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# DB Fundamentals

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INDEXES

# Indexes

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Indexes are vital to efficiently accessing data

- An Index is a set of attributes whose values are used to control the order of tuple storage

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- An index key may be or may not be the primary key  
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- They are generally chosen based on data columns from a table  
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- The data from these columns may be stored in a separate structure known as an index page
  - Indexes are also stored in the database

# Indexes

## Indexes are vital to efficiently accessing data

- It is like the index of a book in that it is additional to the contents of the base tables
- Example Base Table:

```
SELECT * WHERE  
LastName = 'Goldberg'
```

ID	FirstName	MiddleName	LastName
1	Ken	J	Sanchez
2	Terri	Lee	Duffy
3	Roberto		Tamburello
4	Rob		Walters
5	Gail	A	Erickson
6	Jossef	H	<b>Goldberg</b>

6 Rows to scan  
before Golberg  
is reached

If there is no index, the search for the tuple with LastName = Goldberg needs 6 reads  
Every row must be scanned until the last row is reached and checked

# Indexes

Indexes are vital to efficiently accessing data

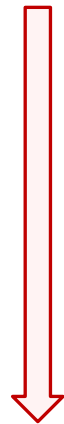
- It is like the index of a book in that it is additional to the contents of the base tables
- Example Index (LastName, FirstName)

INDEX LastName ASC

ID	LastName	FirstName
2	Duffy	Terri
5	Erickson	Gail
6	<b>Goldberg</b>	Jossef
1	Sanchez	Ken
3	Tamburello	Roberto
4	Walters	Rob

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Base Table

ID	FirstName	MiddleName	LastName
1	Ken	J	Sanchez
2	Terri	Lee	Duffy
3	Roberto		Tamburello
4	Rob		Walters
5	Gail	A	Erickson
6	Jossef	H	<b>Goldberg</b>

Now with the (LastName, FirstName) index the search needs only 3 reads

# Indexes

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Indexes are vital to efficiently accessing data

- The size of each index is smaller than the base table
  - This makes it faster to search

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- Multiple indexes can be created for a single base table
  - Indexes are generally created for each type of complex query to speed it up
  - Each index speeds up the search involving the value of the index key only. It is not helpful for searching the values of other attributes
    - In the previous example, the index does not help search on Middle Name
- Indexes are generally stored as binary trees
  - These are efficient for searching

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# Indexes – BTree

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Indexes are vital to efficiently accessing data – they get balanced

- In a balanced tree, the length of the path from the Root Node to every leaf node is the same
- This means access times are constant and optimal

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# Indexes – BTree

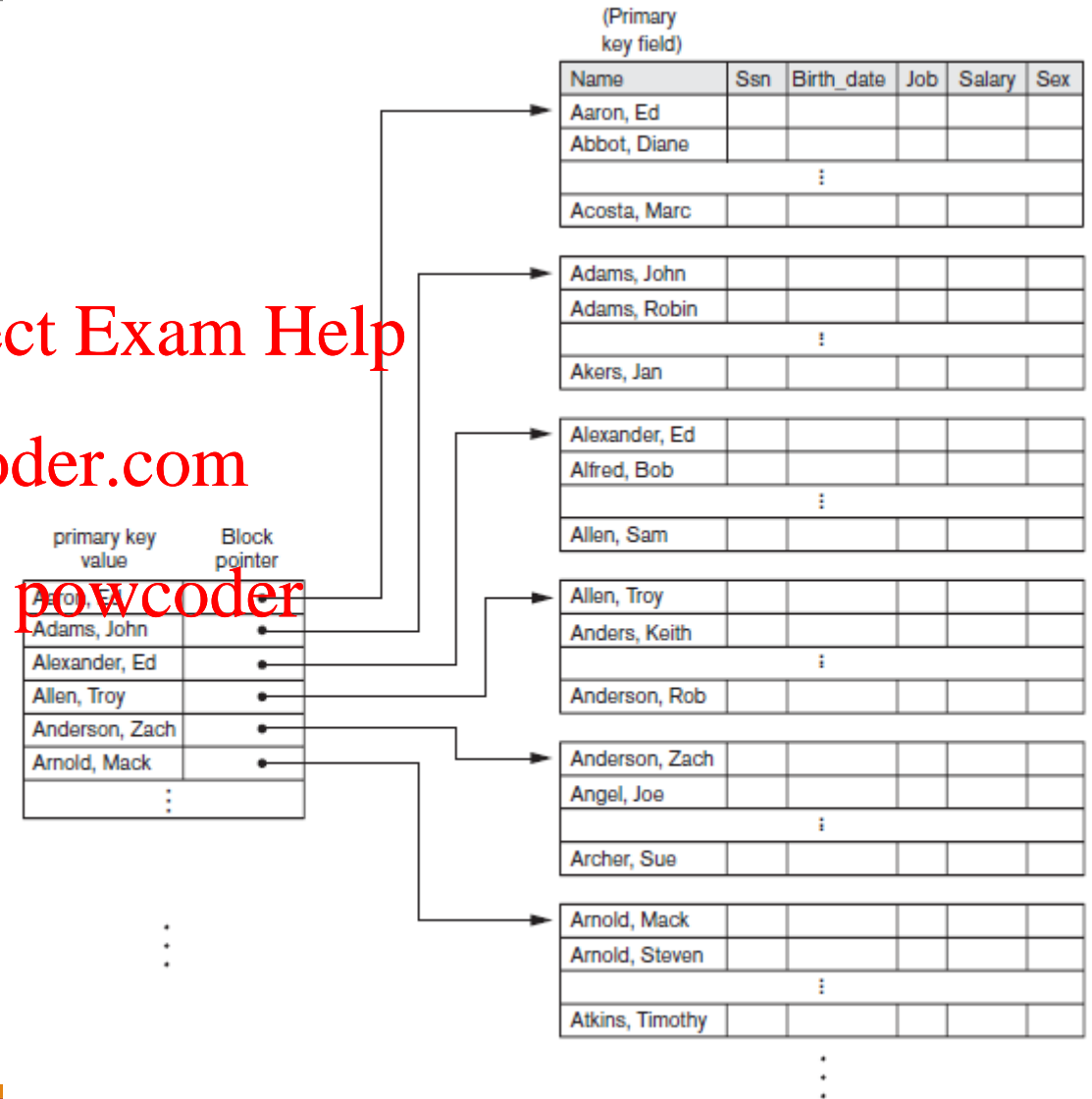
## Indexes are quite complex

- These are covered next year
  - An index can be sparse/dense
- Sparse
  - Only some records may appear in the index
  - The Index points to the actual leaf nodes that contain all the records
- Dense
  - More attribute values in the index (more records to search)

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# Indexes in MS-SQL

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There are two main types of indexes

- **Clustered Indexes**

- The Leaf nodes of the B-Tree contains the actual data rows for the table
- There can only be one clustered index per table
- In MS-SQL this is generally the Primary Key

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- **Non-Clustered Indexes**

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- The Leaf nodes of the B-Tree contain only the index data with a pointer to the associated data page where the remaining data resides
- In MS-SQL these can be alternate keys or just an alternate index to the PK index
- There is also a 3<sup>rd</sup> UNIQUE index type (for implementing alternate keys)



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# Indexes

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CREATING INDEXES SQL

# INDEX – SQL Creation

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-- Creating a PK automatically creates a Clustered Index on that key

```
ALTER TABLE Customers ADD CONSTRAINT PK_Customers Primary  
Key(CustomerID)
```

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-- Add a clustered index that is not the PK

```
CREATE CLUSTERED INDEX Index_Customers ON  
Customers(LastName, FirstName)
```

```
ALTER TABLE Customers ADD CONSTRAINT PK_Customers Primary  
Key(CustomerID)
```

# INDEX – SQL Creation

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-- Put back the standard index/PK (note still not the same)

```
CREATE UNIQUE CLUSTERED INDEX Index_Customers ON  
Customers(CustomerID)
```

```
ALTER TABLE Customers ADD CONSTRAINT PK_Customers  
Primary Key(CustomerID)
```

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-- create non-clustered index

```
CREATE NONCLUSTERED INDEX LNameFName_Customers ON  
Customers(LastName, FirstName);
```

# INDEX – SQL Removal

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-- Drop the Clustered Index

DROP INDEX Index\_Customers ON Customers

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