Database Management System

Unit 1: File Organization and Structure

File Organization and Structure

1.1. Overview of Physical Storage Media

1.2. Types of File Organization
- **1.2.1 Fixed-Length Records**
- **1.2.2 Variable-Length Records**

1.3. Organization of Records in Files
- **1.3.1 Sequential File Organization**
- **1.3.2 Multitable Clustering File Organization**

1.4. Data Dictionary Storage

CE: 1.1
Overview of Physical Storage Media

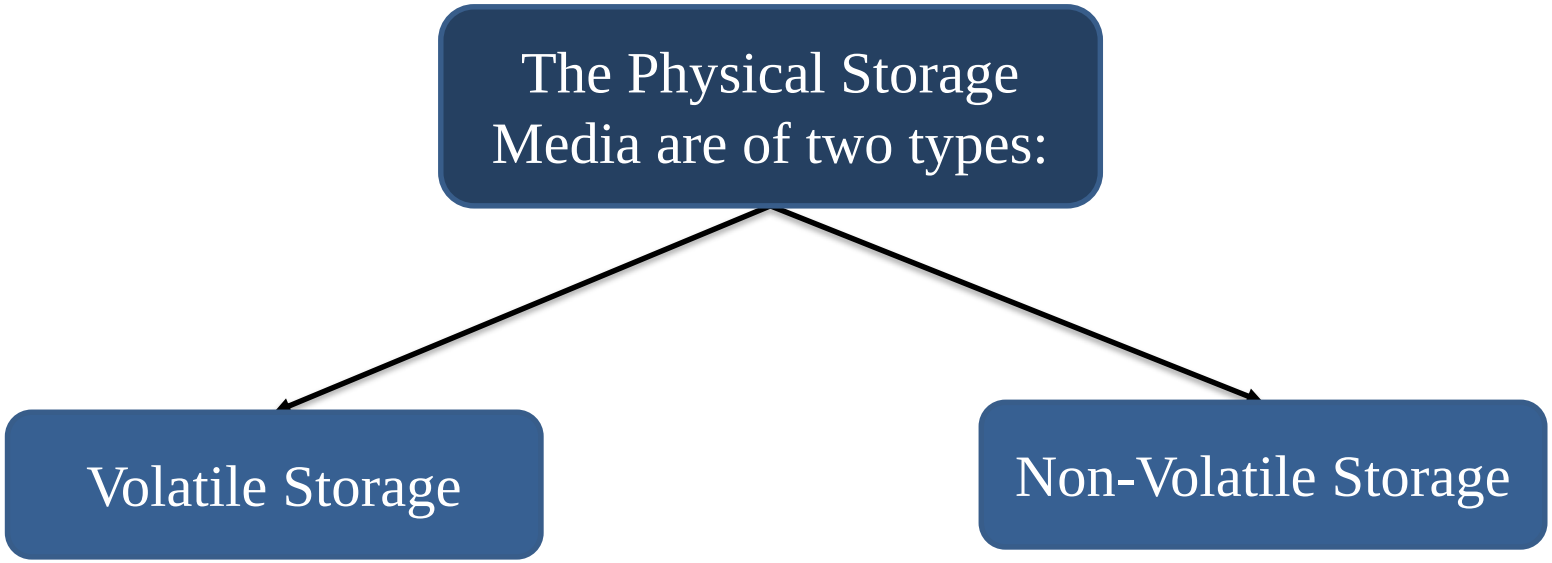
1.1. Overview of Physical Storage Media

- There are several types of data storage exist in most of the computer systems.

- These storage media are classified ….
  - by **the speed** with which data can be accessed,
  - by **the cost** per unit of data to buy the medium, and
  - by **the** medium's **reliability**.

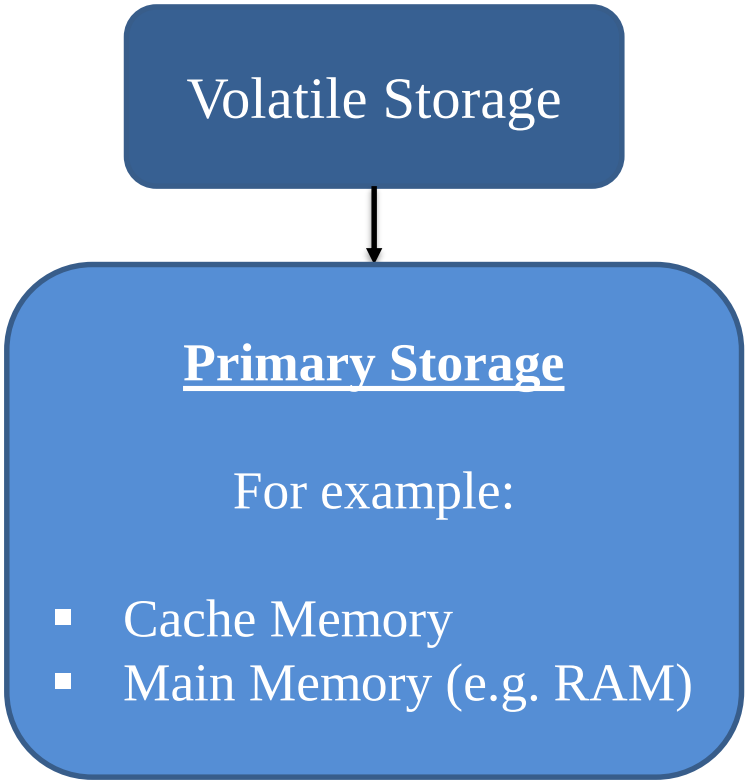
  - ✓ Why "**reliability**"**?**
    - data loss on power failure or system crash.
    - physical failure of the storage device.

1.1. Overview of Physical Storage Media (Conti…)

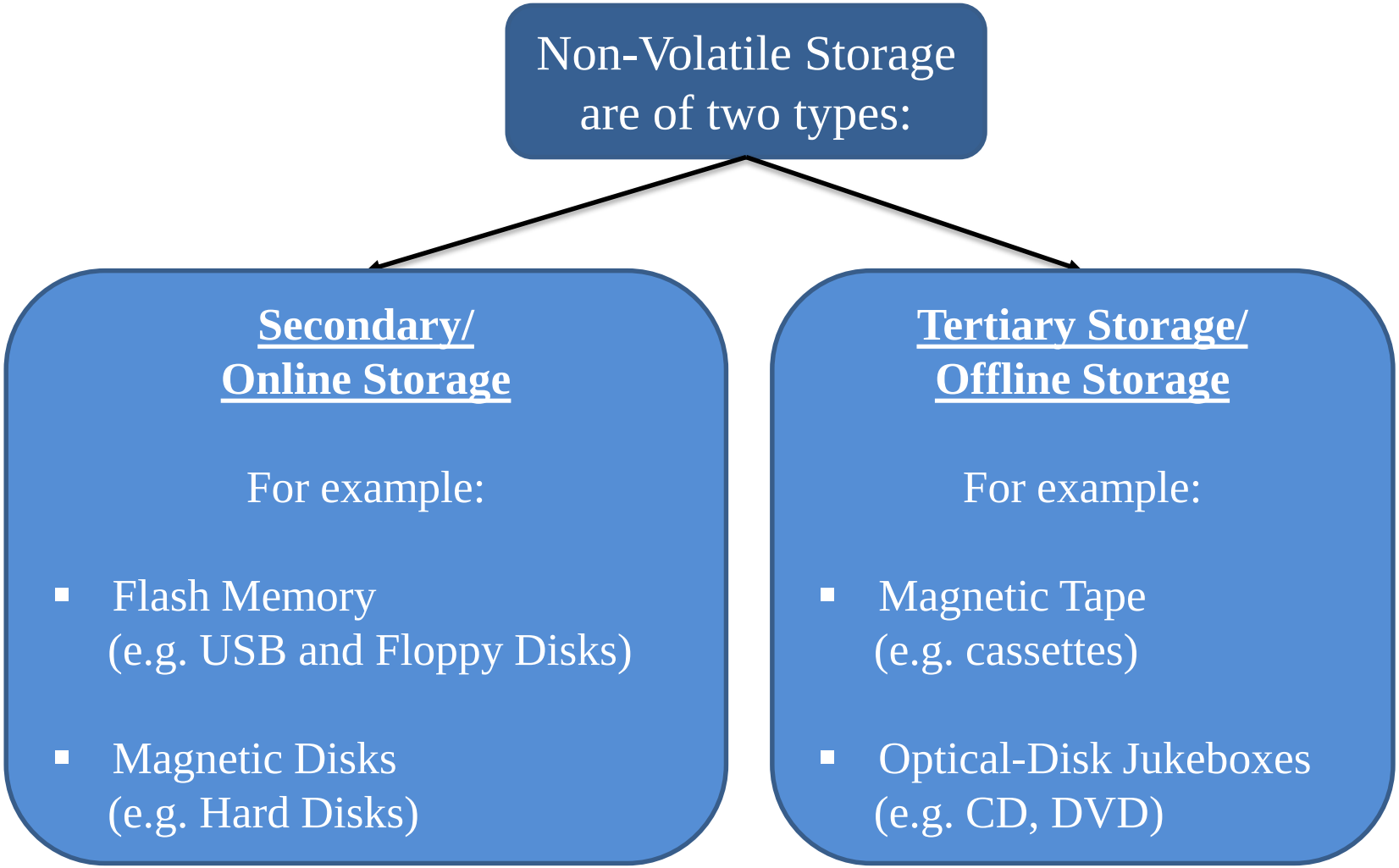


- The storage which loses the content whenever the power is switched off.
- The storage which perseveres the contents even when power is switched off.

1.1. Overview of Physical Storage Media (Conti…)



1.1. Overview of Physical Storage Media (Conti…)



The Physical Storage Media:

- The physical storage media are:
  1. Cache Memory
  2. Main Memory
  3. Flash Memory
  4. Magnetic Disk
  5. Magnetic Tape
  6. Optical Disk

The Physical Storage Media: (Conti…)

1. Cache Memory:

- "Cache" means a collection of items of the same type stored in a hidden or inaccessible place.

- The purpose of cache memory is to store program instructions and the data that are been used repeatedly in the operation of programs or information that the CPU is likely to needed.

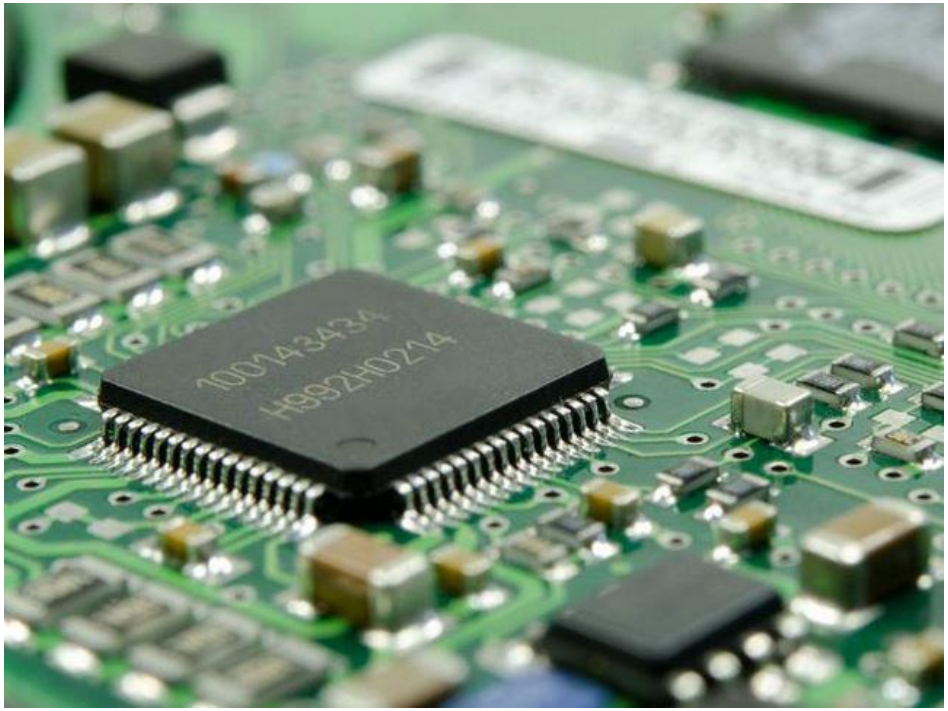
- The cache is the fastest and most costly form of storage.

- It is relatively small and managed by the computer system hardware.

The Physical Storage Media: (Conti…)

1. Cache Memory (Conti…):

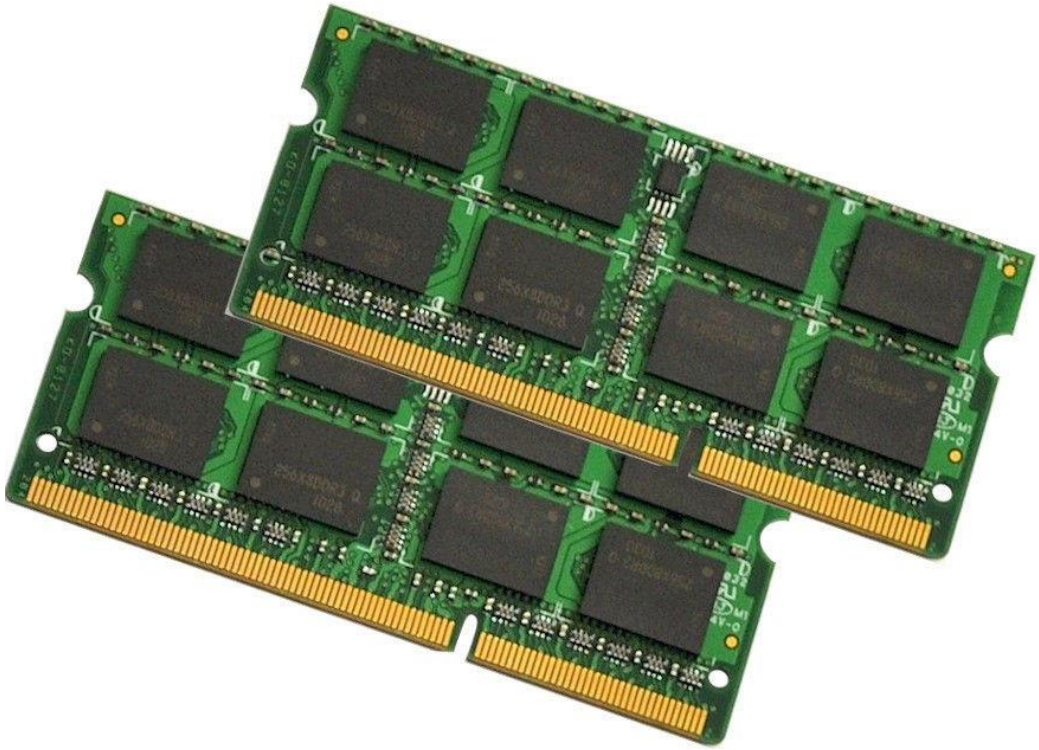
- We shall not be concerned about managing cache storage in the database system.



The Physical Storage Media: (Conti…)

2. Main Memory:

- The main memory in a computer is called RAM(Random Access Memory).



The Physical Storage Media: (Conti…)

2. Main Memory(Conti…):

- This is the part of the computer that stores operating system software, software applications and other information for the central processing unit (CPU) to have faster and direct access when needed to perform tasks.

- It is called "random access“, because the CPU can go directly to any section of main memory for the process, and does not have to go in a sequential order.

- The main memory has fast access (10s to 100s of nanoseconds; 1 nanosecond = 10^{-9} seconds)

The Physical Storage Media: (Conti…)

2. Main Memory(Conti…):

- Generally, it is too small (or too expensive) to store the entire database.

  (because the capacity is up to a very few Gigabytes which is widely used currently.)

- Since it is a ***volatile storage***, the contents of main memory are usually lost if a power failures or system crash occurs.

The Physical Storage Media: (Conti…)

3. Flash Memory:

- The stored data are survive even if power is turned off (or fails).

- Data can be written only once at a location, but the location can be erased and written to again at a same location.
  (because it can support only a limited number (10K – 1M) of write/erase cycles and erasing of memory has to be done to an entire bank of memory.)

- The reading of data is as faster as main memory, but the writing is slow (few microseconds) and erasing of data is also slower.

The Physical Storage Media: (Conti…)

3. Flash Memory (Conti…):

- There are two types of flash memory, called NAND and NOR flash.

- NAND flash has much higher storage capacity for a given cost.

- It is widely used for data storage in devices such as…
  - cameras,
  - music players,
  - cell phones, and
  - increasingly, in laptop computers as well.

The Physical Storage Media: (Conti…)

3. Flash Memory (Conti…):

- It is also widely used for storing data in “USB keys,” which can be plugged into the Universal Serial Bus (USB) slots of computing devices.

The Physical Storage Media: (Conti…)

3. Flash Memory (Conti…):

- A "floppy disks" played the same role in earlier days, but their limited capacity has made them obsolete now.

- Flash memory is also increasingly used as a replacement for magnetic disks for storing moderate (reasonable) amounts of data.

  - For example:
    Disk-drive replacements are called solid-state drives.
    In 2009, a 64 GB solid-state hard drive costs less than $200, and capacities range up to 160 GB.

The Physical Storage Media: (Conti…)

4. Magnetic Disk:

- The primary medium for the long-term storage of data is magnetic disk.
- Usually, the entire database is stored on magnetic disk.
- The data is stored on spinning (revolving) disk, and it read/write magnetically.
- The data must be moved from disk to main memory for the access, and can be written back for the storage.
  (It is much slower access than main memory)

The Physical Storage Media: (Conti…)

4. Magnetic Disk (Conti…):

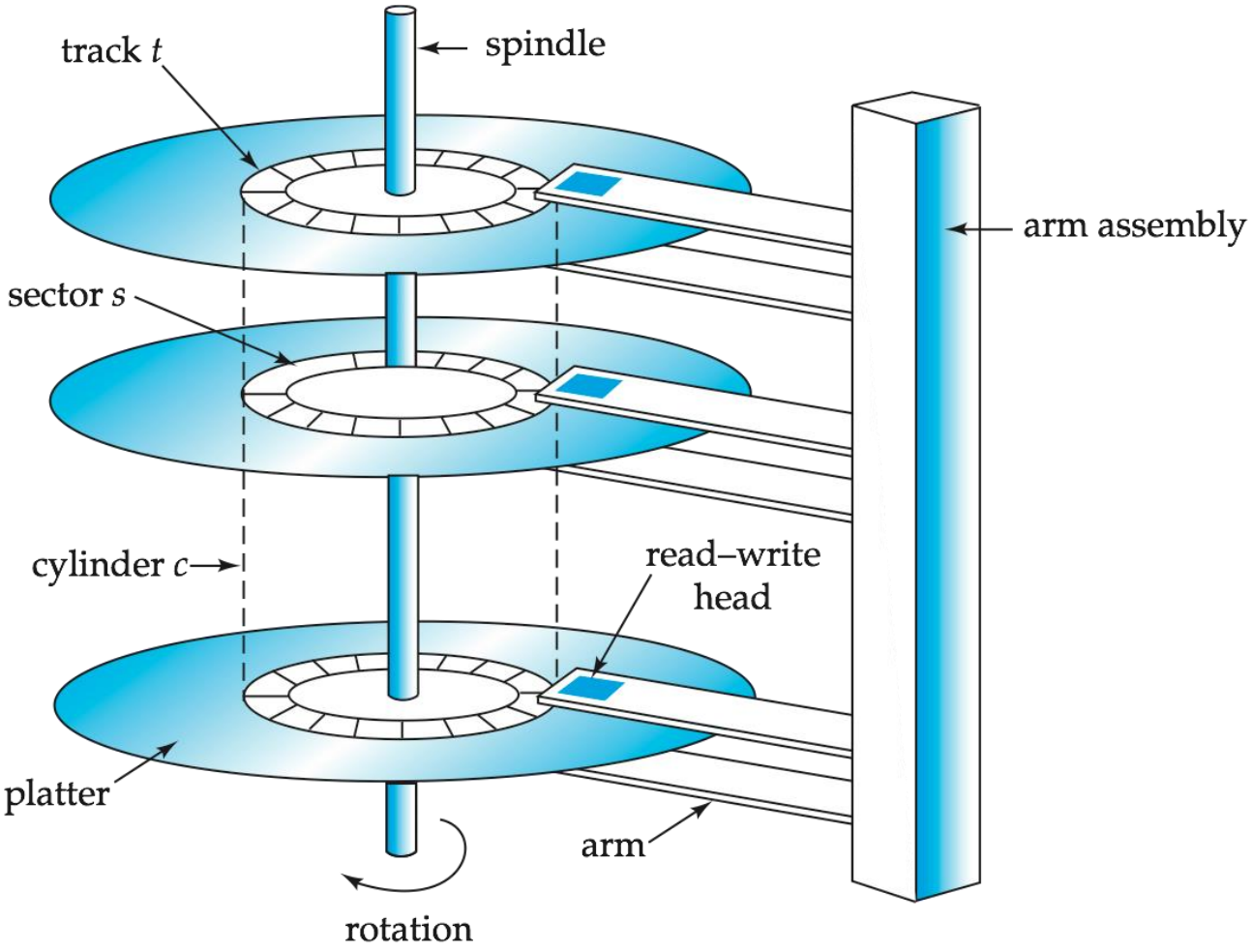
- It is a **direct-access storage**, so it is possible to read data from any location on disk, unlike magnetic tape.

- Its capacities range was approximately 1.5 TB in 2009.
  (Much larger capacity and cost/byte than main memory/flash memory.
  Growing constantly and rapidly with technology improvements (factor of 2 to 3 every 2 years)

- It survives in power failures and system crashes.
  (Disk failure can destroy data, but it is very rare.)

The Physical Storage Media: (Conti…)

4. Magnetic Disk (Conti…):



The Physical Storage Media: (Conti…)

4. Magnetic Disk (Conti…):

The Physical Storage Media: (Conti…)

5. Magnetic Tape:

- It is mainly used for storing backup and for the archival (related) data.
- The accessibility of data is much slower, because the tape read the data sequentially from the beginning. That's why it is known as **sequential-access storage.**
- It has a high capacity (40 to 300 GB tapes available)
- It can be removed from the tape drive, so the storage cost is much cheaper than the disks, but drives are expensive.

The Physical Storage Media: (Conti…)

5. Magnetic Tape (Conti…):

- The tape libraries **(jukeboxes)** available for storing massive amounts of data are in hundreds of TBs (1 terabyte = 10^9 bytes) to even multiple PBs (1 petabyte = 10^{12} bytes).

The Physical Storage Media: (Conti…)

6. Optical Disk:

- The most popular forms of optical storage are:
  1. CD(Compact disk):
     - which can hold about 700 MB of data and
     - has a playtime of about 80 minutes.

  2. DVD(Digital video disk/ Digital versatile disk):
     - which can hold 4.7 to 17 GB.

  - Blu-ray disks:
     - which can hold 27 GB to 54 GB.

The Physical Storage Media: (Conti…)

6. Optical Disk (Conti…):

The Physical Storage Media: (Conti…)

6. Optical Disk(Conti…):

- The optical disks used in…
  - read-only compact disks (CD-ROM) or
  - read-only digital video disks (DVD-ROM)

  both cannot be written, but the prerecorded data can be read.

- Optical disk are also "record-once" versions of…
  - compact disk (called CD-R) and
  - digital video disk (called DVD-R and DVD+R),

  which can be written only once.
- Such disks are also called write-once, read-many (WORM) disks.

The Physical Storage Media: (Conti…)

6. Optical Disk(Conti…):

- The optical disk are also “multiple-write” versions of…
  - compact disk (called CD-RW) and
  - digital video disk (DVD-RW, DVD+RW, and DVD-RAM), which can be written multiple times.

- Reads and writes are slower than with magnetic disk.

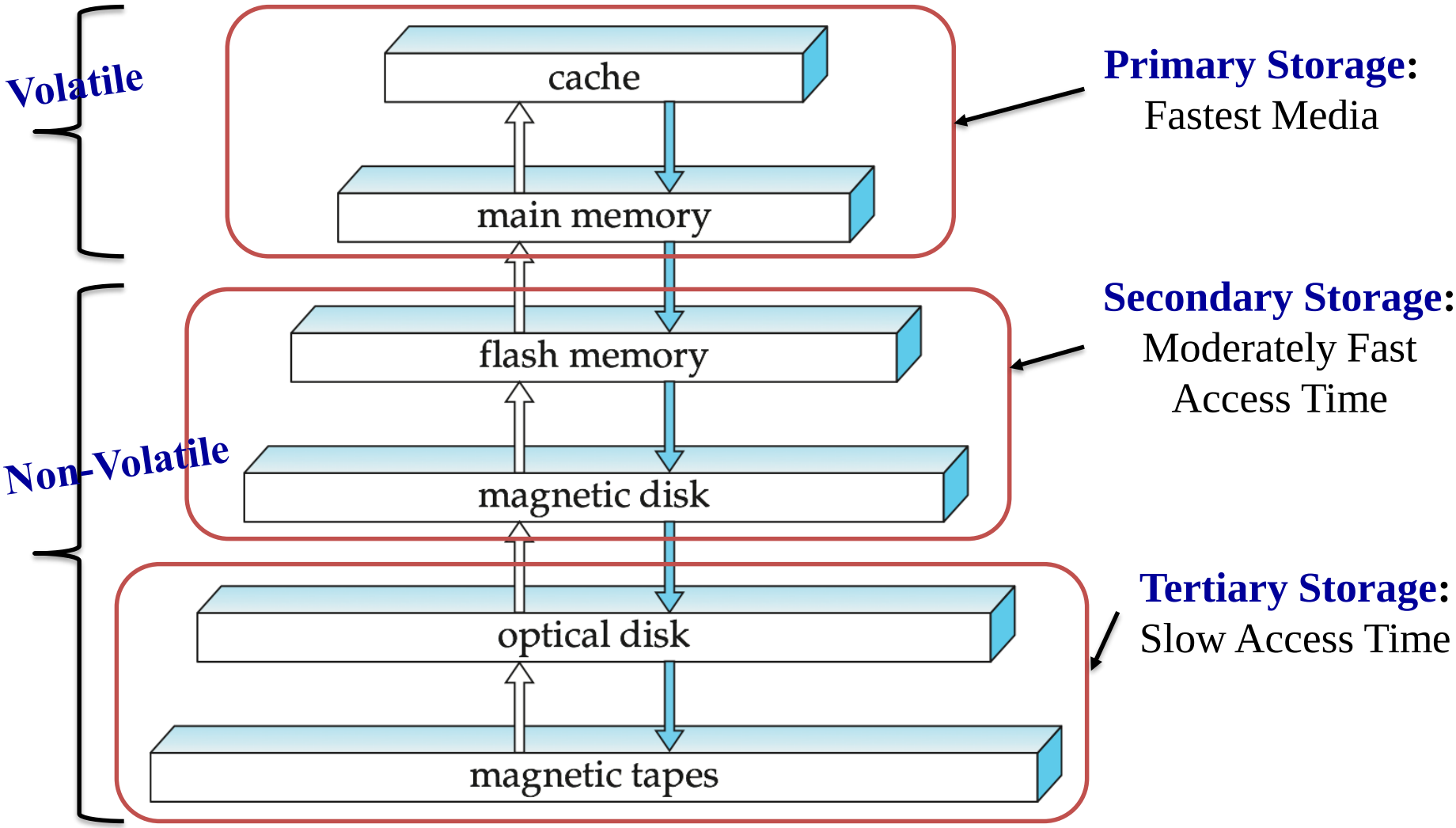
- Optical disk **jukebox** systems contain few drives and numerous disks that can be automatically loaded/unloaded for storing large volumes of data.

- It is a non-volatile, so the data is read optically from a spinning disk using a laser.

Storage Hierarchy

- The various storage media can be organized in a hierarchy according to their speed and their cost.
- The higher levels are expensive, but are fast.
- As we move down the hierarchy, the cost per bit decreases, whereas the access time increases.

Storage Hierarchy (Conti…)



International Certification Question

Q1.	**The storage structure which do not survive system crashes are _____.**
A.	**Stable storage**
B.	**Volatile storage**
C.	**Non-volatile storage**
D.	**Dynamic storage**

Ans: B

International Certification Question

Q2.	**The _____ is the fastest and most costly form of storage, which is relatively small; its use is managed by the computer system hardware.**
A.	**Cache**
B.	**Disk**
C.	**Main memory**
D.	**Flash memory**

Ans: A

Explanation: Because cache storage is easy to access and it is closer to the processor.

International Certification Question

Q3.	**Which of the following stores several gigabytes of data but usually lost when power failure?**
A.	**Flash memory**
B.	**Disk**
C.	**Main memory**
D.	**Secondary memory**

Ans: C

International Certification Question

Q4.	**The flash memory storage used are**
A.	**NOR Flash**
B.	**OR Flash**
C.	**AND Flash**
D.	**All of the mentioned**

Ans: A

International Certification Question

Q5.	Which is the cheapest memory device in terms of costs/bit?
A.	Semiconductor memory
B.	Magnetic disks
C.	Compact disks
D.	Magnetic tapes

Ans: C

International Certification Question

Q6.	**Optical disk _____ systems contain a few drives and numerous disks that can be loaded into one of the drives automatically (by a robot arm) on demand.**
A.	**Tape Storage**
B.	**Jukebox**
C.	**Flash memory**
D.	**All of the mentioned**

Ans: B

International Certification Question

Q7.	**Tape storage is referred to as _____ storage.**
A.	**Direct-access**
B.	**Random-access**
C.	**Sequential-access**
D.	**All of the mentioned**

Ans: C

Industry Interview Questions

1. What is the significant of RAM?
2. How Flash memory differs from Main memory?
3. What is the capacity to store data in Blu-ray disk?
4. Why the disk storage is referred to as direct-access storage?
5. Which are primary and secondary storage media?

Home Work

1. List at least four data storage devices, which use NAND flash memory. [1 Mark]
2. Give the full form of WORM. [1 Mark]
3. What is flash memory? In which storage devices it is used? [2 Marks]
4. Draw the storage device hierarchy. [2 Marks]
5. List and explain several types of data storage exist in computer system. [5 Marks]

CE: 1.2
Types of File Organization

File Organization

- File organization is a way of organizing the data or records in a file.
- A ***file*** is a sequence of records.
- A ***record*** is a sequence of fields.
- In many cases, all records in a file are of the same record type. These records are recorded on disk blocks.
- The **database** is stored as a collection of files. Each file is a sequence of records.

File Organization (Conti…)

- Each file is also logically divided into fixed-length storage units called blocks**.**
- A **block** is the smallest unit of data used by a database.
- A block may contain several records also, and that are determined by the form of physical data organization being used.
- By default, mostly the database uses 4 to 8 KB block size.
- Some database applications use larger block size, which may be useful.

File Organization (Conti…)

- There are several types of file organization:
  1. Fixed-Length Records
  2. Variable-Length Records

1. Fixed-Length Records:

- A file where each records is of the ***same length*** is said to have **fixed-length records**.

- Some fields are always of same length.
  - For example:
    Postcode - is always of 7 characters

- Some fields may need to be 'padded out', so that they can be in the correct length.
  - For example:
    Surname - If 15 characters are stored then Sarang would be stored as 'SARANG ' - 6 characters followed by 8 spaces).

1. Fixed-Length Records (Conti…):

❖ Advantage:

- Access is fast because the computer knows where each record starts. (That means the processing of all the data in a file will be fast).
  - For example:
    - If each record is 120 bytes long then
      - ✓ the 1st record starts at [Start of File] + 0 bytes
      - ✓ the 2nd record starts at [Start of File] + 120 bytes
      - ✓ the 3rd record starts at [Start of File] + 240 bytes etc.....

❖ Disadvantage:

- By using Fixed length records, the records are usually larger. (so, it requires more storage space and are slower to load or save).

1. Fixed-Length Records (Conti…):

- Consider Train Time-Table Program and if we need to quickly access any information about the passengers.

Number	First Name	Last Name	Year	Gender	DOB
91002	Naman	Vora	2018	M	6/2/2000
91205	Kishan	Joshi	2018	M	5/3/2001
98652	Vikash	Rajpurohit	2018	M	12/12/1999
98745	Urja	Naik	2018	F	6/4/2002
90005	Bhavik	Sarang	2018	M	6/1/2000

...the field lengths (in bytes) may be defined as ...

Number: 5
First Name: 15
Last Name: 15
Year: 4
Gender: 1
DOB: 8

Each record would be 48 bytes long.

1. Fixed-Length Records (Conti…):

- The first record of the example file would be stored as ...(each box represents one byte of storage)..

Number	First Name	Last Name	Year	Gender	DOB
91002	Naman	Vora	2018	M	6/2/2000

9	1	0	0	2	N	a	m	a	n									
V	o	r	a											2	0	1	8	M
6	/	2	/	2	0	0	0											

1. Fixed-Length Records (Conti…):

- A Fixed-Length Records follow a very simple approach.
- For the deletion of record also, it do not move records, but it link all the free records on a free list.

1. Fixed-Length Records (Conti…):

- For example: File containing instructor records.

record 0	10101	Srinivasan	Comp. Sci.	65000
record 1	12121	Wu	Finance	90000
record 2	15151	Mozart	Music	40000
record 3	22222	Einstein	Physics	95000
record 4	32343	El Said	History	60000
record 5	33456	Gold	Physics	87000
record 6	45565	Katz	Comp. Sci.	75000
record 7	58583	Califieri	History	62000
record 8	76543	Singh	Finance	80000
record 9	76766	Crick	Biology	72000
record 10	83821	Brandt	Comp. Sci.	92000
record 11	98345	Kim	Elec. Eng.	80000

1. Fixed-Length Records (Conti…):

- By deleting record 3, we have free space.

record 0	10101	Srinivasan	Comp. Sci.	65000
record 1	12121	Wu	Finance	90000
record 2	15151	Mozart	Music	40000
record 4	32343	El Said	History	60000
record 5	33456	Gold	Physics	87000
record 6	45565	Katz	Comp. Sci.	75000
record 7	58583	Califieri	History	62000
record 8	76543	Singh	Finance	80000
record 9	76766	Crick	Biology	72000
record 10	83821	Brandt	Comp. Sci.	92000
record 11	98345	Kim	Elec. Eng.	80000

1. Fixed-Length Records (Conti…):

- By deleting record 3, all records moved.

record 0	10101	Srinivasan	Comp. Sci.	65000
record 1	12121	Wu	Finance	90000
record 2	15151	Mozart	Music	40000
record 4	32343	El Said	History	60000
record 5	33456	Gold	Physics	87000
record 6	45565	Katz	Comp. Sci.	75000
record 7	58583	Califieri	History	62000
record 8	76543	Singh	Finance	80000
record 9	76766	Crick	Biology	72000
record 10	83821	Brandt	Comp. Sci.	92000
record 11	98345	Kim	Elec. Eng.	80000

So, it takes more time and efforts to move every record till the end of the file.

1. Fixed-Length Records (Conti…):

- By deleting record 3, all records moved.

record 0	10101	Srinivasan	Comp. Sci.	65000
record 1	12121	Wu	Finance	90000
record 2	15151	Mozart	Music	40000
record 4	32343	El Said	History	60000
record 5	33456	Gold	Physics	87000
record 6	45565	Katz	Comp. Sci.	75000
record 7	58583	Califieri	History	62000
record 8	76543	Singh	Finance	80000
record 9	76766	Crick	Biology	72000
record 10	83821	Brandt	Comp. Sci.	92000
record 11	98345	Kim	Elec. Eng.	80000

So, instead of moving all records, we could move the final record of the file into the space to occupy free space.

1. Fixed-Length Records (Conti…):

- After deleting record 3, final record moved.

record 0	10101	Srinivasan	Comp. Sci.	65000
record 1	12121	Wu	Finance	90000
record 2	15151	Mozart	Music	40000
record 11	98345	Kim	Elec. Eng.	80000
record 4	32343	El Said	History	60000
record 5	33456	Gold	Physics	87000
record 6	45565	Katz	Comp. Sci.	75000
record 7	58583	Califieri	History	62000
record 8	76543	Singh	Finance	80000
record 9	76766	Crick	Biology	72000
record 10	83821	Brandt	Comp. Sci.	92000

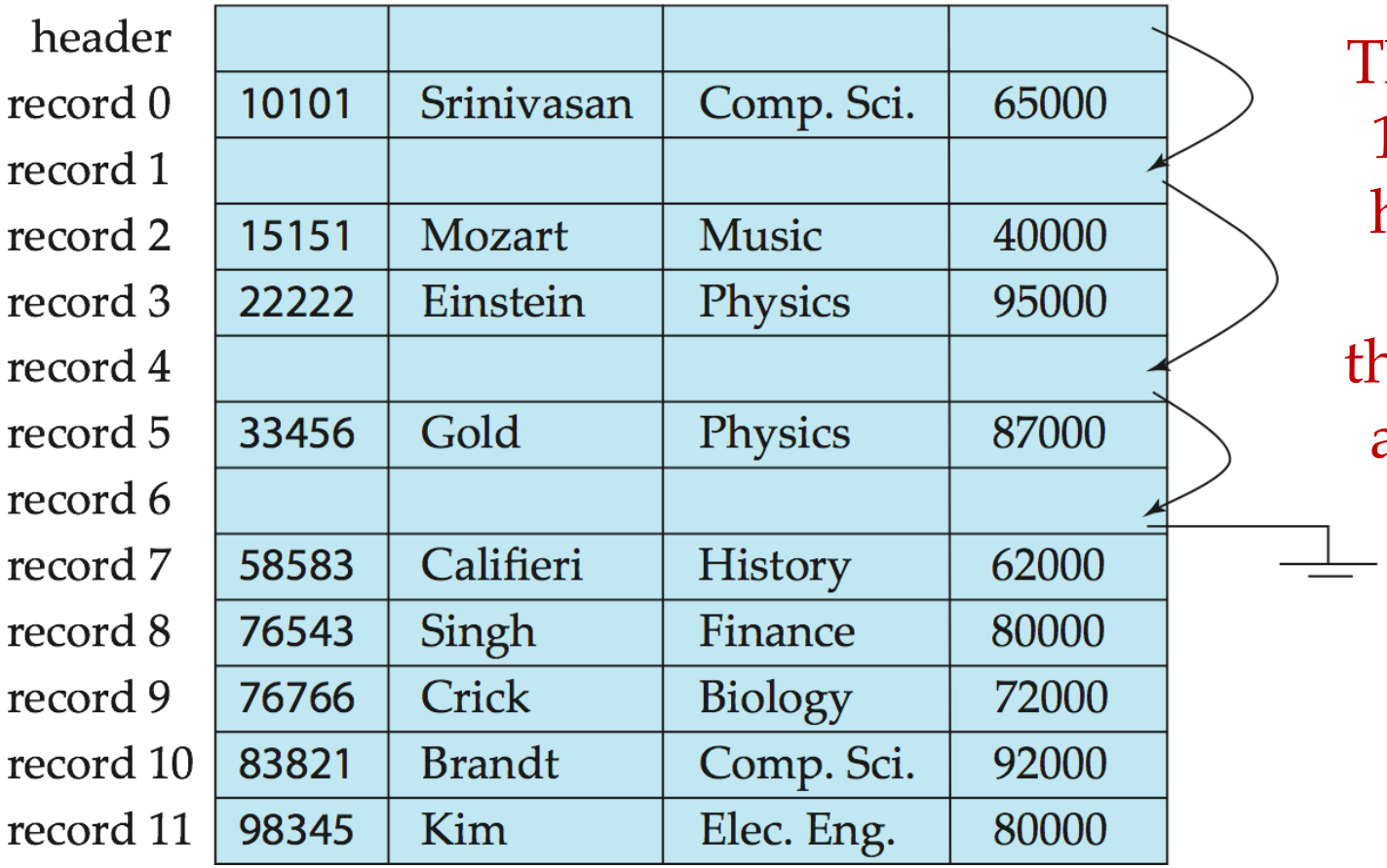
1. Fixed-Length Records (Conti…):

❖ **What are Free Lists?**

- It use to store the address of the first deleted record in the file header.
- ***This first record, stores the address*** of the ***second deleted record***, and so on.
- These stored addresses are like pointers since they "point" to the location of a record.
- The deleted records are form a linked list, which is often referred to as a **free list**.

1. Fixed-Length Records (Conti…):

❖ What are Free Lists? (Conti…)

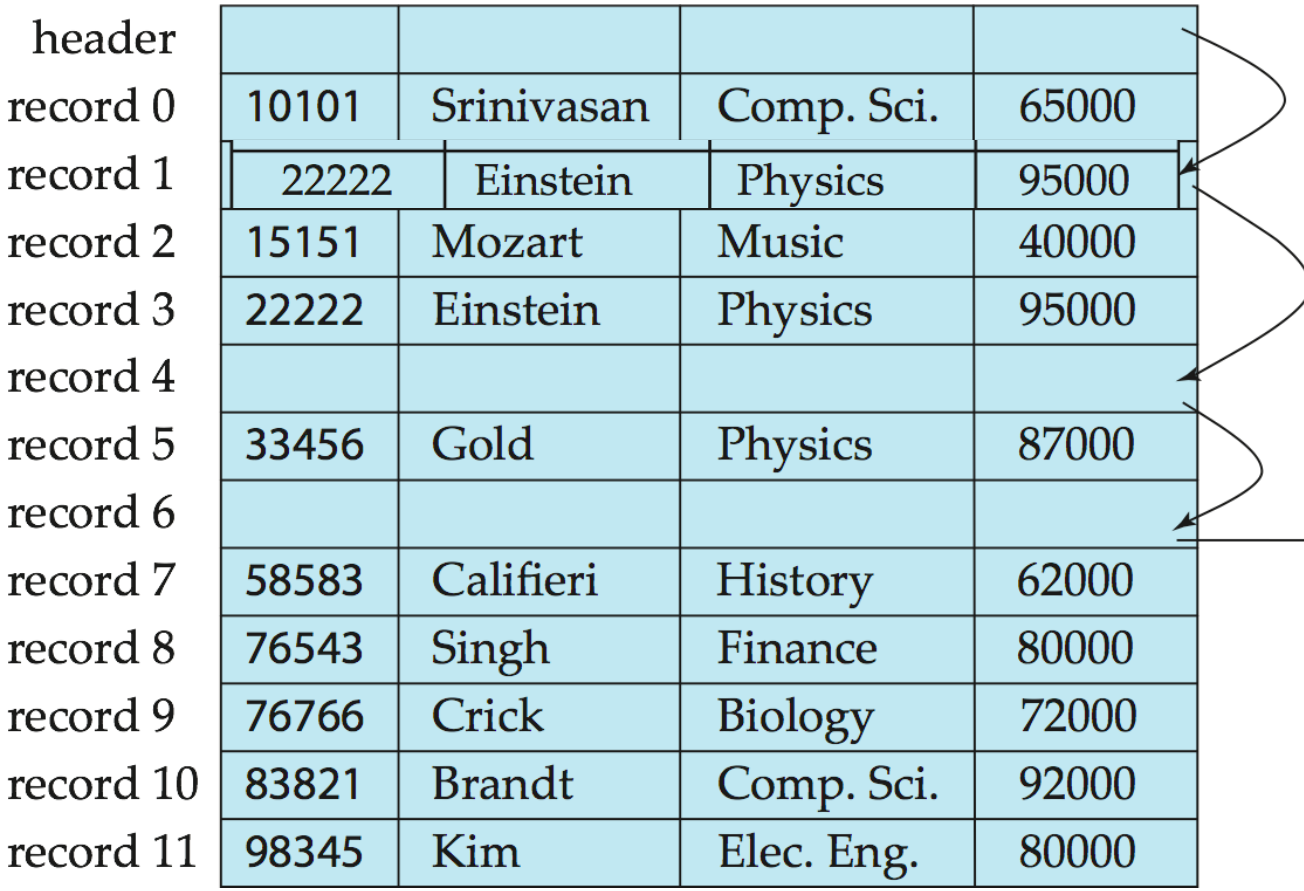


header				
record 0	10101	Srinivasan	Comp. Sci.	65000
record 1				
record 2	15151	Mozart	Music	40000
record 3	22222	Einstein	Physics	95000
record 4				
record 5	33456	Gold	Physics	87000
record 6				
record 7	58583	Califieri	History	62000
record 8	76543	Singh	Finance	80000
record 9	76766	Crick	Biology	72000
record 10	83821	Brandt	Comp. Sci.	92000
record 11	98345	Kim	Elec. Eng.	80000

The records 1, 4, and 6 have been deleted, therefore its a **free list**.

1. Fixed-Length Records (Conti…):

❖ What are Free Lists? (Conti…)



header				
record 0	10101	Srinivasan	Comp. Sci.	65000
record 1	22222	Einstein	Physics	95000
record 2	15151	Mozart	Music	40000
record 3	22222	Einstein	Physics	95000
record 4				
record 5	33456	Gold	Physics	87000
record 6				
record 7	58583	Califieri	History	62000
record 8	76543	Singh	Finance	80000
record 9	76766	Crick	Biology	72000
record 10	83821	Brandt	Comp. Sci.	92000
record 11	98345	Kim	Elec. Eng.	80000

So, inserted of moving records, wait for a later insertion before reusing the space.

1. Fixed-Length Records (Conti…):

- And if no space is available, we add the new record to the end of the file.

- Insertion and deletion for files of fixed-length records are simple to implement.
  - Because the space which is available by a deleted record is exactly the space needed to insert a record.

- If we use **variable-length** in a file, then this above used technique will no longer used.
  - Because an inserted record may not fit in the free space by a deleted record, or it may fill only part of that space.

Class Work

1. Consider the following structure of the file and perform the following steps:

Header				
Record 0	10101	Krishna	Computer Science	65000
Record 1	15151	Darshan	Singing	40000
Record 2	45452	Raj	Finance	80000
Record 3	98989	Parth	Marking	85000
Record 4	28282	Vishva	Music	45000
Record 5	34343	Riya	Finance	80000

a. Insert(12121, Aesha, Music, 45000).
b. Delete record 2.
c. Insert(54545, Kishan, Computer Science, 65000).

Class Work

1. Consider the deletion of record 3 from the file. Compare the relative merits of the following techniques for implementing the deletion:

Header				
Record 0	10101	Krishna	Computer Science	65000
Record 1	15151	Darshan	Singing	40000
Record 2	45452	Raj	Finance	80000
Record 3	98989	Parth	Marking	85000
Record 4	28282	Vishva	Music	45000
Record 5	34343	Riya	Finance	80000

a. Move record 4 to the space occupied by record 3, and move record 5 to the space occupied by record 4.
b. Move record 5 to the space occupied by record 3.
c. Mark record 3 as deleted, and move no records.

Class Work

1. Show the structure of the following file using the following steps:

Header				
Record 0	10101	Krishna	Computer Science	65000
Record 2	45452	Raj	Finance	80000
Record 3	98989	Parth	Marking	85000
Record 5	34343	Riya	Finance	80000

a. Insert(12121, Nirav, Sport, 65000).
b. Delete record 2.
c. Insert(54589, Hardik, Computer Science, 75000)
d. Insert(78412, Ron, Account, 58000).

2. Variable-Length Records:

- If different record in the file have ***different lengths*** is said to be variable-length records.

❖ Advantages:

- The records will be smaller and will need less storage space.
- The records will load faster.

❖ Disadvantages:

- The computer will not be able to decide, where each record starts. (so here the processing records will be slower.)

2. Variable-Length Records (Conti…):

- The main problem with variable-length records is that, when a ***new records is to be inserted, an empty slot of just the right length is required***.

- For example:

Null bitmap

Number	First Name	Last Name	Year	Gender	DOB	
91002	Naman	Vora	2018	M	6/2/2000	⊥
91205	Kishan	Joshi	2018	⊥		
98652	Vikash	Rajpurohit	2018	M	12/12/1999	⊥
98745	Urja	Naik	2018	F	⊥	
90005	Bhavik	Sarang	2018	M	6/1/2000	⊥

This technique representation is known as **Byte-string** representation.

2. Variable-Length Records (Conti…):

- In case, if the empty slot is smaller than the new record length, then it cannot be used.
- Similarly, if the empty slot is too big, then the extra space is wasted.
- Therefore, it is important that just the right length space is allocated while inserting new records and move records to fill the space created by deletion of records, to confirm that all the free space in the file is connecting.
- **So, there is hardly any space for future growth of records.**

2. Variable-Length Records (Conti…):

- Due to the dis-advantages and other limitations, the byte-string technique is not usually used for implementing variable-length records.

- The Variable-length records arise in database systems in several ways:
  1. Storage of multiple record types in a file.
  2. Record types that allow variable lengths for one or more fields. (like string/varchar)
  3. Record types that allow repeating fields, such as arrays or multisets. (used in some older data models)

2. Variable-Length Records (Conti…):

Storage Method: 1

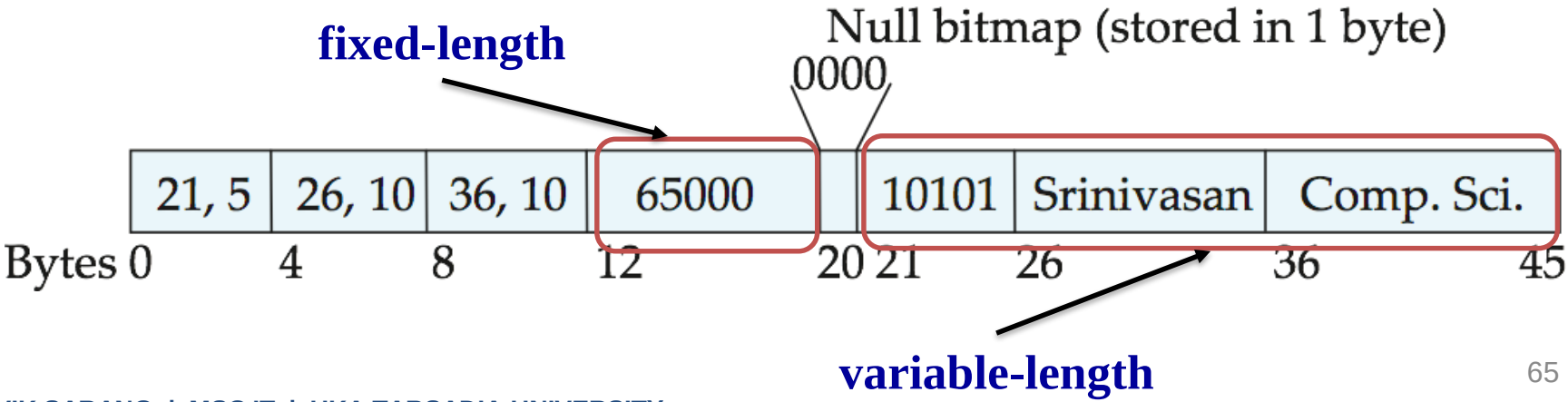
- An initial part with fixed-length attributes, followed by data for variable-length attributes.
- Fixed-length attributes such as…. numeric values, dates, or character strings.
- Variable-length attributes such as…. varchar types.
- The initial part of the record is represented by (offset, length) pair,
  - Where,
    - **offset** is the data for that attribute begins within the record, and
    - **length** is the length in bytes of the variable-sized attribute.

2. Variable-Length Records (Conti…):

Storage Method: 1 (Conti…)

- For example:
- In an *instructor* record, whose first three attributes ID, name, and dept_name are *variable-length strings*, and whose fourth attribute salary is a *fixed-length number*.

- We assume that the offset and length values are stored in two bytes each, for a total of 4 bytes per attribute.



2. Variable-Length Records (Conti…):

Storage Method: 2

- Each field starts with a **byte** showing the **length** of the field. The whole record starts with a byte giving the size of the record.

- For example, it would be stored as .....

Number	First Name	Last Name	Year	Gender	DOB
91002	Naman	Vora	2018	M	6/2/2000

34	**5**	9	1	0	0	2	**5**	N	a	m	a	n	**4**	V	o	r	a	**4**	2
0	1	8	**1**	M	**8**	6	/	2	/	2	0	0	0						

This record requires 34 bytes of storage, but each record will be of different size.
This technique is known as Slotted Page Structure.

2. Variable-Length Records (Conti…):

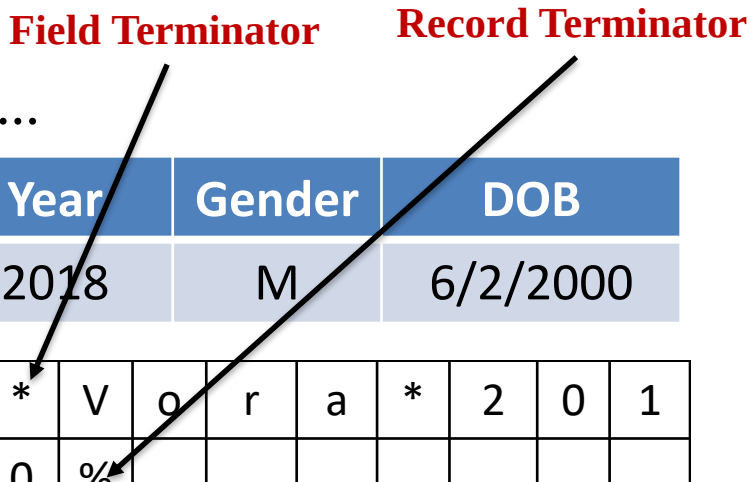
Storage Method: 2 (Conti…)

- **Slotted page header** contains:
  1. The number of record entries in the header.
  2. The end of free space in the block.
  3. An array whose entries contain the location and size of each record.

2. Variable-Length Records (Conti…):

Storage Method: 3

- When the record is stored, each field has a **field terminator** byte stored at the end of it, and there is often a **record terminator** at the end of the whole record.



- For example, it would be stored as .....

Number	First Name	Last Name	Year	Gender	DOB
91002	Naman	Vora	2018	M	6/2/2000

9	1	0	0	2	*	N	a	m	a	n	*	V	o	r	a	*	2	0	1
8	*	M	*	6	/	2	/	2	0	0	0	%							

This record requires 33 bytes of storage, but each record will be of different size.

2. Variable-Length Records (Conti…):

Storage Method: 4

- We can include, in each record a sequence of <field-name, field-value> pairs, rather than just the field values.

- For example, it would be stored as .....

Number	First Name	Last Name	Year	Gender	DOB
91002	Naman	Vora	2018	M	6/2/2000

N	u	m	b	e	r	=	9	1	0	0	2	■	F	i	r	s	t	=	N
a	m	a	n	■	L	a	s	t	=	V	o	r	a	■	Y	e	a	r	=

..... ⊠

Difference between Fixed-Length and Variable-Length Records

Fixed-Length Records	Variable-Length Records
1. All the records in the file are of same size.	1. Different records in the file have different sizes.
2. Leads to memory wastage.	2. Memory efficient.
3. Access of the records is easier and faster.	3. Access of the records is slower.

International Certification Question

Q1.	Which of the following is true about file header?
A.	It is allocated at the beginning of the file
B.	It has information about the file
C.	It generally contains the address of the first record in it
D.	All of the mentioned

Ans: D

International Certification Question

Q2.	**What does a null bitmap indicate?**
A.	**The database does not exist**
B.	**The record does not exist**
C.	**The attributes of a record do not have a value**
D.	**The attributes are missing from record**

Ans: C

Explanation: Because a null-bitmap indicates that the attributes of a particular record have null values.

International Certification Question

Q3.	**Variable length records cannot be implemented**
A.	**True**
B.	**False**

Ans: B

Reason: There are different techniques to implement variable length records.

International Certification Question

Q4.	**The linked list formed by the deleted records is called as _____**
A.	**Delete list**
B.	**Free list**
C.	**Null list**
D.	**Non-existent list**

Ans: B

International Certification Question

Q5.	**It is easier to delete a record from the fixed length records**
A.	**True**
B.	**False**

Ans: B

Reason: It is tough to delete a record from the fixed length records but it is easier to delete a record from the variable length record. Thus, implementation of variable records is preferred.

Industry Interview Questions

1. What are the reasons for having variable-length records? What types of separator characters are needed for each?

2. Which type of technique we should use to store record in database?

3. What do you mean by “Free List”?

4. Can we use the free list space which is remain as it is, after the deletion of record(s)?

5. Why insertion and deletion for files of fixed-length records are simple to implement?

Home Work

1. Define “Block”. [1 Mark]
2. What is Null bitmap? [1 Mark]
3. What is “offset” and “length” in variable-length attribute? [2 Marks]
4. What header contains at the beginning of the each block of information? [2 Marks]
5. Atleast give three difference between Fixed-Length and Variable-Length Records. [2 Marks]
6. Explain the representation of variable-length records. [5 Marks]
7. Discuss different types of file organization techniques in detail. [5 Marks]

CE: 1.3
Organization of Records in Files

Organization of Records in Files

- In a database we have lots of data. Each data is grouped into related groups called ***tables***.
- Each table will have lots of related records.
- Any user can see these records in the form of tables on the screen. But these records are stored as files in the memory. Usually one file will contain all the records of a table.
- As we saw above, in order to access the contents of the files records in the physical memory, it is not that easy.
- They are not stored as tables, so here our SQL queries will not work. We need some accessing methods.

Organization of Records in Files (Conti…)

- To access these files, we need to store them in certain order so that it will be easy to fetch the records.
- It is same as indexes in the books, or catalogues in the library, which helps us to find required topics or books respectively.
- Storing the files in certain order is called ***file organization***.

Organization of Records in Files (Conti…)

- The main objective of file organization is:

1. Records should be accessed/selected as fast as possible.

2. Any insert, update or delete transaction on records should be easy, quick and should not harm other records.

3. No duplicate records should be made as a result of insert, update or delete.

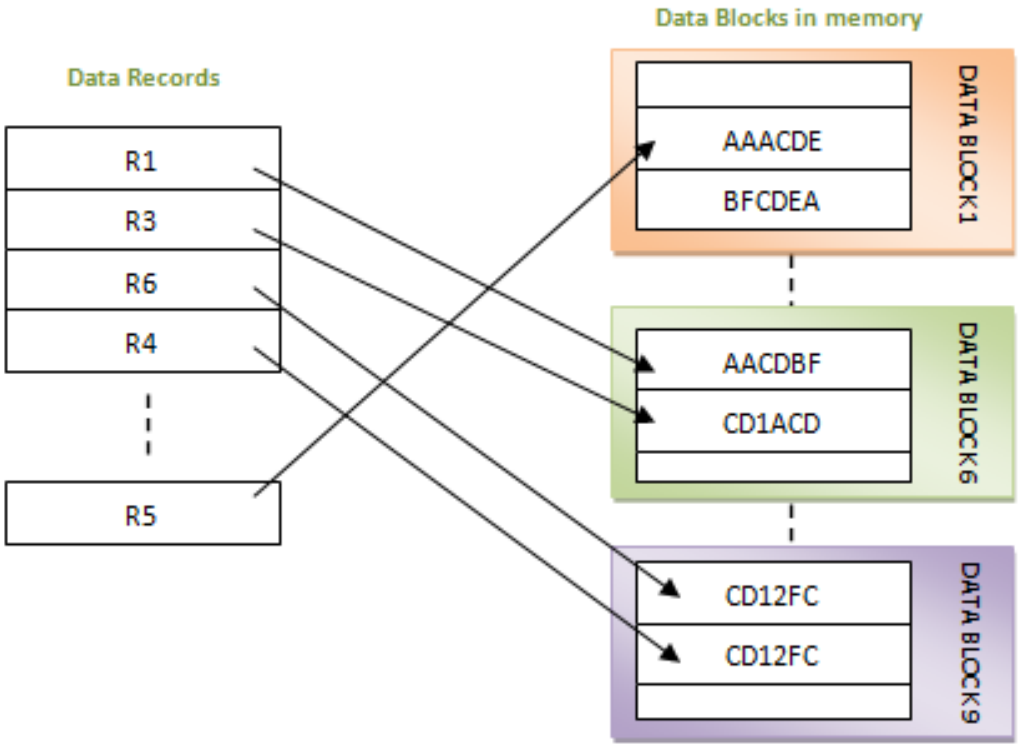
4. Records should be stored efficiently, so that cost of storage is minimal.

Organization of Records in Files

- There are several possible ways of organizing records in files. They are:
  1. Heap file organization
  2. Sequential file organization
  3. Hashing file organization

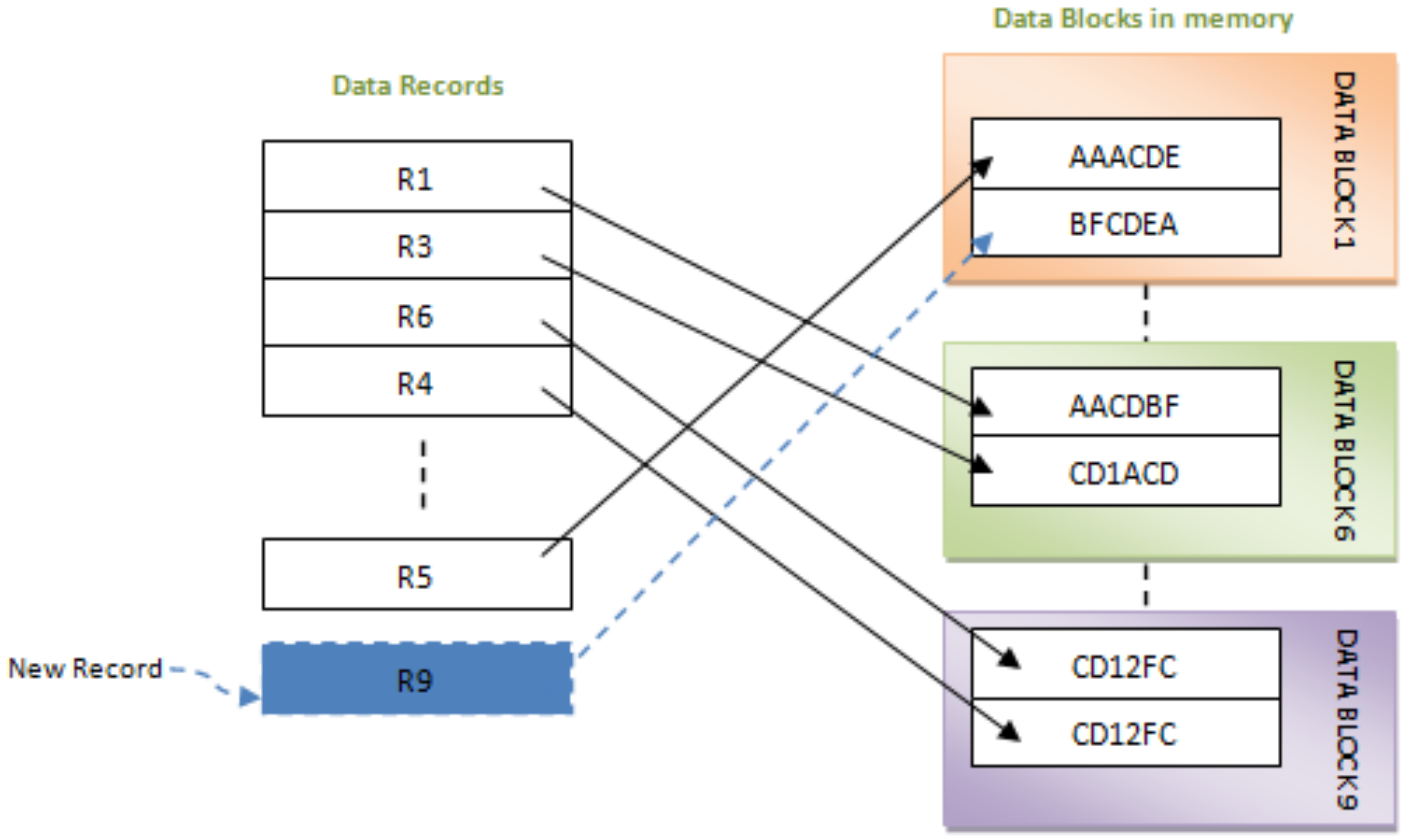
1. Heap file organization:

- A record can be placed anywhere in the file, where there is space.
- There is no sorting or ordering of records.
- For example:



1. Heap file organization (Conti…):

- If a new record is inserted, then it will be inserted into data block 1.



2. Sequential file organization:

- In sequential file, the records in a file are in sorted and in sequential order, based on the value of a “search key” of each record.

or

- A **sequential file** is designed for efficient processing of records in sorted order based on some “search key”.

- A ***search key*** is any attribute or set of attributes.
  - Search can be numeric (like student en.no., etc.) or alphabetic (like student first name, etc.)

- This can be achieved in two ways:
  1) Pile file method
  2) Sorted file method

2. Sequential file organization (Conti…):

1) Pile file method:

- The records are stored one after the other as they are inserted into the tables. This method is called ***pile file method***.

- When a new record is inserted, it is placed at the end of the file.

- In the case of any modification or deletion of record, the record will be searched in the memory blocks, then the operations will be performed.

2. Sequential file organization (Conti…):

1) Pile file method (Conti…):

➢ For example: Consider the following students records.

Search Key

Enrolment No.	First Name	Last Name	Contact No.
201806100110031	HEMAL	SHAH	9658743210
201806100110032	RIDDHI	GAJERA	9856321470
201806100110033	DHRITIKSHA	SAVALIYA	8745632109
201806100110036	RAJ	CHAMPANERIA	7568412300

Insert new record….

(201806100110034, ISHA, SAVALIYA, 6985741230)

2. Sequential file organization (Conti…):

1) Pile file method (Conti…):

After the insertion of new record, we have…..

Enrolment No.	First Name	Last Name	Contact No.
201806100110031	HEMAL	SHAH	9658743210
201806100110032	RIDDHI	GAJERA	9856321470
201806100110033	DHRITIKSHA	SAVALIYA	8745632109
201806100110036	RAJ	CHAMPANERIA	7568412300
201806100110034	ISHA	SAVALIYA	6985741230

2. Sequential file organization (Conti…):

2) Sorted file method:

- The records are sorted (either ascending or descending) each time, whenever they are inserted into the system. This method is called ***sorted file method***.

- Sorting of records may be based on the primary key or on any other columns.

- Whenever a new record is inserted, it will be inserted at the end of the file and then it will sort – ascending or descending based on **key value** and placed at the correct position.

2. Sequential file organization (Conti…):

2) Sorted file method (Conti…):

- In the case of any updation or deletion also, it will first update or delete the record respectively, then the records will be sorted in the file.

- For example: Consider the following students records.

Enrolment No.	First Name	Last Name	Contact No.
201806100110031	HEMAL	SHAH	9658743210
201806100110032	RIDDHI	GAJERA	9856321470
201806100110033	DHRITIKSHA	SAVALIYA	8745632109
201806100110036	RAJ	CHAMPANERIA	7568412300

Insert new record….

(201806100110034, ISHA, SAVALIYA, 6985741230)

2. Sequential file organization (Conti…):

2) Sorted file method (Conti…):

After the insertion of new record, we have…..

Enrolment No.	First Name	Last Name	Contact No.
201806100110031	HEMAL	SHAH	9658743210
201806100110032	RIDDHI	GAJERA	9856321470
201806100110033	DHRITIKSHA	SAVALIYA	8745632109
201806100110036	RAJ	CHAMPANERIA	7568412300
201806100110034	ISHA	SAVALIYA	6985741230

2. Sequential file organization (Conti…):

2) Sorted file method (Conti…):

After sorting the records, we have…..

Enrolment No.	First Name	Last Name	Contact No.
201806100110031	HEMAL	SHAH	9658743210
201806100110032	RIDDHI	GAJERA	9856321470
201806100110033	DHRITIKSHA	SAVALIYA	8745632109
201806100110034	ISHA	SAVALIYA	6985741230
201806100110036	RAJ	CHAMPANERIA	7568412300

If we want to delete the record, whose enrolment number is 201806100110033

2. Sequential file organization (Conti…):

2) Sorted file method (Conti…):

After the deletion and sorting of records, we have…..

Enrolment No.	First Name	Last Name	Contact No.
201806100110031	HEMAL	SHAH	9658743210
201806100110032	RIDDHI	GAJERA	9856321470
201806100110034	ISHA	SAVALIYA	6985741230
201806100110036	RAJ	CHAMPANERIA	7568412300

Insert new record….

(201806100110042, TUSHAR, SAVALIYA, 9825746301)

2. Sequential file organization (Conti…):

2) Sorted file method (Conti…):

After the insertion of new record, we have…..

Enrolment No.	First Name	Last Name	Contact No.
201806100110031	HEMAL	SHAH	9658743210
201806100110032	RIDDHI	GAJERA	9856321470
201806100110042	TUSHAR	SAVALIYA	9825746301
201806100110034	ISHA	SAVALIYA	6985741230
201806100110036	RAJ	CHAMPANERIA	7568412300

Therefore, We can manage deletion of record by using pointer chains, previously.

2. Sequential file organization (Conti…):

2) Sorted file method (Conti…):

❖ Reason to reuse the free space:

- To maintain physical sequential order as records are inserted and deleted.

- And also it is costly to move many records for a single insertion or deletion.

2. Sequential file organization (Conti…):

2) Sorted file method (Conti…):

After sorting the records, we have…..

Enrolment No.	First Name	Last Name	Contact No.
201806100110031	HEMAL	SHAH	9658743210
201806100110032	RIDDHI	GAJERA	9856321470
201806100110034	ISHA	SAVALIYA	6985741230
201806100110036	RAJ	CHAMPANERIA	7568412300
201806100110042	TUSHAR	SAVALIYA	9825746301

Again Insert new record….

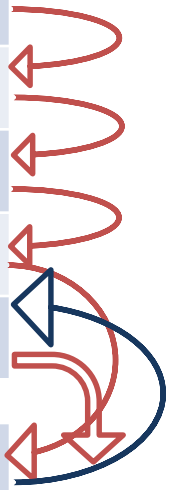
(201806100110038, NIRAV, SAVANI, 7869541230)

2. Sequential file organization (Conti…):

2) Sorted file method (Conti…):

- So, it will first check the search-key of '20180610011038', then it will check whether there is a free space left after 20180610011036. If not, then it will take one ***overflow block***, then with the help of pointers in will sorted.

Enrolment No.	First Name	Last Name	Contact No.
20180610011031	HEMAL	SHAH	9658743210
20180610011032	RIDDHI	GAJERA	9856321470
20180610011034	ISHA	SAVALIYA	6985741230
20180610011036	RAJ	CHAMPANERIA	7568412300
20180610011042	TUSHAR	SAVALIYA	9825746301
20180610011038	NIRAV	SAVANI	7869541230



2. Sequential file organization (Conti…):

2) Sorted file method (Conti…):

After sorting the records, we have…..

Enrolment No.	First Name	Last Name	Contact No.
201806100110031	HEMAL	SHAH	9658743210
201806100110032	RIDDHI	GAJERA	9856321470
201806100110034	ISHA	SAVALIYA	6985741230
201806100110036	RAJ	CHAMPANERIA	7568412300
201806100110038	NIRAV	SAVANI	7869541230
201806100110042	TUSHAR	SAVALIYA	9825746301

2. Sequential file organization:

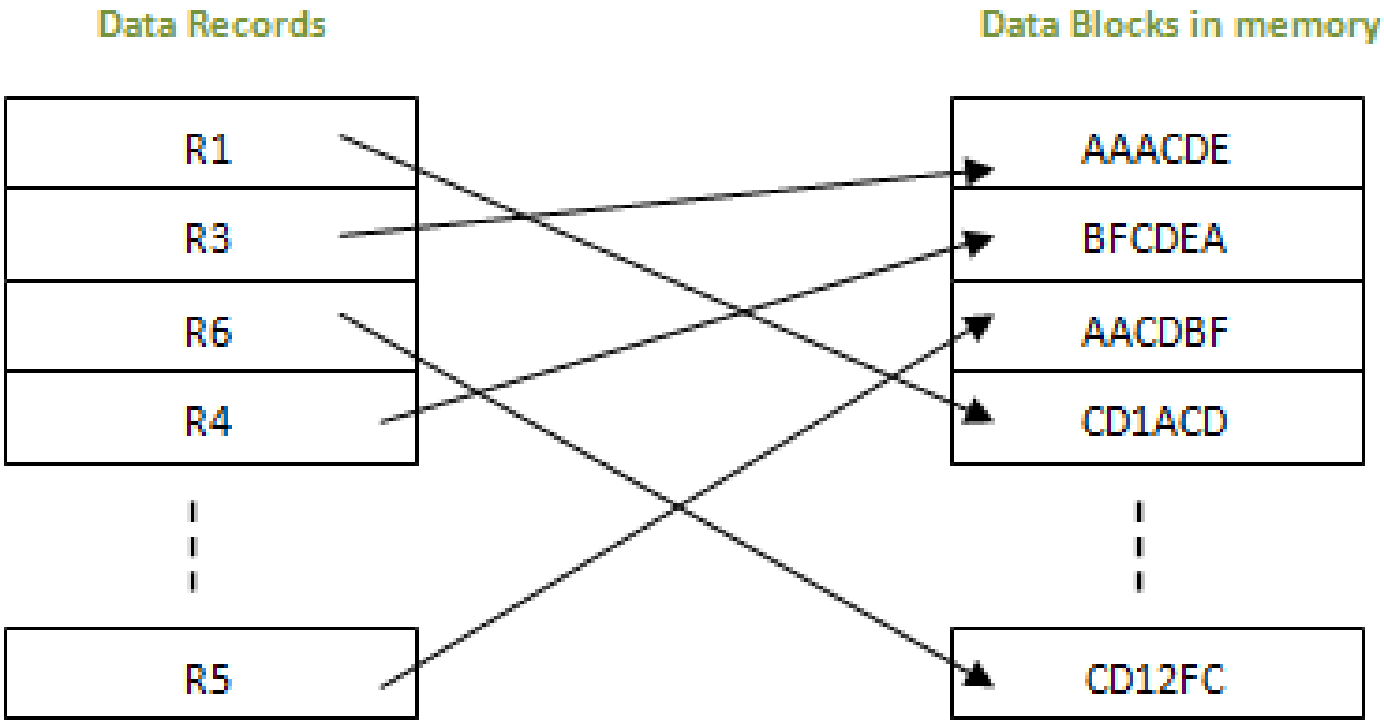
- Therefore, the main used of sequential file is, it permit fast retrieval of records in search-key order using pointers.
- But, if we want jump on a particular record, then that cannot be possible, we have to move record in a sequential manner which takes too much time.
- Since in this file organization, few records need to be stored in overflow blocks, this approach works well.

3. Hashing file organization:

- A hash function is used to calculate the address of the block to store the records.
- It can be any simple or complex mathematical function.
- This function is applied on some columns/attributes to get the block address.
- The result of the hash function specifies in which block of the file, the record should be placed.
- Here, each record is stored randomly in order, so it is also known as ***Direct or Random file organization***.

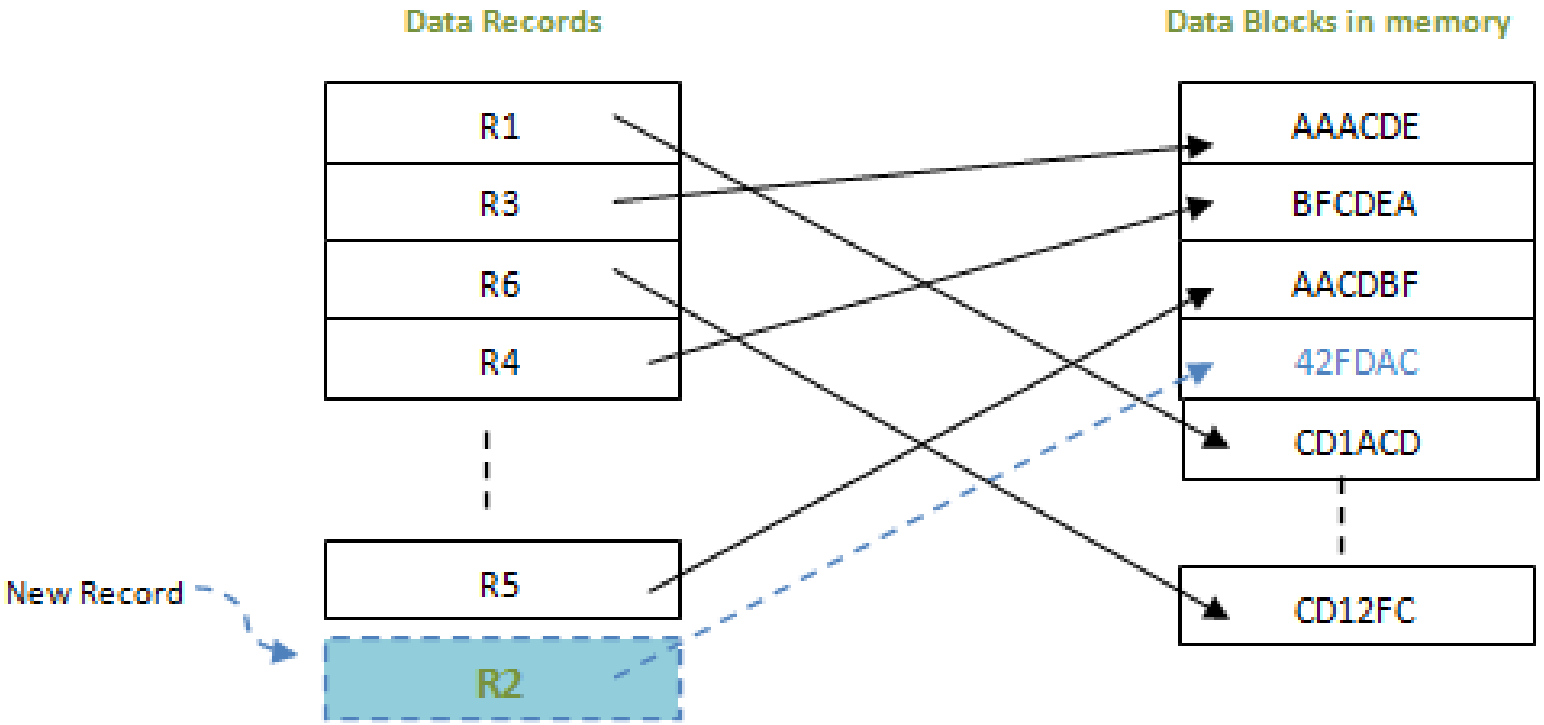
3. Hashing file organization (Conti…):

- For example:



3. Hashing file organization (Conti…):

- When a new record has to be inserted, the address is generated by hash key and record is directly inserted.



Organization of Records in Files (Conti…)

- In all the file organization methods, each file contains single table and are all stored in different ways in the memory.
- In real life situation, retrieving records from single table is comparatively less.
- Most of the cases, we need to combine/join two or more related tables and retrieve the data.
- In such cases, the above all methods will not be faster to give the result.

Organization of Records in Files (Conti…)

- Those methods have to traverse from each table at a time and then combine the results.
- Therefore, it is obvious that the time taken for this is more.

So what could be done to overcome this situation?

::: Solution:::

Multitable Clustering File Organization

Multitable Clustering File Organization

- A multitable clustering file organization is used to store several relations in one file.
- A good for queries involving department and instructor, and for queries involving one single department and its instructors.
- Bad queries involves only department.
- The results in records, can add pointer chains to link records of a particular relation.

Multitable Clustering File Organization (Conti…)

- For example:

Department

dept_name	*building*	*budget*
Comp. Sci.	Taylor	100000
Physics	Watson	70000

Instructor

ID	*name*	*dept_name*	*salary*
10101	Srinivasan	Comp. Sci.	65000
33456	Gold	Physics	87000
45565	Katz	Comp. Sci.	75000
83821	Brandt	Comp. Sci.	92000

Multitable clustering of Department and Instructor

Comp. Sci.	Taylor	100000
45564	Katz	75000
10101	Srinivasan	65000
83821	Brandt	92000
Physics	Watson	70000
33456	Gold	87000

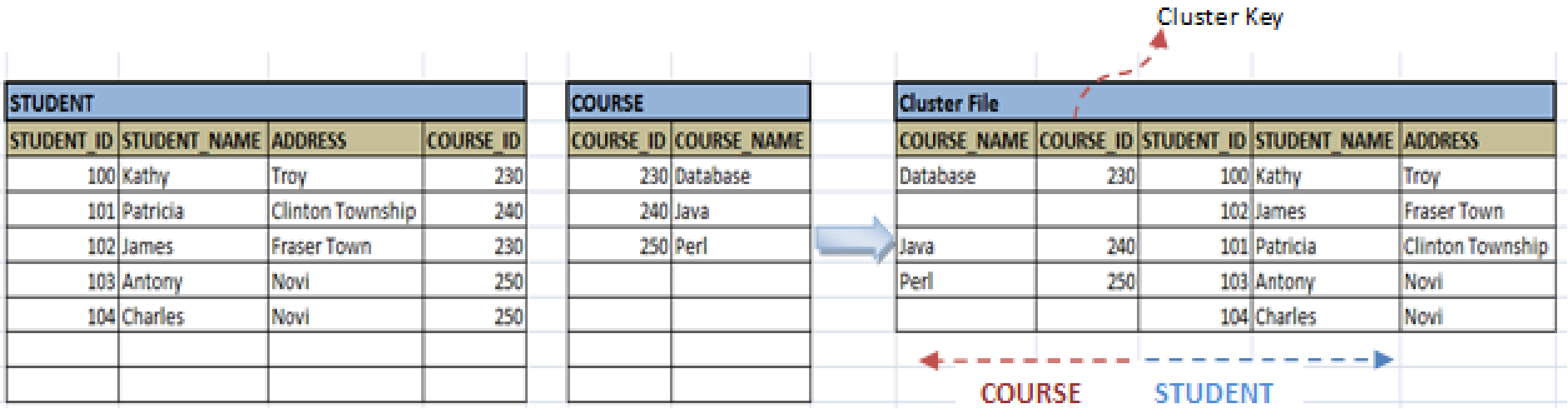
Multitable Clustering File Organization (Conti…)

- For example:

Comp. Sci.	Taylor	100000	
45564	Katz	75000	
10101	Srinivasan	65000	
83821	Brandt	92000	
Physics	Watson	70000	
33456	Gold	87000	

Multitable Clustering File Organization (Conti…)

- For example: If we want to see the students who have taken particular course.



International Certification Question

Q1.	The file organization which allows us to read records that would satisfy the join condition by using one block read is
A.	Heap file organization
B.	Sequential file organization
C.	Clustering file organization
D.	Hash file organization

Ans: C

International Certification Question

Q2.	In …….. file organization, a fixed format is used for records where all records are of the same length, consisting of the same number of fixed length fields in a particular order.
A.	pile
B.	sequential
C.	indexed sequential
D.	indexed

Ans: B

International Certification Question

Q3.	**In which file organization, a record can be placed anywhere in the file, where there is space?**
A.	**Heap**
B.	**Sequential**
C.	**Hash**
D.	**Multitable clustering**

Ans: A

International Certification Question

Q4.	**A _____ is used to calculate the address of the block to store the records.**
A.	**Heap**
B.	**Sequential**
C.	**Hash**
D.	**Multitable clustering**

Ans: C

International Certification Question

Q5.	**In which file organization, each record is stored randomly in order?**
A.	**Heap**
B.	**Sequential**
C.	**Hash**
D.	**Multitable clustering**

Ans: C

Home Work

1. What header contain at the beginning of the each block of information? [2 Marks]
2. What is search key? How pointer is used with search-key? [2 Marks]
3. Explain the several possible ways of organizing records in files. [5 Marks]
4. Write a note on sequential file organization. [5 Marks]

or

4. Explain organization of sequential file in details. [5 Marks]
5. Describe multitable clustering file organization with proper example. [5 Marks]

CE: 1.4
Data Dictionary Storage

Data Dictionary Storage

- The ***Data dictionary*** is also called ***system catalog*** which stores metadata in a structure form.

- Metadata is "data about data", such as…

1. The following types of information that the system must store are:
   - Names of the relations.
   - Names of the attributes of each relation.
   - Domains and lengths of attributes.
   - Names of views defined on the database, and definitions of those views.
   - Integrity constraints (for example, key constraints).

Data Dictionary Storage (Conti…)

2. User and accounting information (including passwords).

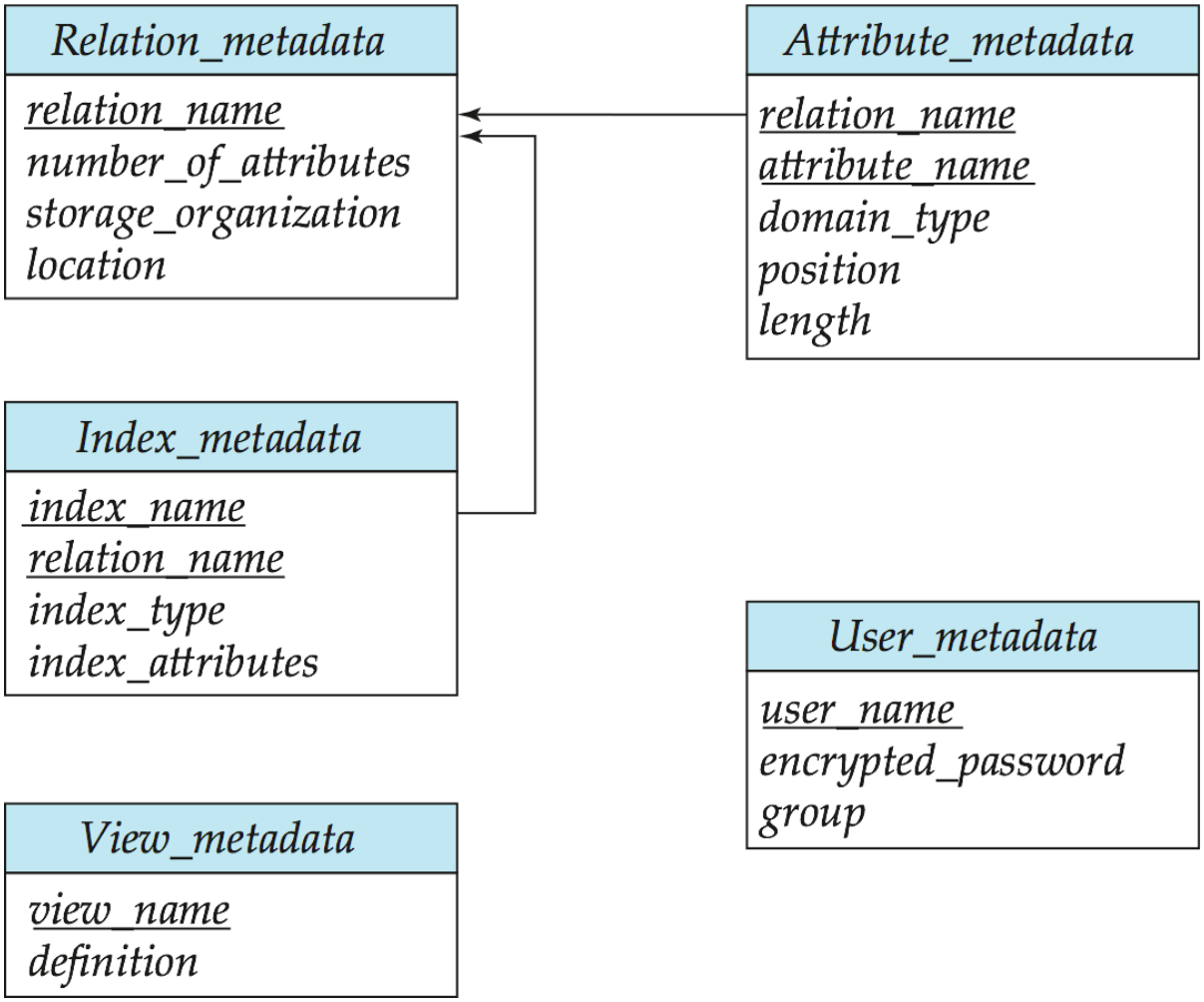
3. Statistical and descriptive data like…
   - number of tuples in each relation

4. Physical file organization information…
   - How relation is stored (sequential/hash/…)
   - Physical location of relation

5. Information about indices, like…
   - Name of the index.
   - Name of the relation being indexed.
   - Attributes on which the index is defined.
   - Type of index formed.

Relational Representation of System Metadata

- Relational representation on disk.
- Specialized data structures designed for efficient access, in memory.



International Certification Question

Q1.	**A relational database system needs to maintain data about the relations, such as the schema of the relations. This is called**
A.	**Metadata**
B.	**Catalog**
C.	**Log**
D.	**Dictionary**

Ans: A

International Certification Question

Q2.	Relational schemas and other metadata about relations are stored in a structure called the _____.
A.	Metadata
B.	Catalog
C.	Log
D.	Data Dictionary

Ans: D

International Certification Question

Q3.	**A data dictionary is created when a _____ is created.**
A.	**Instance**
B.	**Segment**
C.	**Database**
D.	**Dictionary**

Ans: C

Industry Interview Questions

1. What is Data Dictionary?

or

1. What do you meant by system catalog in database?

Home Work

1. Which statistical and descriptive data about the relations may store in database? [1 Mark]
2. What kind of information that must be stored in the database system? [2 Marks]
3. Write necessary information that is to be stored about each index on each of the relations. [2 Marks]

or

3. Which types of information about indices are stored in database system? [2 Marks]
4. Explain Data-Dictionary Storage in detail. [5 Marks]


Thank You