 00 00       øï ? ÿ
00016416   E0 DF 1D 00 00 00 29 5E  95 C6 48 4E 4F 20 4E 41    àß    )^•ÆHNO NA
00016432   4D 45 20 20 20 20 46 41  54 31 36 20 20 20 33 C9    ME    FAT16   3É
00016448   76 46 E2 39 60 5C B0 15  74 A9 E3 07 BA DF 56 3F    vFâ9`\° t©ã °ßV?
00016464   6A 05 9A 50 E2 6F A6 5F  35 C7 EB 2D A6 9A 2B FC    j šPâo¦_5Çë–¦š+ü
00016480   99 42 C2 B3 C5 FF 53 E2  AE AA FB 7E C0 51 81 70    ™BÂ³Å ÿSâ®ªû~ÀQ p
```
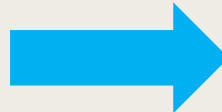
FAT Boot Sector
Number of heads

Byte 26-27: Number of heads

Little-Endian: FF   00

Big-Endian: 00   FF

Value: 0x00FF

$$240 + 15 = 255 \; heads$$

FAT Partition – Details of the First 36 Bytes in the FAT Partition Boot Sector	
Byte Range:	Description:
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00016368	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
00016384	EB	3C	90	4D	53	44	4F	53	35	2E	30	00	02	20	02	00	ë< MSDOS5.0
00016400	02	00	02	00	00	F8	EF	00	3F	00	FF	00	20	00	00	00	øï ? ÿ
00016416	E0	DF	1D	00	00	00	29	5E	95	C6	48	4E	4F	20	4E	41	àß)^•ÆHNO NA
00016432	4D	45	20	20	20	20	46	41	54	31	36	20	20	20	33	C9	ME FAT16 3É
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00016480	99	42	C2	B3	C5	FF	53	E2	AE	AA	FB	7E	C0	51	81	70	™BÂ³ÅÿSâ®ªû~ÀQ p

FAT Boot Sector

Sectors before partition

Byte 28-31: Sectors before partition

Little-Endian: 20 00 00 00

Big-Endian: 00 00 00 20

Value: 0x00000020

32 Sectors

$32 \times 512 = 16384\ B$

Byte Range:	Description:
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FAT Partition – Details of the First 36 Bytes in the FAT Partition Boot Sector

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00016368        00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00016384     EB 3C 90 4D 53 44 4F 53 35 2E 30 00 02 20 02 00   ë< MSDOS5.0
00016400     02 00 02 00 00 F8 EF 00 3F 00 FF 00 20 00 00 00      øï ? ÿ
00016416     E0 DF 1D 00 00 00 29 5E 95 C6 48 4E 4F 20 4E 41   àß    )^•ÆHNO NA
00016432     4D 45 20 20 20 20 46 41 54 31 36 20 20 20 33 C9   ME    FAT16    3É
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00016464     6A 05 9A 50 E2 6F A6 5F 35 C7 EB 2D A6 9A 2B FC   j šPâo¦_5Çë–¦š+ü
00016480     99 42 C2 B3 C5 FF 53 F2 AE AA FB 7E C0 51 81 70   ™BÂ³ÅÿSò®ªû~ÀQ p
```

FAT Boot Sector - Diagrammatic
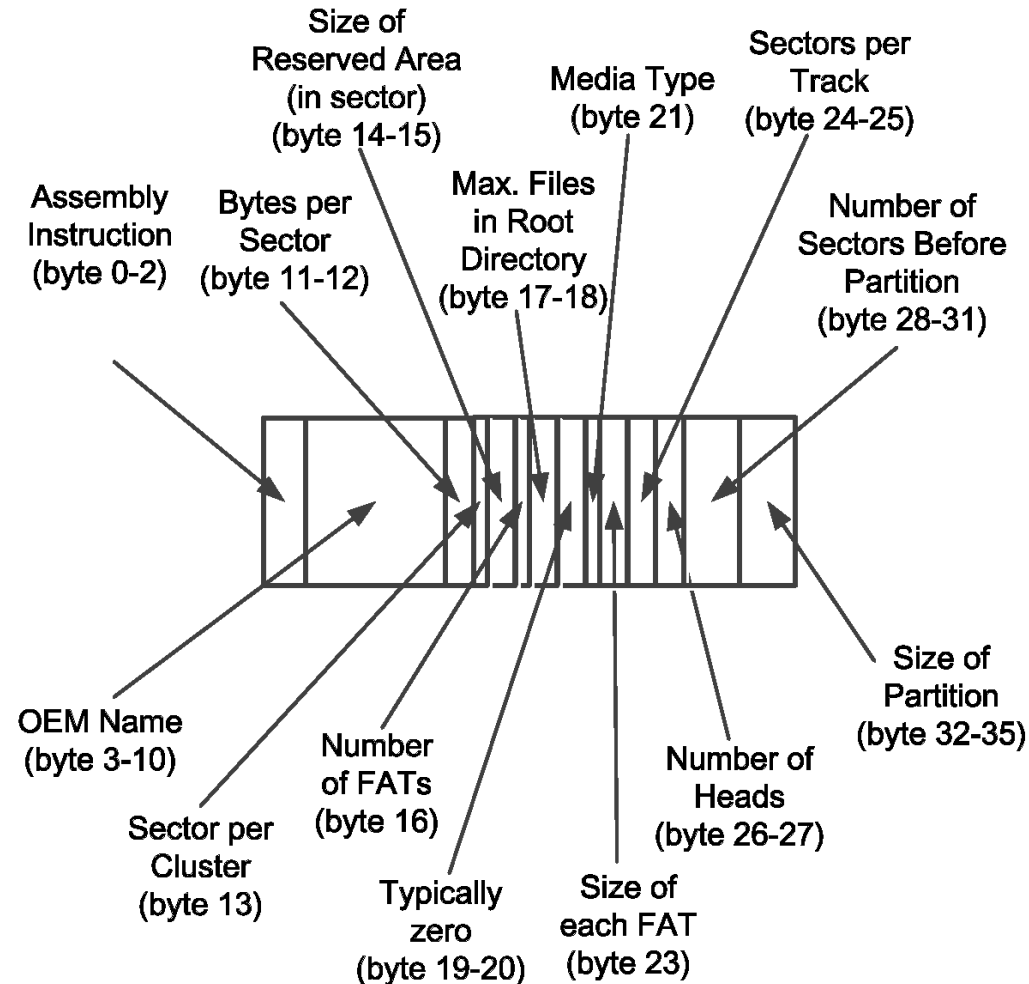
Schematic view of a Disk
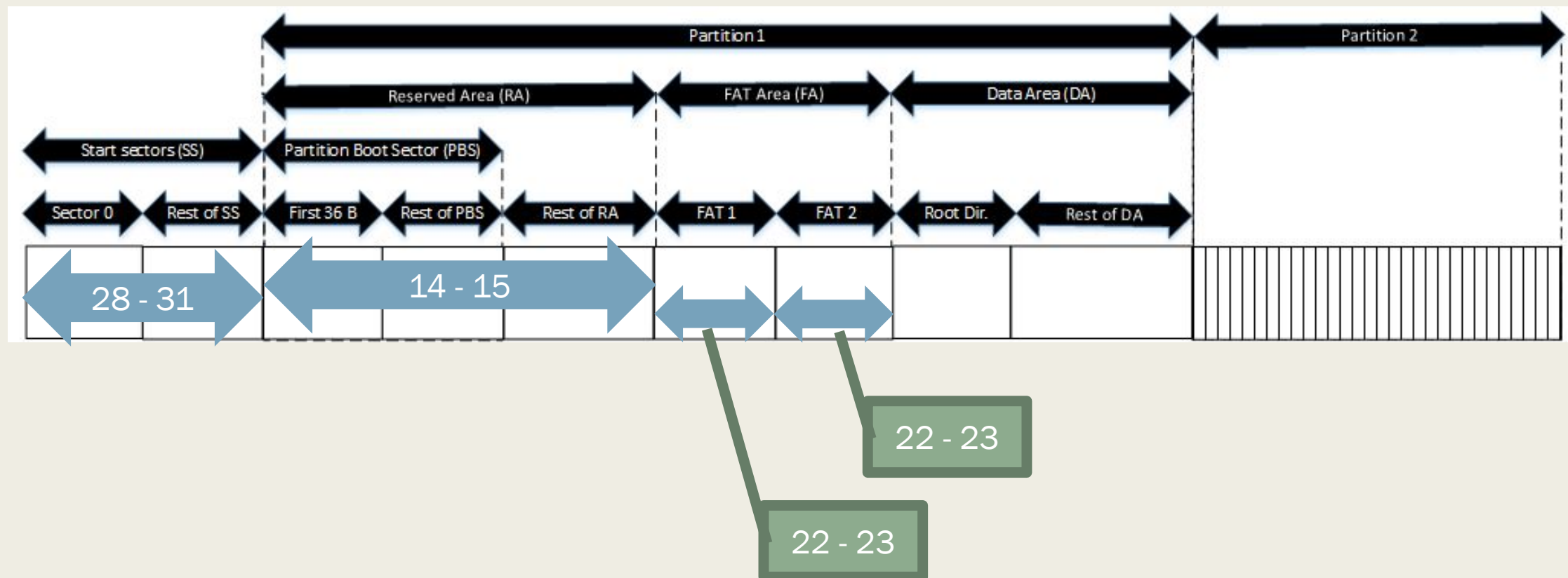
In this lecture we covered:

- Partition Sector Zero
  - *FAT16*
  - *Reading & understanding*