

B⁺Tree

A mechanism to drive existing B⁺Trees to do Join Internally.

RDBMS challenges

Performance has been always a challenge for relational databases. A major problem with relational database that a good schema requires many tables in relation between them, and in consequence the calculation of many joins to satisfy the queries.

DBA spends lots of time to tune the database. Some database schemas are not in BCNF just to avoid some joins. Also some materialized views are just to avoid it. Star Schema born from the fact that joining is complex and to simplify joins.

Standard indexes

The standard indexes used in relational databases are B⁺tree, hashed keys and bitmap indexes but the problem all suffers from some restrictions.

B⁺tree have among others the fact that it work just on one table.

Hashed keys are very fast but they require a full key lookup, a perfect match, and a unique identifying value.

Bitmap is also good but it has a limit on the number of different values a column can have.

Bitmap Join Index & Materialized Views

Bitmap join index is efficient but is not general; it is based on Star Schema. Has a lots of bitmap arrays depending on the size of the dimensions tables.

Materialized Views are redundant. No one use Materialized View to order a table, because index is the more natural way. Also B⁺Tree index is the more natural way to get the join.

B[⋈]TREE Overview

B[⋈]tree is a new index technology that is based on B⁺tree that pre-join the tables inside it.

B[⋈]tree uses “Virtual Tables” and “Join Path Lists” to make pre-join internally, so it doesn't use the multidimensional index technique with the benefit of more easier and more concise algorithm, no limit for the number of tables in join and easy use: the same way as a native B⁺tree.

Given n Tables in join, scanning the B[⋈]tree return a set of pointers for the rows in join for any possible combination of tables in join.

B \bowtie TREE Index

To understand how B \bowtie TREE Index works let see what happens when we insert a new Row R_m from Table T_i into the database.

Suppose that table T_i is in Direct Join with a table T_k , we have to look for all the Rows $R_n \dots R_z$ in T_k that satisfy the join condition with R_m and insert Rows references to $R_m R_n \dots R_m R_z$ in the virtual table T_{ik} .

The process should be repeated for $R_m R_n \dots R_m R_z$ with a table in join at least with one of the base tables constituting the Virtual Join Table T_{ij} and so on until we scan a path in the sequence of tables in join.

Transformation of Existing B+Tree

•The internal definition for the creation of a B+Tree take in consideration the following:

- Name of B+Tree index follow by an index
- Number of base tables constituting the virtual table indexed by the B+Tree
- Length and type of Keys
- Length and type of Inherited Keys (They are supplementary fields inserted in the B+Tree but they are not part of the key and they are not used for comparison)

• Declare the page of B+Tree as a buffer of bytes and divide it as needed. Many existing B+Tree follow this technique to support different type of multiple columns Key.

•The Leaf Page structure consists of:

- Pointer to the previous sibling page
- number of elements in which everyone consists of:
 - Space for the columns forming the keys
 - Space for the Data Pointers (Row Ids) to reference the Row in every table
 - Space for the columns forming the Inherited Keys
- Pointer to the next sibling Page

Transformation of Existing B+Tree (continue)

- **The Non Leaf Page structure consists of:**

- Pointer to a child page which key values are smaller than all the keys in the page
- number of elements in which everyone consists of:
 - Space for the columns forming the keys
- Pointer to a child page which key values are bigger than all the keys in the page

- **Due to the fact that many join keys are duplicates, change has been made for the duplicates in the sense when 2 keys are equals, we consider the data references for them. The B+Tree keeps these possibly duplicated keys separate internally by combining the unique sequence of data references with each key. The process of combination is done logically, and requires no additional space for key storage.**

Transformation of Existing B+Tree (continue)

Many advanced B+Tree in the market use (Key, Data Reference) combination to refer to unique Row eliminating duplicates internally and use additional fields others than the one forming the key to avoid access to the table.

So for those B+Trees, the only modification is instead of space of one Data Reference is a space for multiple Data Reference space.

Definitions

- Base Table:

Base tables are database objects whose structure and the data they contain are both on disk.

- Virtual Table:

Virtual tables are tables whose contents are derived from base tables. Only its definition (base tables Names constituting it) is stored on disk.

Definitions

Direct Join:

Two tables are in Direct Join if there is a link between them (in other sense if there is common columns between them).

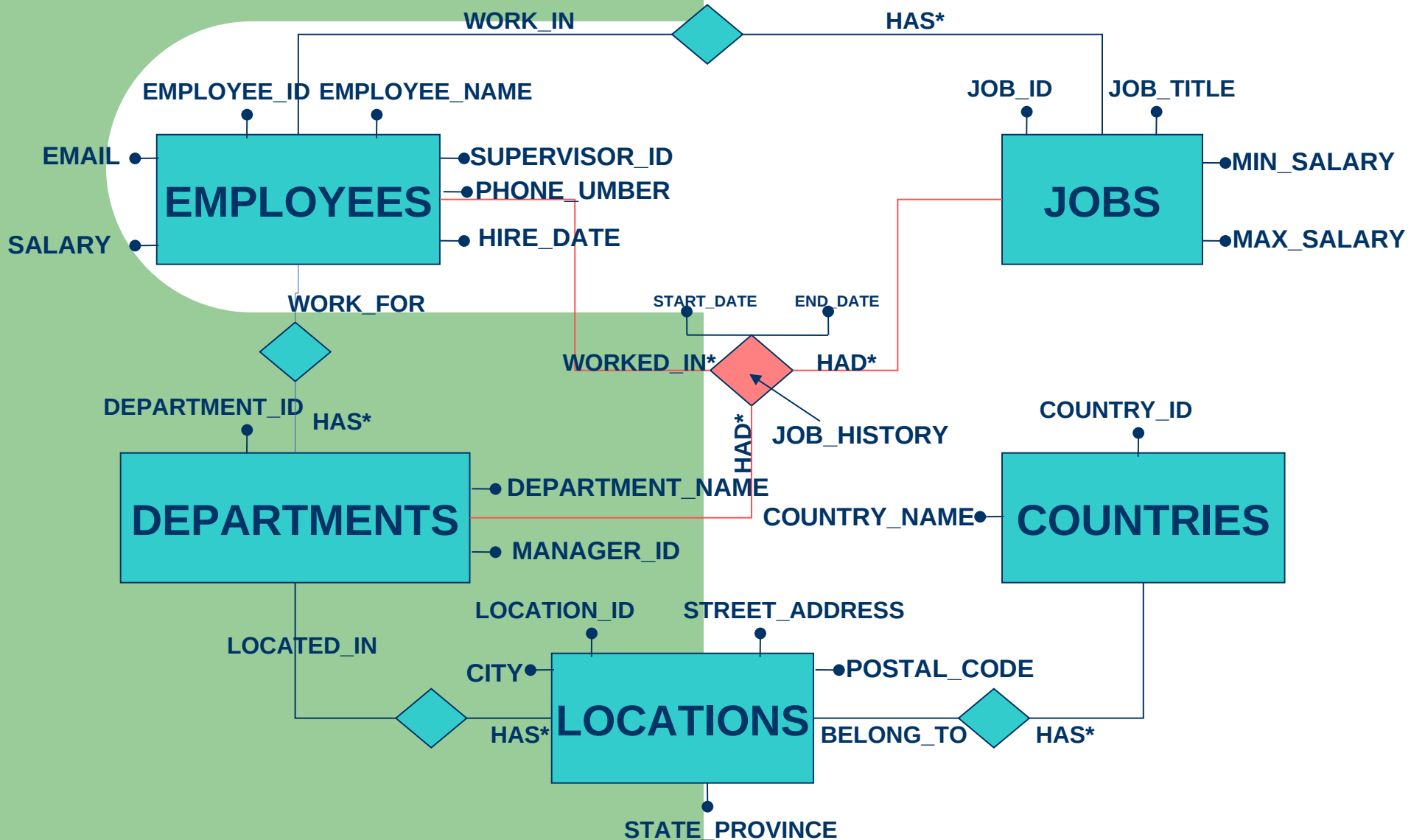
Join Graph:

A graph representing direct join between tables.

Adjacency List:

List for every table T_i in the database all those tables in direct Join with it.

Example:



Transforming the entity relationship schema into the relational model, we get the following tables:

```
CREATE TABLE EMPLOYEES
```

```
(
```

```
    EMPLOYEE_ID INT NOT NULL,  
    EMPLOYEE_NAME VARCHAR(35),  
    EMAIL VARCHAR(25),  
    PHONE_NUMBER VARCHAR(20),  
    HIRE_DATE DATE,  
    SUPERVISOR_ID INT NOT NULL,  
    JOB_ID VARCHAR(10),  
    SALARY NUMERIC(8,2),  
    DEPARTMENT_ID VARCHAR(3)
```

```
);
```

```
CREATE TABLE JOB_HISTORY
```

```
(
```

```
    EMPLOYEE_ID INT,  
    START_DATE DATE,  
    END_DATE DATE,  
    DEPARTMENT_ID VARCHAR(3),  
    JOB_ID VARCHAR(10)
```

```
);
```

```
CREATE TABLE JOBS
```

```
(
```

```
    JOB_ID VARCHAR(10),  
    JOB_TITLE VARCHAR(35),  
    MIN_SALARY DOUBLE,  
    MAX_SALARY DOUBLE
```

```
);
```

CREATE TABLE DEPARTMENTS

```
(  
    DEPARTMENT_ID VARCHAR(3),  
    DEPARTMENT_NAME VARCHAR(30),  
    MANAGER_ID INT,  
    LOCATION_ID INT  
);
```

CREATE TABLE LOCATIONS

```
(  
    LOCATION_ID INT,  
    STREET_ADDRESS VARCHAR(40),  
    POSTAL_CODE VARCHAR(12),  
    CITY VARCHAR(30),  
    STATE_PROVINCE VARCHAR(25),  
    COUNTRY_ID CHAR(2)  
);
```

CREATE TABLE COUNTRIES

```
(  
    COUNTRY_ID CHAR(2),  
    COUNTRY_NAME VARCHAR(40)  
);
```

The join for the example (A) going step by step over is the following:

List where every employee have been worked before along with the department that he is working now:

```
CREATE JOIN INDEX RECENT_IDX
```

```
ON      EMPLOYEES(LAST_NAME), DEPARTMENTS, JOBS, JOB_HISTORY, LOCATIONS, COUNTRIES
WHERE   EMPLOYEES.EMPLOYEE_ID = JOB_HISTORY.EMPLOYEE_ID
AND     JOBS.JOB_ID = JOB_HISTORY.JOB_ID
AND     EMPLOYEES.DEPARTMENT_ID = DEPARTMENTS.DEPARTMENT_ID
AND     DEPARTMENTS.LOCATION_ID = LOCATIONS.LOCATION_ID
AND     LOCATIONS.COUNTRY_ID = COUNTRIES.COUNTRY_ID;
```

```
SELECT EMPLOYEES.EMPLOYEE_NAME,
```

Example A

```
      JOBS.JOB_TITLE AS JOB_TITLE,
      DEPARTMENTS.DEPARTMENT_NAME AS DEPARTMENT_NAME,
      COUNTRIES.COUNTRY_NAME AS COUNTRY_NAME
FROM   EMPLOYEES, JOB_HISTORY, DEPARTMENTS,
      LOCATIONS, JOBS, COUNTRIES
WHERE  EMPLOYEES.EMPLOYEE_ID = JOB_HISTORY.EMPLOYEE_ID
AND    JOBS.JOB_ID = JOB_HISTORY.JOB_ID
AND    EMPLOYEES.DEPARTMENT_ID = DEPARTMENTS.DEPARTMENT_ID
AND    DEPARTMENTS.LOCATION_ID = LOCATIONS.LOCATION_ID
AND    LOCATIONS.COUNTRY_ID = COUNTRIES.COUNTRY_ID;
```

This is another join for the example (B) on the same tables:

List where every employee have been worked before along with the department that he is working before:

```
CREATE JOIN INDEX HISTORY_IDX
```

```
ON      EMPLOYEES(LAST_NAME), DEPARTMENTS, JOBS, JOB_HISTORY, LOCATIONS, COUNTRIES
WHERE   EMPLOYEES.EMPLOYEE_ID = JOB_HISTORY.EMPLOYEE_ID
AND     JOBS.JOB_ID = JOB_HISTORY.JOB_ID
AND     JOB_HISTORY.DEPARTMENT_ID = DEPARTMENTS.DEPARTMENT_ID
AND     DEPARTMENTS.LOCATION_ID = LOCATIONS.LOCATION_ID
AND     LOCATIONS.COUNTRY_ID = COUNTRIES.COUNTRY_ID;
```

```
SELECT EMPLOYEES.FIRST_NAME +
```

Example B

```
    EMPLOYEES.LAST_NAME AS NAME,
    JOBS.JOB_TITLE AS JOB_TITLE,
    DEPARTMENTS.DEPARTMENT_NAME AS DEPARTMENT_NAME,
    COUNTRIES.COUNTRY_NAME AS COUNTRY_NAME
FROM    JOB_HISTORY, DEPARTMENTS,
        LOCATIONS, JOBS, COUNTRIES, EMPLOYEES
WHERE   EMPLOYEES.EMPLOYEE_ID = JOB_HISTORY.EMPLOYEE_ID
AND     JOBS.JOB_ID = JOB_HISTORY.JOB_ID
AND     JOB_HISTORY.DEPARTMENT_ID = DEPARTMENTS.DEPARTMENT_ID
AND     DEPARTMENTS.LOCATION_ID = LOCATIONS.LOCATION_ID
AND     LOCATIONS.COUNTRY_ID = COUNTRIES.COUNTRY_ID;
```


Generating Join Graph

- Base Tables represent the vertexes of the Join Graph.
- Due to the fact that join is commutative, for every pair of tables in direct join between them as defined by DBA create an undirected edge to link them.
- It is very easy to know which tables are in direct join with others tables from the definition of common columns between them.

The algorithm for generating the Linked List representation of the join Graph is the following:

generateJoinGraph (in BaseTables; out JoinGraph)

insert the base tables as vertexes of the graph

for every direct join between 2 tables T_i and T_k where T_i is the table of order i and T_k is the table of order k as defined by the DBA do

 AdjacentList[T_i] += T_k follow by the common key

 AdjacentList[T_k] += T_i follow by the common key

This function is different from the one in BjoinTree.pas because this one is simplified for the example and the other is general.

→ generateJoinGraph (in BaseTables; out JoinGraph)
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Base Tables

| Employees | Job_History | Jobs | Departments | Locations | Countries |
|-----------|-------------|------|-------------|-----------|-----------|
| 0 | 1 | 2 | 3 | 4 | 5 |

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Employees

Job_History

Jobs

Departments

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| 0 | 1 | 2 | 3 | 4 | 5 |

| | |
|-------------|---------------------------|
| Employees | → Job_History Employee_Id |
| Job_History | |
| Jobs | |
| Departments | |
| Locations | |
| Countries | |

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| | | | | | |
|-------------|---|-------------|-------------|-------------|---------------|
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| Job_History | → | Employees | Employee_Id | | |
| Jobs | | | | | |
| Departments | | | | | |
| Locations | | | | | |
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| Job_History | → Employees | Employee_Id | | |
| Jobs | | | | |
| Departments | → Employees | Department_Id | | |
| Locations | | | | |
| Countries | | | | |

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| Employees | → | Job_History | Employee_Id | Departments | Department_Id |
|-------------|---|-------------|---------------|-------------|---------------|
| Job_History | → | Employees | Employee_Id | Jobs | Job_Id |
| Jobs | | | | | |
| Departments | → | Employees | Department_Id | | |
| Locations | | | | | |
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| Job_History | → Employees | Employee_Id | Jobs | Job_Id |
| Jobs | → Job_History | Job_Id | | |
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Base Tables

The diagram illustrates the mapping of table indices to names and their join relationships. A horizontal table at the top lists the tables in order: Employees (0), Job_History (1), Jobs (2), Departments (3), Locations (4), and Countries (5). Below this, a vertical list on the left shows each table name. To the right of each name, arrows point to the tables it joins, with the common key highlighted in green. The join relationships are: Employees joins Job_History (Employee_Id) and Departments (Department_Id); Job_History joins Employees (Employee_Id) and Jobs (Job_Id); Jobs joins Job_History (Job_Id); Departments joins Employees (Department_Id). Locations and Countries have no joins shown.

| Employees | Job_History | Jobs | Departments | Locations | Countries |
|-----------|-------------|------|-------------|-----------|-----------|
| 0 | 1 | 2 | 3 | 4 | 5 |

| | | | | |
|-------------|---------------|---------------|-------------|---------------|
| Employees | → Job_History | Employee_Id | Departments | Department_Id |
| Job_History | → Employees | Employee_Id | Jobs | Job_Id |
| Jobs | → Job_History | Job_Id | | |
| Departments | → Employees | Department_Id | | |
| Locations | | | | |
| Countries | | | | |

generateJoinGraph (in BaseTables; out JoinGraph)

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Base Tables

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|-------------|---------------|---------------|-------------|---------------|-----------|
| 0 | 1 | 2 | 3 | 4 | 5 |
| Employees | → Job_History | Employee_Id | Departments | Department_Id | |
| Job_History | → Employees | Employee_Id | Jobs | Job_Id | |
| Jobs | → Job_History | Job_Id | | | |
| Departments | → Employees | Department_Id | Locations | Location_Id | |
| Locations | | | | | |
| Countries | | | | | |

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| | | | | | |
|-------------|---------------|---------------|-------------|---------------|--|
| Employees | → Job_History | Employee_Id | Departments | Department_Id | |
| Job_History | → Employees | Employee_Id | Jobs | Job_Id | |
| Jobs | → Job_History | Job_Id | | | |
| Departments | → Employees | Department_Id | Locations | Location_Id | |
| Locations | → Departments | Location_Id | | | |
| Countries | | | | | |

generateJoinGraph (in BaseTables; out JoinGraph)

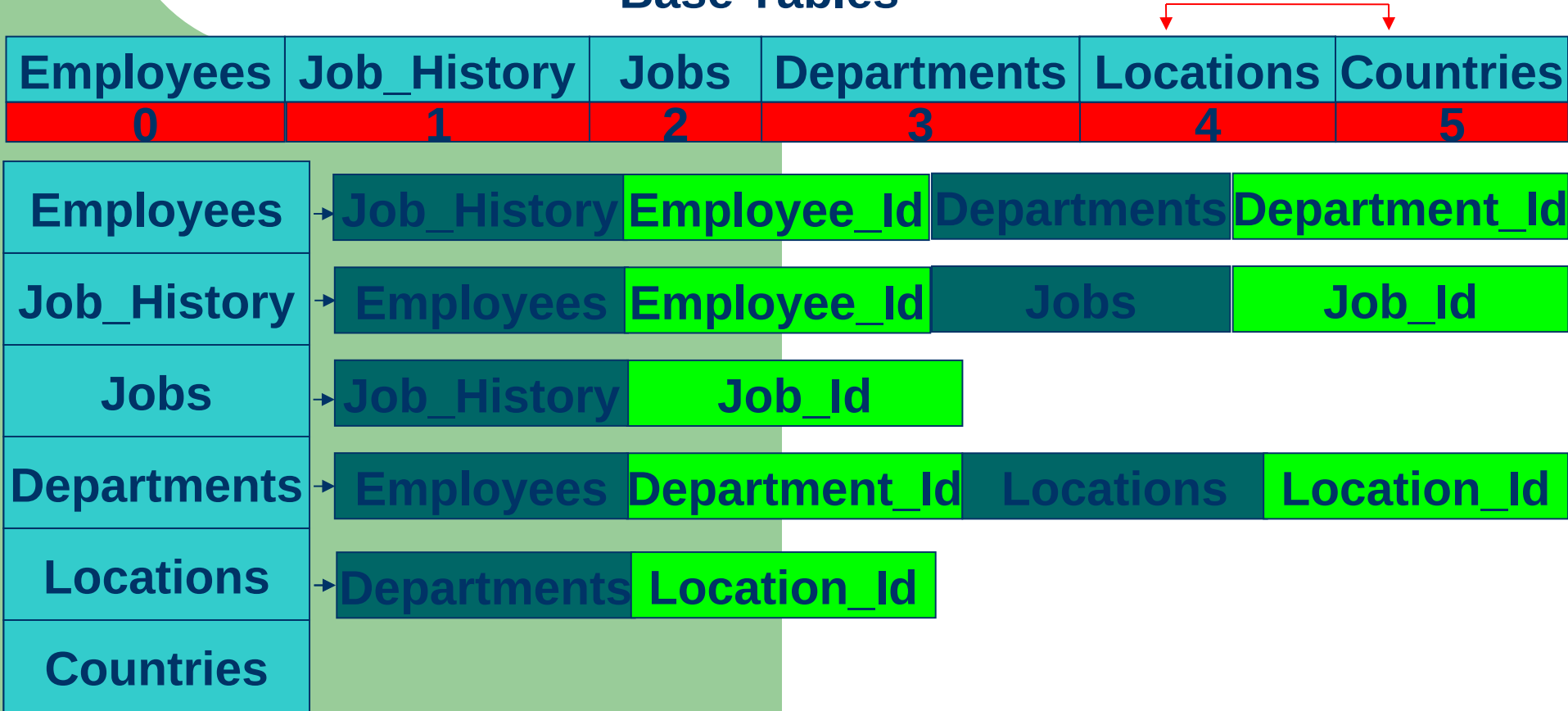
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Base Tables

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| Jobs | → Job_History | Job_Id | | | |
| Departments | → Employees | Department_Id | Locations | Location_Id | |
| Locations | → Departments | Location_Id | Countries | Country_Id | |
| Countries | | | | | |

generateJoinGraph (in BaseTables; out JoinGraph)

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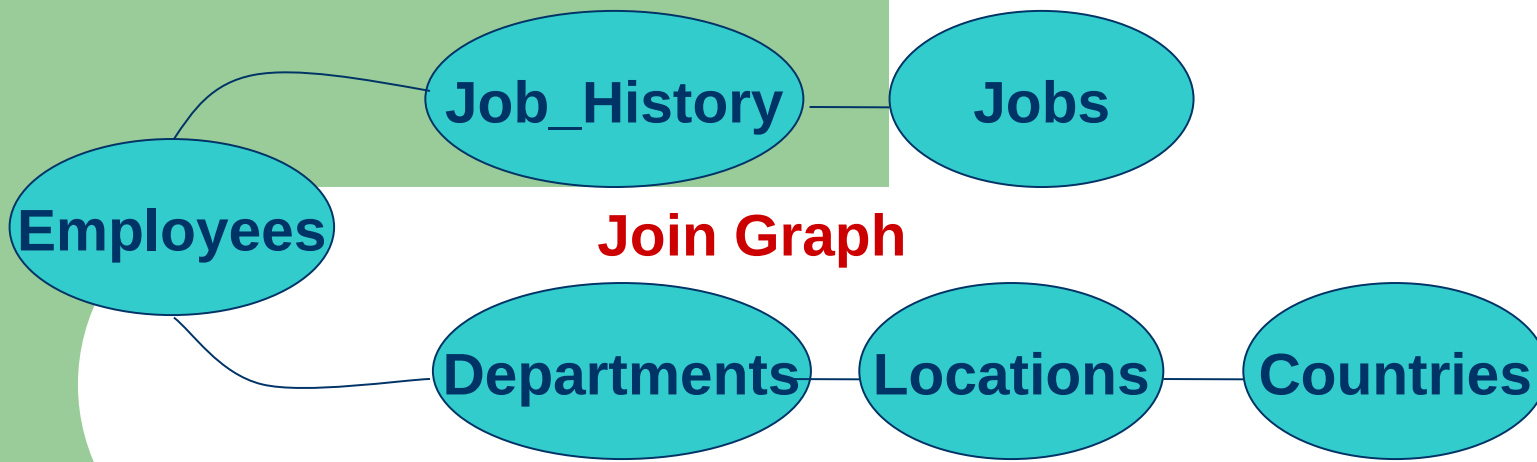
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Base Tables

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| Job_History | → Employees | Employee_Id | Jobs | Job_Id | |
| Jobs | → Job_History | Job_Id | | | |
| Departments | → Employees | Department_Id | Locations | Location_Id | |
| Locations | → Departments | Location_Id | Countries | Country_Id | |
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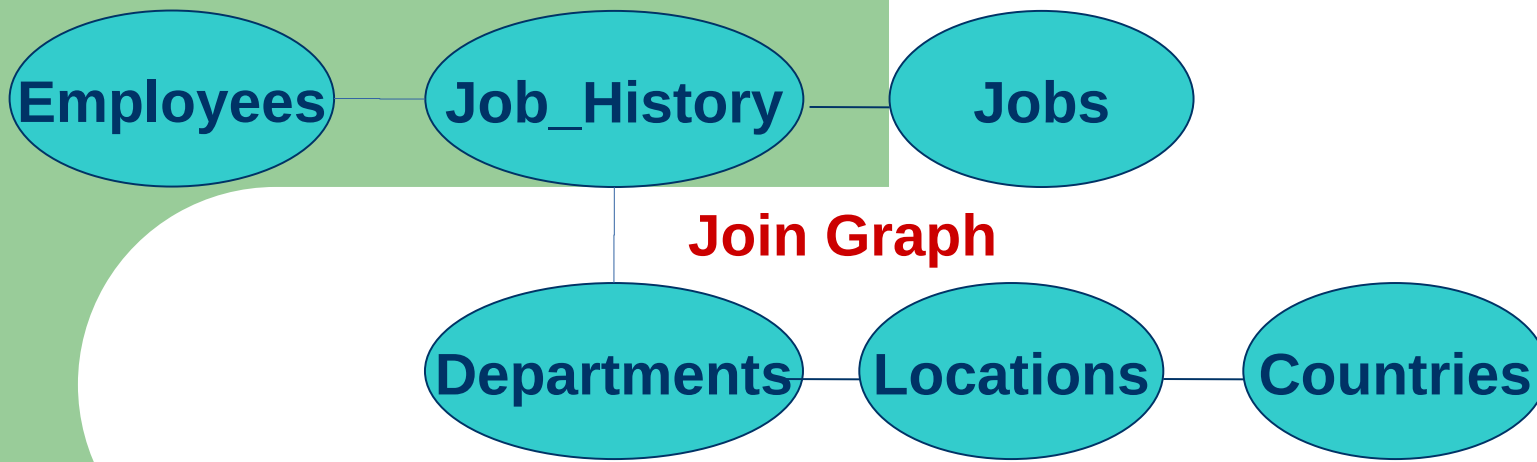


Example A

Linked List representation of the Join Graph

| | | | | | |
|-------------|---|-------------|---------------|-------------|---------------|
| Employees | → | Job_History | Employee_Id | Departments | Department_Id |
| Job_History | → | Employees | Employee_Id | Jobs | Job_Id |
| Jobs | → | Job_History | Job_Id | | |
| Departments | → | Employees | Department_Id | Locations | Location_Id |
| Locations | → | Departments | Location_Id | Countries | Country_Id |
| Countries | → | Locations | Country_Id | | |

Adjacency List



Join Graph

Example B

Linked List representation of the Join Graph

| | | | | |
|-------------|---|-------------|---------------|---|
| Employees | → | Job_History | Employee_Id | |
| Job_History | → | Employees | Employee_Id | Jobs Job_Id DepartmentsDepartment_Id |
| Jobs | → | Job_History | Job_Id | |
| Departments | → | Job_History | Department_Id | Locations Location_Id |
| Locations | → | Departments | Location_Id | Countries Country_Id |
| Countries | → | Locations | Country_Id | |

Adjacency List

Definition

Join Path List:

A sequence of tables $T_0 \dots T_{n-1}$ is in the Join Path List if every T_i of them is at least in direct join with another table in the sequence.

Notation

- When index i is not between brackets like in T_i , it represent a base table T_i .
- When index i is between brackets like in $T_{[i]}$, it represent a base table T_i or a virtual table in which index i represent a set of indexes for the base tables forming the virtual table.

Steps to generate function: $\text{Key}(T_{[j]})$ $\text{getFirstAdjacentListKey}(T_{[j]}, T_{[k]})$

for every Base Table T_i in $T_{[j]}$ do

 Take one at a time

 for every $T_{\text{Link}(l)}$ do

 Take one at a time

 if $T_{\text{Link}(l)}$ in $T_{[k]}$ then

 return($\text{key}(T_i, T_{\text{Link}(l)})$)

Normally one of the 2 tables $T_{[j]}$ or $T_{[k]}$ is a base table this is why we stop after founding the key.

Key could be a one column key or multicolumn key that satisfy the join condition.

Steps to generate Join Path List for the join sequence $T_0 \dots T_m$

let $T_0 \dots T_m$ be the base tables

create 2 dynamic arrays queue and path

insert T_0 into path

insert T_0 into queue

repeat

T_{Element} = First Table in queue

 for every Link Item in Adjacent Link of T_{Element} from the Join Graph do

 if the Link Item is in the join sequence then

 if path doesn't contain the Link Item then

 insert Link Item into path

 insert Link Item into queue

 remove T_{Element} from queue

until queue is empty

Steps to generate Join Path List for the join sequence $T_0 \dots T_m$ (continue)

insert all the names of base tables from path as vertexes in the JoinPathList

create a local buffer buf

insert into buf the first entry from path

for all the remainder entries in path do

take one T_i at a time

$\text{PathJoinAdjacentList}(T_i) = T_{[\text{buf}]}$

$\text{Key}(T_i) = \text{getFirstAdjacentListKey}(T_i, T_{[\text{buf}]})$

$\text{PathJoinAdjacentList}(T_{[\text{buf}]}) = T_i$

$\text{Key}(T_{[\text{buf}]}) = \text{getFirstAdjacentListKey}(T_{[\text{buf}]}, T_i)$

$T_{[\text{buf}]} \oplus = T_i$

$\text{Insert NodeList}[T_{[\text{buf}]}] = T_{[\text{buf}]}$

Steps to generate Join Path List for the join sequence $T_0 \dots T_m$ (continue)

```
create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
    take one  $T_{[i]}$  at a time
    for all Base Tables in  $T_{[i]}$  do
        take one  $T_k$  at a time
        for every buf.Table =  $T_k$  do
            if (buf.key != Key( $T_{[i]}$ ) ) and (buf.Key not in InheritedKey( $T_{[i]}$ )) then
                InheritedKey( $T_{[i]}$ ) += buf.key
        if  $T_i$  is the table from which comes Key( $T_{[i]}$ ) then
            buf.Table =  $T_i$ 
            buf.key = Key( $T_{[i]}$ )
```

→ generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables
create 2 dynamic arrays queue and path
insert T_0 into path
insert T_0 into queue
repeat

T_{Element} = First Table in queue

for every Link Item in Adjacent Link of T_{Element} from the Join Graph do
if the Link Item is in the join sequence then
if path doesn't contain the Link Item then
insert Link Item into path
insert Link Item into queue

remove T_{Element} from queue

until queue is empty

Join Base Tables

| | | |
|-------------|-------------|-----------|
| Employees | Job_History | Jobs |
| Departments | Locations | Countries |

Join Graph

| | | | | | |
|-------------|---|-------------|---------------|-------------|---------------|
| Employees | → | Job_History | Employee_Id | Departments | Department_Id |
| Job_History | → | Employees | Employee_Id | Jobs | Job_Id |
| Jobs | → | Job_History | Job_Id | | |
| Departments | → | Employees | Department_Id | Locations | Location_Id |
| Locations | → | Departments | Location_Id | Countries | Country_Id |
| Countries | → | Locations | Country_Id | | |

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

→ let $T_0 \dots T_m$ be the base tables

create 2 dynamic arrays queue and path

insert T_0 into path

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repeat

T_{Element} = First Table in queue

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if the Link Item is in the join sequence then

if path doesn't contain the Link Item then

insert Link Item into path

insert Link Item into queue

remove T_{Element} from queue

until queue is empty

Join Base Tables

| Employees | Job_History | Jobs | Departments | Locations | Countries |
|-----------|-------------|-------|-------------|-----------|-----------|
| T_0 | T_1 | T_2 | T_3 | T_4 | T_5 |

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables

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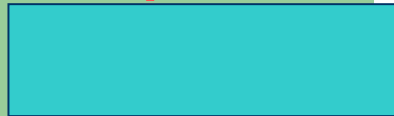
insert Link Item into path

insert Link Item into queue

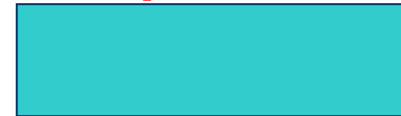
remove T_{Element} from queue

until queue is empty

queue



path



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables

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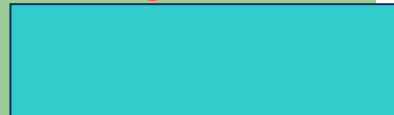
insert Link Item into path

insert Link Item into queue

remove T_{Element} from queue

until queue is empty

queue



path

Employees



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables

create 2 dynamic arrays queue and path

insert T_0 into path

→ insert T_0 into queue

repeat

T_{Element} = First Table in queue

for every Link Item in Adjacent Link of T_{Element} from the Join Graph do

if the Link Item is in the join sequence then

if path doesn't contain the Link Item then

insert Link Item into path

insert Link Item into queue

remove T_{Element} from queue

until queue is empty

queue

Employees

path

Employees

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables

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remove T_{Element} from queue

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queue

Employees

path

Employees

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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remove T_{Element} from queue

until queue is empty

queue



Employees

path

Employees

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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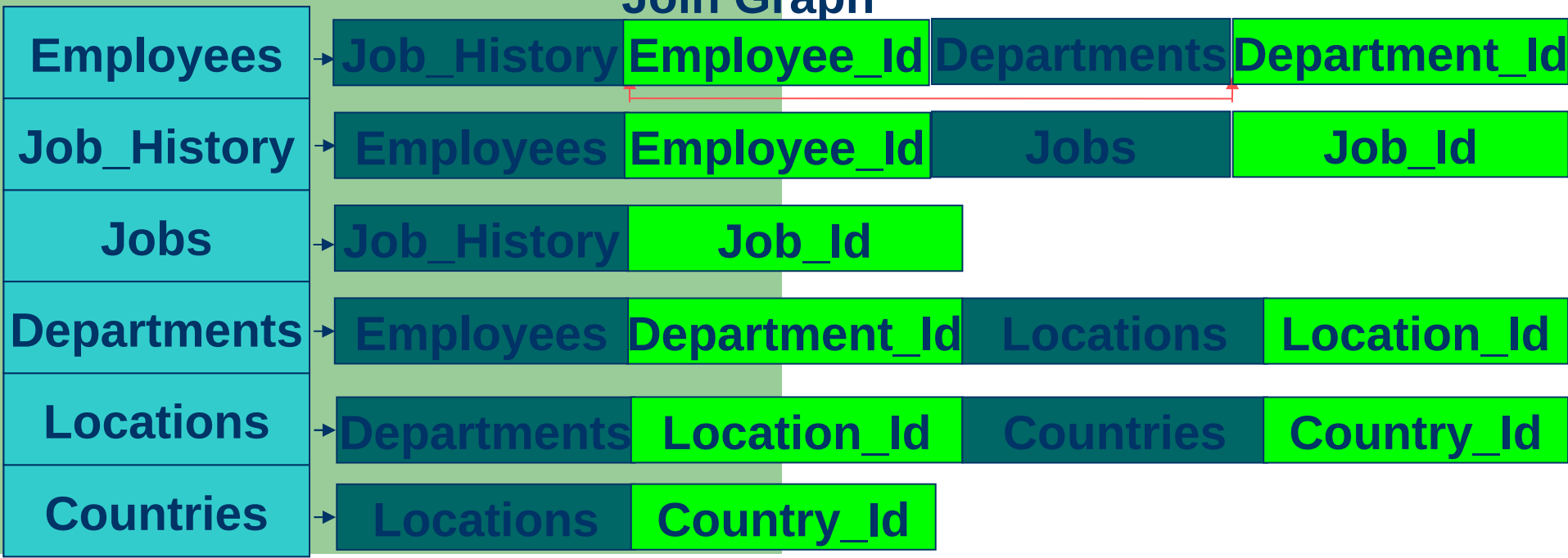
insert Link Item into path

insert Link Item into queue

remove T_{Element} from queue

until queue is empty

Join Graph



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables

create 2 dynamic arrays queue and path

insert T_0 into path

insert T_0 into queue

repeat

T_{Element} = First Table in queue

for every Link Item in Adjacent Link of T_{Element} from the Join Graph do

if the Link Item is in the join sequence then

if path doesn't contain the Link Item then

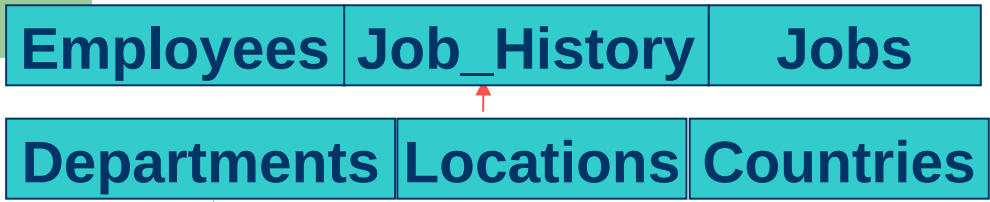
insert Link Item into path

insert Link Item into queue

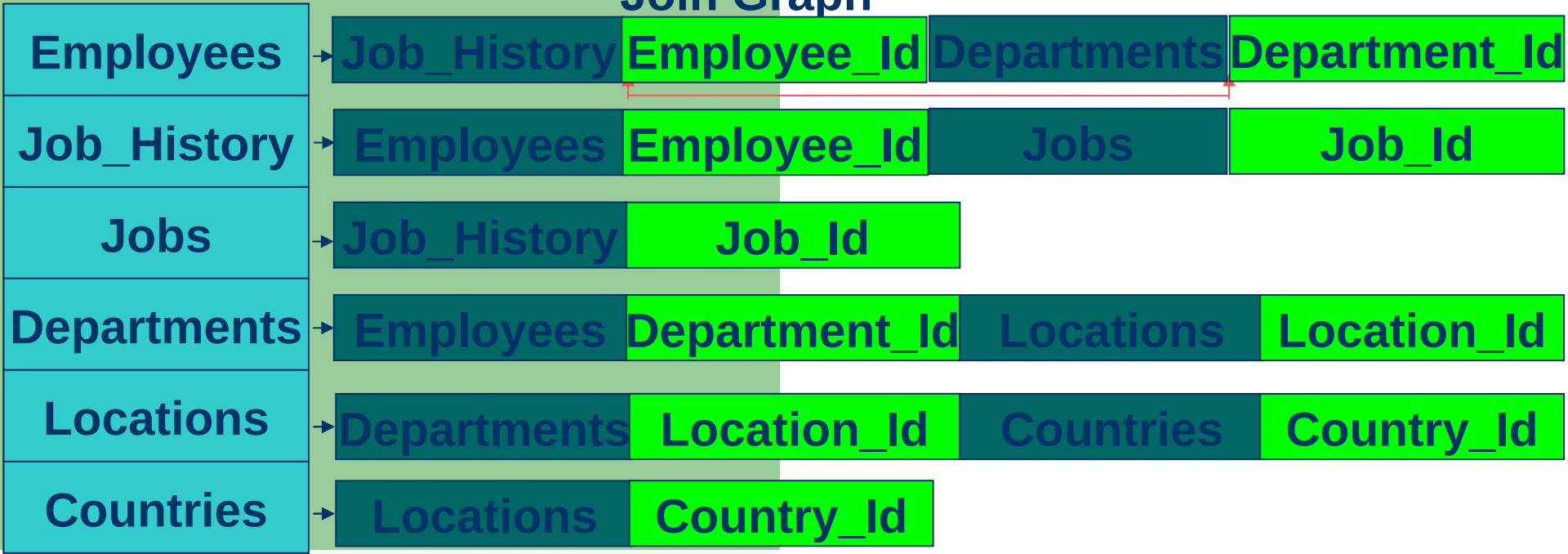
remove T_{Element} from queue

until queue is empty

Join Base Tables



Join Graph



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables

create 2 dynamic arrays queue and path

insert T_0 into path

insert T_0 into queue

repeat

T_{Element} = First Table in queue

for every Link Item in Adjacent Link of T_{Element} from the Join Graph do

if the Link Item is in the join sequence then

if path doesn't contain the Link Item then

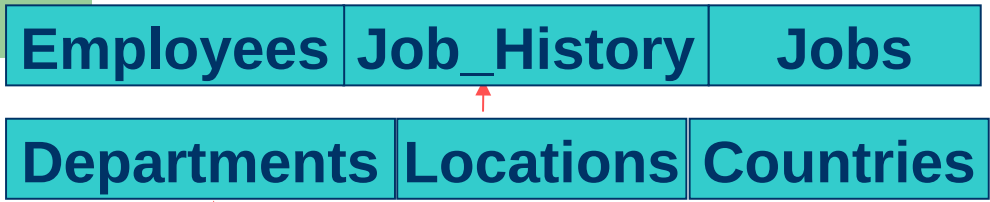
insert Link Item into path

insert Link Item into queue

remove T_{Element} from queue

until queue is empty

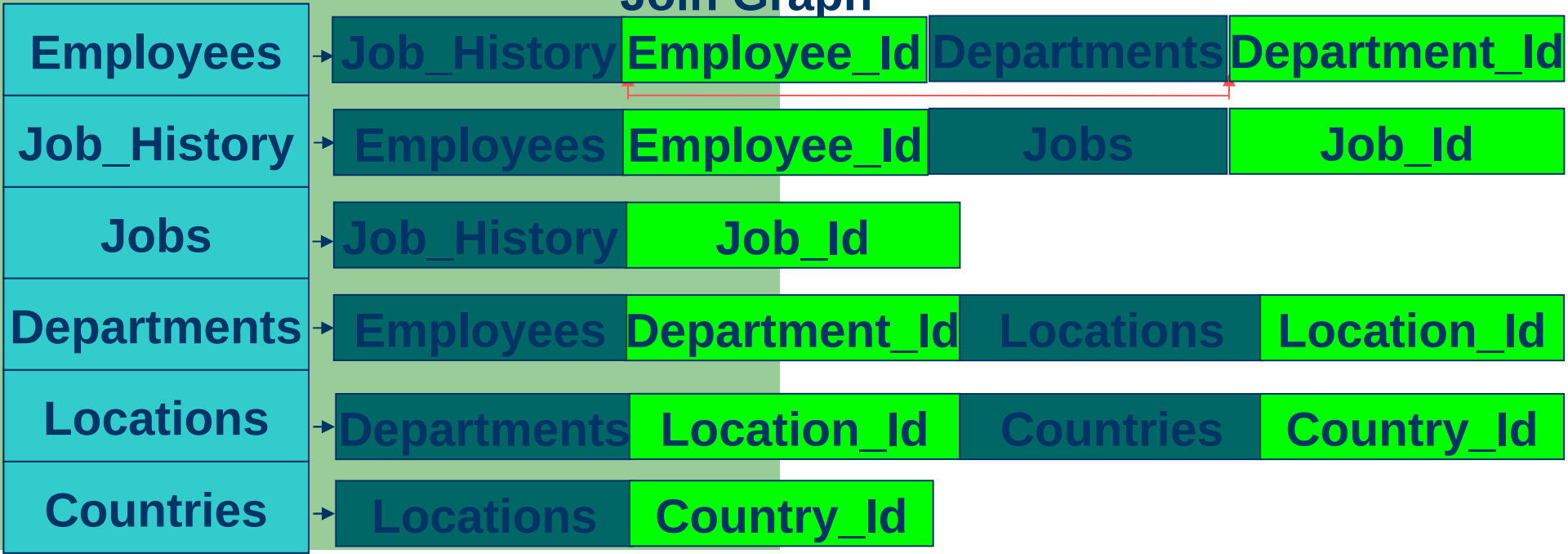
Join Base Tables



path



Join Graph



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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insert Link Item into queue

remove T_{Element} from queue

until queue is empty

queue



Employees

path

Employees

Job_History

Departments

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables

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insert Link Item into queue

remove T_{Element} from queue

until queue is empty

queue



| |
|-------------|
| Employees |
| Job_History |
| Departments |

path

| |
|-------------|
| Employees |
| Job_History |
| Departments |

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables

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insert Link Item into queue

→ remove T_{Element} from queue

until queue is empty

queue

Job_History

Departments

path

Employees

Job_History

Departments

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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insert Link Item into queue

remove T_{Element} from queue

until queue is empty

queue



| |
|-------------|
| Job_History |
| Departments |

path

| |
|-------------|
| Employees |
| Job_History |
| Departments |

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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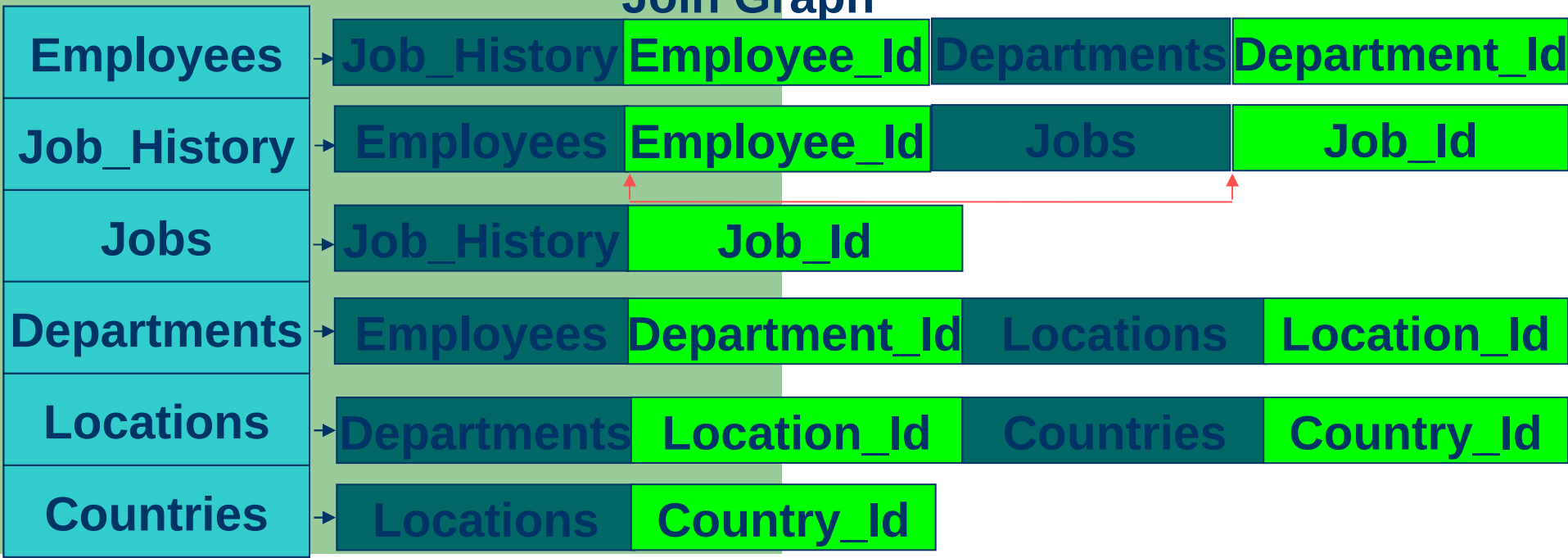
insert Link Item into path

insert Link Item into queue

remove T_{Element} from queue

until queue is empty

Join Graph



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables

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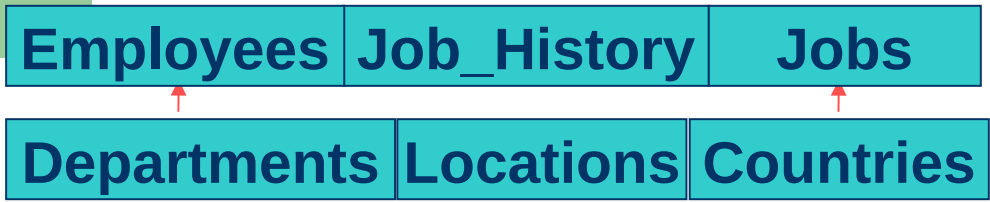
insert Link Item into path

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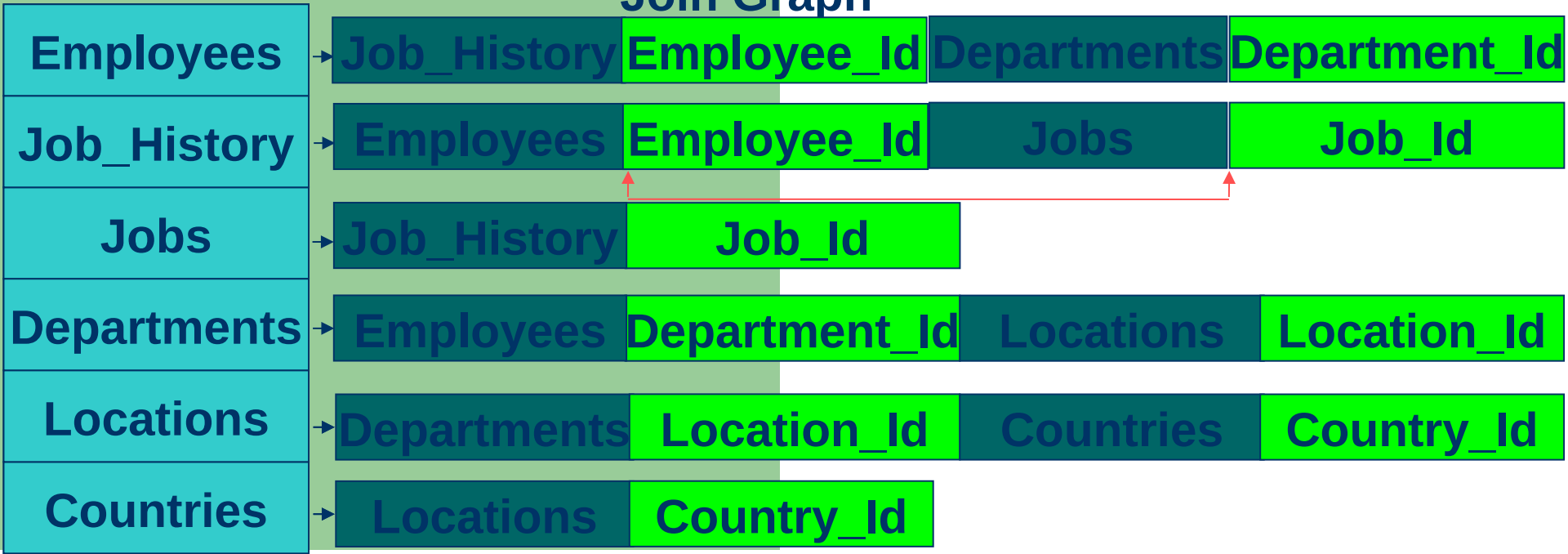
remove T_{Element} from queue

until queue is empty

Join Base Tables



Join Graph



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables

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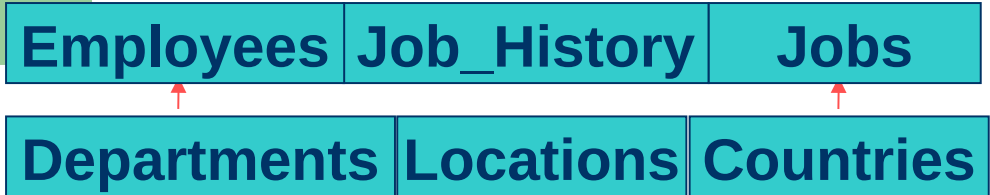
insert Link Item into path

insert Link Item into queue

remove T_{Element} from queue

until queue is empty

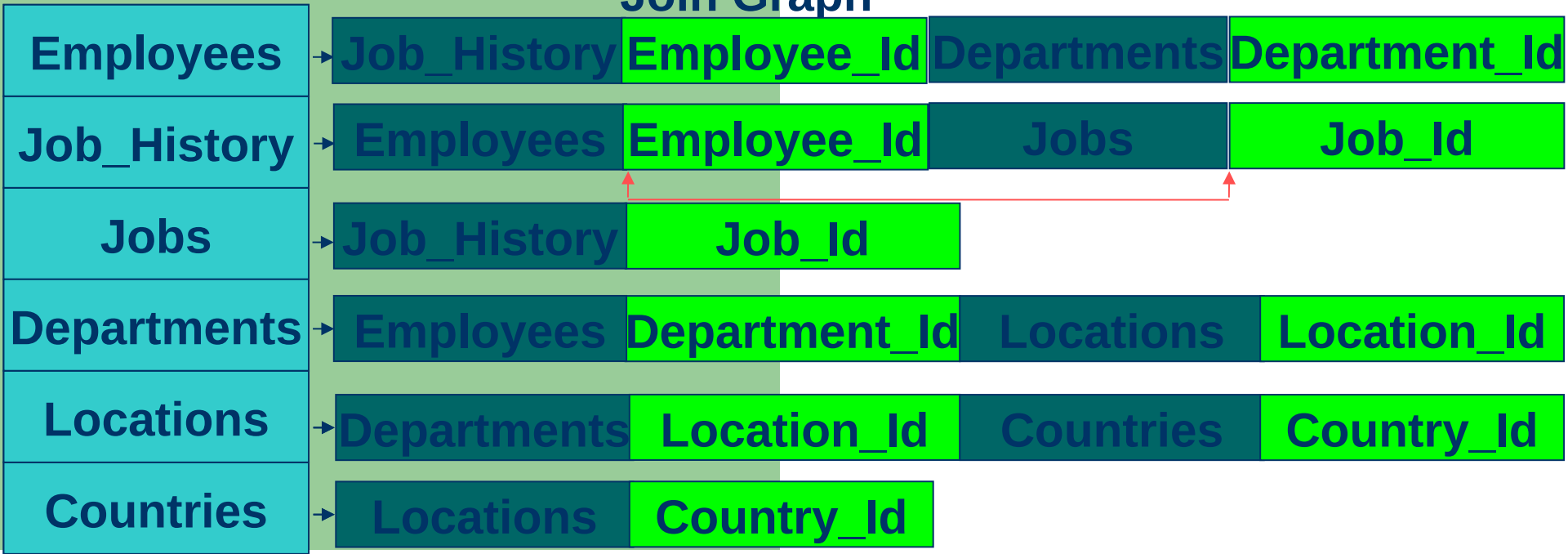
Join Base Tables



path



Join Graph



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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remove T_{Element} from queue

until queue is empty

queue



| |
|-------------|
| Job_History |
| Departments |

path

| |
|-------------|
| Employees |
| Job_History |
| Departments |
| Jobs |

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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insert Link Item into queue

remove T_{Element} from queue

until queue is empty

queue



Job_History

Departments

Jobs

path

Employees

Job_History

Departments

Jobs

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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insert Link Item into queue

→ remove T_{Element} from queue

until queue is empty

queue

| |
|-------------|
| Departments |
|-------------|

| |
|------|
| Jobs |
|------|

path

| |
|-----------|
| Employees |
|-----------|

| |
|-------------|
| Job_History |
|-------------|

| |
|-------------|
| Departments |
|-------------|

| |
|------|
| Jobs |
|------|

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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queue



Departments

Jobs

path

Employees

Job_History

Departments

Jobs

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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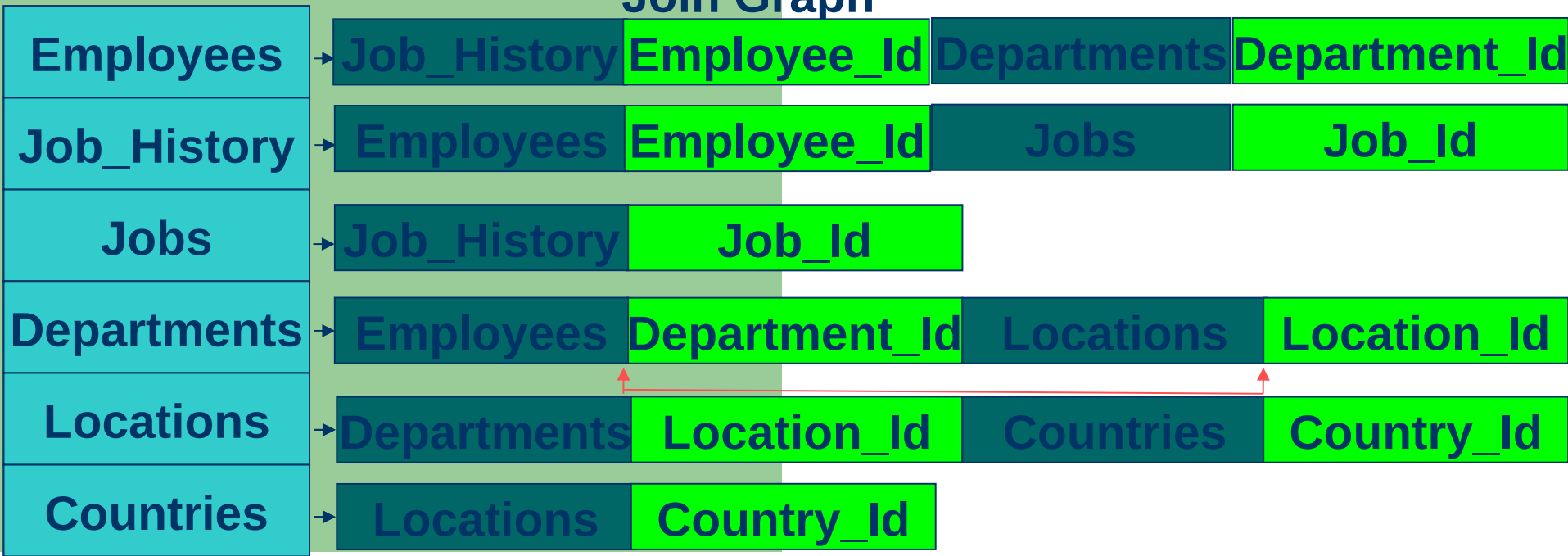
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until queue is empty

Join Graph



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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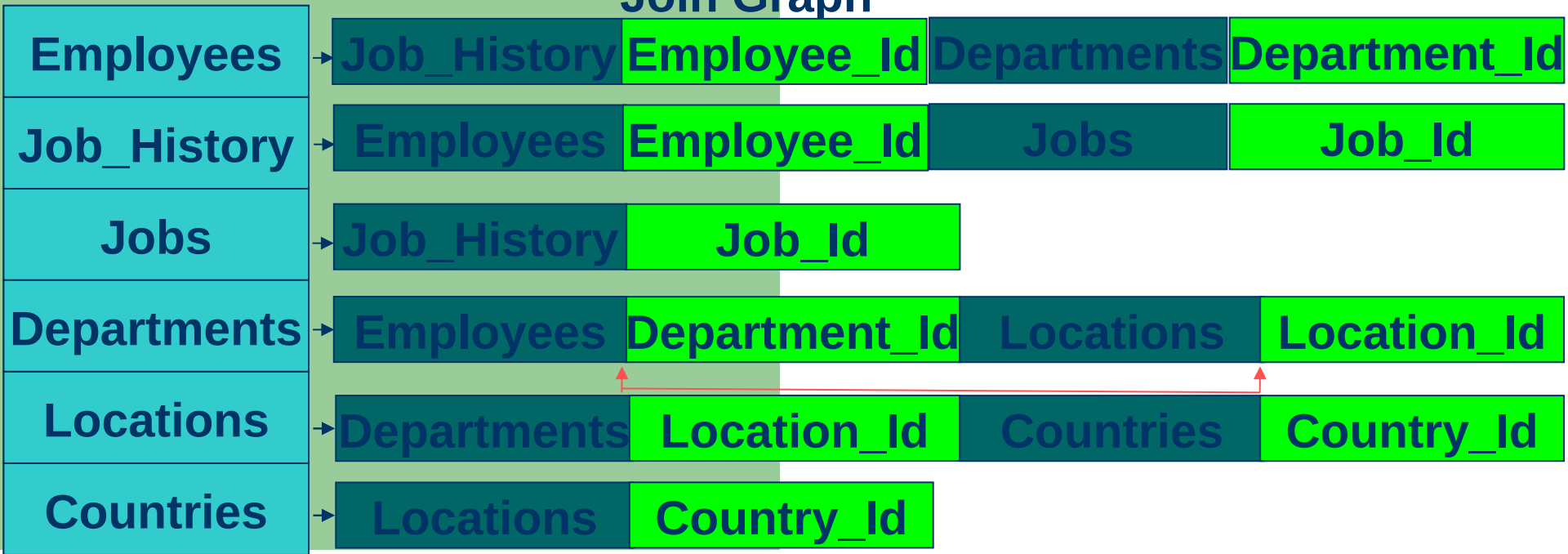
remove T_{Element} from queue

until queue is empty

Join Base Tables



Join Graph



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables

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insert Link Item into queue

remove T_{Element} from queue

until queue is empty

Join Base Tables

| | | |
|-------------|-------------|-----------|
| Employees | Job_History | Jobs |
| Departments | Locations | Countries |

| | |
|-------------|------|
| Employees | Jobs |
| Job_History | |
| Departments | |

path

Join Graph

| | | | | | |
|-------------|---|-------------|---------------|-------------|---------------|
| Employees | → | Job_History | Employee_Id | Departments | Department_Id |
| Job_History | → | Employees | Employee_Id | Jobs | Job_Id |
| Jobs | → | Job_History | Job_Id | | |
| Departments | → | Employees | Department_Id | Locations | Location_Id |
| Locations | → | Departments | Location_Id | Countries | Country_Id |
| Countries | → | Locations | Country_Id | | |

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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remove T_{Element} from queue

until queue is empty

queue



Departments

Jobs

path

Employees

Job_History

Departments

Jobs

Locations

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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remove T_{Element} from queue

until queue is empty

queue



Departments

Jobs

Locations

path

Employees

Job_History

Departments

Jobs

Locations

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insert Link Item into queue

→ remove T_{Element} from queue

until queue is empty

queue

| |
|-----------|
| Jobs |
| Locations |

path

| |
|-------------|
| Employees |
| Job_History |
| Departments |
| Jobs |
| Locations |

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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remove T_{Element} from queue

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queue



path



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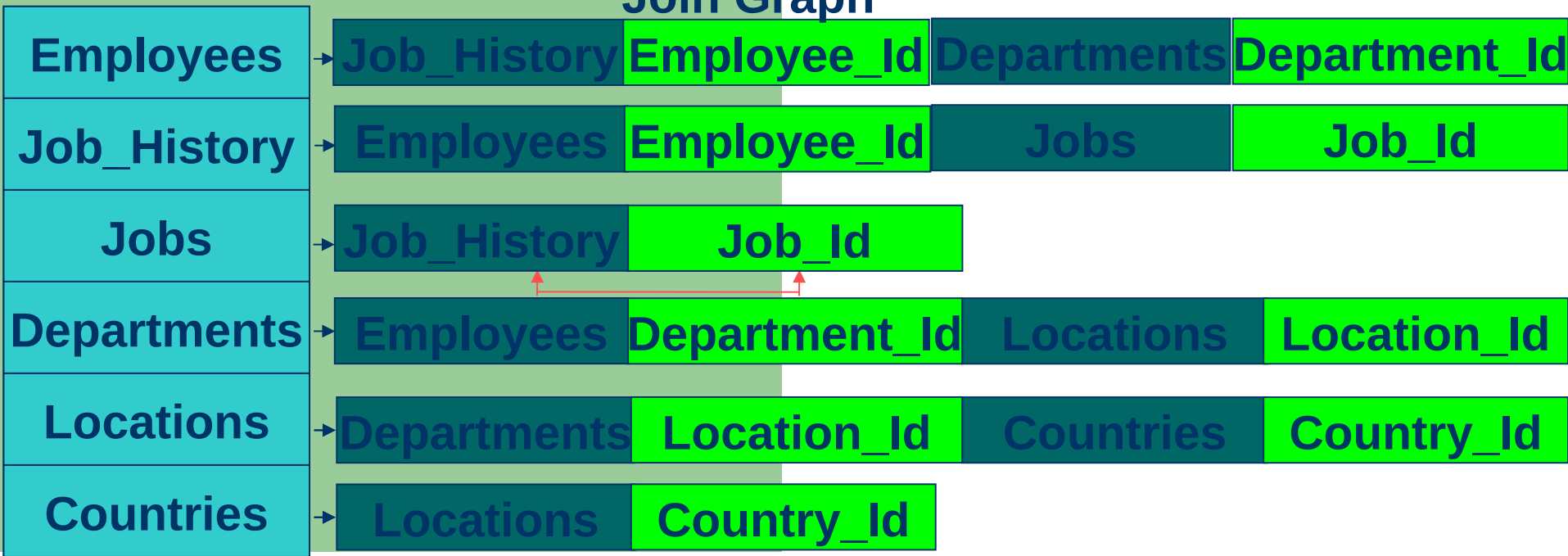
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insert Link Item into queue

remove T_{Element} from queue

until queue is empty

Join Graph



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables

create 2 dynamic arrays queue and path

insert T_0 into path

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repeat

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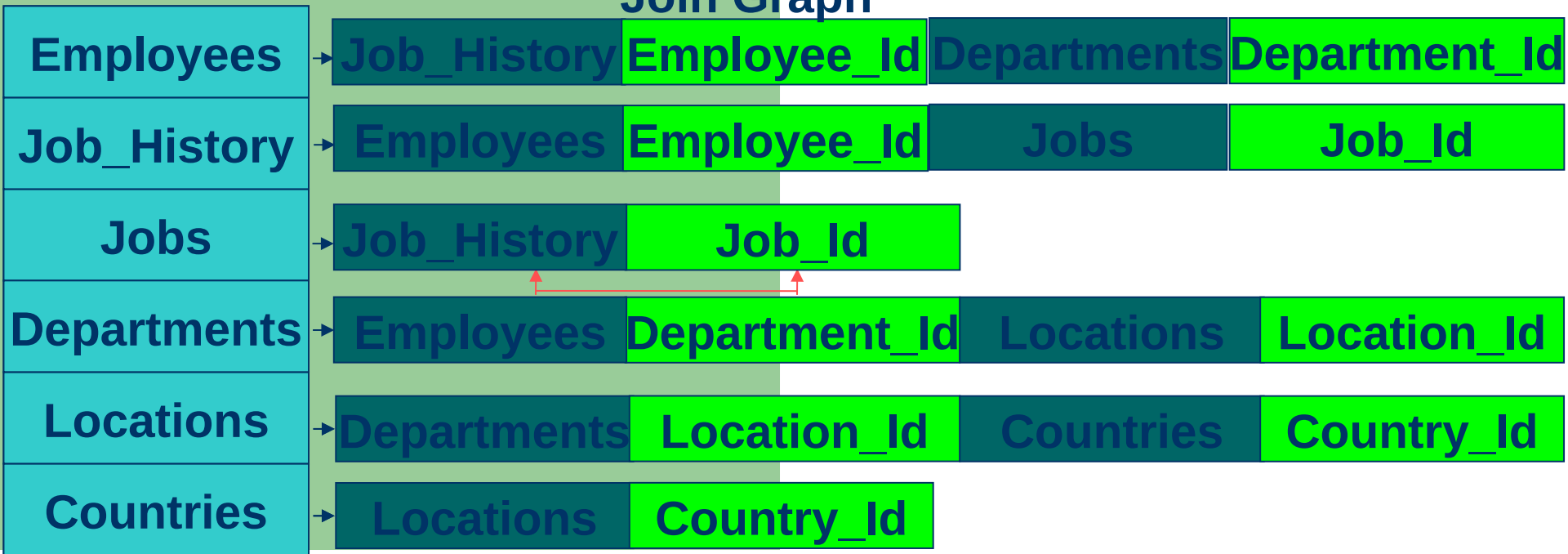
remove T_{Element} from queue

until queue is empty

Join Base Tables



Join Graph



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables

create 2 dynamic arrays queue and path

insert T_0 into path

insert T_0 into queue

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for every Link Item in Adjacent Link of T_{Element} from the Join Graph do

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if path doesn't contain the Link Item then

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insert Link Item into queue

remove T_{Element} from queue

until queue is empty

Join Base Tables

| | | |
|-------------|-------------|-----------|
| Employees | Job_History | Jobs |
| Departments | Locations | Countries |

path

| | |
|-------------|-----------|
| Employees | Jobs |
| Job_History | Locations |
| Departments | |

Join Graph

| | | | | | |
|-------------|---|-------------|---------------|-------------|---------------|
| Employees | → | Job_History | Employee_Id | Departments | Department_Id |
| Job_History | → | Employees | Employee_Id | Jobs | Job_Id |
| Jobs | → | Job_History | Job_Id | | |
| Departments | → | Employees | Department_Id | Locations | Location_Id |
| Locations | → | Departments | Location_Id | Countries | Country_Id |
| Countries | → | Locations | Country_Id | | |

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables

create 2 dynamic arrays queue and path

insert T_0 into path

insert T_0 into queue

repeat

T_{Element} = First Table in queue

for every Link Item in Adjacent Link of T_{Element} from the Join Graph do

if the Link Item is in the join sequence then

if path doesn't contain the Link Item then

insert Link Item into path

insert Link Item into queue

→ remove T_{Element} from queue

until queue is empty

queue

Locations

path

Employees

Job_History

Departments

Jobs

Locations

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Locations

path

Employees

Job_History

Departments

Jobs

Locations

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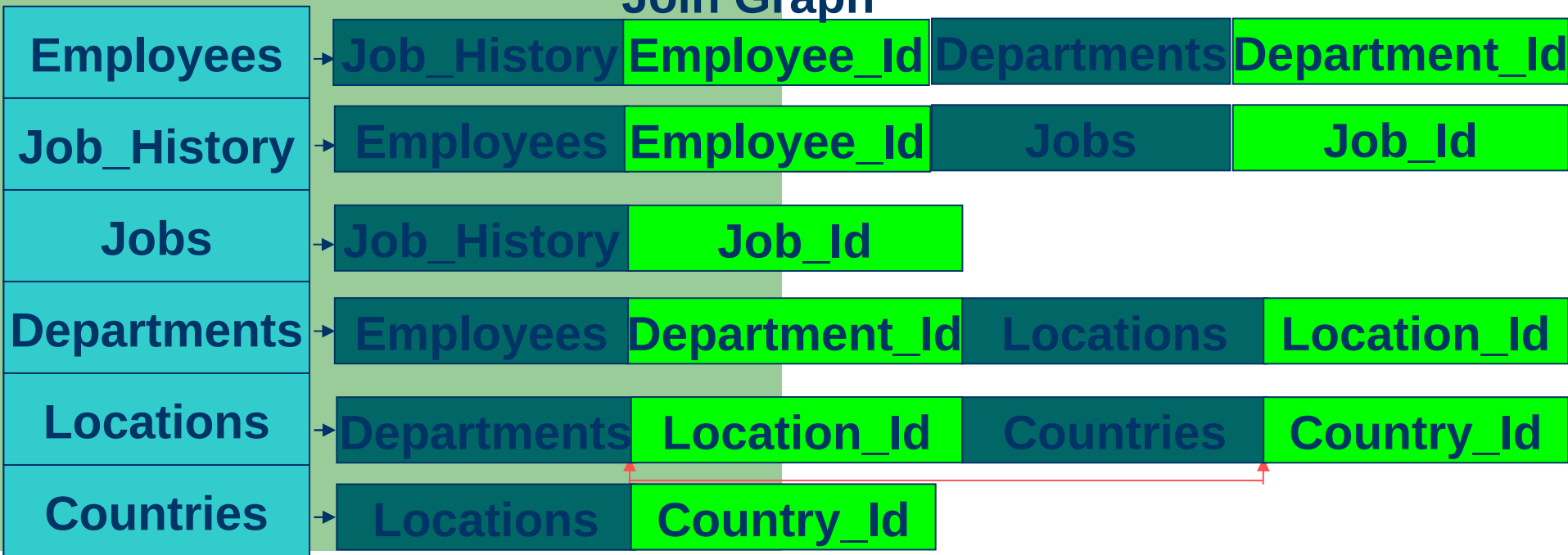
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remove T_{Element} from queue

until queue is empty

Join Graph



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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remove T_{Element} from queue

until queue is empty

Join Base Tables

| | | |
|-------------|-------------|-----------|
| Employees | Job_History | Jobs |
| Departments | Locations | Countries |



Join Graph

| | | | | | |
|-------------|---|-------------|---------------|-------------|---------------|
| Employees | → | Job_History | Employee_Id | Departments | Department_Id |
| Job_History | → | Employees | Employee_Id | Jobs | Job_Id |
| Jobs | → | Job_History | Job_Id | | |
| Departments | → | Employees | Department_Id | Locations | Location_Id |
| Locations | → | Departments | Location_Id | Countries | Country_Id |
| Countries | → | Locations | Country_Id | | |



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Join Base Tables

| | | |
|-----------|-------------|------|
| Employees | Job_History | Jobs |
|-----------|-------------|------|

| | | |
|-------------|-----------|-----------|
| Departments | Locations | Countries |
|-------------|-----------|-----------|

path

| |
|-----------|
| Employees |
|-----------|

| |
|------|
| Jobs |
|------|

| |
|-------------|
| Job_History |
|-------------|

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|-----------|
| Locations |
|-----------|

| |
|-------------|
| Departments |
|-------------|

Join Graph

| |
|-----------|
| Employees |
|-----------|

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|-------------|
| Job_History |
|-------------|

| |
|-------------|
| Employee_Id |
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|-------------|
| Departments |
|-------------|

| |
|---------------|
| Department_Id |
|---------------|

| |
|-------------|
| Job_History |
|-------------|

| |
|-----------|
| Employees |
|-----------|

| |
|-------------|
| Employee_Id |
|-------------|

| |
|------|
| Jobs |
|------|

| |
|--------|
| Job_Id |
|--------|

| |
|------|
| Jobs |
|------|

| |
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| Job_History |
|-------------|

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| Job_Id |
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| Departments |
|-------------|

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|-----------|
| Employees |
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| Department_Id |
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| Locations |
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| Location_Id |
|-------------|

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|-----------|
| Locations |
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|-------------|
| Departments |
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|-------------|
| Location_Id |
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|-----------|
| Countries |
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|------------|
| Country_Id |
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|-----------|
| Countries |
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| Locations |
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| |
|------------|
| Country_Id |
|------------|

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queue



Locations

path

Employees

Job_History

Departments

Jobs

Locations

Countries

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Locations

Countries

path

Employees

Job_History

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Countries

path

Employees

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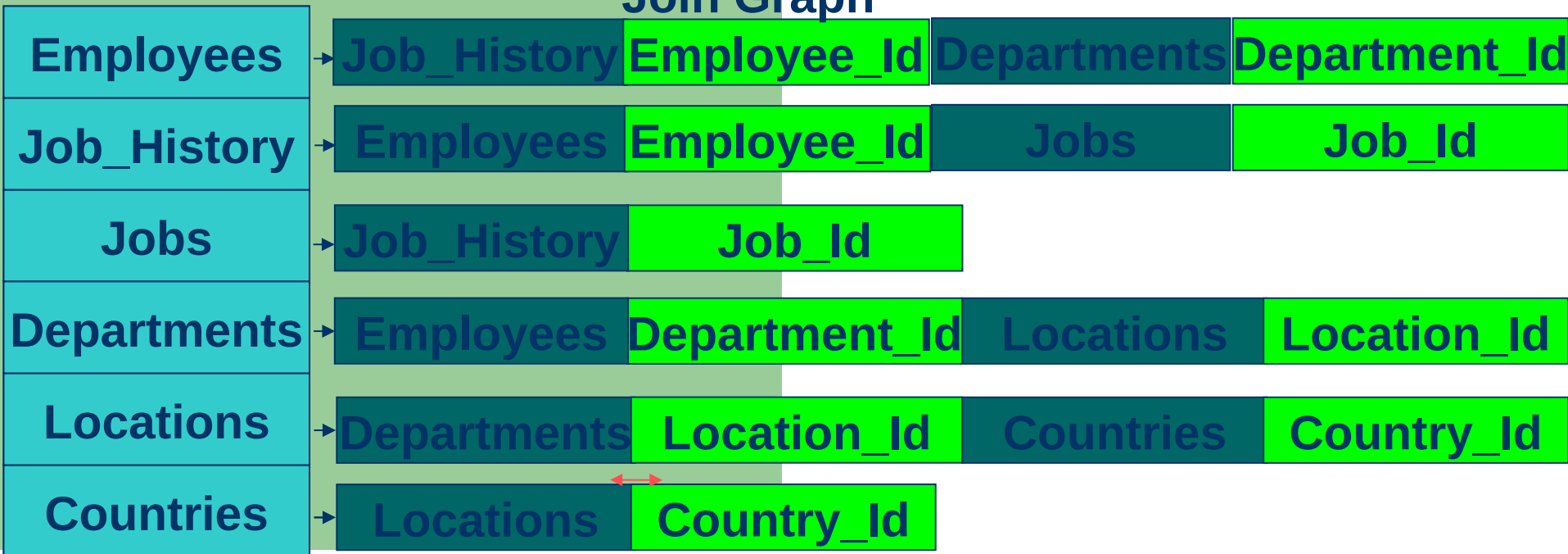
insert Link Item into path

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remove T_{Element} from queue

until queue is empty

Join Graph



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables
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T_{Element} = First Table in queue

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Join Base Tables

| | | |
|-------------|-------------|-----------|
| Employees | Job_History | Jobs |
| Departments | Locations | Countries |



Join Graph

| | | | | | |
|-------------|---|-------------|---------------|-------------|---------------|
| Employees | → | Job_History | Employee_Id | Departments | Department_Id |
| Job_History | → | Employees | Employee_Id | Jobs | Job_Id |
| Jobs | → | Job_History | Job_Id | | |
| Departments | → | Employees | Department_Id | Locations | Location_Id |
| Locations | → | Departments | Location_Id | Countries | Country_Id |
| Countries | → | Locations | Country_Id | | |

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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Join Base Tables

| | | |
|-----------|-------------|------|
| Employees | Job_History | Jobs |
|-----------|-------------|------|

| | | |
|-------------|-----------|-----------|
| Departments | Locations | Countries |
|-------------|-----------|-----------|

↑
path

| | |
|-------------|-----------|
| Employees | Jobs |
| Job_History | Locations |
| Departments | Countries |

Join Graph



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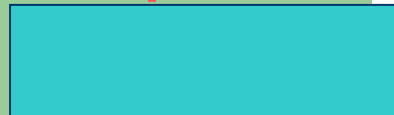
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queue



path



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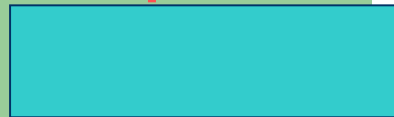
insert Link Item into path

insert Link Item into queue

remove T_{Element} from queue

→ until queue is empty

queue



path



→ insert all the names of base tables from path as vertexes in JoinPathList
create a local buffer buf
insert into buf the first entry from path
for all the remainder entries in path do

vertexes

Employees

Job_History

Departments

Jobs

Locations

Countries

take one T_i at a time

$\text{JoinPathAdjacentList}(T_i) = T_{[buf]}$

$\text{Key}(T_i) = \text{getFirstAdjacentListKey}(T_i, T_{[buf]})$

$\text{JoinPathAdjacentList}(T_{[buf]}) = T_i$

$\text{Key}(T_{[buf]}) = \text{getFirstAdjacentListKey}(T_{[buf]}, T_i)$

$T_{[buf]} += T_i$

$\text{Insert NodesList}[T_{[buf]}] = T_{[buf]}$

path

Employees

Job_History

Departments

Jobs

Locations

Countries

insert all the names of base tables from path as vertexes in JoinPathList

→ create a local buffer buf

insert into buf the first entry from path

for all the remainder entries in path do

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$T_{[\text{buf}]} += T_i$

$\text{Insert NodesList}[T_{[\text{buf}]}] = T_{[\text{buf}]}$

vertexes

Employees

Job_History

Departments

Jobs

Locations

Countries

buf

path

Employees

Job_History

Departments

Jobs

Locations

Countries

insert all the names of base tables from path as vertexes in JoinPathList

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$T_{[\text{buf}]} += T_i$

$\text{Insert NodesList}[T_{[\text{buf}]}] = T_{[\text{buf}]}$

vertexes

Employees

Job_History

Departments

Jobs

Locations

Countries

buf

Employees

path

Employees

Job_History

Departments

Jobs

Locations

Countries

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vertexes

Employees

Job_History

Departments

Jobs

Locations

Countries

buf

Employees

path

Employees

Job_History

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Locations

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$T_{[\text{buf}]} += T_i$

$\text{Insert NodesList}[T_{[\text{buf}]}] = T_{[\text{buf}]}$

buf

Employees

path

| |
|-------------|
| Employees |
| Job_History |
| Departments |
| Jobs |
| Locations |
| Countries |



| |
|-------------|
| Employees |
| Job_History |
| Departments |
| Jobs |
| Locations |
| Countries |

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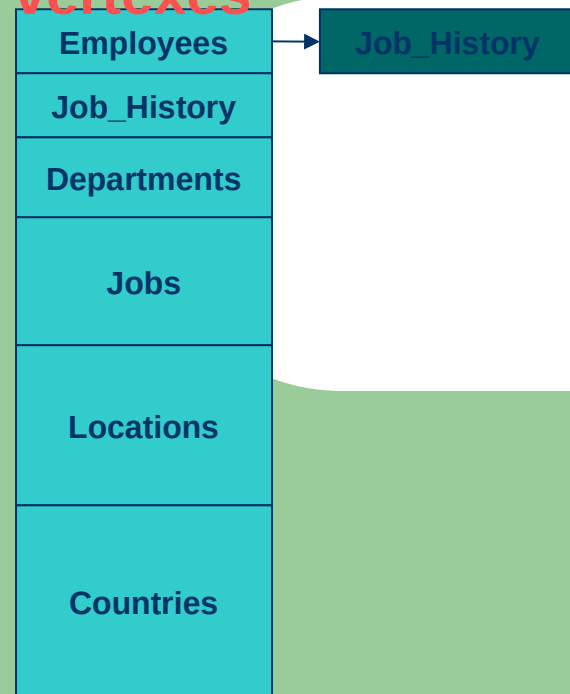
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$T_{[\text{buf}]} += T_i$

$\text{Insert NodesList}[T_{[\text{buf}]}] = T_{[\text{buf}]}$

vertexes



buf

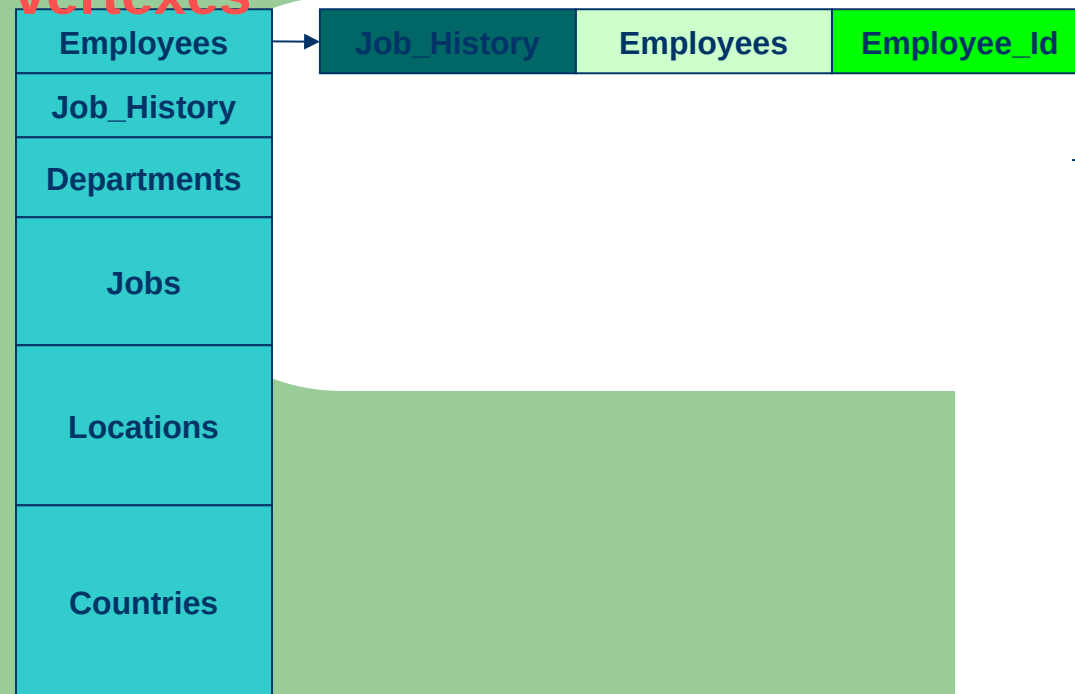


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vertexes



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$T_{[\text{buf}]} += T_i$

$\text{Insert NodesList}[T_{[\text{buf}]}] = T_{[\text{buf}]}$

buf

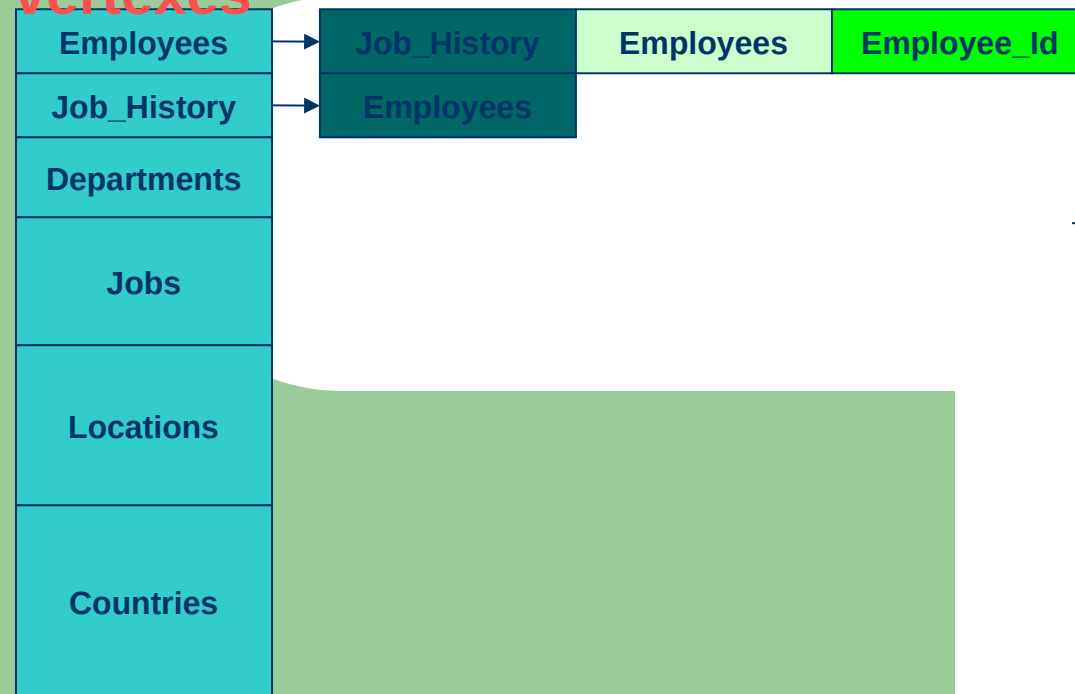


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buf

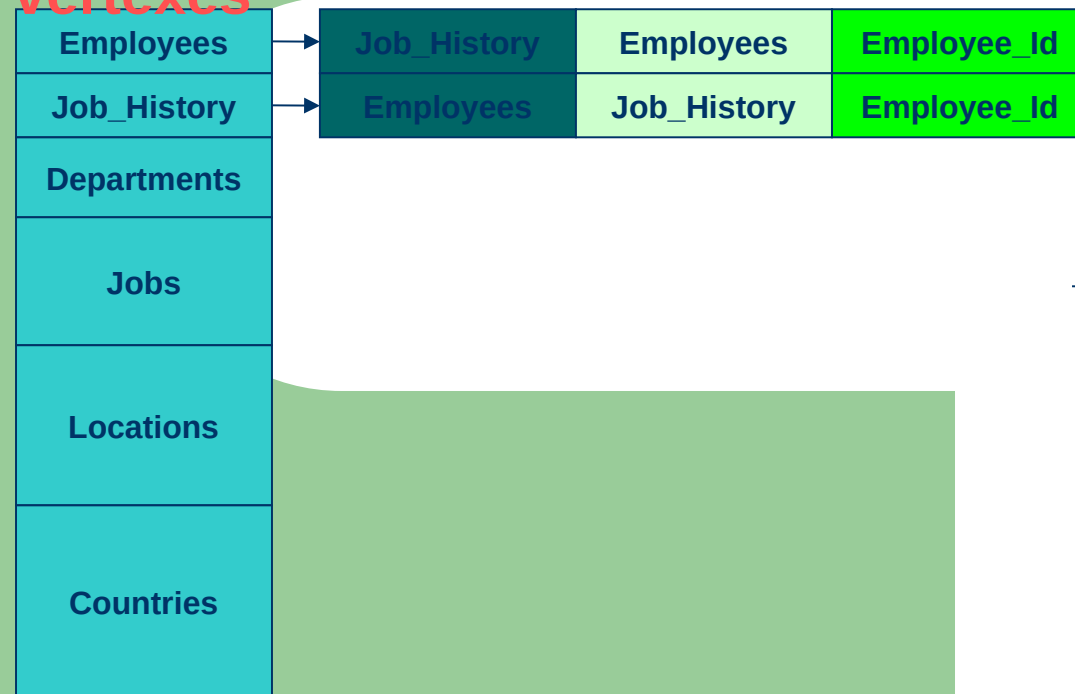


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$T_{[\text{buf}]} += T_i$

$\text{Insert NodesList}[T_{[\text{buf}]}] = T_{[\text{buf}]}$

buf

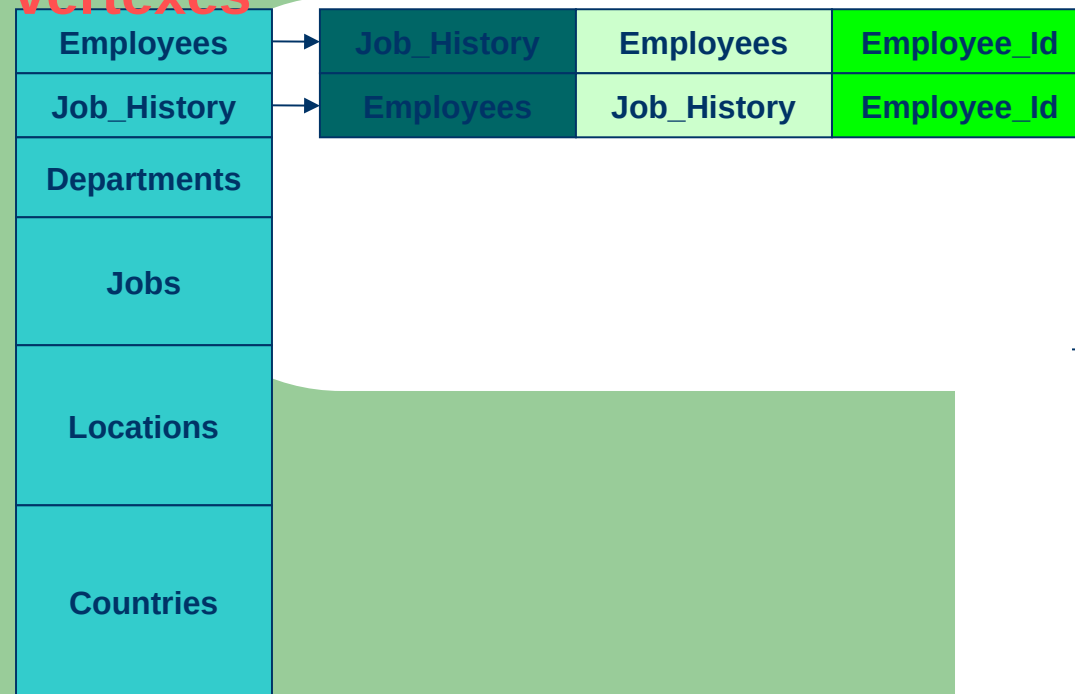


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$\text{Insert NodesList}[T_{[\text{buf}]}] = T_{[\text{buf}]}$

buf

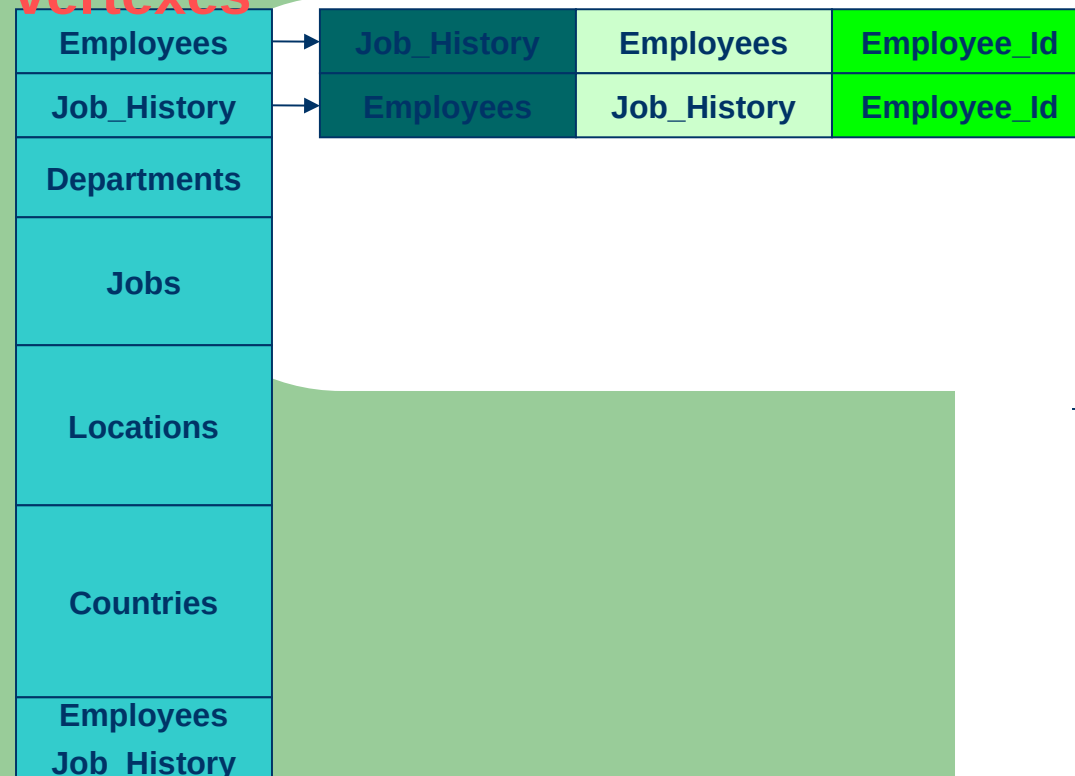


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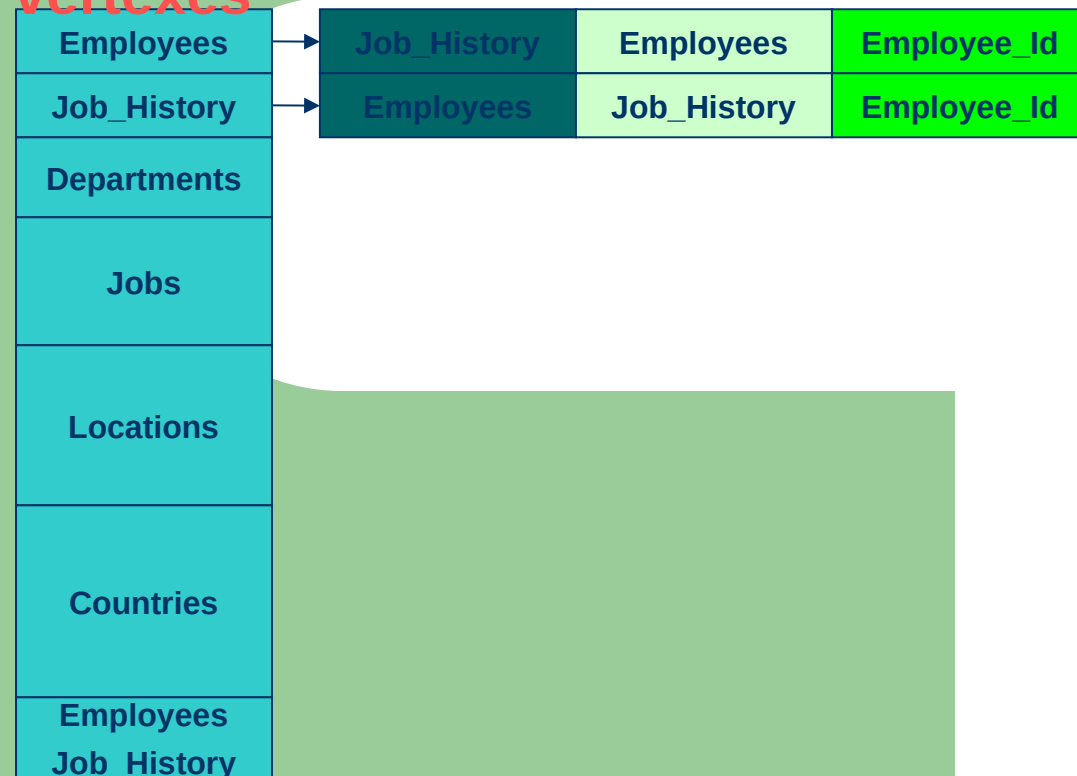
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$T_{[\text{buf}]} += T_i$

$\text{Insert NodesList}[T_{[\text{buf}]}] = T_{[\text{buf}]}$

vertexes



buf

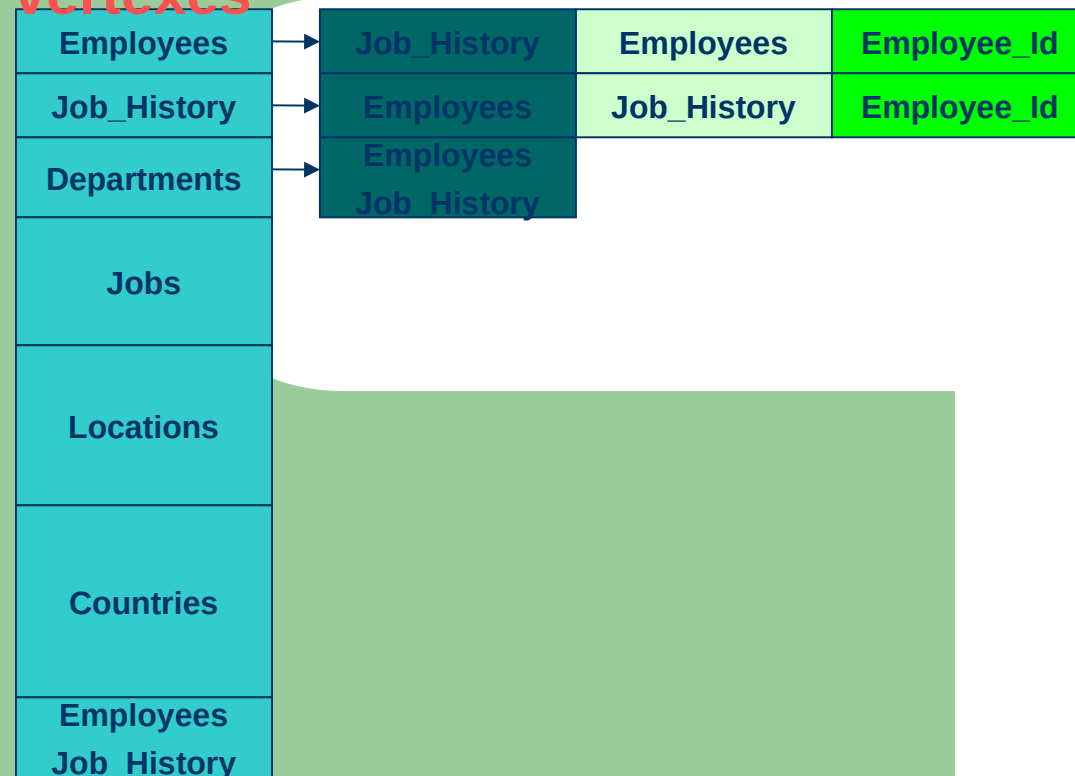


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vertexes



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buf



path



insert all the names of base tables from path as vertexes in JoinPathList

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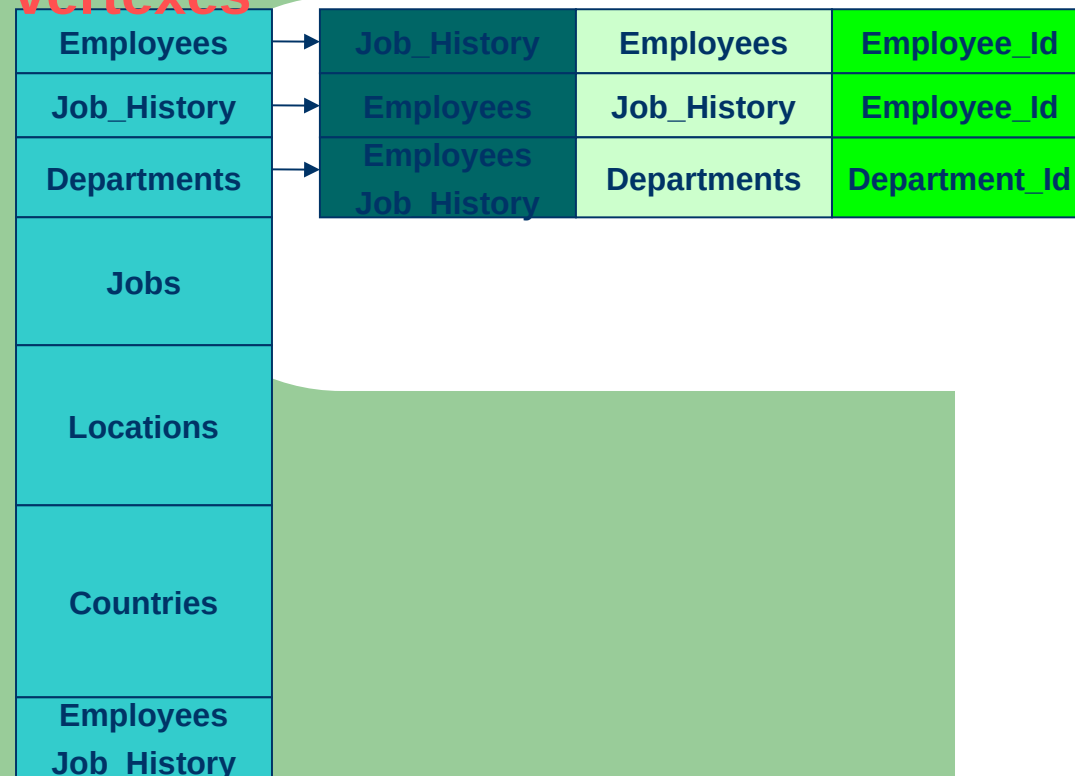
$\text{JoinPathAdjacentList}(T_{[\text{buf}]}) = T_i$

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$T_{[\text{buf}]} += T_i$

$\text{Insert NodesList}[T_{[\text{buf}]}] = T_{[\text{buf}]}$

vertexes



buf

Employees
Job_History

path

Employees
Job_History
Departments
Jobs
Locations
Countries

insert all the names of base tables from path as vertexes in JoinPathList

create a local buffer buf

insert into buf the first entry from path

for all the remainder entries in path do

take one T_i at a time

$\text{JoinPathAdjacentList}(T_i) = T_{[\text{buf}]}$

$\text{Key}(T_i) = \text{getFirstAdjacentListKey}(T_i, T_{[\text{buf}]})$

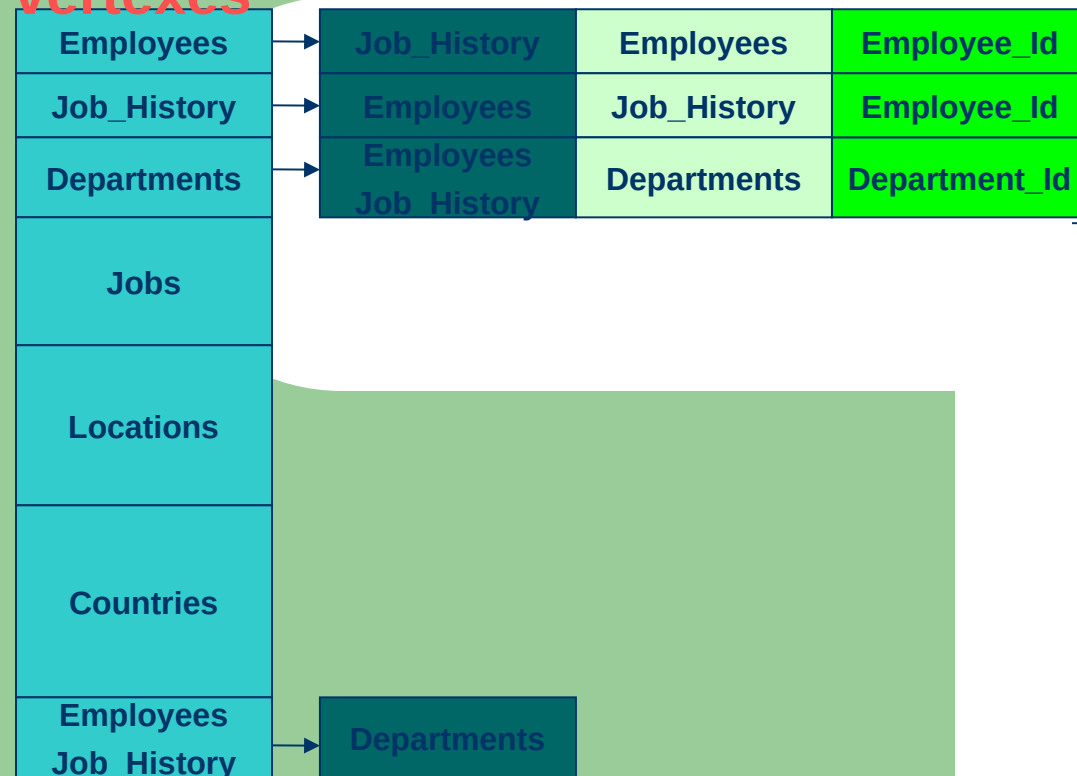
$\text{JoinPathAdjacentList}(T_{[\text{buf}]}) = T_i$

$\text{Key}(T_{[\text{buf}]}) = \text{getFirstAdjacentListKey}(T_{[\text{buf}]}, T_i)$

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$\text{Insert NodesList}[T_{[\text{buf}]}] = T_{[\text{buf}]}$

vertexes



buf

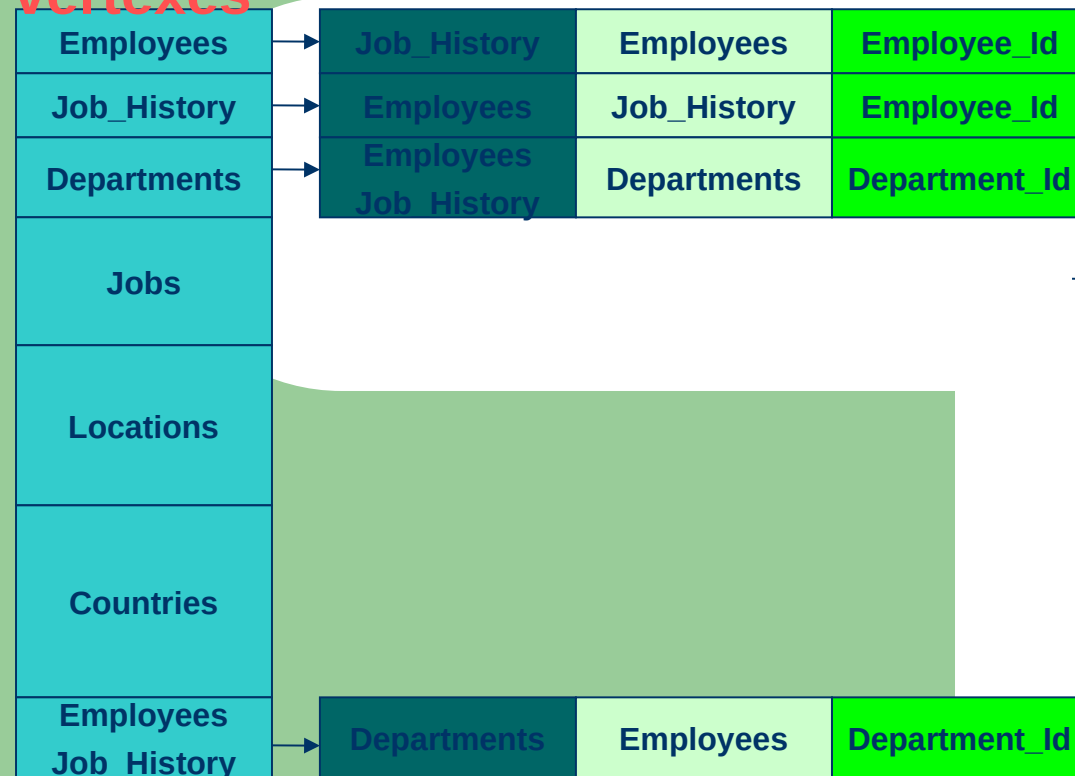
Employees
Job_History

path

Employees
Job_History
Departments
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Locations
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$\text{Insert NodesList}[T_{[\text{buf}]}] = T_{[\text{buf}]}$

buf

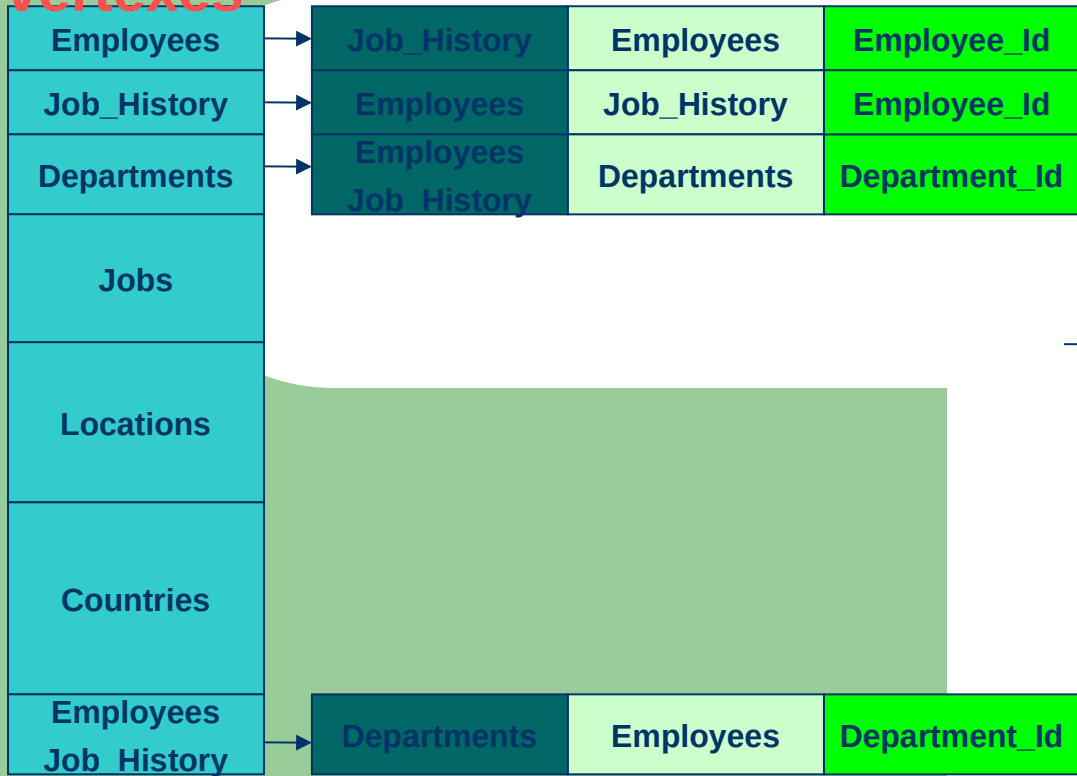
Employees
Job_History

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Employees
Job_History
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$Insert\ NodesList[T_{[buf]}] = T_{[buf]}$

buf



path



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$T_{[\text{buf}]} += T_i$

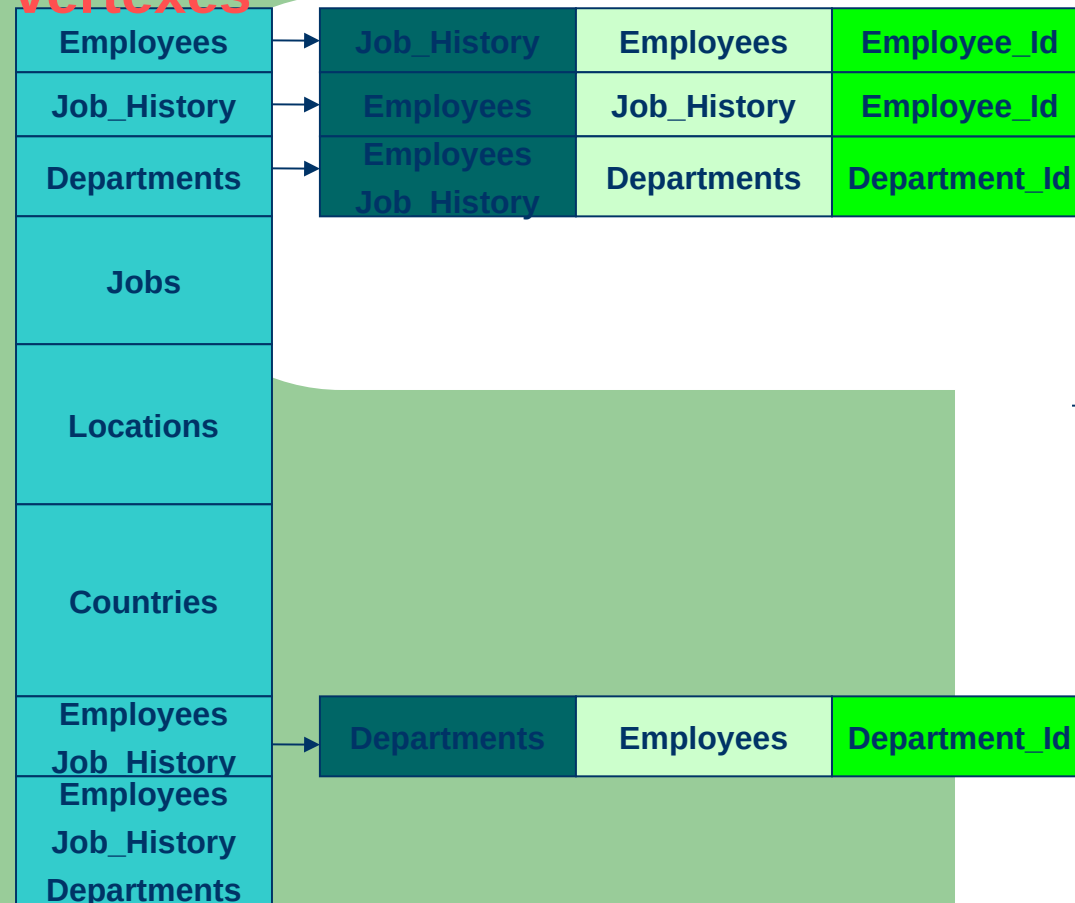
→ $\text{Insert NodesList}[T_{[\text{buf}]}] = T_{[\text{buf}]}$

buf

path

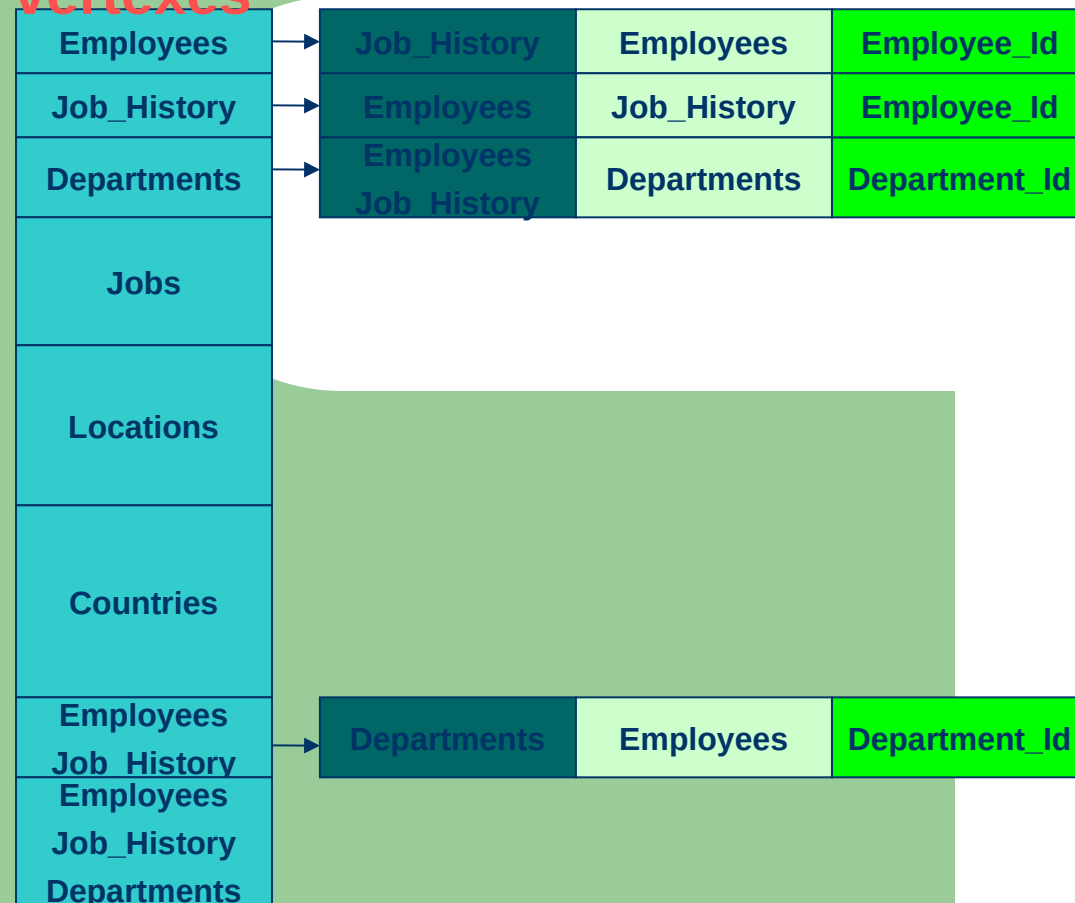
Employees
Job_History
Departments

Employees
Job_History
Departments
Jobs
Locations
Countries



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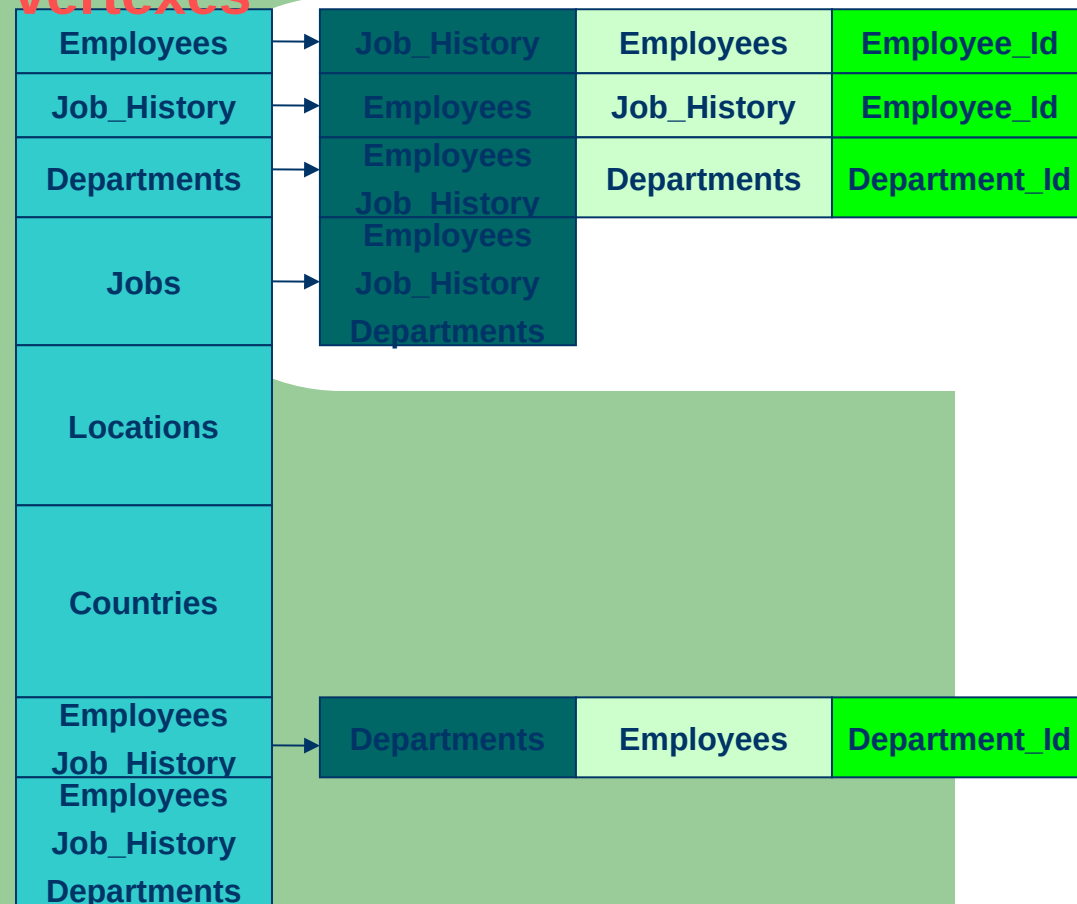
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vertexes



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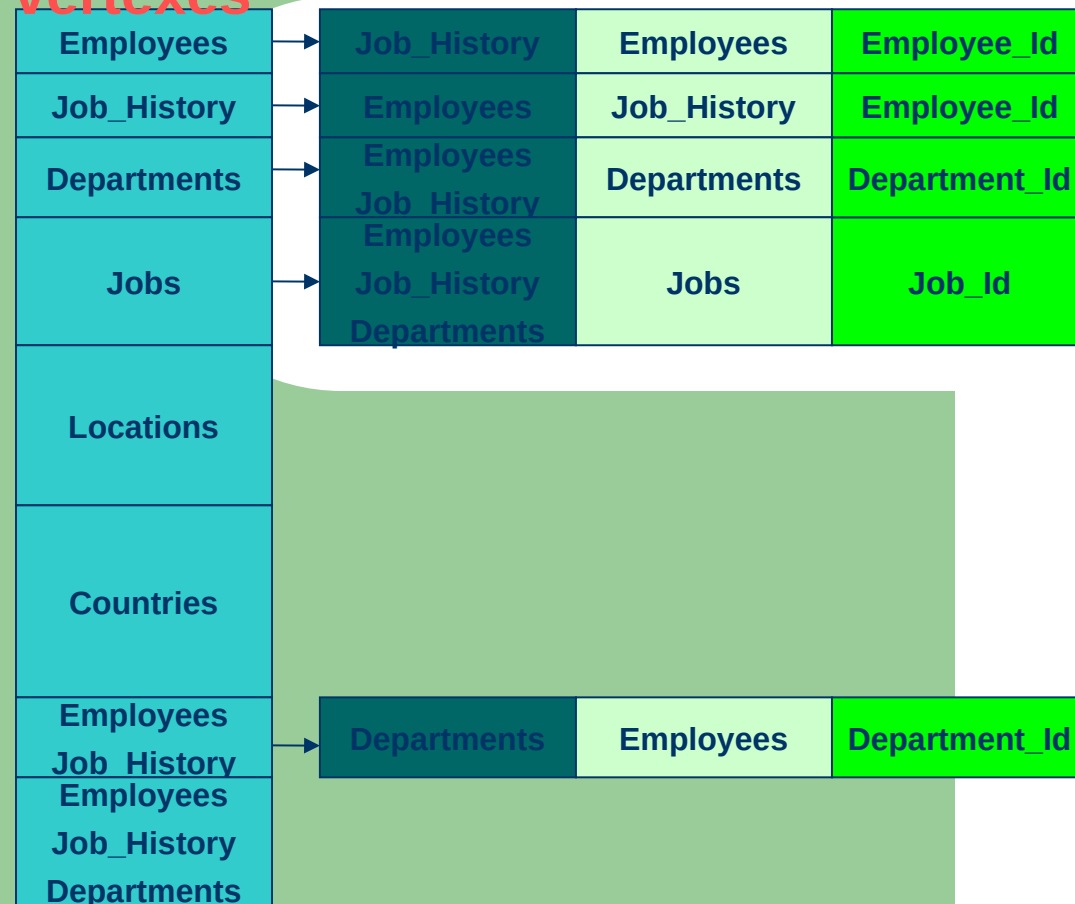
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vertexes



buf

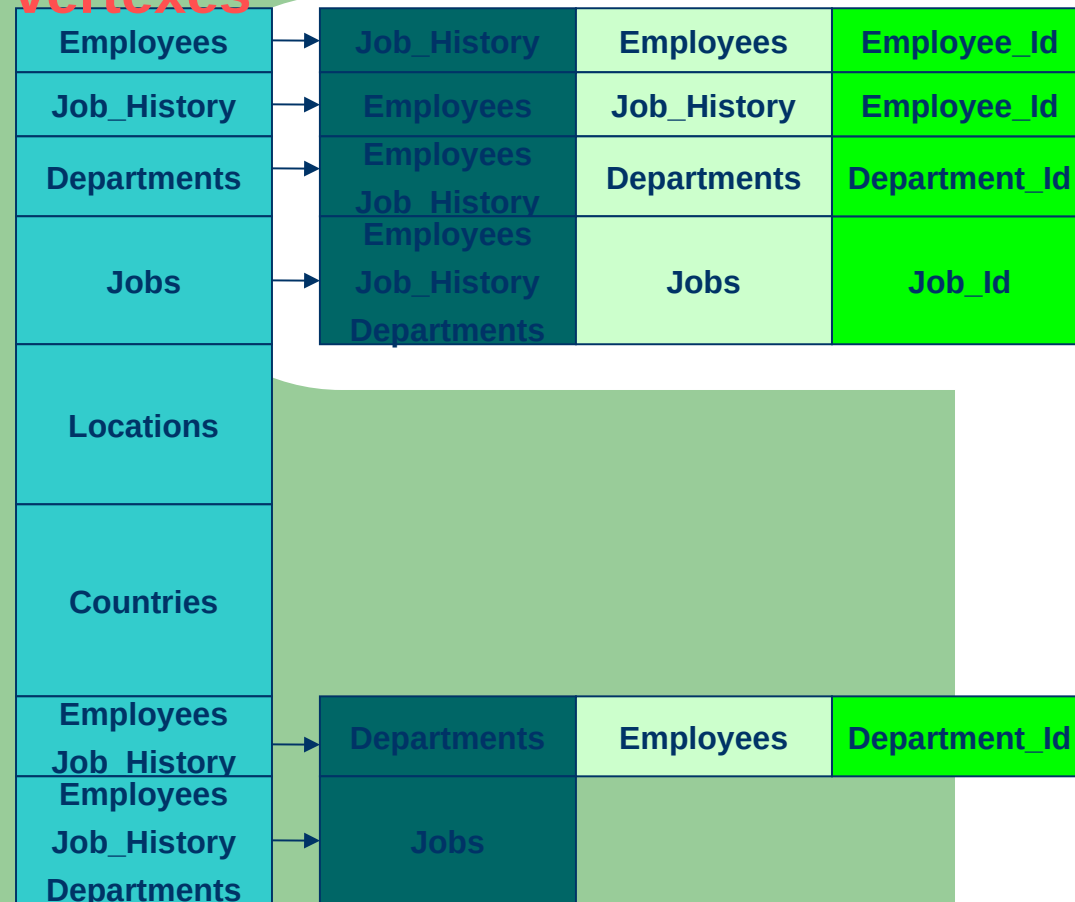
Employees
Job_History
Departments

path

Employees
Job_History
Departments
Jobs
Locations
Countries

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buf

Employees
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path

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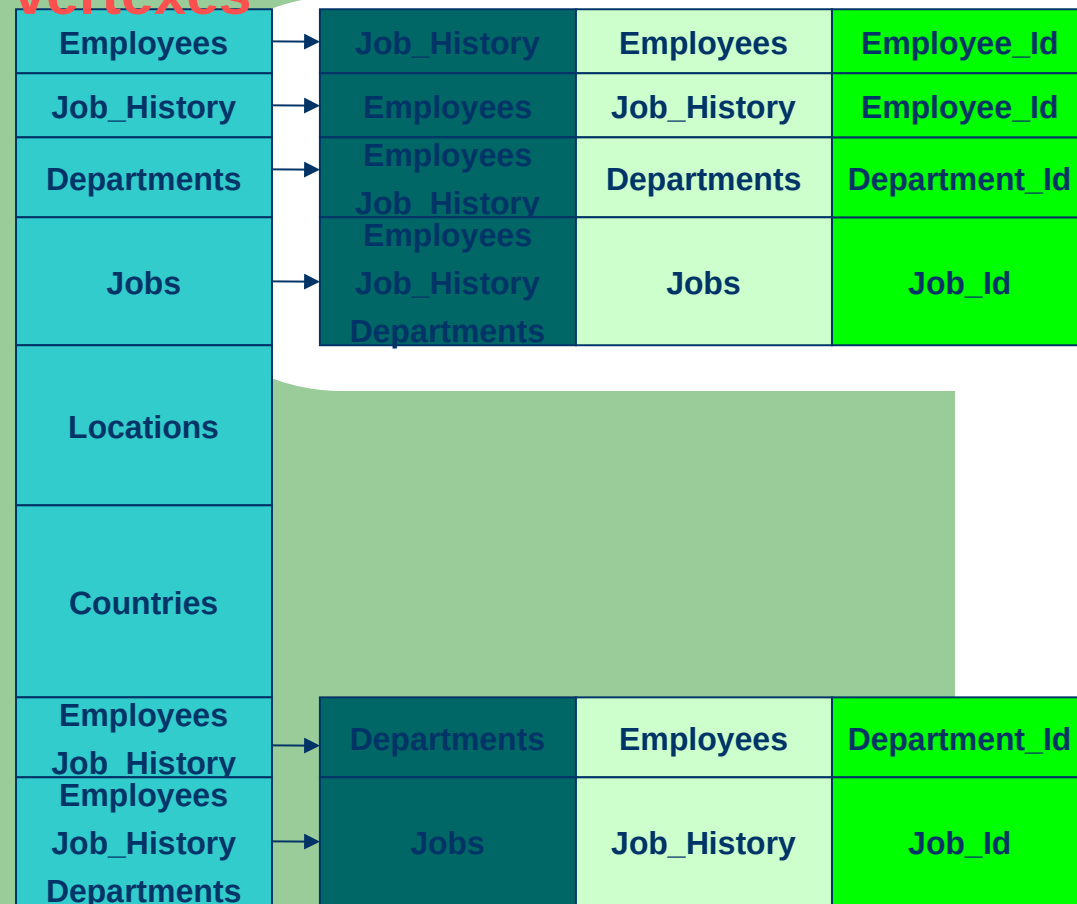
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vertexes



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Job_History
Departments

path

Employees
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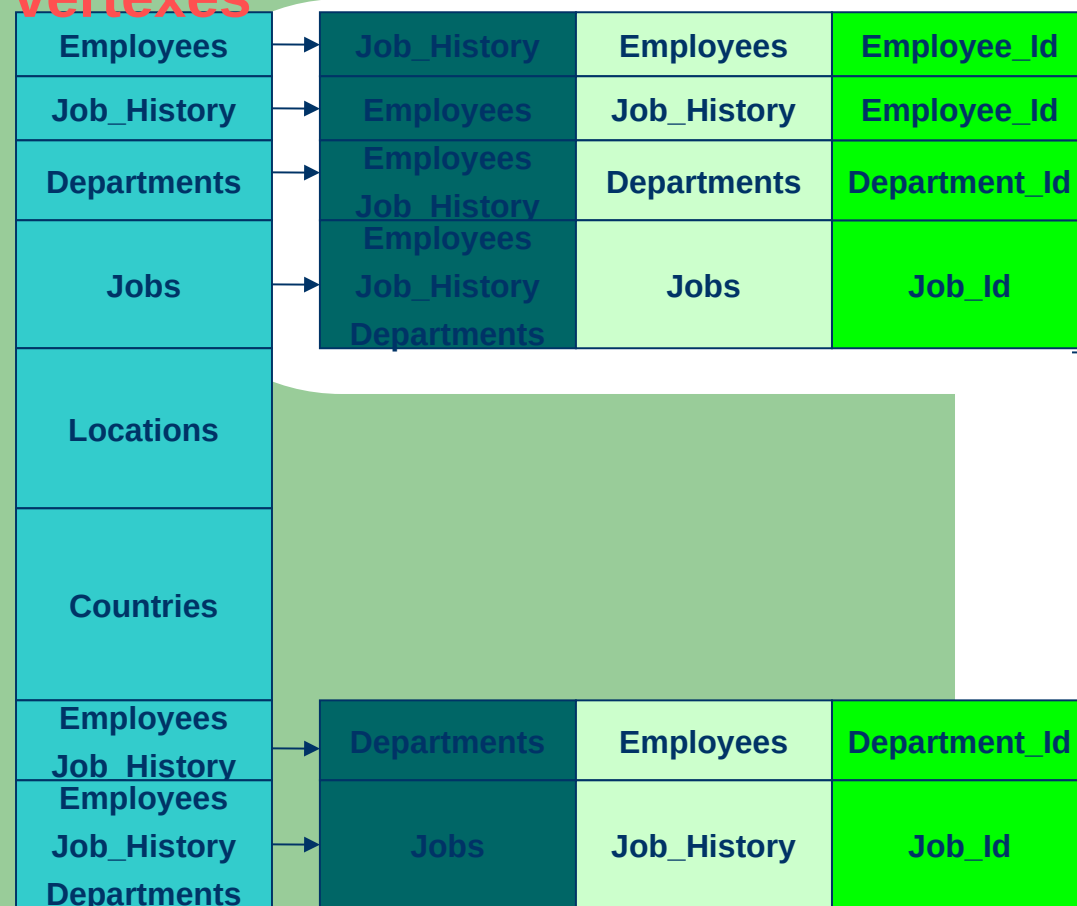
$\text{JoinPathAdjacentList}(T_{[\text{buf}]}) = T_i$

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vertexes



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Job_History
Departments
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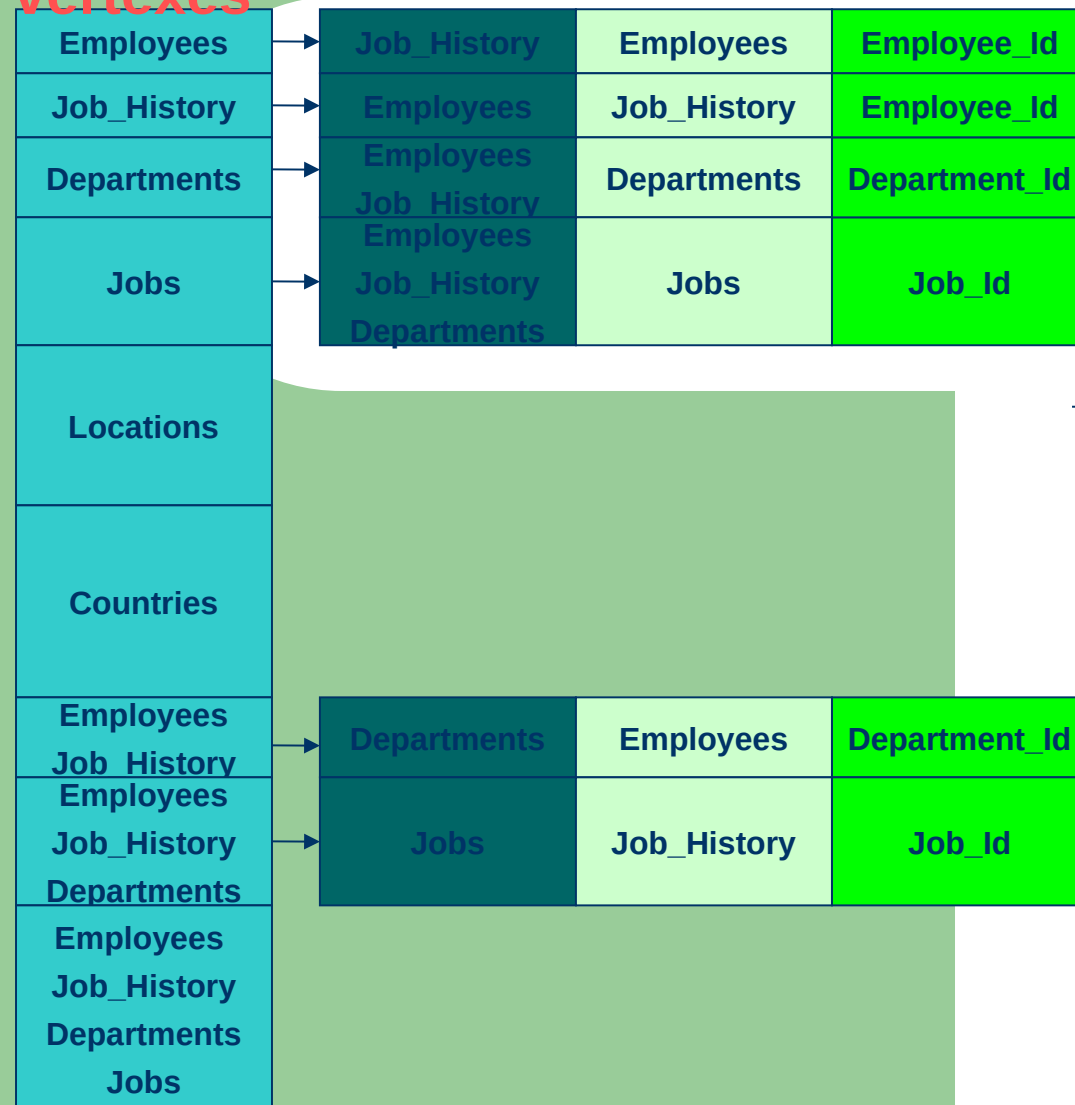
$\text{JoinPathAdjacentList}(T_{[\text{buf}]}) = T_i$

$\text{Key}(T_{[\text{buf}]}) = \text{getFirstAdjacentListKey}(T_{[\text{buf}]}, T_i)$

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vertexes



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Job_History
Departments
Jobs

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Employees
Job_History
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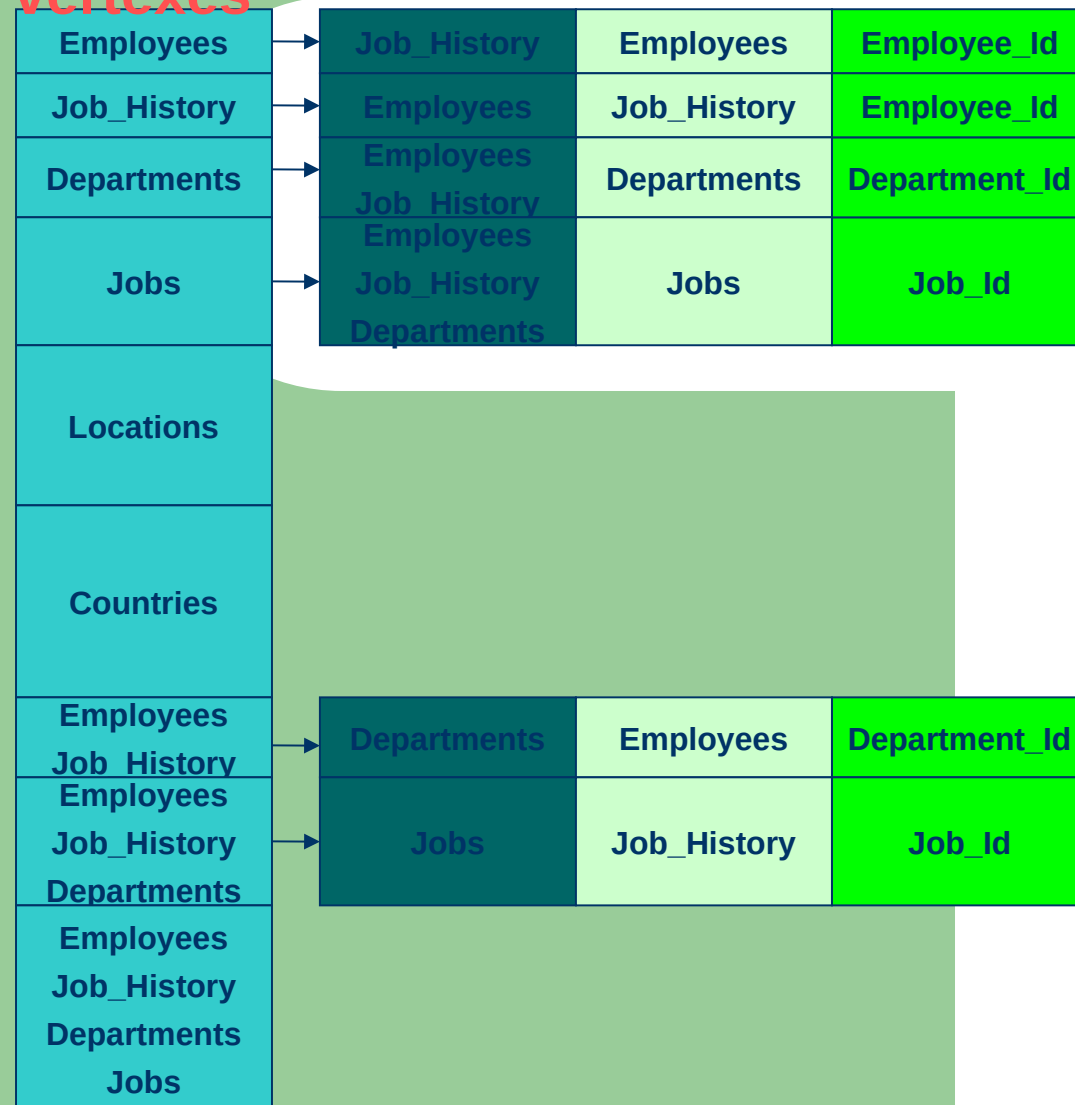
$\text{JoinPathAdjacentList}(T_{[\text{buf}]}) = T_i$

$\text{Key}(T_{[\text{buf}]}) = \text{getFirstAdjacentListKey}(T_{[\text{buf}]}, T_i)$

$T_{[\text{buf}]} += T_i$

$\text{Insert NodesList}[T_{[\text{buf}]}] = T_{[\text{buf}]}$

vertexes



buf

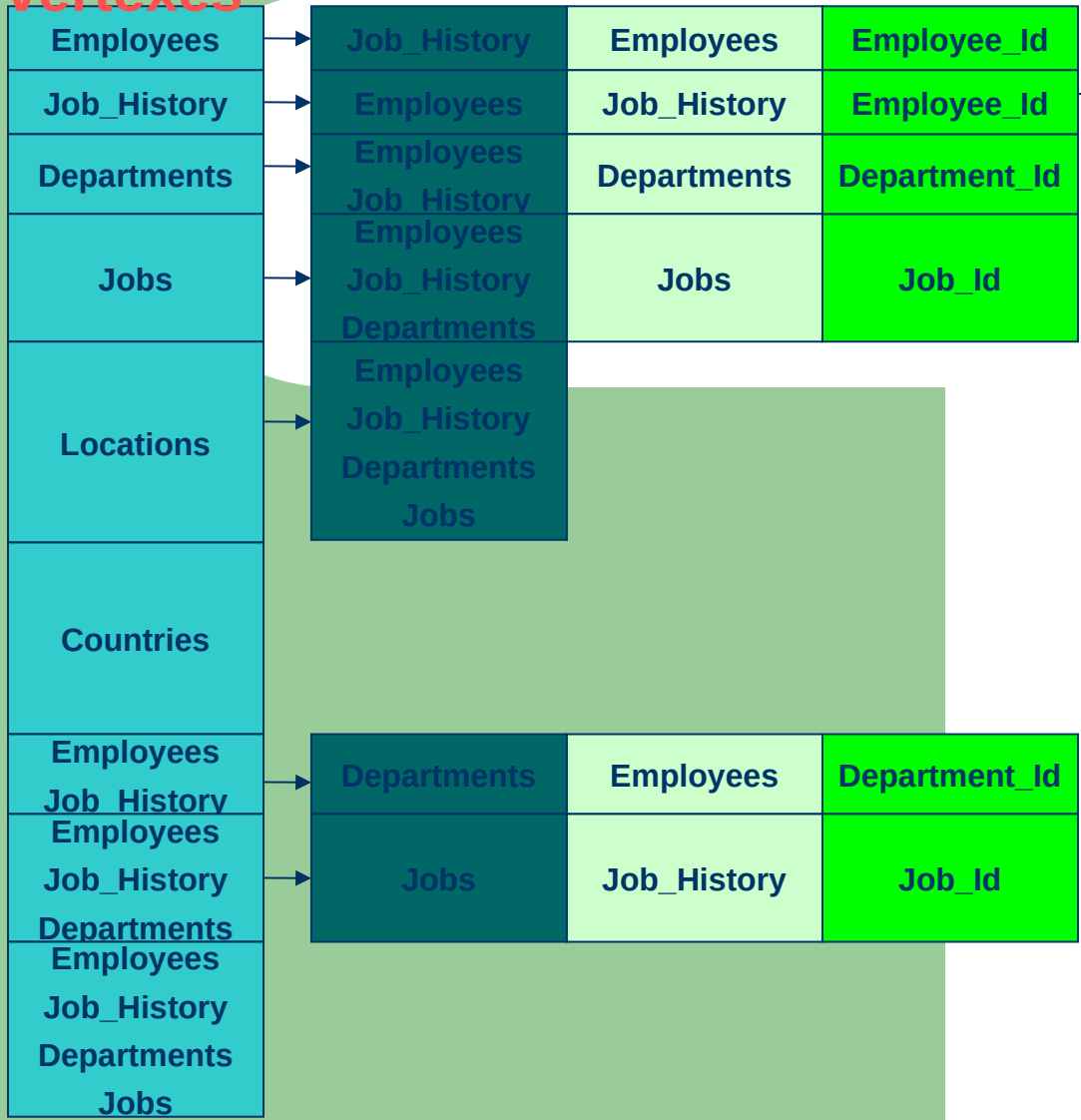
Employees
Job_History
Departments
Jobs

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Locations
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$T_{[buf]} += T_i$

$Insert\ NodesList[T_{[buf]}] = T_{[buf]}$

buf

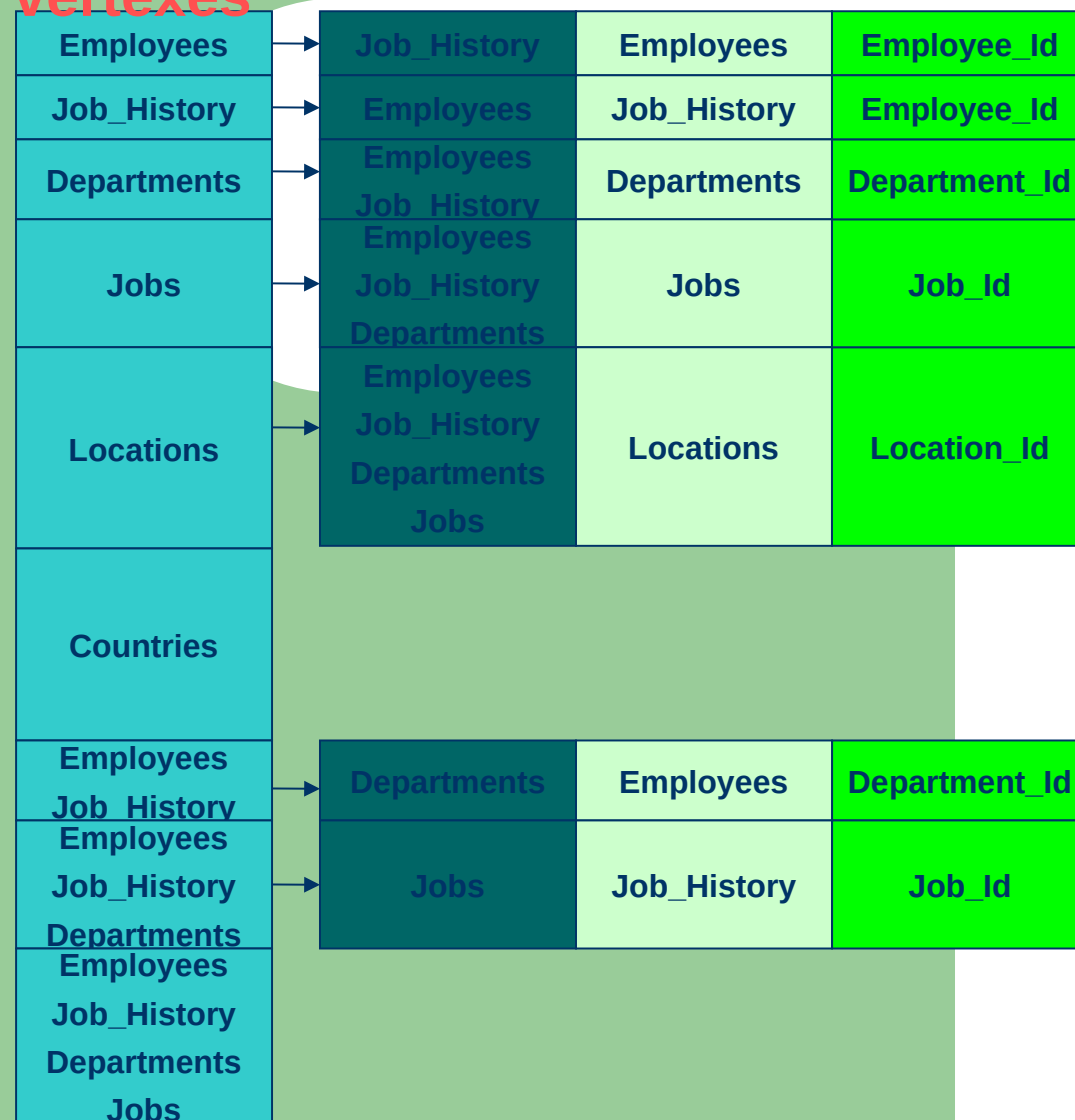


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$T_{[\text{buf}]} += T_i$

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buf

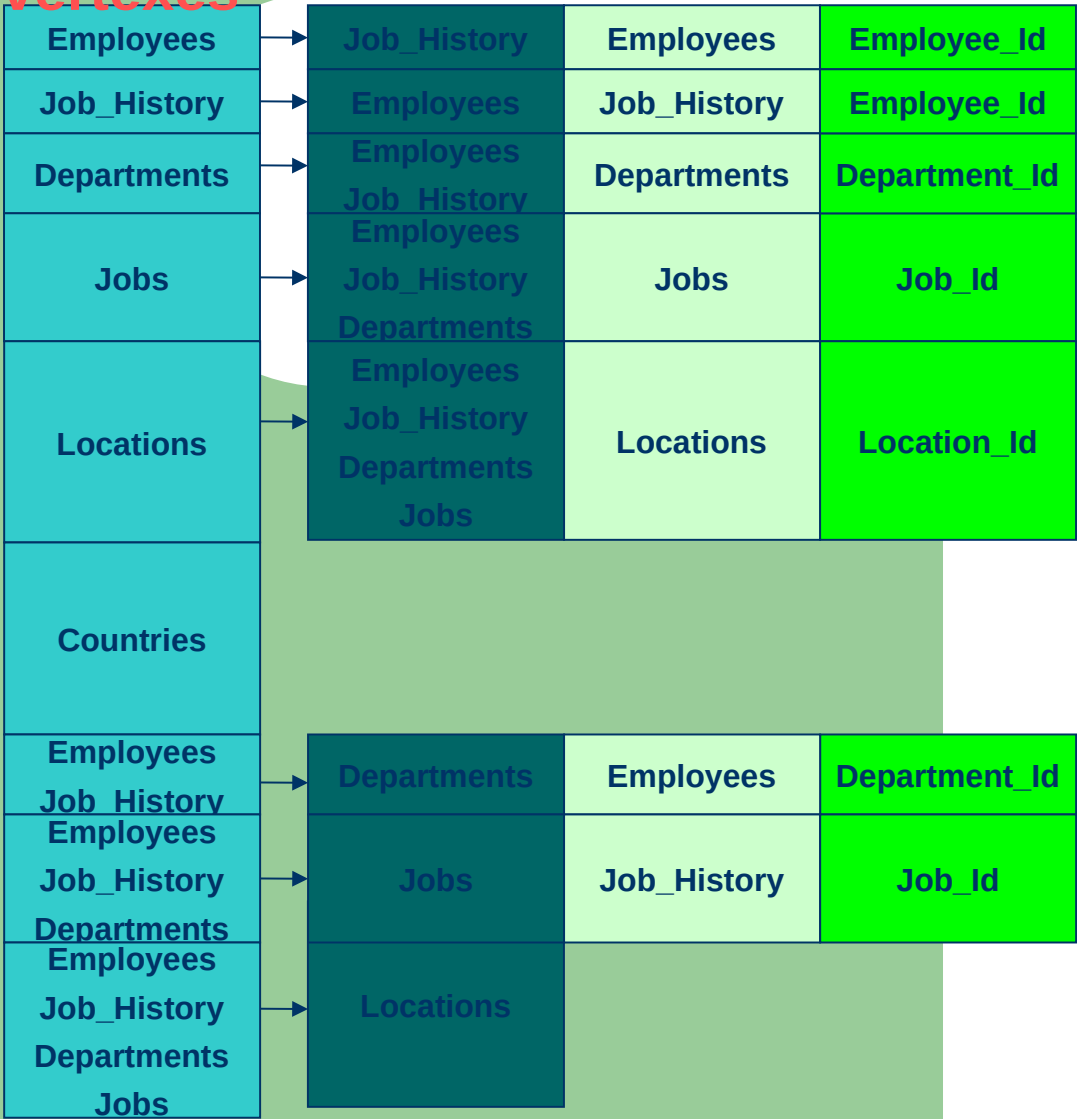
Employees
Job_History
Departments
Jobs

path

Employees
Job_History
Departments
Jobs
Locations
Countries

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$T_{[\text{buf}]} += T_i$

$\text{Insert NodesList}[T_{[\text{buf}]}] = T_{[\text{buf}]}$

buf

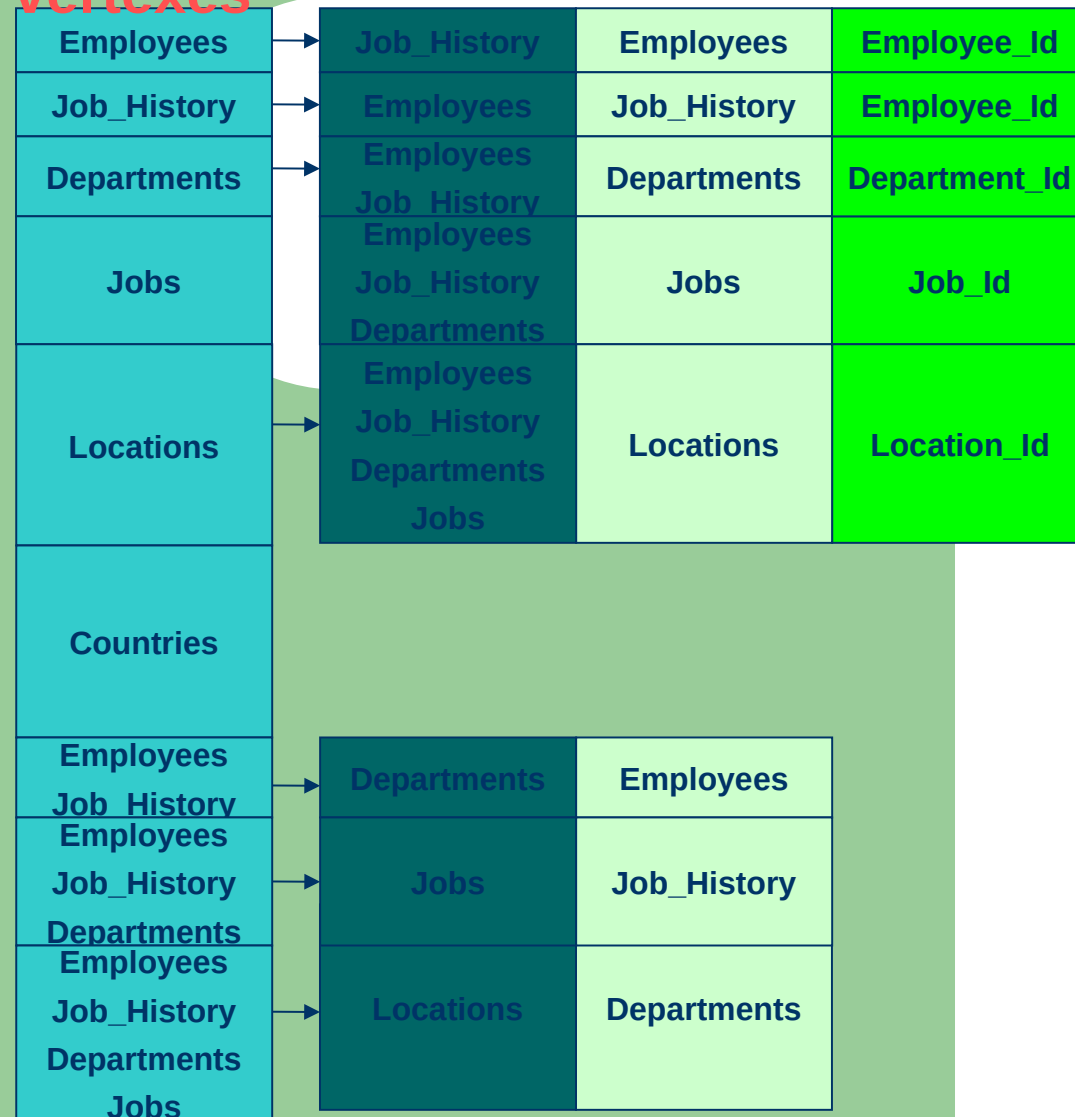


path



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$\text{Insert NodesList}[T_{[\text{buf}]}] = T_{[\text{buf}]}$

buf

Employees
Job_History
Departments
Jobs

path

Employees
Job_History
Departments
Jobs
Locations
Countries

insert all the names of base tables from path as vertexes in JoinPathList
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vertexes

| | | | | |
|--|---|---|-------------|---------------|
| Employees | → | Job_History | Employees | Employee_Id |
| Job_History | → | Employees | Job_History | Employee_Id |
| Departments | → | Employees Job_History | Departments | Department_Id |
| Jobs | | Employees Job_History Departments | Jobs | Job_Id |
| Locations | → | Employees Job_History Departments Jobs | Locations | Location_Id |
| Countries | | | | |
| Employees Job_History | → | Departments | Employees | Department_Id |
| Employees Job_History | → | Jobs | Job_History | Job_Id |
| Departments Employees Job_History Departments Jobs | → | Locations | Departments | Location_Id |

take one T_i at a time

$JoinPathAdjacentList(T_i) = T_{[buf]}$

$Key(T_i) = getFirstAdjacentListKey(T_i, T_{[buf]})$

$JoinPathAdjacentList(T_{[buf]}) = T_i$

$Key(T_{[buf]}) = getFirstAdjacentListKey(T_{[buf]}, T_i)$

$T_{[buf]} += T_i$

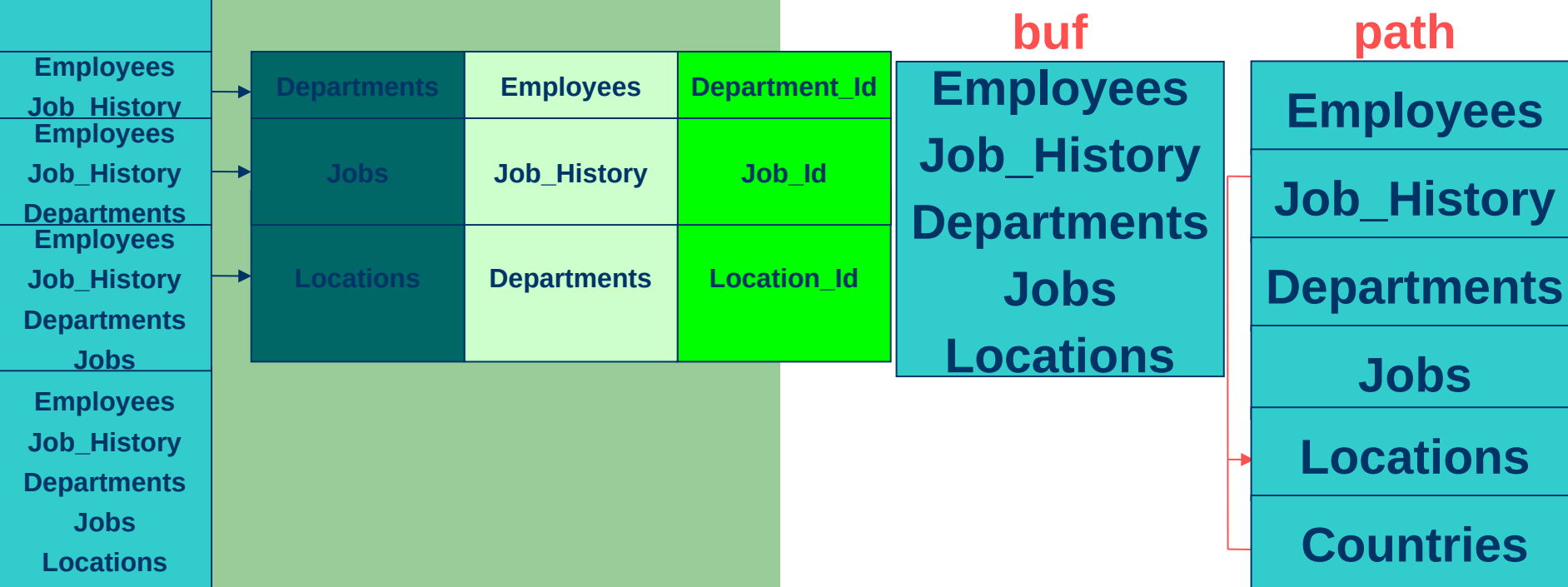
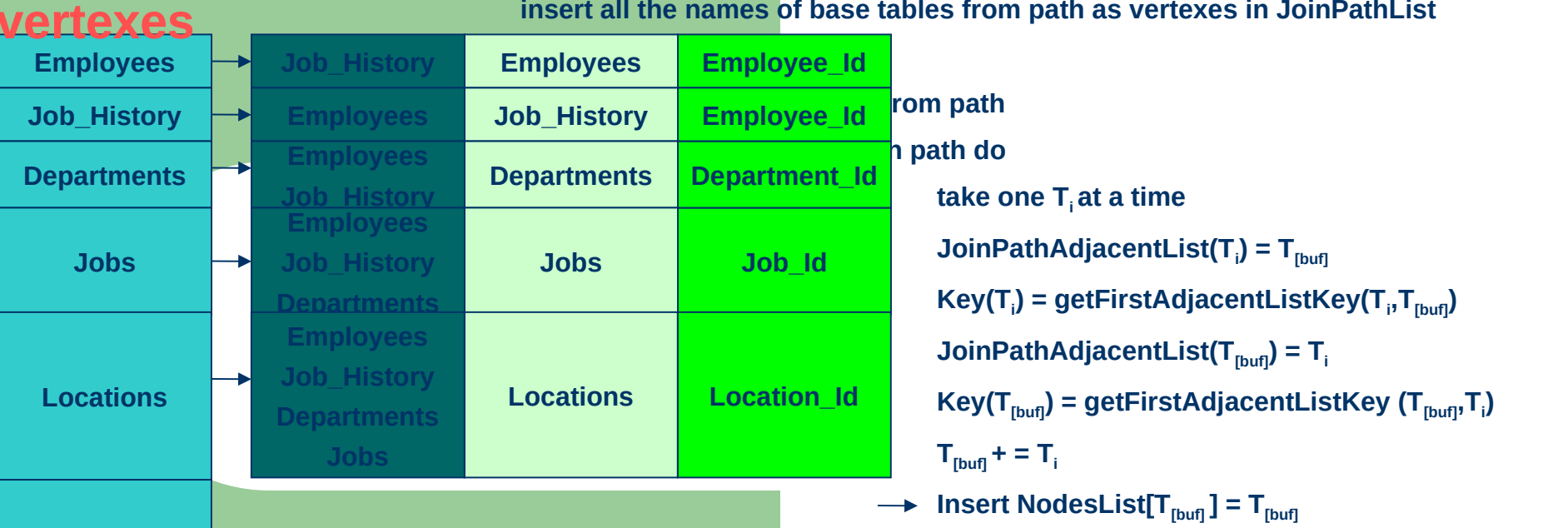
$Insert\ NodesList[T_{[buf]}] = T_{[buf]}$

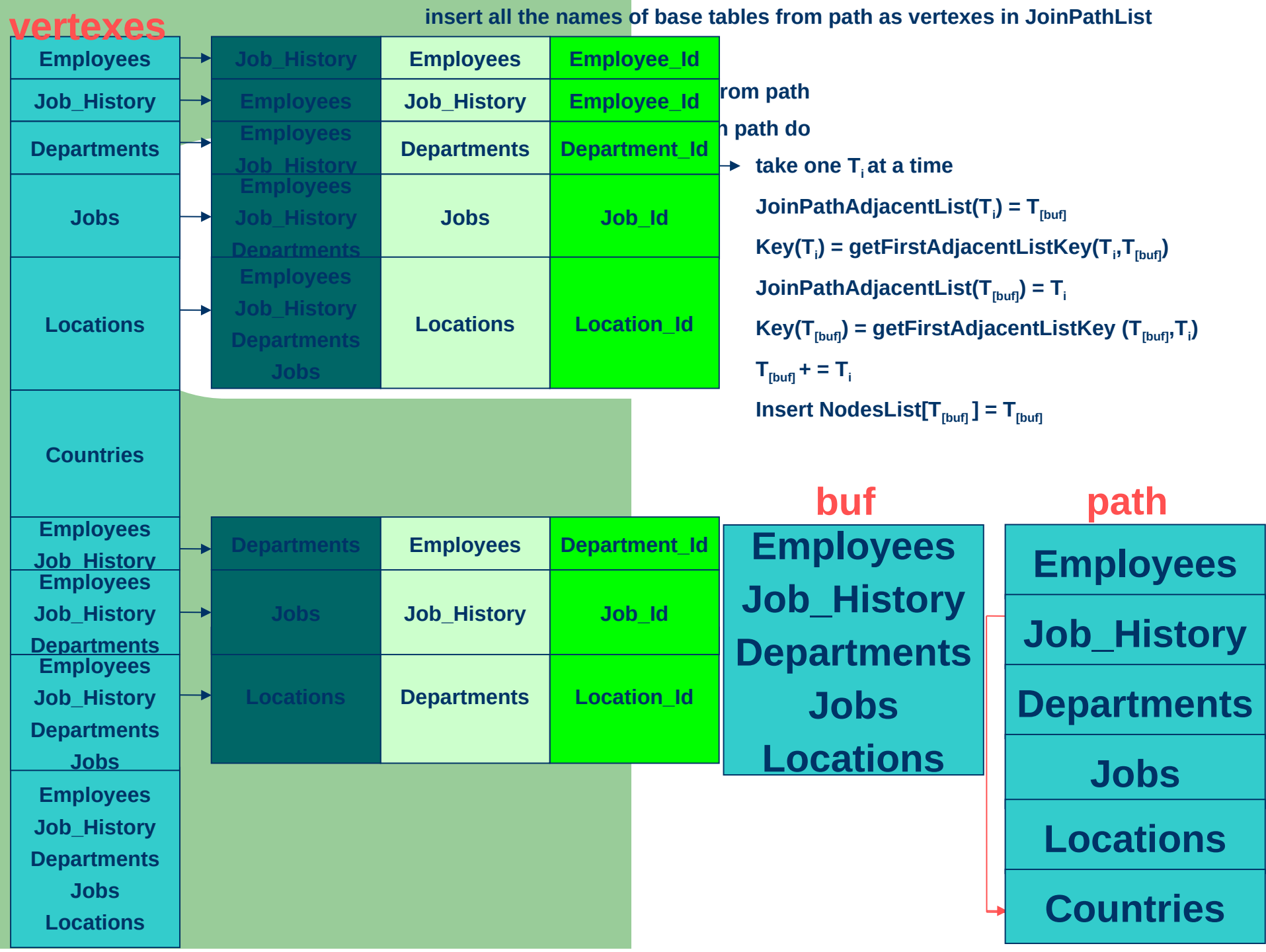
buf

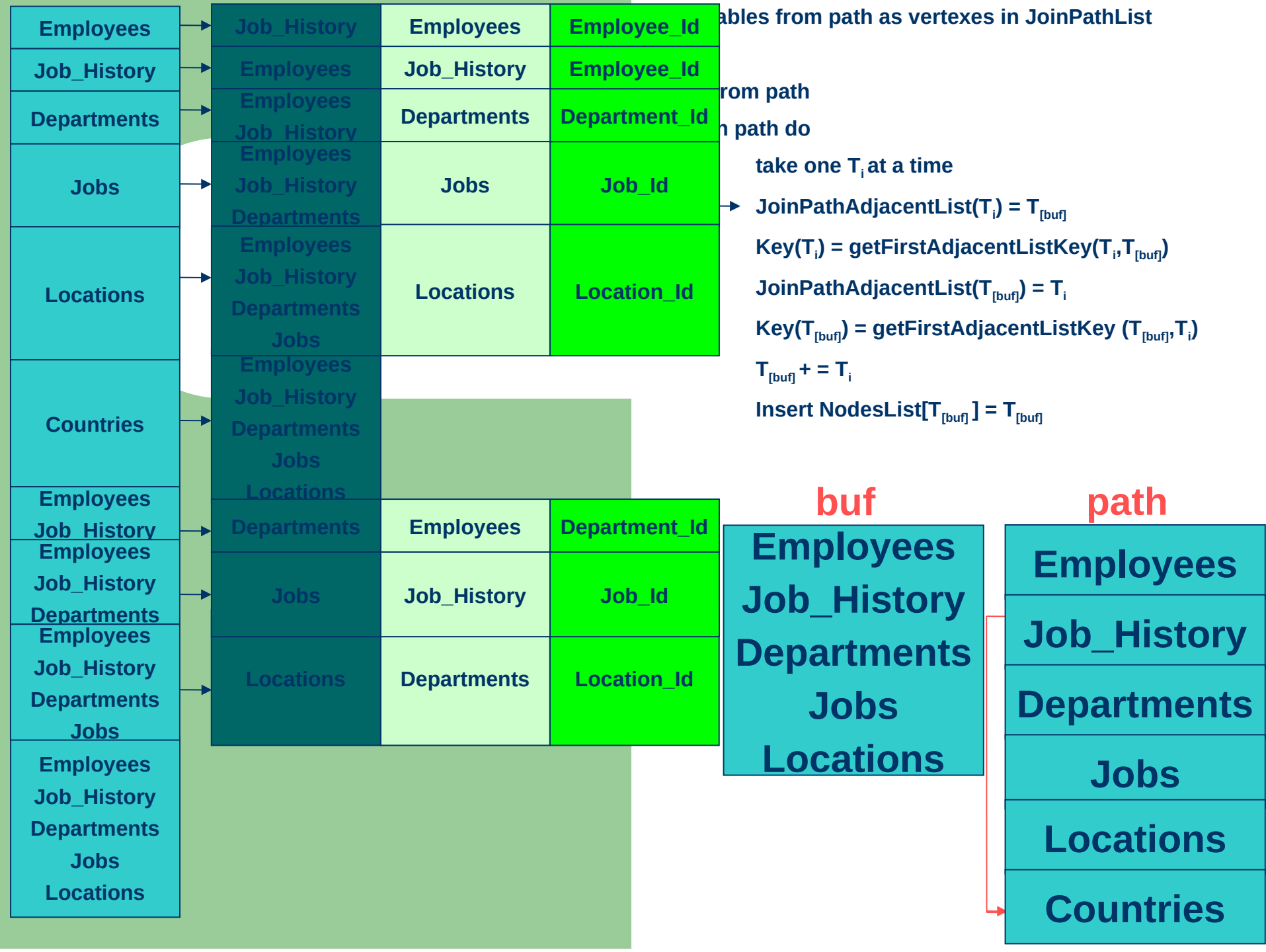
| |
|-------------|
| Employees |
| Job_History |
| Departments |
| Jobs |
| Locations |

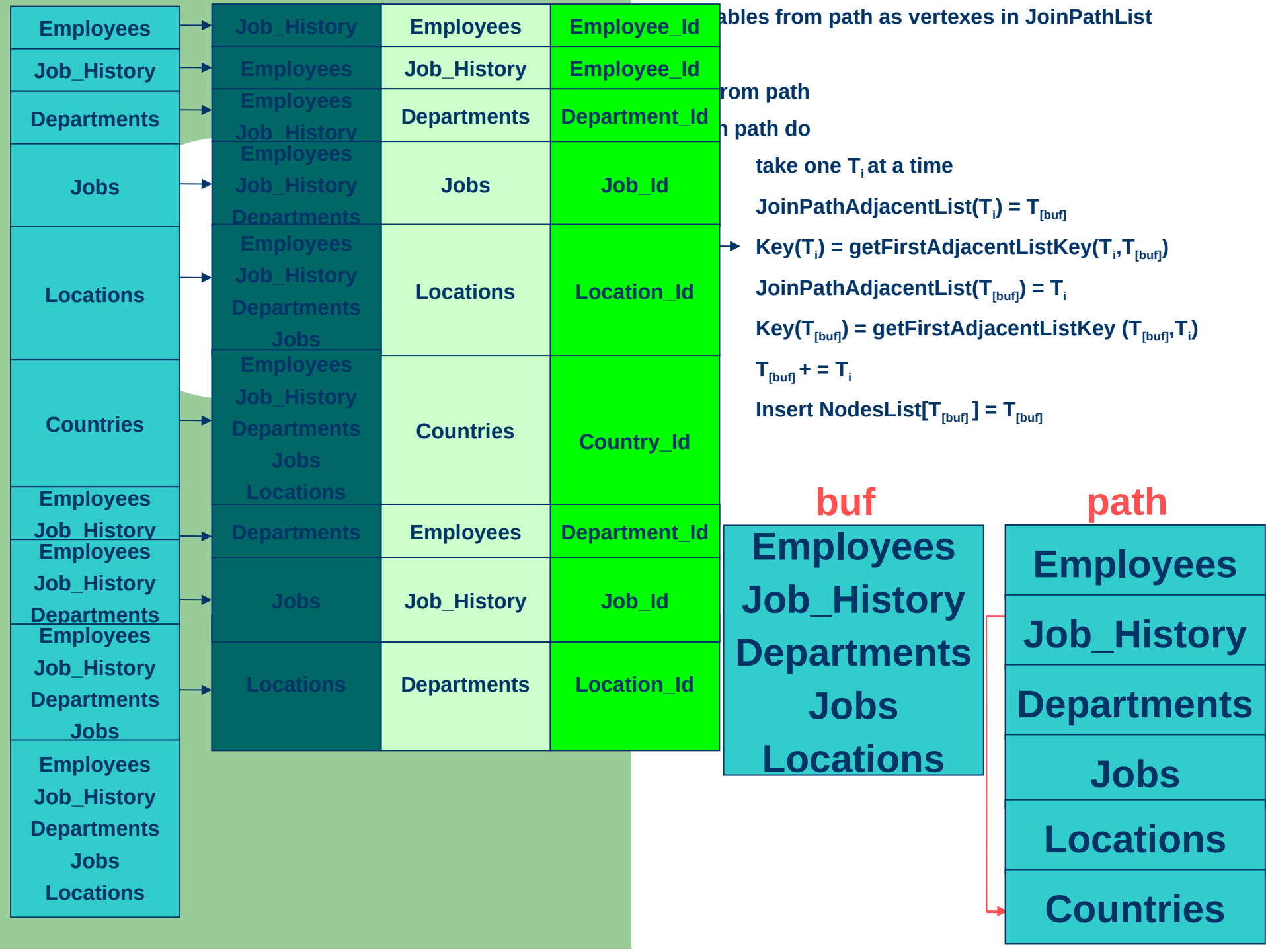
path

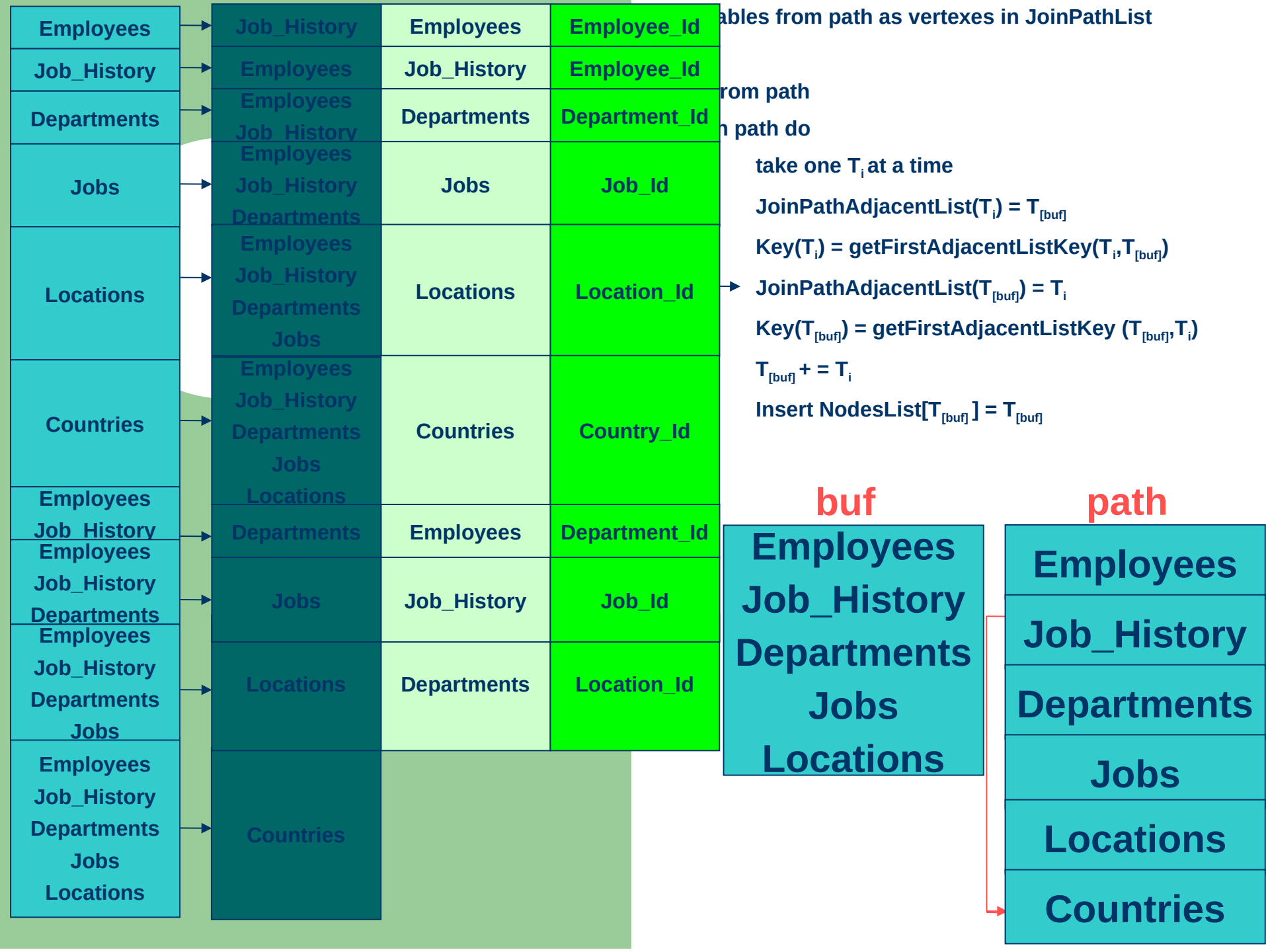
| |
|-------------|
| Employees |
| Job_History |
| Departments |
| Jobs |
| Locations |
| Countries |

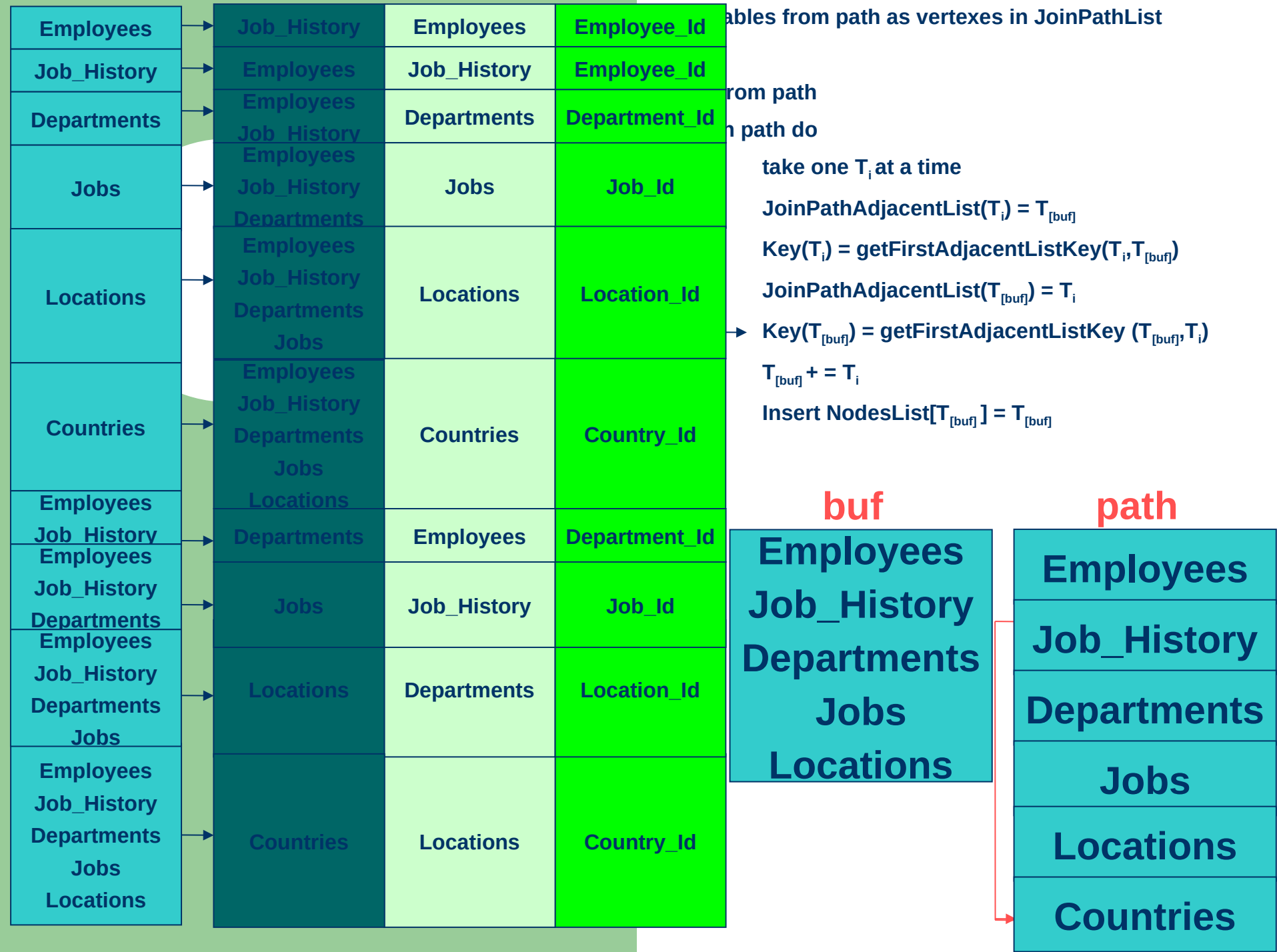


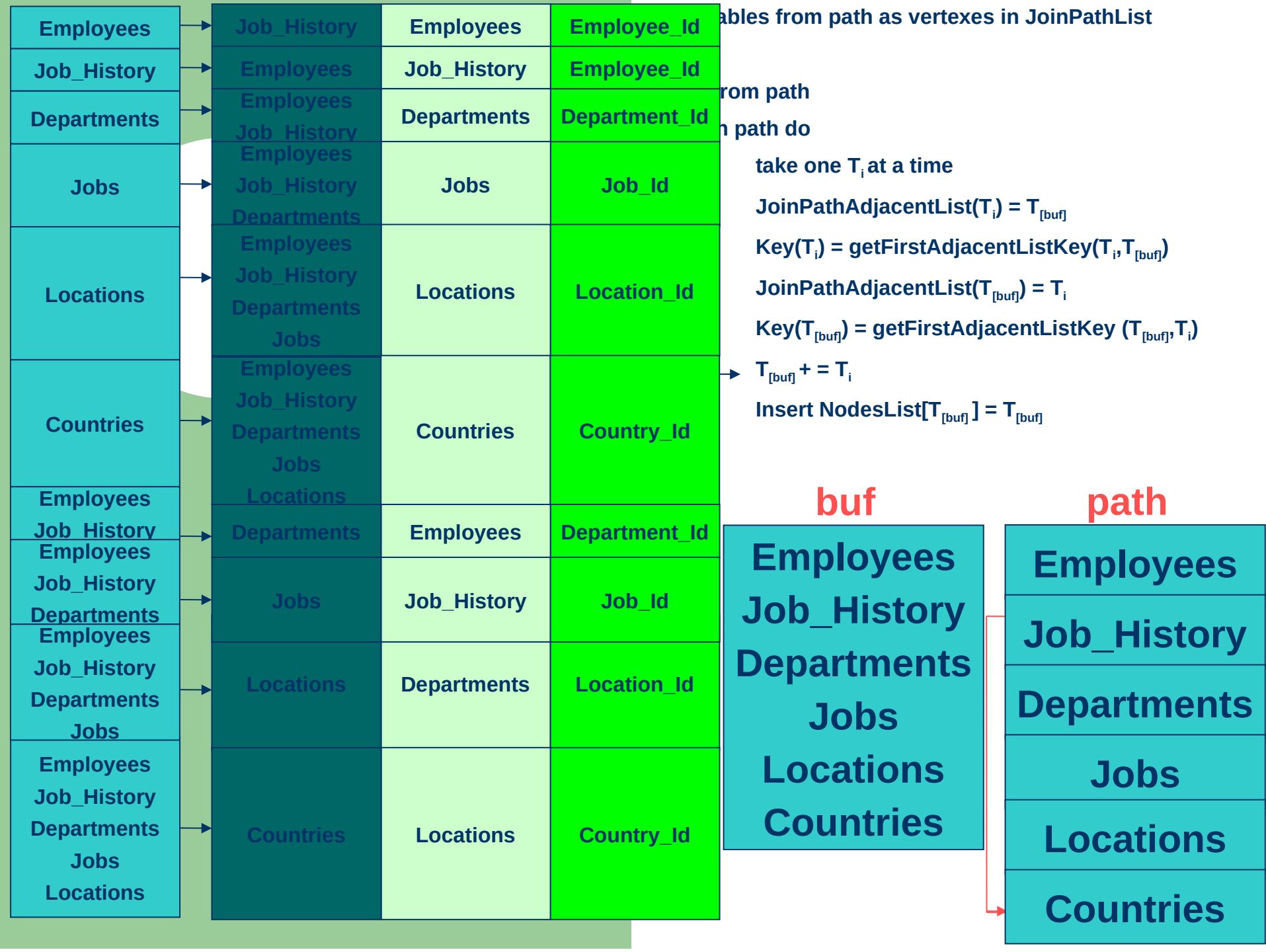


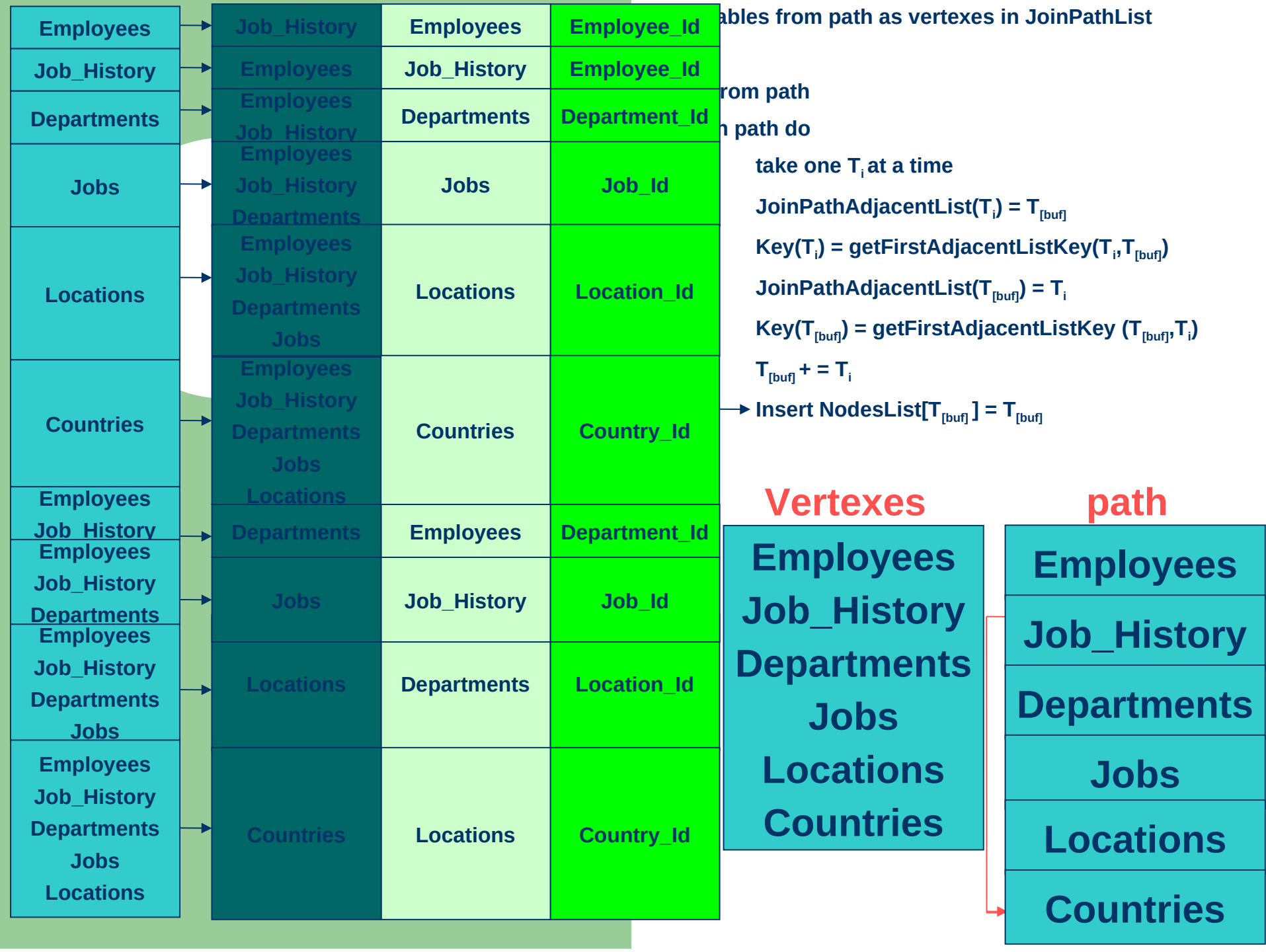








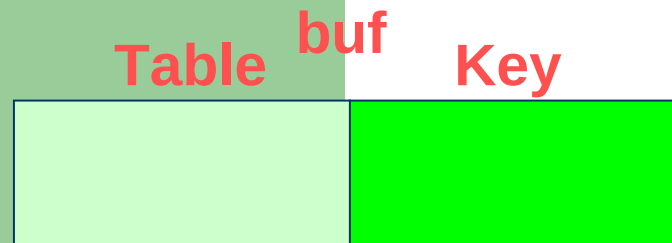




Join Path List

| | | | | |
|--|---|---|-------------|---------------|
| Employees | → | Job_History | Employees | Employee_Id |
| Job_History | → | Employees | Job_History | Employee_Id |
| Departments | → | Employees Job_History | Departments | Department_Id |
| Jobs | → | Employees Job_History Departments | Jobs | Job_Id |
| Locations | → | Employees Job_History Departments Jobs | Locations | Location_Id |
| Countries | → | Employees Job_History Departments Jobs Locations | Countries | Country_Id |
| Employees Job_History | → | Departments | Employees | Department_Id |
| Employees Job_History Departments | → | Jobs | Job_History | Job_Id |
| Employees Job_History Departments Jobs | → | Locations | Departments | Location_Id |
| Employees Job_History Departments Jobs Locations | → | Countries | Locations | Country_Id |
| Employees Job_History Departments Jobs Locations Countries | | | | |

→ create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
 take one $T_{[i]}$ at a time
 for all Base Tables in $T_{[i]}$ do
 take one T_k at a time
 for every buf.Table = T_k do
 if (buf.key != Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
 InheritedKey($T_{[i]}$) += buf.key
 if T_i is the table from which comes Key($T_{[i]}$) then
 buf.Table = T_i
 buf.key = Key($T_{[i]}$)



create a structure buf with 2 fields: Table and Key

→ for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

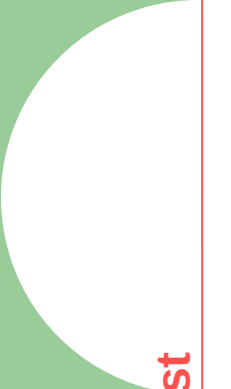
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Join Path List

| | | | | |
|--|---|---|-------------|---------------|
| Employees | → | Job_History | Employees | Employee_Id |
| Job_History | → | Employees | Job_History | Employee_Id |
| Departments | → | Employees Job_History | Departments | Department_Id |
| Jobs | → | Employees Job_History Departments | Jobs | Job_Id |
| Locations | → | Employees Job_History Departments Jobs | Locations | Location_Id |
| Countries | → | Employees Job_History Departments Jobs Locations | Countries | Country_Id |
| Employees Job_History | → | Departments | Employees | Department_Id |
| Employees Job_History Departments | → | Jobs | Job_History | Job_Id |
| Employees Job_History Departments Jobs | → | Locations | Departments | Location_Id |
| Employees Job_History Departments Jobs Locations | → | Countries | Locations | Country_Id |
| Employees Job_History Departments Jobs Locations Countries | | | | |

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for all the tables in JoinPathList going downward do

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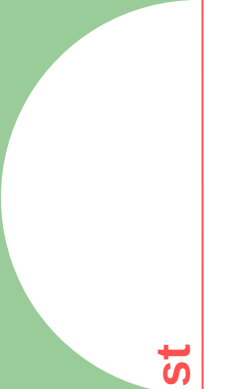
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Join Path List

T
[i]

| | | | | |
|--|---|---|-------------|---------------|
| Employees | → | Job_History | Employees | Employee_Id |
| Job_History | → | Employees | Job_History | Employee_Id |
| Departments | → | Employees Job_History | Departments | Department_Id |
| Jobs | → | Employees Job_History Departments | Jobs | Job_Id |
| Locations | → | Employees Job_History Departments Jobs | Locations | Location_Id |
| Countries | → | Employees Job_History Departments Jobs Locations | Countries | Country_Id |
| Employees Job_History | → | Departments | Employees | Department_Id |
| Job_History Employees | → | Jobs | Job_History | Job_Id |
| Departments Employees Job_History | → | Locations | Departments | Location_Id |
| Jobs Employees Job_History Departments | → | Countries | Locations | Country_Id |
| Locations Jobs Employees Job_History Departments | → | | | |

create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

→ for all Base Tables in $T_{[i]}$ do

take one T_k at a time

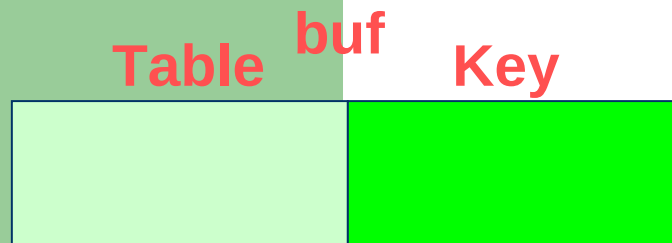
for every buf.Table = T_k do

if (buf.key != Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)



create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

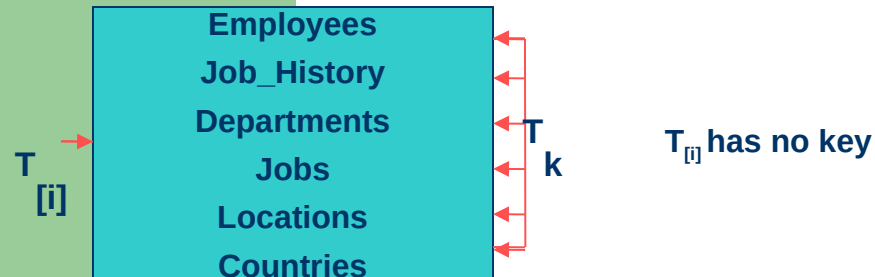
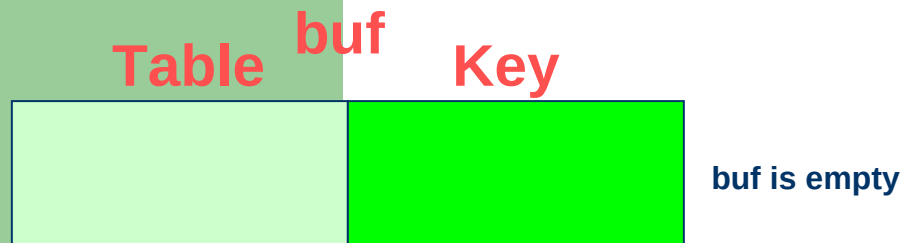
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Join Path List

| | | | | |
|--|---|---|-------------|---------------|
| Employees | → | Job_History | Employees | Employee_Id |
| Job_History | → | Employees | Job_History | Employee_Id |
| Departments | → | Employees Job_History | Departments | Department_Id |
| Jobs | → | Employees Job_History Departments | Jobs | Job_Id |
| Locations | → | Employees Job_History Departments Jobs | Locations | Location_Id |
| Countries | → | Employees Job_History Departments Jobs Locations | Countries | Country_Id |
| Employees Job_History | → | Departments | Employees | Department_Id |
| Employees Job_History Departments | → | Jobs | Job_History | Job_Id |
| Employees Job_History Departments Jobs | → | Locations | Departments | Location_Id |
| Employees Job_History Departments Jobs Locations | → | Countries | Locations | Country_Id |
| Employees Job_History Departments Jobs Locations Countries | | | | |

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take one T_k at a time

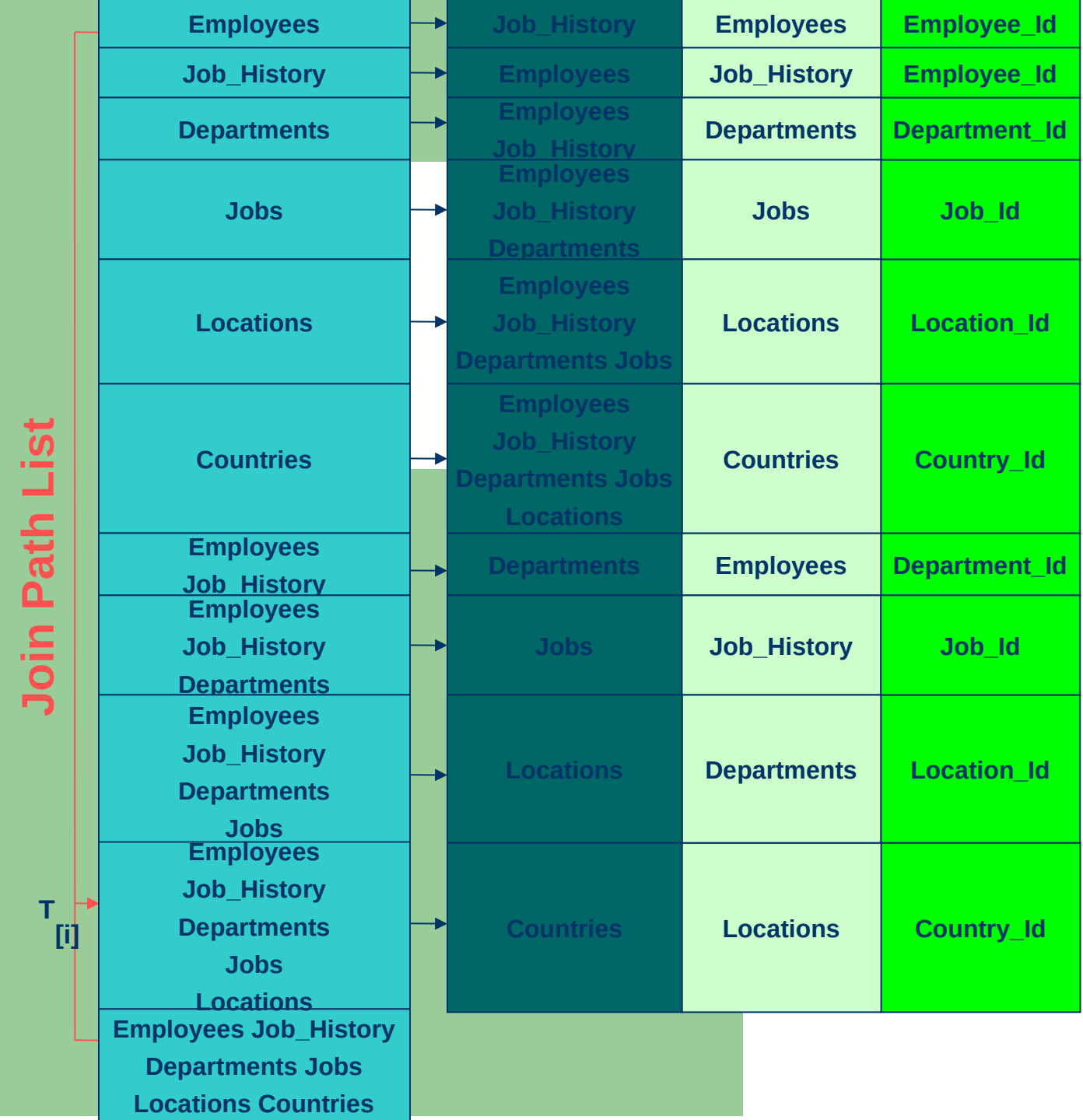
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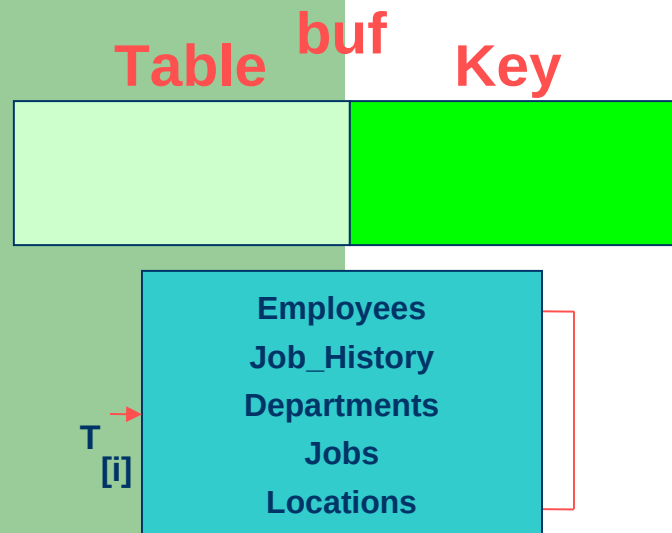
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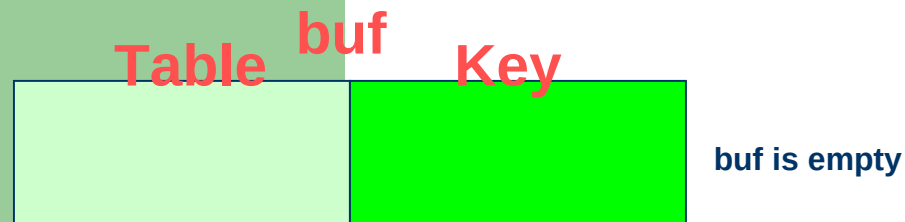
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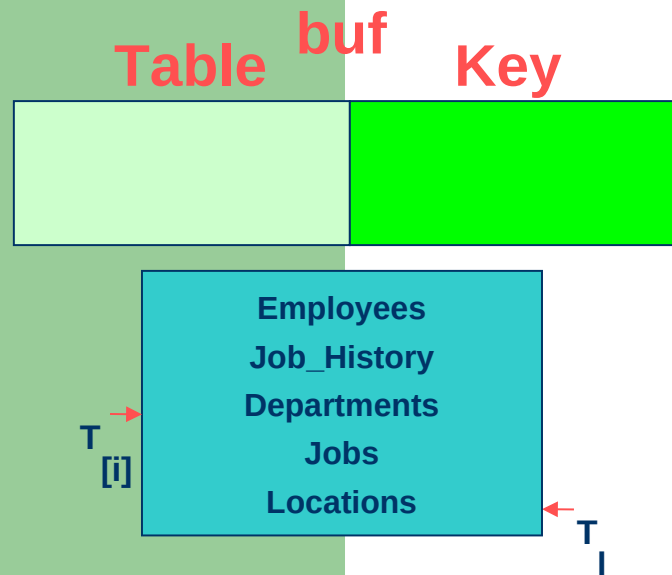
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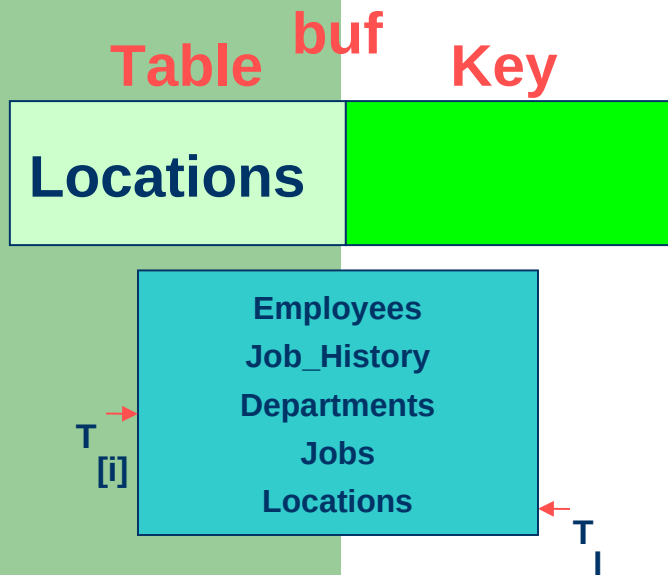
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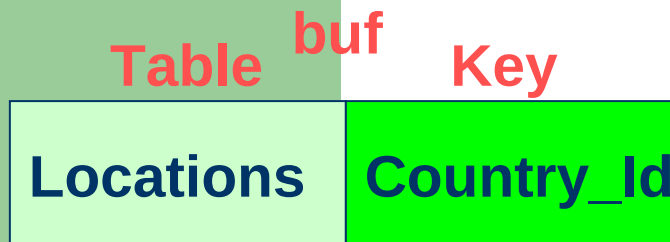
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Join Path List

| | | | | |
|---|---|--|-------------|---------------|
| Employees | → | Job_History | Employees | Employee_Id |
| Job_History | → | Employees | Job_History | Employee_Id |
| Departments | → | Employees Job_History | Departments | Department_Id |
| Jobs | → | Employees Job_History Departments | Jobs | Job_Id |
| Locations | → | Employees Job_History Departments Jobs | Locations | Location_Id |
| Countries | → | Employees Job_History Departments Jobs Locations | Countries | Country_Id |
| Employees Job_History | → | Departments | Employees | Department_Id |
| Employees Job_History Departments | → | Jobs | Job_History | Job_Id |
| Employees Job_History Departments Jobs | → | Locations | Departments | Location_Id |
| Employees Job_History Departments Jobs Locations | → | Countries | Locations | Country_Id |
| Employees Job_History Departments Jobs Locations Countries | | | | |

create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do

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for all Base Tables in $T_{[i]}$ do

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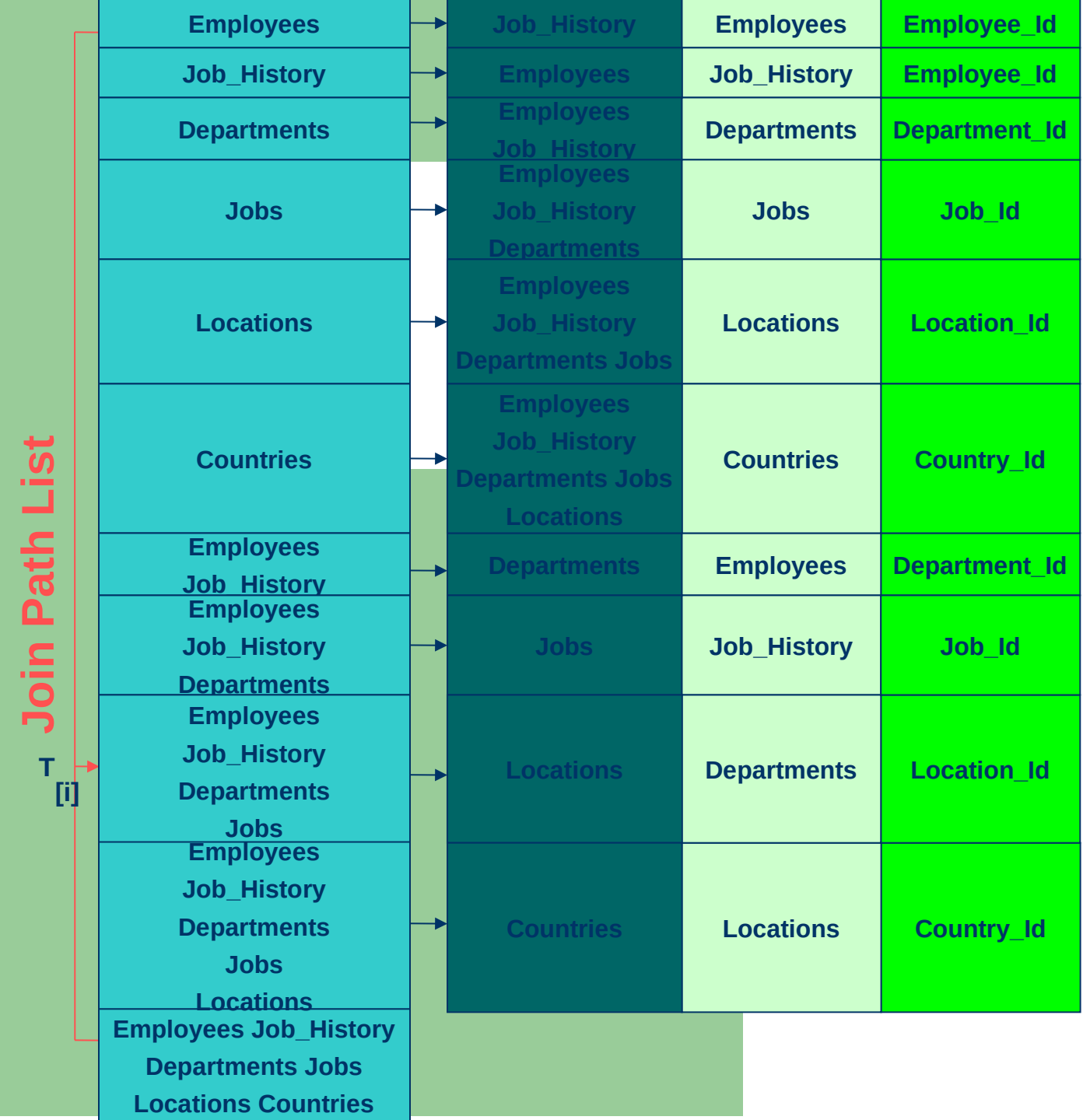
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take one $T_{[i]}$ at a time

→ for all Base Tables in $T_{[i]}$ do

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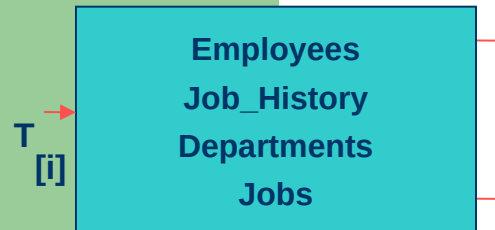
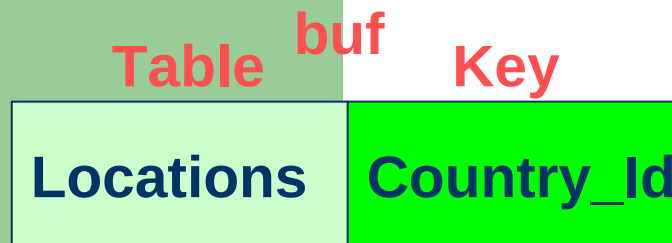
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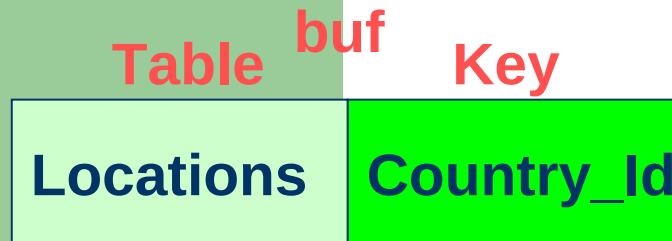
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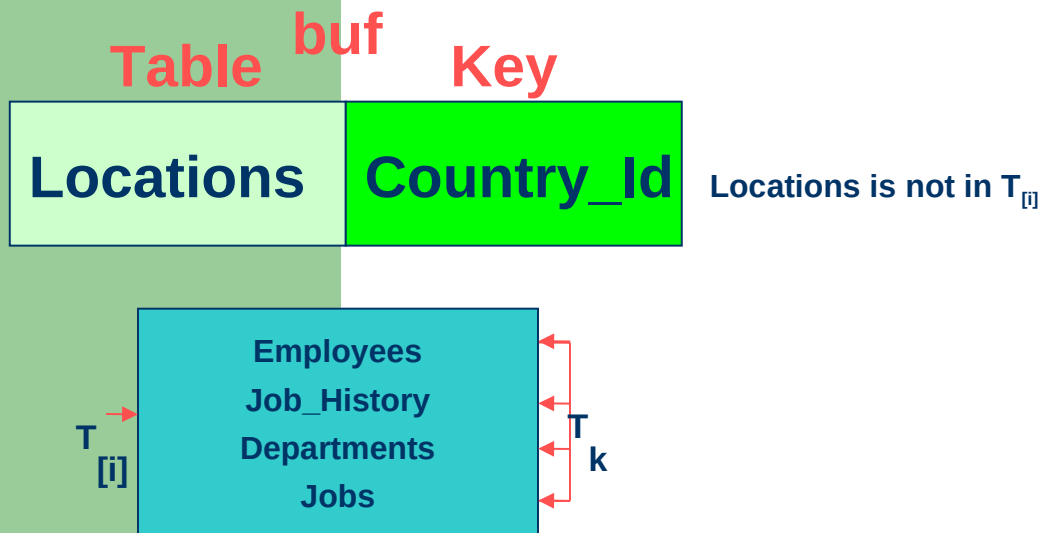
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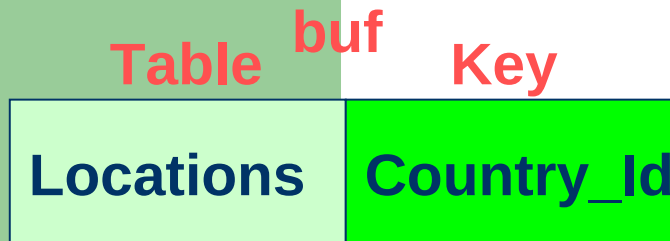
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Table buf Key

Locations

Country_Id

Departments

Employees
Job_History
Departments
Jobs

$T_{[i]}$

T_i

create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for every buf.Table = T_k do

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buf.Table = T_i

buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|-------------|
| Locations | Country_Id |
| Departments | Location_Id |



create a structure buf with 2 fields: Table and Key

→ for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

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Join Path List

| | | | | |
|---|---|--|-------------|---------------|
| Employees | → | Job_History | Employees | Employee_Id |
| Job_History | → | Employees | Job_History | Employee_Id |
| Departments | → | Employees Job_History | Departments | Department_Id |
| Jobs | → | Employees Job_History Departments | Jobs | Job_Id |
| Locations | → | Employees Job_History Departments Jobs | Locations | Location_Id |
| Countries | → | Employees Job_History Departments Jobs Locations | Countries | Country_Id |
| Employees Job_History | → | Departments | Employees | Department_Id |
| Employees Job_History Departments | → | Jobs | Job_History | Job_Id |
| Employees Job_History Departments Jobs | → | Locations | Departments | Location_Id |
| Employees Job_History Departments Jobs Locations | → | Countries | Locations | Country_Id |
| Employees Job_History Departments Jobs Locations Countries | | | | |

create a structure buf with 2 fields: Table and Key
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for all Base Tables in $T_{[i]}$ do

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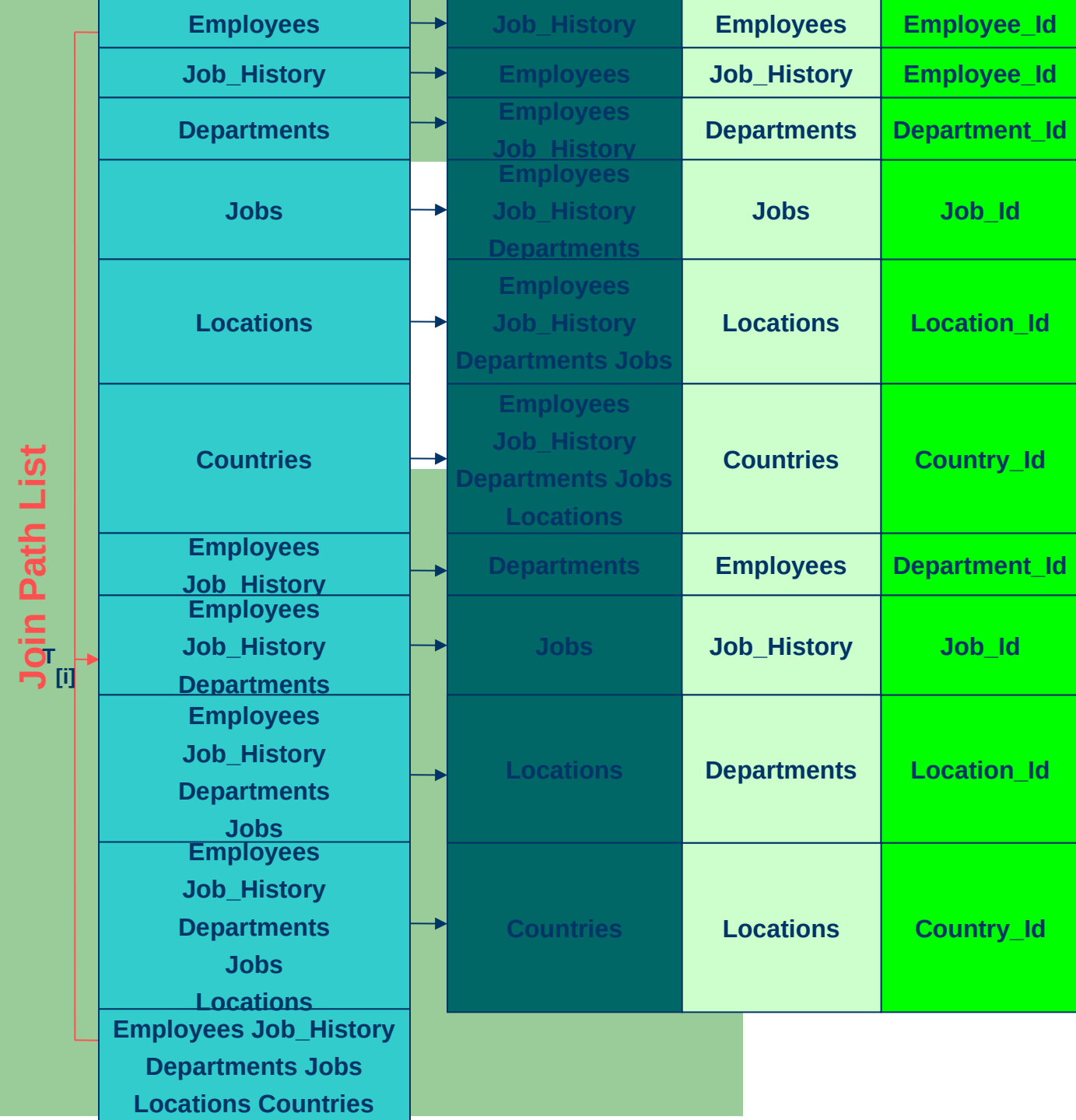
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take one $T_{[i]}$ at a time

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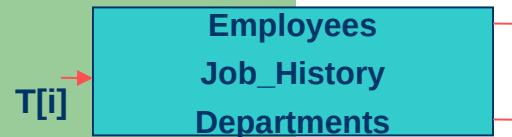
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buf.key = Key($T_{[i]}$)

| Table | Key |
|-------------|-------------|
| Locations | Country_Id |
| Departments | Location_Id |



create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
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for all Base Tables in $T_{[i]}$ do

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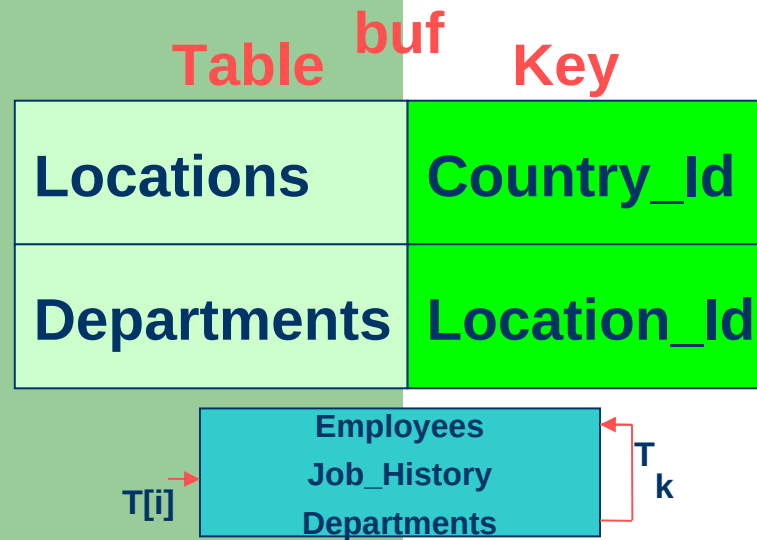
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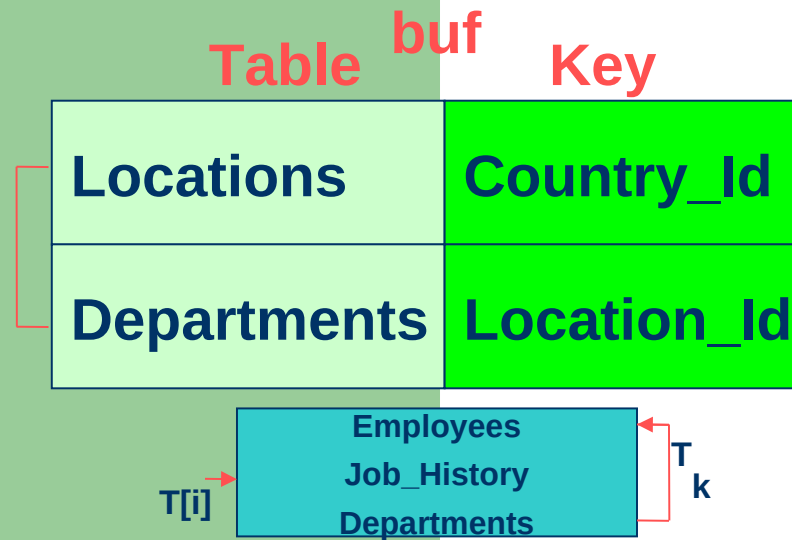
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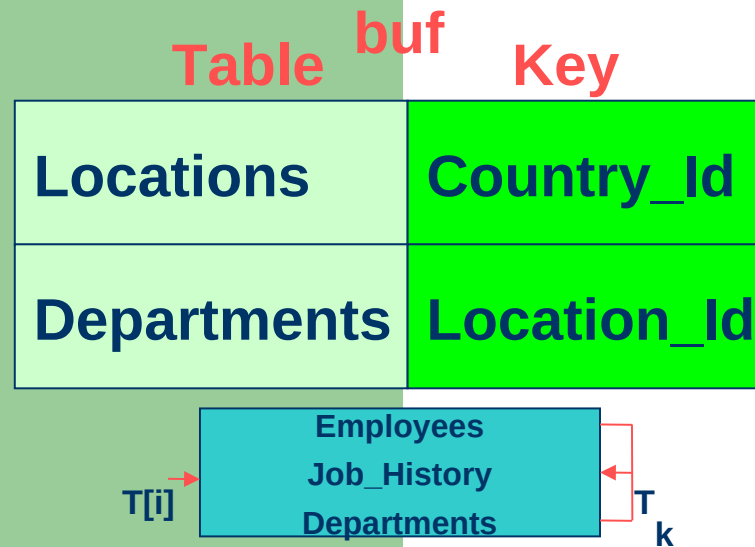
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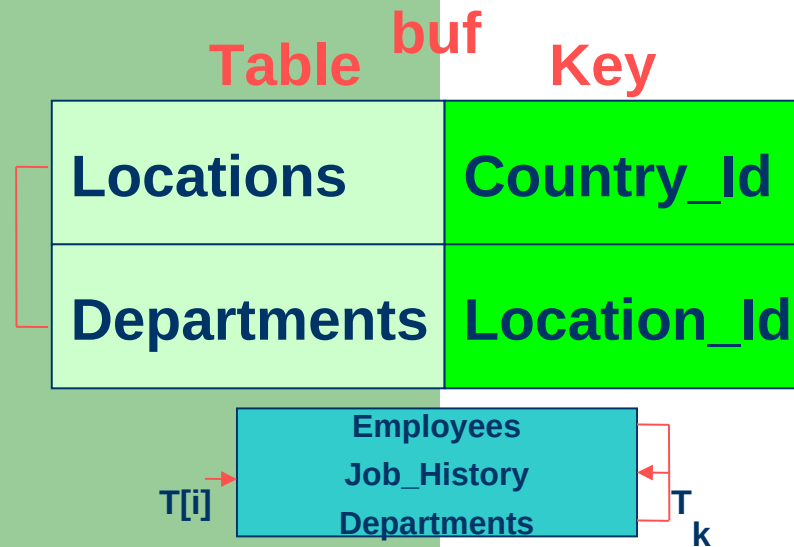
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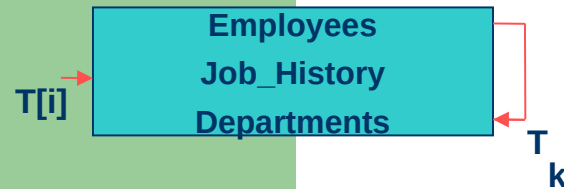
if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|-------------|
| Locations | Country_Id |
| Departments | Location_Id |



create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

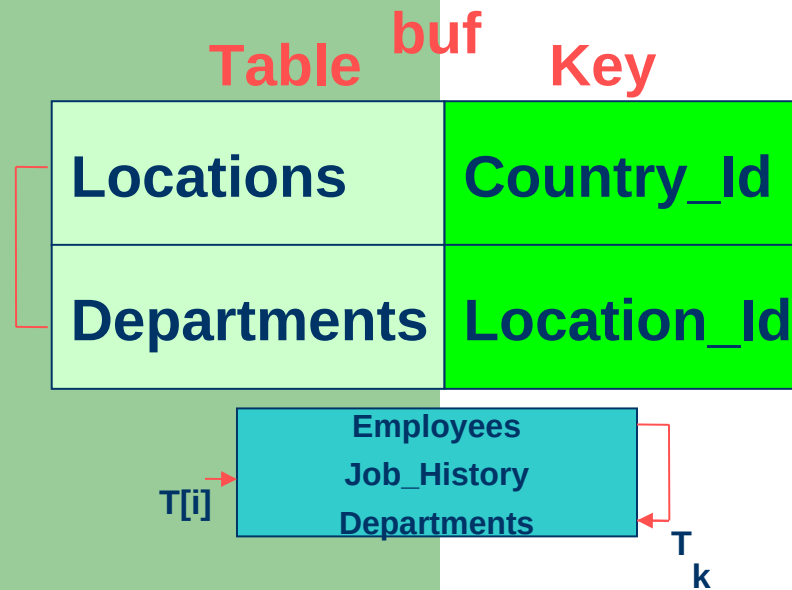
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take one T_k at a time

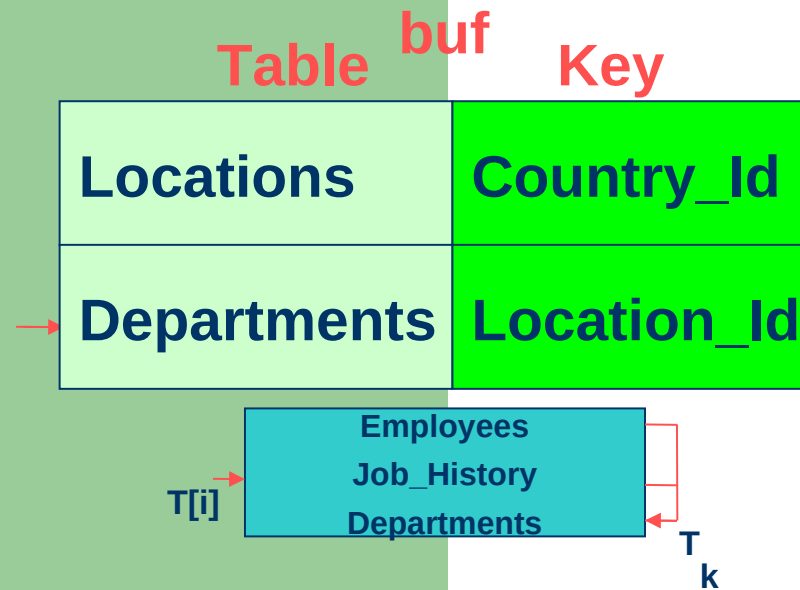
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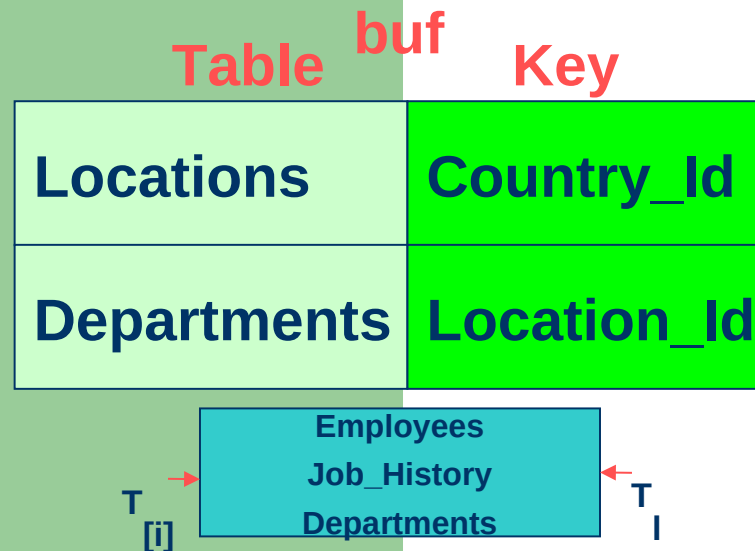
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buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|-------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | |



create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for every buf.Table = T_k do

if (buf.key != Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|-------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |



create a structure buf with 2 fields: Table and Key

→ for all the tables in JoinPathList going downward do

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create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do

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take one T_k at a time

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for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

→ for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for every buf.Table = T_k do

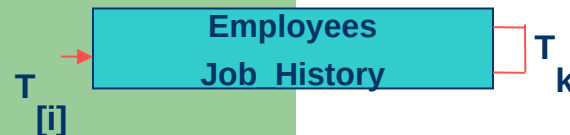
if (buf.key != Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)

| Table | Key |
|-------------|-------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |



create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

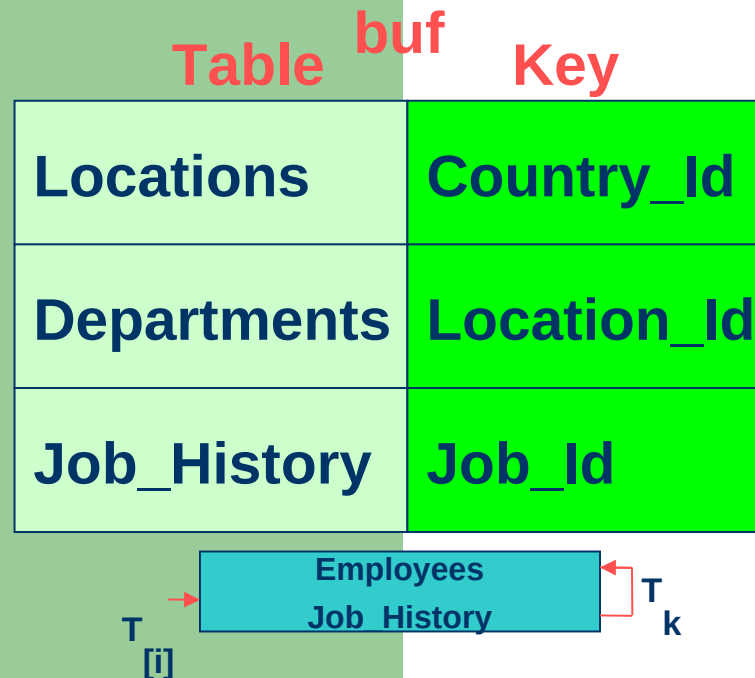
for every buf.Table = T_k do

if (buf.key != Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
InheritedKey($T_{[i]}$) += buf.key

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for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

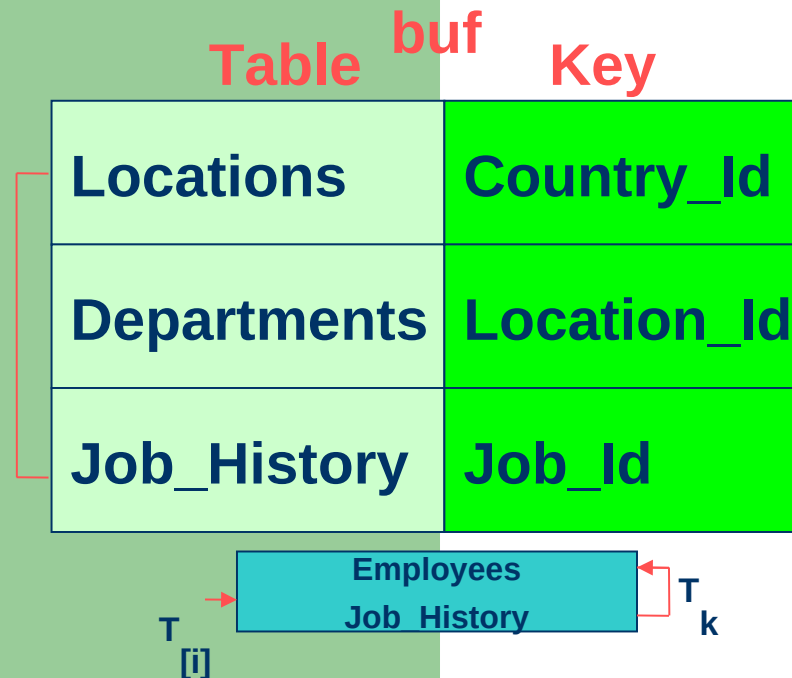
for every buf.Table = T_k do

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InheritedKey($T_{[i]}$) += buf.key

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for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

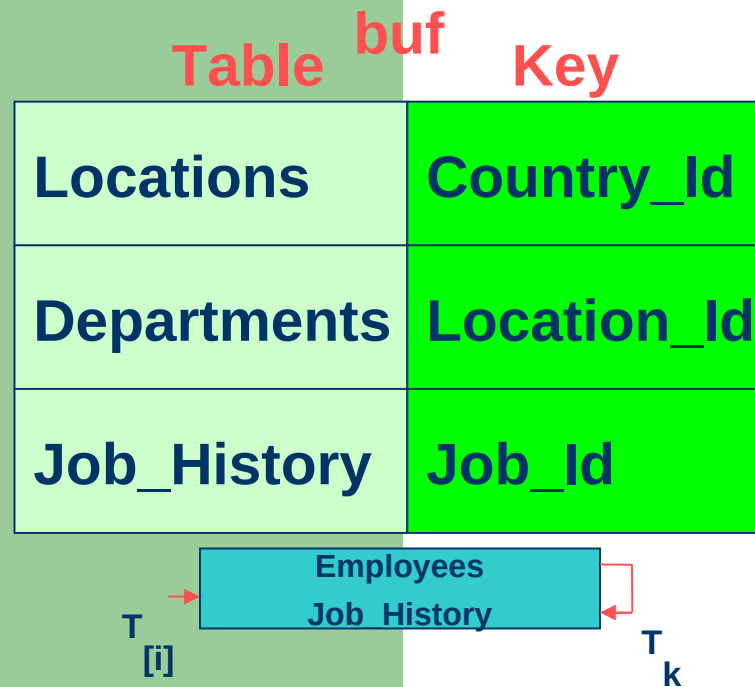
for every buf.Table = T_k do

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for all the tables in JoinPathList going downward do
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for all Base Tables in $T_{[i]}$ do

take one T_k at a time

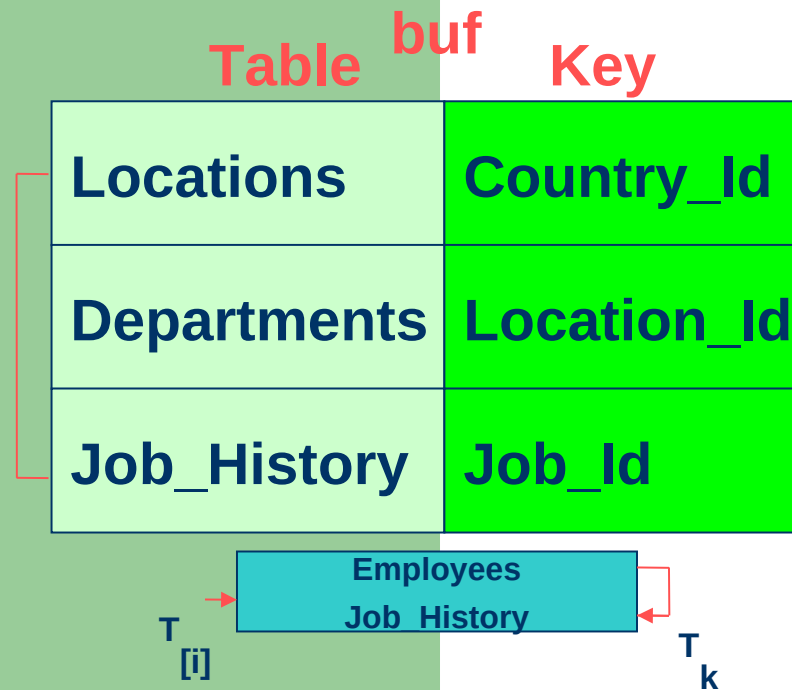
for every buf.Table = T_k do

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create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

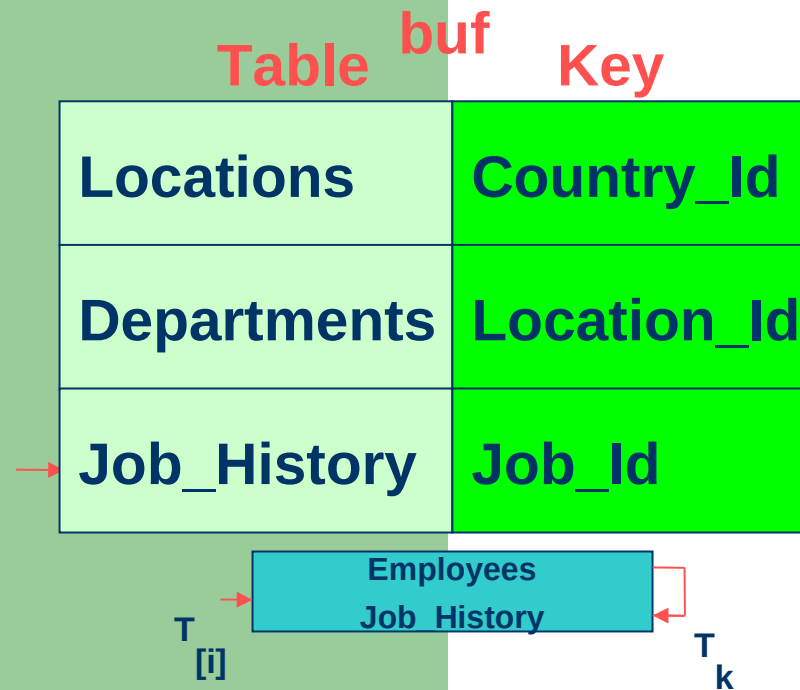
for every buf.Table = T_k do

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InheritedKey($T_{[i]}$) += buf.key

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for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

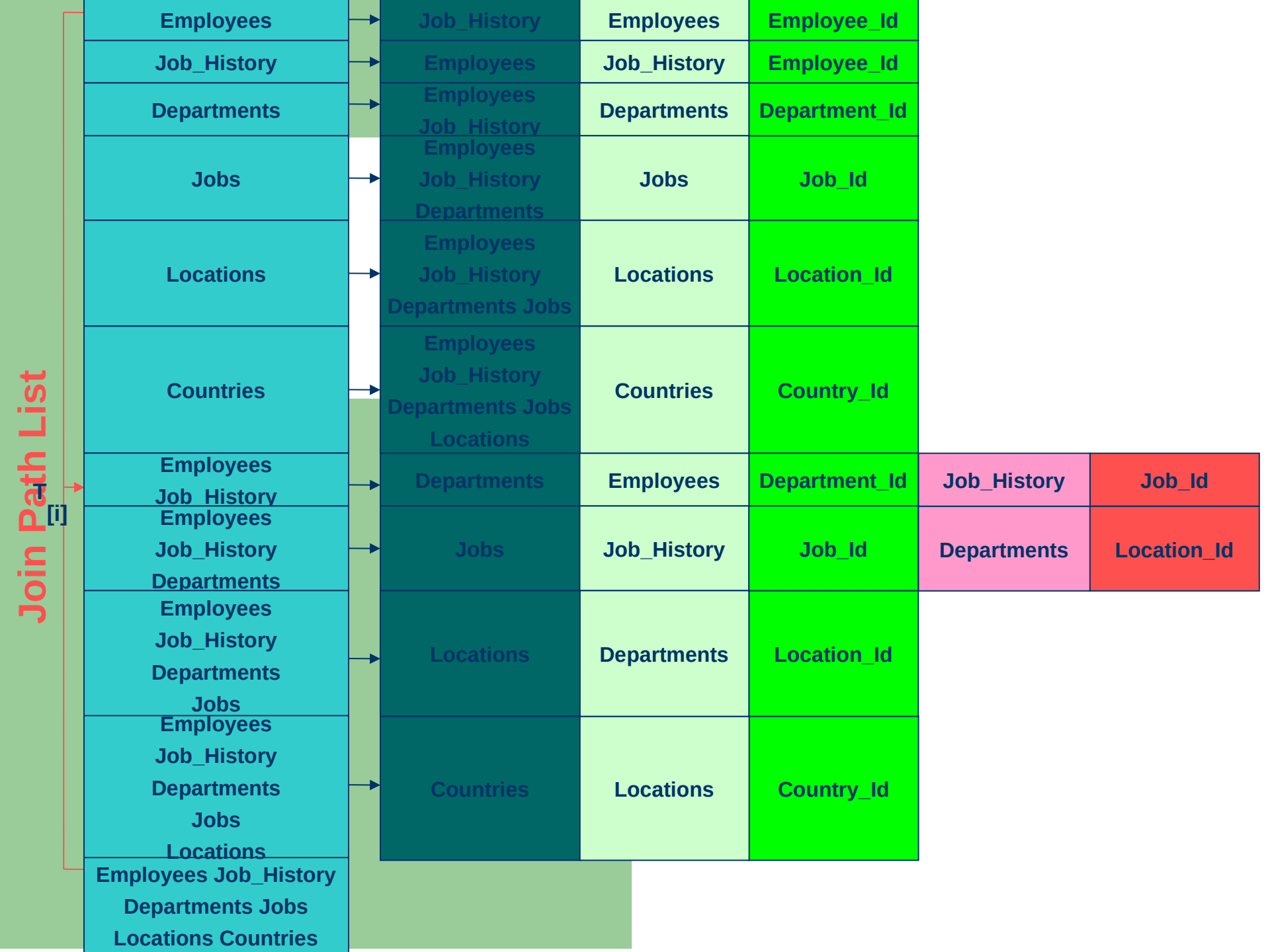
for every buf.Table = T_k do

if (buf.key \neq Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
InheritedKey($T_{[i]}$) += buf.key

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create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
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for every buf.Table = T_k do

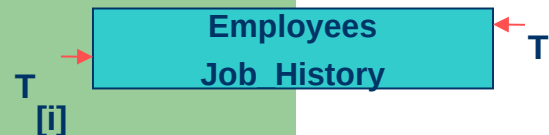
if (buf.key != Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)

| Table | Key |
|-------------|-------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |



create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for every buf.Table = T_k do

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if T_i is the table from which comes Key($T_{[i]}$) then

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buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|-------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | |



create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

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buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |



create a structure buf with 2 fields: Table and Key

→ for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

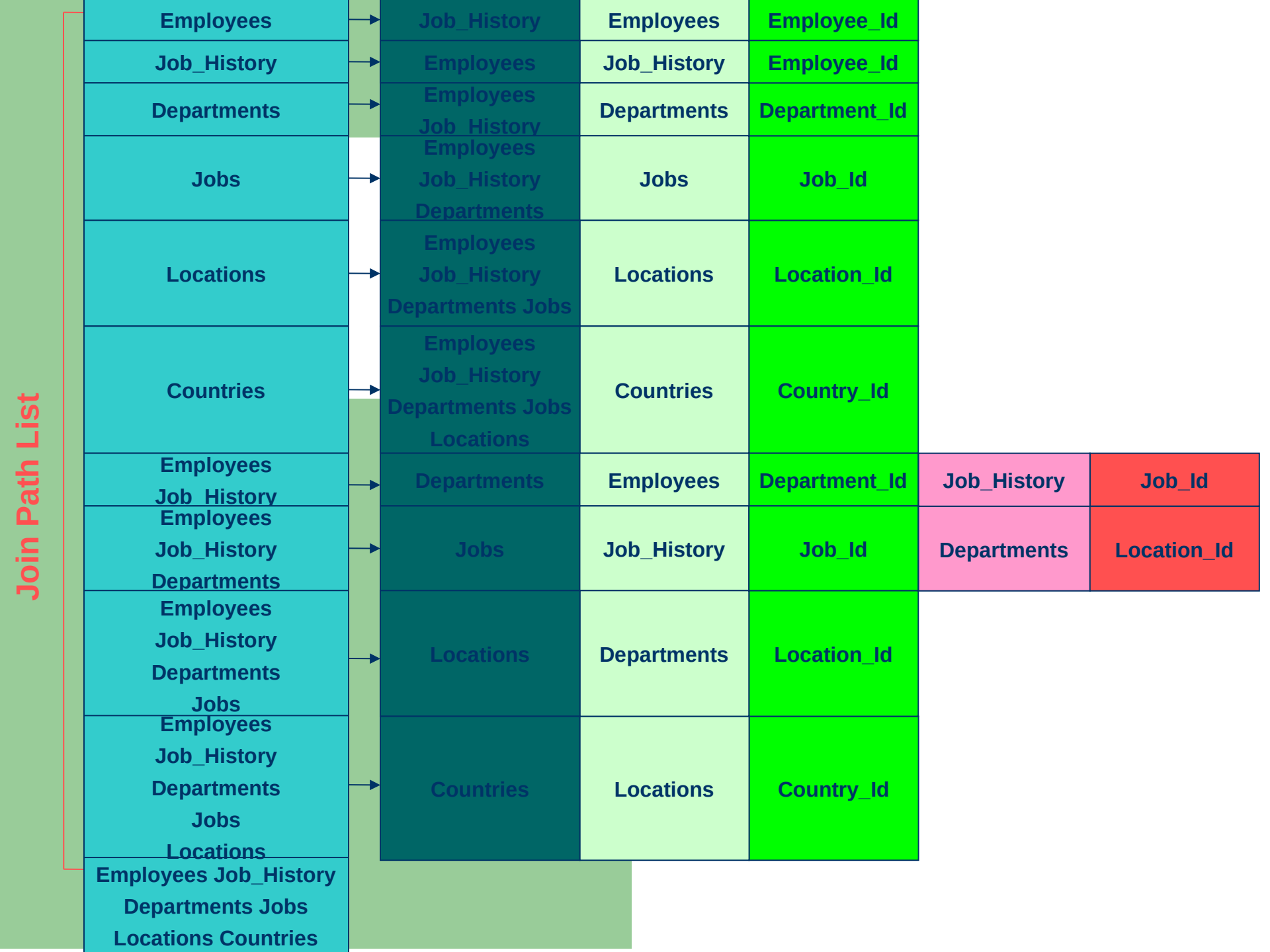
for every buf.Table = T_k do

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→ take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

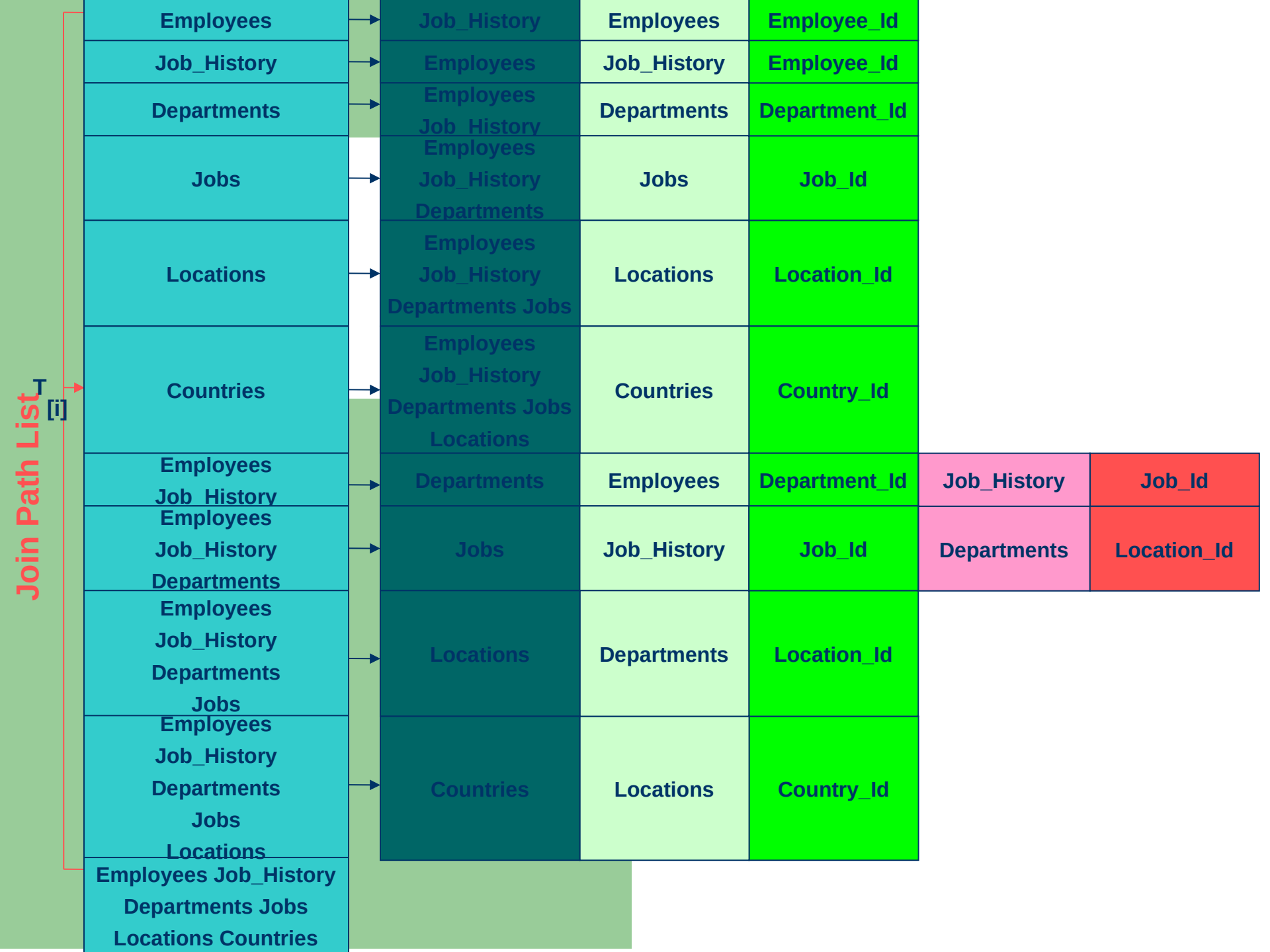
for every buf.Table = T_k do

if (buf.key != Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
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Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |

$T[i]$



Countries



create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for every buf.Table = T_k do

if (buf.key != Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then
InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

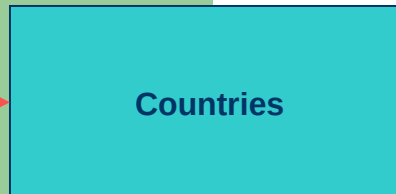
buf.Table = T_i

buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |

$T[i]$



Countries

T_k

create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for every buf.Table = T_k do

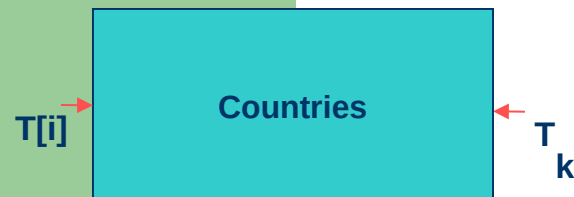
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| Table | Key |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
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Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |

$T[i]$



Countries

create a structure buf with 2 fields: Table and Key

→ for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

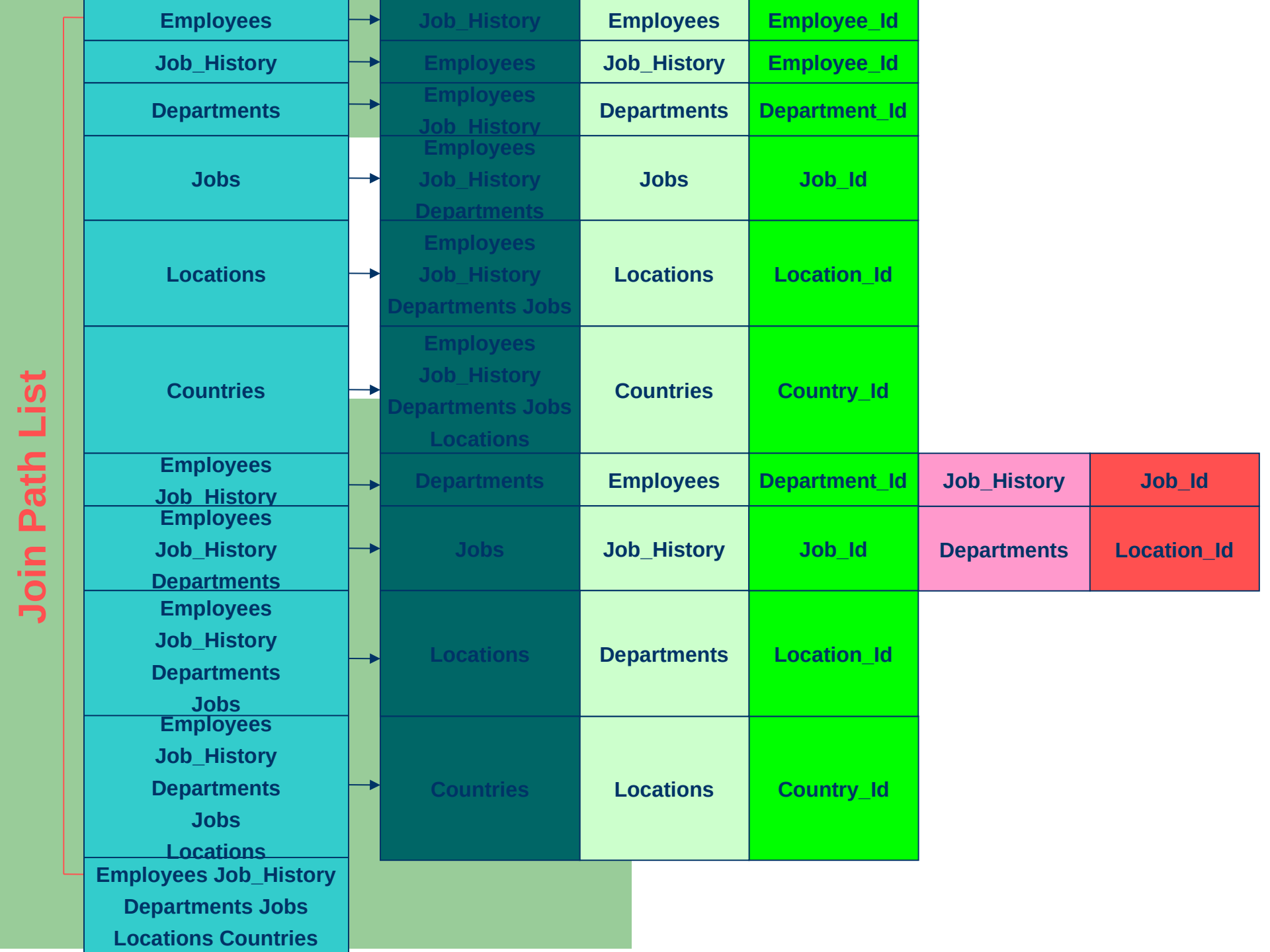
for every buf.Table = T_k do

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for all Base Tables in $T_{[i]}$ do

take one T_k at a time

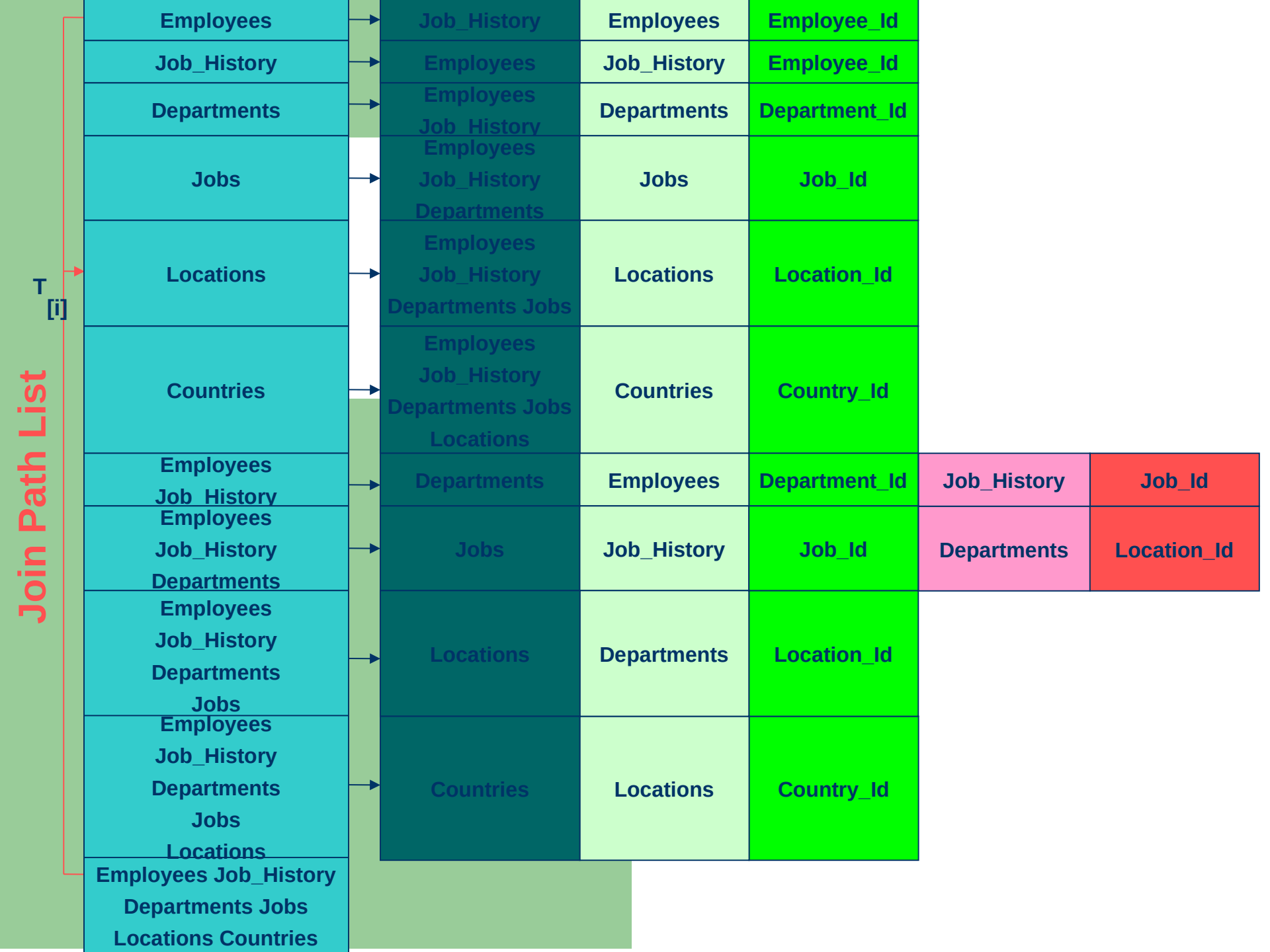
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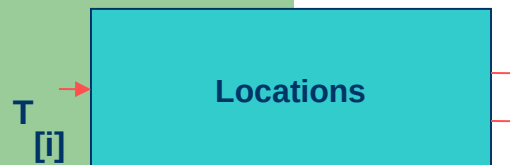
if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |



create a structure buf with 2 fields: Table and Key
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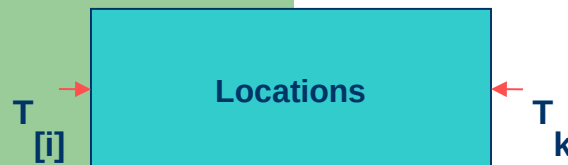
if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
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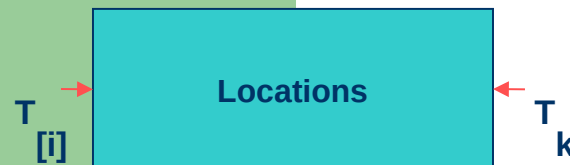
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buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |



create a structure buf with 2 fields: Table and Key
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take one T_k at a time

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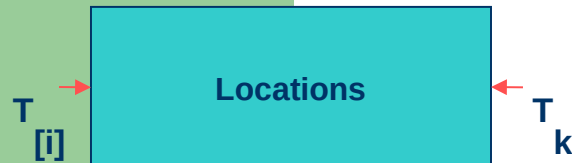
if T_i is the table from which comes Key($T_{[i]}$) then

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buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |



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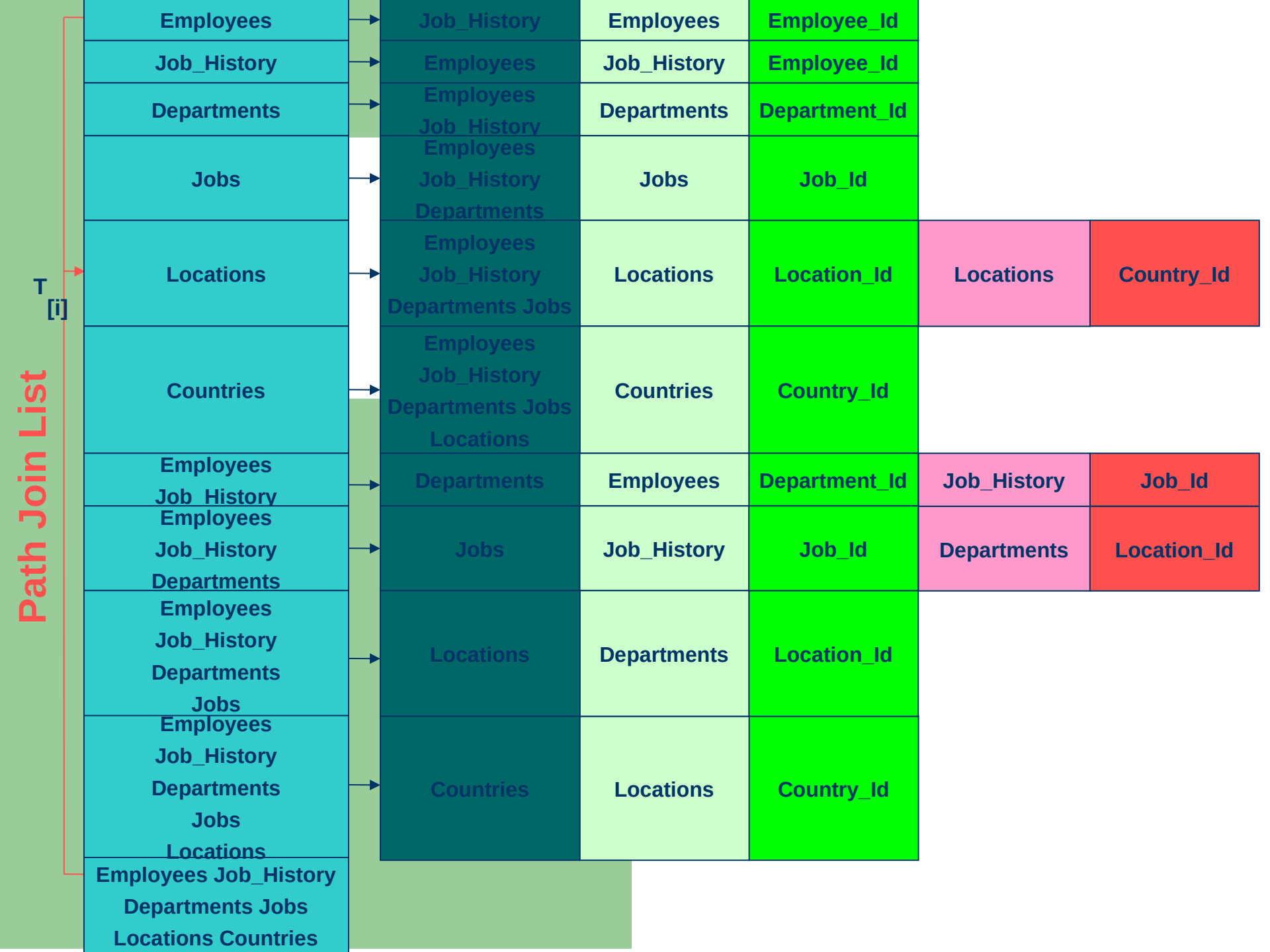
for every buf.Table = T_k do

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create a structure buf with 2 fields: Table and Key

→ for all the tables in JoinPathList going downward do

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buf.key = Key($T_{[i]}$)

Join Path List

| | | | | | | |
|---|---|--|-------------|---------------|-------------|-------------|
| Employees | → | Job_History | Employees | Employee_Id | | |
| Job_History | → | Employees | Job_History | Employee_Id | | |
| Departments | → | Employees Job_History | Departments | Department_Id | | |
| Jobs | → | Employees Job_History Departments | Jobs | Job_Id | | |
| Locations | → | Employees Job_History Departments Jobs | Locations | Location_Id | Locations | Country_Id |
| Countries | → | Employees Job_History Departments Jobs Locations | Countries | Country_Id | | |
| Employees Job_History | → | Departments | Employees | Department_Id | Job_History | Job_Id |
| Employees Job_History Departments | → | Jobs | Job_History | Job_Id | Departments | Location_Id |
| Employees Job_History Departments Jobs | → | Locations | Departments | Location_Id | | |
| Employees Job_History Departments Jobs Locations | → | Countries | Locations | Country_Id | | |
| Employees Job_History Departments Jobs Locations Countries | | | | | | |

create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do

→ take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

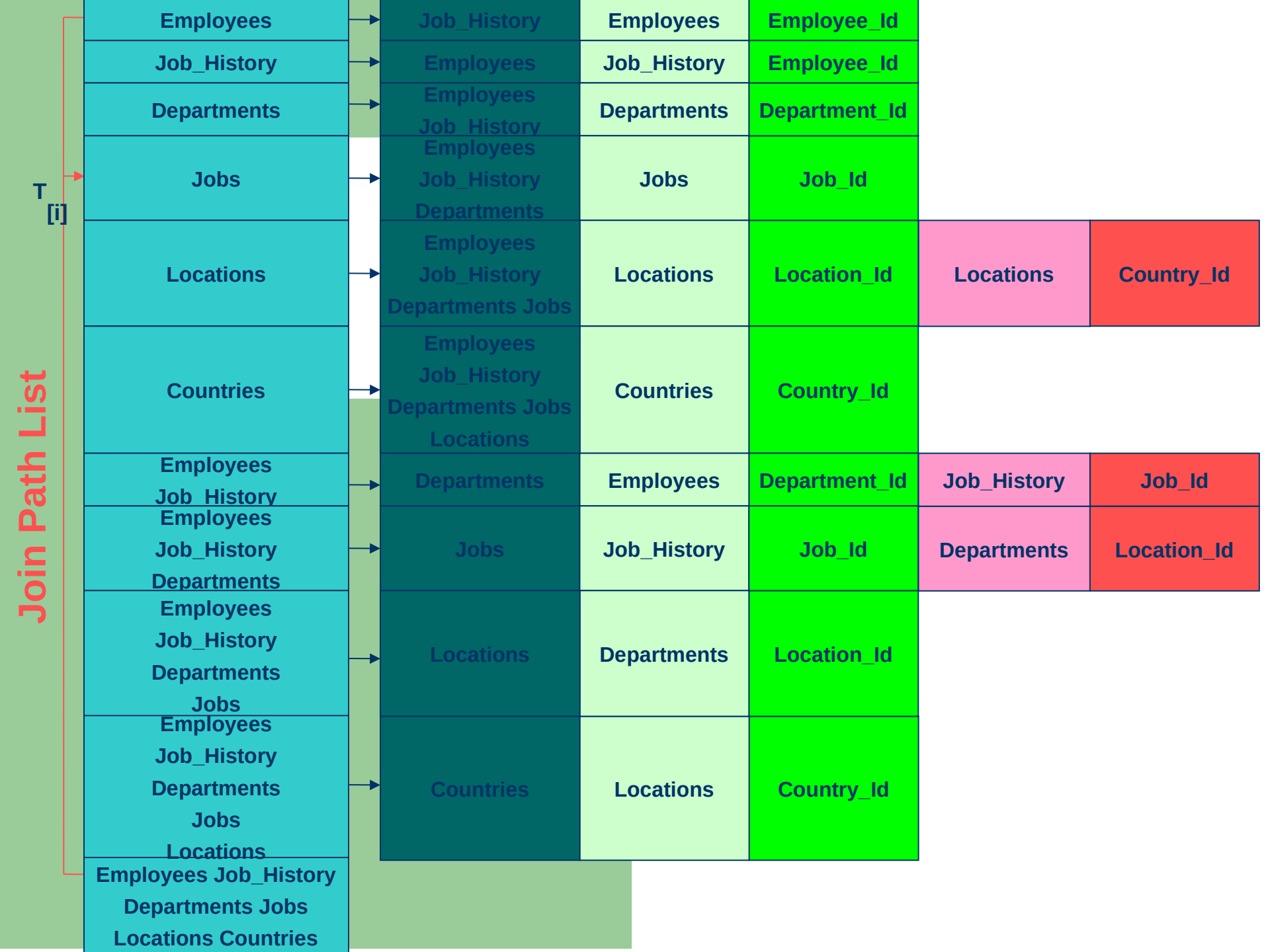
for every buf.Table = T_k do

if (buf.key != Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

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create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
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take one T_k at a time

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buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |



create a structure buf with 2 fields: Table and Key
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| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
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| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |



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take one T_k at a time

for every buf.Table = T_k do

if (buf.key != Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |



create a structure buf with 2 fields: Table and Key

→ for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for every buf.Table = T_k do

if (buf.key != Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)

Join Path List

| | | | | | | |
|---|---|--|-------------|---------------|-------------|-------------|
| Employees | → | Job_History | Employees | Employee_Id | | |
| Job_History | → | Employees | Job_History | Employee_Id | | |
| Departments | → | Employees Job_History | Departments | Department_Id | | |
| Jobs | → | Employees Job_History Departments | Jobs | Job_Id | | |
| Locations | → | Employees Job_History Departments Jobs | Locations | Location_Id | Locations | Country_Id |
| Countries | → | Employees Job_History Departments Jobs Locations | Countries | Country_Id | | |
| Employees Job_History | → | Departments | Employees | Department_Id | Job_History | Job_Id |
| Employees Job_History Departments | → | Jobs | Job_History | Job_Id | Departments | Location_Id |
| Employees Job_History Departments Jobs | → | Locations | Departments | Location_Id | | |
| Employees Job_History Departments Jobs Locations | → | Countries | Locations | Country_Id | | |
| Employees Job_History Departments Jobs Locations Countries | | | | | | |

create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do

→ take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

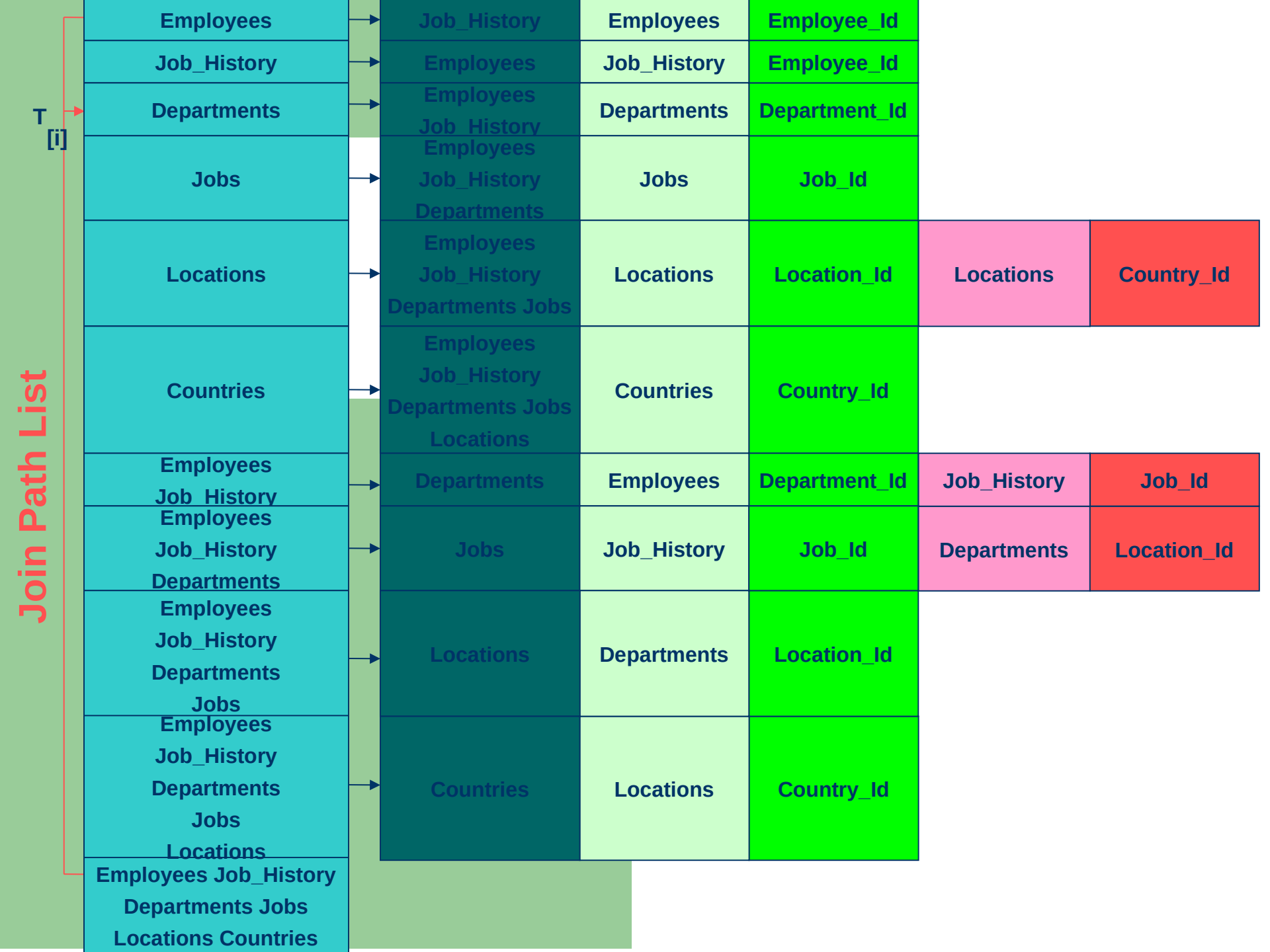
for every buf.Table = T_k do

if (buf.key != Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

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for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

→ for all Base Tables in $T_{[i]}$ do

take one T_k at a time

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InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |



create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
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for all Base Tables in $T_{[i]}$ do

take one T_k at a time

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buf.Table = T_i

buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |



create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

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buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |



create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

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InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |



create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

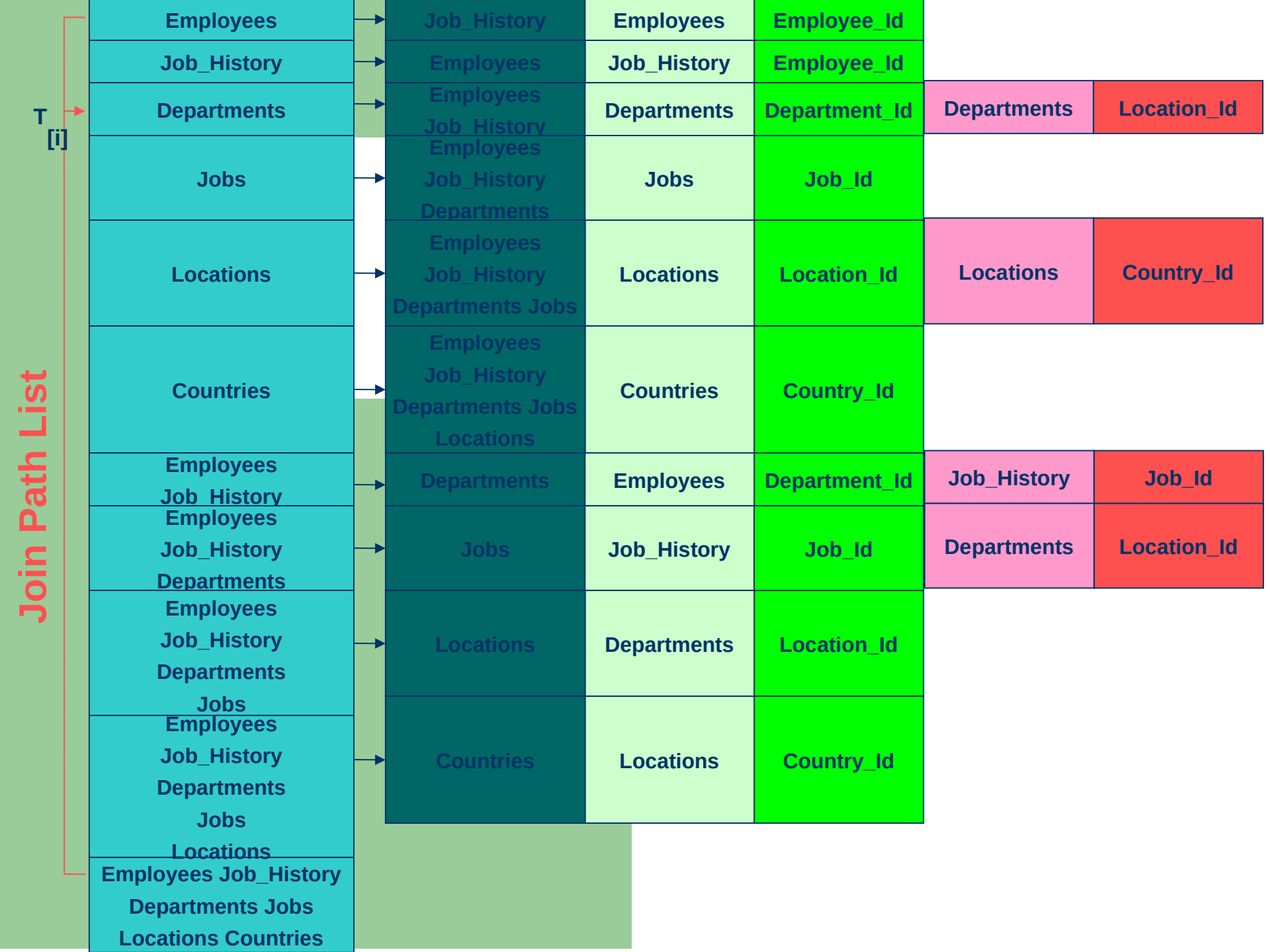
for every buf.Table = T_k do

if (buf.key \neq Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)



create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for every buf.Table = T_k do

if (buf.key != Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |

$T_{[i]}$



Departments

create a structure buf with 2 fields: Table and Key

→ for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for every buf.Table = T_k do

if (buf.key \neq Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)

Join Path List

| | | | | | | |
|---|---|--|-------------|---------------|-------------|-------------|
| Employees | → | Job_History | Employees | Employee_Id | | |
| Job_History | → | Employees | Job_History | Employee_Id | | |
| Departments | → | Employees Job_History | Departments | Department_Id | Departments | Location_Id |
| Jobs | → | Employees Job_History Departments | Jobs | Job_Id | | |
| Locations | → | Employees Job_History Departments Jobs | Locations | Location_Id | Locations | Country_Id |
| Countries | → | Employees Job_History Departments Jobs Locations | Countries | Country_Id | | |
| Employees Job_History | → | Departments | Employees | Department_Id | Job_History | Job_Id |
| Employees Job_History Departments | → | Jobs | Job_History | Job_Id | Departments | Location_Id |
| Employees Job_History Departments Jobs | → | Locations | Departments | Location_Id | | |
| Employees Job_History Departments Jobs Locations | → | Countries | Locations | Country_Id | | |
| Employees Job_History Departments Jobs Locations Countries | | | | | | |

create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do

→ take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

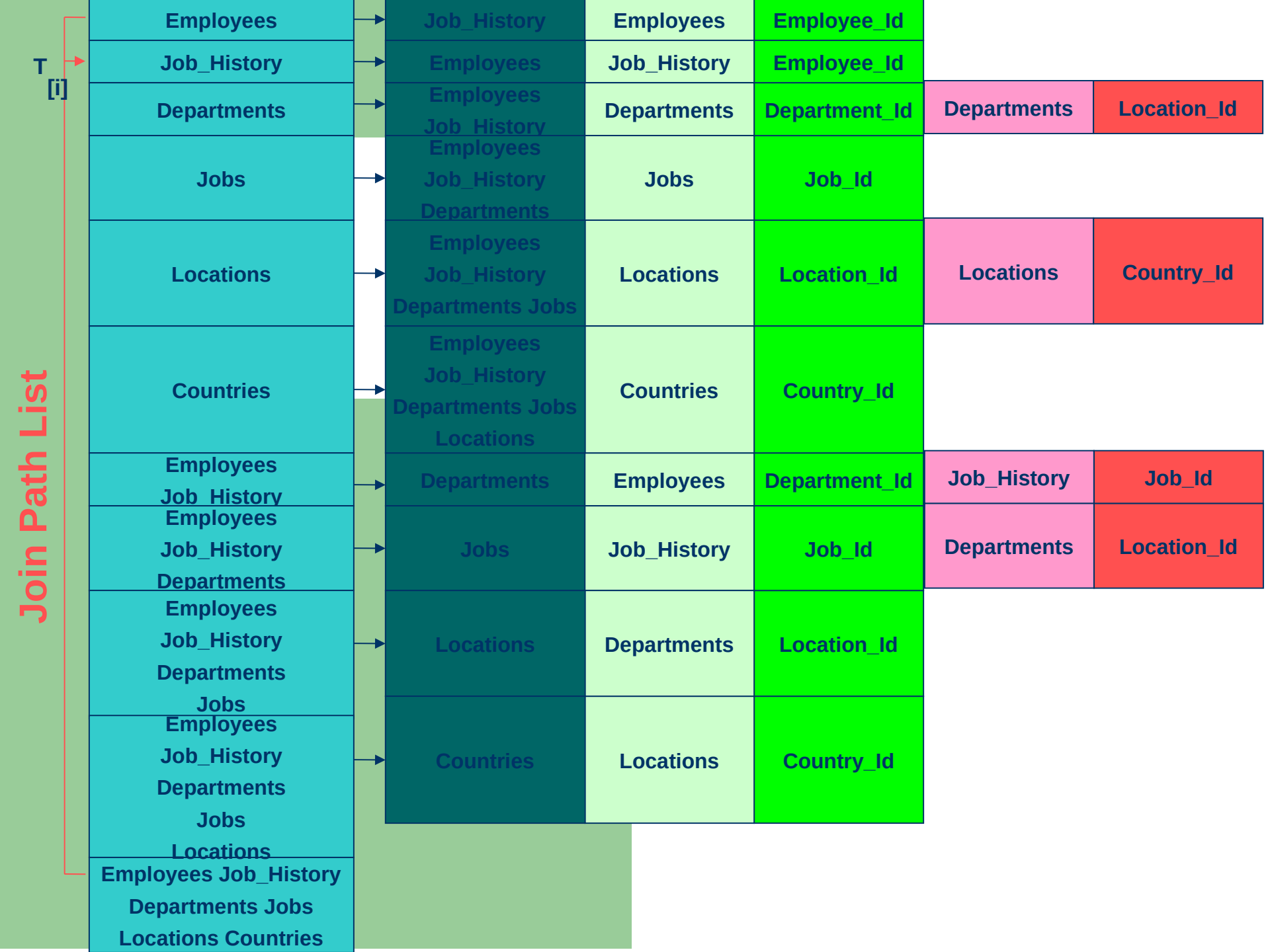
for every buf.Table = T_k do

if (buf.key != Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)



create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

→ for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for every buf.Table = T_k do

if (buf.key != Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |



create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

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if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
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create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
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buf.Table = T_i

buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |



create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

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if (buf.key != Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)

| Table | Key |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |



create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

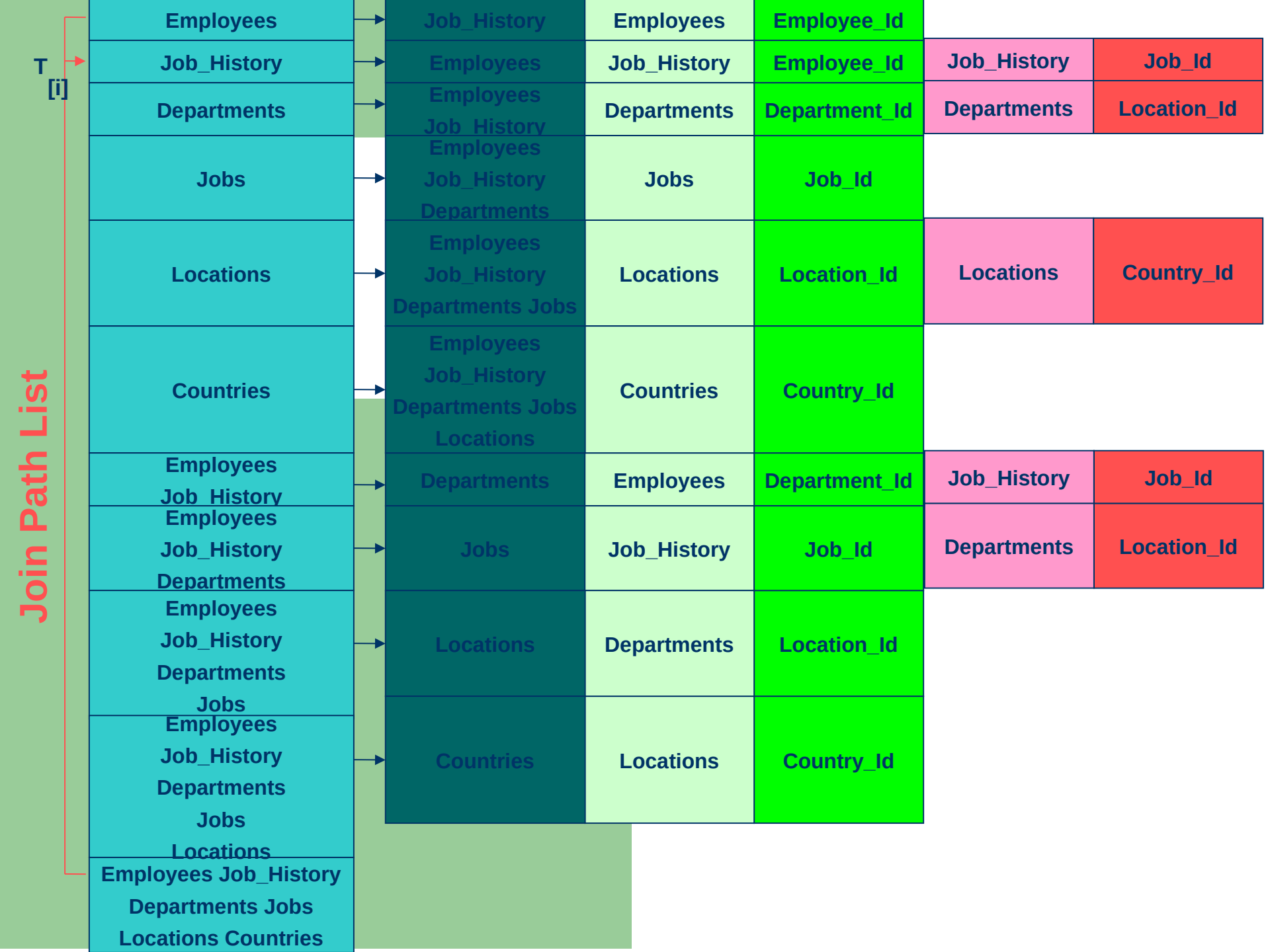
for every buf.Table = T_k do

if (buf.key \neq Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)



create a structure buf with 2 fields: Table and Key

→ for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for every buf.Table = T_k do

if (buf.key != Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)

Join Path List

| | | | | | | |
|---|---|--|-------------|---------------|-------------|-------------|
| Employees | → | Job_History | Employees | Employee_Id | | |
| Job_History | → | Employees | Job_History | Employee_Id | Job_History | Job_Id |
| Departments | → | Employees Job_History | Departments | Department_Id | Departments | Location_Id |
| Jobs | → | Employees Job_History Departments | Jobs | Job_Id | | |
| Locations | → | Employees Job_History Departments Jobs | Locations | Location_Id | Locations | Country_Id |
| Countries | → | Employees Job_History Departments Jobs Locations | Countries | Country_Id | | |
| Employees Job_History | → | Departments | Employees | Department_Id | Job_History | Job_Id |
| Employees Job_History Departments | → | Jobs | Job_History | Job_Id | Departments | Location_Id |
| Employees Job_History Departments Jobs | → | Locations | Departments | Location_Id | | |
| Employees Job_History Departments Jobs Locations | → | Countries | Locations | Country_Id | | |
| Employees Job_History Departments Jobs Locations Countries | | | | | | |

create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do

→ take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

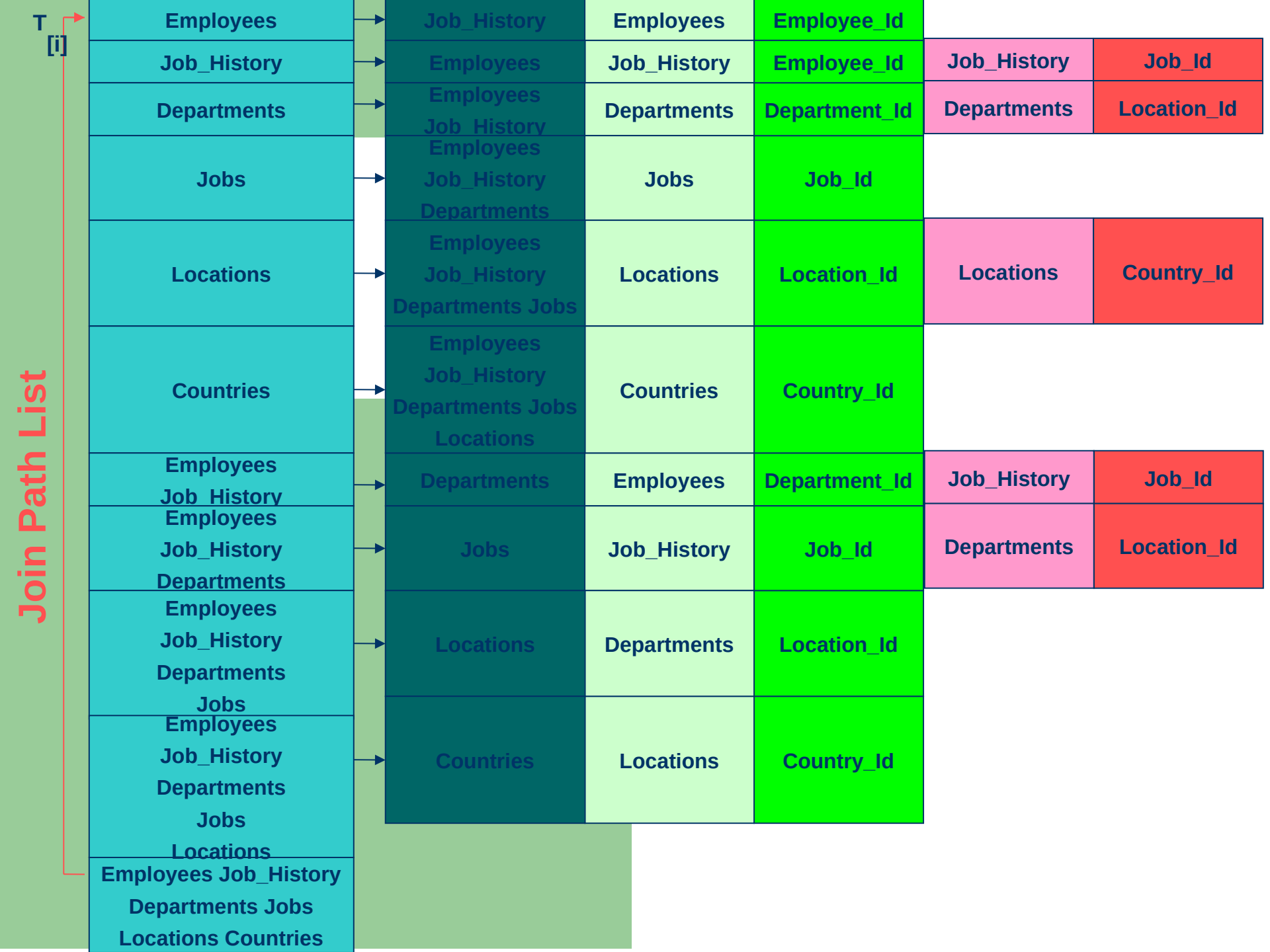
for every buf.Table = T_k do

if (buf.key != Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
InheritedKey($T_{[i]}$) += buf.key

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InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |



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for all Base Tables in $T_{[i]}$ do

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Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |



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for all Base Tables in $T_{[i]}$ do

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if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

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Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |



create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
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for all Base Tables in $T_{[i]}$ do

take one T_k at a time

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if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)

Table buf Key

| | |
|-------------|---------------|
| Locations | Country_Id |
| Departments | Location_Id |
| Job_History | Job_Id |
| Employees | Department_Id |



create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

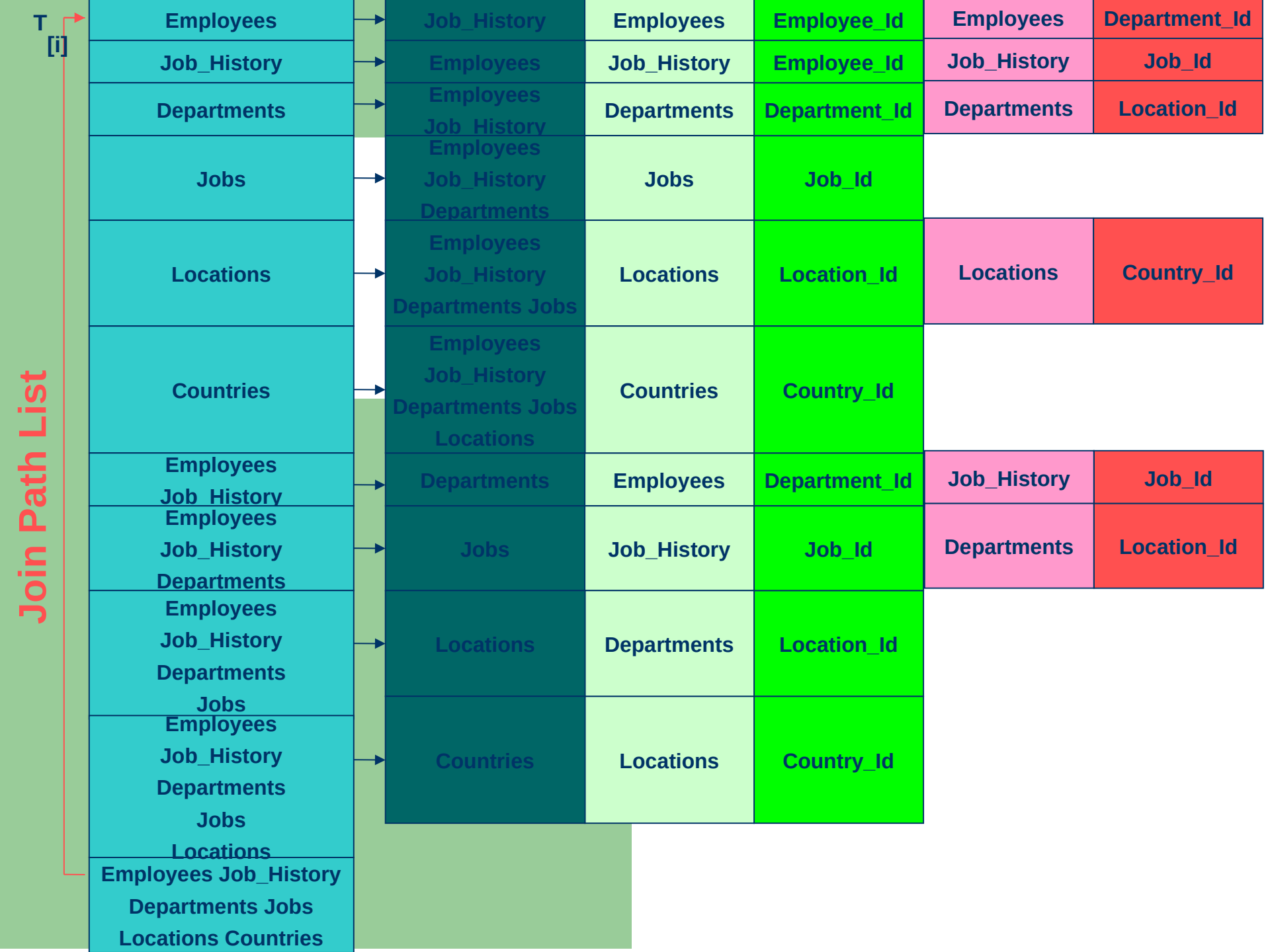
for every buf.Table = T_k do

if (buf.key \neq Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

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create a structure buf with 2 fields: Table and Key
for all the tables in JoinPathList going downward do
take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for every buf.Table = T_k do

if (buf.key != Key($T_{[i]}$)) and (buf.Key not in InheritedKey($T_{[i]}$)) then I
InheritedKey($T_{[i]}$) += buf.key

if T_i is the table from which comes Key($T_{[i]}$) then

buf.Table = T_i

buf.key = Key($T_{[i]}$)



Join Path List

| Nodes List | | Adjacent Table | | Table | Key | Inherited Table | | Key |
|------------|--|----------------|---|-------------|---------------|-----------------|--|---------------|
| 0 | Employees | → | Job_History | Employees | Employee_Id | Employees | | Department_Id |
| 1 | Job_History | → | Employees | Job_History | Employee_Id | Job_History | | Job_Id |
| 2 | Departments | → | Employees Job_History | Departments | Department_Id | Departments | | Location_Id |
| 3 | Jobs | → | Employees Job_History Departments | Jobs | Job_Id | | | |
| 4 | Locations | → | Employees Job_History Departments Jobs | Locations | Location_Id | Locations | | Country_Id |
| 5 | Countries | → | Employees Job_History Departments Jobs Locations | Countries | Country_Id | | | |
| 6 | Employees Job_History | → | Departments | Employees | Department_Id | Job_History | | Job_Id |
| 7 | Job_History Employees Departments | → | Jobs | Job_History | Job_Id | Departments | | Location_Id |
| 8 | Employees Job_History Departments Jobs | → | Locations | Departments | Location_Id | | | |
| 9 | Employees Job_History Departments Jobs Locations | → | Countries | Locations | Country_Id | | | |
| 10 | Employees Job_History Departments Jobs Locations Countries | Adjacent List | | | Example A | | | |

Suppose we want the join sequence of the tables ordered by Employees.Name and Departments.Department_Id, applying the algorithm, the JoinPathList becomes:

| Nodes List | | Adjacent Table | Table | Key | Inherited Table | Key |
|----------------|---|---|--|-------------|-----------------|---|
| Join Path List | 0 | Employees | Job_History | Employees | Employee_Id | Employees Name Employees Department_Id |
| | 1 | Job_History | Employees | Job_History | Employee_Id | Job_History Job_Id |
| | 2 | Departments | Employees Job_History | Departments | Department_Id | Departments Location_Id |
| | 3 | Jobs | Employees Job_History Departments | Jobs | Job_Id | |
| | 4 | Locations | Employees Job_History Departments Jobs | Locations | Location_Id | Locations Country_Id |
| | 5 | Countries | Employees Job_History Departments Jobs Locations | Countries | Country_Id | |
| | 6 | Employees Job_History | Departments | Employees | Department_Id | Employees Name Job_History Job_Id |
| Example A | 7 | Employees Job_History Departments | Jobs | Job_History | Job_Id | Employees Name |
| | | | | | | Departments Department_Id |
| | | | | | | Departments Location_Id |

8

Employees
Job_History
Departments
Jobs



Locations

Departments

Location_Id

Employees

Name

Departments

Departments_Id

9

Employees
Job_History
Departments
Jobs
Locations



Countries

Locations

Country_Id

Employees

Name

Departments

Department_Id

10

Employees Job_History
Departments Jobs
Locations Countries



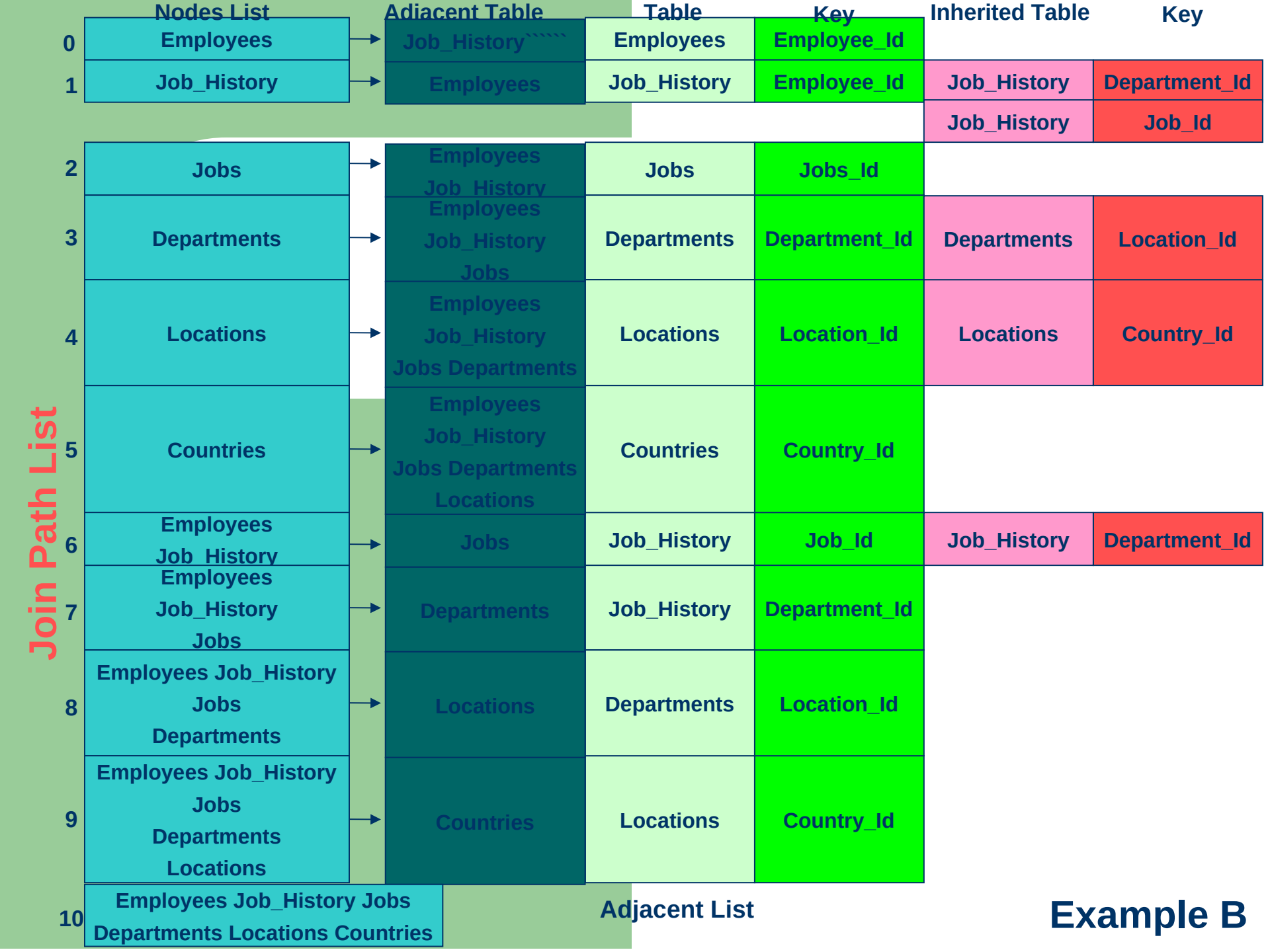
Employees

Name

Departments

Department_Id

Example A



Create B⁺Trees

- The Nodes (Vertexes) in the JoinPathList represents all the base tables + virtual tables constituting from the base tables by adding one at a time in mode that the one added is at least in direct join with its precedents.
- Defining a B⁺Tree for every node, the ones for the virtual tables have for every key a set of data pointers equal to the number of base tables constituting it and from definition of the virtual tables, combining the rows pointed by those data pointers we obtain a joined row.

The algorithm for creating B⁺Trees is the following:

create B+Trees(in PathJoinList; out B+Trees);

give a general name for the BJoinTree

for all entries in JoinPathList do

 take one node at a time

 create a B+Tree for the node defined as

 name of the B+Tree equal to the name of BJoinTree follow by the
 index number of the node entry

 Number of data pointers equal to the number of base tables
 constituting the virtual table of the node

 Key is defined by the pair <Table, Key> in the adjacent list of the
 node

 Inherited Keys are defined by the pairs <Table, Inherited Key> in
 the adjacent list of the node

Give a general name for the B⁺Tree.

Give for every entry in the JoinPathList a B⁺Tree index with name as the B⁺Tree + the PathJoinList entry number.

About the last virtual table, its index has no keys, it works because we consider pairs of < keys, Data Pointers > as key, so they are ordered by their data pointers. Scanning the index we get all the sequences of joined data pointers.

Non Terminal has repeated empty keys they point to different pages.

Duplicate keys are inserted and when a page is full, the key is repeated in the non terminal.

In any case we can incorporate any key of our choice from the tables forming the virtual table.

If the table is in join with itself, consider the table twice as aliases.

Implementation:

Use a big buffer and from the Data Dictionary divide it by the keys length, inherited keys length and space for the number of Data Pointers.

The B⁺Tree is formed from $(2*n-1)$ indexes.

We can use one index that includes all these indexes by including an index number and treated like a key, so instead of <keys, Data Pointers> treated as a Key, we can use <Index PathJoinList entry number, Keys, Data Pointers> as a key.

IMPORTANT NOTE

The data pointers to the tables in join are in order with the Base Tables of the last Virtual Table and not as declared in the create constructor, this is due to the fact that Path is not always in the same order as the tables declared in the constructor.

So to know the order of data pointers in respect to the tables in join, the property “BaseTables” in “BjoinTreeU.pas” should be called to get it.

The function `GetDataRefByTableName(BaseTable: string; DataRef: array of DataPointerType): DataPointerType`; give the data reference to the row in base table. See Test Index (Button5) in SQLProject.

Insert routine

When a new row R_m from table T_i get inserted do the following:

- Locate the entry of T_i in the JoinPathList
- From its adjacent List, locate the definition of the keys and inherited keys
- From Row R_m get the columns constituting the keys and the inherited keys
- Call $\text{AddJoinKey}(T_i, \text{Keys}, \text{InheritedKeys}, \text{DP}_i)$ where DP_i is the row id of row R_m .

Notice that Keys_i , InheritedKeys_i and DP_i are relative to the row R_m from table T_i

AddJoinKey ($T_{[i]}$, $Keys_{[i]}$, InheritedKeys $_{[i]}$, [DP $_i$])

- Call AddKey (B⁺Tree($T_{[i]}$), $keys_{[i]}$, InheritedKeys $_{[i]}$, [DP $_i$]) for the index of table $T_{[i]}$
- Locate the entry of $T_{[i]}$ in the JoinPathList
- From its adjacent List, locate the Table $T_{[k]}$ adjacent to it and do the following:
 - Locate the entry of $T_{[k]}$ in the JoinPathList
 - FindKey(B⁺Tree($T_{[k]}$), $Keys_{[i]}$)
 - While found($keys_{[i]}$) do
 - ReturnKeys(B⁺Tree($T_{[k]}$), $keys_{[k]}$, InheritedKeys $_{[k]}$, [DP $_k$])
 - Locate the entry of $T_{[ik]}$ in the JoinPathList
 - From its adjacent List, locate the definition of the keys and inherited keys
 - From $keys_{[i]}$, inheritedkeys $_{[i]}$, $keys_{[k]}$, inheritedkeys $_{[k]}$ get the keys and inherited keys of $T_{[ik]}$
 - AddJoinKey ($T_{[ik]}$, $Keys_{[ik]}$, InheritedKeys $_{[ik]}$, [DP $_{ik}$])
 - NextKey(B⁺Tree($T_{[k]}$), $Keys_{[i]}$)

Employees table

DP start from 0

| | EMPLOYEE_ID | NAME | EMAIL | PHONE_NUMBER | HIRE_DATE | JOB_ID | SALARY | DEPARTMENT_ID |
|---|-------------|------------------|-----------|--------------|------------|--------|--------|---------------|
| 0 | 101 | Mark Stench | mstench | 233-4268 | 12/02/1998 | FI_MGR | 60000 | FIN |
| 1 | 102 | Jorge Perez | jperez | 448-5268 | 05/14/1999 | AC_MGR | 60000 | ACC |
| 2 | 103 | Edward Cartier | ecartier | 742-8429 | 03/01/2003 | SA_MGR | 60000 | SAL |
| 3 | 104 | Teresa Gonzalez | tgonzalez | 134-8329 | 12/20/2002 | AC_AUD | 55000 | ACC |
| 4 | 105 | Michelle Blanche | mblanche | 745-7496 | 01/02/2001 | SA_REP | 35000 | SAL |

Job_History table

DP start from 0

| | EMPLOYEE_ID | START_DATE | END_DATE | JOB_ID | DEPARTMENT_ID |
|---|-------------|------------|------------|--------|---------------|
| 0 | 101 | 12/16/1998 | 12/15/1999 | AC_AUD | ACC |
| 1 | 102 | 05/16/1999 | 05/15/2001 | AC_AUD | ACC |
| 2 | 101 | 12/16/1999 | 12/15/2001 | SA_REP | SAL |
| 3 | 103 | 03/16/2003 | 03/15/2004 | AC_AUD | ACC |

Departments table

DP start from 0

| | Deparment_Id | Department_Name | Manager_Id | Location_Id |
|---|--------------|-----------------|------------|-------------|
| 0 | FIN | FINANCE | 101 | 1000 |
| 1 | ACC | ACCOUNTING | 102 | 1010 |
| 2 | SAL | SALES | 103 | 1020 |

Jobs Table

DP start from 0

| | JOB_ID | JOB_TITLE | MIN_SALARY | MAX_SALARY |
|---|--------|----------------------|------------|------------|
| 0 | AC_AUD | Accounting Auditor | 30000 | 60000 |
| 1 | AC_MGR | Accounting Manager | 60000 | 70000 |
| 2 | FI_MGR | Finance Manager | 50000 | 70000 |
| 3 | SA_MGR | Sales Manager | 50000 | 60000 |
| 4 | SA_REP | Sales Representative | 30000 | 40000 |

Locations table

DP start from 0

| | LOCATION_ ID | STREET_ADDRESS | POSTAL_ CODE | CITY | STATE PROVINCE | COUNTRY_ ID |
|---|-----------------|-------------------------------|-----------------|-------------|-------------------|----------------|
| 0 | 1000 | 22220 Cochrane Drive | V6V 2T9 | Richmond | B.C. | ca |
| 1 | 1010 | Calle Sermiento numero 300 | 62547 | Guadalajara | Baja | me |
| 2 | 1020 | Rue des fleurs n. 345 | 78921 | Toulouse | Moyenne | fr |

Countries table

DP start from 0

| | Country_Id | Country_Name |
|---|------------|--------------|
| 0 | ca | Canada |
| 1 | fr | France |
| 2 | me | Mexico |

Inserting first row from table Employees

Base Table

| Employees |
|-----------|
| 0 |

| EMPLOYEE_ID | NAME | EMAIL | PHONE_NUMBER | HIRE_DATE | JOB_ID | SALARY | DEPARTMENT_ID |
|-------------|-------------|---------|--------------|------------|--------|--------|---------------|
| 101 | Mark Stench | mstench | 233-4268 | 12/02/1998 | FI_MGR | 60000 | FIN |

→ insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i,Keys_i,InheritedKeys_i,DP_i)

Base Table

| |
|-----------|
| Employees |
| 0 |

T_i

DP_i
0



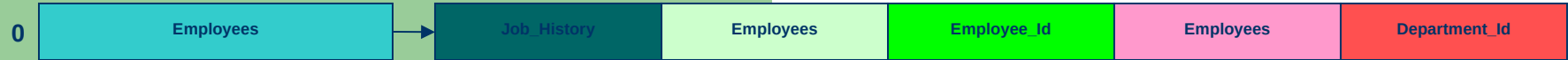
DataRef

| EMPLOYEE_ID | NAME | EMAIL | PHONE_NUMBER | HIRE_DATE | JOB_ID | SALARY | DEPARTMENT_ID |
|-------------|-------------|---------|--------------|------------|--------|--------|---------------|
| 101 | Mark Stench | mstench | 233-4268 | 12/02/1998 | FI_MGR | 60000 | FIN |

Row R_m

insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

locate the entry of T in JoinPathList
from its adjacentList, locate the definition of Keys & Inherited Keys
from row R_m get the columns constituting the keys & Inherited Keys
call AddJoinKey(T_i,Keys_i,InheritedKeys_i,DP_i)



insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

locate the entry of T in JoinPathList
from its adjacentList, locate the definition of Keys & Inherited Keys
from row R_m get the columns constituting the keys & Inherited Keys
call AddJoinKey(T_i,Keys_i,InheritedKeys_i,DP_i)



Keys

Inherited Keys

insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

locate the entry of T in JoinPathList
from its adjacentList, locate the definition of Keys & Inherited Keys
from row R_m get the columns constituting the keys & Inherited Keys
call AddJoinKey(T_i,Keys_i,InheritedKeys_i,DP_i)

| EMPLOYEE_ID | NAME | EMAIL | PHONE_NUMBER | HIRE_DATE | JOB_ID | SALARY | DEPARTMENT_ID |
|-------------|-------------|---------|--------------|------------|--------|--------|---------------|
| 101 | Mark Stench | mstench | 233-4268 | 12/02/1998 | FI_MGR | 60000 | FIN |

DP_i
0

Keys

Row R_m

Inherited Keys

```
insertRoutine(in BaseTable Ti, Row Rm, DataRef DPi)
```

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

```
call AddJoinKey(Ti, Keysi, InheritedKeysi, DPi)
```



| |
|--------|
| EMPLO |
| YEE_ID |
| 101 |

Keys

| |
|-----------|
| Employees |
| 0 |

T_i

| |
|---|
| 0 |
|---|

DP_i

| |
|---------|
| DEPART |
| MENT_ID |
| FIN |

Inherited Keys



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

| |
|--------|
| EMPLO |
| YEE_ID |
| 101 |

Keys_[i]

| |
|-----------|
| Employees |
| 0 |

T_[i]

| |
|---|
| 0 |
|---|

[DP]_i

| |
|---------|
| DEPART |
| MENT_ID |
| FIN |

Inherited Keys_[i]

addJoinKey(in Virtual Table $T_{[i]}$, Keys $_{[i]}$, InheritedKeys $_{[i]}$, [DP $_{[i]}$])

call addKey(B+Tree($T_{[i]}$), Keys $_{[i]}$, InheritedKeys $_{[i]}$, [DP $_{[i]}$])

locate the entry of $T_{[i]}$ in JoinPathList

from its adjacentList, locate the table $T_{[k]}$ adjacent to it

locate the entry of $T_{[k]}$ in JoinPathList

Found = findKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)

while found do

returnKeys(B+Tree($T_{[k]}$), Keys $_{[k]}$, InheritedKeys $_{[k]}$, [DP $_{[k]}$])

locate the entry of $T_{[ik]}$ in JoinPathList

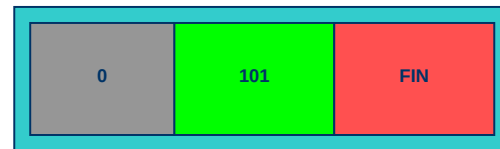
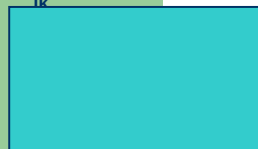
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys $_{[i]}$, InheritedKeys $_{[i]}$, Keys $_{[k]}$ & InheritedKeys $_{[k]}$ get the keys & Inherited keys of $T_{[ik]}$

call AddJoinKey($T_{[ik]}$, Keys $_{[ik]}$, InheritedKeys $_{[ik]}$, [DP $_{[ik]}$])

Found = nextKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)

B+Tree(T_0)



addJoinKey(in Virtual Table $T_{[i]}$, Keys $_{[i]}$, InheritedKeys $_{[i]}$, [DP $_{[i]}$])

call addKey(B+Tree($T_{[i]}$), Keys $_{[i]}$, InheritedKeys $_{[i]}$, [DP $_{[i]}$])

locate the entry of $T_{[i]}$ in JoinPathList

from its adjacentList, locate the table $T_{[k]}$ adjacent to it

locate the entry of $T_{[k]}$ in JoinPathList

Found = findKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)

while found do

returnKeys(B+Tree($T_{[k]}$), Keys $_{[k]}$, InheritedKeys $_{[k]}$, [DP $_{[k]}$])

locate the entry of $T_{[ik]}$ in JoinPathList

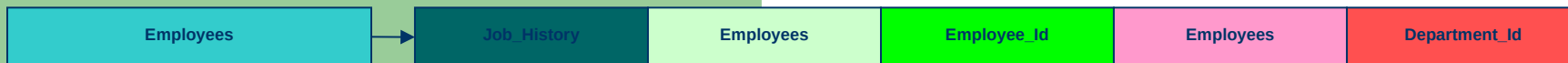
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys $_{[i]}$, InheritedKeys $_{[i]}$, Keys $_{[k]}$ & InheritedKeys $_{[k]}$ get the keys & Inherited keys of $T_{[ik]}$

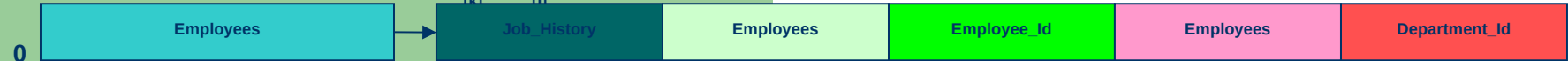
call AddJoinKey($T_{[ik]}$, Keys $_{[ik]}$, InheritedKeys $_{[ik]}$, [DP $_{[ik]}$])

Found = nextKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)

0

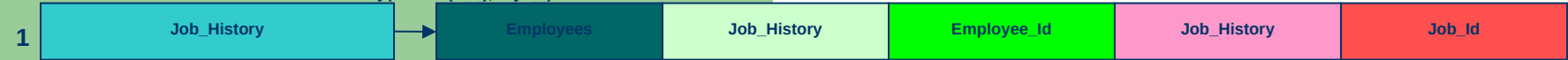


```
addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call AddJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
            Found = nextKey(B+Tree(T[ik]), Keys[i])
```



Adjacent Table

```
addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call AddJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
            Found = nextKey(B+Tree(T[ik]), Keys[i])
```



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

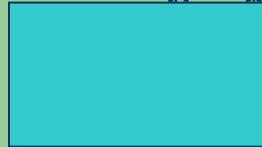
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

B+Tree(T₁)



Found: FALSE

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

Found: FALSE

addJoinKey(in Virtual Table $T_{[i]}$, Keys $_{[i]}$, InheritedKeys $_{[i]}$, [DP $_i$])

call addKey(B+Tree($T_{[i]}$), Keys $_{[i]}$, InheritedKeys $_{[i]}$, [DP $_i$])

locate the entry of $T_{[i]}$ in JoinPathList

from its adjacentList, locate the table $T_{[k]}$ adjacent to it

locate the entry of $T_{[k]}$ in JoinPathList

Found = findKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)

while found do

returnKeys(B+Tree($T_{[k]}$), Keys $_{[k]}$, InheritedKeys $_{[k]}$, [DP $_k$])

locate the entry of $T_{[ik]}$ in JoinPathList

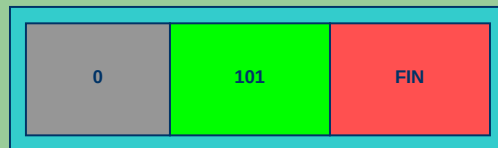
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys $_{[i]}$, InheritedKeys $_{[i]}$, Keys $_{[k]}$ & InheritedKeys $_{[k]}$ get the keys & Inherited keys of $T_{[ik]}$

call AddJoinKey($T_{[ik]}$, Keys $_{[ik]}$, InheritedKeys $_{[ik]}$, [DP $_{ik}$])

Found = nextKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)

B+Tree(T_0)



Inserting first row from table Job_History

Base Table

| Job_History |
|-------------|
| 1 |

| EMPLOYEE_ID | START_DATE | END_DATE | JOB_ID | DEPARTMENT_ID |
|-------------|------------|------------|--------|---------------|
| 101 | 12/16/1998 | 12/15/1999 | AC_AUD | ACC |

→ insertRoutine(in BaseTable T_i , Row R_m , DataRef DP_i)

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i , Keys $_i$, InheritedKeys $_i$, DP_i)

Base Table

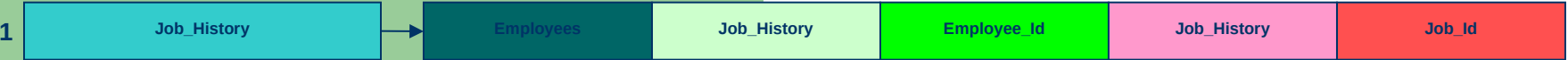
| Job_History |
|-------------|
| 1 |

T_i

| | EMPLOYEE_ID | START_DATE | END_DATE | JOB_ID | DEPARTMENT_ID |
|-----------------------------|-------------|------------|------------|--------|---------------|
| DP_i 0 ↑ DataRef | 101 | 12/16/1998 | 12/15/1999 | AC_AUD | ACC |
| | Row R_m | | | | |

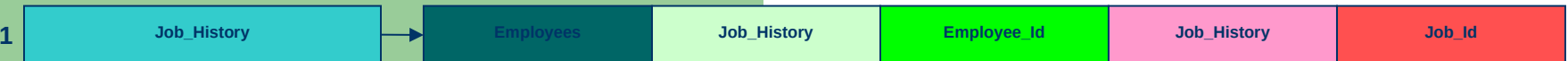
insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

locate the entry of T in JoinPathList
from its adjacentList, locate the definition of Keys & Inherited Keys
from row R_m get the columns constituting the keys & Inherited Keys
call AddJoinKey(T_i,Keys_i,InheritedKeys_i,DP_i)



insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

locate the entry of T in JoinPathList
from its adjacentList, locate the definition of Keys & Inherited Keys
from row R_m get the columns constituting the keys & Inherited Keys
call AddJoinKey(T_i,Keys_i,InheritedKeys_i,DP_i)



Keys Inherited Keys

insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

locate the entry of T in JoinPathList
from its adjacentList, locate the definition of Keys & Inherited Keys
from row R_m get the columns constituting the keys & Inherited Keys
call AddJoinKey(T_i,Keys_i,InheritedKeys_i,DP_i)

| DP _i | EMPLOYEE_ID | START_DATE | END_DATE | JOB_ID | DEPARTMENT_ID |
|-----------------|-------------|------------|------------|--------|---------------|
| | 101 | 12/16/1998 | 12/15/1999 | AC_AUD | ACC |

Keys Row R_m Inherited Keys


```
insertRoutine(in BaseTable Ti, Row Rm, DataRef DPi)
```

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i,Keys_i,InheritedKeys_i,DP_i)



| EMPLOYEE_ID |
|-------------|
| 101 |

Keys

| Job_History |
|-------------|
| 1 |

T_i

| |
|---|
| 0 |
|---|

DP_i

| JOB_ID |
|--------|
| AC_AUD |

Inherited Keys



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

| EMPLOYEE_ID |
|-------------|
| 101 |

Keys_[i]

| Job_History |
|-------------|
| 1 |

T_[i]

| |
|---|
| 0 |
|---|

[DP]_i

| JOB_ID |
|--------|
| AC_AUD |

Inherited Keys_[i]

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

B+Tree(T₁)

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

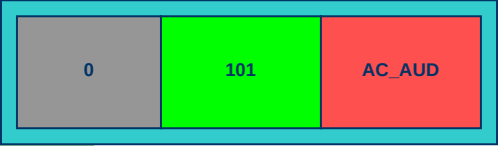
locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

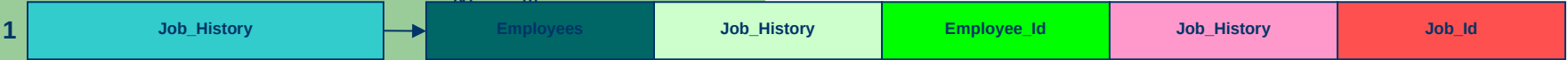
from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

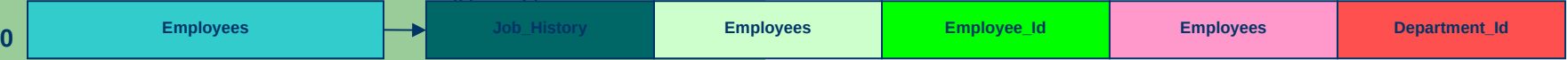


```
addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call AddJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
            Found = nextKey(B+Tree(T[k]), Keys[i])
```



Adjacent Table

```
addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call AddJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
            Found = nextKey(B+Tree(T[k]), Keys[i])
```



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

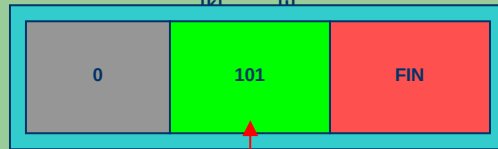
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[ik]), Keys_[i])

B+Tree(T₀)



Found: TRUE

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[ik]), Keys_[i])

Found: TRUE

```
addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DP]i)
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DP]i)
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DP]k)
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DP]ik)
            Found = nextKey(B+Tree(T[k]), Keys[i])
```

| |
|-----------------|
| EMPLO YEE_ID |
| 101 |

Keys_[k]

| |
|---|
| 0 |
|---|

[DP]_k

| |
|-------------------|
| DEPART MENT_ID |
| FIN |

Inherited

Keys_[i]

```

addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
            Found = nextKey(B+Tree(T[k]), Keys[i])

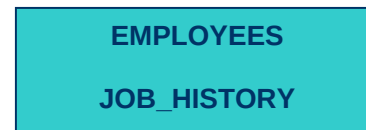
```



T_i

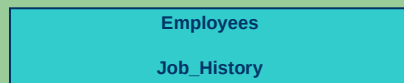


T_k



T_{ik}

6



```

addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList

```

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP_k])

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP_{ik}])

Found = nextKey(B+Tree(T_[k]), Keys_[i])

6



Keys

Inherited Keys


```

addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DP]i)
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DP]i)
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do

```

```

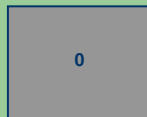
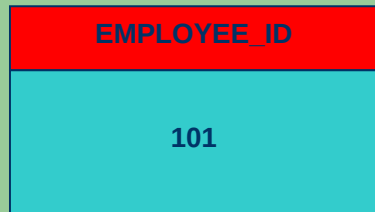
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DP]k)
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call AddJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DP]ik)
            Found = nextKey(B+Tree(T[k]), Keys[i])

```

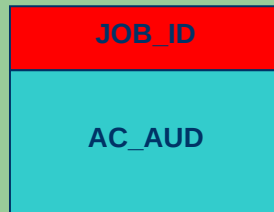


Keys

inherited Keys

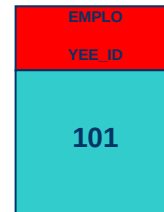


[DP]_i

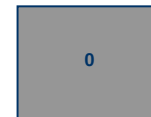


Inherited

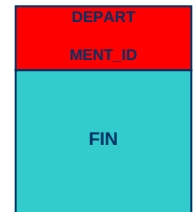
Keys_[i]



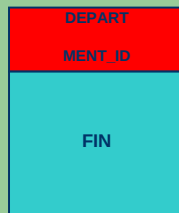
Keys_[k]



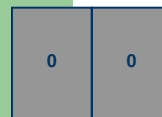
[DP]_k



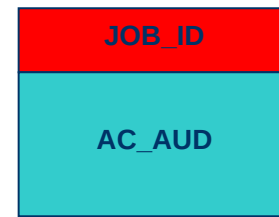
Inherited Keys_[k]



Keys_[ik]



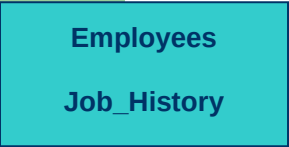
[DP]_{ik}



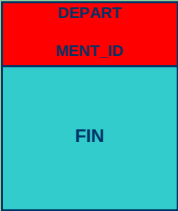
Inherited Keys_[ik]

```
addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DP]i)
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DP]i)
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
```

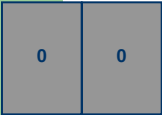
```
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DP]k)
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DP]ik)
            Found = nextKey(B+Tree(T[k]), Keys[i])
```



T_{ik}



Keys_[ik]



[DP]_{ik}



Inherited Keys_[ik]



addJoinKey(in Virtual Table $T_{[i]}$, Keys $_{[i]}$, InheritedKeys $_{[i]}$, $[DP_i]$)

call addKey($B+Tree(T_{[i]})$, Keys $_{[i]}$, InheritedKeys $_{[i]}$, $[DP_i]$)

locate the entry of $T_{[i]}$ in JoinPathList

from its adjacentList, locate the table $T_{[k]}$ adjacent to it

locate the entry of $T_{[k]}$ in JoinPathList

Found = findKey($B+Tree(T_{[k]})$, Keys $_{[i]}$)

while found do

returnKeys($B+Tree(T_{[k]})$, Keys $_{[k]}$, InheritedKeys $_{[k]}$, $[DP_k]$)

locate the entry of $T_{[ik]}$ in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys $_{[i]}$, InheritedKeys $_{[i]}$, Keys $_{[k]}$ & InheritedKeys $_{[k]}$ get the keys & Inherited keys of $T_{[ik]}$

call addJoinKey($T_{[ik]}$, Keys $_{[ik]}$, InheritedKeys $_{[ik]}$, $[DP_{ik}]$)

Found = nextKey($B+Tree(T_{[k]})$, Keys $_{[i]}$)

| |
|---------|
| DEPART |
| MENT_ID |
| FIN |

Keys $_{[i]}$

| |
|-------------|
| Employees |
| Job_History |

$T_{[i]}$

| | |
|---|---|
| 0 | 0 |
|---|---|

$[DP_{ik}]$

| |
|--------|
| JOB_ID |
| AC_AUD |

Inherited Keys $_{[ik]}$

addJoinKey(in Virtual Table $T_{[i]}$, Keys $_{[i]}$, InheritedKeys $_{[i]}$, [DP] $_i$)

call addKey(B+Tree($T_{[i]}$), Keys $_{[i]}$, InheritedKeys $_{[i]}$, [DP] $_i$)

locate the entry of $T_{[i]}$ in JoinPathList

from its adjacentList, locate the table $T_{[k]}$ adjacent to it

locate the entry of $T_{[k]}$ in JoinPathList

Found = findKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)

while found do

returnKeys(B+Tree($T_{[k]}$), Keys $_{[k]}$, InheritedKeys $_{[k]}$, [DP] $_k$)

locate the entry of $T_{[ik]}$ in JoinPathList

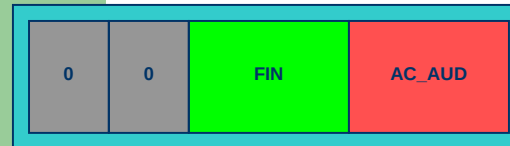
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys $_{[i]}$, InheritedKeys $_{[i]}$, Keys $_{[k]}$ & InheritedKeys $_{[k]}$ get the keys & Inherited keys of $T_{[ik]}$

call addJoinKey($T_{[ik]}$, Keys $_{[ik]}$, InheritedKeys $_{[ik]}$, [DP] $_{ik}$)

Found = nextKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)

B+Tree(T_6)



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP_k])

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP_k])

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP_k])

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP_{ik}])

Found = nextKey(B+Tree(T_[k]), Keys_[i])



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP_k])

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP_k])

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP_k])

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP_{ik}])

Found = nextKey(B+Tree(T_[k]), Keys_[i])



Keys

Inherited Keys

Adjacent Table

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

B+Tree(T_[k])
2



Found: FALSE

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

Found: FALSE

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

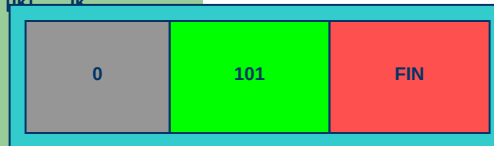
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

B+Tree(T₀)



Found: FALSE

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

Found: FALSE

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP_i])

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP_i])

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP_k])

locate the entry of T_[ik] in JoinPathList

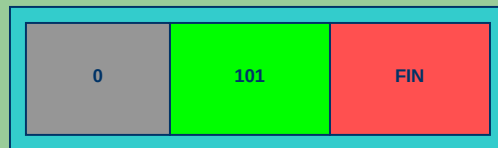
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

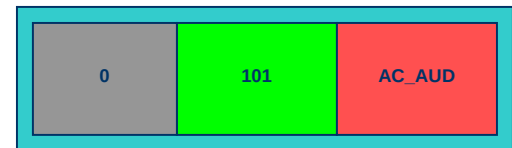
call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP_{ik}])

Found = nextKey(B+Tree(T_[k]), Keys_[i])

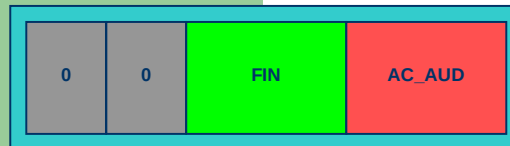
B+Tree(T₀)



B+Tree(T₁)



B+Tree(T₆)



Inserting first row from table Locations

Base Table

| Locations |
|-----------|
| 4 |

| LOCATION_ ID | STREET_ADDRESS | POSTAL_ CODE | CITY | STATE PROVINCE | COUNTRY_ ID |
|-----------------|----------------------|-----------------|----------|-------------------|----------------|
| 1000 | 22220 Cochrane Drive | V6V 2T9 | Richmond | B.C. | ca |

→ insertRoutine(in BaseTable T_i , Row R_m , DataRef DP_i)

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i , Keys $_i$, InheritedKeys $_i$, DP_i)

Base Table

| Locations |
|-----------|
| 4 |

T_i

DP_i

0



DataRef

| LOCATION_ ID | STREET_ADDRESS | POSTAL_ CODE | CITY | STATE PROVINCE | COUNTRY_ ID |
|-----------------|----------------------|-----------------|----------|-------------------|----------------|
| 1000 | 22220 Cochrane Drive | V6V 2T9 | Richmond | B.C. | ca |

Row R_m

m

insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i,Keys_i,InheritedKeys_i,DP_i)

4

| |
|-----------|
| Locations |
|-----------|

| |
|-------------|
| Employees |
| Job_History |
| Departments |
| Jobs |

| |
|-----------|
| Locations |
|-----------|

| |
|-------------|
| Location_Id |
|-------------|

| |
|-----------|
| Locations |
|-----------|

| |
|------------|
| Country_Id |
|------------|

insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i,Keys_i,InheritedKeys_i,DP_i)

4

| |
|-----------|
| Locations |
|-----------|

| |
|-------------|
| Employees |
| Job_History |
| Departments |
| Jobs |

| |
|-----------|
| Locations |
|-----------|

| |
|-------------|
| Location_Id |
|-------------|

| |
|-----------|
| Locations |
|-----------|

| |
|------------|
| Country_Id |
|------------|

insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i,Keys_i,InheritedKeys_i,DP_i)

DP_{i0}

| LOCATION_ ID | STREET_ADDRESS | POSTAL_ CODE | CITY | STATE PROVINCE | COUNTRY_ ID |
|-----------------|----------------------|-----------------|----------|-------------------|----------------|
| 1000 | 22220 Cochrane Drive | V6V 2T9 | Richmond | B.C. | ca |

Keys

Row R_m

Keys

Keys

Inherited Keys

```
insertRoutine(in BaseTable Ti, Row Rm, DataRef DPi)
```

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i, Keys_i, InheritedKeys_i, DP_i)

| LOCATION_ ID |
|-----------------|
| 1000 |

Keys

| Locations |
|-----------|
| 4 |

T_i

| |
|---|
| 0 |
|---|

DP_i

| COUNTRY_ ID |
|----------------|
| ca |

Inherited Keys



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

| LOCATION_ ID |
|-----------------|
| 1000 |

Keys_[i]

| Locations |
|-----------|
| 4 |

T_[i]

| |
|---|
| 0 |
|---|

[DP]_i

| COUNTRY_ ID |
|----------------|
| ca |

Inherited Keys_[i]

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

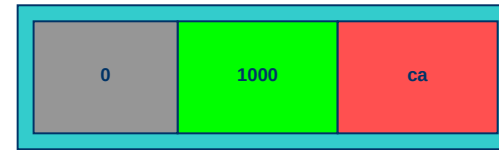
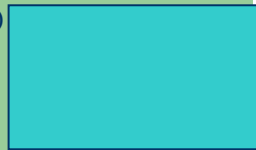
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

B+Tree(T_[i])



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

4



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP_i])

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP_i])

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP_k])

locate the entry of T_[ik] in JoinPathList

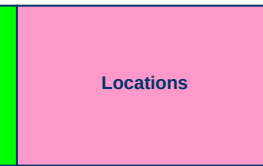
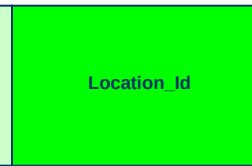
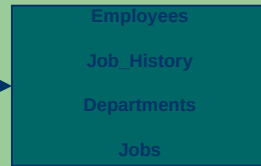
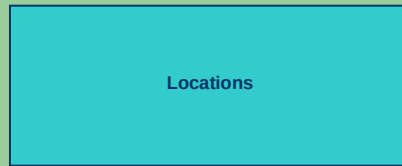
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP_{ik}])

Found = nextKey(B+Tree(T_[k]), Keys_[i])

4



Adjacent Table

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP_i])

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP_i])

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP_k])

locate the entry of T_[ik] in JoinPathList

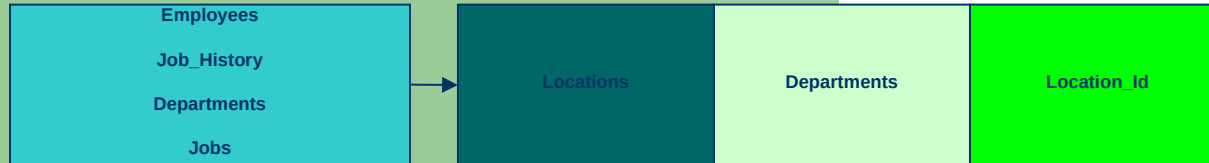
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP_{ik}])

Found = nextKey(B+Tree(T_[k]), Keys_[i])

8



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

B+Tree(T₈)

Found: FALSE

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

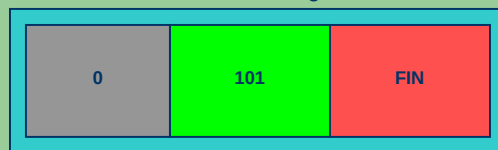
Found: FALSE

```

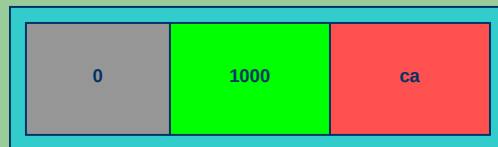
addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
            Found = nextKey(B+Tree(T[k]), Keys[i])

```

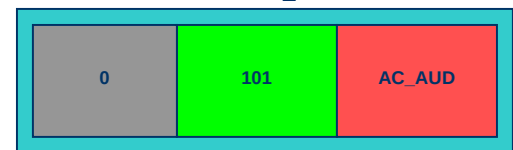
B+Tree(T₀)



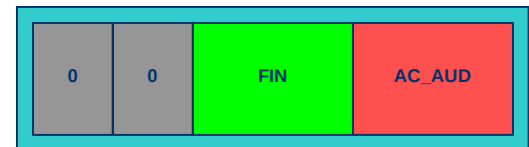
B+Tree(T₄)



B+Tree(T₁)



B+Tree(T₆)



Inserting first row from table Departments

Base Table

| DEPARTMENTS |
|-------------|
| 2 |

| Department_Id | Department_Name | Manager_Id | Location_Id |
|---------------|-----------------|------------|-------------|
| FIN | FINANCE | 101 | 1000 |

→ insertRoutine(in BaseTable T_i , Row R_m , DataRef DP_i)

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i , Keys $_i$, InheritedKeys $_i$, DP_i)

Base Table

| DEPARTMENTS |
|-------------|
| 2 |

T_i

| Department_Id | Department_Name | Manager_Id | Location_Id |
|---------------|-----------------|------------|-------------|
| FIN | FINANCE | 101 | 1000 |

DP_i
0
↑
DataRef

Row R_m

insertRoutine(in BaseTable T_i , Row R_m , DataRef DP_i)

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i , Keys $_i$, InheritedKeys $_i$, DP_i)

2

Departments

Employees

Job_History

Departments

Department_Id

Departments

Location_Id

insertRoutine(in BaseTable T_i , Row R_m , DataRef DP_i)

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i , Keys $_i$, InheritedKeys $_i$, DP_i)

2

Departments

Employees

Job_History

Departments

Department_Id

Departments

Location_Id

insertRoutine(in BaseTable T_i , Row R_m , DataRef DP_i)

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i , Keys $_i$, InheritedKeys $_i$, DP_i)

DP_i
0

Department_Id

Department_Name

Manager_Id

Location_Id

FIN

FINANCE

101

1000

Keys

Row R_m

Inherited Keys

Keys

Inherited Keys

```
insertRoutine(in BaseTable Ti, Row Rm, DataRef DPi)
```

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i, Keys_i, InheritedKeys_i, DP_i)



| Department_Id |
|---------------|
| FIN |

Keys

| DEPARTMENTS |
|-------------|
| 2 |

T_i

| |
|---|
| 0 |
|---|

DP_i

| Location_Id |
|-------------|
| 1000 |

Keys



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

DEPARTMENTS

2

T_[i]

Deparment_Id

FIN

Keys_[i]

0

[DP]_i

Location_Id

1000

Inherited Keys_[i]

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

B+Tree(T₂)

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

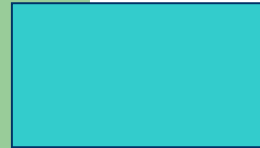
locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])



2



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP_i])

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP_i])

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP_k])

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP_{ik}])

Found = nextKey(B+Tree(T_[k]), Keys_[i])



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP_i])

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP_i])

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP_k])

locate the entry of T_[ik] in JoinPathList

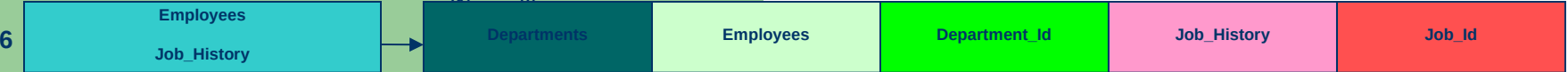
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP_{ik}])

Found = nextKey(B+Tree(T_[k]), Keys_[i])

Adjacent
Table



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

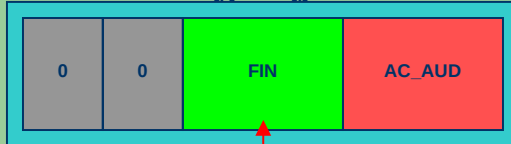
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

B+Tree(T₆)



Found: TRUE

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

Found: TRUE

```
addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DP]i)
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DP]i)
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacate to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
```

```
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DP]k)
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DP]ik)
            Found = nextKey(B+Tree(T[k]), Keys[i])
```

| |
|---------|
| DEPART |
| MENT_ID |
| FIN |

Keys_[k]

| | |
|---|---|
| 0 | 0 |
|---|---|

[DP]_k

| |
|--------|
| JOB_ID |
| AC_AUD |

Inherited Keys_[k]

```

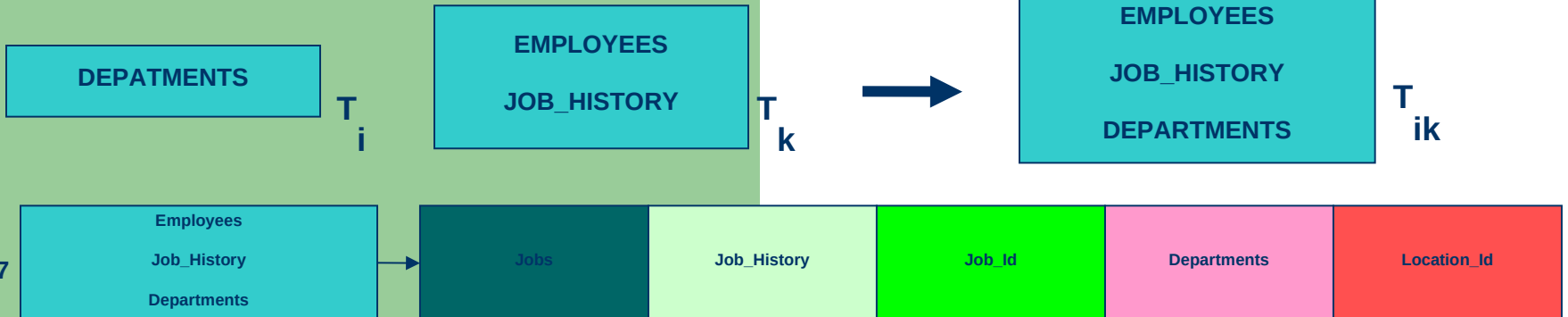
addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do

```

```

            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
            Found = nextKey(B+Tree(T[k]), Keys[i])

```



addJoinKey(in Virtual Table $T_{[i]}$, Keys $_{[i]}$, InheritedKeys $_{[i]}$, [DP])

call addKey(B+Tree($T_{[i]}$), Keys $_{[i]}$, InheritedKeys $_{[i]}$, [DP])

locate the entry of $T_{[i]}$ in JoinPathList

from its adjacentList, locate the table $T_{[k]}$ adjacent to it

locate the entry of $T_{[k]}$ in JoinPathList

Found = findKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)

while found do

returnKeys(B+Tree($T_{[k]}$), Keys $_{[k]}$, InheritedKeys $_{[k]}$, [DP])

locate the entry of $T_{[ik]}$ in JoinPathList

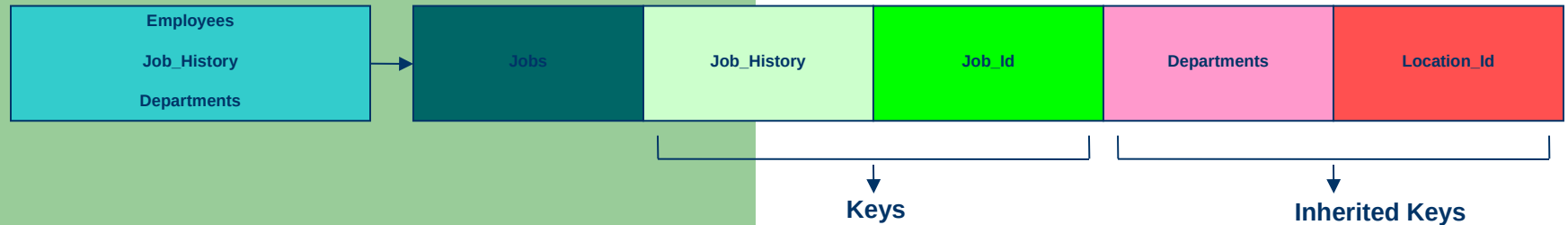
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys $_{[i]}$, InheritedKeys $_{[i]}$, Keys $_{[k]}$ & InheritedKeys $_{[k]}$ get the keys & Inherited keys of $T_{[ik]}$

call addJoinKey($T_{[ik]}$, Keys $_{[ik]}$, InheritedKeys $_{[ik]}$, [DP])

Found = nextKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)

7



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

7

Employees

Job_History

Departments

Jobs

Job_History

Job_Id

Departments

Location_Id

Deparment_Id

FIN

Keys_[i]

[DP]_i

0

Location_Id

1000

Inherited

Keys_[i]

JOB_ID

AC_AUD

Keys_[ik]

Keys

DEPART

MENT_ID

FIN

Keys_[k]

Inherited Keys

JOB_ID

AC_AUD

Inherited Keys_[k]

0

0

[DP]_k

0

Location_Id

1000

Inherited Keys_[ik]



[DP]_{ik}

0 0 0

```
addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DP]i)
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DP]i)
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DP]k)
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DP]ik)
            Found = nextKey(B+Tree(T[k]), Keys[i])
```

| EMPLOYEES | | |
|-------------|--|--|
| JOB_HISTORY | | |
| DEPARTMENTS | | |

T_{ik}

| JOB_ID |
|--------|
| AC_AUD |

Keys_{[ik]c}

| | | |
|---|---|---|
| 0 | 0 | 0 |
|---|---|---|

[DP]_{ik}

| Location_Id |
|-------------|
| 1000 |

Inherited Keys_[i]



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

| JOB_ID |
|--------|
| AC_AUD |

Keys_[i]

| EMPLOYEES |
|-------------|
| JOB_HISTORY |
| DEPARTMENTS |

T_[i]

| | | |
|---|---|---|
| 0 | 0 | 0 |
|---|---|---|

[DP]_i

| Location_Id |
|-------------|
| 1000 |

Inherited Keys_[i]

addJoinKey(in Virtual Table $T_{[i]}$, Keys $_{[i]}$, InheritedKeys $_{[i]}$, [DP] $_{[i]}$)

call addKey(B+Tree($T_{[i]}$), Keys $_{[i]}$, InheritedKeys $_{[i]}$, [DP] $_{[i]}$)

locate the entry of $T_{[i]}$ in JoinPathList

from its adjacentList, locate the table $T_{[k]}$ adjacent to it

locate the entry of $T_{[k]}$ in JoinPathList

Found = findKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)

while found do

returnKeys(B+Tree($T_{[k]}$), Keys $_{[k]}$, InheritedKeys $_{[k]}$, [DP] $_{[k]}$)

locate the entry of $T_{[ik]}$ in JoinPathList

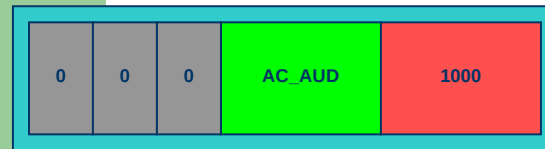
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys $_{[i]}$, InheritedKeys $_{[i]}$, Keys $_{[k]}$ & InheritedKeys $_{[k]}$ get the keys & Inherited keys of $T_{[ik]}$

call addJoinKey($T_{[ik]}$, Keys $_{[ik]}$, InheritedKeys $_{[ik]}$, [DP] $_{[ik]}$)

Found = nextKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)

B+Tree(T_7)



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP_i])

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP_i])

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP_k])

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP_{ik}])

Found = nextKey(B+Tree(T_[k]), Keys_[i])

7



Keys

Inherited Keys

```

addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
            Found = nextKey(B+Tree(T[k]), Keys[i])

```

7



Adjacent Table

```

addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it

```

```

    locate the entry of T[k] in JoinPathList
    Found = findKey(B+Tree(T[k]), Keys[i])

```

```

    while found do

```

```

        returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])

```

```

        locate the entry of T[ik] in JoinPathList

```

```

        from its adjacentList, locate the definition of Keys & Inherited Keys

```

```

        from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]

```

```

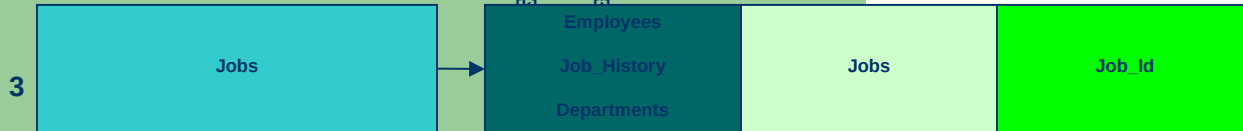
        call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])

```

```

        Found = nextKey(B+Tree(T[k]), Keys[i])

```



```

addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it

```

```

    locate the entry of T[k] in JoinPathList
    Found = findKey(B+Tree(T[k]), Keys[i])

```

```

    while found do

```

```

        returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])

```

```

        locate the entry of T[ik] in JoinPathList

```

```

        from its adjacentList, locate the definition of Keys & Inherited Keys

```

```

        from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]

```

```

        call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])

```

```

        Found = nextKey(B+Tree(T[k]), Keys[i])

```

B+Tree(T₃)



Found: FALSE

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

Found: FALSE

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

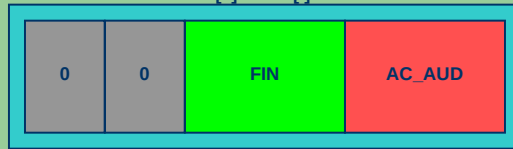
Found = nextKey(B+Tree(T_[k]), Keys_[i])

```

addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
            Found = nextKey(B+Tree(T[k]), Keys[i])

```

B+Tree(T₆)



Found: FALSE

```

addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
            Found = nextKey(B+Tree(T[k]), Keys[i])

```

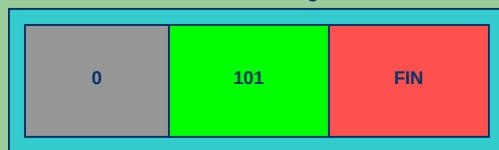
Found: FALSE

```

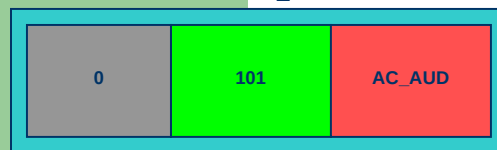
addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
            Found = nextKey(B+Tree(T[k]), Keys[i])

```

B+Tree(T₀)



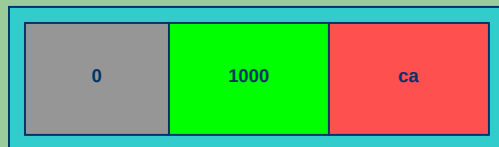
B+Tree(T₁)



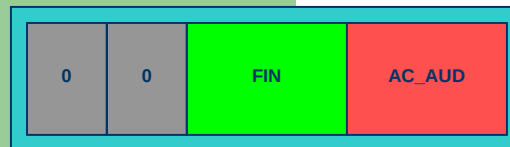
B+Tree(T₂)



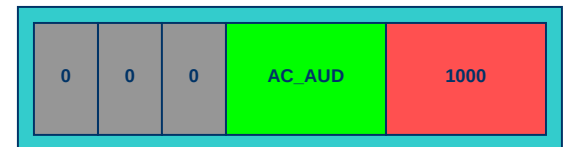
B+Tree(T₄)



B+Tree(T₆)



B+Tree(T₇)



Inserting first row from table Jobs

Base Table

| JOB_ID |
|--------|
| 3 |

| JOB_ID | JOB_TITLE | MIN_SALARY | MAX_SALARY |
|--------|--------------------|------------|------------|
| AC_AUD | Accounting Auditor | 30000 | 60000 |

→ insertRoutine(in BaseTable T_i , Row R_m , DataRef DP_i)

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i , Keys $_i$, InheritedKeys $_i$, DP_i)

Base Table

| |
|------|
| JOBS |
| 3 |

T_i

| | JOB_ID | JOB_TITLE | MIN_SALARY | MAX_SALARY |
|-----------------------------|-----------|--------------------|------------|------------|
| DP_i 0 ↑ DataRef | AC_AUD | Accounting Auditor | 30000 | 60000 |
| | Row R_m | | | |

insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i,Keys_i,InheritedKeys_i,DP_i)

3

| |
|------|
| Jobs |
|------|



| |
|-------------|
| Employees |
| Job_History |
| Departments |

| |
|------|
| Jobs |
|------|

| |
|--------|
| Job_Id |
|--------|

insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i,Keys_i,InheritedKeys_i,DP_i)

3

| |
|------|
| Jobs |
|------|



| |
|-------------|
| Employees |
| Job_History |
| Departments |

| |
|------|
| Jobs |
|------|

| |
|--------|
| Job_Id |
|--------|

insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i,Keys_i,InheritedKeys_i,DP_i)

DP_{i0}

| |
|--------|
| JOB_ID |
|--------|

| |
|-----------|
| JOB_TITLE |
|-----------|

| |
|------------|
| MIN_SALARY |
|------------|

| |
|------------|
| MAX_SALARY |
|------------|

| |
|--------|
| AC_AUD |
|--------|

| |
|--------------------|
| Accounting Auditor |
|--------------------|

| |
|-------|
| 30000 |
|-------|

| |
|-------|
| 60000 |
|-------|

Keys

Row R_m

Keys

Inherited Keys

insertRoutine(in BaseTable T_i , Row R_m , DataRef DP_i)

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i ,Keys $_i$,InheritedKeys $_i$, DP_i)

| |
|--------|
| JOB_ID |
| AC_AUD |

Keys

| |
|------|
| JOBS |
| 3 |

T_i

| |
|---|
| 0 |
|---|

DP_i



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

| |
|--------|
| JOB_ID |
| AC_AUD |

Keys_[i]

| |
|------|
| JOBS |
| 3 |

T_[i]

| |
|---|
| 0 |
|---|

[DP]_i

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

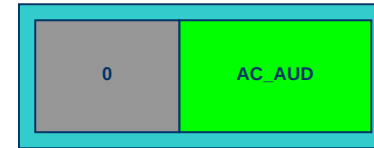
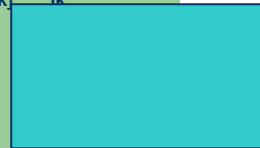
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

B+Tree(T₃)



3



| | | |
|-------------|------|--------|
| Employees | Jobs | Job_id |
| Job_History | | |
| Departments | | |

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP_i])

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP_i])

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP_k])

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP_{ik}])

Found = nextKey(B+Tree(T_[k]), Keys_[i])

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP_i])

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP_i])

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP_k])

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP_{ik}])

Found = nextKey(B+Tree(T_[k]), Keys_[i])

3

| |
|------|
| Jobs |
|------|



| | | |
|-------------|--|--|
| Employees | | |
| Job_History | | |
| Departments | | |

Adjacent Table

7

| |
|-------------|
| Employees |
| Job_History |
| Departments |



| | | | | |
|------|-------------|--------|-------------|-------------|
| Jobs | Job_History | Job_Id | Departments | Location_Id |
|------|-------------|--------|-------------|-------------|

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

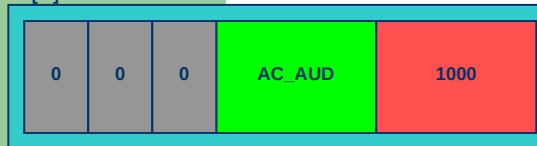
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

B+Tree(T₇)



Found: TRUE

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

Found: TRUE


```
addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
            Found = nextKey(B+Tree(T[k]), Keys[i])
```

| JOB_ID |
|--------|
| AC_AUD |

Keys_[k]

| | | |
|---|---|---|
| 0 | 0 | 0 |
|---|---|---|

[DP_k]

| Location_Id |
|-------------|
| 1000 |

Inherited Keys_[i]

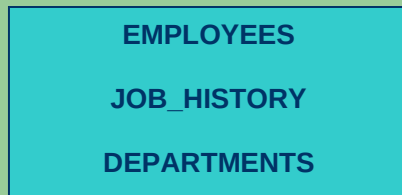
```

addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
            Found = nextKey(B+Tree(T[k]), Keys[i])

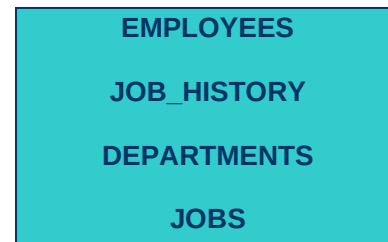
```



T_i

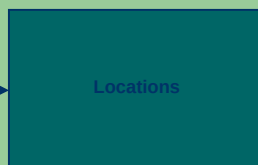


T_k



T_{ik}

8



addJoinKey(in Virtual Table $T_{[i]}$, Keys $_{[i]}$, InheritedKeys $_{[i]}$, [DP] $_i$)

call addKey(B+Tree($T_{[i]}$), Keys $_{[i]}$, InheritedKeys $_{[i]}$, [DP] $_i$)

locate the entry of $T_{[i]}$ in JoinPathList

from its adjacentList, locate the table $T_{[k]}$ adjacent to it

locate the entry of $T_{[k]}$ in JoinPathList

Found = findKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)

while found do

returnKeys(B+Tree($T_{[k]}$), Keys $_{[k]}$, InheritedKeys $_{[k]}$, [DP] $_k$)

locate the entry of $T_{[ik]}$ in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys $_{[i]}$, InheritedKeys $_{[i]}$, Keys $_{[k]}$ & InheritedKeys $_{[k]}$ get the keys & Inherited keys of $T_{[ik]}$

call addJoinKey($T_{[ik]}$, Keys $_{[ik]}$, InheritedKeys $_{[ik]}$, [DP] $_{ik}$)

Found = nextKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)

8



Keys

Inherited Keys

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

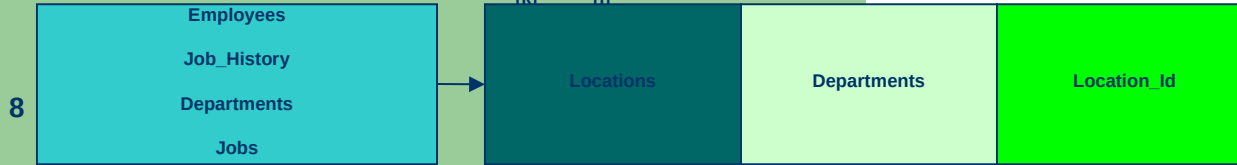
locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

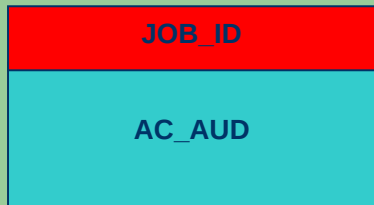
call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

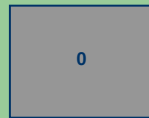


Keys

Inherited Keys

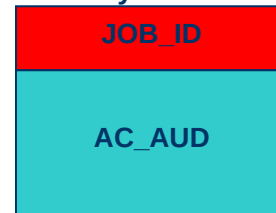


Keys_[i]

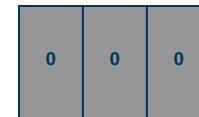


[DP]_i

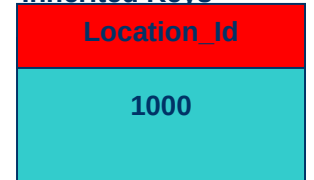
Inherited Keys_[i]



Keys_[k]



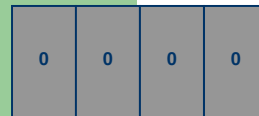
[DP]_k



Inherited Keys_[k]



Keys_[ik]



[DP]_{ik}

Inherited Keys_[ik]

```
addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
            Found = nextKey(B+Tree(T[k]), Keys[i])
```

| Location_Id |
|-------------|
| 1000 |

Keys_[ik]

| EMPLOYEES |
|-------------|
| JOB_HISTORY |
| DEPARTMENTS |
| JOBS |

T_{ik}

| | | | |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
|---|---|---|---|

[DP_{ik}]
ik

Inherited Keys_[ik]



addJoinKey(in Virtual Table $T_{[i]}$, Keys $_{[i]}$, InheritedKeys $_{[i]}$, $[DP]_i$)

call addKey($B+Tree(T_{[i]})$, Keys $_{[i]}$, InheritedKeys $_{[i]}$, $[DP]_i$)

locate the entry of $T_{[i]}$ in JoinPathList

from its adjacentList, locate the table $T_{[k]}$ adjacent to it

locate the entry of $T_{[k]}$ in JoinPathList

Found = findKey($B+Tree(T_{[k]})$, Keys $_{[i]}$)

while found do

returnKeys($B+Tree(T_{[k]})$, Keys $_{[k]}$, InheritedKeys $_{[k]}$, $[DP]_k$)

locate the entry of $T_{[ik]}$ in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys $_{[i]}$, InheritedKeys $_{[i]}$, Keys $_{[k]}$ & InheritedKeys $_{[k]}$ get the keys & Inherited keys of $T_{[ik]}$

call addJoinKey($T_{[ik]}$, Keys $_{[ik]}$, InheritedKeys $_{[ik]}$, $[DP]_{ik}$)

Found = nextKey($B+Tree(T_{[k]})$, Keys $_{[i]}$)

| Location_Id |
|-------------|
| 1000 |

Keys $_{[i]}$

| |
|-------------|
| EMPLOYEES |
| JOB_HISTORY |
| DEPARTMENTS |
| JOBS |

$T_{[i]}$

| | | | |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
|---|---|---|---|

$[DP]_i$

Inherited Keys $_{[i]}$

addJoinKey(in Virtual Table $T_{[i]}$, Keys $_{[i]}$, InheritedKeys $_{[i]}$, [DP] $_i$)

call addKey(B+Tree($T_{[i]}$), Keys $_{[i]}$, InheritedKeys $_{[i]}$, [DP] $_i$)

locate the entry of $T_{[i]}$ in JoinPathList

from its adjacentList, locate the table $T_{[k]}$ adjacent to it

locate the entry of $T_{[k]}$ in JoinPathList

Found = findKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)

while found do

returnKeys(B+Tree($T_{[k]}$), Keys $_{[k]}$, InheritedKeys $_{[k]}$, [DP] $_k$)

locate the entry of $T_{[ik]}$ in JoinPathList

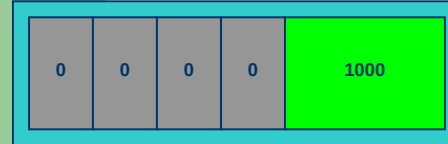
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys $_{[i]}$, InheritedKeys $_{[i]}$, Keys $_{[k]}$ & InheritedKeys $_{[k]}$ get the keys & Inherited keys of $T_{[ik]}$

call addJoinKey($T_{[ik]}$, Keys $_{[ik]}$, InheritedKeys $_{[ik]}$, [DP] $_{ik}$)

Found = nextKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)

B+Tree(T_8)



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP_i])

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP_i])

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP_k])

locate the entry of T_[ik] in JoinPathList

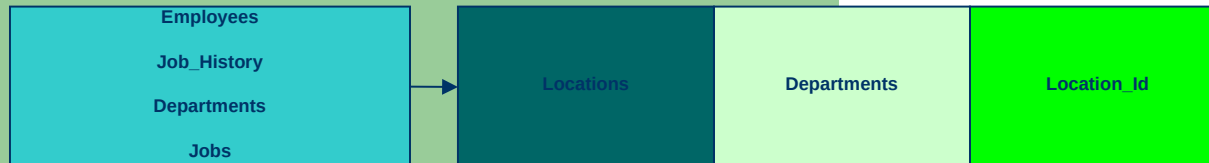
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP_{ik}])

Found = nextKey(B+Tree(T_[k]), Keys_[i])

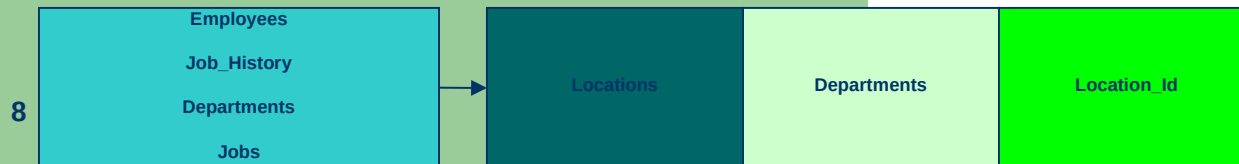
8




```

addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
            Found = nextKey(B+Tree(T[k]), Keys[i])

```



**Adjacent
Table**

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP_i])

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP_i])

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP_k])

locate the entry of T_[ik] in JoinPathList

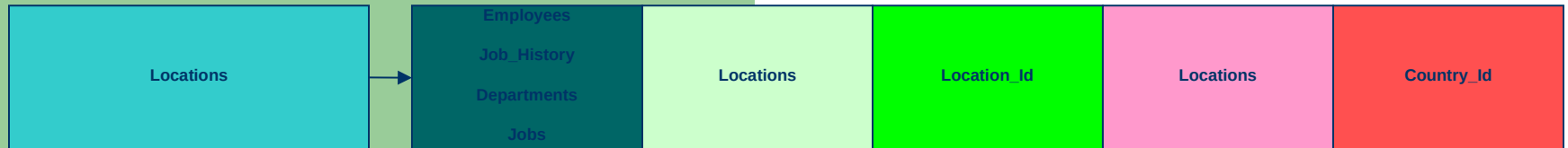
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP_{ik}])

Found = nextKey(B+Tree(T_[k]), Keys_[i])

4



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

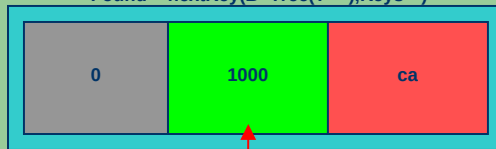
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

B+Tree(T₄)



Found: TRUE

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

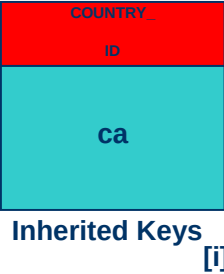
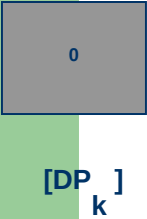
call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

Found: TRUE

```
addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DP]i)
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DP]i)
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
```

```
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DP]k)
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DP]ik)
            Found = nextKey(B+Tree(T[k]), Keys[i])
```



```

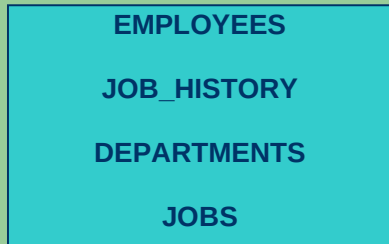
addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do

```

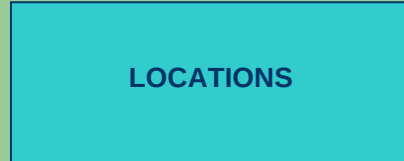
```

    returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
    locate the entry of T[ik] in JoinPathList
    from its adjacentList, locate the definition of Keys & Inherited Keys
    from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
    call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
    Found = nextKey(B+Tree(T[k]), Keys[i])

```



T_i

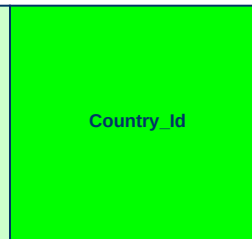
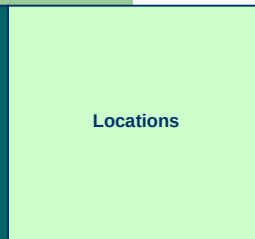
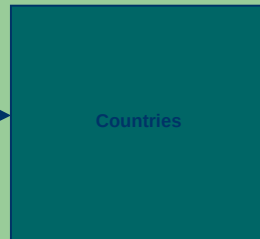


T_k



T_{ik}

9



```

addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DP]i)
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DP]i)
    locate the entry of T[i] in JoinPathList

```

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

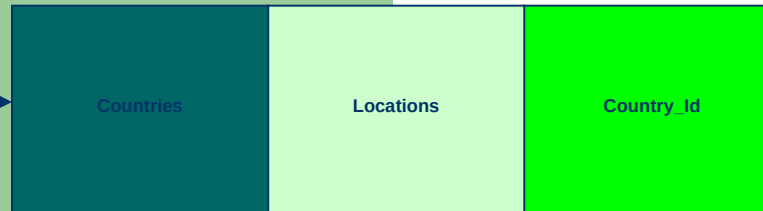
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

9



↓
Keys

↓
Inherited Keys

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

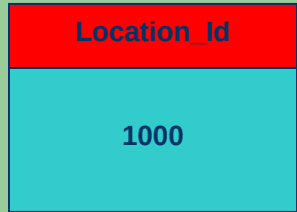
locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

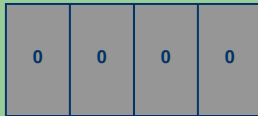
from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

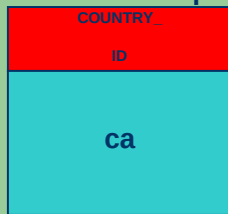
Found = nextKey(B+Tree(T_[k]), Keys_[i])



Keys_[i]

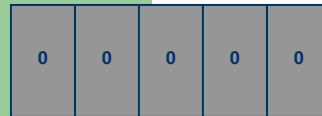


[DP]_i

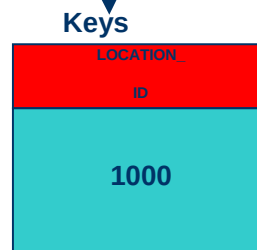


Keys_[ik]

Inherited Keys_[i]



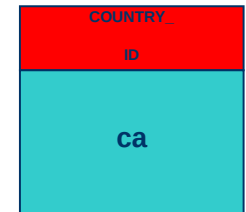
[DP]_{ik}



Keys_[k]



[DP]_k

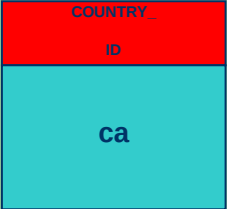


Inherited Keys_[k]

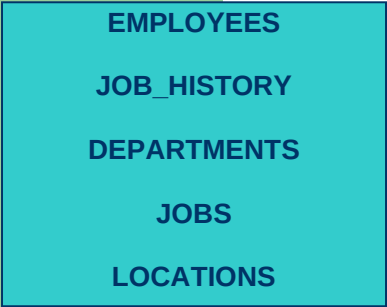
Inherited Keys_[ik]

```
addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DP]i)
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DP]i)
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
```

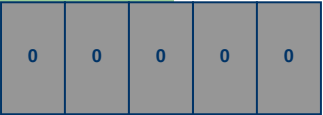
```
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DP]k)
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DP]ik)
            Found = nextKey(B+Tree(T[k]), Keys[i])
```



Keys_[ik]



T_{ik}



[DP]_{ik}

Inherited Keys_[ik]



addJoinKey(in Virtual Table $T_{[i]}$, Keys $_{[i]}$, InheritedKeys $_{[i]}$, $[DP]_i$)

call addKey(B+Tree($T_{[i]}$), Keys $_{[i]}$, InheritedKeys $_{[i]}$, $[DP]_i$)

locate the entry of $T_{[i]}$ in JoinPathList

from its adjacentList, locate the table $T_{[k]}$ adjacent to it

locate the entry of $T_{[k]}$ in JoinPathList

Found = findKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)

while found do

returnKeys(B+Tree($T_{[k]}$), Keys $_{[k]}$, InheritedKeys $_{[k]}$, $[DP]_k$)

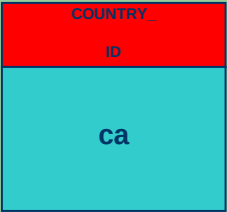
locate the entry of $T_{[ik]}$ in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

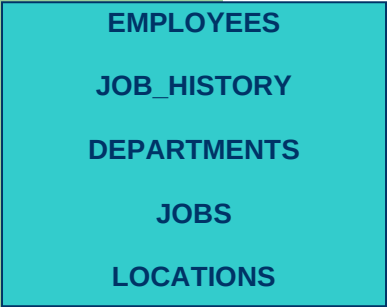
from keys $_{[i]}$, InheritedKeys $_{[i]}$, Keys $_{[k]}$ & InheritedKeys $_{[k]}$ get the keys & Inherited keys of $T_{[ik]}$

call addJoinKey($T_{[ik]}$, Keys $_{[ik]}$, InheritedKeys $_{[ik]}$, $[DP]_{ik}$)

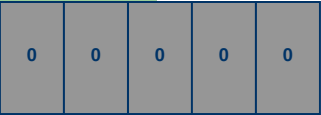
Found = nextKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)



Keys $_{[i]}$



$T_{[i]}$



$[DP]_i$

Inherited Keys $_{[i]}$

addJoinKey(in Virtual Table $T_{[i]}$, Keys $_{[i]}$, InheritedKeys $_{[i]}$, [DP] $_{[i]}$)

call addKey(B+Tree($T_{[i]}$), Keys $_{[i]}$, InheritedKeys $_{[i]}$, [DP] $_{[i]}$)

locate the entry of $T_{[i]}$ in JoinPathList

from its adjacentList, locate the table $T_{[k]}$ adjacent to it

locate the entry of $T_{[k]}$ in JoinPathList

Found = findKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)

while found do

returnKeys(B+Tree($T_{[k]}$), Keys $_{[k]}$, InheritedKeys $_{[k]}$, [DP] $_{[k]}$)

locate the entry of $T_{[ik]}$ in JoinPathList

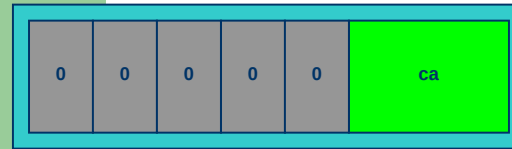
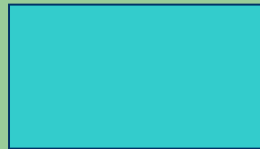
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys $_{[i]}$, InheritedKeys $_{[i]}$, Keys $_{[k]}$ & InheritedKeys $_{[k]}$ get the keys & Inherited keys of $T_{[ik]}$

call addJoinKey($T_{[ik]}$, Keys $_{[ik]}$, InheritedKeys $_{[ik]}$, [DP] $_{[ik]}$)

Found = nextKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)

B+Tree(T_9)



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP_i])

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP_i])

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP_k])

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP_{ik}])

Found = nextKey(B+Tree(T_[k]), Keys_[i])

9

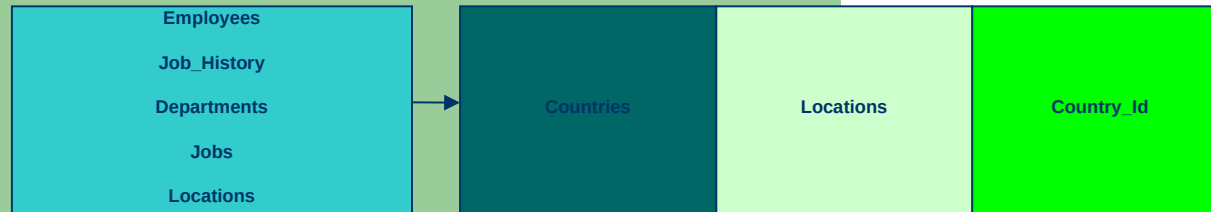


```

addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
            Found = nextKey(B+Tree(T[k]), Keys[i])

```

9



Adjacent Table

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[i]), Keys_[i])

5

Countries

Employees

Job_History

Departments

Jobs

Locations

Countries

Country_Id

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[i]), Keys_[i])

B+Tree(T₅)

Found: FALSE

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

Found: FALSE

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

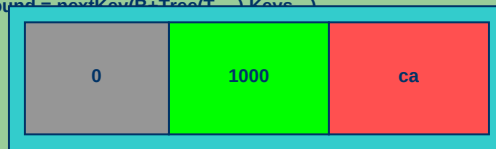
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

B+Tree(T₄)



Found: FALSE

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

Found: FALSE

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

B+Tree(T₇)

| | | | | |
|---|---|---|--------|------|
| 0 | 0 | 0 | AC_AUD | 1000 |
|---|---|---|--------|------|

Found: FALSE

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP_i])

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP_i])

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP_k])

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP_{ik}])

Found = nextKey(B+Tree(T_[k]), Keys_[i])

Found: FALSE

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP_i])

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP_i])

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP_k])

locate the entry of T_[ik] in JoinPathList

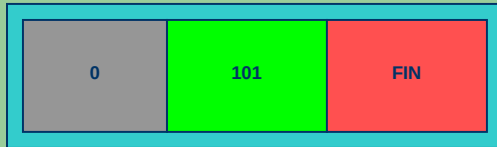
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

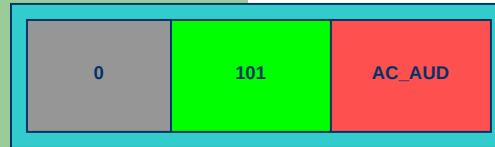
call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP_{ik}])

Found = nextKey(B+Tree(T_[k]), Keys_[i])

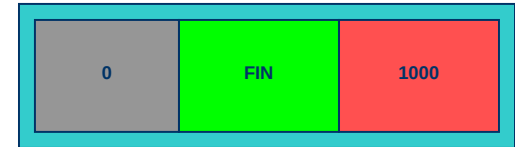
B+Tree(T₀)



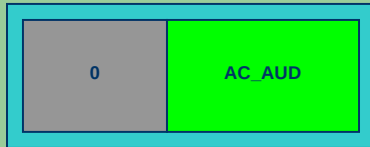
B+Tree(T₁)



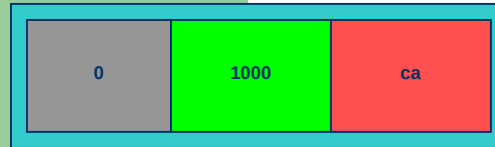
B+Tree(T₂)



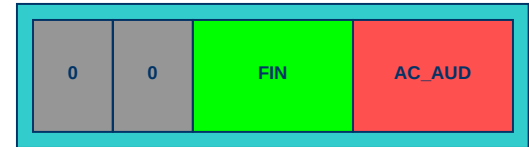
B+Tree(T₃)



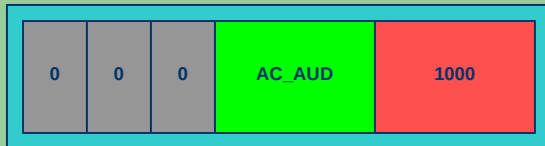
B+Tree(T₄)



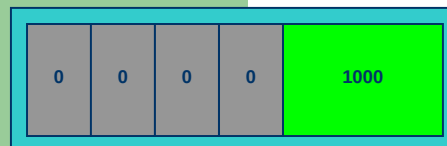
B+Tree(T₆)



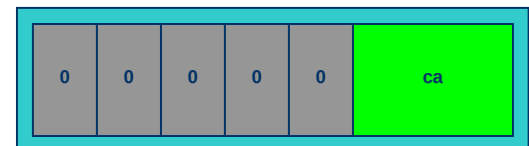
B+Tree(T₇)



B+Tree(T₈)



B+Tree(T₉)



Inserting first row from table Countries

Base Table

| COUNTRIES |
|-----------|
| 5 |

| Country_Id | Country_Name |
|------------|--------------|
| ca | Canada |

→ insertRoutine(in BaseTable T_i , Row R_m , DataRef DP_i)

locate the entry of T in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i , Keys $_i$, InheritedKeys $_i$, DP_i)

Base Table

| COUNTRIES |
|-----------|
| 5 |

T_i

| Country_Id | Country_Name |
|------------|--------------|
| ca | Canada |

DP_i
0
↑
DataRef

Row R_m

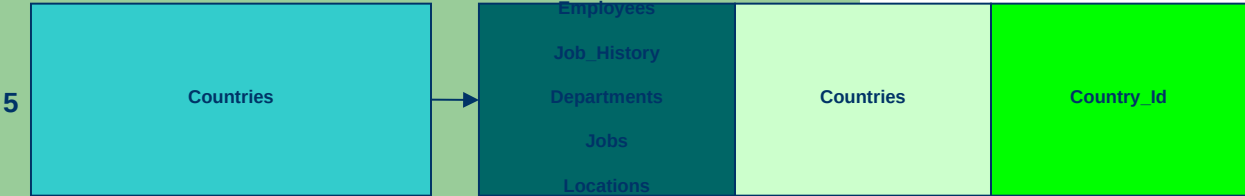
insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i,Keys_i,InheritedKeys_i,DP_i)



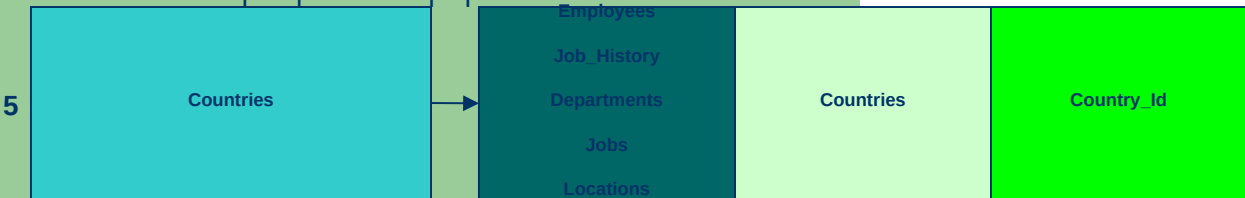
insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i,Keys_i,InheritedKeys_i,DP_i)



insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i,Keys_i,InheritedKeys_i,DP_i)

| Country_Id | | Country_Name | |
|------------|--|--------------|--|
| ca | | Canada | |

Keys

Inherited Keys

Keys

Row R_m

```
insertRoutine(in BaseTable Ti, Row Rm, DataRef DPi)
```

locate the entry of T_i in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from row R_m get the columns constituting the keys & Inherited Keys

call AddJoinKey(T_i, Keys_i, InheritedKeys_i, DP_i)



| Country_Id |
|------------|
| ca |

Keys

| COUNTRIES |
|-----------|
| 5 |

T_i

| |
|---|
| 0 |
|---|

DP_i

Inherited Keys



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

| COUNTRIES |
|-----------|
| 5 |

T_[i]

| Country_Id |
|------------|
| ca |

Keys_[i]

| |
|---|
| 0 |
|---|

[DP]_i

Inherited Keys_[i]

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP_i])

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP_i])

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP_k])

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP_{ik}])

Found = nextKey(B+Tree(T_[k]), Keys_[i])

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP_i])

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP_i])

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP_k])

locate the entry of T_[ik] in JoinPathList

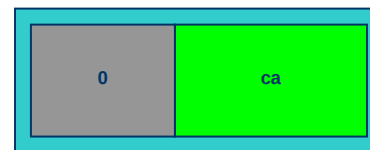
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

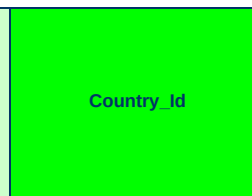
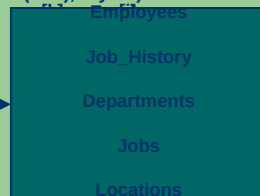
call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP_{ik}])

Found = nextKey(B+Tree(T_[k]), Keys_[i])

B+Tree(T₅)



5



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP_i])

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP_i])

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP_k])

locate the entry of T_[ik] in JoinPathList

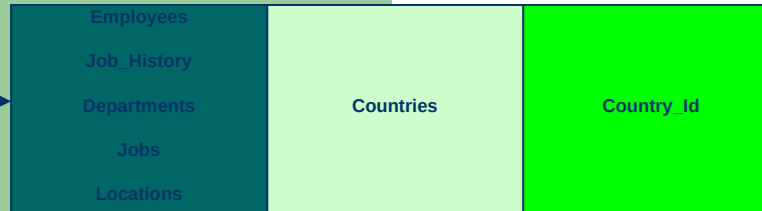
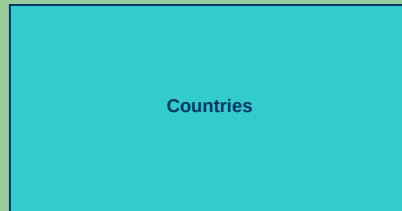
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP_{ik}])

Found = nextKey(B+Tree(T_[k]), Keys_[i])

5



Adjacent Table

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP_i])

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP_i])

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP_k])

locate the entry of T_[ik] in JoinPathList

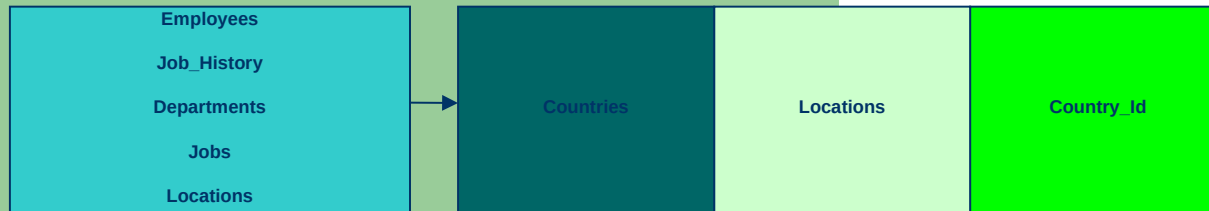
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP_{ik}])

Found = nextKey(B+Tree(T_[k]), Keys_[i])

9

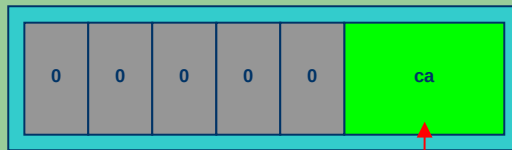


```

addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call AddJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
            Found = nextKey(B+Tree(T[k]), Keys[i])

```

B+Tree(T₉)



Found: TRUE

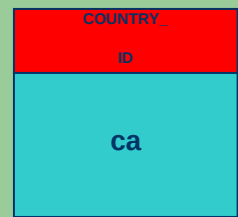
```

addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call AddJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
            Found = nextKey(B+Tree(T[k]), Keys[i])

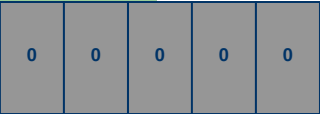
```

Found: TRUE

```
addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
            Found = nextKey(B+Tree(T[k]), Keys[i])
```



Keys_[k]



[DP_k]

Inherited Keys_[i]

```

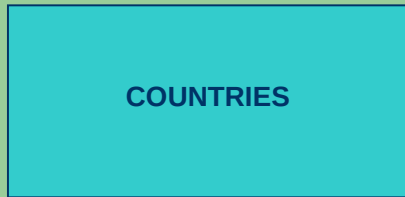
addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do

```

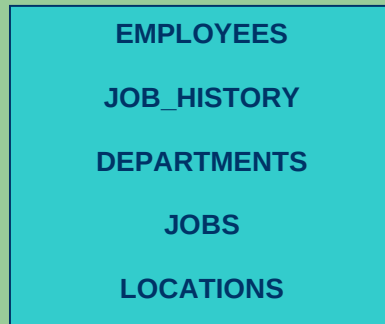
```

    returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
    locate the entry of T[ik] in JoinPathList
    from its adjacentList, locate the definition of Keys & Inherited Keys
    from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
    call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
    Found = nextKey(B+Tree(T[k]), Keys[i])

```



T_i

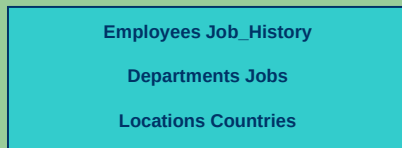


T_k



T_{ik}

10



```

addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
            Found = nextKey(B+Tree(T[k]), Keys[i])

```

Employees Job_History

Departments Jobs

Locations Countries

10

Keys

Inherited Keys

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call AddJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

10

Employees Job_History

Departments Jobs

Locations Countries

Keys

Inherited Keys

Country_Id

ca

Keys_[i]

0

[DP]_i

Inherited

Keys_[i]

COUNTRY_

ID

ca

Keys_[k]

[DP]_k

Inherited Keys_[k]

| | | | | |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|---|

Keys_[ik]

[DP]_{ik}

Inherited Keys_[ik]

```
addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DP]i)
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DP]i)
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DP]k)
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DP]ik)
            Found = nextKey(B+Tree(T[k]), Keys[i])
```



T_{ik}

| | | | | | |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|---|

Keys_[ik]

[DP]_{ik}

Inherited Keys_[ik]

→ addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

EMPLOYEES

JOB_HISTORY

DEPARTMENTS

JOBS

LOCATIONS

COUNTRIES

T_[i]

| | | | | | |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|---|

Keys_[i]

[DP]_i

Inherited Keys_[i]

addJoinKey(in Virtual Table $T_{[i]}$, Keys $_{[i]}$, InheritedKeys $_{[i]}$, [DP] $_i$)

call addKey(B+Tree($T_{[i]}$), Keys $_{[i]}$, InheritedKeys $_{[i]}$, [DP] $_i$)

locate the entry of $T_{[i]}$ in JoinPathList

from its adjacentList, locate the table $T_{[k]}$ adjacent to it

locate the entry of $T_{[k]}$ in JoinPathList

Found = findKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)

while found do

returnKeys(B+Tree($T_{[k]}$), Keys $_{[k]}$, InheritedKeys $_{[k]}$, [DP] $_k$)

locate the entry of $T_{[ik]}$ in JoinPathList

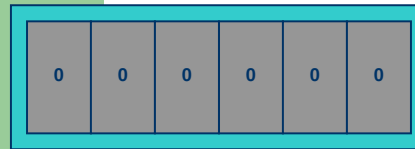
from its adjacentList, locate the definition of Keys & Inherited Keys

from keys $_{[i]}$, InheritedKeys $_{[i]}$, Keys $_{[k]}$ & InheritedKeys $_{[k]}$ get the keys & Inherited keys of $T_{[ik]}$

call addJoinKey($T_{[ik]}$, Keys $_{[ik]}$, InheritedKeys $_{[ik]}$, [DP] $_{ik}$)

Found = nextKey(B+Tree($T_{[k]}$), Keys $_{[i]}$)

B+Tree(T_{10})



addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP_i])

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP_i])

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP_k])

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP_{ik}])

Found = nextKey(B+Tree(T_[k]), Keys_[i])

10

Employees Job_History

Departments Jobs

Locations Countries

```

addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]), Keys[i], InheritedKeys[i], [DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found = findKey(B+Tree(T[k]), Keys[i])
        while found do
            returnKeys(B+Tree(T[k]), Keys[k], InheritedKeys[k], [DPk])
            locate the entry of T[ik] in JoinPathList
            from its adjacentList, locate the definition of Keys & Inherited Keys
            from keys[i], InheritedKeys[i], Keys[k] & InheritedKeys[k] get the keys & Inherited keys of T[ik]
            call addJoinKey(T[ik], Keys[ik], InheritedKeys[ik], [DPik])
            Found = nextKey(B+Tree(T[k]), Keys[i])

```

10

| |
|-----------------------|
| Employees Job_History |
| Departments Jobs |
| Locations Countries |

Adjacent
Table

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

Found: FALSE

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

Found: FALSE

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

Found = nextKey(B+Tree(T_[k]), Keys_[i])

Found: FALSE

addJoinKey(in Virtual Table T_[i], Keys_[i], InheritedKeys_[i], [DP]_i)

call addKey(B+Tree(T_[i]), Keys_[i], InheritedKeys_[i], [DP]_i)

locate the entry of T_[i] in JoinPathList

from its adjacentList, locate the table T_[k] adjacent to it

locate the entry of T_[k] in JoinPathList

Found = findKey(B+Tree(T_[k]), Keys_[i])

while found do

returnKeys(B+Tree(T_[k]), Keys_[k], InheritedKeys_[k], [DP]_k)

locate the entry of T_[ik] in JoinPathList

from its adjacentList, locate the definition of Keys & Inherited Keys

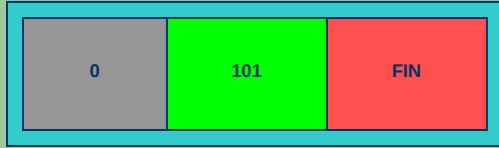
from keys_[i], InheritedKeys_[i], Keys_[k] & InheritedKeys_[k] get the keys & Inherited keys of T_[ik]

call addJoinKey(T_[ik], Keys_[ik], InheritedKeys_[ik], [DP]_{ik})

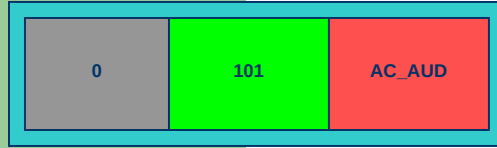
Found = nextKey(B+Tree(T_[k]), Keys_[i])

Found: FALSE

B+Tree(T₀)



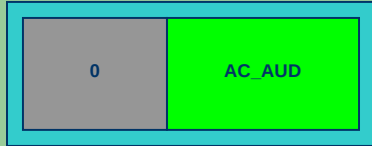
B+Tree(T₁)



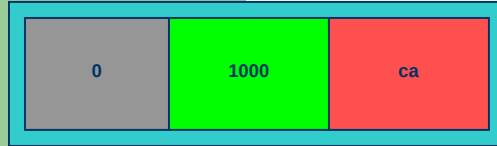
B+Tree(T₂)



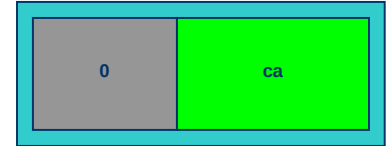
B+Tree(T₃)



B+Tree(T₄)



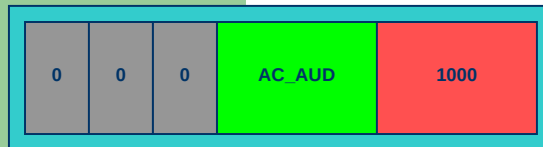
B+Tree(T₅)



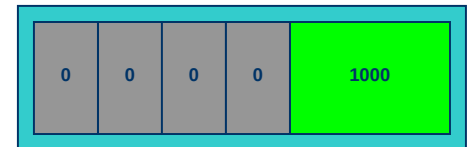
B+Tree(T₆)



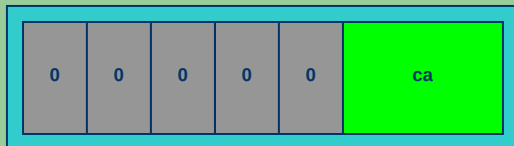
B+Tree(T₇)



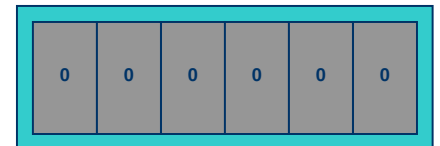
B+Tree(T₈)



B+Tree(T₉)



B+Tree(T₁₀)



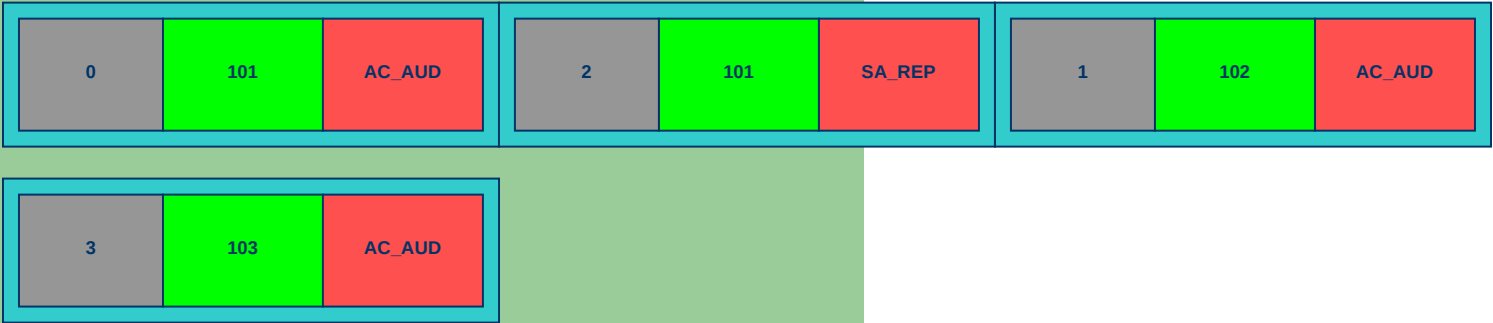
As we can notice from the last index we have an element with 6 data pointers respectively pointing to the 6 base tables forming the virtual table T_{10} , with all values equal to the first row on each table, those rows are in join together.

Inserting all the remaining rows from the tables we obtain the following indexes where the last index shows the join between the rows from the tables.

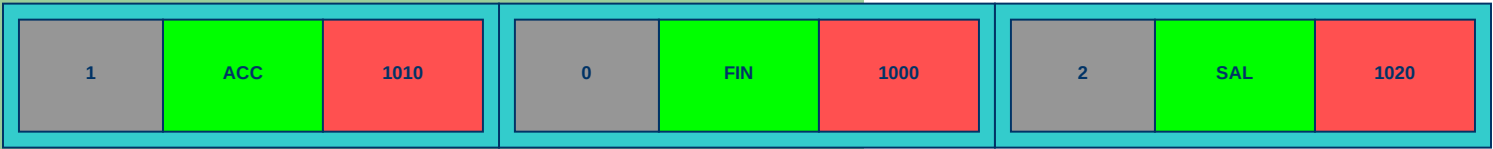
B+Tree(T_0)



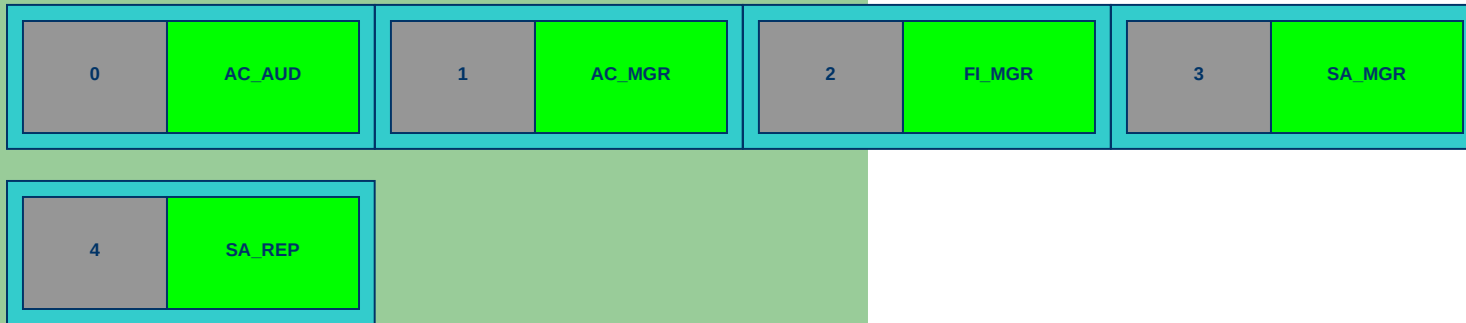
B+Tree(T_1)



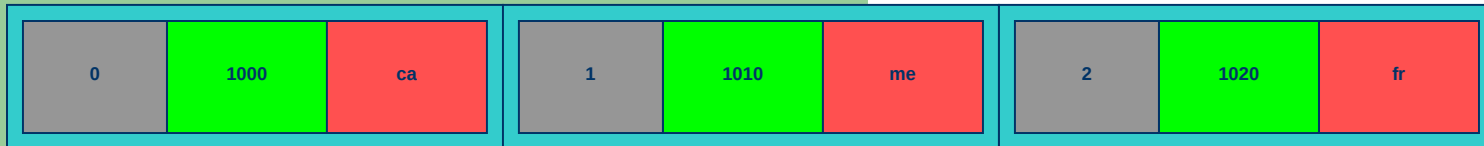
B+Tree(T_2)



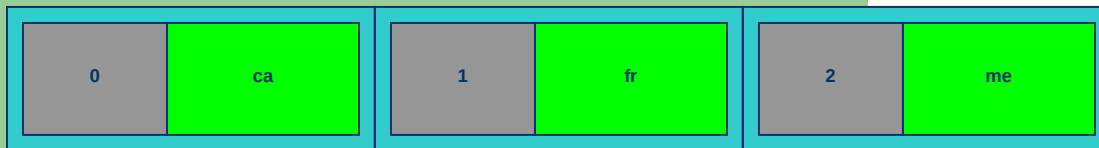
B+Tree(T₃)



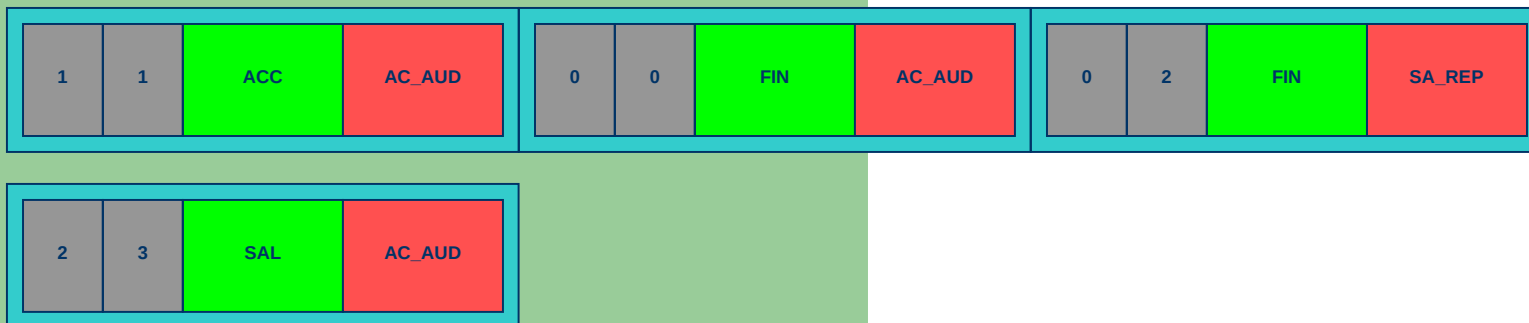
B+Tree(T₄)



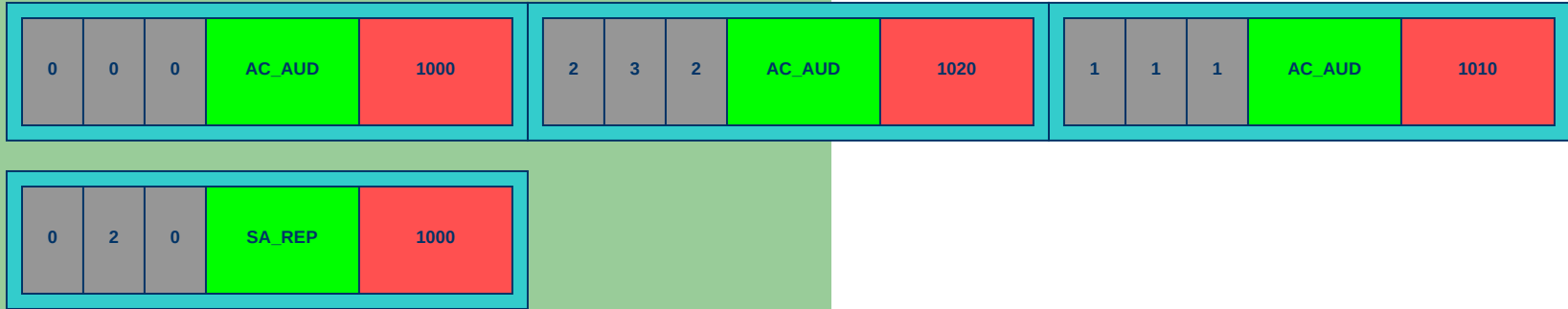
B+Tree(T₅)



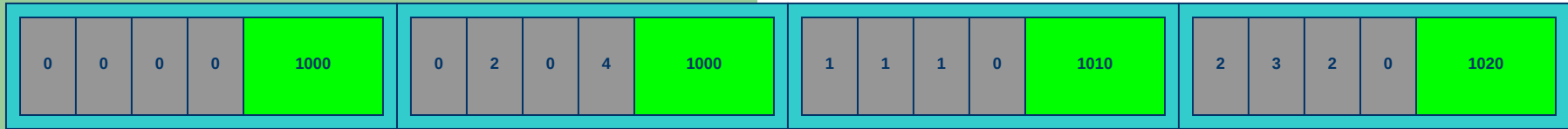
B+Tree(T₆)



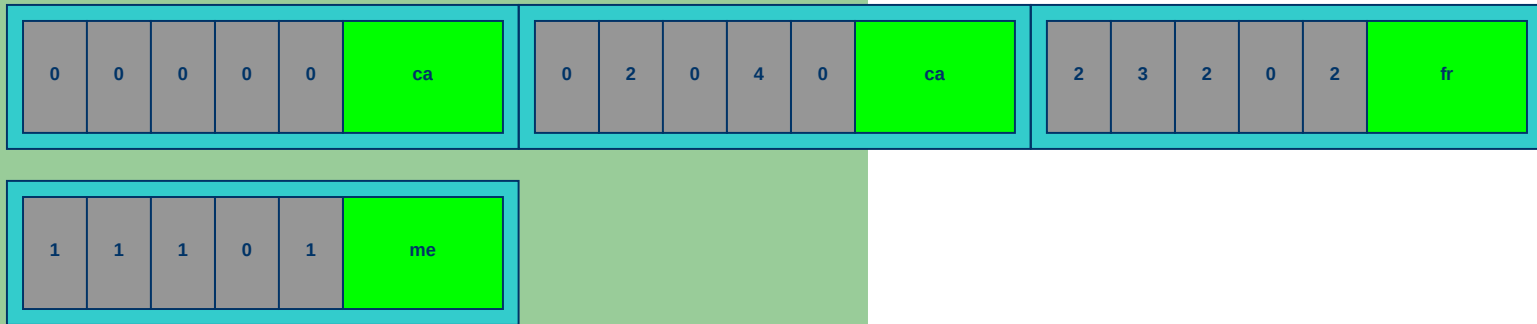
B+Tree(T₇)



B+Tree(T₈)



B+Tree(T₉)



B+Tree(T₁₀)



Delete routine

When a row R_m from table T_i get deleted do the following:

- Locate the entry of T_i in the JoinPathList
- From its adjacent List, locate the definition of the keys and inherited keys
- From Row R_m get the columns constituting the keys and the inherited keys
- Call DelJoinKey (T_i , $Keys_i$, $InheritedKeys_i$, DP_i) where DP_i is the row id of row R_m

Notice that $Keys_i$, $InheritedKeys_i$ and DP_i are relative to the row R_m from table T_i

DelJoinKey ($T_{[i]}$, $Keys_{[i]}$, InheritedKeys $_{[i]}$, [DP $_i$])

- Call DelKey (B⁺Tree($T_{[i]}$), $keys_{[i]}$, InheritedKeys $_{[i]}$, [DP $_i$]) for the index of table $T_{[i]}$
- Locate the entry of $T_{[i]}$ in the JoinPathList
- From its adjacent List, locate the Table $T_{[k]}$ adjacent to it and do the following:
 - Locate the entry of $T_{[k]}$ in the JoinPathList
 - FindKey(B⁺Tree($T_{[k]}$), $Keys_{[i]}$)
 - While found($keys_{[i]}$) do
 - ReturnKeys(B⁺Tree($T_{[k]}$), $keys_{[k]}$, InheritedKeys $_{[k]}$, [DP $_k$])
 - Locate the entry of $T_{[ik]}$ in the JoinPathList
 - From its adjacent List, locate the definition of the keys and inherited keys
 - From $keys_{[i]}$, inheritedkeys $_{[i]}$, $keys_{[k]}$, inheritedkeys $_{[k]}$ get the keys and inherited keys of $T_{[ik]}$
 - DelJoinKey ($T_{[ik]}$, $Keys_{[ik]}$, InheritedKeys $_{[ik]}$, [DP $_{ik}$])
 - NextKey(B⁺Tree($T_{[k]}$), $Keys_{[i]}$)

B \bowtie Tree with incremental Join

Due to the fact that join is commutative and associative and we are working on Virtual Tables and using indexes on them; it is possible instead of calculating all the join combinations to calculate incrementally the join.

This issue works just when the n tables are in direct path join between them but if they are not we are not interested.

Giving a casual order for the tables.

Beginning from Table 0, get a table T_i in direct join with it.

A Join Path List comes out with 2 entries from T_0 to T_i and from T_i to T_0 .

The index number start always with 0.

Repeat, with T_0 or T_i and get a next table that is in direct join with T_0 or with T_i , the process continue till we scan all the tables.

This algorithm is linear, is $2*n - 1$.

Complexity of the algorithm for the creation of JoinPathList.

The complexity for the creation of JoinPathList structure is: $2*n-1$ where n is the number of tables in join.

Proof:

We can prove it by induction on the number of tables in join.

For $m = 1$:

The complexity should be $2*1-1 = 1$ in fact it is the only table that get inserted in the JoinPathList.

For $m = n-1$:

Suppose that the number of tables in JoinPathList is $2*(n-1)-1$.

For $m = n$:

The n^{th} table get inserted as a Vertex in the JoinPathList at the beginning of the algorithm.

The n^{th} table get inserted in queue and path dynamic arrays because the n tables are in join and at least there is one table in the $(n-1)$ remaining table that is in join with the n^{th} table.

So when the algorithm run at certain point should execute:

$$T_{[\text{buf}]} += T_i$$

$$\text{Insert NodesList}[T_{[\text{buf}]}] = T_{[\text{buf}]}$$

where T_i is T_n , so the number of tables in JoinPathList are: $2*(n-1)-1 + 1 + 1 = 2*n-1$

Complexity of the algorithm for the insertion and deletion.

Delete is symmetric to insert in the algorithm in the sense where there is an insert we use a delete, so they have both the same complexity.

When inserting a new row in the database we use the **B⁺tree mechanism to drive us in the insert for the join.**

Suppose that the order of the B⁺Trees is m and the number of elements for every B⁺Tree with i as index from the (2*n-1) B⁺Trees is $p_i * l_i$ where in average there is l_i elements satisfying the join between every pair of tables.

In the worst case when get inserted a row that need to call recursively all other B⁺Trees, the insert procedure will be running for $(2*n - 1) - (n - 1) = n$ times.

The complexity will be:

$\text{Ord}(n * \log_m(l_i * p_i))$

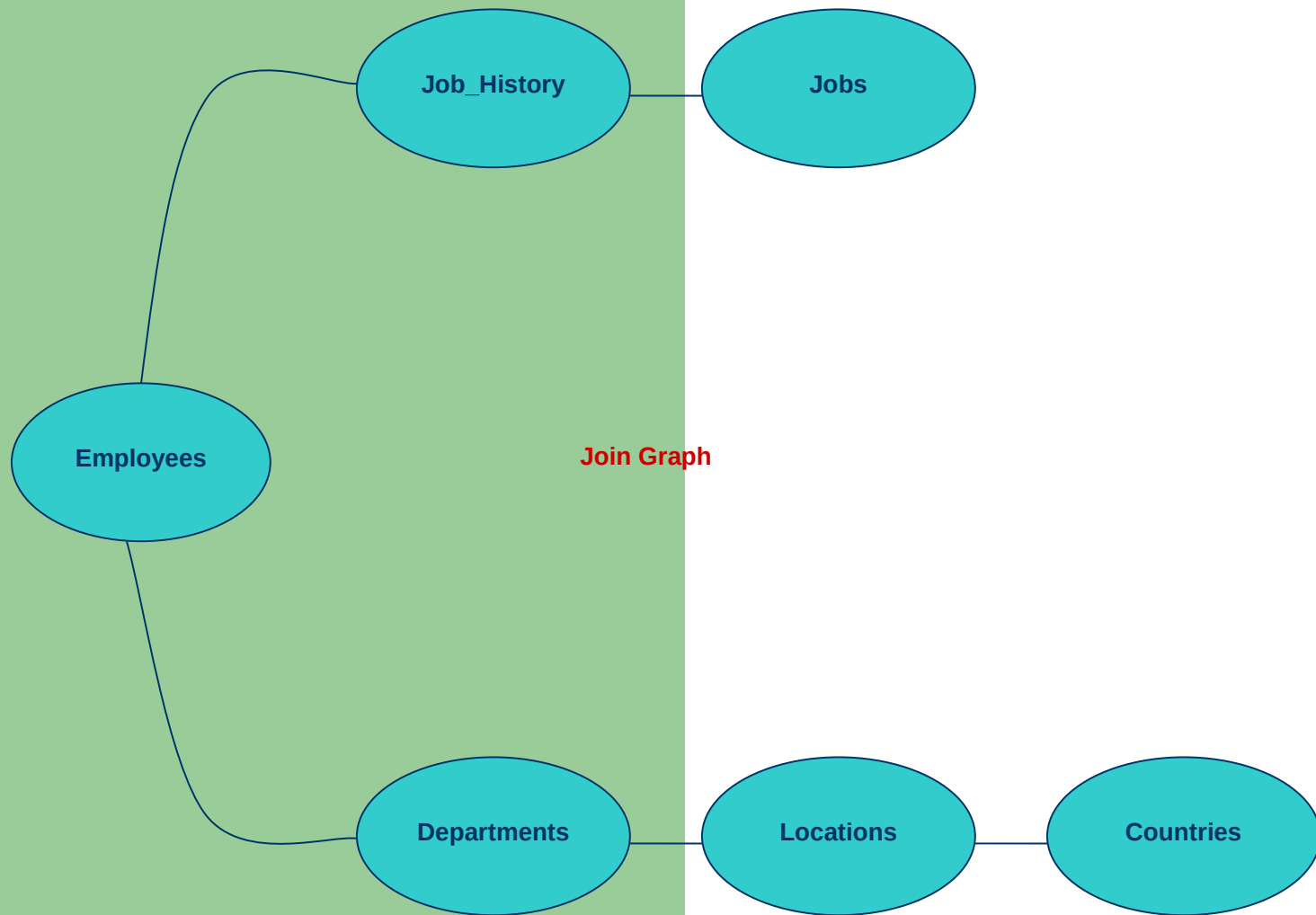
Complexity of the algorithm for the other operations.

The only B⁺Tree of our interest for the scan is the one with the latest index that have the join of the tables inside it.

Suppose that the number of elements for the latest index is $p_{(2*n-1)}$ so the other operations on this B⁺Tree for find, search, prev, next,... are the same as for normal B⁺Tree.with the same number of elements.

Proof of correctness.

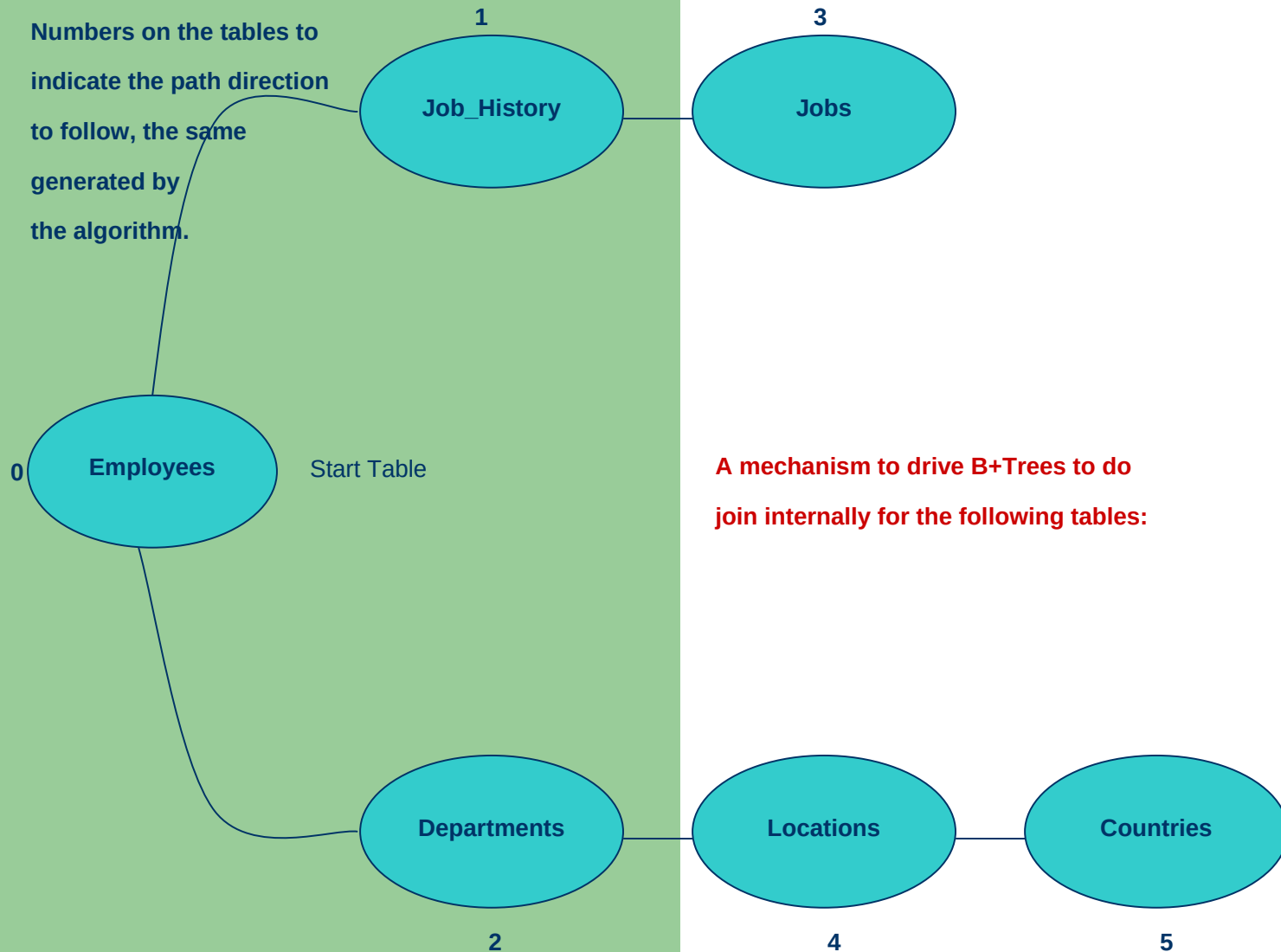
**To prove the correctness of the algorithm
let see how does the algorithm work for
the example above and later generalize it.
The Join Graph could be calculated easily
even manually when we know which
Tables are in direct join with others.**



Join Graph

Let define a path in the Join Graph, the same path generated by the algorithm:

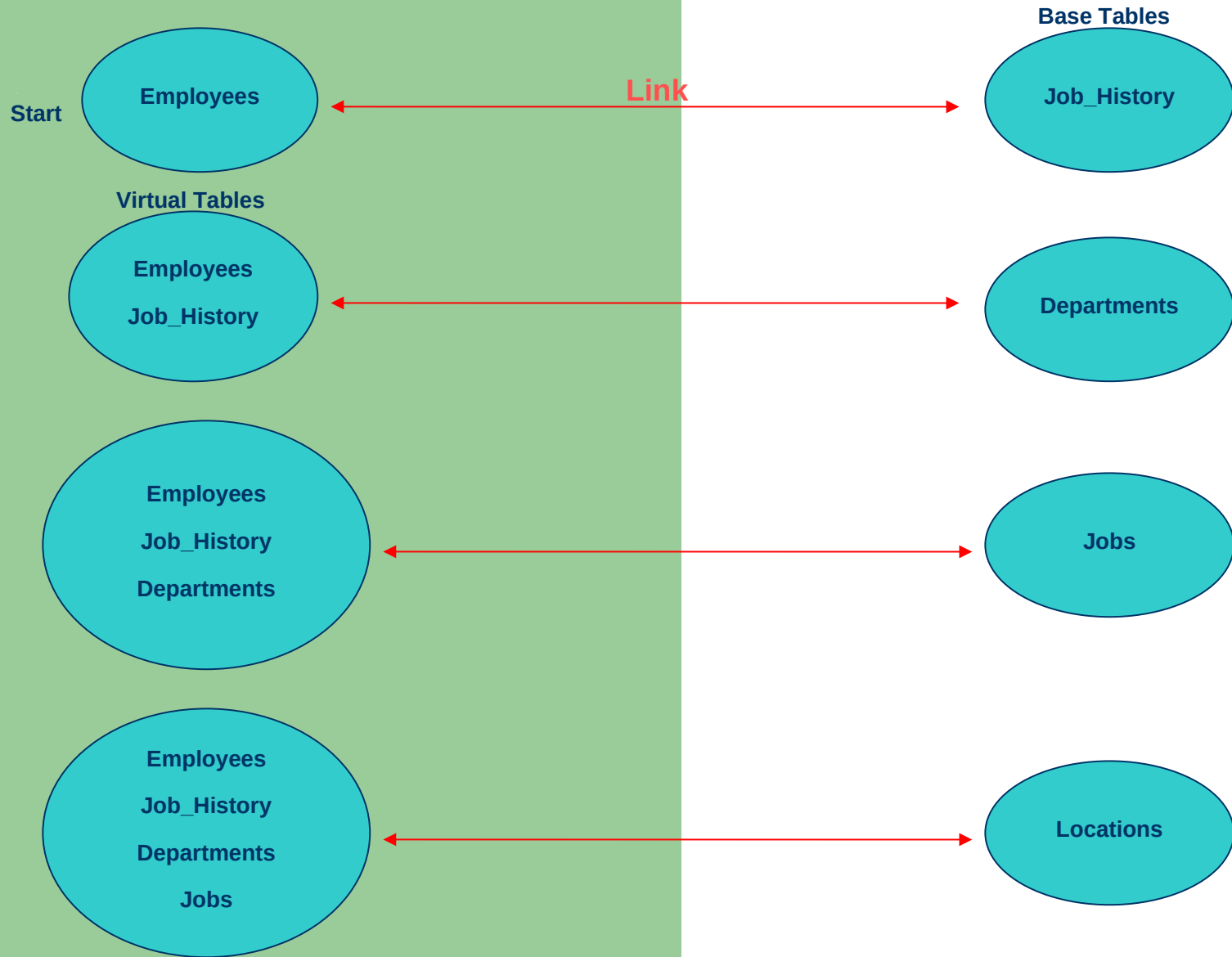
`generateJoinPathList`

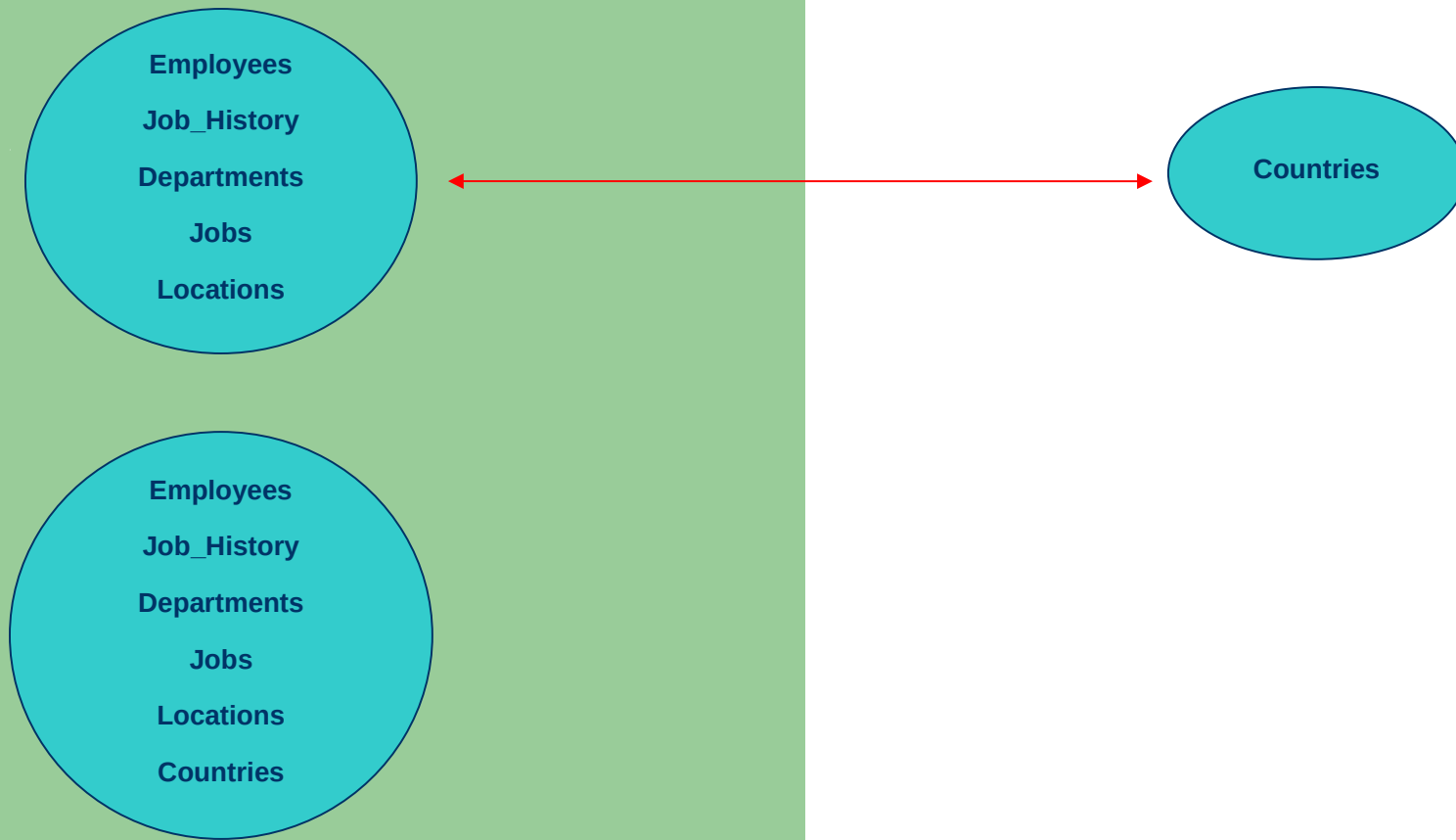


Notice that in the path if we reach one table it is not necessary to continue from it.

This is very important because this makes the tables free from any order, independent selection of the start table.

By grouping comes out: `





There is no restriction on how the rows from base tables get inserted (Any order with any sequence).

As we can see for every Virtual Table there is a Base Table in which there is a direct join between them and vice versa, in fact they belongs to the same Path in the Join Graph.

The idea consists in that every Virtual Table is constituted from Base Tables that are in join together. In fact the Base Tables constituting the Virtual Table appears by adding one at time that is in direct join with the one of the previous tables.

Now the join between tables should be calculated and stored to be found. For this reason B+Tree is declared for every Virtual Table that can hold references for rows from Base Tables constituting the Virtual Table in mode that concatenating them together bring out a joined Row.

Rows are inserted into a database as one row from a base table at a time, the system look for the link table, and check the B+Tree to see if there is any row that satisfy the join with the newly inserted; if this is the case combine each row satisfying with newly inserted by their references, and insert the combined row in the virtual table that has as base tables the base tables of the 2 previously tables.

So at any time when a row get inserted, the link table may eventually have the rows that satisfy the join with it, so they are combined and the process continue to the last virtual table or if they didn't get inserted yet in the virtual table, later when they get inserted they are confronted with the one inserted yet and the process continue on the same way.

The last table will contain all base tables in join together.

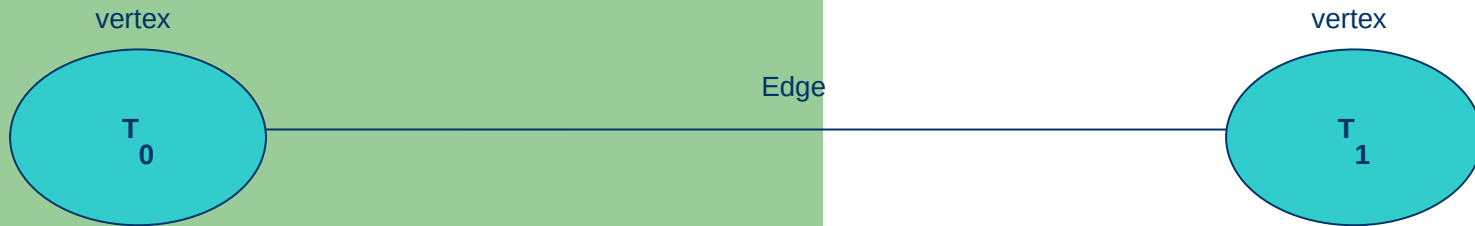
Proof of correctness.

Notice that what we show before is independent from the number of tables, so that the same reasoning apply to any number of tables and the proof of correctness could be easily proved by induction.

Let prove the correctness by induction.

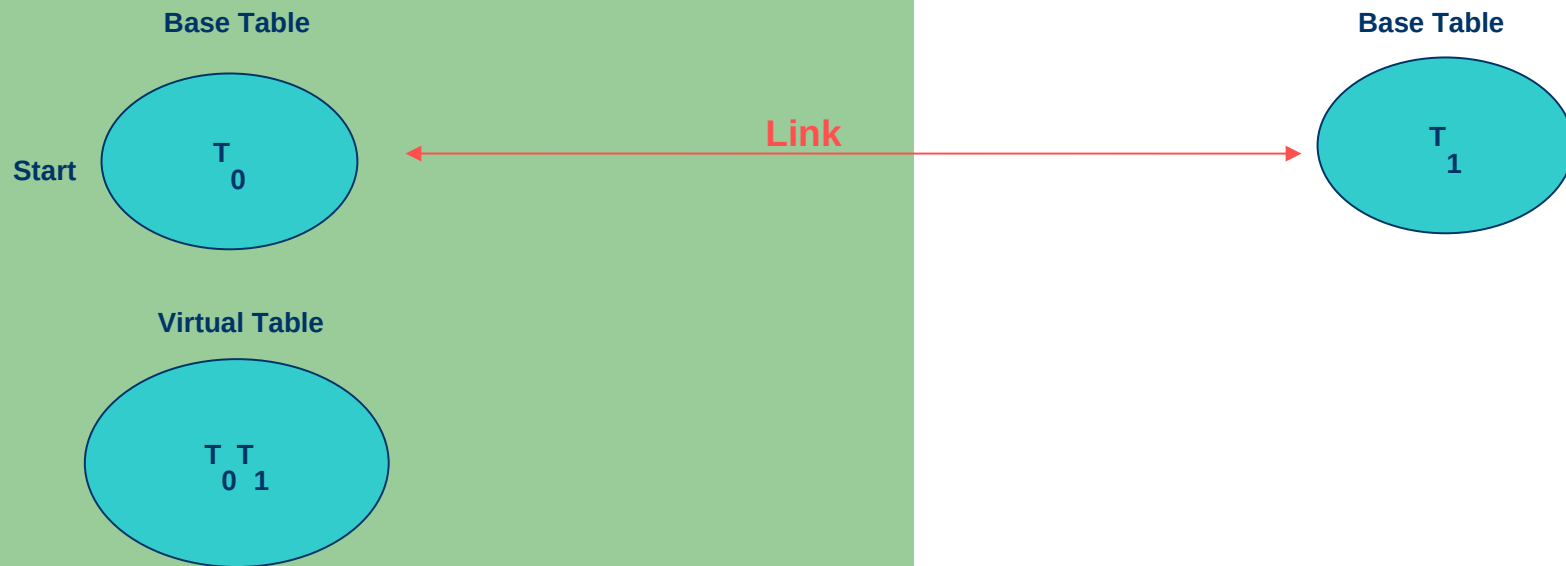
To do it, let see the correctness for 2 tables T_0 and T_1 in join together.

The join graph should be the following:

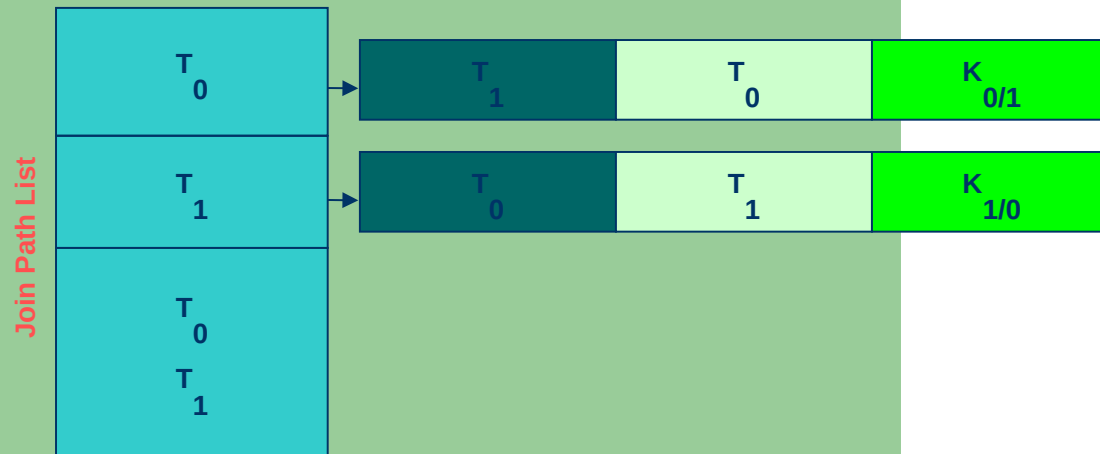


There are just 2 paths between the 2 tables: or from T_0 going toward T_1 or vice versa, let consider the former, the second case is symmetric and after all T_0 and T_1 are of arbitrarily choice.

By grouping comes out:



So, the JoinPathList should be the following:



If any key has been defined on the last virtual table and doesn't exist as a key on the base tables then should be propagated as inherited key in the appropriate base table; but for the prove of correctness in case of 2 tables, it is not important.

To prove the correctness of the algorithm, we have to prove that the last virtual table contain data references to all the rows that combined form the join between the 2 base tables and only those in other sense it is equivalent to the result of the join between the 2 tables.

Let prove that the last virtual table contain data references to all the rows that combined form the join between the 2 base tables:

Suppose by absurd that there is a row $R_{m/0}$ from table T_0 and a row $R_{n/1}$ from table T_1 that are in join together and they don't have references in the last virtual table.

If the 2 rows are in join together so their respective keys satisfy the join condition.

Suppose that $R_{m/0}$ comes first, so $\text{key}(R_{m/0})$ is inserted in the $\text{B+Tree}(T_0)$.

When $R_{n/1}$ get inserted later, the insert algorithm look in JoinPathList the adjacent table to T_1 , it finds that T_0 is such table and look in $\text{B+Tree}(T_0)$ all the keys that satisfy the join condition with the value of $\text{key}(R_{n/1})$. It will get $\text{key}(R_{m/0})$ because such key satisfy the join condition, it will combine the data references of the 2 Rows and insert in the virtual table such couple of references.

This is in contradiction on what we assume initially.

The case that $R_{n/1}$ comes first is symmetric.

Let prove that the only couples of data references in the last virtual table are those that combined make the join between the 2 base tables:

Suppose by absurd that there is a couple of references DP_0 and DP_1 that are data pointers to rows from table T_0 and table T_1 respectively in the virtual table and that the combined row doesn't belong to a join between the 2 base tables.

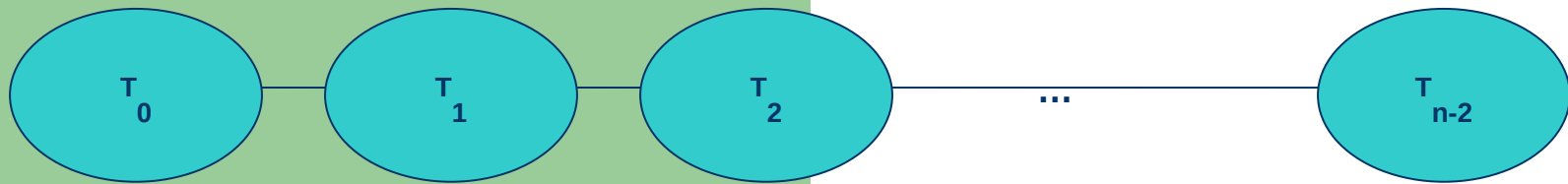
If such a couple of data pointers exist, it comes out because there is 2 keys belonging to the rows pointed by the data pointers and such keys satisfy the join condition, this is in contradiction on what we assume initially.

The initial case when there is only 2 tables in join is proved to be correct. Now let suppose that the correctness is true for $n-1$ tables and let prove it when the number of tables is n tables.

The easiest way to prove it for n tables is to expand the virtual table with $(n-1)$ base tables. This virtual table has a B+Tree that is constituted from set of elements in which every element has a common key value with the n th table and $(n-1)$ data pointers that points to the $(n-1)$ base tables. By expanding in the sense that from every element taking the $(n-1)$ rows from the $(n-1)$ tables and considering them as one row in a virtual table, we can look at the virtual table as a table populated with such rows.

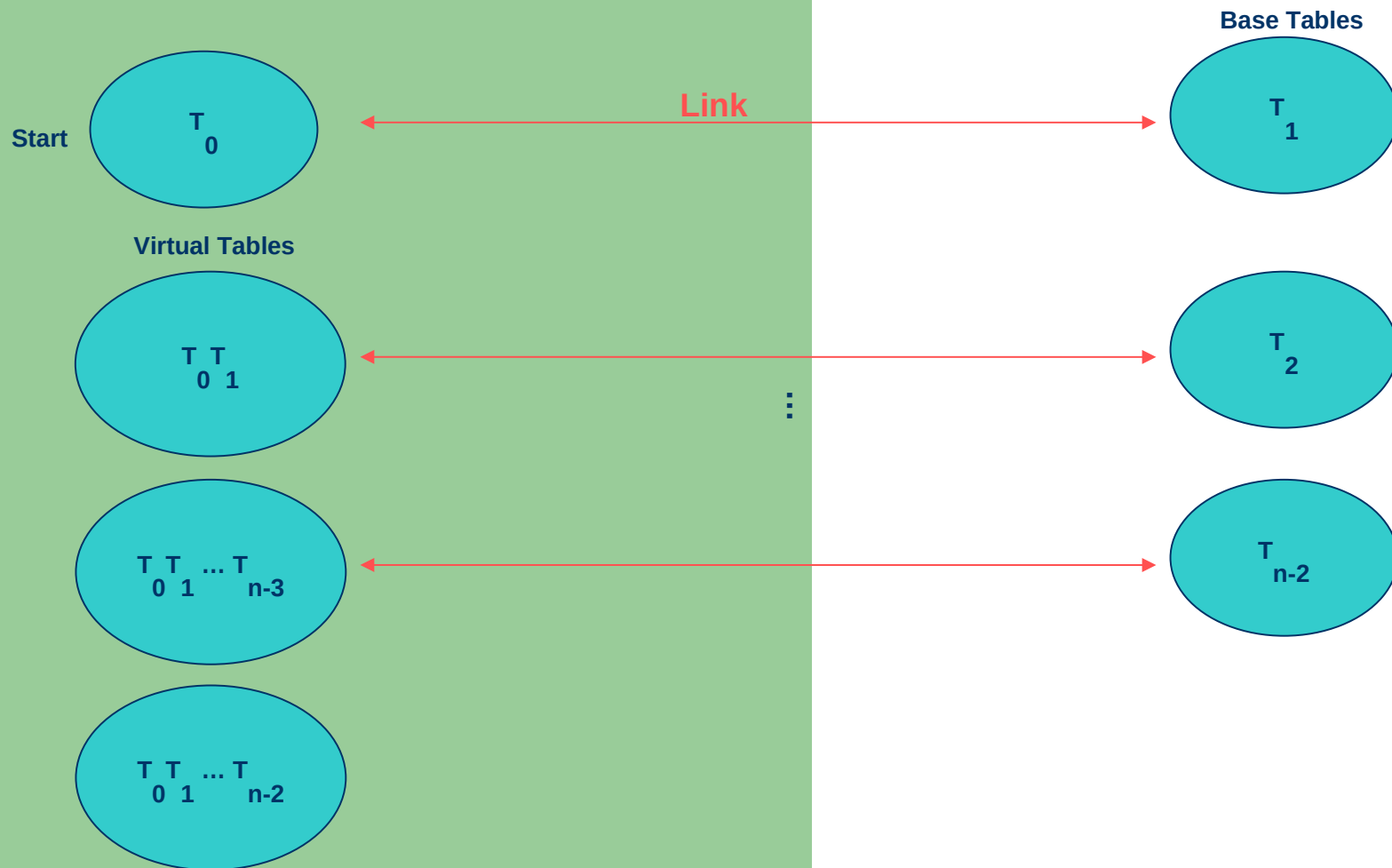
Let see first the Join Graph for the $(n-1)$ tables and how they went in group and later what happens when we consider the n th table.

The join graph for the (n-1) tables should be the following:

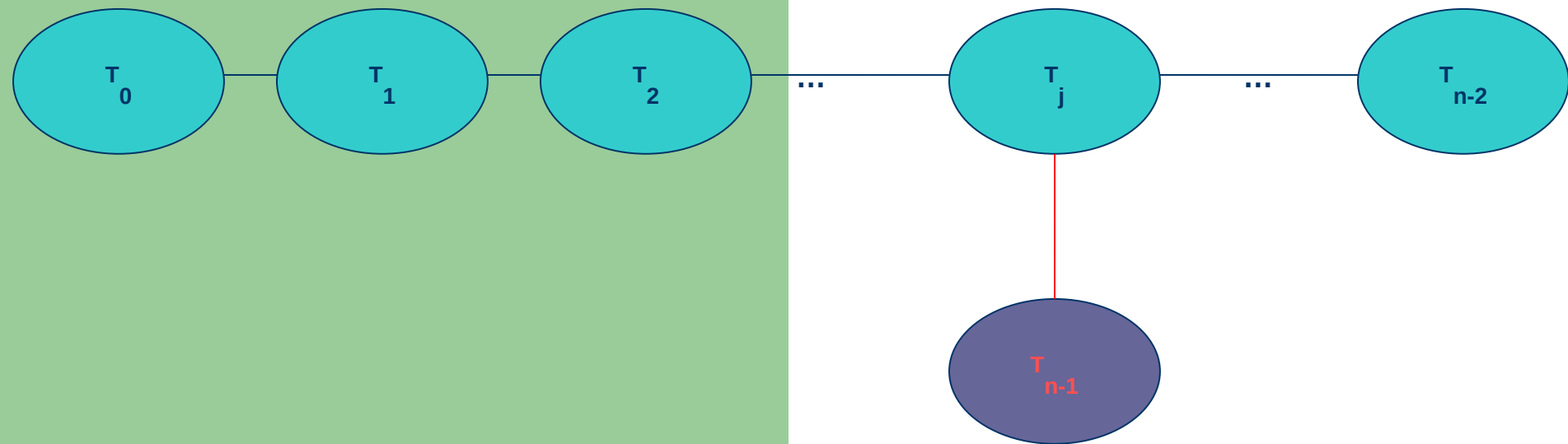


Suppose that the choice of $T_0 \dots T_{n-2}$ are in the way that the path start from T_0 , continue by $T_1 \dots T_{n-3}$ till the end to arrive at T_{n-2} .

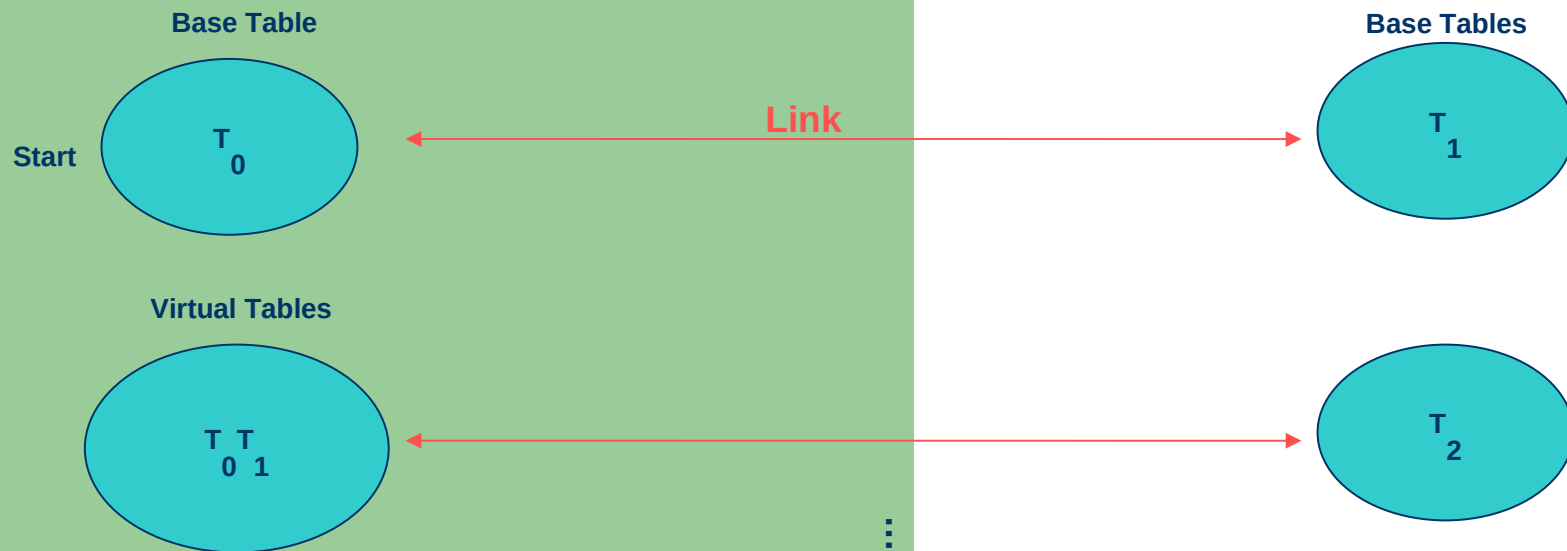
By grouping comes out:

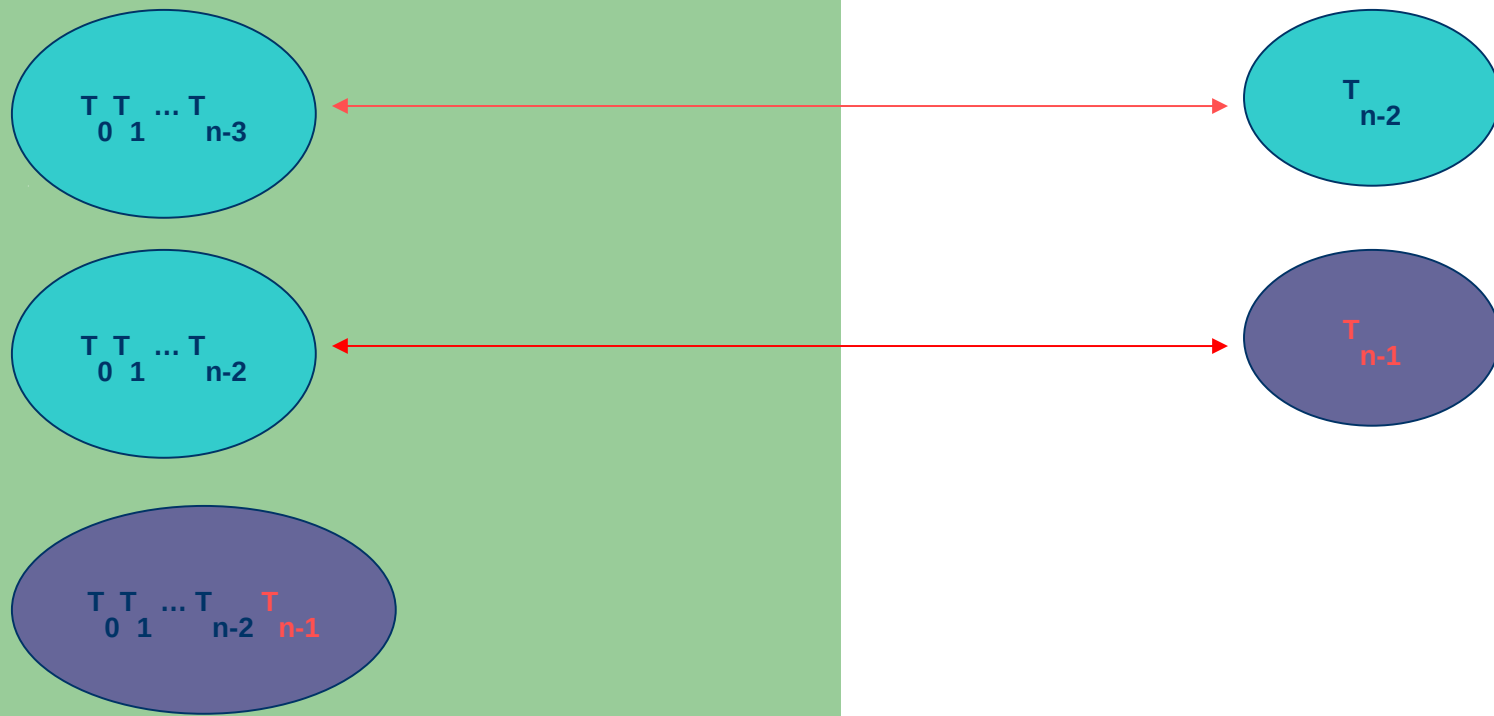


If there is one more table, the join graph would be the following:



The path should look like this:





So if we expand the virtual table $T_0 \dots T_{n-2}$ so the link would be just between it and the table T_{n-1} , where the common key should be from table T_j .

So we have the following situation:

Table $T_0 \dots T_{n-2}$ an expanded table from the virtual table $T_0 \dots T_{n-2}$ and by induction it is the same table obtained by the join of the $(n-1)$ base tables.

Table T_{n-1}

So if we name $T_0 \dots T_{n-2}$ as T_0 and T_{n-1} as T_1 , we return to the case already proved of 2 tables where the common key in $T_0 \dots T_{n-2}$ is calculated from the combined joined row in the place of the row pointed by DP_j .

The only thing remain to prove is the propagation of the key from $T_0 \dots T_{n-2}$ to T_j and the eventual keys from $T_0 \dots T_{n-1}$ to some base tables in the base tables $T_0 \dots T_{n-1}$ but this is guaranteed in the third phase of the algorithm `generateJoinPathList` because it goes backward and insert eventual inherited keys.

Self Join

If the table is in join with itself, consider the table twice, every one with the necessary index.

Let see an example of self join.

Suppose that we add a column named `SUPERVISOR_ID` in the table `EMPLOYEES`, it has the id of the supervisor for a given employee.

Suppose that we have the following query:

```
SELECT A.EMPLOYEE_NAME, B.EMPLOYEE_NAME  
FROM EMPLOYEES AS A, EMPLOYEES AS B  
WHERE A.EMPLOYEE_ID = B.SUPERVISOR_ID
```

The table `EMPLOYEES` with the new column `SUPERVISOR_ID` is shown in in the next slide.

Employees table

DP start from 0

| | EMPLOYEE_ID | NAME | EMAIL | PHONE_NUMBER | HIRE_DATE | JOB_ID | SALARY | SUPERVISOR_ID | DEPARTMENT_ID |
|---|-------------|------------------|-----------|--------------|------------|--------|--------|---------------|---------------|
| 0 | 101 | Mark Stench | mstench | 233-4268 | 12/02/1998 | FI_MGR | 60000 | 106 | FIN |
| 1 | 102 | Jorge Perez | jperez | 448-5268 | 05/14/1999 | AC_MGR | 60000 | 106 | ACC |
| 2 | 103 | Edward Cartier | ecartier | 742-8429 | 03/01/2003 | SA_MGR | 60000 | 106 | SAL |
| 3 | 104 | Teresa Gonzalez | tgonzalez | 134-8329 | 12/20/2002 | AC_AUD | 55000 | 102 | ACC |
| 4 | 105 | Michelle Blanche | mblanche | 745-7496 | 01/02/2001 | SA_REP | 35000 | 103 | SAL |
| 5 | 106 | Peter Spencer | pspencer | 111-2222 | 01/01/1996 | GE_MGR | 120000 | NULL | GEN |

→ generateJoinGraph (in BaseTables; out JoinGraph)

insert the base tables as vertexes of the graph

for every direct join between 2 tables of the form T_i and T_k where T_i is the table of order i and T_k is the table of order k as defined by the DBA do

AdjacentList[T_i] += T_k follow by the common key

AdjacentList[T_k] += T_i follow by the common key

Base Tables

| Employees/Employee_Id (A) | Employees/Supervisor_Id (B) |
|---------------------------|-----------------------------|
| 0 | 1 |

generateJoinGraph (in BaseTables; out JoinGraph)

→ insert the base tables as vertexes of the graph

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Base Tables

| Employees/Employee_Id (A) | Employees/Supervisor_Id (B) |
|---------------------------|-----------------------------|
| 0 | 1 |

| |
|-----------------------------|
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| Employees/Supervisor_Id (B) |

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Base Tables

| | |
|---------------------------|-----------------------------|
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| |
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| | |
|---------------------------|-----------------------------|
| Employees/Employee_Id (A) | Employees/Supervisor_Id (B) |
| 0 | 1 |



generateJoinGraph (in BaseTables; out JoinGraph)

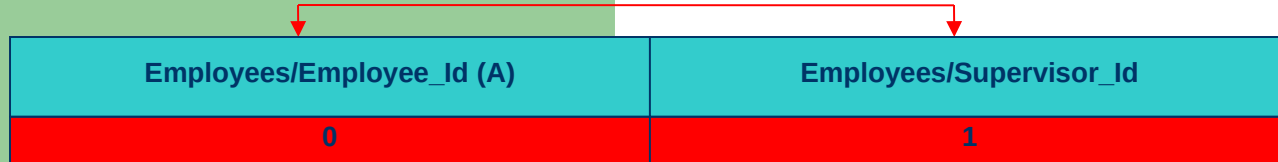
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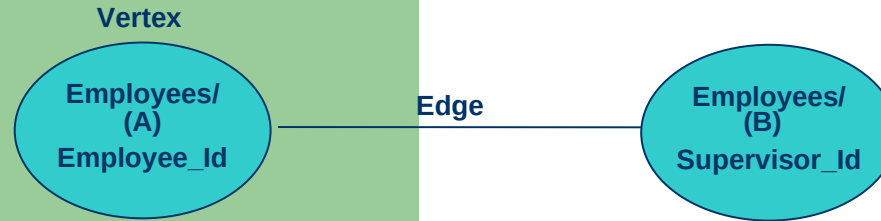
Base Tables



| Employees/Employee_Id (A) | Employees/Supervisor_Id |
|---------------------------|-------------------------|
| 0 | 1 |



Join Graph



Linked List representation of the Join Graph

Adjacent List



Node

Tables

Adjacent

Tables

Common keys between
Node & Adjacent Tables
belongs to Node Tables

→ generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

```
let T0 ... Tm be the base tables
create 2 dynamic arrays queue and path

insert T0 into path

insert T0 into queue

repeat
    TElement = First Table in queue
    for every Link Item in Adjacent Link of TElement from the Join Graph do
        if the Link Item is in the join sequence then
            if path doesn't contain the Link Item then
                insert Link Item into path
                insert Link Item into queue
    remove TElement from queue
until queue is empty
```

Join Base Tables

| | |
|---------------------------|-----------------------------|
| Employees/Employee_Id (A) | Employees/Supervisor_Id (B) |
|---------------------------|-----------------------------|

Join Graph



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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                insert Link Item into path
                insert Link Item into queue

remove TElement from queue
until queue is empty
```

Join Base Tables

| | |
|---------------------------|-----------------------------|
| Employees/Employee_Id (A) | Employees/Supervisor_Id (B) |
| T ₀ | T ₁ |

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables

→ create 2 dynamic arrays queue and path

insert T_0 into path

insert T_0 into queue

repeat

T_{Element} = First Table in queue

 for every Link Item in Adjacent Link of T_{Element} from the Join Graph do

 if the Link Item is in the join sequence then

 if path doesn't contain the Link Item then

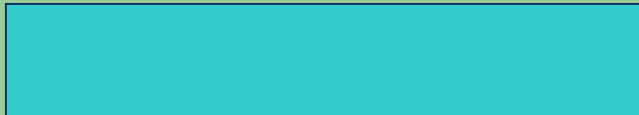
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 insert Link Item into queue

 remove T_{Element} from queue

until queue is empty

queue



path



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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→ insert T_0 into path

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if path doesn't contain the Link Item then

insert Link Item into path

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remove T_{Element} from queue

until queue is empty

Join Base Tables

| | |
|---------------------------|-----------------------------|
| Employees/Employee_Id (A) | Employees/Supervisor_Id (B) |
|---------------------------|-----------------------------|

T_0

T_1

queue

| |
|--|
| |
|--|

path

| |
|---------------------------|
| Employees/Employee_Id (A) |
|---------------------------|

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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→ insert T_0 into queue

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remove T_{Element} from queue

until queue is empty

Join Base Tables



T_0

T_1

queue



path



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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until queue is empty

queue

Employees/Employee_Id (A)

path

Employees/Employee_Id (A)

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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queue



Employees/Employee_Id (A)

path

Employees/Employee_Id (A)

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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queue



Employees/Employee_Id (A)

path

Employees/Employee_Id (B)

Join Graph

Employees/Employee_Id (A)

Employees/Supervisor_Id (B)

Employee_Id

Employees/Supervisor_Id (B)

Employees/Employee_Id (A)

Supervisor_Id



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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until queue is empty

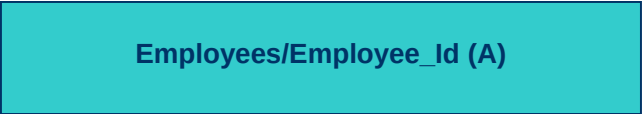
Join Base Tables



queue



path



Join Graph



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables

create 2 dynamic arrays queue and path

insert T_0 into path

insert T_0 into queue

repeat

$T_{Element}$ = First Table in queue

for every Link Item in Adjacent Link of $T_{Element}$ from the Join Graph do

if the Link Item is in the join sequence then

if path doesn't contain the Link Item then

insert Link Item into path

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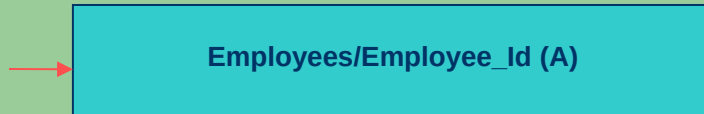
remove $T_{Element}$ from queue

until queue is empty

Join Base Tables



queue



path



Join Graph



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

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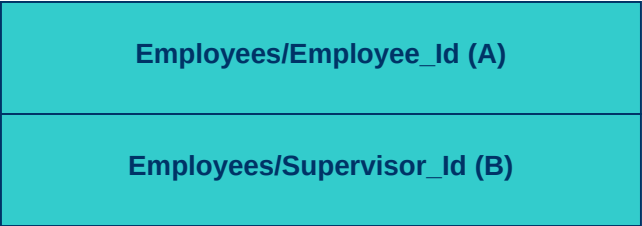
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until queue is empty
```

queue



path



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let T₀...T_m be the base tables
create 2 dynamic arrays queue and path

insert T₀ into path

insert T₀ into queue

repeat

 T_{Element} = First Table in queue

 for every Link Item in Adjacent Link of T_{Element} from the Join Graph do

 if the Link Item is in the join sequence then

 if path doesn't contain the Link Item then

 insert Link Item into path

 insert Link Item into queue

 remove T_{Element} from queue

until queue is empty

queue



| |
|-----------------------------|
| Employees/Employee_Id (A) |
| Employees/Supervisor_Id (B) |

path

| |
|-----------------------------|
| Employees/Employee_Id (A) |
| Employees/Supervisor_Id (B) |

generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

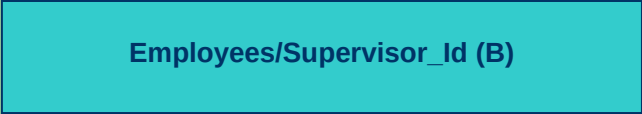
```
let T0 ... Tm be the base tables
create 2 dynamic arrays queue and path

insert T0 into path

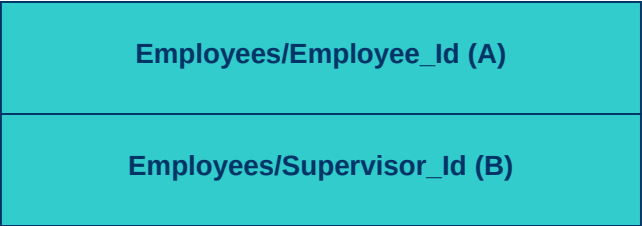
insert T0 into queue

repeat
    TElement = First Table in queue
    for every Link Item in Adjacent Link of TElement from the Join Graph do
        if the Link Item is in the join sequence then
            if path doesn't contain the Link Item then
                insert Link Item into path
                insert Link Item into queue
    remove TElement from queue
until queue is empty
```

queue



path



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables
create 2 dynamic arrays queue and path

insert T_0 into path

insert T_0 into queue

repeat

→ T_{Element} = First Table in queue

for every Link Item in Adjacent Link of T_{Element} from the Join Graph do

if the Link Item is in the join sequence then

if path doesn't contain the Link Item then

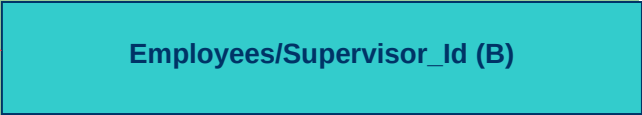
insert Link Item into path

insert Link Item into queue

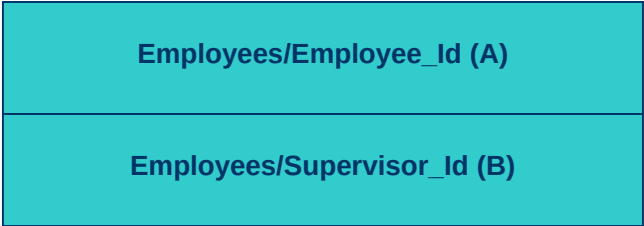
remove T_{Element} from queue

until queue is empty

queue



path



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables
create 2 dynamic arrays queue and path

insert T_0 into path

insert T_0 into queue

repeat

$T_{Element}$ = First Table in queue

for every Link Item in Adjacent Link of $T_{Element}$ from the Join Graph do

if the Link Item is in the join sequence then

if path doesn't contain the Link Item then

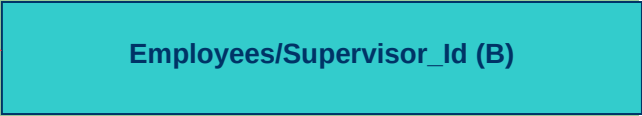
insert Link Item into path

insert Link Item into queue

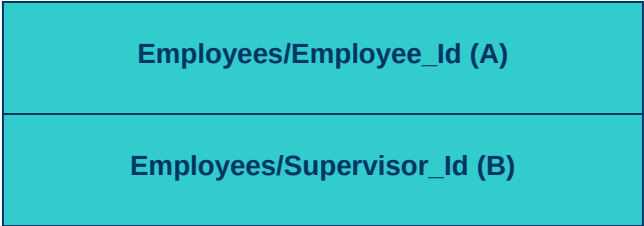
remove $T_{Element}$ from queue

until queue is empty

queue



path



Join Graph



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables
create 2 dynamic arrays queue and path

insert T_0 into path

insert T_0 into queue

repeat

$T_{Element}$ = First Table in queue

for every Link Item in Adjacent Link of $T_{Element}$ from the Join Graph do

if the Link Item is in the join sequence then

if path doesn't contain the Link Item then

insert Link Item into path

insert Link Item into queue

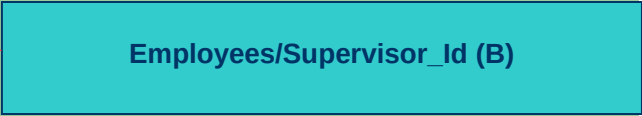
remove $T_{Element}$ from queue

until queue is empty

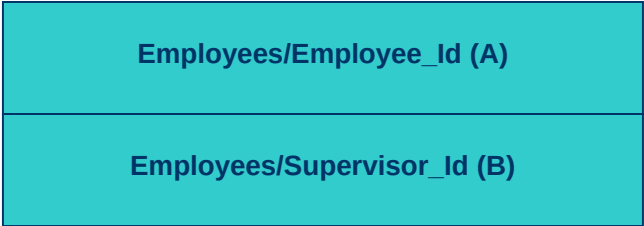
Join Base Tables



queue



path



Join Graph



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

let $T_0 \dots T_m$ be the base tables

create 2 dynamic arrays queue and path

insert T_0 into path

insert T_0 into queue

repeat

$T_{Element}$ = First Table in queue

for every Link Item in Adjacent Link of $T_{Element}$ from the Join Graph do

if the Link Item is in the join sequence then

if path doesn't contain the Link Item then

insert Link Item into path

insert Link Item into queue

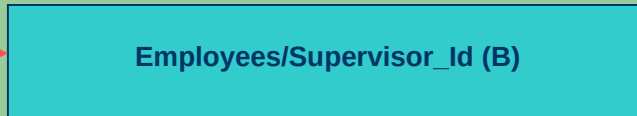
remove $T_{Element}$ from queue

until queue is empty

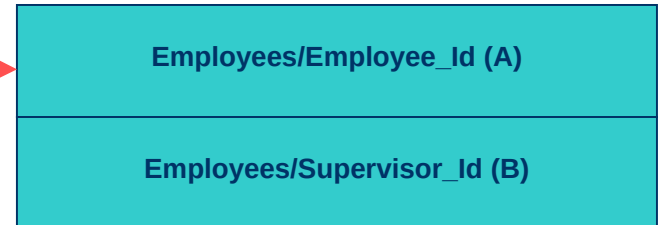
Join Base Tables



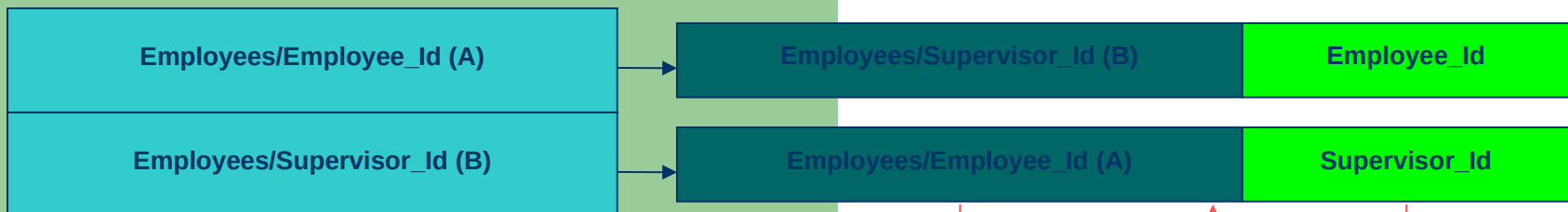
queue



path



Join Graph



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

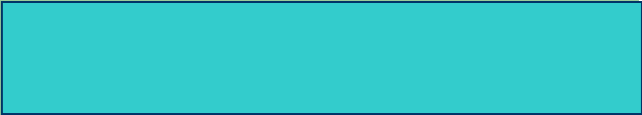
```
let T0 ... Tm be the base tables
create 2 dynamic arrays queue and path

insert T0 into path

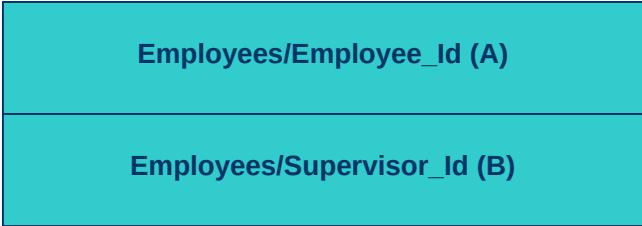
insert T0 into queue

repeat
    TElement = First Table in queue
    for every Link Item in Adjacent Link of TElement from the Join Graph do
        if the Link Item is in the join sequence then
            if path doesn't contain the Link Item then
                insert Link Item into path
                insert Link Item into queue
    remove TElement from queue
until queue is empty
```

queue



path



generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)

```
let T0 ... Tm be the base tables
create 2 dynamic arrays queue and path

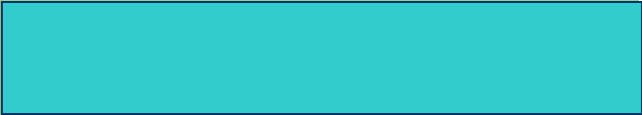
insert T0 into path

insert T0 into queue

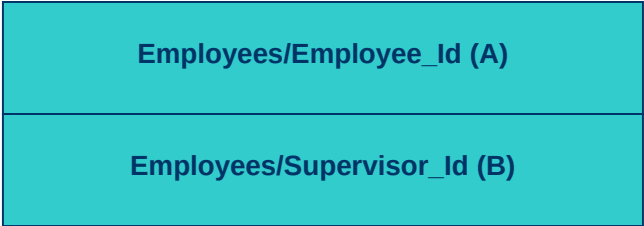
repeat
    TElement = First Table in queue
    for every Link Item in Adjacent Link of TElement from the Join Graph do
        if the Link Item is in the join sequence then
            if path doesn't contain the Link Item then
                insert Link Item into path
                insert Link Item into queue

remove TElement from queue
until queue is empty
```

queue



path



→ insert all the names of base tables from path as vertexes in JoinPathList

create a local buffer buf

insert into buf the first entry from path

for all the remainder entries in path do

take one T_i at a time

$\text{JoinPathAdjacentList}(T_i) = T_{[buf]}$

$\text{Key}(T_i) = \text{getFirstAdjacentListKey}(T_i, T_{[buf]})$

$\text{JoinPathAdjacentList}(T_{[buf]}) = T_i$

$\text{Key}(T_{[buf]}) = \text{getFirstAdjacentListKey}(T_{[buf]}, T_i)$

$T_{[buf]} + = T_i$

$\text{Insert NodesList}[T_{[buf]}] = T_{[buf]}$

Nodes

Employees/Employee_Id (A)

Employees/Supervisor_Id (B)

path

Employees/Employee_Id (A)

Employees/Supervisor_Id (B)

insert all the names of base tables from path as vertexes in JoinPathList



create a local buffer buf

insert into buf the first entry from path

for all the remainder entries in path do

take one T_i at a time

$\text{JoinPathAdjacentList}(T_i) = T_{[buf]}$

$\text{Key}(T_i) = \text{getFirstAdjacentListKey}(T_i, T_{[buf]})$

$\text{JoinPathAdjacentList}(T_{[buf]}) = T_i$

$\text{Key}(T_{[buf]}) = \text{getFirstAdjacentListKey}(T_{[buf]}, T_i)$

$T_{[buf]} + = T_i$

$\text{Insert NodesList}[T_{[buf]}] = T_{[buf]}$

Nodes

Employees/Employee_Id (A)

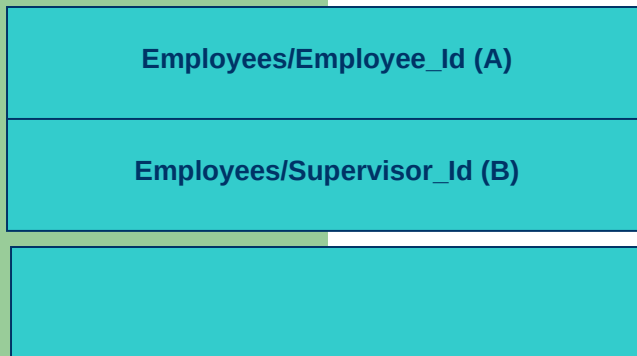
Employees/Supervisor_Id (B)

path

Employees/Employee_Id (A)

Employees/Supervisor_Id (B)

buf



insert all the names of base tables from path as vertexes in JoinPathList

create a local buffer buf

→ insert into buf the first entry from path

for all the remainder entries in path do

take one T_i at a time

$\text{JoinPathAdjacentList}(T_i) = T_{[buf]}$

$\text{Key}(T_i) = \text{getFirstAdjacentListKey}(T_i, T_{[buf]})$

$\text{JoinPathAdjacentList}(T_{[buf]}) = T_i$

$\text{Key}(T_{[buf]}) = \text{getFirstAdjacentListKey}(T_{[buf]}, T_i)$

$T_{[buf]} + = T_i$

$\text{Insert NodesList}[T_{[buf]}] = T_{[buf]}$

Nodes

Employees/Employee_Id (A)

Employees/Supervisor_Id (B)

path

Employees/Employee_Id (A)

Employees/Supervisor_Id (B)

buf

Employees/Employee_Id (A)

insert all the names of base tables from path as vertexes in JoinPathList

create a local buffer buf

insert into buf the first entry from path

→ for all the remainder entries in path do

take one T_i at a time

$\text{JoinPathAdjacentList}(T_i) = T_{[buf]}$

$\text{Key}(T_i) = \text{getFirstAdjacentListKey}(T_i, T_{[buf]})$

$\text{JoinPathAdjacentList}(T_{[buf]}) = T_i$

$\text{Key}(T_{[buf]}) = \text{getFirstAdjacentListKey}(T_{[buf]}, T_i)$

$T_{[buf]} + = T_i$

$\text{Insert NodesList}[T_{[buf]}] = T_{[buf]}$

Nodes

Employees/Employee_Id (A)

Employees/Supervisor_Id (B)

path

Employees/Employee_Id (A)

Employees/Supervisor_Id (B)

buf

Employees/Employee_Id (A)

insert all the names of base tables from path as vertexes in JoinPathList

create a local buffer buf

insert into buf the first entry from path

for all the remainder entries in path do

→ take one T_i at a time

$\text{JoinPathAdjacentList}(T_i) = T_{[buf]}$

$\text{Key}(T_i) = \text{getFirstAdjacentListKey}(T_i, T_{[buf]})$

$\text{JoinPathAdjacentList}(T_{[buf]}) = T_i$

$\text{Key}(T_{[buf]}) = \text{getFirstAdjacentListKey}(T_{[buf]}, T_i)$

$T_{[buf]} + = T_i$

$\text{Insert NodesList}[T_{[buf]}] = T_{[buf]}$

Nodes

Employees/Employee_Id (A)

Employees/Supervisor_Id (B)

Employees/Employee_Id (A)

Employees/Supervisor_Id (B)

Employees/Employee_Id (A)

path

T_i

buf

insert all the names of base tables from path as vertexes in JoinPathList

create a local buffer buf

insert into buf the first entry from path

for all the remainder entries in path do

take one T_i at a time



$\text{JoinPathAdjacentList}(T_i) = T_{[buf]}$

$\text{Key}(T_i) = \text{getFirstAdjacentListKey}(T_i, T_{[buf]})$

$\text{JoinPathAdjacentList}(T_{[buf]}) = T_i$

$\text{Key}(T_{[buf]}) = \text{getFirstAdjacentListKey}(T_{[buf]}, T_i)$

$T_{[buf]} + T_i$

$\text{Insert NodesList}[T_{[buf]}] = T_{[buf]}$

Nodes

Employees/Employee_Id (A)

Employees/Supervisor_Id (B)

Employees/Employee_Id (A)

Employees/Employee_Id (A)

Employees/Supervisor_Id (B)

Employees/Employee_Id (A)

path

T_i

buf

insert all the names of base tables from path as vertexes in JoinPathList

create a local buffer buf

insert into buf the first entry from path

for all the remainder entries in path do

take one T_i at a time

$\text{JoinPathAdjacentList}(T_i) = T_{[buf]}$

→ $\text{Key}(T_i) = \text{getFirstAdjacentListKey}(T_i, T_{[buf]})$

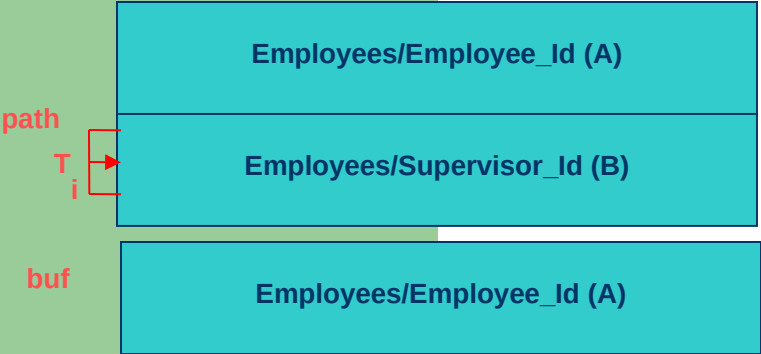
$\text{JoinPathAdjacentList}(T_{[buf]}) = T_i$

$\text{Key}(T_{[buf]}) = \text{getFirstAdjacentListKey}(T_{[buf]}, T_i)$

$T_{[buf]} += T_i$

$\text{Insert NodesList}[T_{[buf]}] = T_{[buf]}$

Nodes



insert all the names of base tables from path as vertexes in JoinPathList

create a local buffer buf

insert into buf the first entry from path

for all the remainder entries in path do

take one T_i at a time

$\text{JoinPathAdjacentList}(T_i) = T_{[buf]}$

$\text{Key}(T_i) = \text{getFirstAdjacentListKey}(T_i, T_{[buf]})$

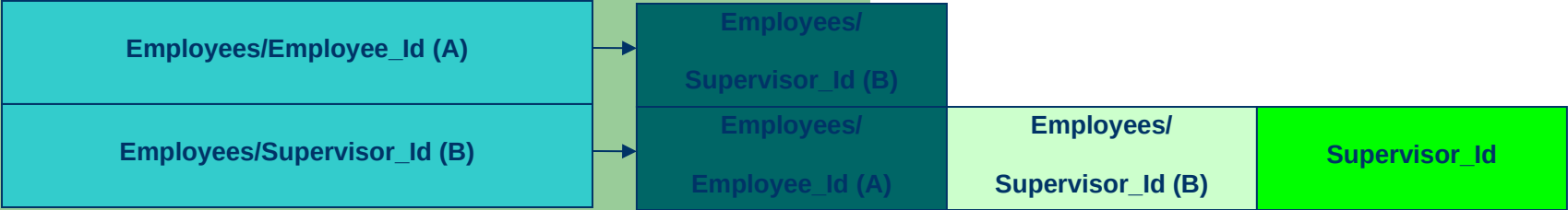
→ $\text{JoinPathAdjacentList}(T_{[buf]}) = T_i$

$\text{Key}(T_{[buf]}) = \text{getFirstAdjacentListKey}(T_{[buf]}, T_i)$

$T_{[buf]} += T_i$

$\text{Insert NodesList}[T_{[buf]}] = T_{[buf]}$

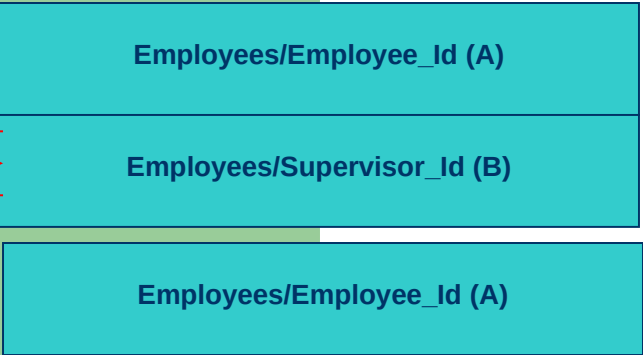
Nodes



path

T_i

buf



insert all the names of base tables from path as vertexes in JoinPathList

create a local buffer buf

insert into buf the first entry from path

for all the remainder entries in path do

take one T_i at a time

$\text{JoinPathAdjacentList}(T_i) = T_{[buf]}$

$\text{Key}(T_i) = \text{getFirstAdjacentListKey}(T_i, T_{[buf]})$

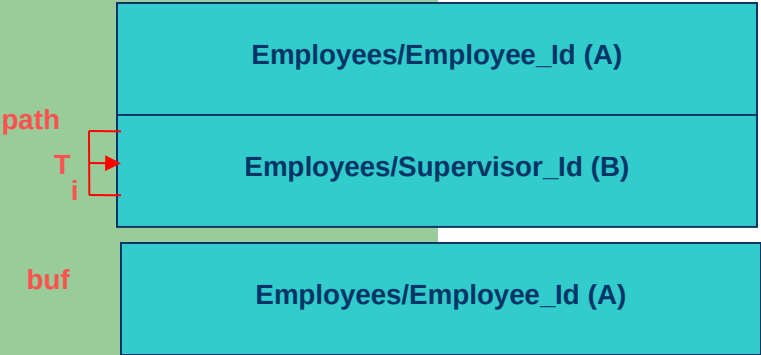
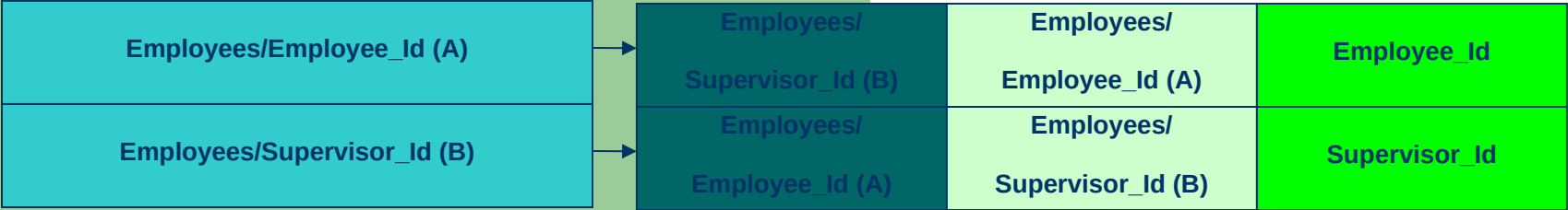
$\text{JoinPathAdjacentList}(T_{[buf]}) = T_i$

→ $\text{Key}(T_{[buf]}) = \text{getFirstAdjacentListKey}(T_{[buf]}, T_i)$

$T_{[buf]} += T_i$

$\text{Insert NodesList}[T_{[buf]}] = T_{[buf]}$

Nodes



insert all the names of base tables from path as vertexes in JoinPathList

create a local buffer buf

insert into buf the first entry from path

for all the remainder entries in path do

take one T_i at a time

$\text{JoinPathAdjacentList}(T_i) = T_{[buf]}$

$\text{Key}(T_i) = \text{getFirstAdjacentListKey}(T_i, T_{[buf]})$

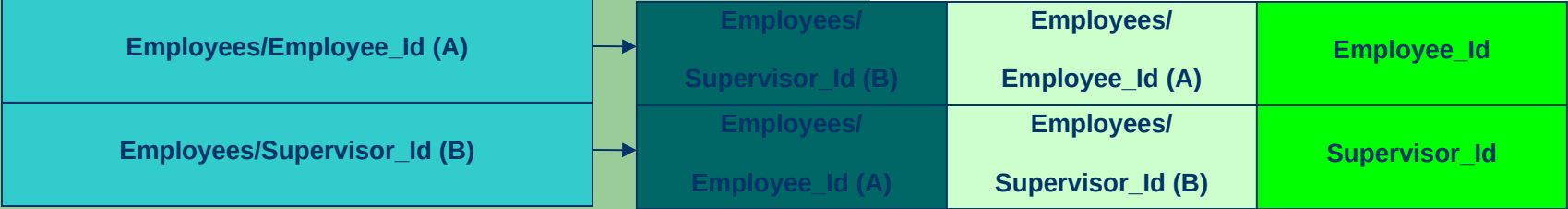
$\text{JoinPathAdjacentList}(T_{[buf]}) = T_i$

$\text{Key}(T_{[buf]}) = \text{getFirstAdjacentListKey}(T_{[buf]}, T_i)$

→ $T_{[buf]} += T_i$

$\text{Insert NodesList}[T_{[buf]}] = T_{[buf]}$

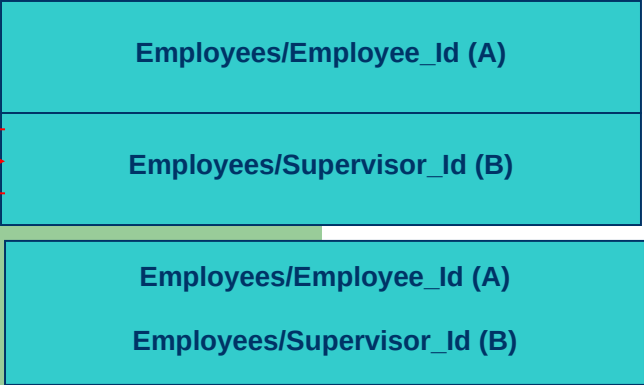
Nodes



path

T_i

buf



insert all the names of base tables from path as vertexes in JoinPathList

create a local buffer buf

insert into buf the first entry from path

for all the remainder entries in path do

take one T_i at a time

$\text{JoinPathAdjacentList}(T_i) = T_{[buf]}$

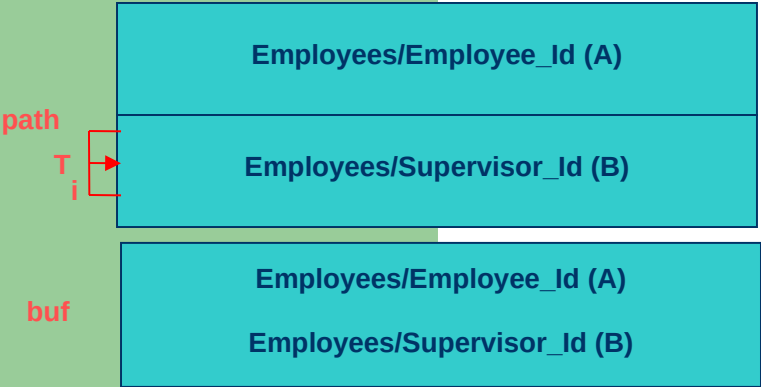
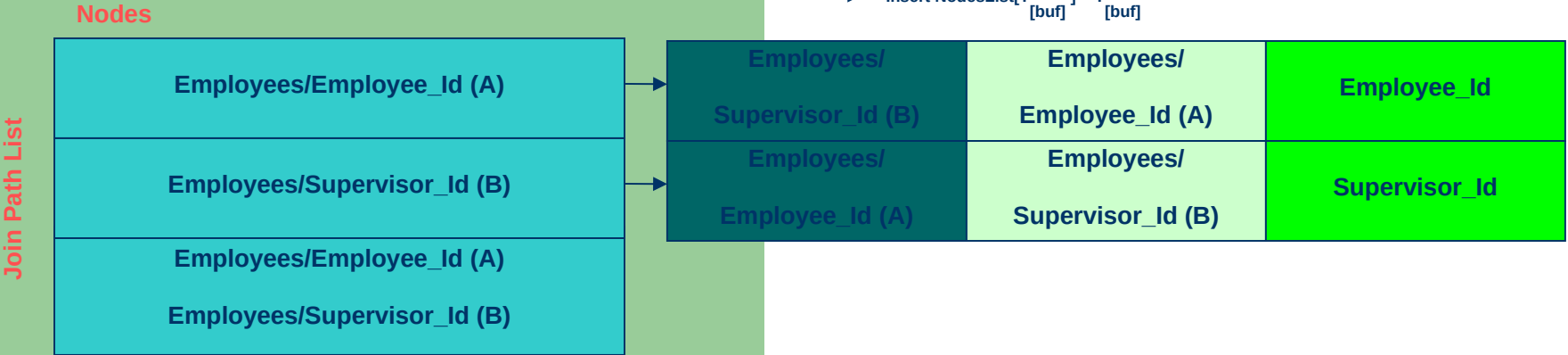
$\text{Key}(T_i) = \text{getFirstAdjacentListKey}(T_i, T_{[buf]})$

$\text{JoinPathAdjacentList}(T_{[buf]}) = T_i$

$\text{Key}(T_{[buf]}) = \text{getFirstAdjacentListKey}(T_{[buf]}, T_i)$

$T_{[buf]} += T_i$

→ $\text{Insert NodesList}[T_{[buf]}] = T_{[buf]}$





create a structure buf with 2 fields: Table and Key

for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for all the couples of $\langle \text{Table}, \text{key} \rangle$ in buf do

take one couple buf_c at a time

if (buf_c.Table = T_k) then

if (buf_c != Key($T_{[i]}$)) and (buf_c not in InheritedKey($T_{[i]}$)) then

InheritedKey($T_{[i]}$) += buf_c

if $T_{[i]}$ is not a base table then

if T_l is the table from which comes Key($T_{[i]}$) and k_l is the respective key then

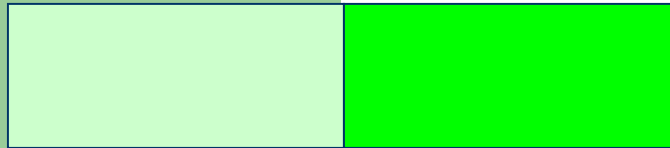
buf.Table += T_l

buf.key += K_{k_l}

Table

buf

Key



create a structure buf with 2 fields: Table and Key

→ for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for all the couples of $\langle \text{Table}, \text{key} \rangle$ in buf do

take one couple buf_c at a time

if $(\text{buf}_c.\text{Table} = T_k)$ then

if $(\text{buf}_c.\text{Key} \neq \text{Key}(T_{[i]}))$ and $(\text{buf}_c \text{ not in InheritedKey}(T_{[i]}))$ then

$\text{InheritedKey}(T_{[i]}) += \text{buf}_c$

if $T_{[i]}$ is not a base table then

if $T_{[i]}$ is the table from which comes $\text{Key}(T_{[i]})$ and k_i is the respective key then

$\text{buf}.\text{Table} += T_{[i]}$

$\text{buf}.\text{key} += K_{[i]}$

Table

Key

| | |
|--|--|
| | |
|--|--|

Join Path List

| |
|--|
| Employees/ Employee_Id (A) |
| Employees/ Supervisor_Id (B) |
| Employees/ Employee_Id (A) Employees/ Supervisor_Id (B) |

| | | |
|-----------------------------------|---------------------------------|---------------|
| Employees/ Supervisor_Id (B) | Employees/ Employee_Id (A) | Employee_Id |
| Employees/ Employee_Id (A) (A) | Employees/ Supervisor_Id (B) | Supervisor_Id |

create a structure buf with 2 fields: Table and Key

for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for all the couples of $\langle \text{Table}, \text{key} \rangle$ in buf do

take one couple buf_c at a time

if $(\text{buf}_c.\text{Table} = T_k)$ then

if $(\text{buf}_c.\text{Key} \neq \text{Key}(T_{[i]}))$ and $(\text{buf}_c$ not in $\text{InheritedKey}(T_{[i]})$) then

$\text{InheritedKey}(T_{[i]}) += \text{buf}_c$

if $T_{[i]}$ is not a base table then

if T_l is the table from which comes $\text{Key}(T_{[i]})$ and k_l is the respective key then

$\text{buf}.\text{Table} += T_l$

$\text{buf}.\text{key} += K_{k_l}$

Table

Key

| | |
|--|--|
| | |
|--|--|

Join Path List

$T_{[i]}$

| |
|--|
| Employees/ Employee_Id (A) |
| Employees/ Supervisor_Id (B) |
| Employees/ Employee_Id (A) Employees/ Supervisor_Id (B) |

| | | |
|---------------------------------|---------------------------------|---------------|
| Employees/ Supervisor_Id (B) | Employees/ Employee_Id (A) | Employee_Id |
| Employees/ Employee_Id (A) | Employees/ Supervisor_Id (B) | Supervisor_Id |

create a structure buf with 2 fields: Table and Key

for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for all the couples of $\langle \text{Table}, \text{key} \rangle$ in buf do

take one couple buf_c at a time

if $(\text{buf}_c.\text{Table} = T_k)$ then

if $(\text{buf}_c.\text{Key} \neq \text{Key}(T_{[i]}))$ and $(\text{buf}_c$ not in $\text{InheritedKey}(T_{[i]})$) then

$\text{InheritedKey}(T_{[i]}) += \text{buf}_c$

if $T_{[i]}$ is not a base table then

if T_l is the table from which comes $\text{Key}(T_{[i]})$ and k_l is the respective key then

$\text{buf}.\text{Table} += T_l$

$\text{buf}.\text{key} += K_{l_i}$

Table

Key

| | |
|--|--|
| | |
|--|--|

Join Path List

$T_{[i]}$

| |
|--|
| Employees/ Employee_Id (A) |
| Employees/ Supervisor_Id (B) |
| Employees/ Employee_Id (A) Employees/ Supervisor_Id (B) |

| | | |
|---------------------------------|---------------------------------|---------------|
| Employees/ Supervisor_Id (B) | Employees/ Employee_Id (A) | Employee_Id |
| Employees/ Employee_Id (A) | Employees/ Supervisor_Id (B) | Supervisor_Id |

create a structure buf with 2 fields: Table and Key

for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for all the couples of $\langle \text{Table}, \text{key} \rangle$ in buf do

take one couple buf_c at a time

if ($\text{buf}_c.\text{Table} = T_k$) then

if ($\text{buf}_c \neq \text{Key}(T_{[i]})$) and (buf_c not in $\text{InheritedKey}(T_{[i]})$) then

$\text{InheritedKey}(T_{[i]}) += \text{buf}_c$

if $T_{[i]}$ is not a base table then

if T_l is the table from which comes $\text{Key}(T_{[i]})$ and k_l is the respective key then

$\text{buf}.\text{Table} += T_l$

$\text{buf}.\text{key} += K_{k_l}$

Table

Key

| | |
|--|--|
| | |
|--|--|

Join Path List

$T_{[i]}$

| |
|--|
| Employees/ Employee_Id (A) |
| Employees/ Supervisor_Id (B) |
| Employees/ Employee_Id (A) Employees/ Supervisor_Id (B) |

| | | |
|---------------------------------|---------------------------------|---------------|
| Employees/ Supervisor_Id (B) | Employees/ Employee_Id (A) | Employee_Id |
| Employees/ Employee_Id (A) | Employees/ Supervisor_Id (B) | Supervisor_Id |

T_k

create a structure buf with 2 fields: Table and Key

for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for all the couples of $\langle \text{Table}, \text{key} \rangle$ in buf do

take one couple buf_c at a time

if $(\text{buf}_c.\text{Table} = T_k)$ then

if $(\text{buf}_c.\text{key} \neq \text{Key}(T_{[i]}))$ and $(\text{buf}_c \text{ not in InheritedKey}(T_{[i]}))$ then

$\text{InheritedKey}(T_{[i]}) += \text{buf}_c$

if $T_{[i]}$ is not a base table then

if $T_{[i]}$ is the table from which comes $\text{Key}(T_{[i]})$ and k_i is the respective key then

$\text{buf}.\text{Table} += T_{[i]}$

$\text{buf}.\text{key} += K_{k_i}$

Table

Key

N/A

| | |
|--|--|
| | |
|--|--|

Join Path List

$T_{[i]}$

| |
|--|
| Employees/ Employee_Id (A) |
| Employees/ Supervisor_Id (B) |
| Employees/ Employee_Id (A) Employees/ Supervisor_Id (B) |

| | | |
|---------------------------------|---------------------------------|---------------|
| Employees/ Supervisor_Id (B) | Employees/ Employee_Id (A) | Employee_Id |
| Employees/ Employee_Id (A) | Employees/ Supervisor_Id (B) | Supervisor_Id |

T_k

create a structure buf with 2 fields: Table and Key

for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for all the couples of $\langle \text{Table}, \text{key} \rangle$ in buf do

take one couple buf_c at a time

if (buf_c.Table = T_k) then

if (buf_c.Key != Key($T_{[i]}$)) and (buf_c not in InheritedKey($T_{[i]}$)) then

InheritedKey($T_{[i]}$) += buf_c

if $T_{[i]}$ is not a base table then

if T_l is the table from which comes Key($T_{[i]}$) and k_l is the respective key then

buf.Table += T_l

buf.key += K_{k_l}

Table

Key

| | |
|--|--|
| | |
|--|--|

Join Path List

$T_{[i]}$

| |
|--|
| Employees/ Employee_Id (A) |
| Employees/ Supervisor_Id (B) |
| Employees/ Employee_Id (A) Employees/ Supervisor_Id (B) |

| | | |
|---------------------------------|---------------------------------|---------------|
| Employees/ Supervisor_Id (B) | Employees/ Employee_Id (A) | Employee_Id |
| Employees/ Employee_Id (A) | Employees/ Supervisor_Id (B) | Supervisor_Id |

T_k

create a structure buf with 2 fields: Table and Key

for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for all the couples of $\langle \text{Table}, \text{key} \rangle$ in buf do

take one couple buf_c at a time

if $(\text{buf}_c.\text{Table} = T_k)$ then

if $(\text{buf}_c.\text{key} \neq \text{Key}(T_{[i]}))$ and $(\text{buf}_c$ not in $\text{InheritedKey}(T_{[i]})$) then

$\text{InheritedKey}(T_{[i]}) += \text{buf}_c$

if $T_{[i]}$ is not a base table then

if T_l is the table from which comes $\text{Key}(T_{[i]})$ and k_l is the respective key then

$\text{buf}.\text{Table} += T_l$

$\text{buf}.\text{key} += K_{k_l}$

Table

Key

N/A

| | |
|--|--|
| | |
|--|--|

Join Path List

$T_{[i]}$

| |
|--|
| Employees/ Employee_Id (A) |
| Employees/ Supervisor_Id (B) |
| Employees/ Employee_Id (A) Employees/ Supervisor_Id (B) |

T_k

| | | |
|---------------------------------|---------------------------------|---------------|
| Employees/ Supervisor_Id (B) | Employees/ Employee_Id (A) | Employee_Id |
| Employees/ Employee_Id (A) | Employees/ Supervisor_Id (B) | Supervisor_Id |

create a structure buf with 2 fields: Table and Key

for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for all the couples of $\langle \text{Table}, \text{key} \rangle$ in buf do

take one couple buf_c at a time

if $(\text{buf}_c.\text{Table} = T_k)$ then

if $(\text{buf}_c.\text{key} \neq \text{Key}(T_{[i]}))$ and $(\text{buf}_c$ not in $\text{InheritedKey}(T_{[i]})$) then

$\text{InheritedKey}(T_{[i]}) += \text{buf}_c$

if $T_{[i]}$ is not a base table then

if T_l is the table from which comes $\text{Key}(T_{[i]})$ and k_l is the respective key then

$\text{buf}.\text{Table} += T_l$

$\text{buf}.\text{key} += K_{k_l}$

Table

Key

| | |
|--|--|
| | |
|--|--|

| | | |
|---------------------------------|---------------------------------|---------------|
| Employees/ Supervisor_Id (B) | Employees/ Employee_Id (A) | Employee_Id |
| Employees/ Employee_Id (A) | Employees/ Supervisor_Id (B) | Supervisor_Id |

Join Path List

| |
|--|
| Employees/ Employee_Id (A) |
| Employees/ Supervisor_Id (B) |
| Employees/ Employee_Id (A) Employees/ Supervisor_Id (B) |

$T_{[i]}$

create a structure buf with 2 fields: Table and Key

for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for all the couples of $\langle \text{Table}, \text{key} \rangle$ in buf do

take one couple buf_c at a time

if $(\text{buf}_c.\text{Table} = T_k)$ then

if $(\text{buf}_c \neq \text{Key}(T_{[i]}))$ and $(\text{buf}_c \text{ not in InheritedKey}(T_{[i]}))$ then

InheritedKey($T_{[i]}$) += buf_c

if $T_{[i]}$ is not a base table then

if T_l is the table from which comes $\text{Key}(T_{[i]})$ and k_l is the respective key then

$\text{buf}.\text{Table} += T_l$

$\text{buf}.\text{key} += K_{k_l}$

Table

Key

| | |
|--|--|
| | |
|--|--|

| | | |
|---------------------------------|---------------------------------|---------------|
| Employees/ Supervisor_Id (B) | Employees/ Employee_Id (A) | Employee_Id |
| Employees/ Employee_Id (A) | Employees/ Supervisor_Id (B) | Supervisor_Id |

N/A

Join Path List

| |
|--|
| Employees/ Employee_Id (A) |
| Employees/ Supervisor_Id (B) |
| Employees/ Employee_Id (A) Employees/ Supervisor_Id (B) |

$T_{[i]}$

create a structure buf with 2 fields: Table and Key

for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for all the couples of $\langle \text{Table}, \text{key} \rangle$ in buf do

take one couple buf_c at a time

if $(\text{buf}_c.\text{Table} = T_k)$ then

if $(\text{buf}_c.\text{key} \neq \text{Key}(T_{[i]}))$ and $(\text{buf}_c$ not in $\text{InheritedKey}(T_{[i]})$) then

$\text{InheritedKey}(T_{[i]}) += \text{buf}_c$

if $T_{[i]}$ is not a base table then

if $T_{[i]}$ is the table from which comes $\text{Key}(T_{[i]})$ and k_i is the respective key then

$\text{buf}.\text{Table} += T_{[i]}$

$\text{buf}.\text{key} += K_{[i]}$

Table

Key

| | |
|--|--|
| | |
|--|--|

| | | | |
|---------------------------------|---------------------------------|---------------------------------|---------------|
| Employees/ Employee_Id (A) | Employees/ Supervisor_Id (B) | Employees/ Employee_Id (A) | Employee_Id |
| Employees/ Supervisor_Id (B) | Employees/ Employee_Id (A) | Employees/ Supervisor_Id (B) | Supervisor_Id |

Join Path List

$T_{[i]}$

| |
|---------------------------------|
| Employees/ Employee_Id (A) |
| Employees/ Supervisor_Id (B) |
| Employees/ Employee_Id (A) |
| Employees/ Supervisor_Id (B) |

create a structure buf with 2 fields: Table and Key

for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for all the couples of $\langle \text{Table}, \text{key} \rangle$ in buf do

take one couple buf_c at a time

if $(\text{buf}_c.\text{Table} = T_k)$ then

if $(\text{buf}_c.\text{Key} \neq \text{Key}(T_{[i]}))$ and $(\text{buf}_c$ not in $\text{InheritedKey}(T_{[i]})$) then

$\text{InheritedKey}(T_{[i]}) += \text{buf}_c$

if $T_{[i]}$ is not a base table then

if T_l is the table from which comes $\text{Key}(T_{[i]})$ and k_l is the respective key then

$\text{buf}.\text{Table} += T_l$

$\text{buf}.\text{key} += K_{l_i}$

Table

Key

| | |
|--|--|
| | |
|--|--|

| | | | |
|---------------------------------|---------------------------------|---------------------------------|---------------|
| Employees/ Employee_Id (A) | Employees/ Supervisor_Id (B) | Employees/ Employee_Id (A) | Employee_Id |
| Employees/ Supervisor_Id (B) | Employees/ Employee_Id (A) | Employees/ Supervisor_Id (B) | Supervisor_Id |

Join Path List

$T_{[i]}$

| |
|---------------------------------|
| Employees/ Employee_Id (A) |
| Employees/ Supervisor_Id (B) |
| Employees/ Employee_Id (A) |
| Employees/ Supervisor_Id (B) |

create a structure buf with 2 fields: Table and Key

for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for all the couples of $\langle \text{Table}, \text{key} \rangle$ in buf do

take one couple buf_c at a time

if $(\text{buf}_c.\text{Table} = T_k)$ then

if $(\text{buf}_c.\text{Key} \neq \text{Key}(T_{[i]}))$ and $(\text{buf}_c$ not in $\text{InheritedKey}(T_{[i]})$) then

$\text{InheritedKey}(T_{[i]}) += \text{buf}_c$

if $T_{[i]}$ is not a base table then

if T_l is the table from which comes $\text{Key}(T_{[i]})$ and k_l is the respective key then

$\text{buf}.\text{Table} += T_l$

$\text{buf}.\text{key} += K_{k_l}$

Table

Key

| | |
|--|--|
| | |
|--|--|

| | | | |
|---------------------------------|---------------------------------|---------------------------------|---------------|
| Employees/ Employee_Id (A) | Employees/ Supervisor_Id (B) | Employees/ Employee_Id (A) | Employee_Id |
| Employees/ Supervisor_Id (B) | Employees/ Employee_Id (A) | Employees/ Supervisor_Id (B) | Supervisor_Id |

Join Path List

$T_{[i]}$

T_k

k_l

| |
|---------------------------------|
| Employees/ Employee_Id (A) |
| Employees/ Supervisor_Id (B) |
| Employees/ Employee_Id (A) |
| Employees/ Supervisor_Id (B) |

create a structure buf with 2 fields: Table and Key

for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for all the couples of $\langle \text{Table}, \text{key} \rangle$ in buf do

take one couple buf_c at a time

if $(\text{buf}_c.\text{Table} = T_k)$ then

if $(\text{buf}_c.\text{key} \neq \text{Key}(T_{[i]}))$ and $(\text{buf}_c$ not in $\text{InheritedKey}(T_{[i]})$) then

$\text{InheritedKey}(T_{[i]}) += \text{buf}_c$

if $T_{[i]}$ is not a base table then

if T_l is the table from which comes $\text{Key}(T_{[i]})$ and k_l is the respective key then

$\text{buf}.\text{Table} += T_l$

$\text{buf}.\text{key} += K_{k_l}$

Table

Key

N/A

| | |
|--|--|
| | |
|--|--|

Employees/
Employee_Id (A)

Employees/
Supervisor_Id (B)

Employees/
Employee_Id (A)

Employee_Id

Employees/
Supervisor_Id (B)

Employees/
Employee_Id (A)

Employees/
Supervisor_Id (B)

Supervisor_Id

Employees/
Employee_Id (A)

Employees/
Supervisor_Id (B)

Join Path List

$T_{[i]}$

T_k

create a structure buf with 2 fields: Table and Key

for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for all the couples of $\langle \text{Table}, \text{key} \rangle$ in buf do

take one couple buf_c at a time

if $(\text{buf}_c.\text{Table} = T_k)$ then

if $(\text{buf}_c.\text{key} \neq \text{Key}(T_{[i]}))$ and $(\text{buf}_c$ not in $\text{InheritedKey}(T_{[i]})$) then

$\text{InheritedKey}(T_{[i]}) += \text{buf}_c$

if $T_{[i]}$ is not a base table then

if T_l is the table from which comes $\text{Key}(T_{[i]})$ and k_l is the respective key then

$\text{buf}.\text{Table} += T_l$

$\text{buf}.\text{key} += K_{k_l}$

Table

Key

| | |
|--|--|
| | |
|--|--|

| | | |
|---------------------------------|---------------------------------|---------------|
| Employees/ Supervisor_Id (B) | Employees/ Employee_Id (A) | Employee_Id |
| Employees/ Employee_Id (A) | Employees/ Supervisor_Id (B) | Supervisor_Id |

Employees/
Employee_Id (A)

Employees/
Supervisor_Id (B)

Employees/
Employee_Id (A)

Employees/
Supervisor_Id (B)

Join Path List

$T_{[i]}$

create a structure buf with 2 fields: Table and Key

for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for all the couples of $\langle \text{Table}, \text{key} \rangle$ in buf do

take one couple buf_c at a time

if $(\text{buf}_c.\text{Table} = T_k)$ then

if $(\text{buf}_c.\text{key} \neq \text{Key}(T_{[i]}))$ and $(\text{buf}_c$ not in $\text{InheritedKey}(T_{[i]})$) then

$\text{InheritedKey}(T_{[i]}) += \text{buf}_c$

if $T_{[i]}$ is not a base table then

if T_l is the table from which comes $\text{Key}(T_{[i]})$ and k_l is the respective key then

$\text{buf}.\text{Table} += T_l$

$\text{buf}.\text{key} += K_{k_l}$

Table

Key

| | |
|--|--|
| | |
|--|--|

$T_{[i]}$

Employees/
Employee_Id (A)

Employees/
Supervisor_Id (B)

Employees/
Employee_Id (A)

Employees/
Supervisor_Id (B)

Employees/
Supervisor_Id (B)

Employees/
Employee_Id (A)

Employees/
Employee_Id (A)

Employees/
Supervisor_Id (B)

Employee_Id

Supervisor_Id

Join Path List

create a structure buf with 2 fields: Table and Key

for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for all the couples of $\langle \text{Table}, \text{key} \rangle$ in buf do

take one couple buf_c at a time

if $(\text{buf}_c.\text{Table} = T_k)$ then

if $(\text{buf}_c.\text{key} \neq \text{Key}(T_{[i]}))$ and $(\text{buf}_c$ not in $\text{InheritedKey}(T_{[i]})$) then

$\text{InheritedKey}(T_{[i]}) += \text{buf}_c$

if $T_{[i]}$ is not a base table then

if T_l is the table from which comes $\text{Key}(T_{[i]})$ and k_l is the respective key then

$\text{buf}.\text{Table} += T_l$

$\text{buf}.\text{key} += K_{k_l}$

Table

Key

| | |
|--|--|
| | |
|--|--|

$T_{[i]}$

Employees/
Employee_Id (A)

Employees/
Supervisor_Id (B)

Employees/
Employee_Id (A)
Employees/
Supervisor_Id (B)

Employees/
Supervisor_Id (B)

Employees/
Employee_Id (A)

Employees/
Employee_Id (A)

Employees/
Supervisor_Id (B)

Employee_Id

Supervisor_Id

Join Path List

create a structure buf with 2 fields: Table and Key

for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for all the couples of $\langle \text{Table}, \text{key} \rangle$ in buf do

take one couple buf_c at a time

if $(\text{buf}_c.\text{Table} = T_k)$ then

if $(\text{buf}_c.\text{key} \neq \text{Key}(T_{[i]}))$ and $(\text{buf}_c$ not in $\text{InheritedKey}(T_{[i]})$) then

$\text{InheritedKey}(T_{[i]}) += \text{buf}_c$

if $T_{[i]}$ is not a base table then

if T_l is the table from which comes $\text{Key}(T_{[i]})$ and k_l is the respective key then

$\text{buf}.\text{Table} += T_l$

$\text{buf}.\text{key} += K_{k_l}$

Table

Key

| | |
|--|--|
| | |
|--|--|

$T_{[i]}$

Employees/
Employee_Id (A)

Employees/
Supervisor_Id (B)

Employees/
Employee_Id (A)
Employees/
Supervisor_Id (B)

Employees/
Supervisor_Id (B)

Employees/
Employee_Id (A)

Employees/
Employee_Id (A)

Employees/
Supervisor_Id (B)

Employee_Id

Supervisor_Id

Join Path List

create a structure buf with 2 fields: Table and Key

for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for all the couples of $\langle \text{Table}, \text{key} \rangle$ in buf do

take one couple buf_c at a time

if $(\text{buf}_c.\text{Table} = T_k)$ then

if $(\text{buf}_c.\text{key} \neq \text{Key}(T_{[i]}))$ and $(\text{buf}_c \text{ not in InheritedKey}(T_{[i]}))$ then

$\text{InheritedKey}(T_{[i]}) += \text{buf}_c$

if $T_{[i]}$ is not a base table then

if T_l is the table from which comes $\text{Key}(T_{[i]})$ and k_l is the respective key then

$\text{buf}.\text{Table} += T_l$

$\text{buf}.\text{key} += K_{k_l}$

Table

Key

N/A

| | |
|--|--|
| | |
|--|--|

$T_{[i]}$

Employees/
Employee_Id (A)

Employees/
Supervisor_Id (B)

Employees/
Employee_Id (A)

Employees/
Supervisor_Id (B)

Employees/
Supervisor_Id (B)

Employees/
Employee_Id (A)

Employee_Id

Employees/
Employee_Id (A)

Employees/
Supervisor_Id (B)

Supervisor_Id

$T_{[i]}$
 k_l

Join Path List

create a structure buf with 2 fields: Table and Key

for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for all the couples of $\langle \text{Table}, \text{key} \rangle$ in buf do

take one couple buf_c at a time

if $(\text{buf}_c.\text{Table} = T_k)$ then

if $(\text{buf}_c.\text{Key} \neq \text{Key}(T_{[i]}))$ and $(\text{buf}_c \text{ not in InheritedKey}(T_{[i]}))$ then

$\text{InheritedKey}(T_{[i]}) += \text{buf}_c$

if $T_{[i]}$ is not a base table then

if $T_{[i]}$ is the table from which comes $\text{Key}(T_{[i]})$ and k_i is the respective key then

$\text{buf}.\text{Table} += T_{[i]}$

$\text{buf}.\text{key} += K_{k_i}$

Table

Key

| | |
|--|--|
| | |
|--|--|

| | | |
|---------------------------------|---------------------------------|---------------|
| Employees/ Supervisor_Id (B) | Employees/ Employee_Id (A) | Employee_Id |
| Employees/ Employee_Id (A) | Employees/ Supervisor_Id (B) | Supervisor_Id |

| |
|---------------------------------|
| Employees/ Employee_Id (A) |
| Employees/ Supervisor_Id (B) |
| Employees/ Employee_Id (A) |
| Employees/ Supervisor_Id (B) |

$T_{[i]}$

Join Path List

create a structure buf with 2 fields: Table and Key

for all the tables in JoinPathList going downward do

take one $T_{[i]}$ at a time

for all Base Tables in $T_{[i]}$ do

take one T_k at a time

for all the couples of $\langle \text{Table}, \text{key} \rangle$ in buf do

take one couple buf_c at a time

if (buf_c.Table = T_k) then

if (buf_c.key != Key($T_{[i]}$)) and (buf_c not in InheritedKey($T_{[i]}$)) then

InheritedKey($T_{[i]}$) += buf_c

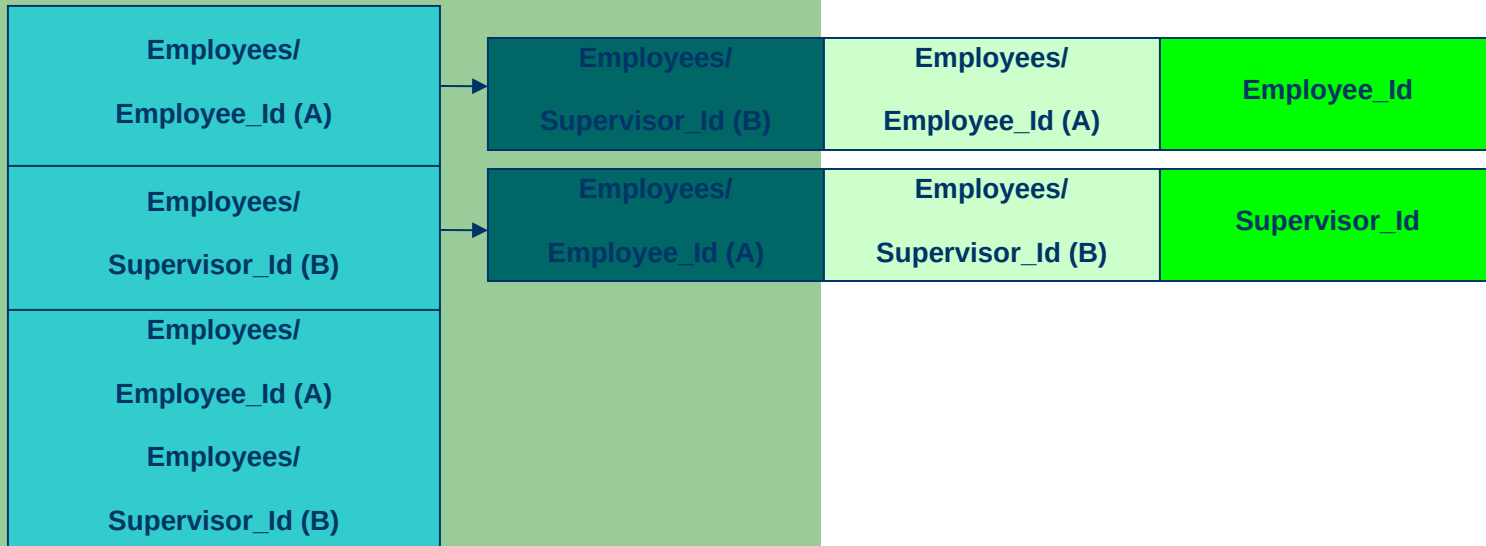
if $T_{[i]}$ is not a base table then

if T_l is the table from which comes Key($T_{[i]}$) and k_l is the respective key then

buf.Table += T_l

buf.key += K_{k_l}

Join Path List



Applying the insert routine for all the rows in the table EMPLOYEES, we obtain the following indexes:

