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# Hierarchical Retrieval

# Objectives

After completing this appendix, you should be able to:

- Interpret the concept of a hierarchical query
- Create a tree-structured report
- Format hierarchical data
- Exclude branches from the tree structure







In this appendix, you learn how to use hierarchical queries to create tree-structured reports.

# Sample Data from the EMPLOYEES Table

| | EMPLOYEE_ID | LAST_NAME | JOB_ID | MANAGER_ID |
|---|---|---|---|---|
| 1 | 100 | King | AD_PRES | (null) |
| 2 | 101 | Kochhar | AD_VP | 100 |
| 3 | 102 | De Haan | AD_VP | 100 |
| 4 | 103 | Hunold | IT_PROG | 102 |
| 5 | 104 | Ernst | IT_PROG | 103 |
| 6 | 107 | Lorentz | IT_PROG | 103 |

. . .

| | | | | |
|---|---|---|---|---|
| 16 | 200 | Whalen | AD_ASST | 101 |
| 17 | 201 | Hartstein | MK_MAN | 100 |
| 18 | 202 | Fay | MK_REP | 201 |
| 19 | 205 | Higgins | AC_MGR | 101 |
| 20 | 206 | Gietz | AC_ACCOUNT | 205 |



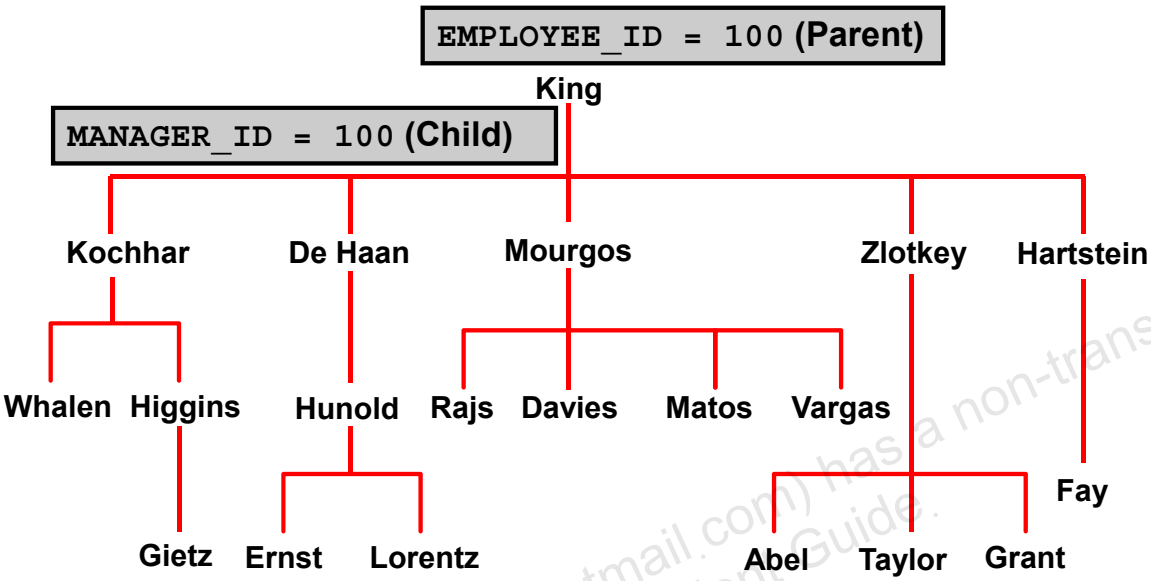
Using hierarchical queries, you can retrieve data based on a natural hierarchical relationship between the rows in a table. A relational database does not store records in a hierarchical way. However, where a hierarchical relationship exists between the rows of a single table, a process called *tree walking* enables the hierarchy to be constructed. A hierarchical query is a method of reporting, with the branches of a tree in a specific order.

Imagine a family tree with the eldest members of the family found close to the base or trunk of the tree and the youngest members representing branches of the tree. Branches can have their own branches, and so on.

A hierarchical query is possible when a relationship exists between rows in a table. For example, in the slide, you see that Kochhar, De Haan, and Hartstein report to `MANAGER_ID` 100, which is King's `EMPLOYEE_ID`.

**Note:** Hierarchical trees are used in various fields such as human genealogy (family trees), livestock (breeding purposes), corporate management (management hierarchies), manufacturing (product assembly), evolutionary research (species development), and scientific research.

# Natural Tree Structure






The `EMPLOYEES` table has a tree structure representing the management reporting line. The hierarchy can be created by looking at the relationship between equivalent values in the `EMPLOYEE_ID` and `MANAGER_ID` columns. This relationship can be exploited by joining the table to itself. The `MANAGER_ID` column contains the employee number of the employee's manager.

The parent/child relationship of a tree structure enables you to control:

- The direction in which the hierarchy is walked
- The starting point inside the hierarchy

**Note:** The slide displays an inverted tree structure of the management hierarchy of the employees in the `EMPLOYEES` table.

# Hierarchical Queries

```
SELECT [LEVEL], column, expr...
FROM   table
[WHERE condition(s)]
[START WITH condition(s)]
[CONNECT BY PRIOR condition(s)] ;
```

*condition*:

```
expr comparison_operator expr
```







## Keywords and Clauses

Hierarchical queries can be identified by the presence of the `CONNECT BY` and `START WITH` clauses.

In the syntax:

| | |
|---|---|
| `SELECT` | Is the standard `SELECT` clause |
| `LEVEL` | For each row returned by a hierarchical query, the `LEVEL` pseudocolumn returns 1 for a root row, 2 for a child of a root, and so on. |
| `FROM` *table* | Specifies the table, view, or snapshot containing the columns. You can select from only one table. |
| `WHERE` | Restricts the rows returned by the query without affecting other rows of the hierarchy |
| *condition* | Is a comparison with expressions |
| `START WITH` | Specifies the root rows of the hierarchy (where to start). This clause is required for a true hierarchical query. |
| `CONNECT BY PRIOR` | Specifies the columns in which the relationship between parent and child `PRIOR` rows exist. This clause is required for a hierarchical query. |

# Walking the Tree



Starting Point

- Specifies the condition that must be met
- Accepts any valid condition

```
START WITH column1 = value
```

Using the EMPLOYEES table, start with the employee whose last name is Kochhar.

```
...START WITH last_name = 'Kochhar'
```



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The row or rows to be used as the root of the tree are determined by the START WITH clause. The START WITH clause can contain any valid condition.

**Examples**

Using the EMPLOYEES table, start with King, the president of the company.

```
... START WITH manager_id IS NULL
```

Using the EMPLOYEES table, start with employee Kochhar. A START WITH condition can contain a subquery.

```
... START WITH employee_id = (SELECT employee_id
                              FROM   employees
                              WHERE  last_name = 'Kochhar')
```

If the START WITH clause is omitted, the tree walk is started with all the rows in the table as root rows.

**Note:** The CONNECT BY and START WITH clauses are not American National Standards Institute (ANSI) SQL standard.

# Walking the Tree

```
CONNECT BY PRIOR column1 = column2
```

Walk from the top down, using the EMPLOYEES table.

```
... CONNECT BY PRIOR employee_id = manager_id
```

**Direction**

Top down → Column1 = Parent Key
Column2 = Child Key

Bottom up → Column1 = Child Key
Column2 = Parent Key

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The direction of the query is determined by the CONNECT BY PRIOR column placement. For top-down, the PRIOR operator refers to the parent row. For bottom-up, the PRIOR operator refers to the child row. To find the child rows of a parent row, the Oracle server evaluates the PRIOR expression for the parent row and the other expressions for each row in the table. Rows for which the condition is true are the child rows of the parent. The Oracle server always selects child rows by evaluating the CONNECT BY condition with respect to a current parent row.

**Examples**

Walk from the top down using the EMPLOYEES table. Define a hierarchical relationship in which the EMPLOYEE_ID value of the parent row is equal to the MANAGER_ID value of the child row:

```
... CONNECT BY PRIOR employee_id = manager_id
```

Walk from the bottom up using the EMPLOYEES table:

```
... CONNECT BY PRIOR manager_id = employee_id
```

The PRIOR operator does not necessarily need to be coded immediately following CONNECT BY. Thus, the following CONNECT BY PRIOR clause gives the same result as the one in the preceding example:

```
... CONNECT BY employee_id = PRIOR manager_id
```

**Note:** The CONNECT BY clause cannot contain a subquery.

# Walking the Tree: From the Bottom Up

```
SELECT employee_id, last_name, job_id, manager_id
FROM   employees
START  WITH  employee_id = 101
CONNECT BY PRIOR manager_id = employee_id ;
```

| | EMPLOYEE_ID | LAST_NAME | JOB_ID | MANAGER_ID |
|---|---|---|---|---|
| 1 | 101 | Kochhar | AD_VP | 100 |
| 2 | 100 | King | AD_PRES | (null) |



The example in the slide displays a list of managers starting with the employee whose employee ID is 101.

# Walking the Tree: From the Top Down

```
SELECT  last_name||' reports to '||
PRIOR   last_name "Walk Top Down"
FROM    employees
START   WITH last_name = 'King'
CONNECT BY PRIOR employee_id = manager_id ;
```

| | Walk Top Down |
|---|---|
| 1 | King reports to |
| 2 | King reports to |
| 3 | Kochhar reports to King |
| 4 | Greenberg reports to Kochhar |
| 5 | Faviet reports to Greenberg |

...

| | |
|---|---|
| 105 | Grant reports to Zlotkey |
| 106 | Johnson reports to Zlotkey |
| 107 | Hartstein reports to King |
| 108 | Fay reports to Hartstein |



Walking from the top down, display the names of the employees and their manager. Use employee King as the starting point. Print only one column.

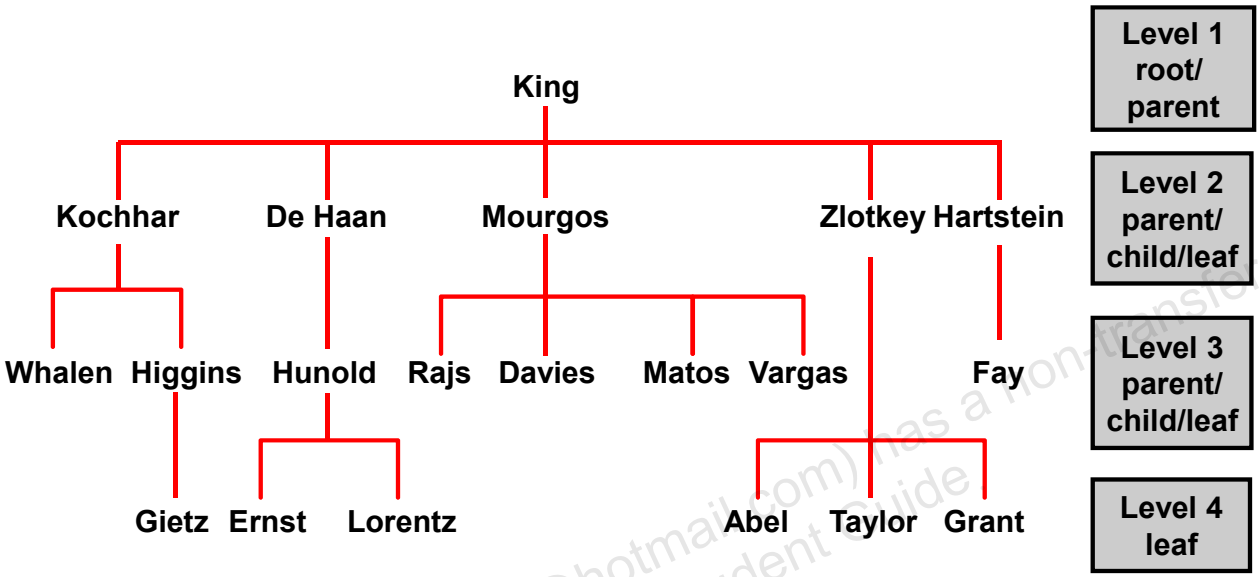
**Example**

In the following example, `EMPLOYEE_ID` values are evaluated for the parent row and `MANAGER_ID` and `SALARY` values are evaluated for the child rows. The `PRIOR` operator applies only to the `EMPLOYEE_ID` value.

```
... CONNECT BY PRIOR employee_id = manager_id
                     AND salary > 15000;
```

To qualify as a child row, a row must have a `MANAGER_ID` value equal to the `EMPLOYEE_ID` value of the parent row and must have a `SALARY` value greater than $15,000.

# Ranking Rows with the LEVEL Pseudocolumn

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You can explicitly show the rank or level of a row in the hierarchy by using the LEVEL pseudocolumn. This will make your report more readable. The forks where one or more branches split away from a larger branch are called nodes, and the very end of a branch is called a leaf or leaf node. The graphic in the slide shows the nodes of the inverted tree with their LEVEL values. For example, employee Higgens is a parent and a child, whereas employee Davies is a child and a leaf.

### LEVEL Pseudocolumn

| Value | Level for Top Down | Level for Bottom up |
|---|---|---|
| 1 | A root node | A root node |
| 2 | A child of a root node | The parent of a root node |
| 3 | A child of a child, and so on | A parent of a parent, and so on |

In the slide, King is the root or parent (LEVEL = 1). Kochhar, De Haan, Mourgos, Zlotkey, Hartstein, Higgens, and Hunold are children and also parents (LEVEL = 2). Whalen, Rajs, Davies, Matos, Vargas, Gietz, Ernst, Lorentz, Abel, Taylor, Grant, and Fay are children and leaves (LEVEL = 3 and LEVEL = 4).

**Note:** A *root node* is the highest node within an inverted tree. A *child node* is any nonroot node. A parent node is any node that has children. A leaf node is any node without children. The number of levels returned by a hierarchical query may be limited by available user memory.

# Formatting Hierarchical Reports Using LEVEL and LPAD

Create a report displaying company management levels, beginning with the highest level and indenting each of the following levels.

```
COLUMN org_chart FORMAT A12
SELECT LPAD(last_name, LENGTH(last_name)+(LEVEL*2)-2,'_')
       AS org_chart
FROM   employees
START WITH first_name='Steven' AND last_name='King'
CONNECT BY PRIOR employee_id=manager_id
```







The nodes in a tree are assigned level numbers from the root. Use the `LPAD` function in conjunction with the `LEVEL` pseudocolumn to display a hierarchical report as an indented tree.

In the example in the slide:

- `LPAD(char1,n [,char2])` returns *char1*, left-padded to length *n* with the sequence of characters in *char2*. The argument *n* is the total length of the return value as it is displayed on your terminal screen.
- `LPAD(last_name, LENGTH(last_name)+(LEVEL*2)-2,'_')` defines the display format
- *char1* is the `LAST_NAME`, *n* the total length of the return value, is length of the `LAST_NAME` + `(LEVEL*2)-2`, and *char2* is `'_'`

That is, this tells SQL to take the `LAST_NAME` and left-pad it with the `'_'` character until the length of the resultant string is equal to the value determined by `LENGTH(last_name)+(LEVEL*2)-2`.

For King, `LEVEL = 1`. Therefore, (2 * 1) – 2 = 2 – 2 = 0. So King does not get padded with any `'_'` character and is displayed in column 1.

For Kochhar, `LEVEL = 2`. Therefore, (2 * 2) – 2 = 4 – 2 = 2. So Kochhar gets padded with 2 `'_'` characters and is displayed indented.

The rest of the records in the `EMPLOYEES` table are displayed similarly.

| | ORG_CHART |
|---|---|
| 1 | King |
| 2 | __Kochhar |
| 3 | ____Greenberg |
| 4 | ______Faviet |
| 5 | ______Chen |
| 6 | ______Sciarra |
| 7 | ______Urman |
| 8 | ______Popp |
| 9 | ____Whalen |
| 10 | ____Mavris |
| 11 | ____Baer |
| 12 | ____Higgins |
| 13 | ______Gietz |
| 14 | __De Haan |
| 15 | ____Hunold |
| 16 | ______Ernst |
| 17 | ______Austin |

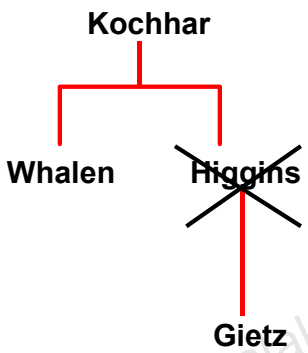
# Pruning Branches

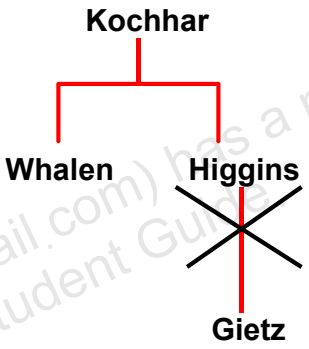
Use the `WHERE` clause to eliminate a node.

Use the `CONNECT BY` clause to eliminate a branch.

```
WHERE last_name != 'Higgins'
```

```
CONNECT BY PRIOR
employee_id = manager_id
AND last_name != 'Higgins'
```






You can use the `WHERE` and `CONNECT BY` clauses to prune the tree (that is, to control which nodes or rows are displayed). The predicate you use acts as a Boolean condition.

**Examples**

Starting at the root, walk from the top down, and eliminate employee Higgins in the result, but process the child rows.

```
SELECT  department_id, employee_id,last_name, job_id, salary
FROM    employees
WHERE   last_name  != 'Higgins'
START   WITH manager_id IS NULL
CONNECT BY PRIOR employee_id = manager_id;
```

Starting at the root, walk from the top down, and eliminate employee Higgins and all child rows.

```
SELECT  department_id, employee_id,last_name, job_id, salary
FROM    employees
START   WITH manager_id IS NULL
CONNECT BY PRIOR employee_id = manager_id
AND     last_name != 'Higgins';
```

# Summary

In this appendix, you should have learned how to:

- Use hierarchical queries to view a hierarchical relationship between rows in a table
- Specify the direction and starting point of the query
- Eliminate nodes or branches by pruning







You can use hierarchical queries to retrieve data based on a natural hierarchical relationship between rows in a table. The `LEVEL` pseudocolumn counts how far down a hierarchical tree you have traveled. You can specify the direction of the query using the `CONNECT BY PRIOR` clause. You can specify the starting point using the `START WITH` clause. You can use the `WHERE` and `CONNECT BY` clauses to prune the tree branches.