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

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⋈TREE Index

To understand how B⋈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 $R_n \ldots R_z$ in T_k that satisfy the join condition with R_m and insert Rows references to $R_m R_{n....}$ $R_m R_z$ in the virtual table T_{ik}.

The process should be repeated for $R_m R_{n....}$ $R_m R_z$ 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 the keys in the Element

- 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.

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.

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 knows 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:

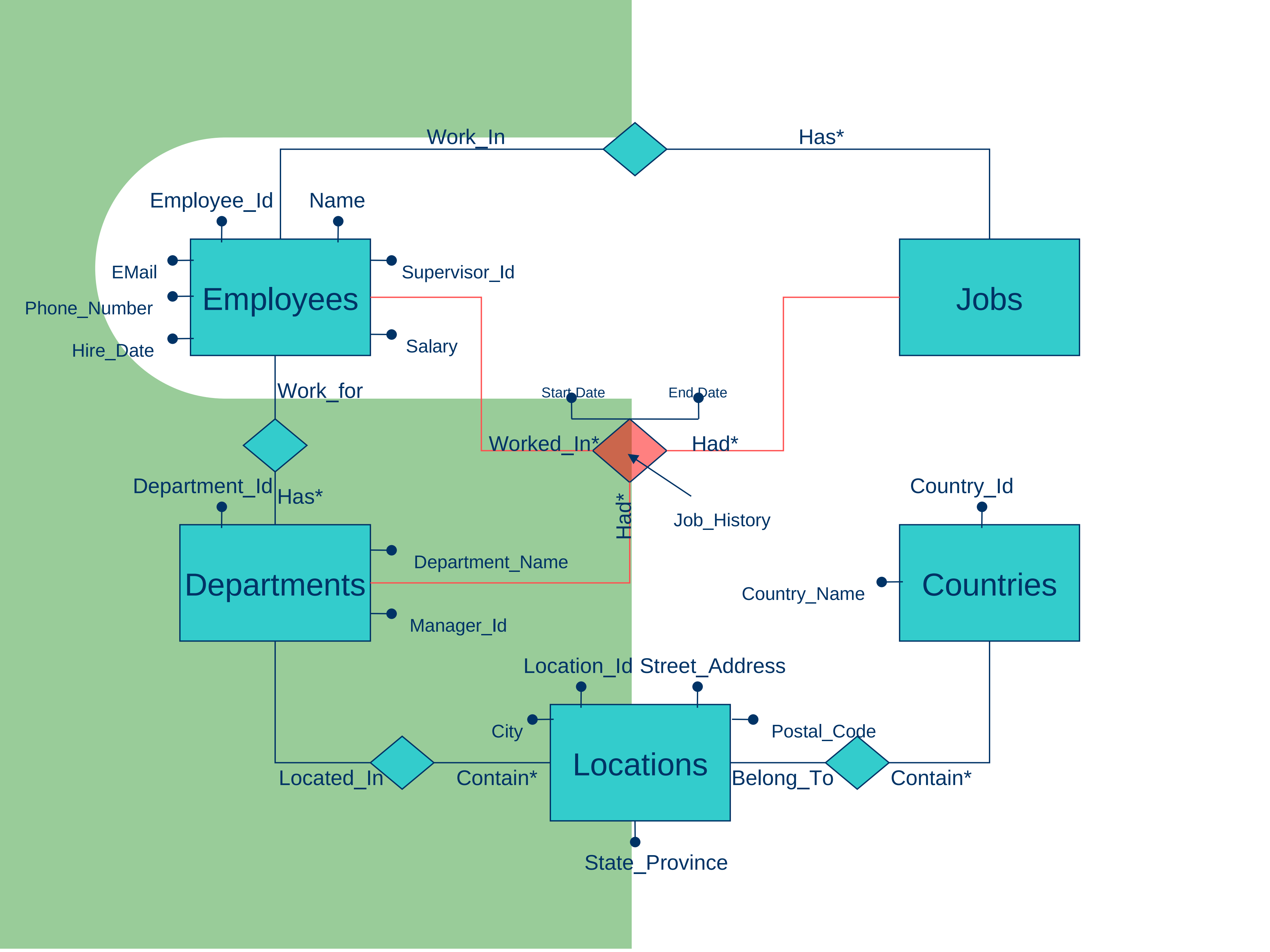
generateJoinGraph (in BaseTables; out JoinGraph)

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



Work_In
Has*
Employee_Id
Name
EMail
Phone_Number
Hire_Date
Employees
Supervisor_Id
Salary
Jobs
Work_for
Start_Date
End_Date
Worked_In*
Had*
Job_History
Department_Id
Has*
Had*
Country_Id
Departments
Department_Name
Manager_Id
Country_Name
Countries
Location_Id
Street_Address
City
Postal_Code
Locations
Located_In
Contain*
Belong_To
Contain*
State_Province

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,
    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 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,
       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 on the same table:

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 +
      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;
```

generateJoinGraph (in BaseTables; out JoinGraph)

insert the base tables as vertexes of the graph

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

Base Tables

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

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Jobs		
Departments		
Locations		
Countries		

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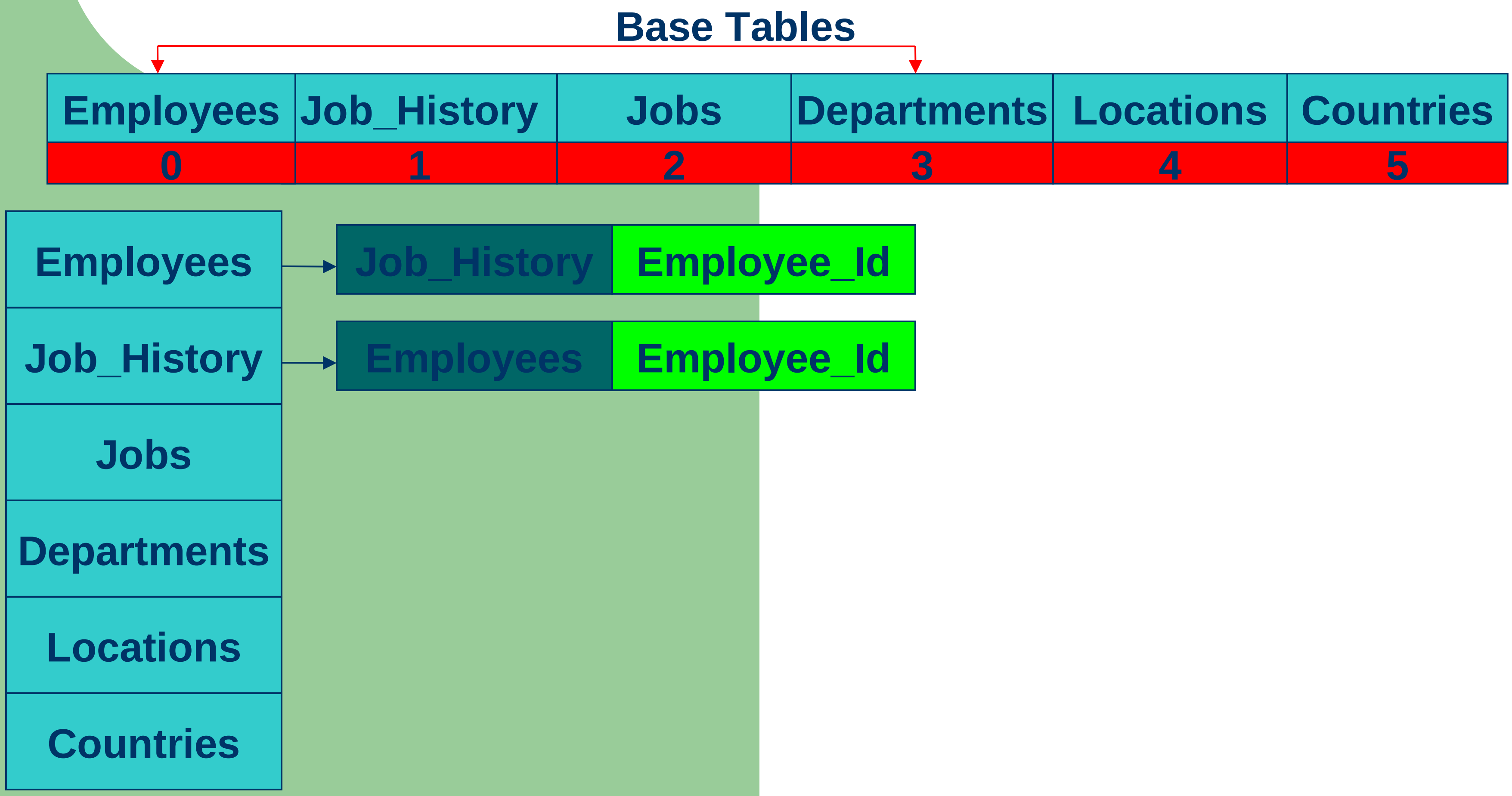

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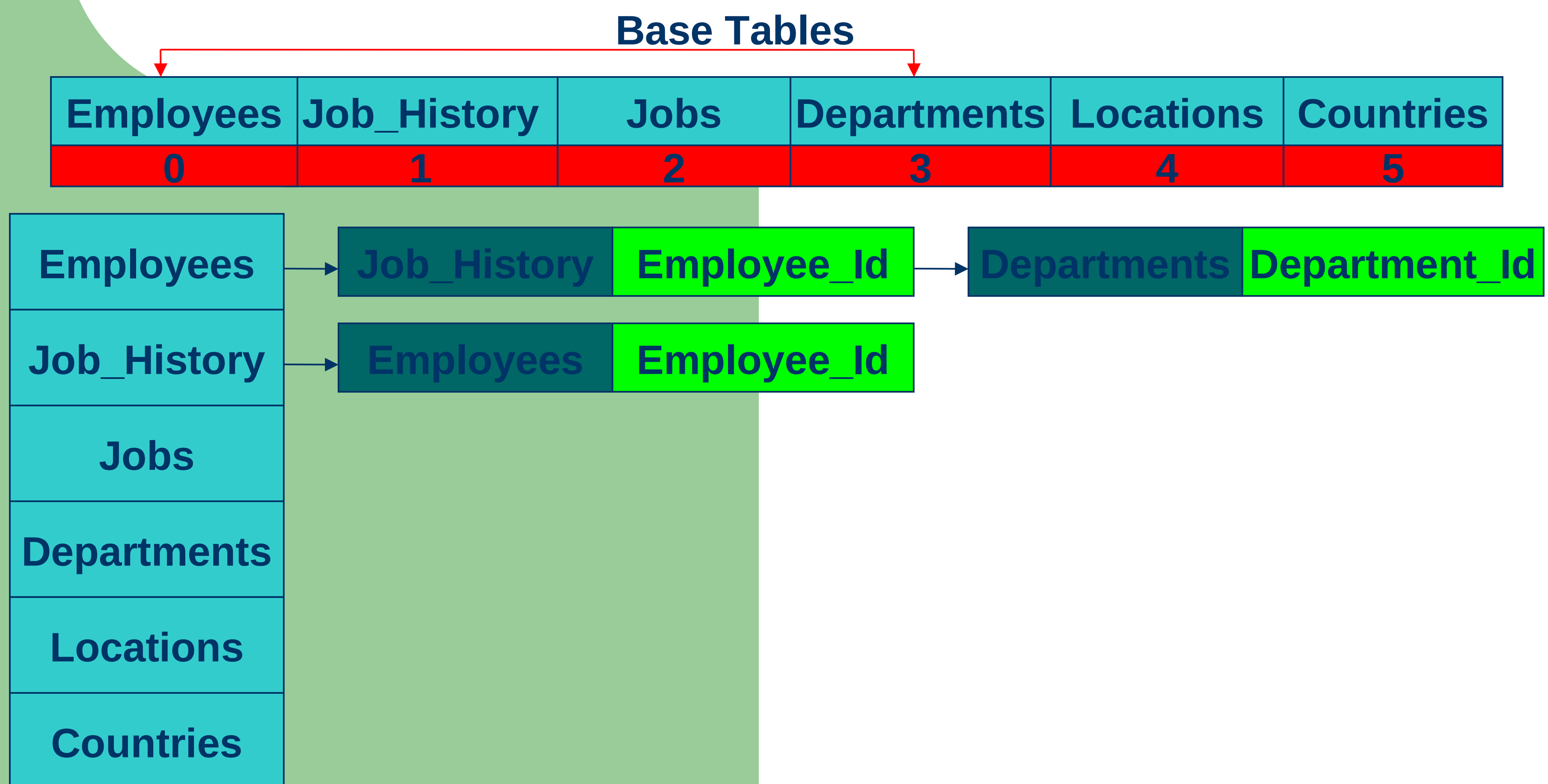

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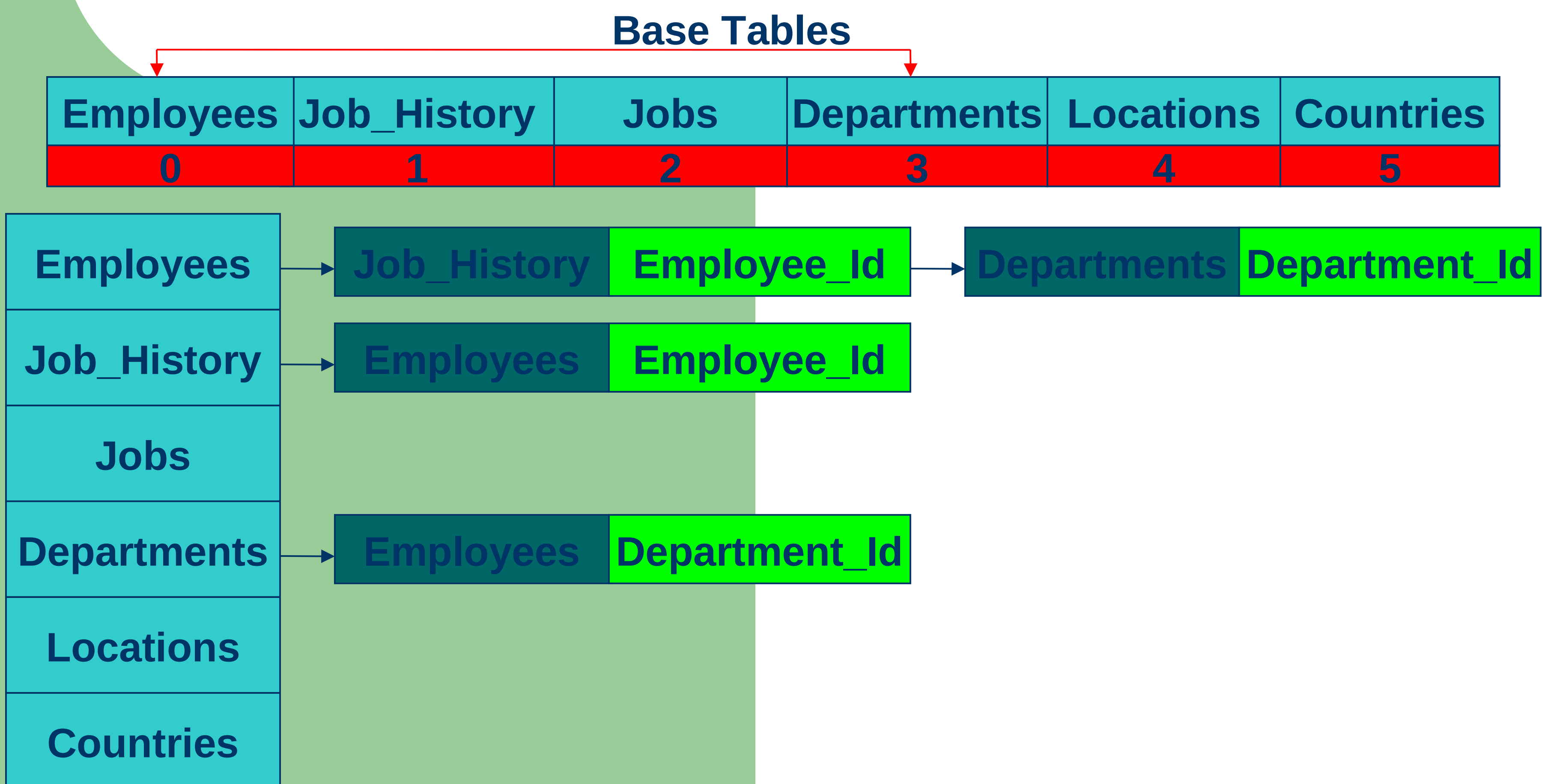

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Jobs				
Departments	Employees	Department_Id		
Locations				
Countries				

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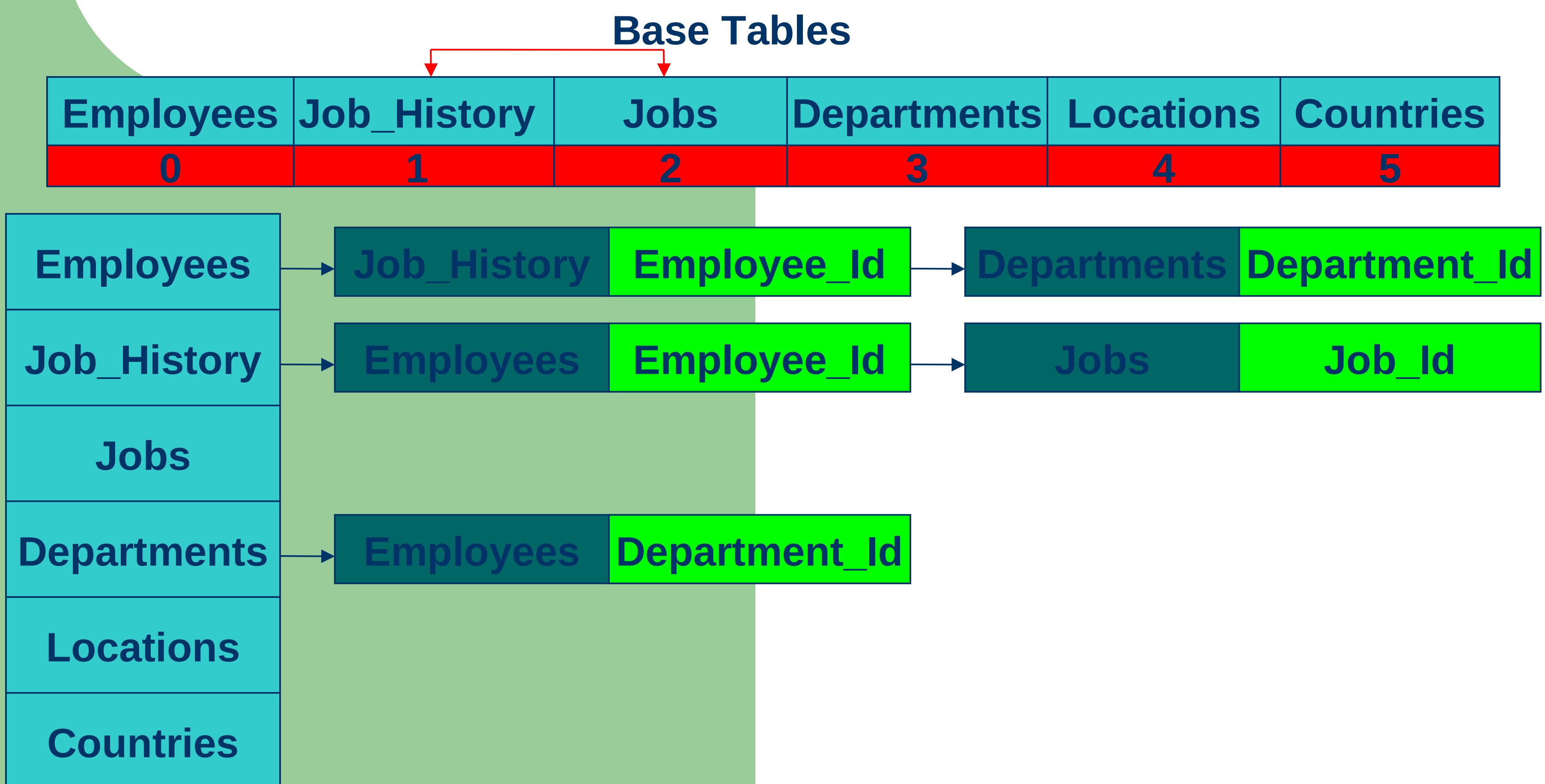

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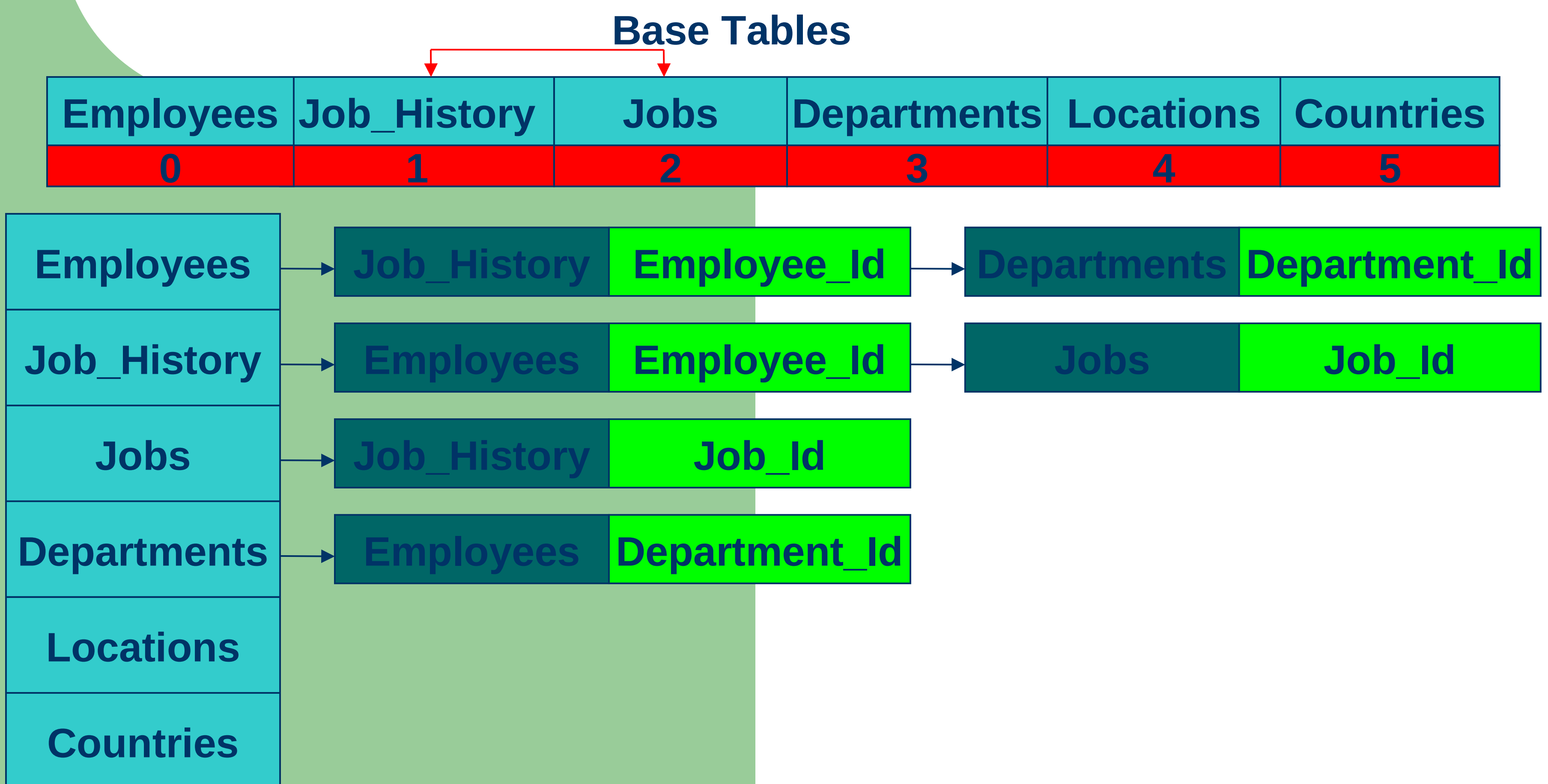

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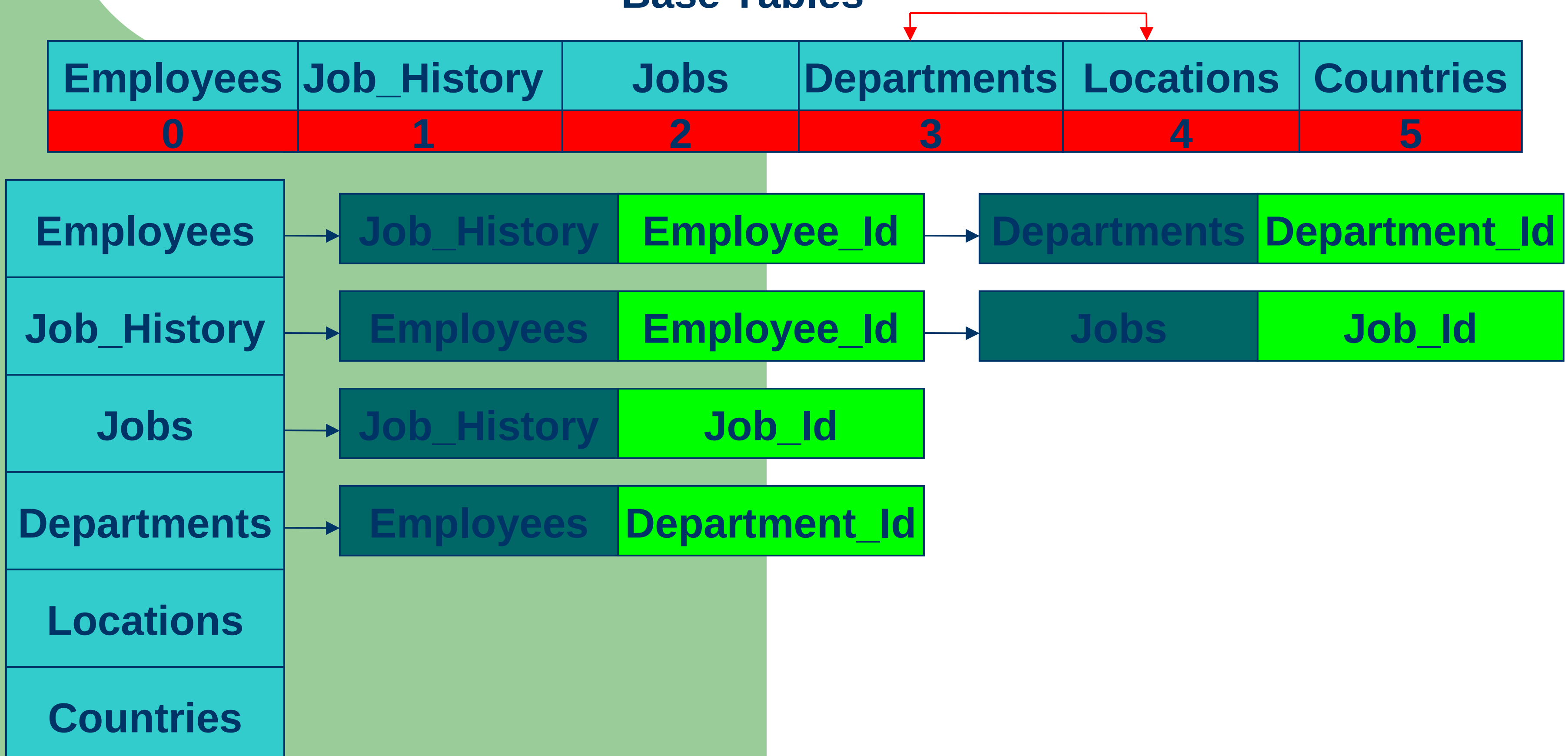

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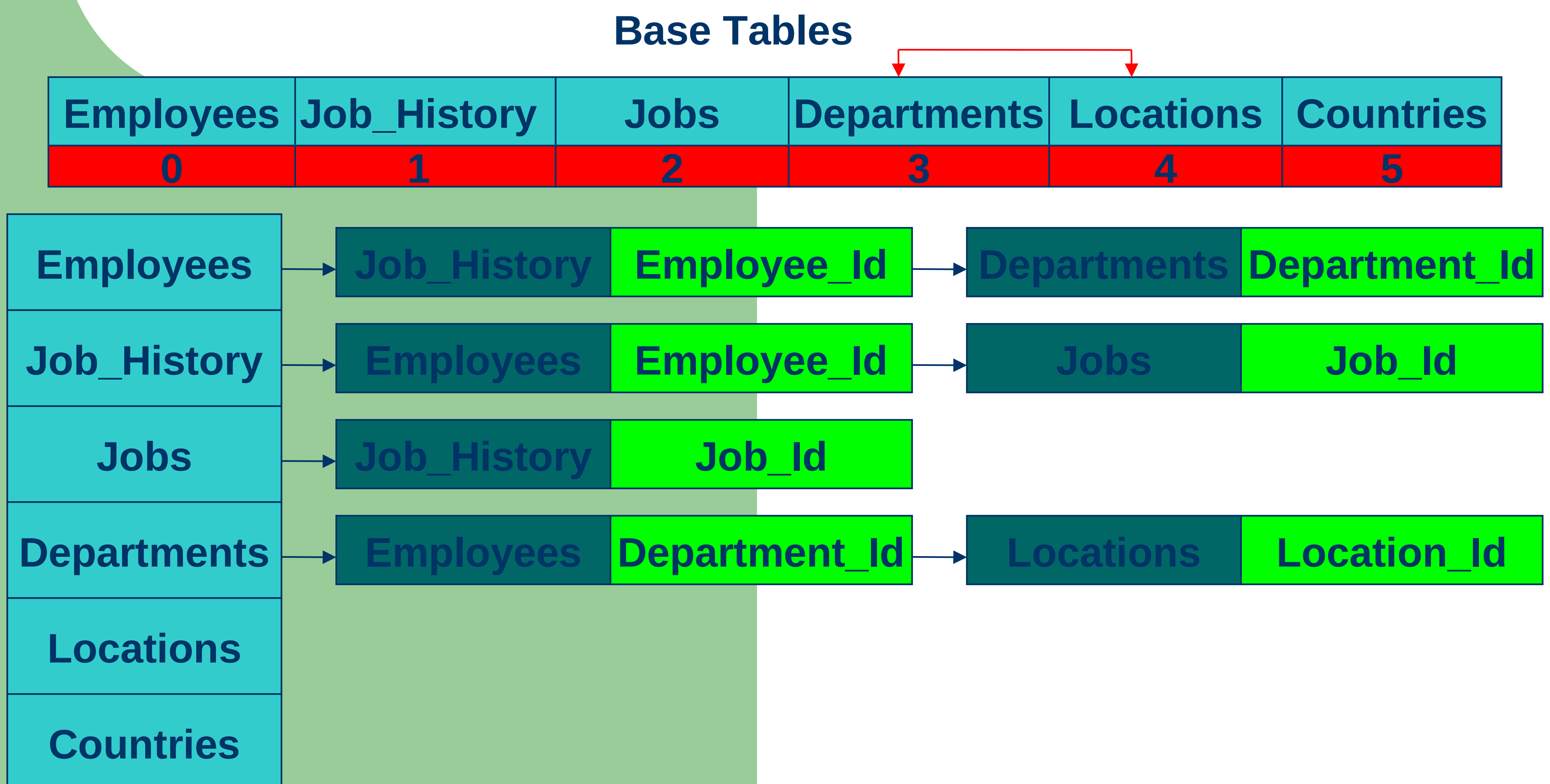

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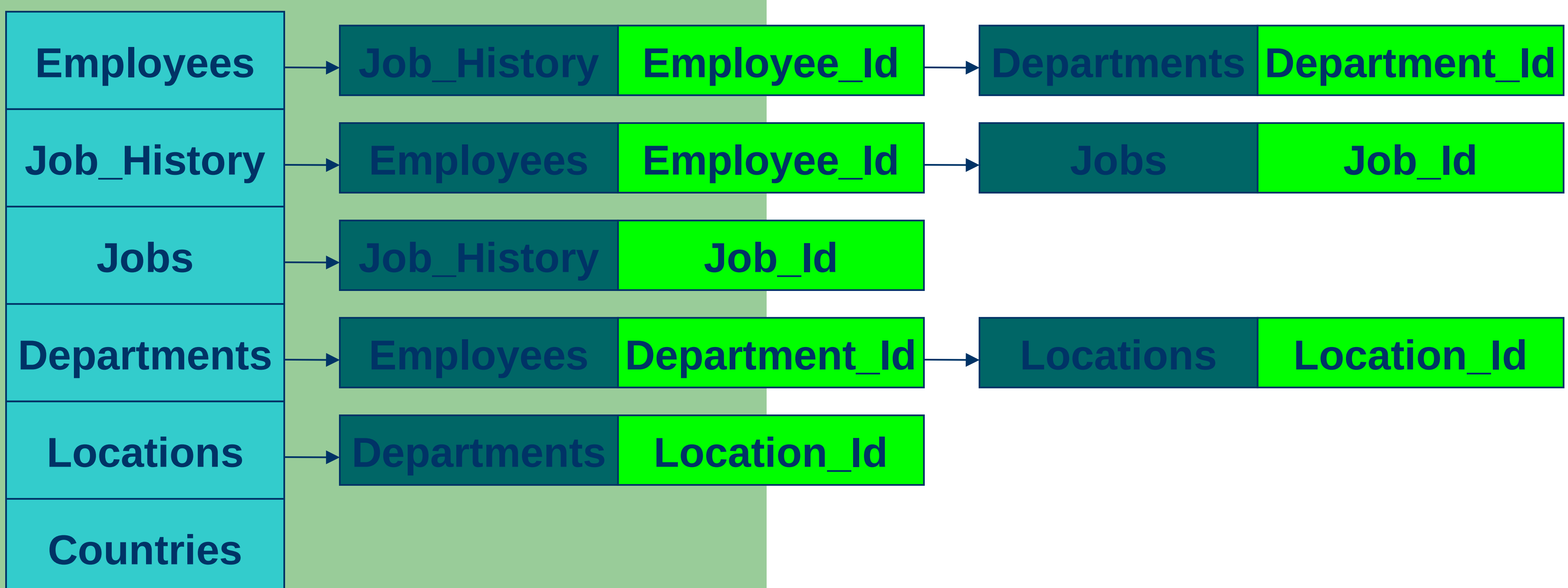

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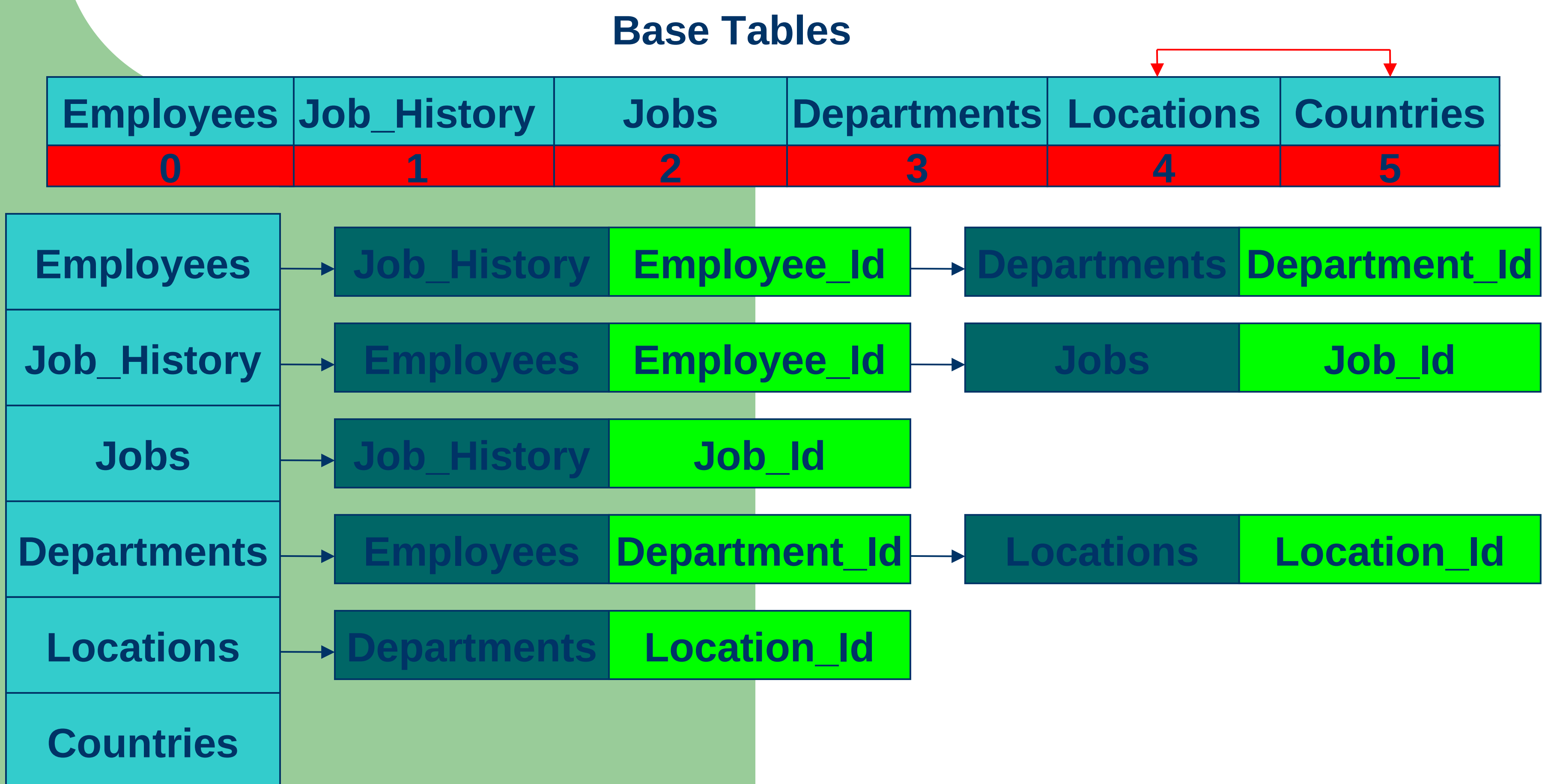

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Base Tables

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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 → Departments | Location_Id → Countries | Country_Id

Countries

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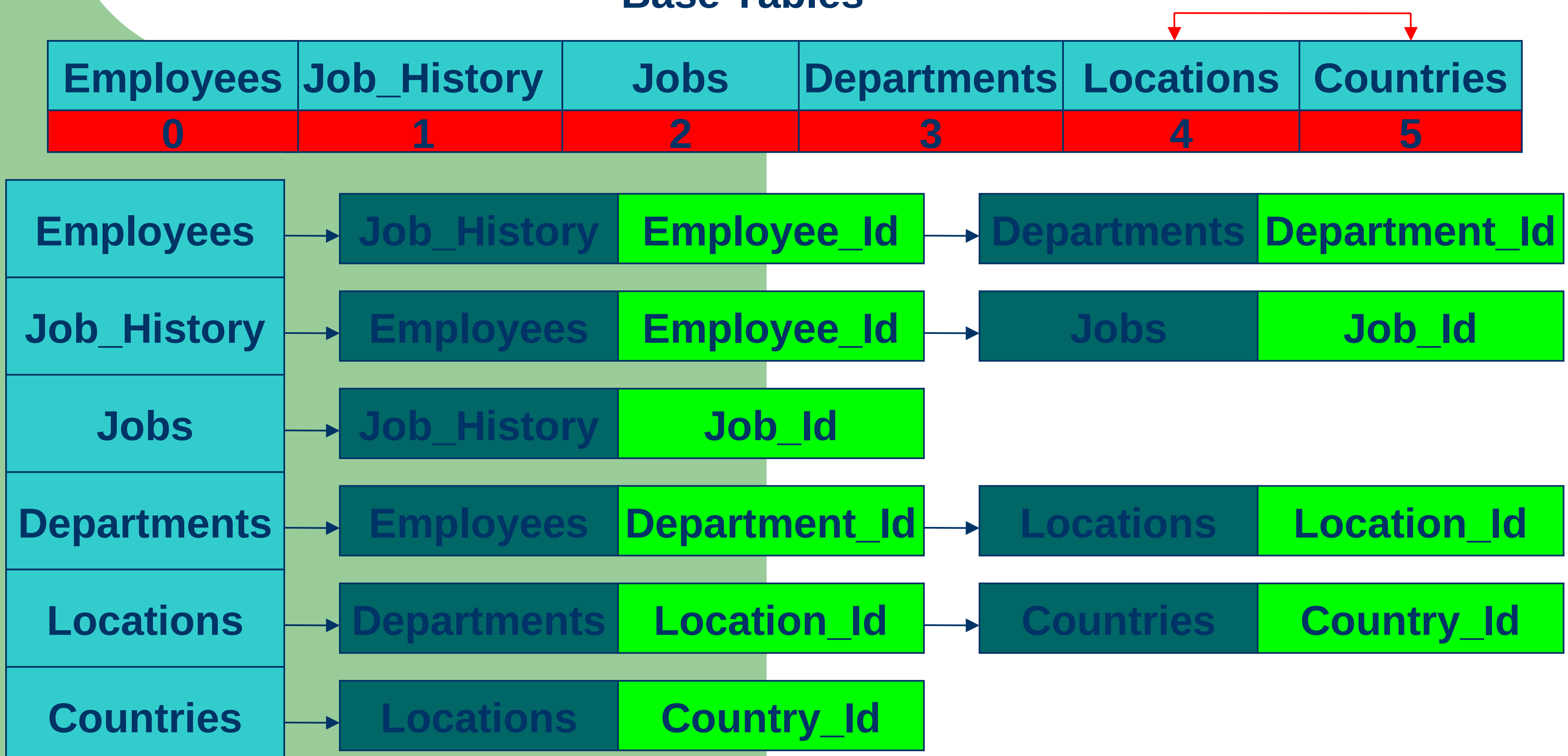
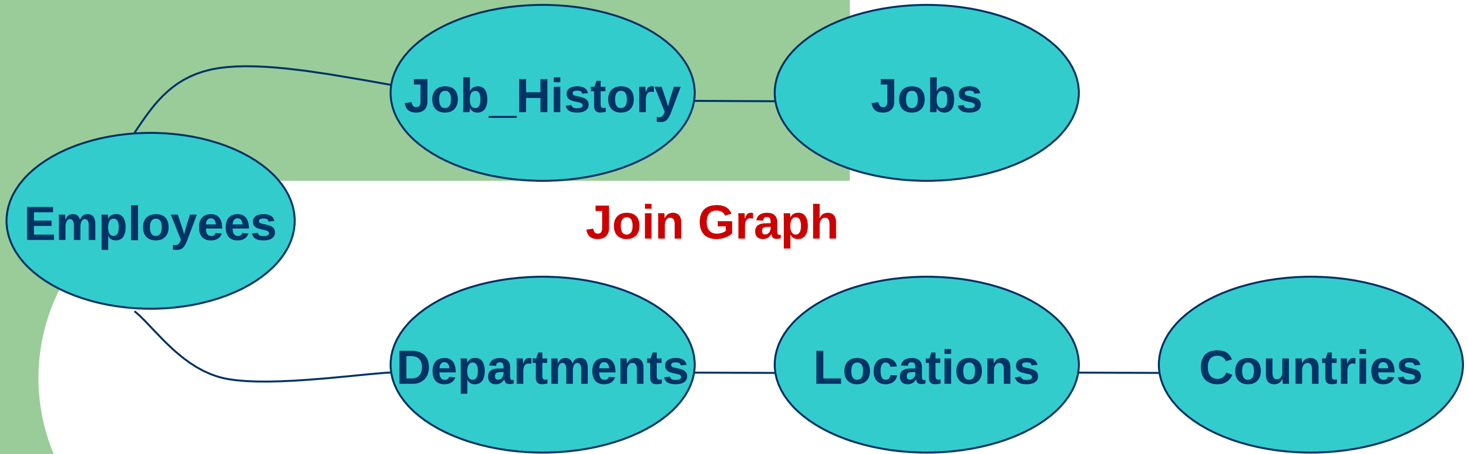
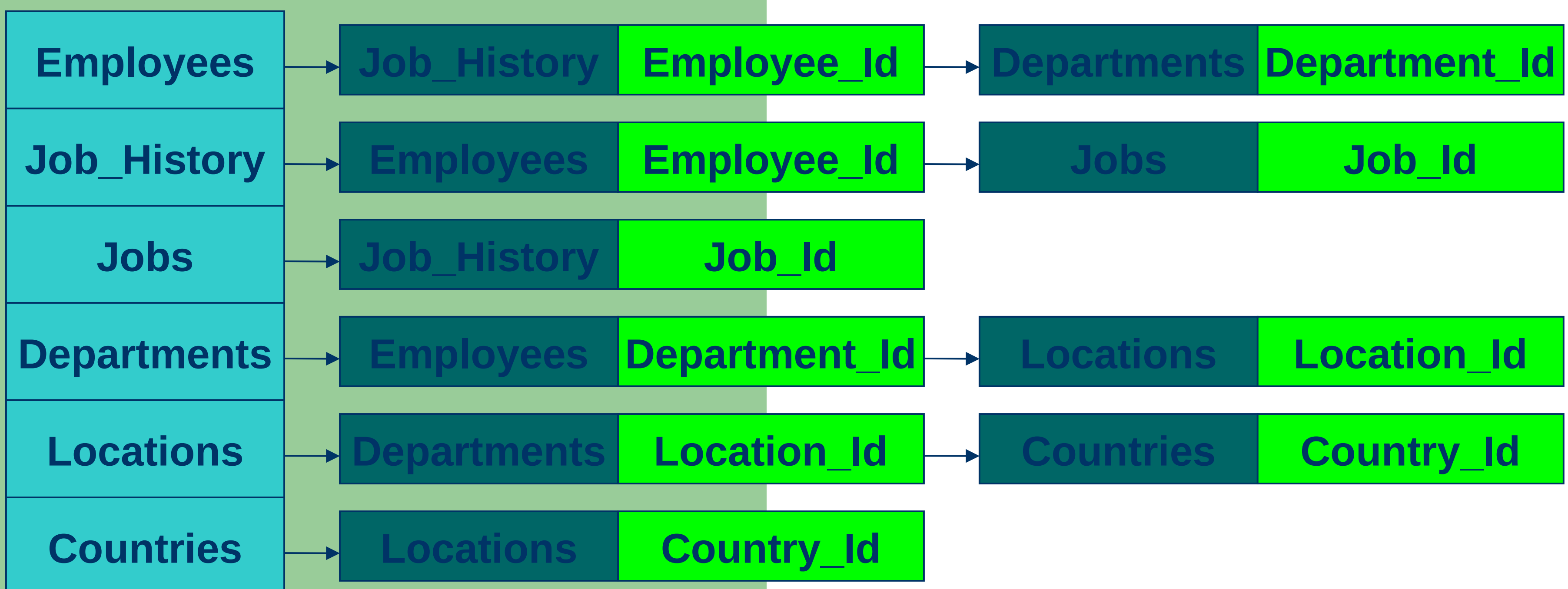




Join Graph

Linked List representation of the Join Graph



Adjacency List

Definitions

Join Path List:

A sequence of tables $T_0 \ldots T_{n-1}$ 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: Key($T_{[j]}$)

getFirstAdjacentListKey($T_{[j]}$, $T_{[k]}$)

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

Take one at a time

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

Take one at a time

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

return(key(T_l,$T_{Link(l)}$))

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 $T_0 \ldots T_m$

let $T_0 \ldots T_m$ 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 $T_0 \ldots T_m$ (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**
- **PathJoinAdjacentList(T_i) = $T_{[buf]}$**
- **Key(T_i) = getFirstAdjacentListKey(T_i,$T_{[buf]}$)**
- **PathJoinAdjacentList($T_{[buf]}$) = T_i**
- **Key($T_{[buf]}$) = getFirstAdjacentListKey ($T_{[buf]}$,T_i)**
- **$T_{[buf]}$ + = T_i**
- **Insert NodesList[$T_{[buf]}$] = $T_{[buf]}$**

Steps to generate Join Path List for the join sequence $T_0 \ldots T_m$ (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_l is the table from which comes Key($T_{[i]}$) then

buf.Table = T_l

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

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

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until queue is empty

Join Base Tables

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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

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T_0	T_1	T_2	T_3	T_4	T_5

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

let $T_0 \ldots T_m$ 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)

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until queue is empty

queue	path
	Employees

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

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until queue is empty

queue

Employees

path

Employees

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

let $T_0 \ldots T_m$ be the base tables
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queue

Employees

path

Employees

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

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queue

Employees

path

Employees

<u>generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)</u>

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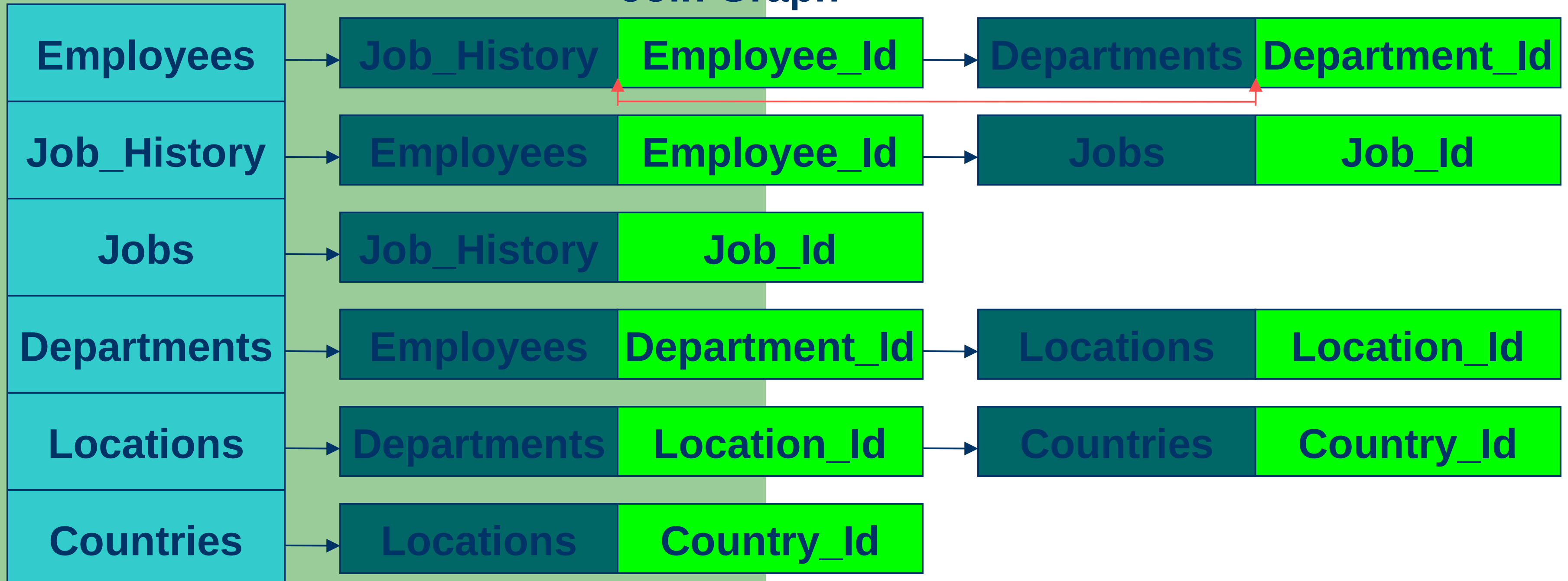
Join Graph



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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		

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

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until queue is empty

path

Employees

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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until queue is empty

queue

Employees

path

Employees
Job_History
Departments

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

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until queue is empty

queue	path
Employees	Employees
Job_History	Job_History
Departments	Departments

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

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queue

Job_History
Departments

path

Employees
Job_History
Departments

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until queue is empty

queue
Job_History
Departments

path
Employees
Job_History
Departments

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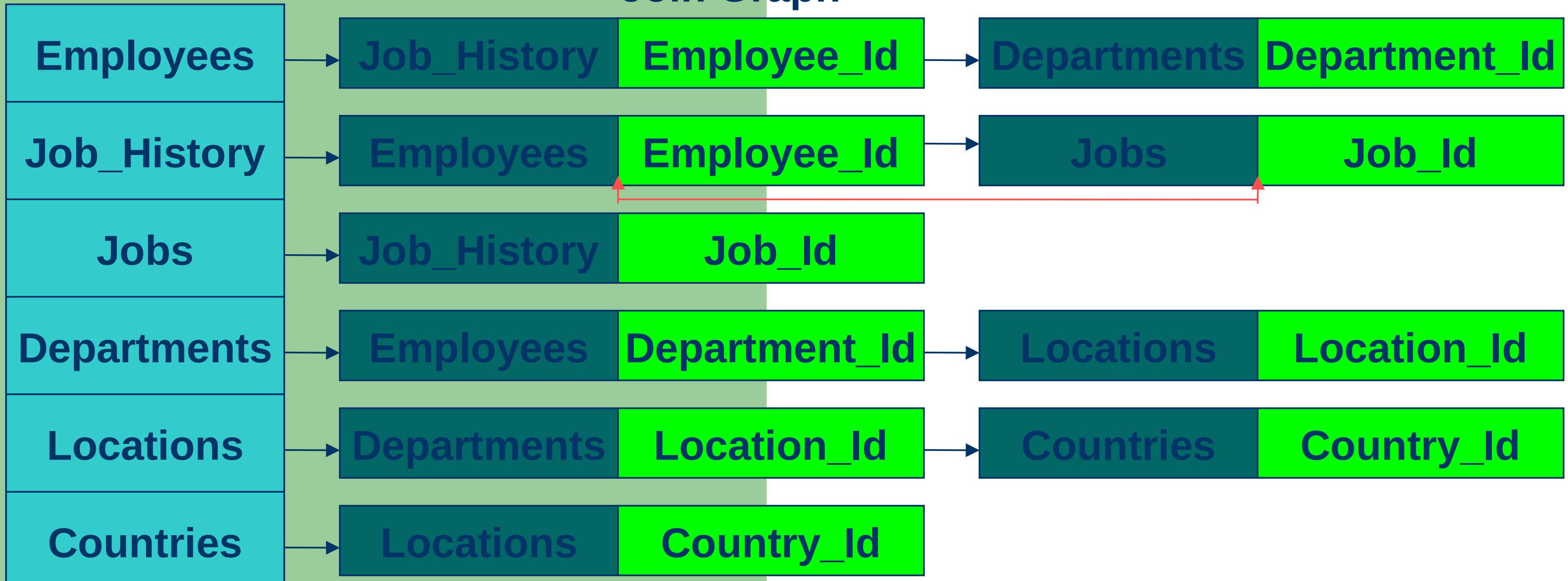
Join Graph



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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)

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until queue is empty

path

Employees
Job_History
Departments

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
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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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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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queue
Departments
Jobs

path
Employees
Job_History
Departments
Jobs

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queue
Departments
Jobs

path
Employees
Job_History
Departments
Jobs

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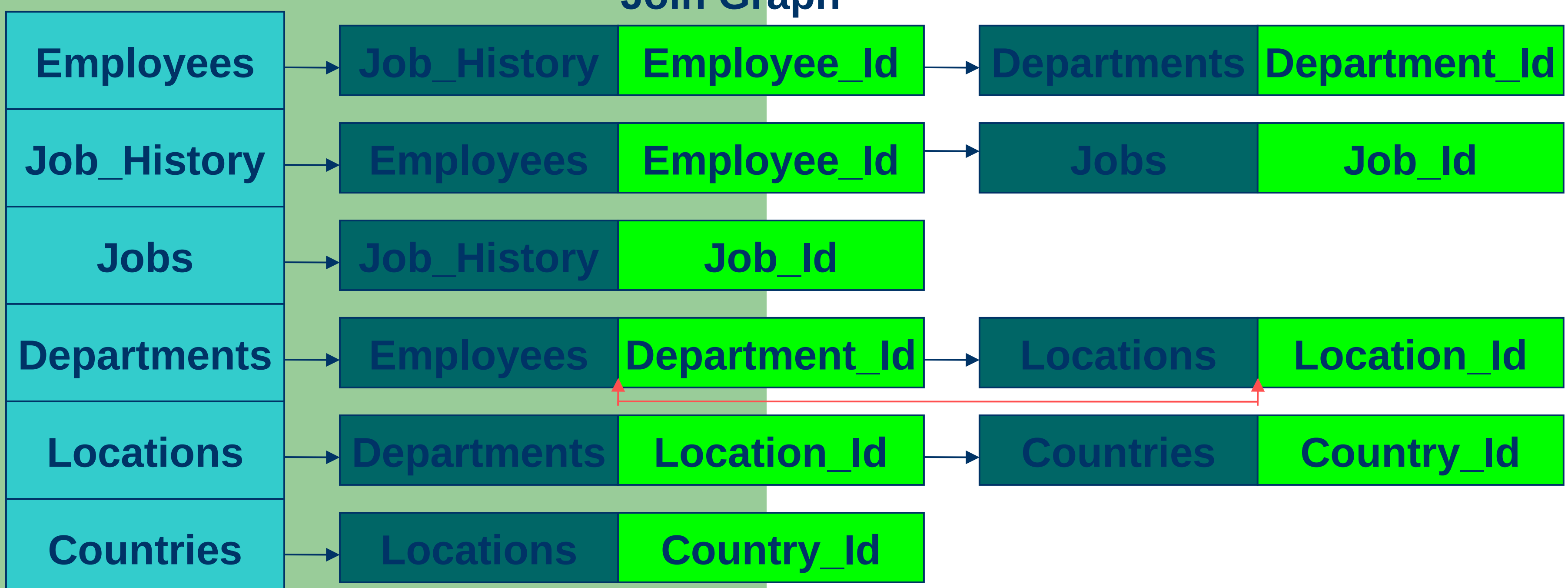
Join Graph



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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

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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                insert Link Item into path
                insert Link Item into queue
    remove $T_{Element}$ from queue
until queue is empty

path

Employees	Jobs
Job_History	
Departments	

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 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
Departments
Jobs

path
Employees
Job_History
Departments
Jobs
Locations

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

let $T_0 \ldots T_m$ be the base tables

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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

queue

- Departments
- Jobs
- Locations

path

- Employees
- Job_History
- Departments
- Jobs
- Locations

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

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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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```

queue
Jobs
Locations

path
Employees
Job_History
Departments
Jobs
Locations

__generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)__

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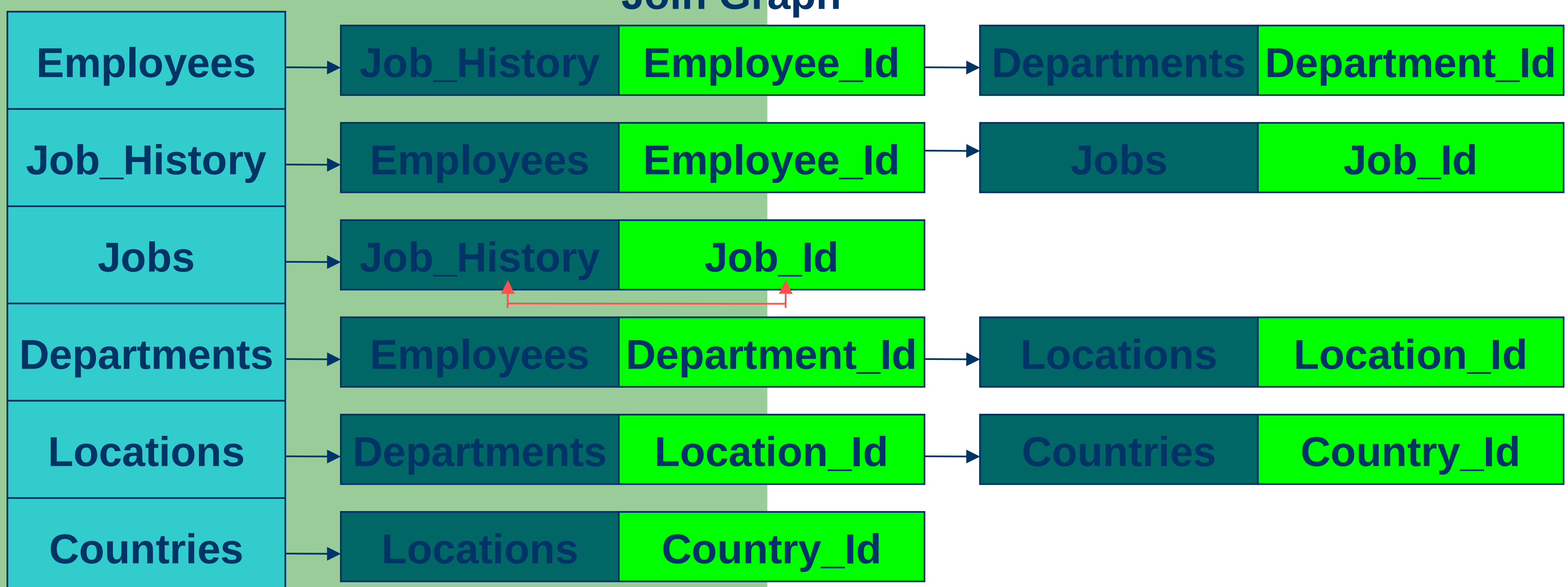
Join Graph



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until queue is empty

Join Base Tables

Employees	Job_History	Jobs	Departments	Locations	Countries

Join Graph

Table	Link	Key	Link	Key
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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        insert Link Item into path

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  remove $T_{Element}$ from queue

until queue is empty

path

Employees	Jobs
Job_History	Locations
Departments	

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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queue

Locations

path

Employees
Job_History
Departments
Jobs
Locations

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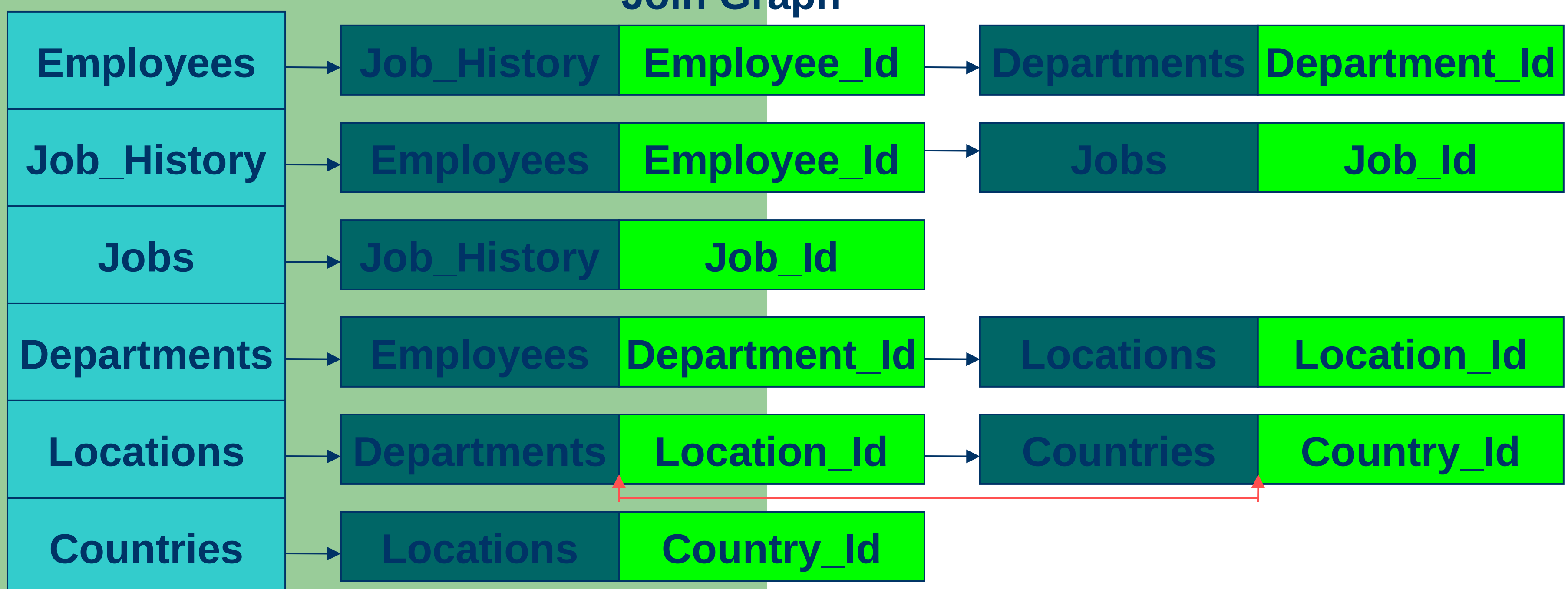

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Join Base Tables

Employees	Job_History	Jobs	Departments	Locations	Countries

Join Graph

Table	Link Item	Key	Link Item	Key
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
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until queue is empty

path

Employees	Jobs
Job_History	Locations
Departments	

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		
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Locations	Departments	Location_Id	Countries	Country_Id
Countries	Locations	Country_Id		

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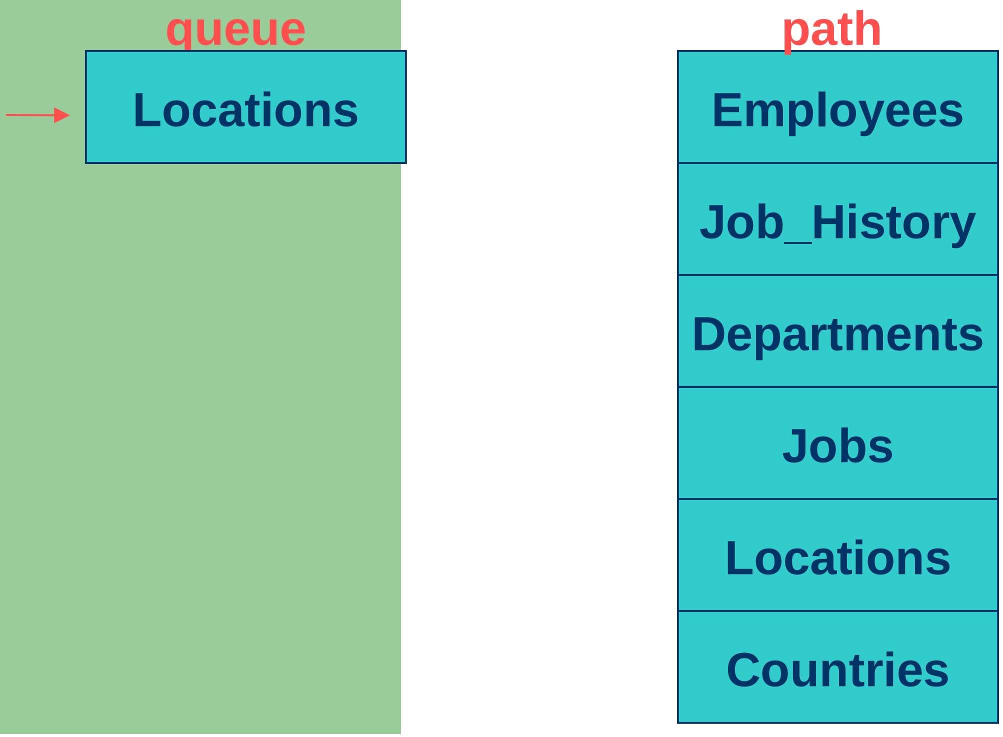

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                insert Link Item into path

                insert Link Item into queue

    remove $T_{Element}$ from queue

until queue is empty

queue
Locations
Countries

path
Employees
Job_History
Departments
Jobs
Locations
Countries

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

let $T_0 \ldots T_m$ 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

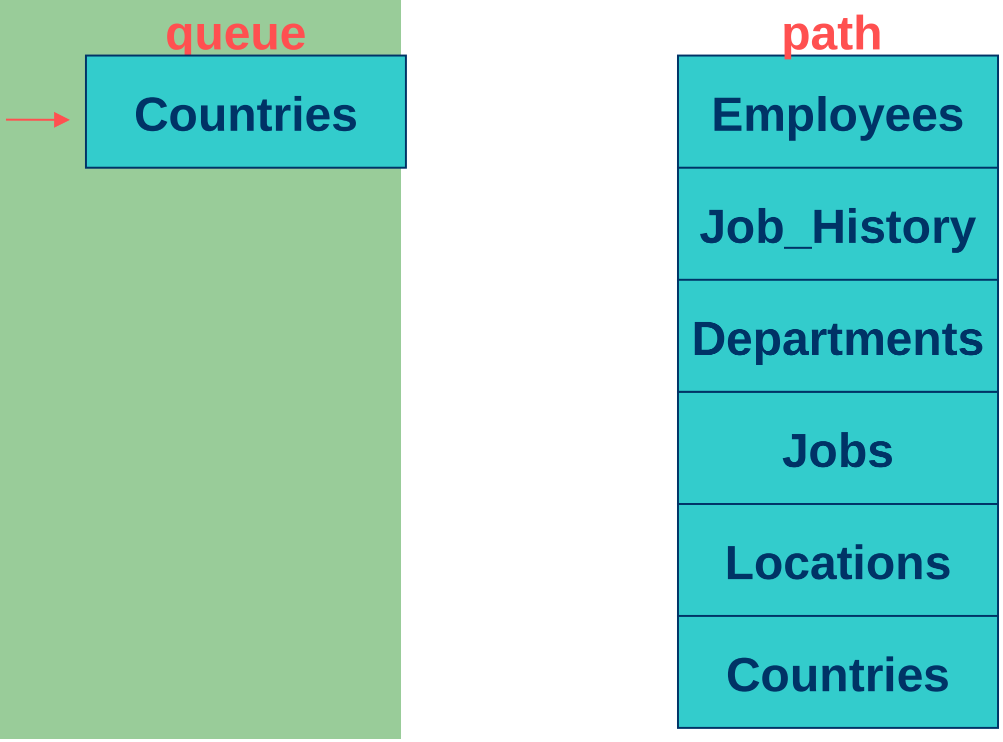
until queue is empty

queue
Countries

path
Employees
Job_History
Departments
Jobs
Locations
Countries

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
```



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- 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
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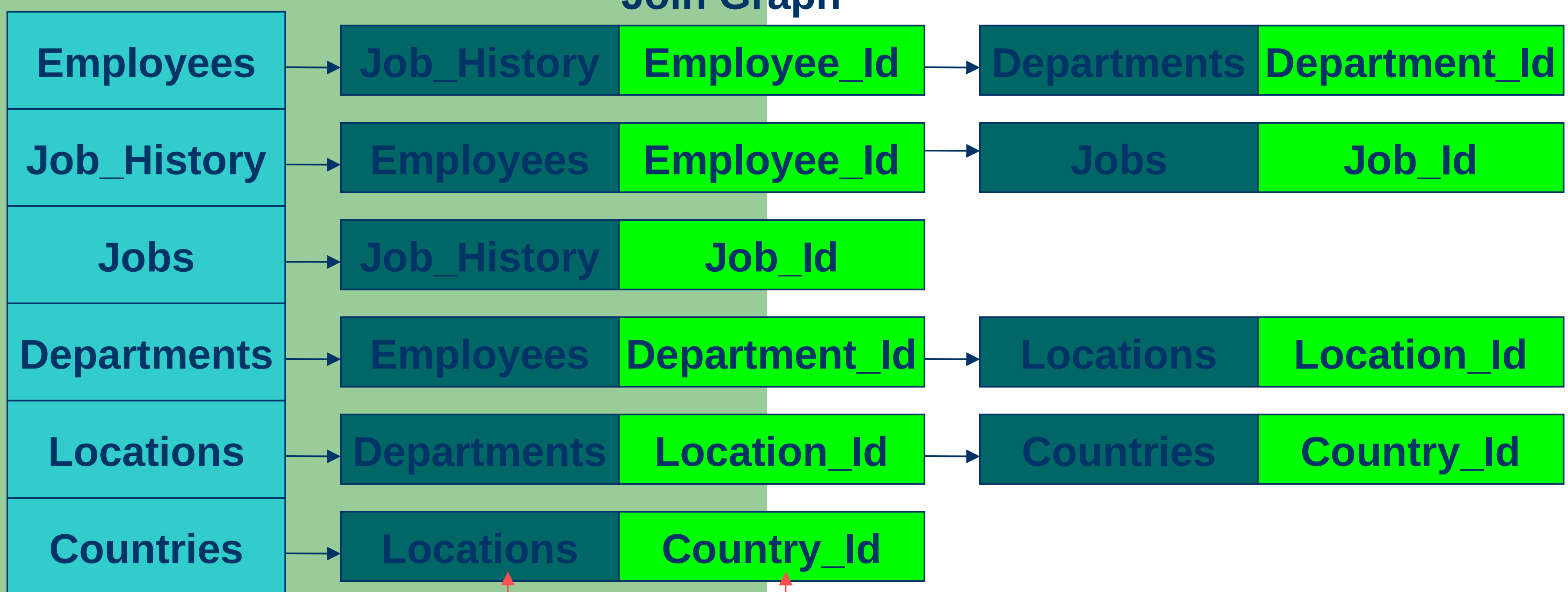
      - insert Link Item into path
      - insert Link Item into queue
- remove $T_{Element}$ from queue

until queue is empty

Join Graph



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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

Table	Link Table	Link Column	Link Table	Link Column
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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until queue is empty

path

Employees	Jobs
Job_History	Locations
Departments	Countries

Join Base Tables

Employees	Job_History	Jobs	Departments	Locations	Countries

Join Graph

Table	Link Item	Join Column	Link Item	Join Column
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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queue

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Employees
Job_History
Departments
Jobs
Locations
Countries

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remove $T_{Element}$ from queue

until queue is empty

queue

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

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

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

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

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

$T_{[buf]} += T_i$

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

vertexes

- Employees
- Job_History
- Deparments
- Jobs
- Locations
- Countries

path

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

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

vertexes

- Employees
- Job_History
- Deparments
- Jobs
- Locations
- Countries

buf

path

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- Job_History
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- Jobs
- Locations
- Countries

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vertexes

Employees
Job_History
Deparments
Jobs
Locations
Countries

buf

Employees

path

Employees
Job_History
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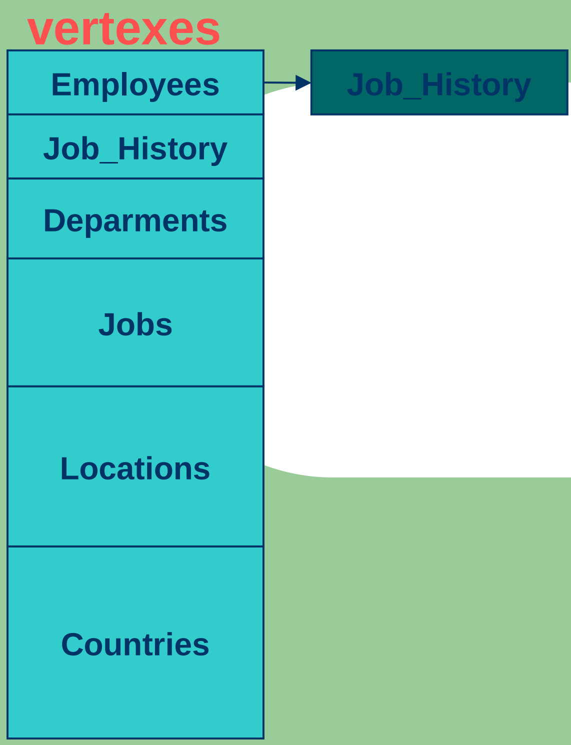

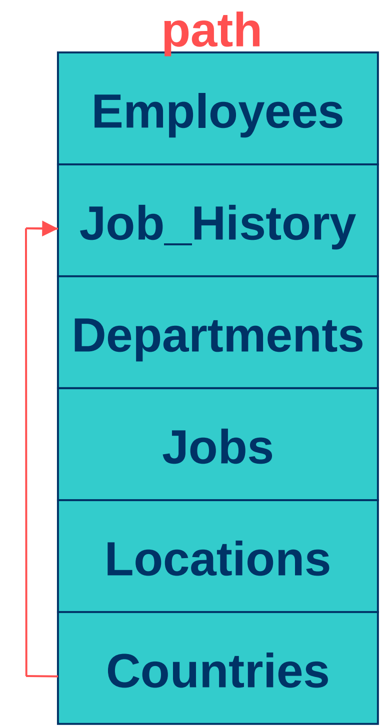

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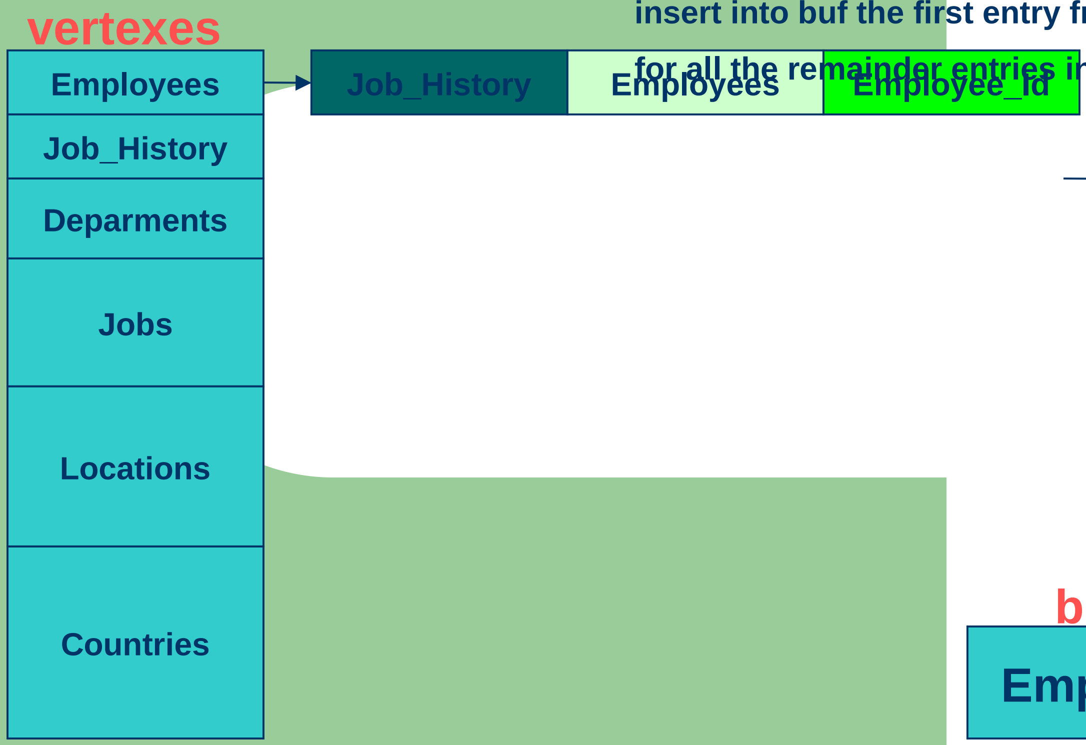

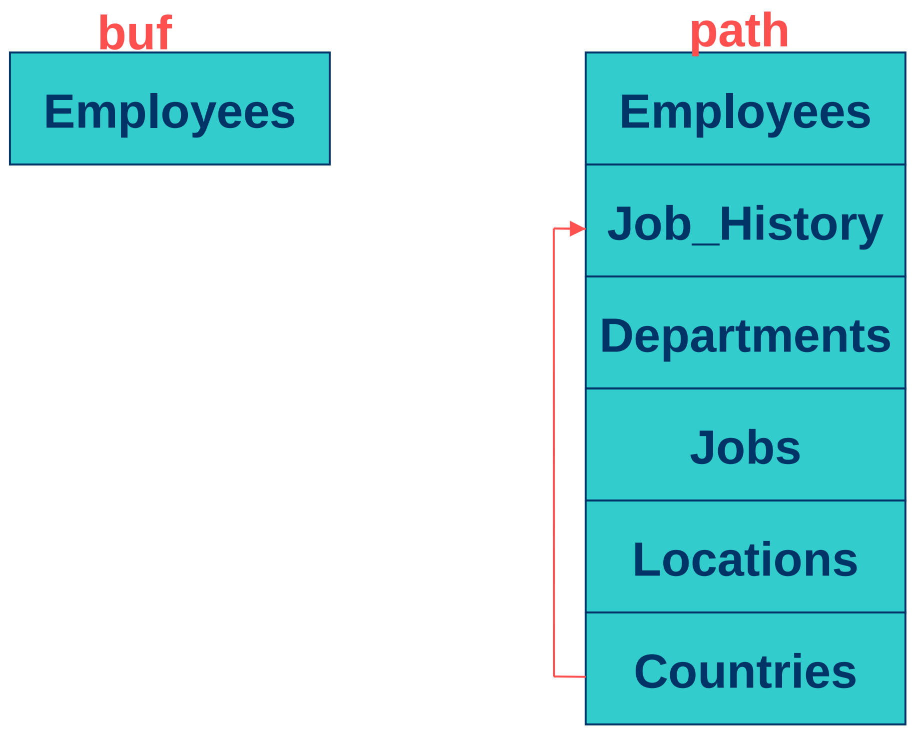

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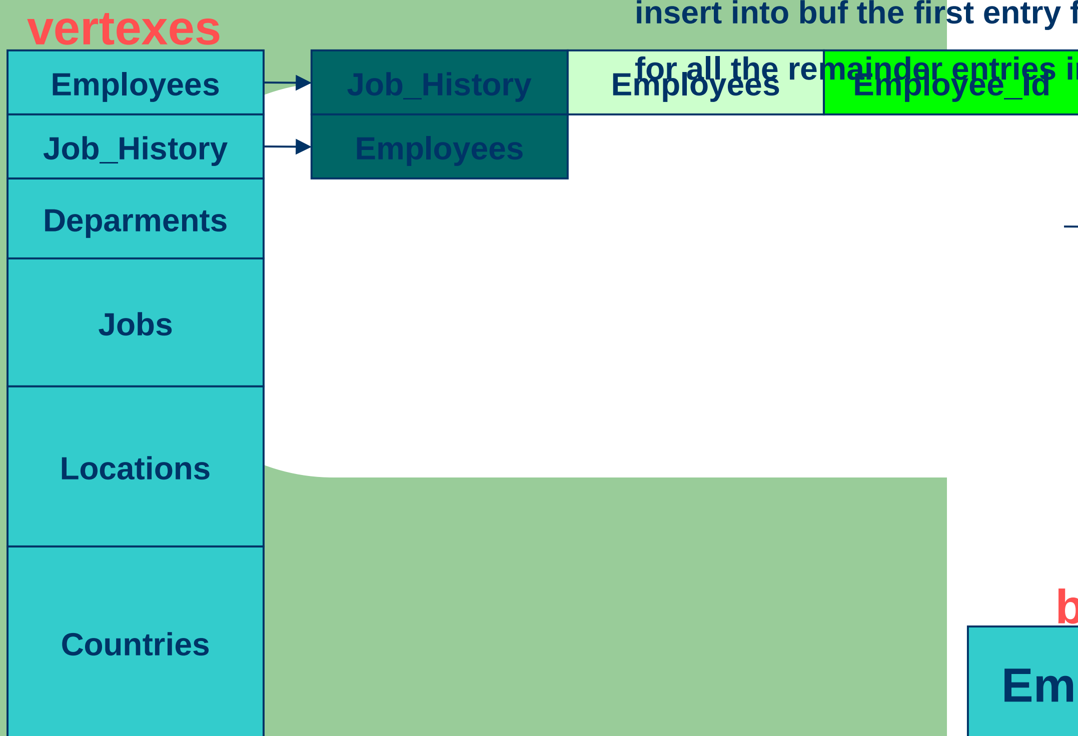

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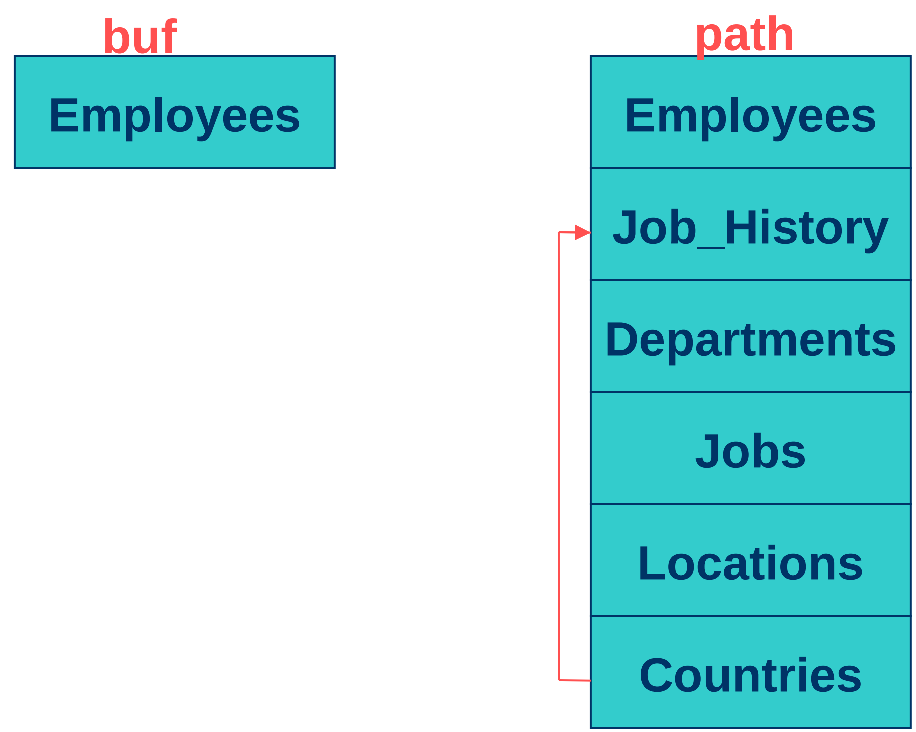

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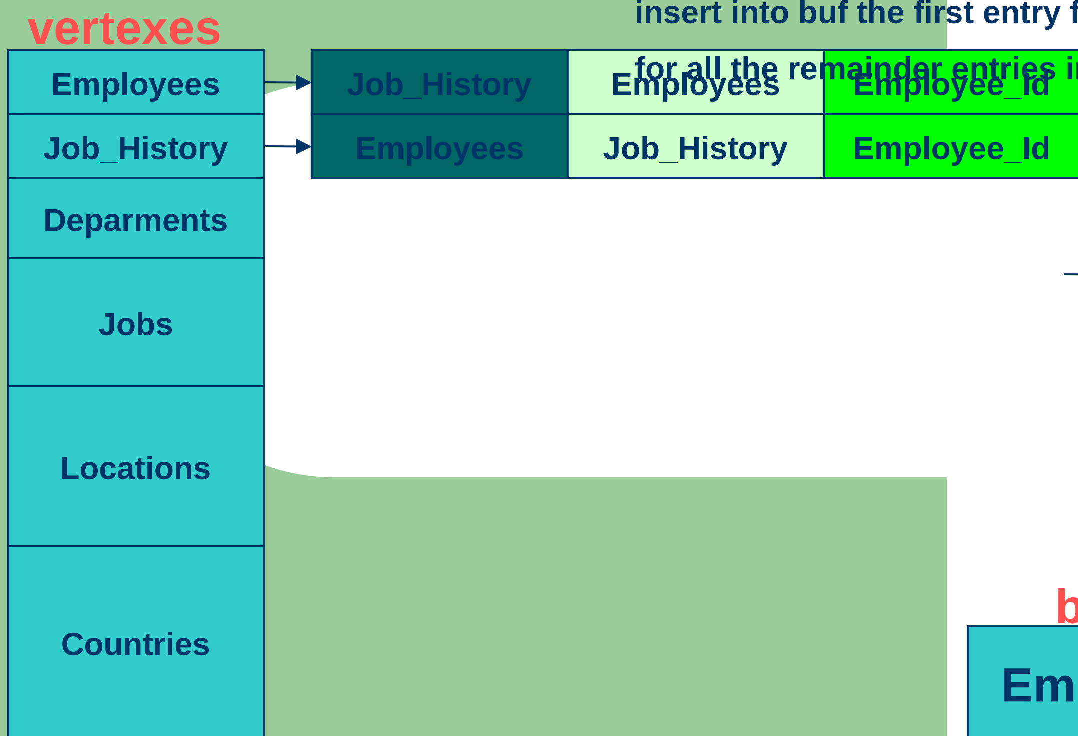

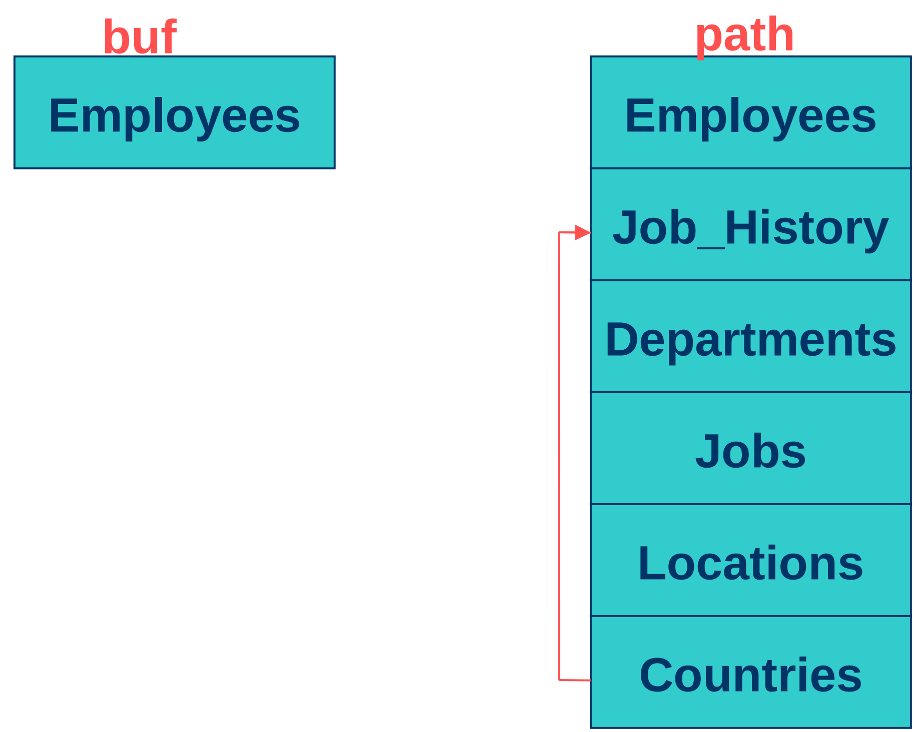

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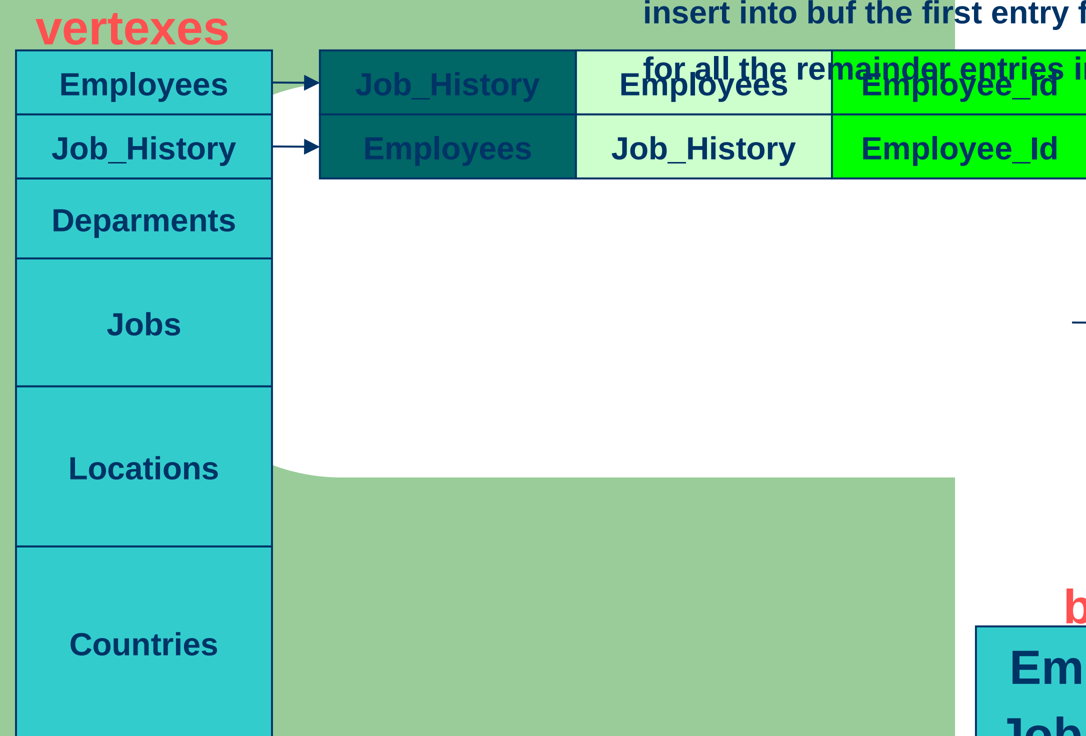

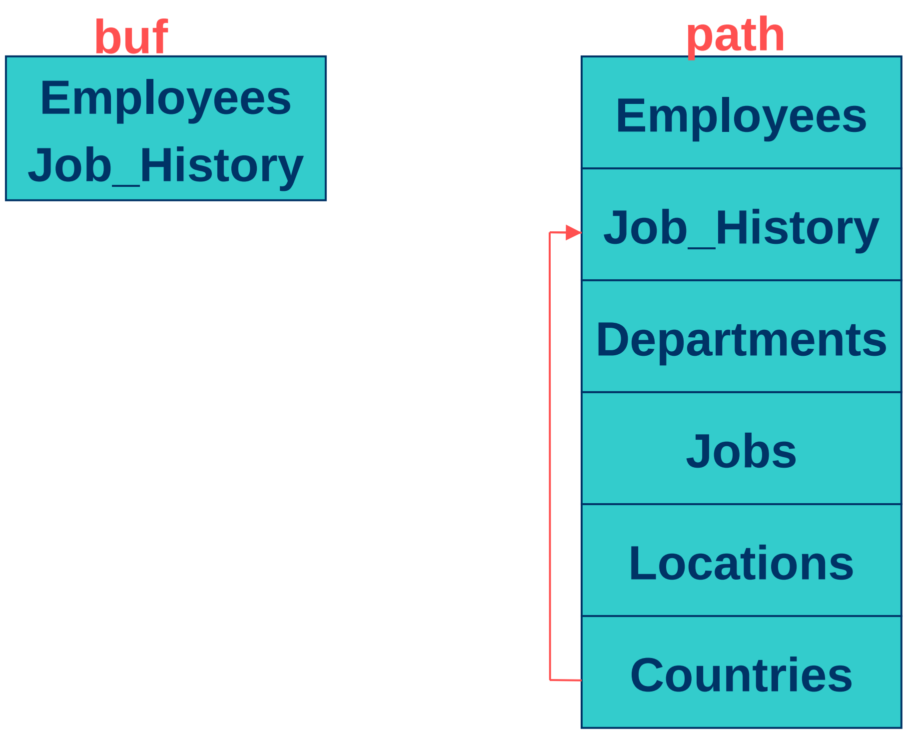

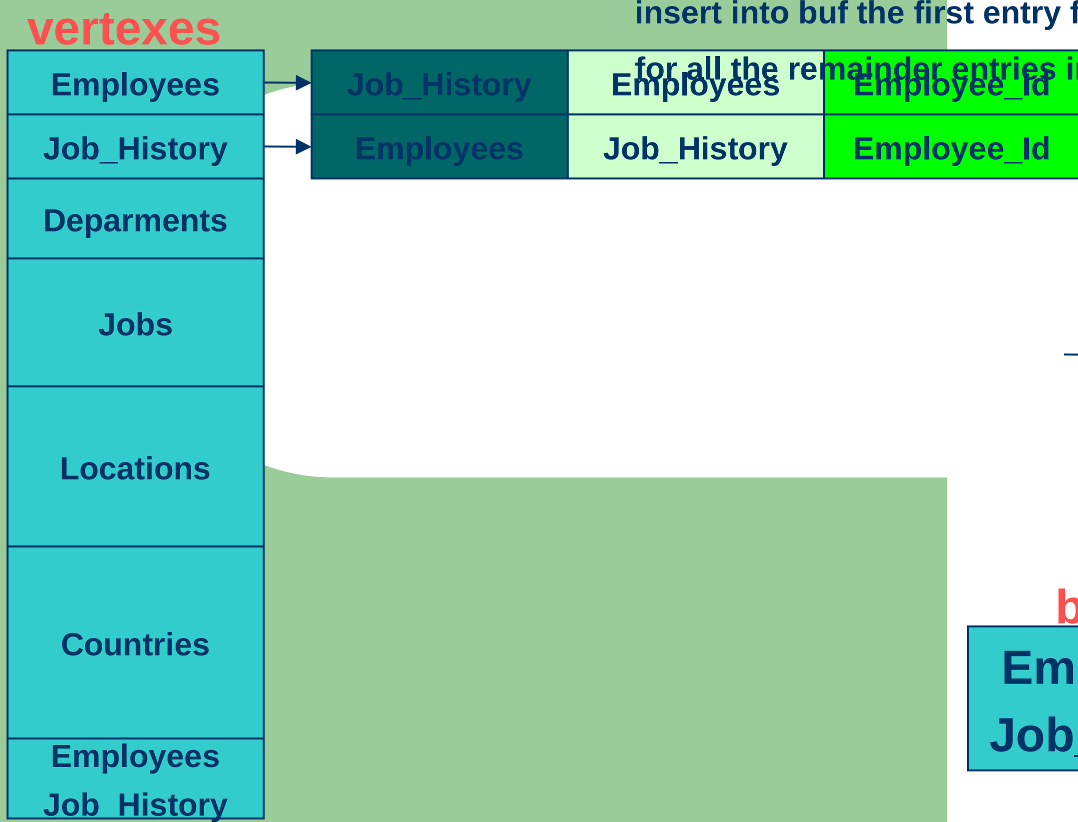

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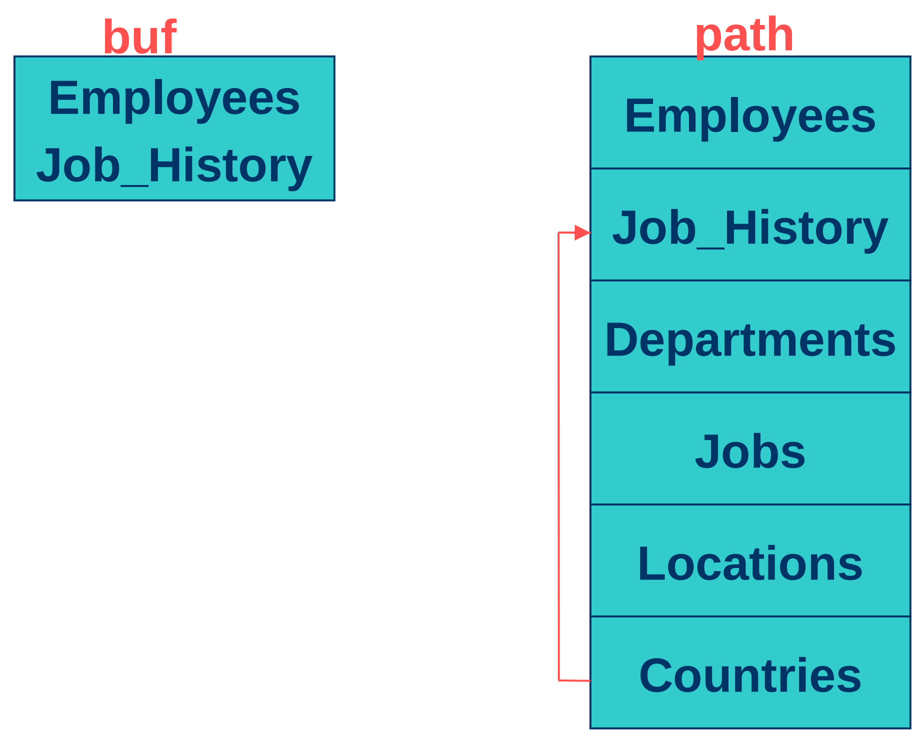

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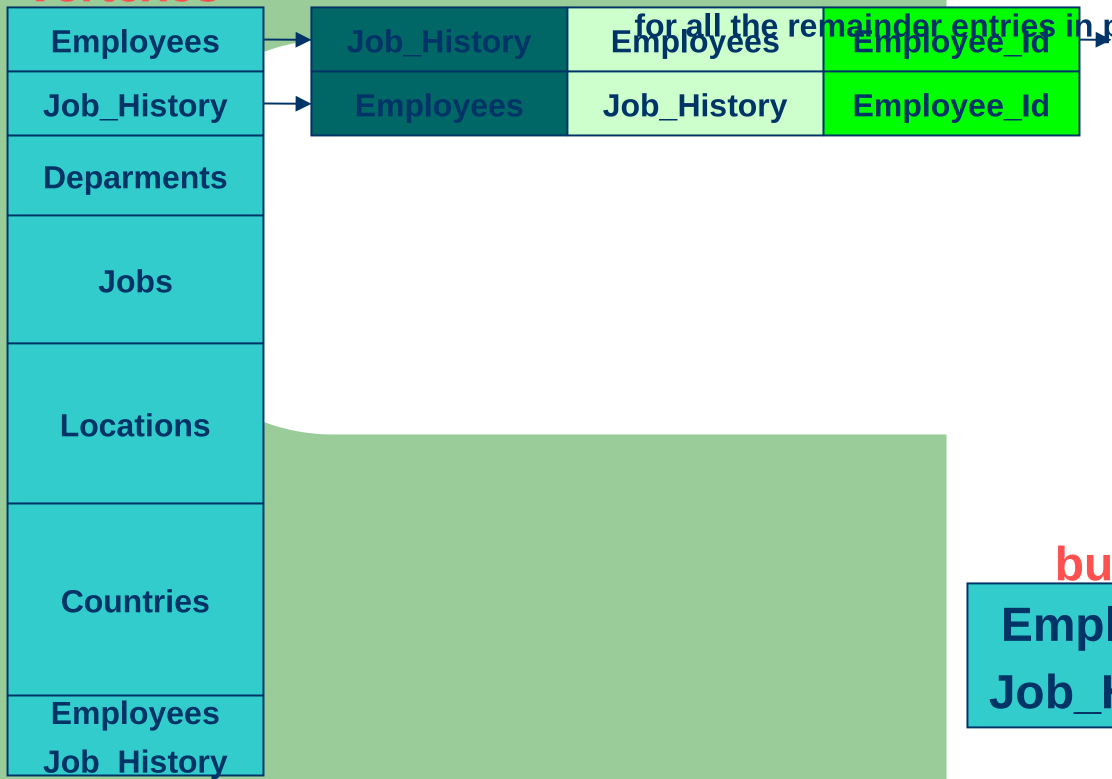
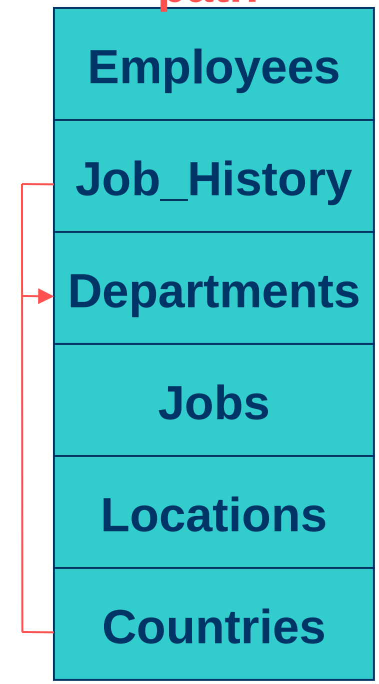
vertexes



buf

path



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$T_{[buf]} += T_i$

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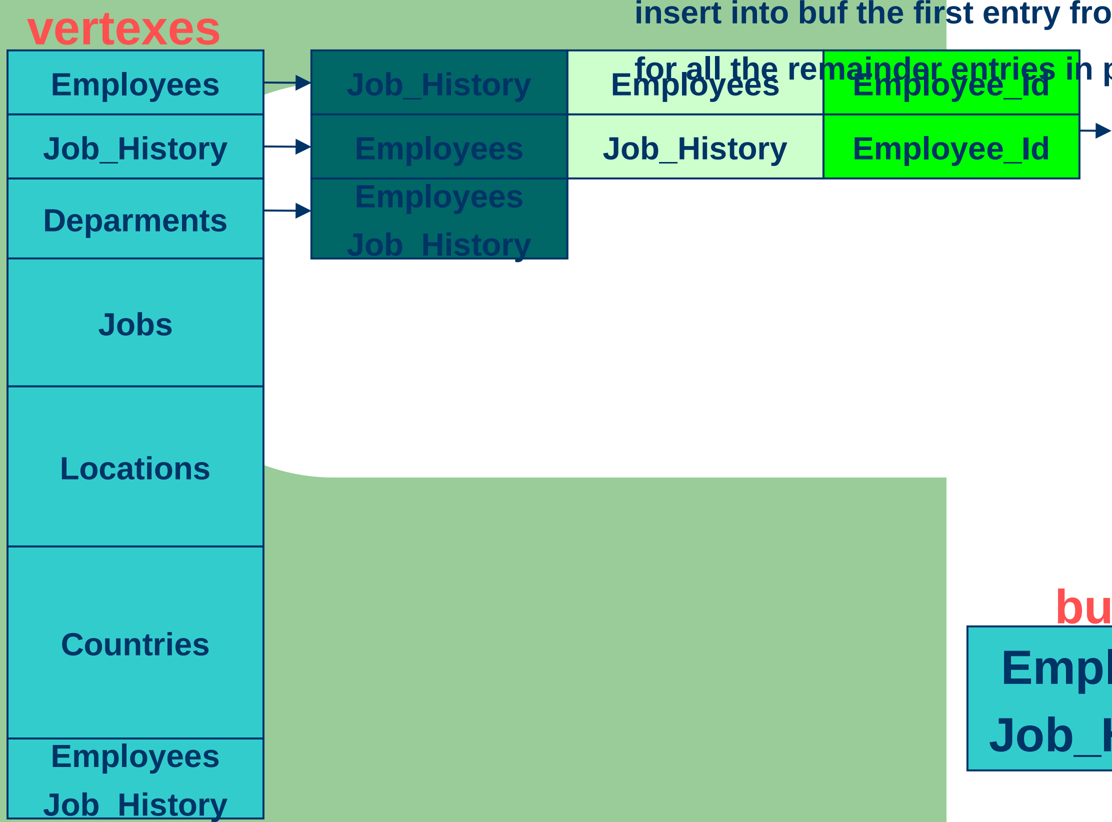

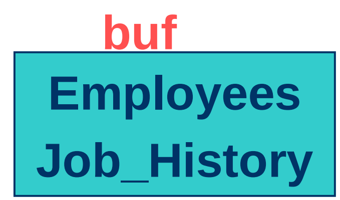

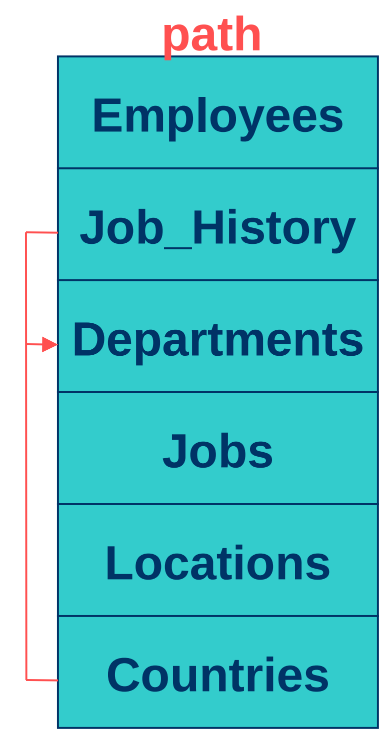

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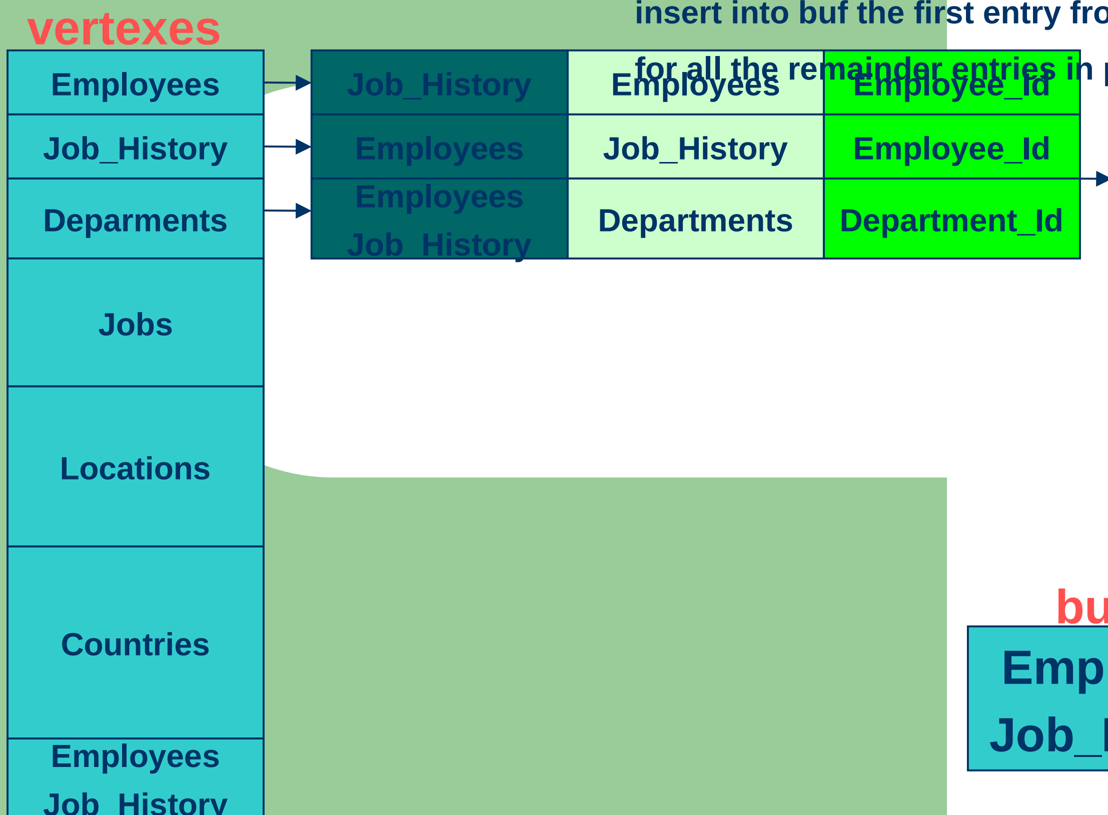

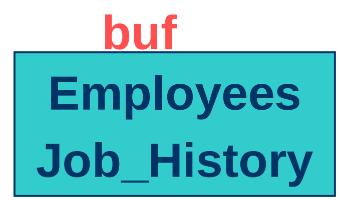

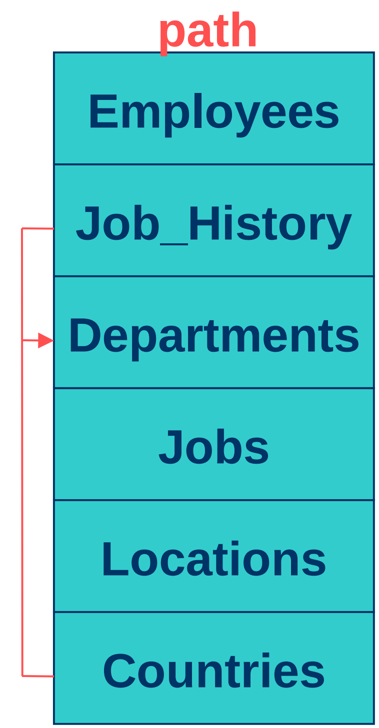

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$T_{[buf]} += T_i$

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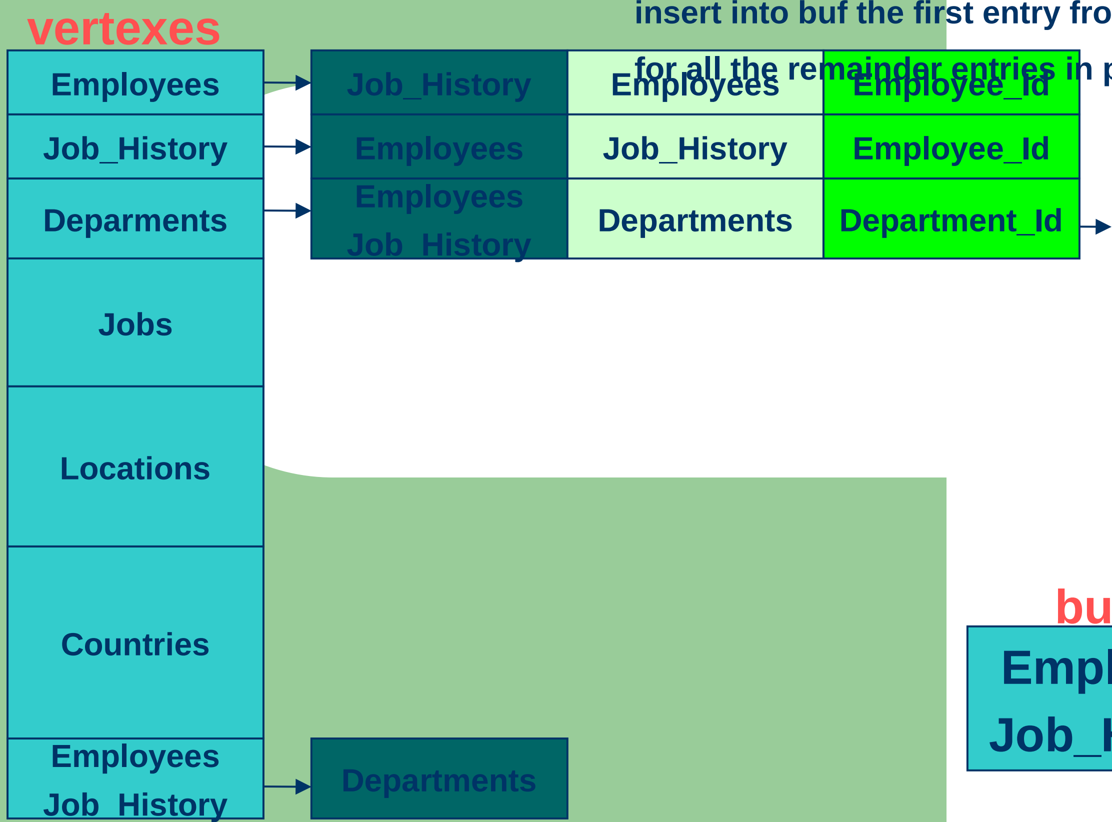

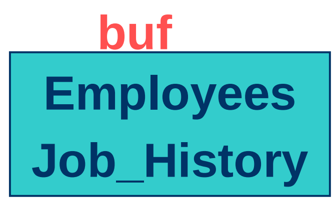

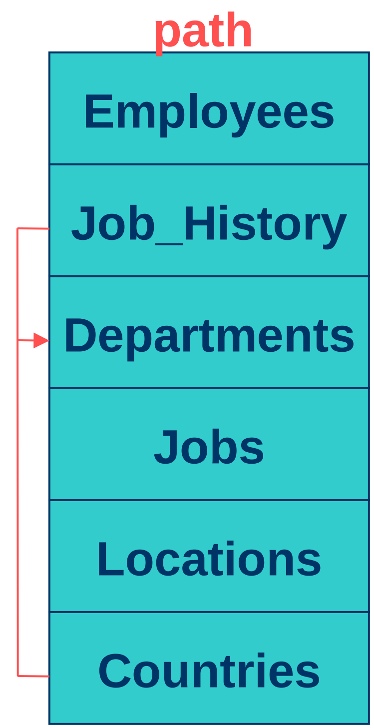

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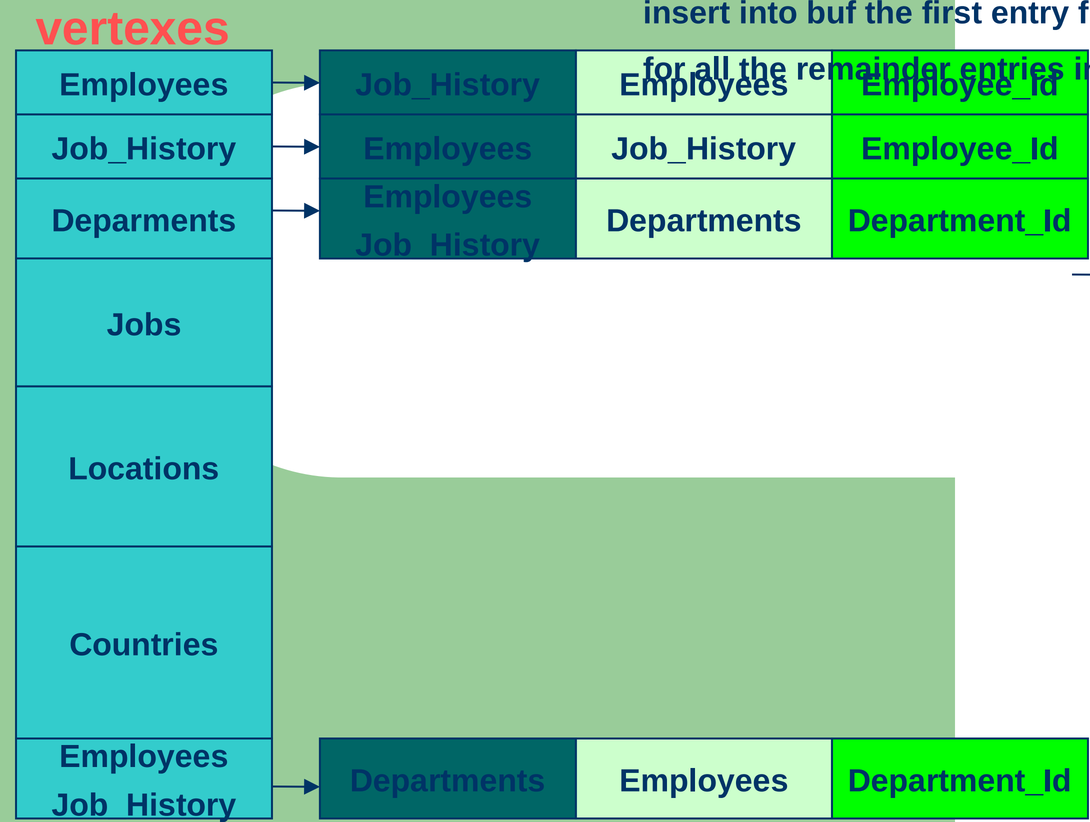

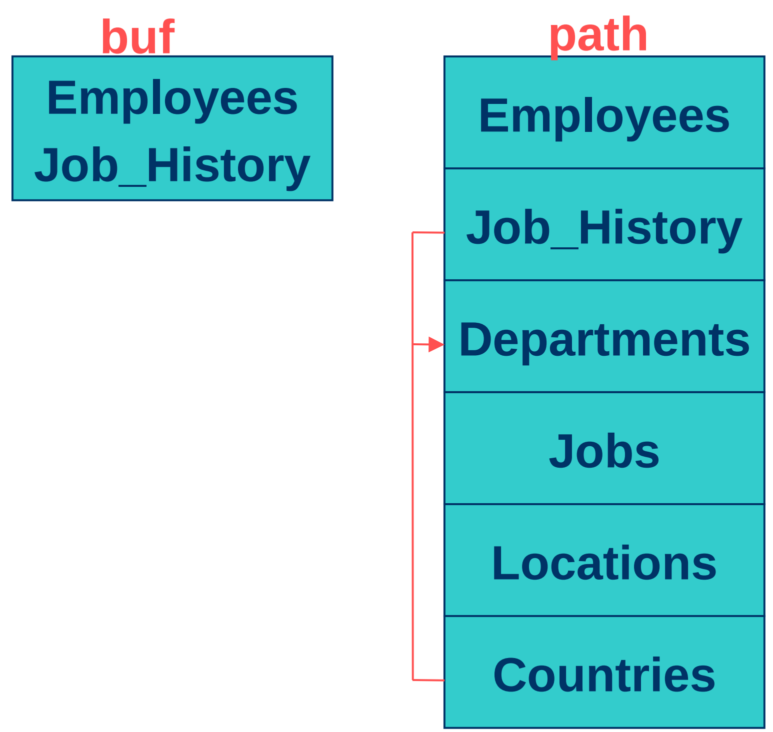

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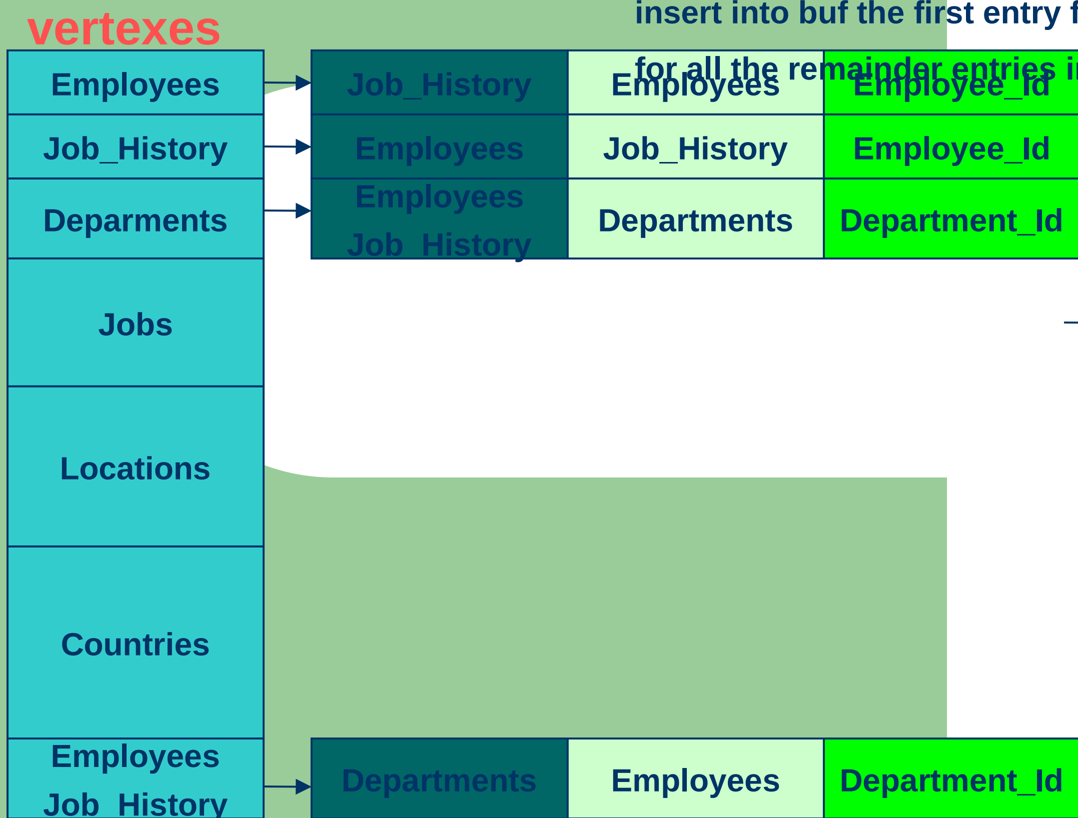

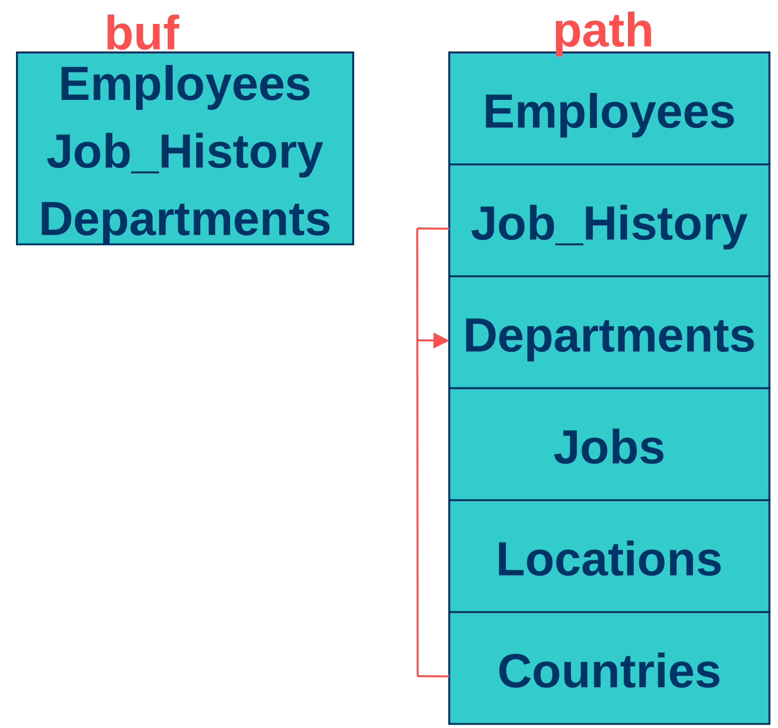

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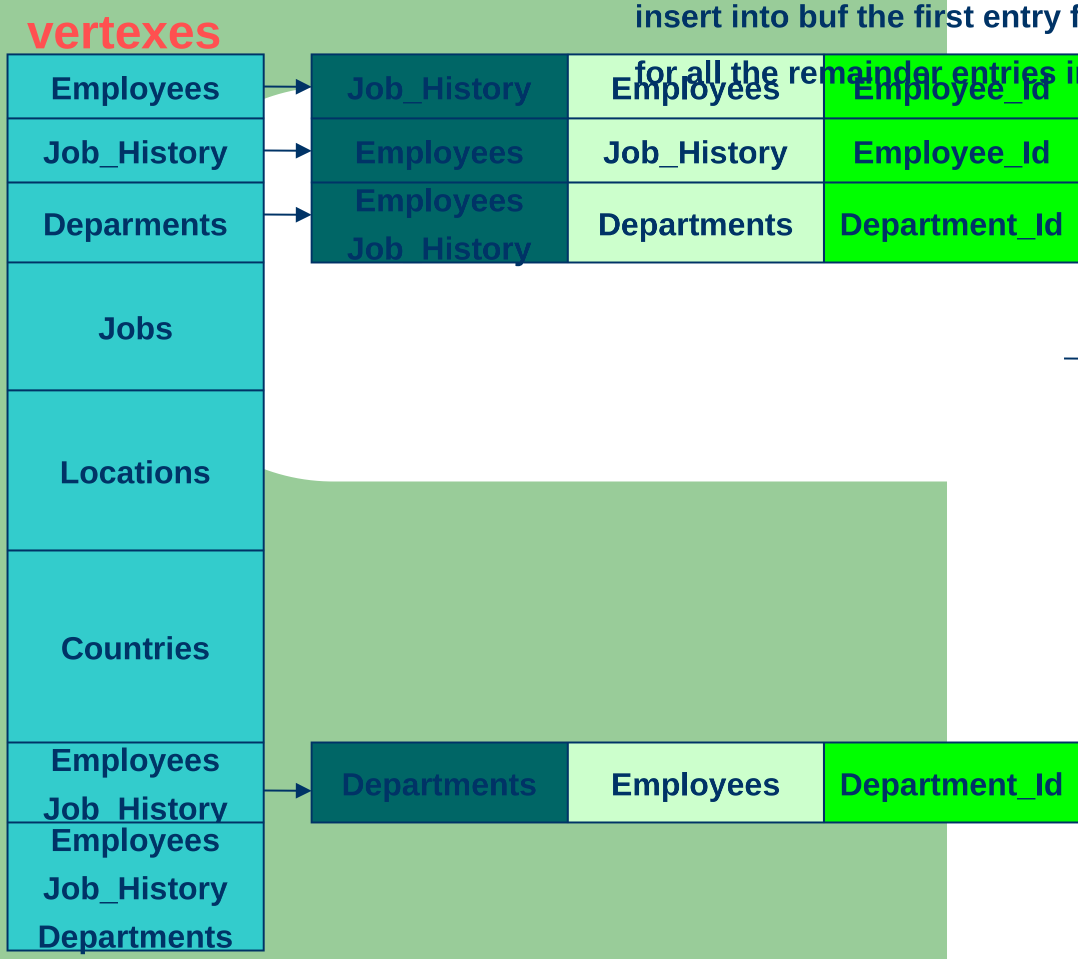

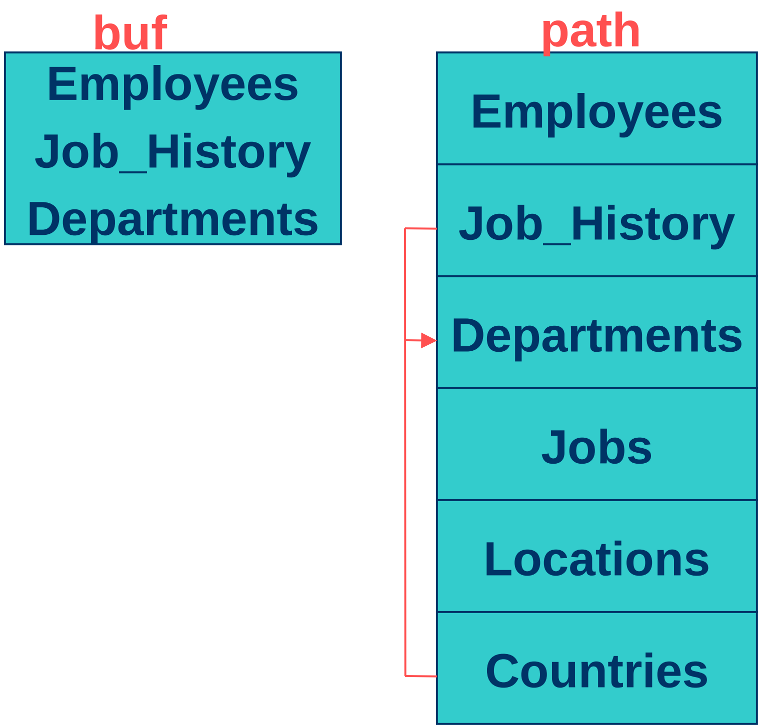

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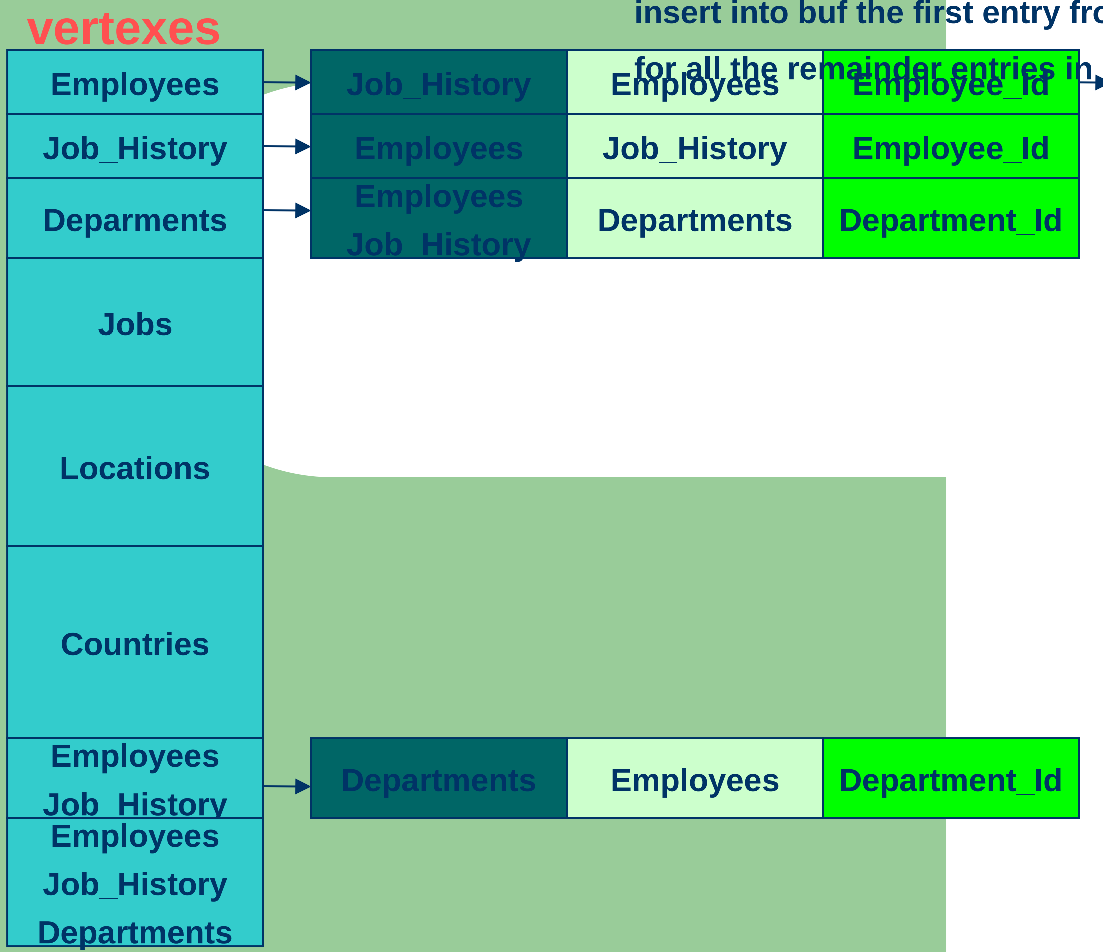

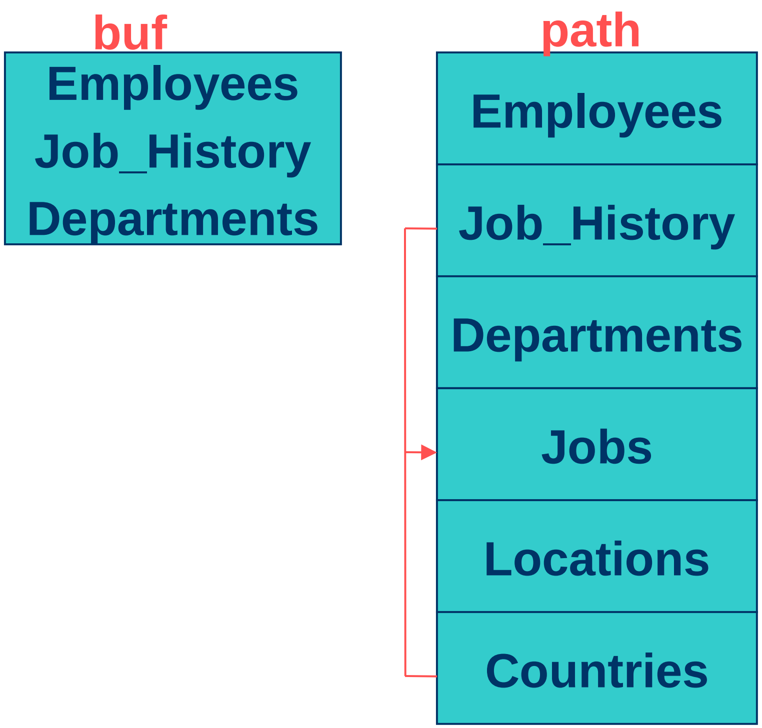

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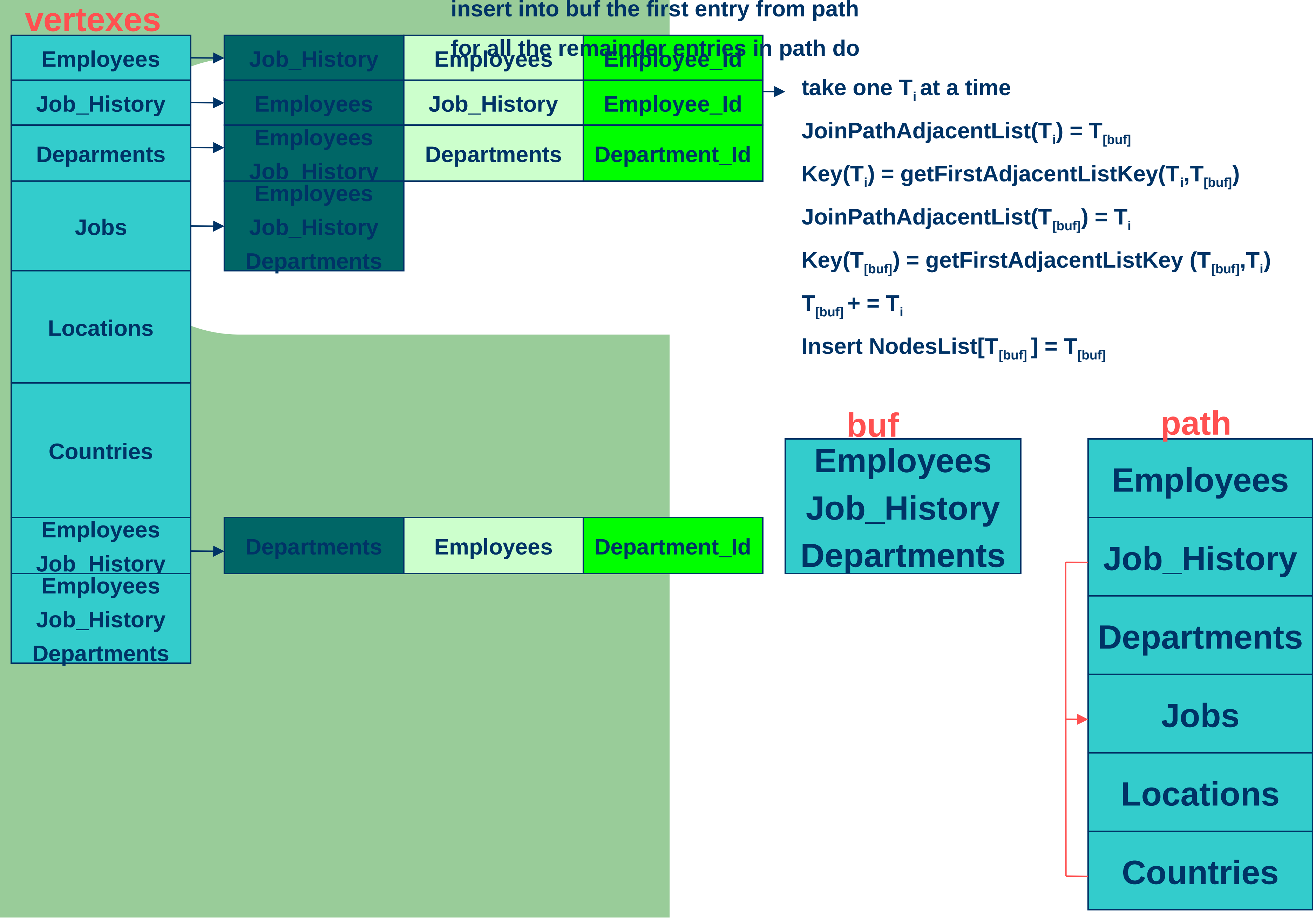

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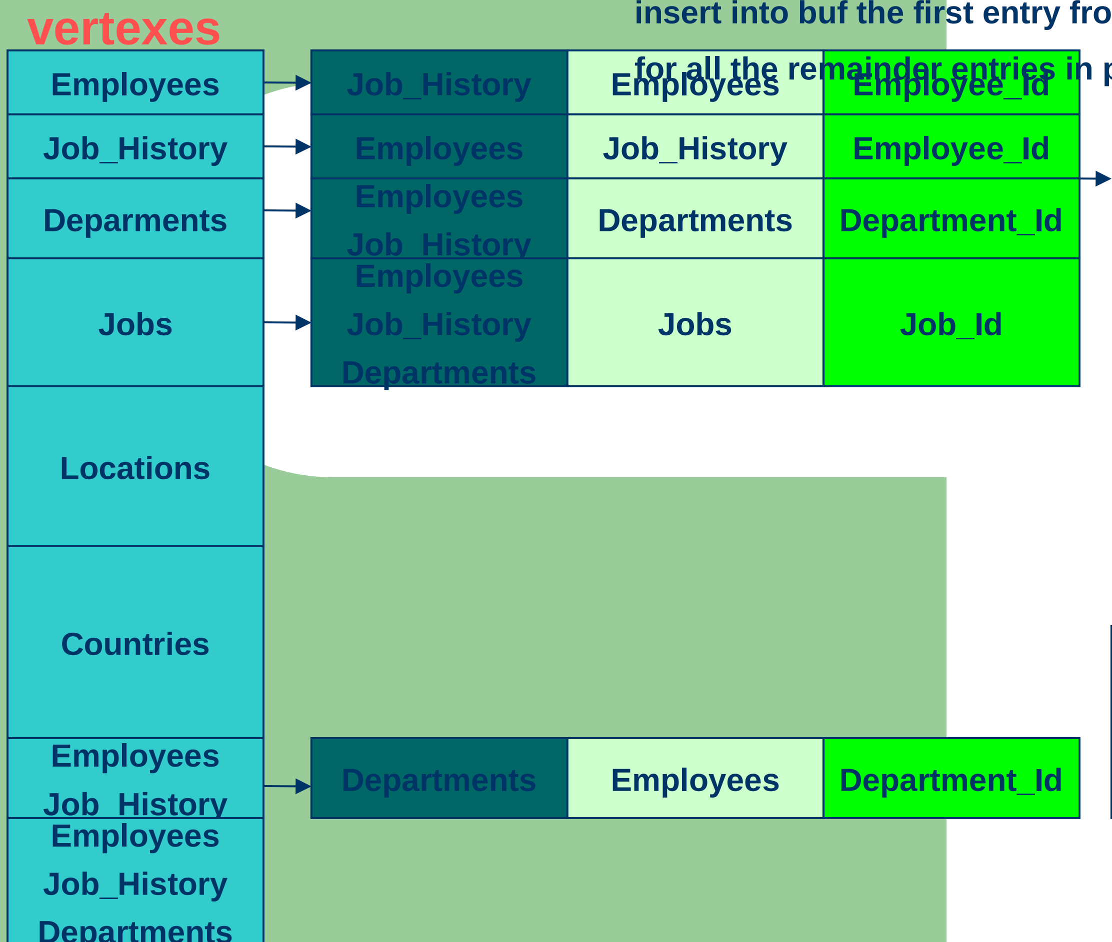

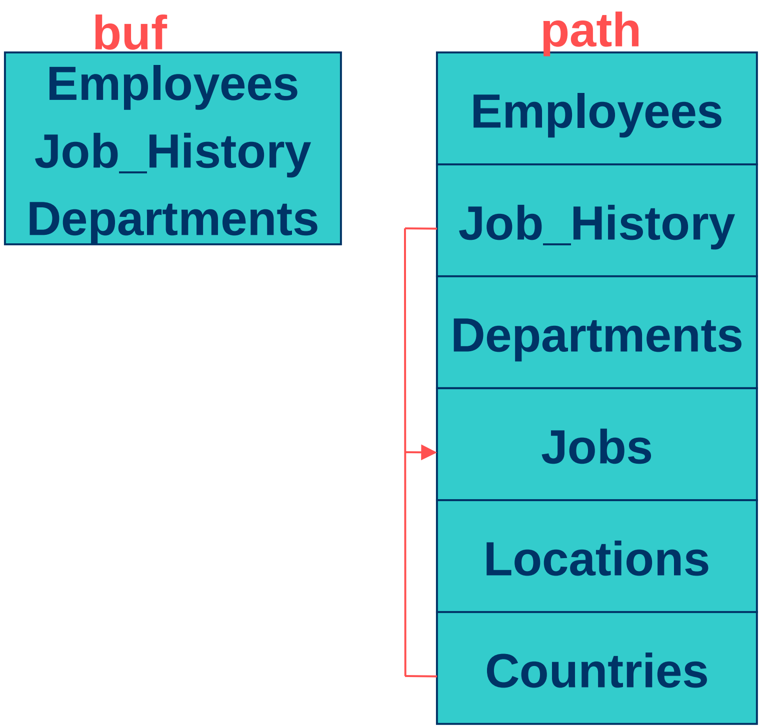

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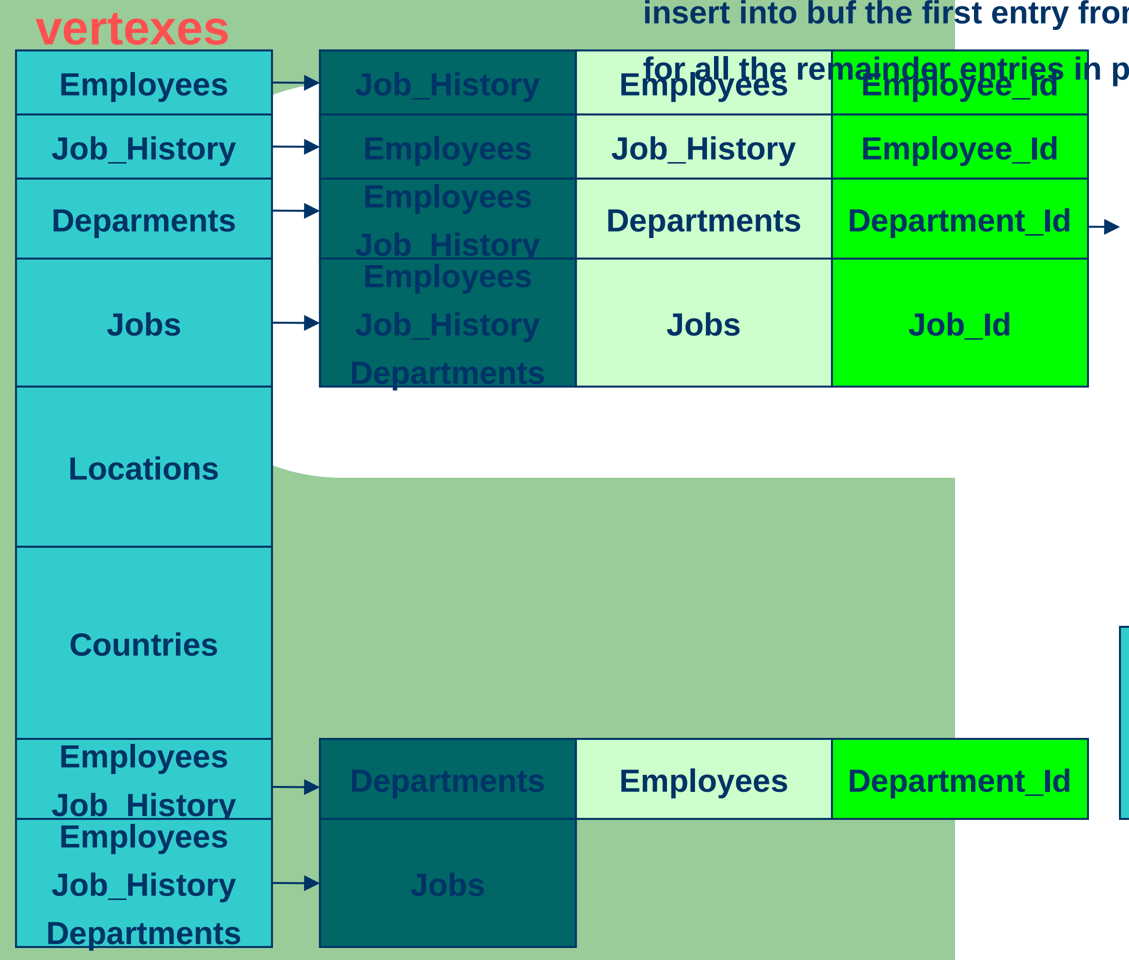

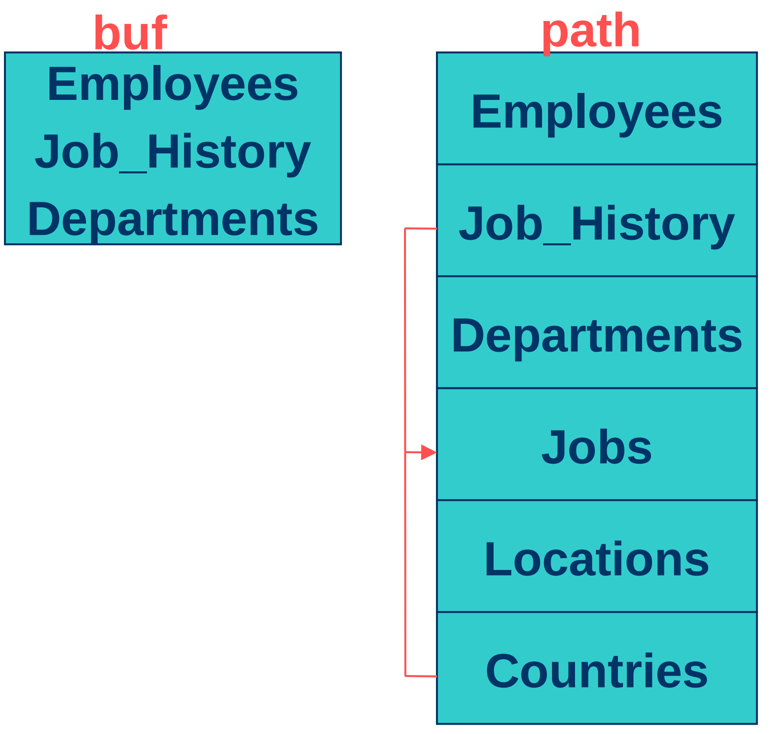

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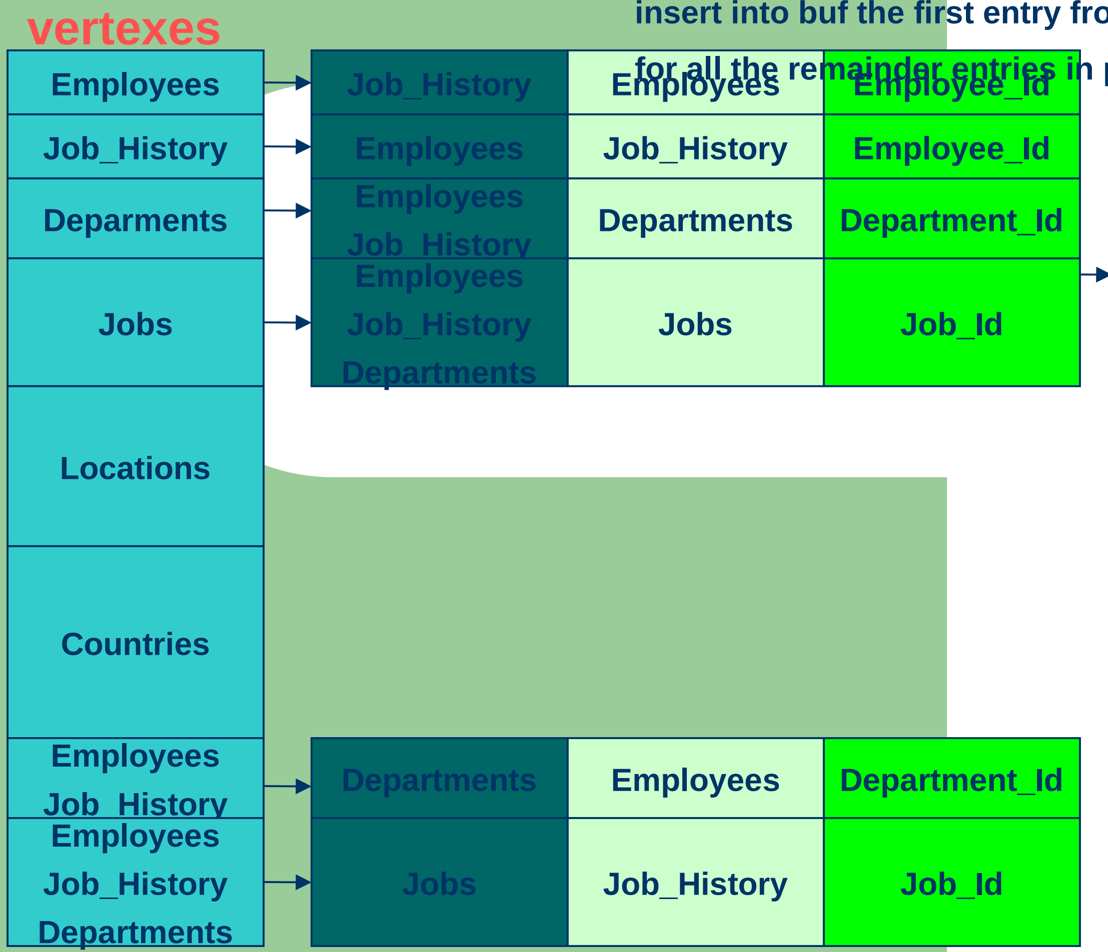

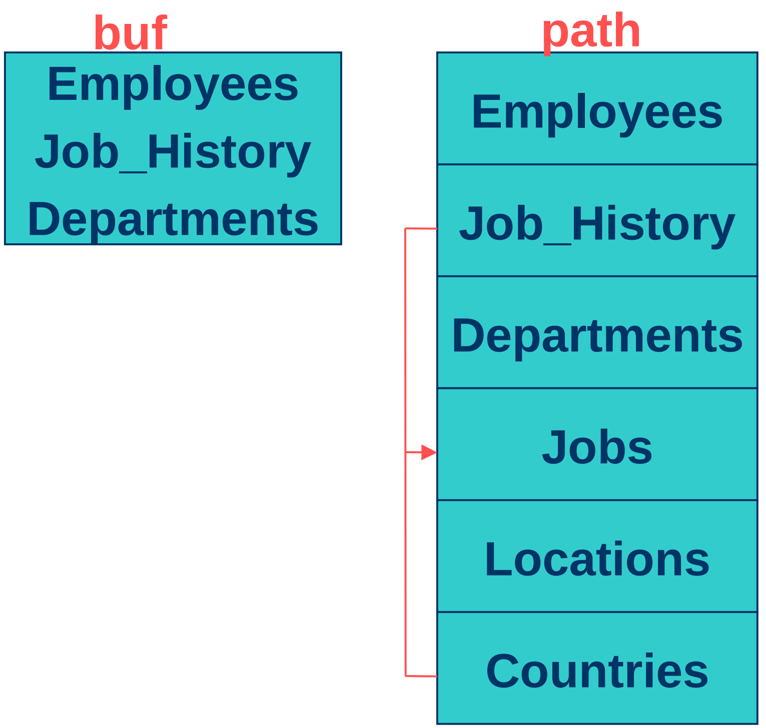

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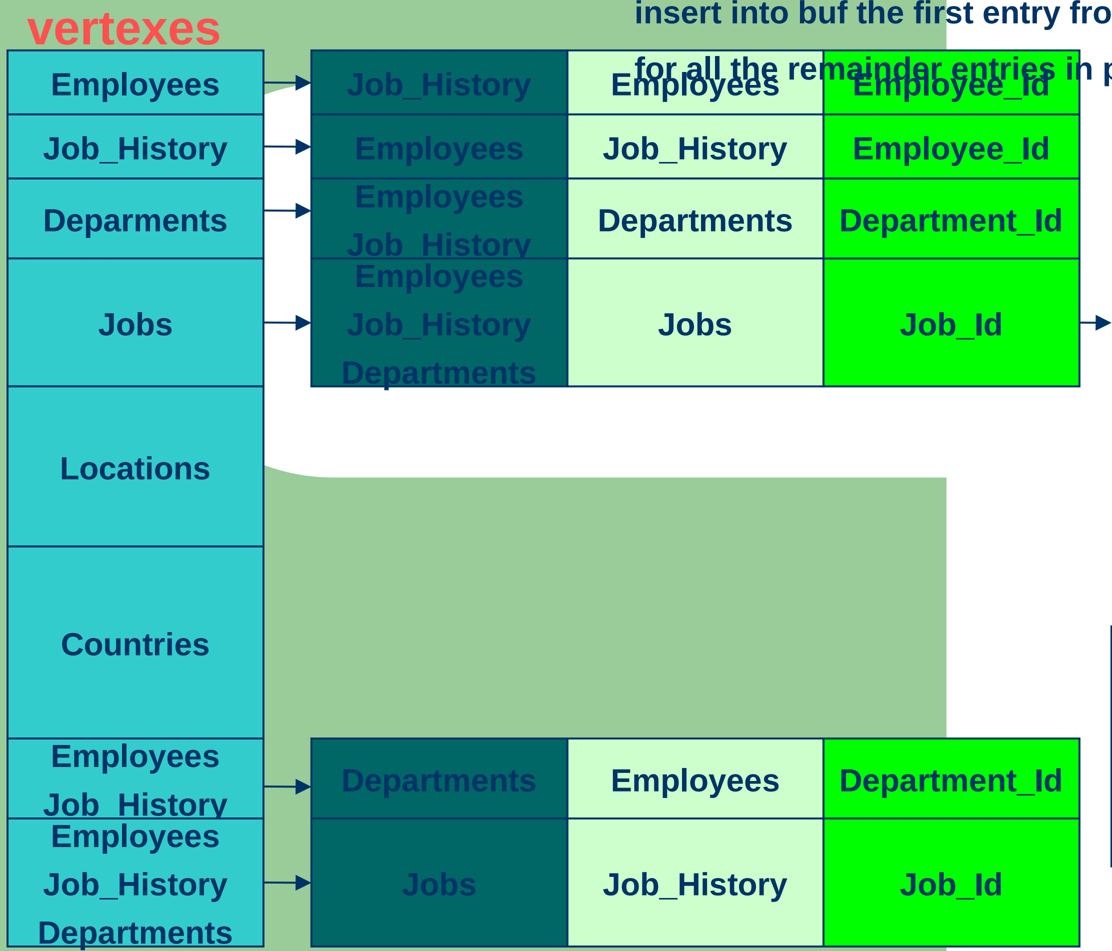

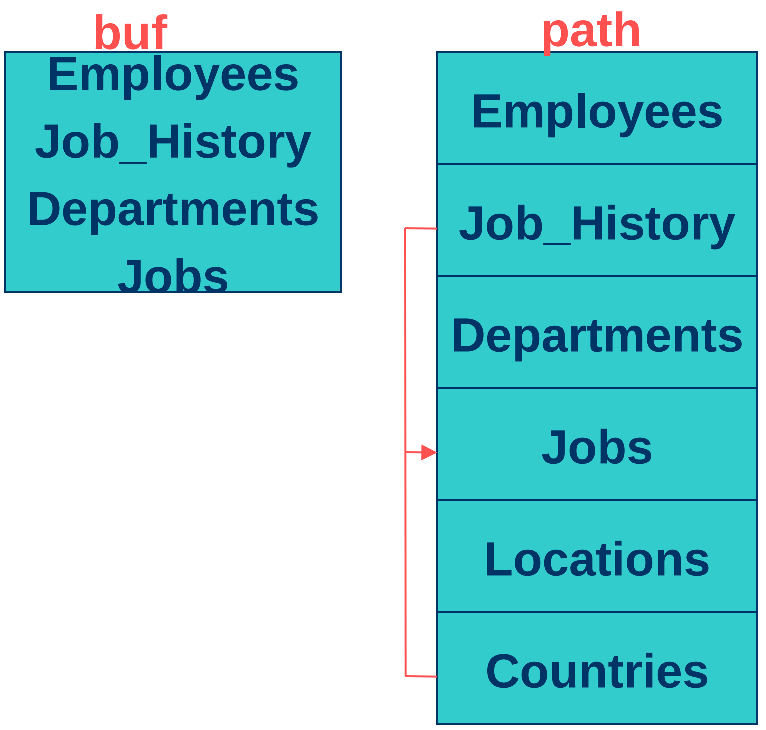

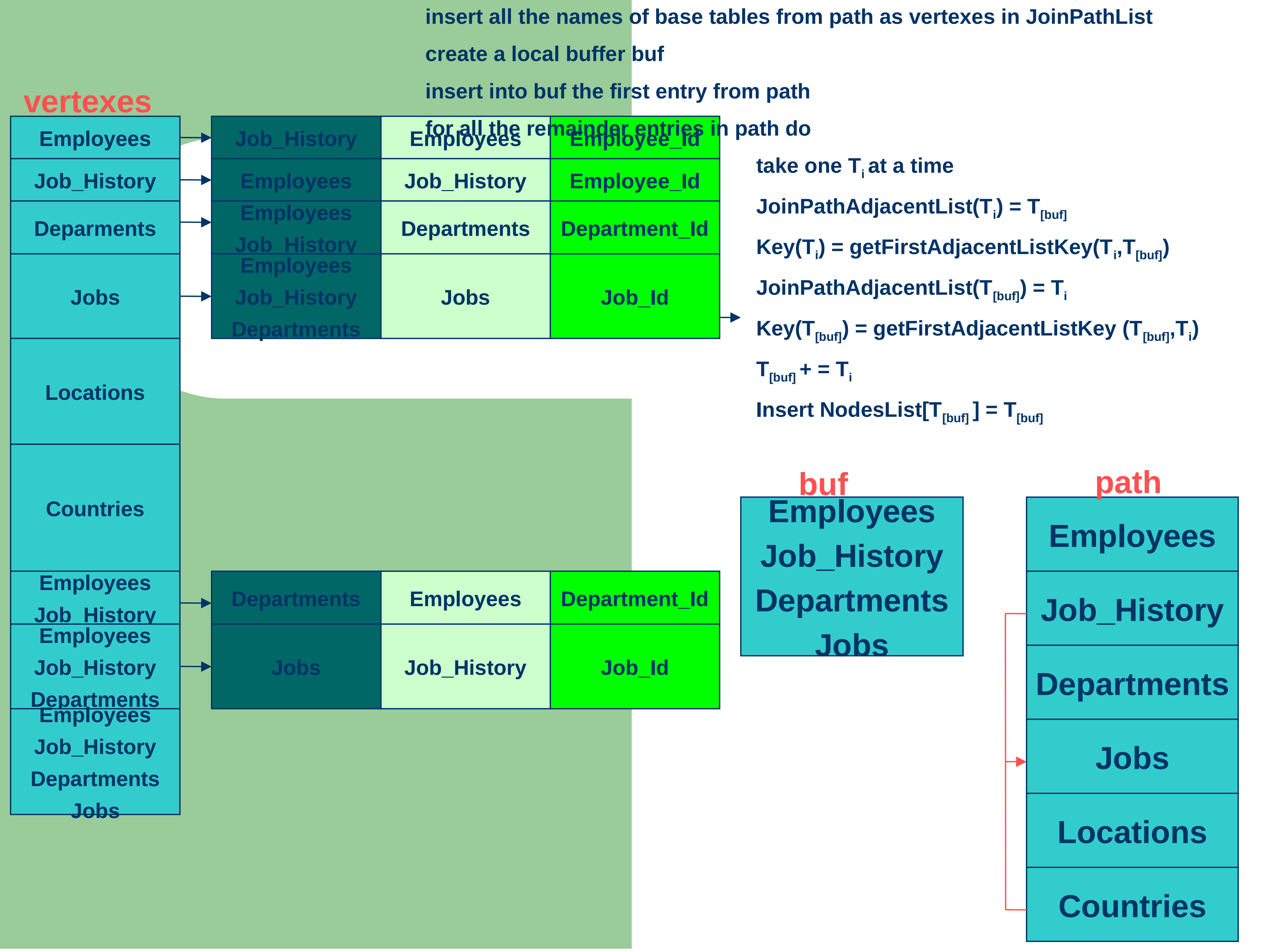

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vertexes
Employees
Job_History
Deparments
Jobs
Locations
Countries
Employees Job_History
Employees Job_History Departments
Employees Job_History Departments Jobs
Job_History | Employees | Employee_Id
Employees | Job_History | Employee_Id
Employees Job_History | Departments | Department_Id
Employees Job_History Departments | Jobs | Job_Id
Departments | Employees | Department_Id
Jobs | Job_History | Job_Id
buf
Employees
Job_History
Departments
Jobs
path
Employees
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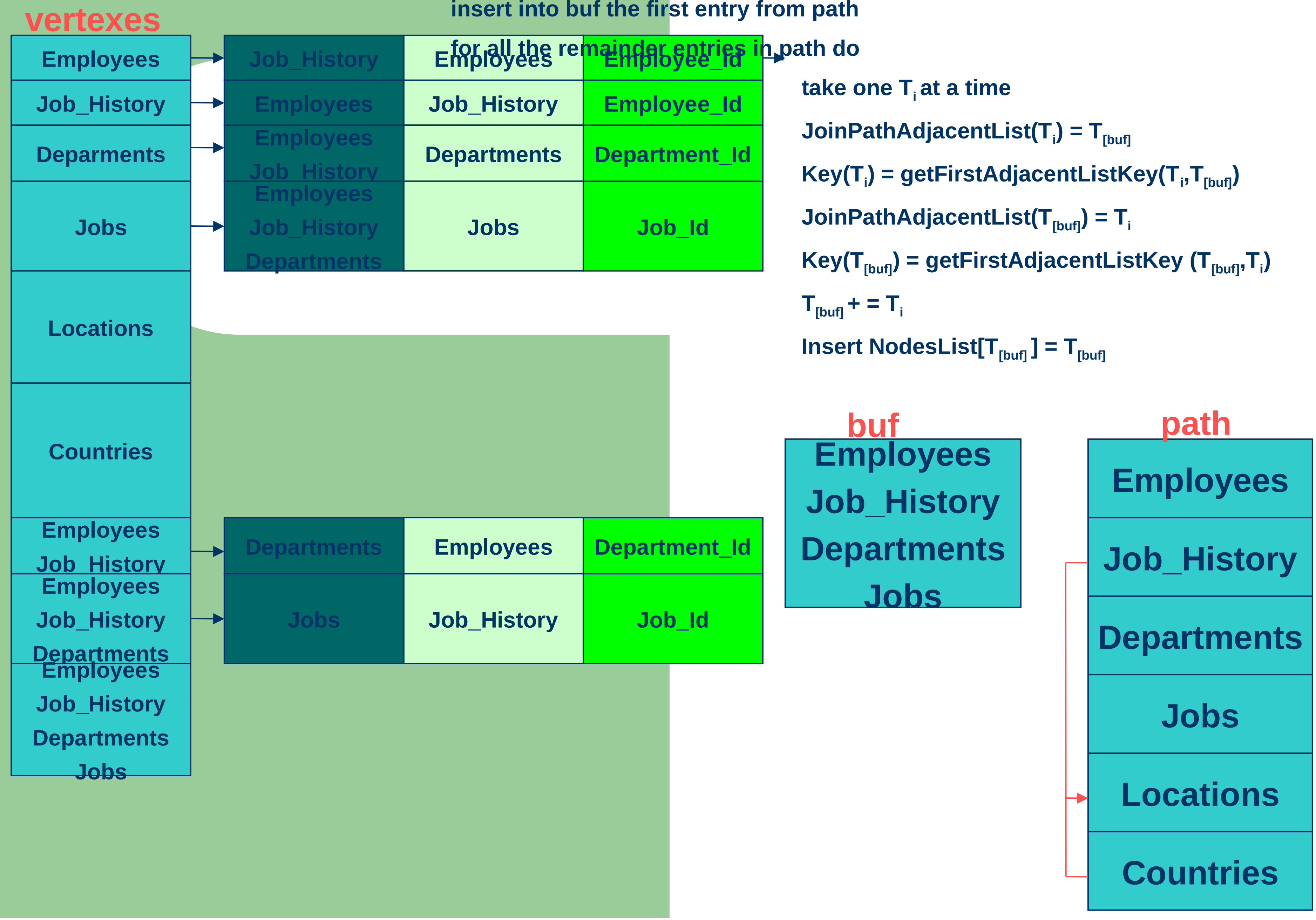

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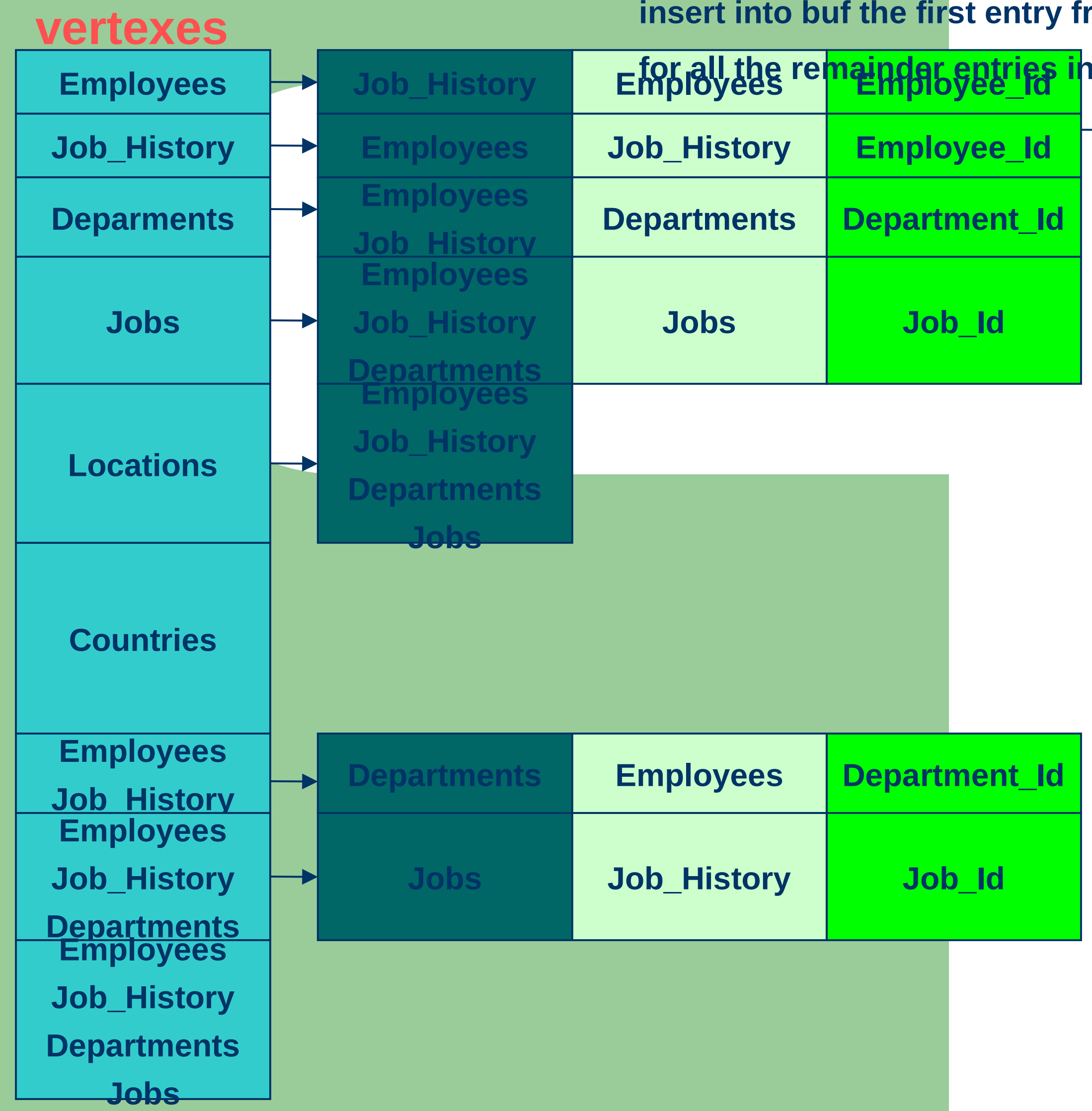

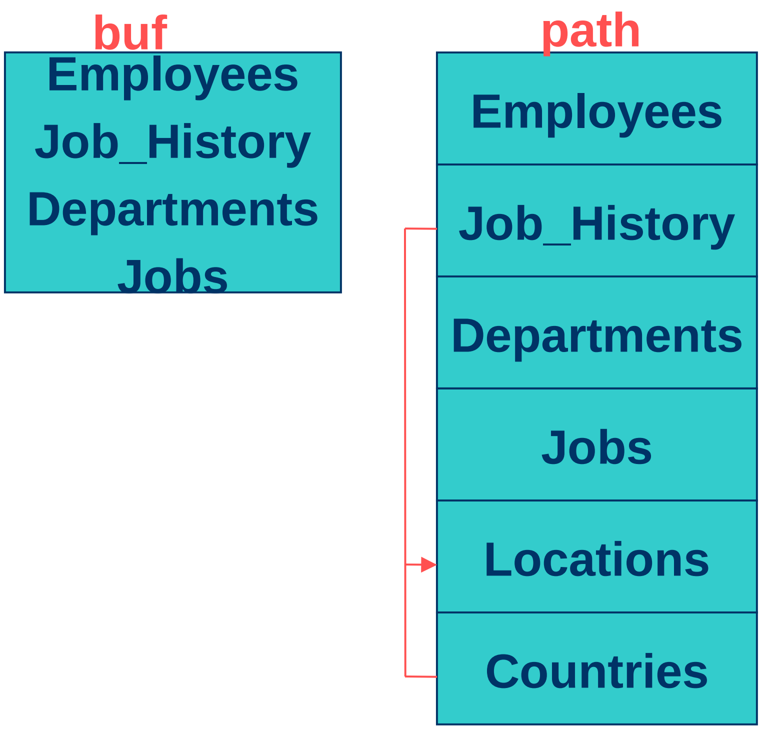

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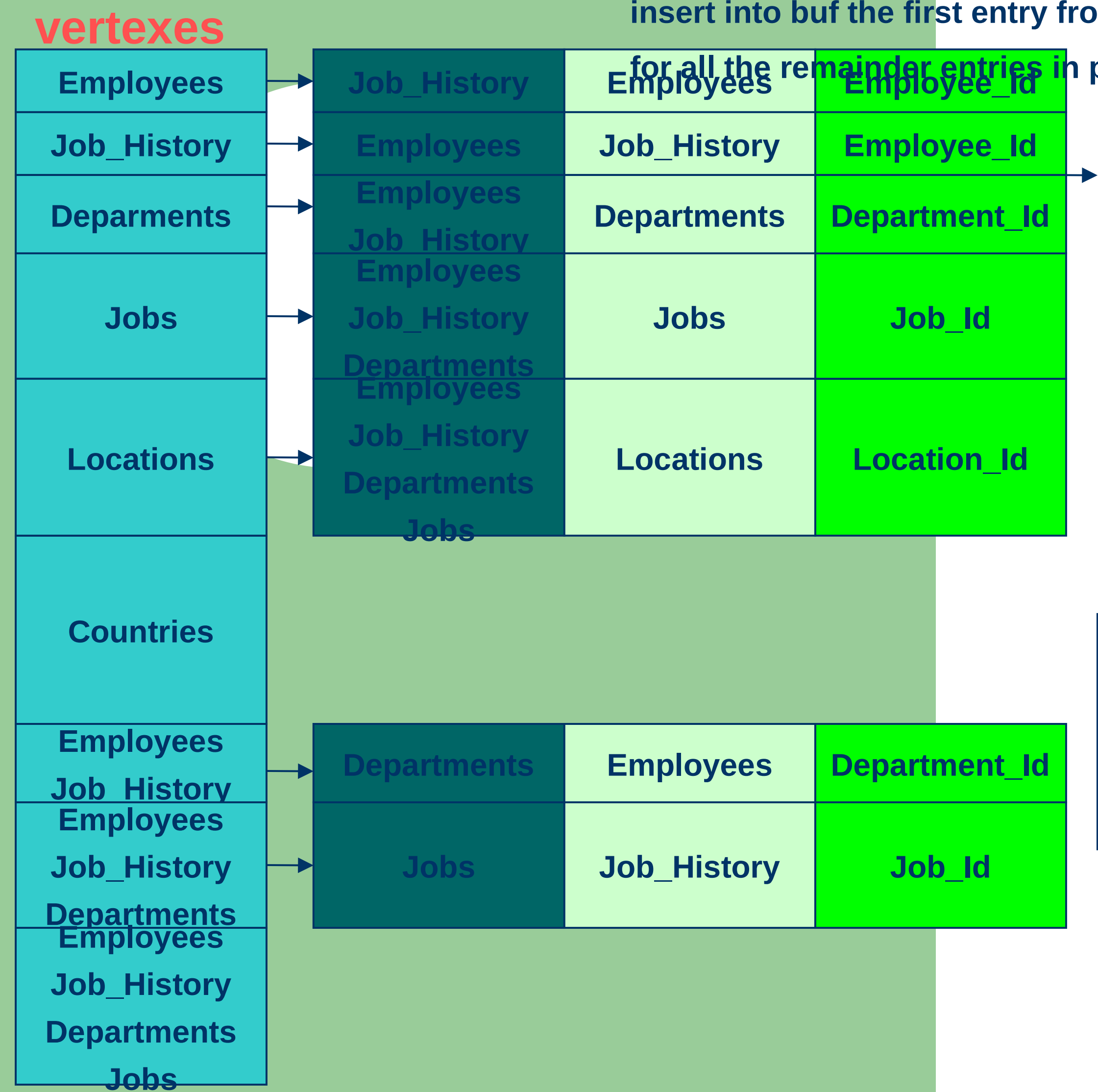

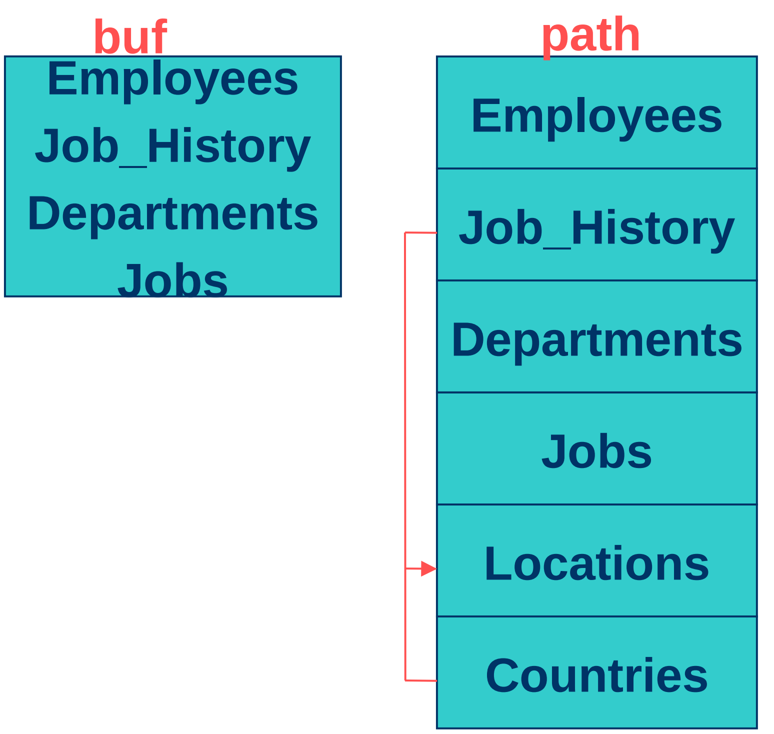

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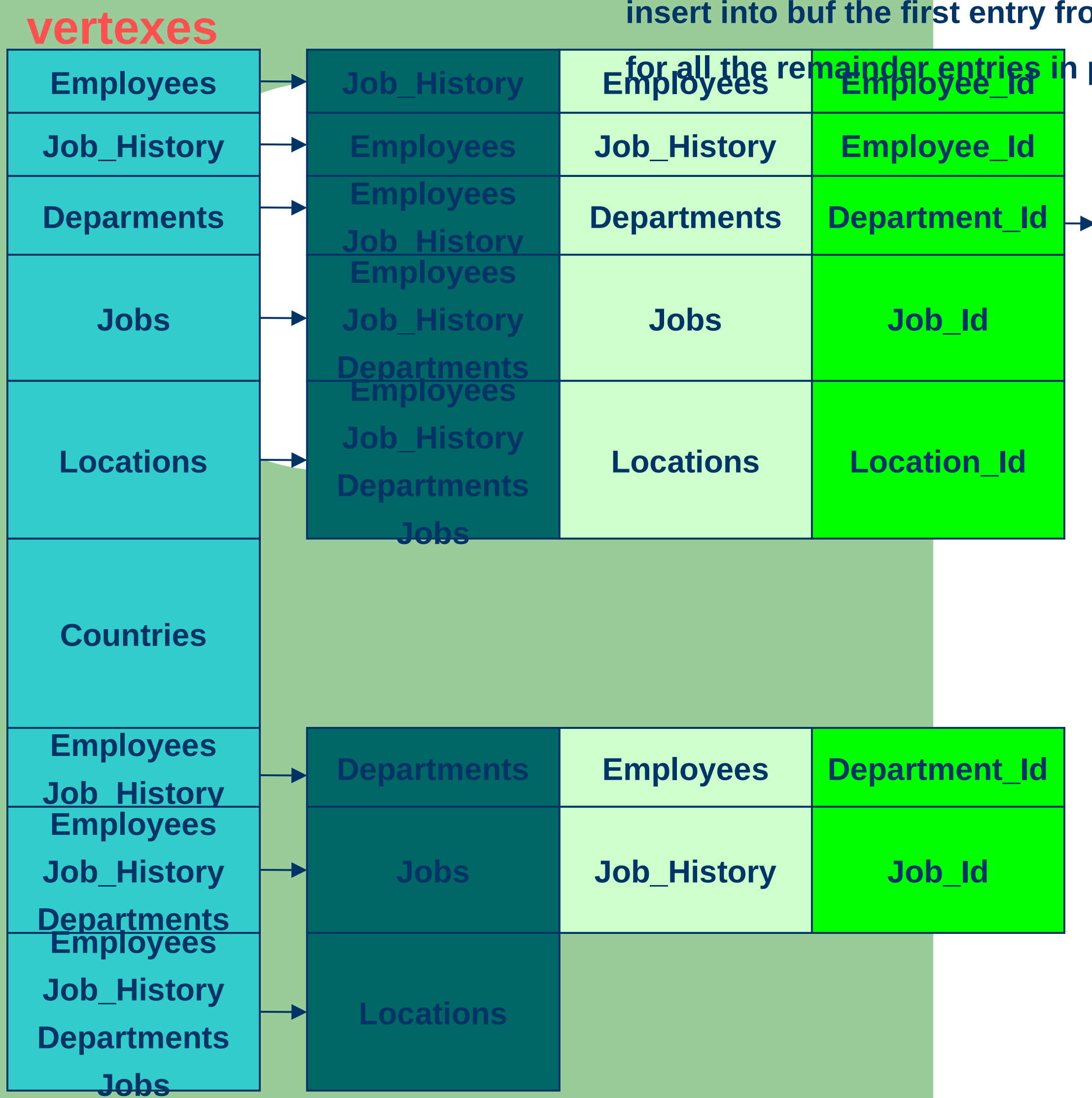

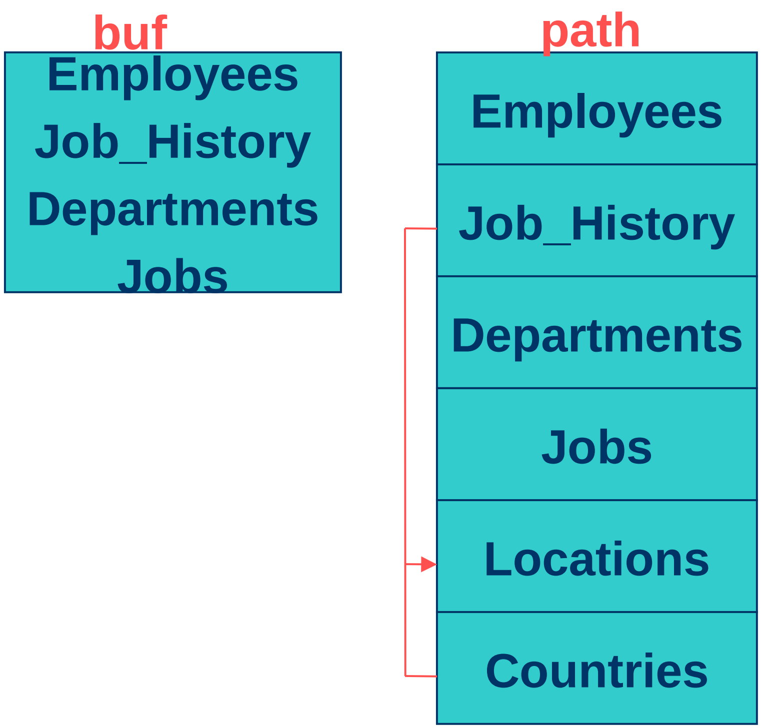

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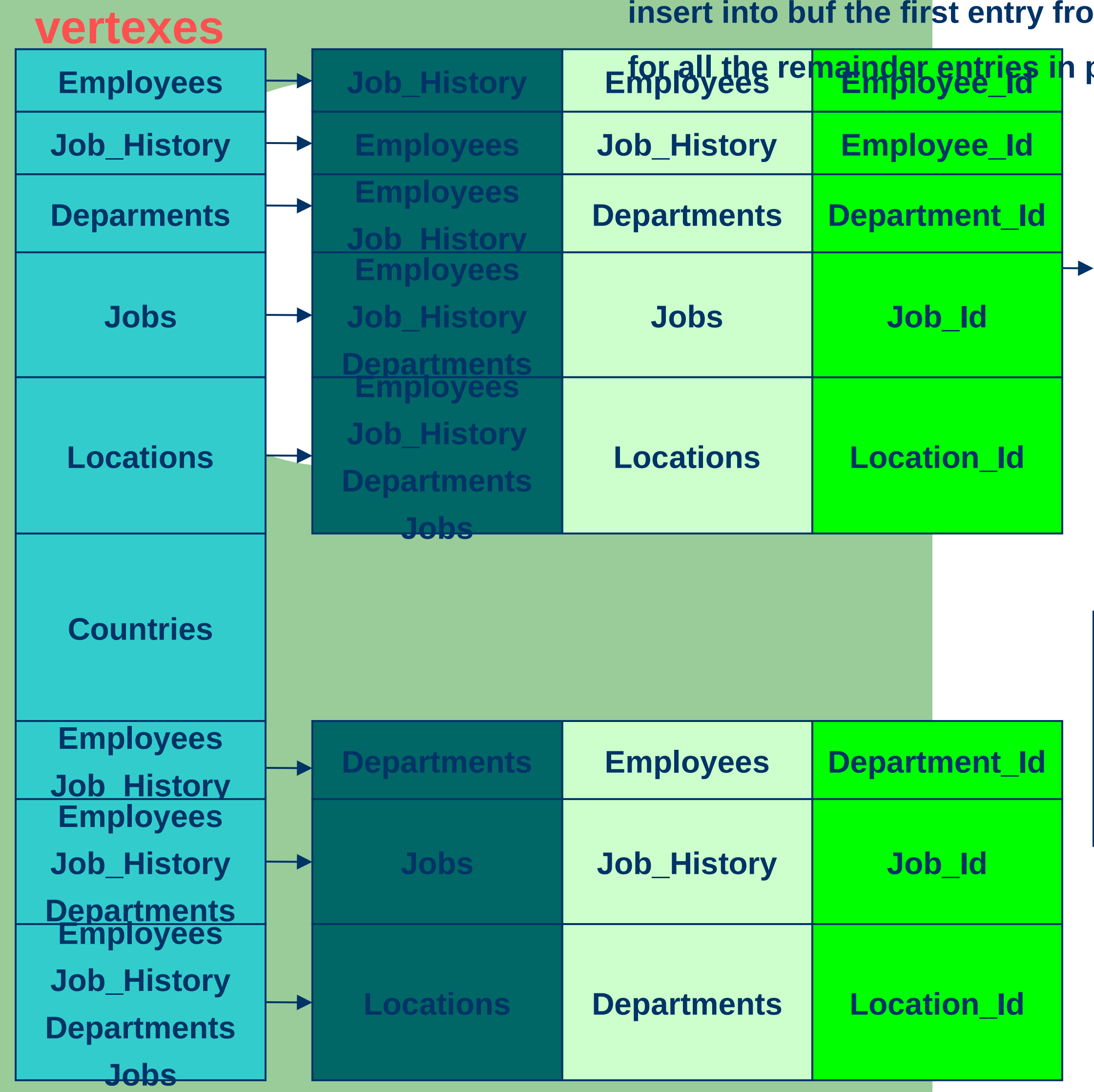

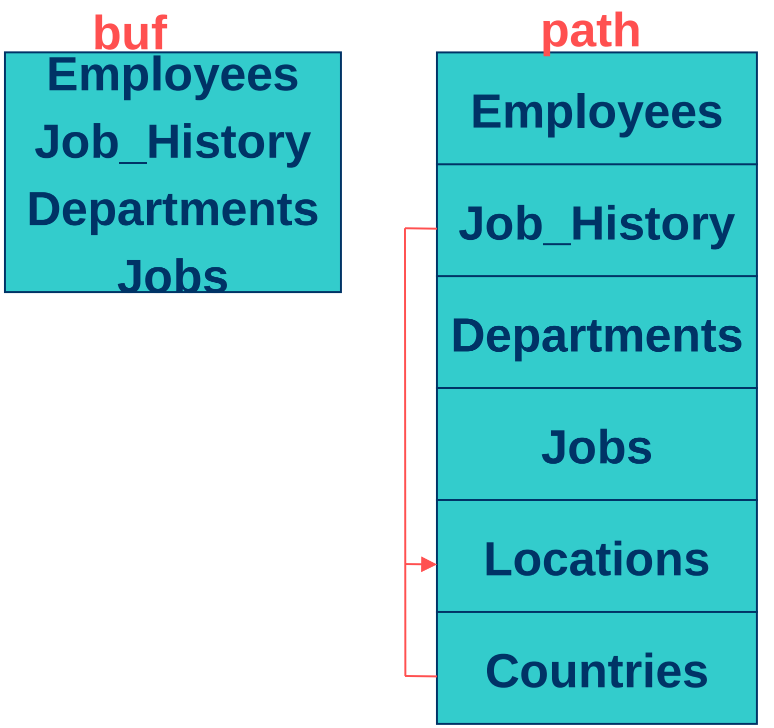

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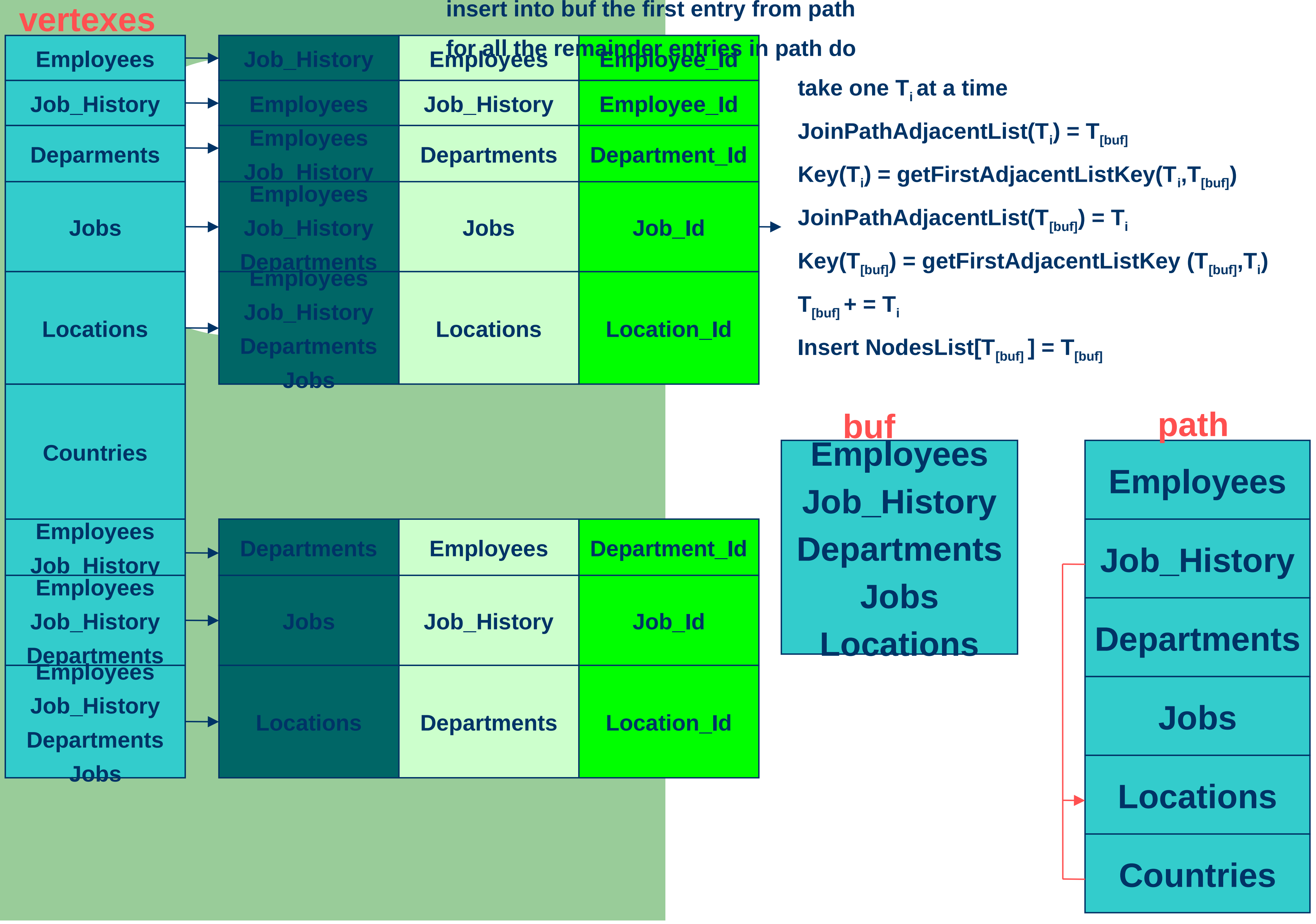

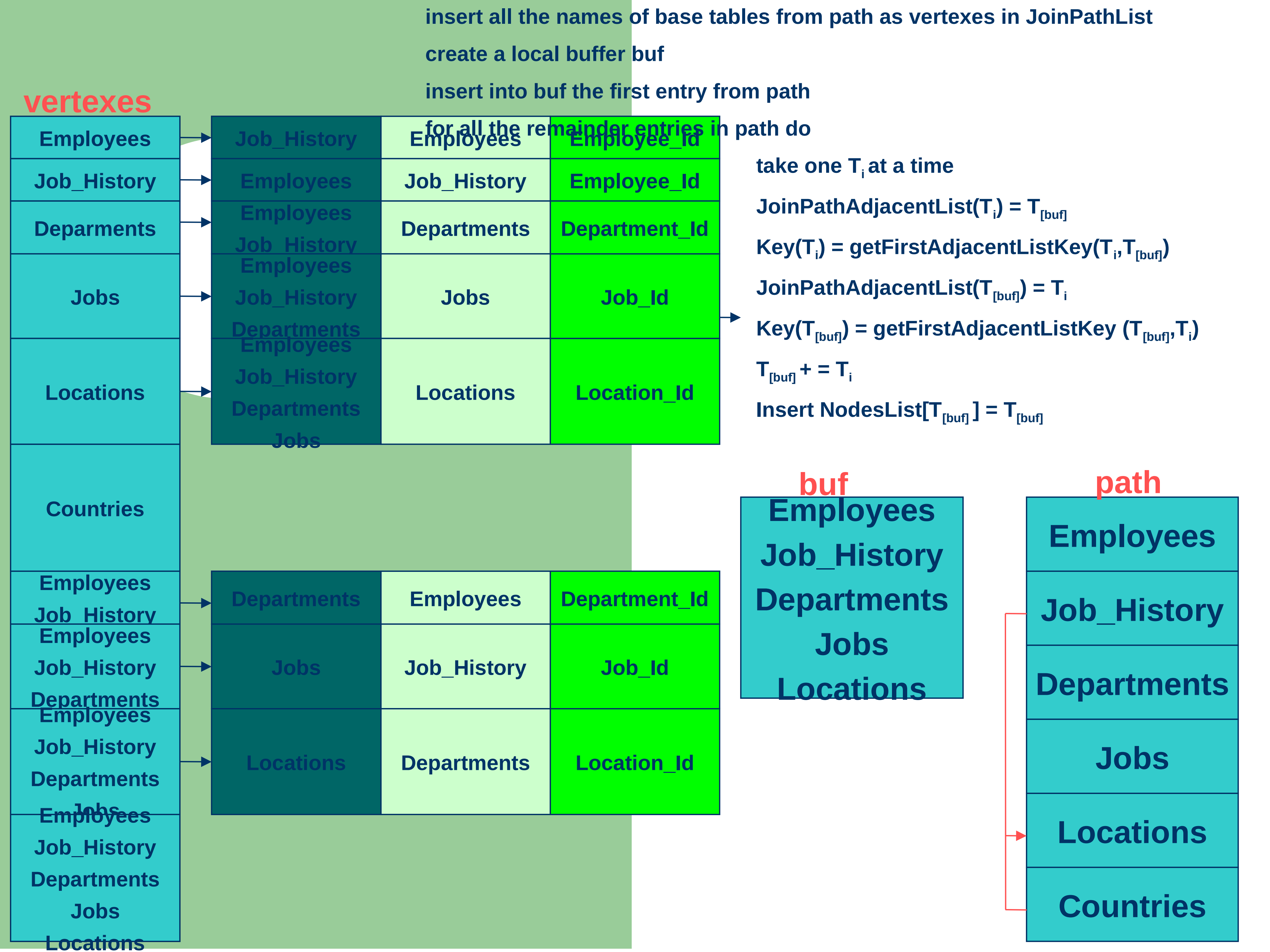
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vertexes
Employees
Job_History
Deparments
Jobs
Locations
Countries
Employees Job_History
Employees Job_History Departments
Employees Job_History Departments Jobs
Employees Job_History Departments Jobs Locations
Job_History
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Locations
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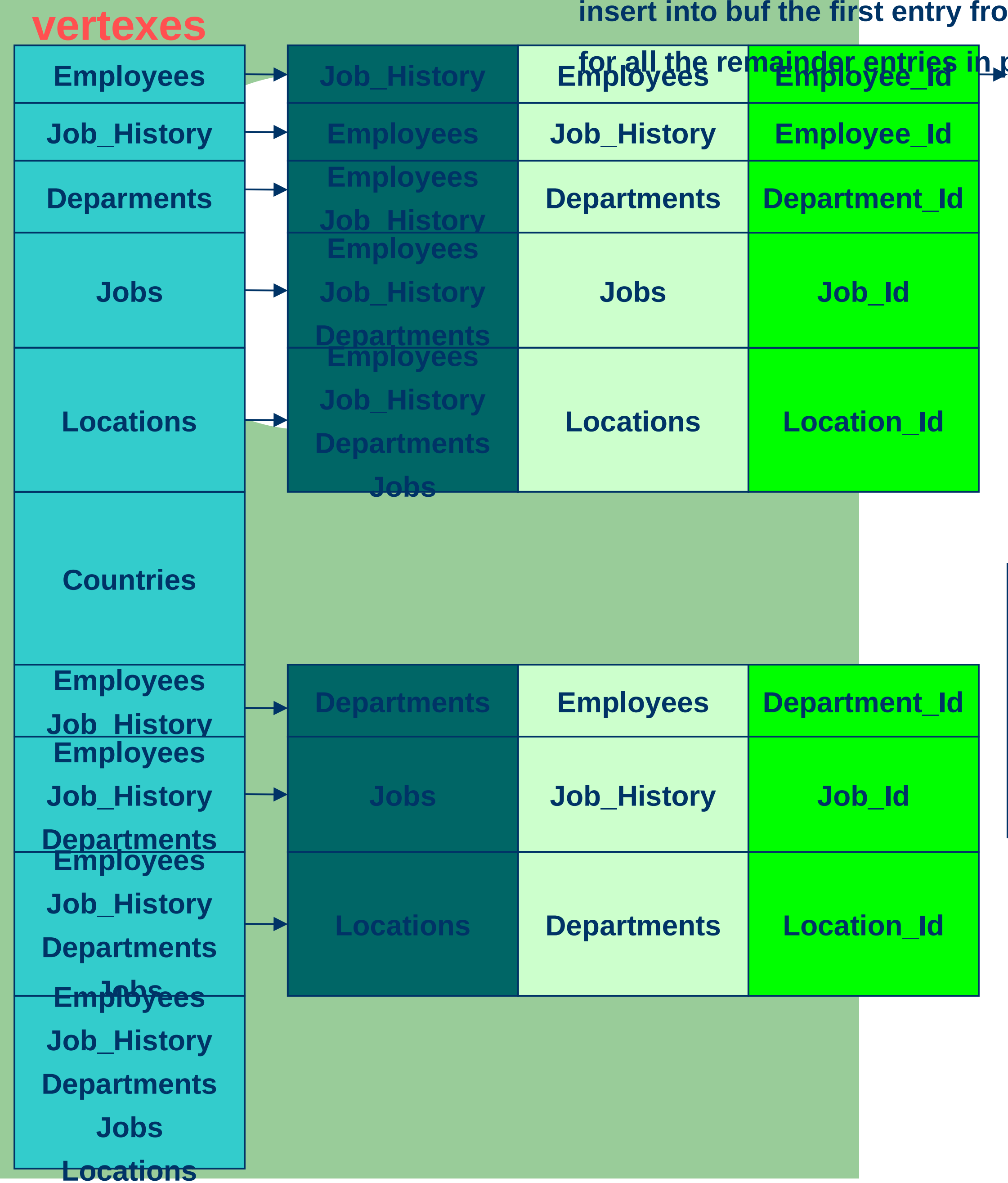

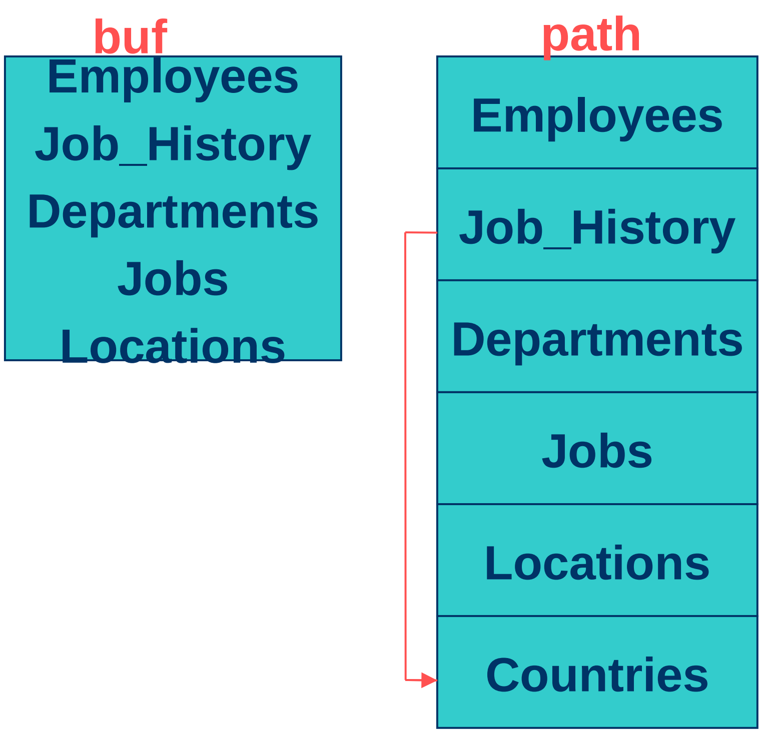

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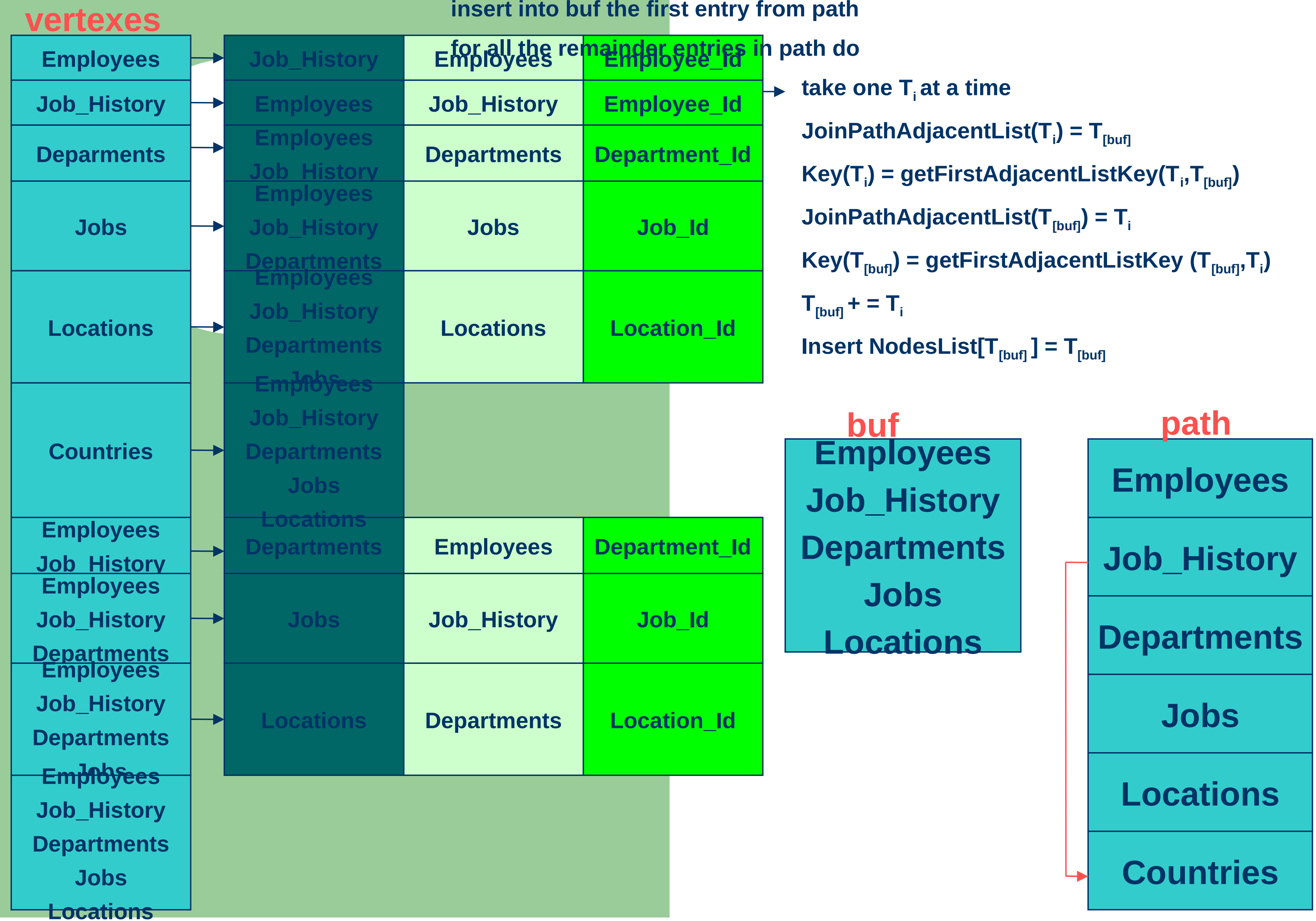

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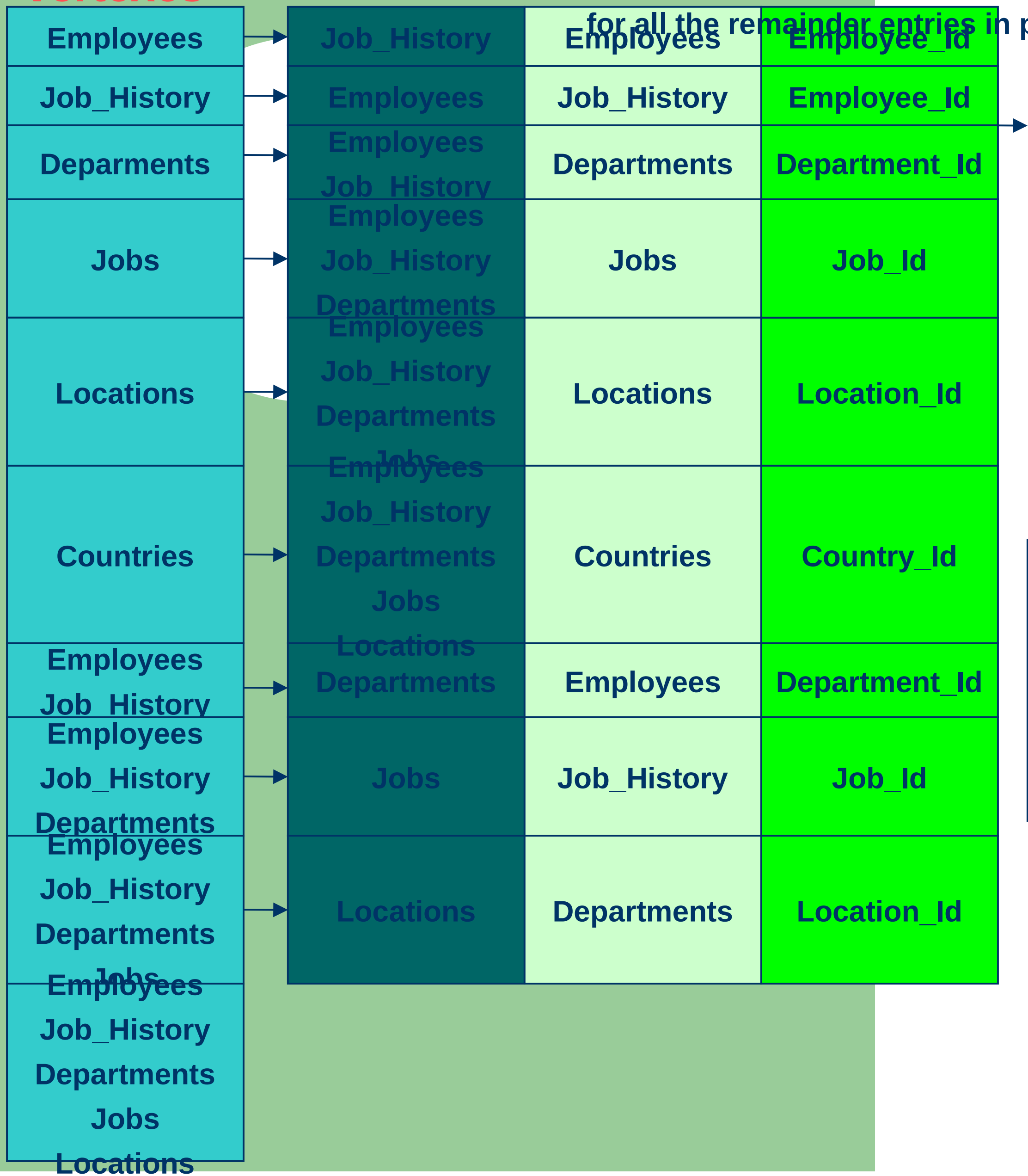

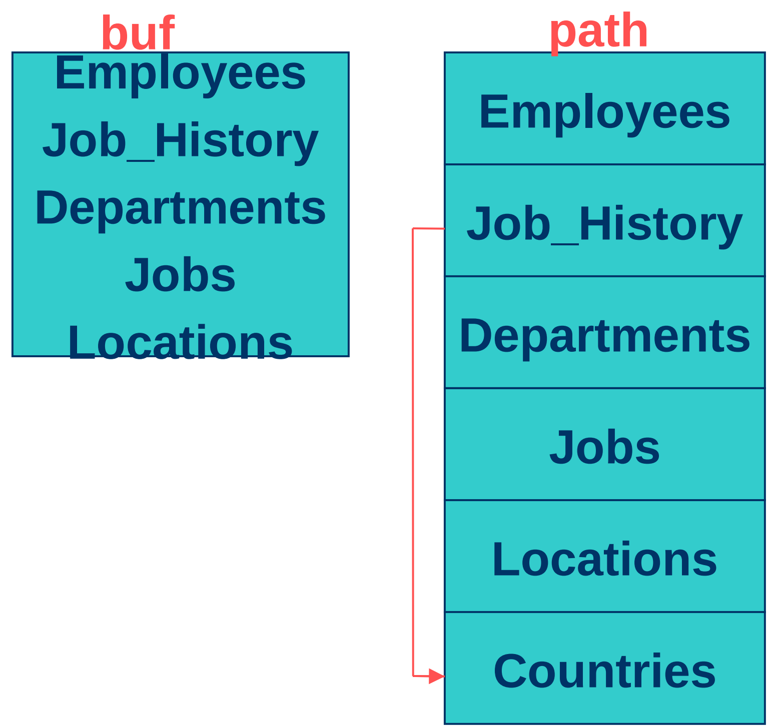

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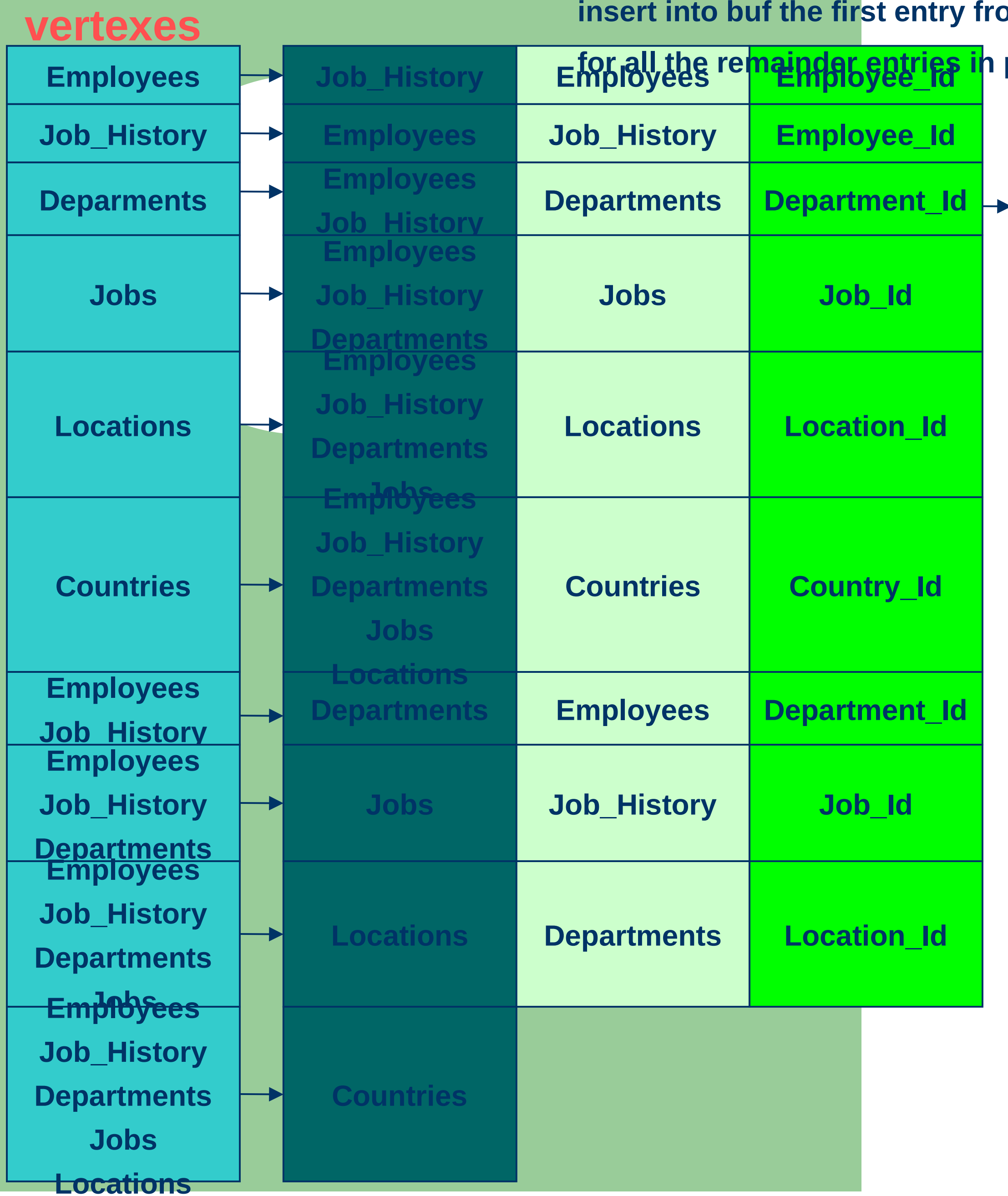

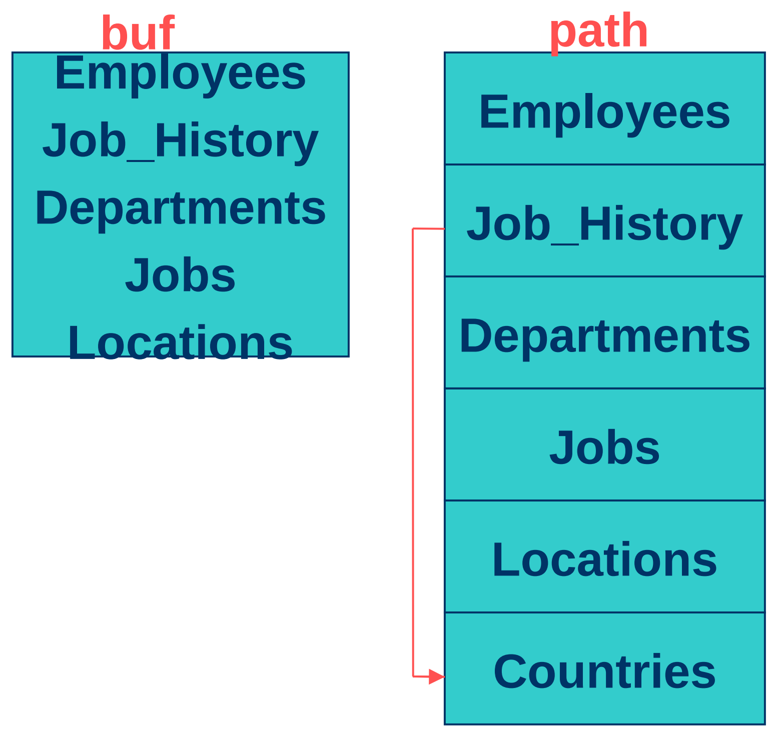

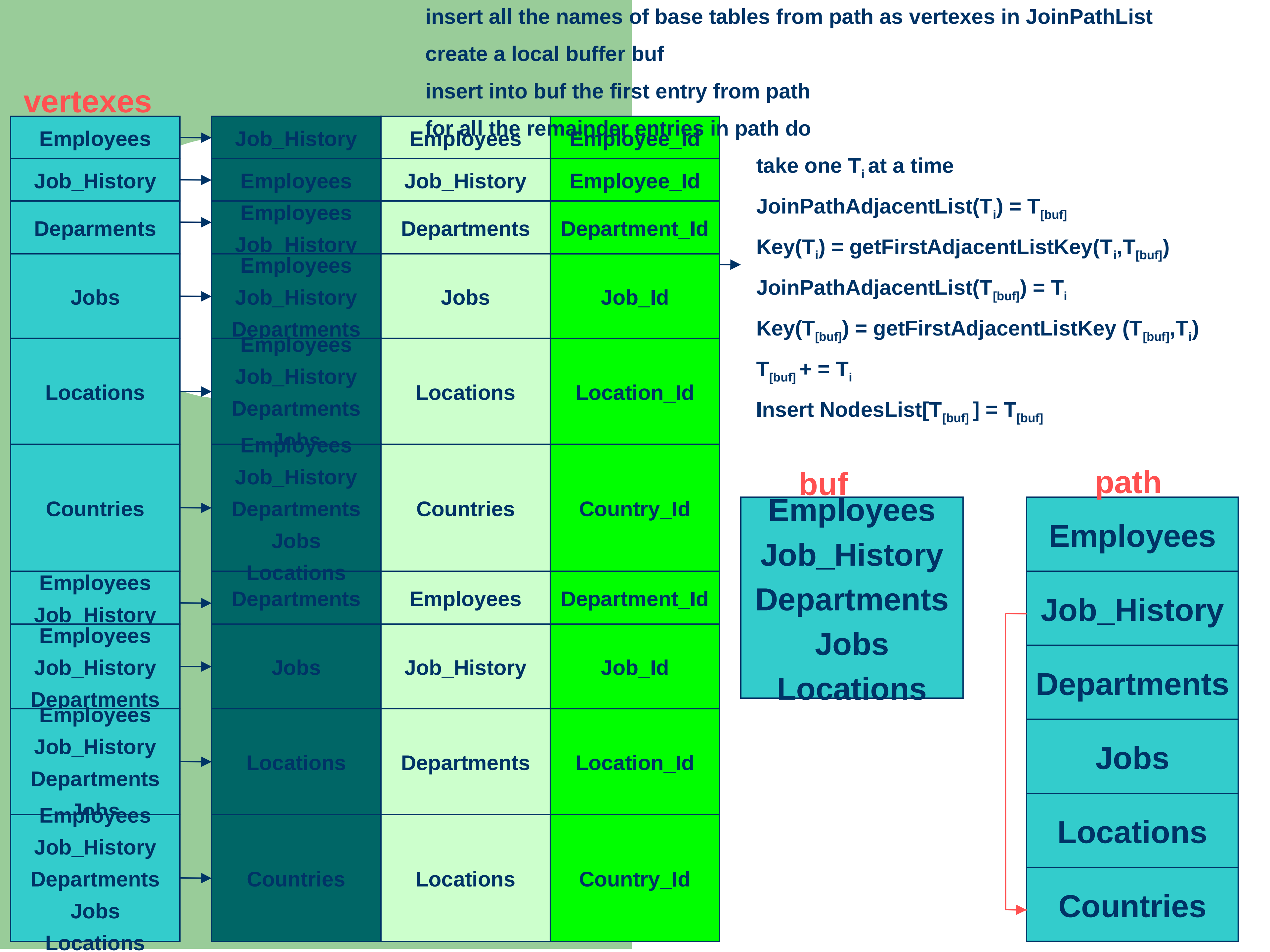
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vertexes
Employees
Job_History
Departments
Jobs
Locations
Countries
Employees Job_History
Employees Job_History Departments
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Job_History
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Employees Job_History
Employees Job_History Departments
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Employees Job_History Departments Jobs Locations
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Locations | Departments | Location_Id
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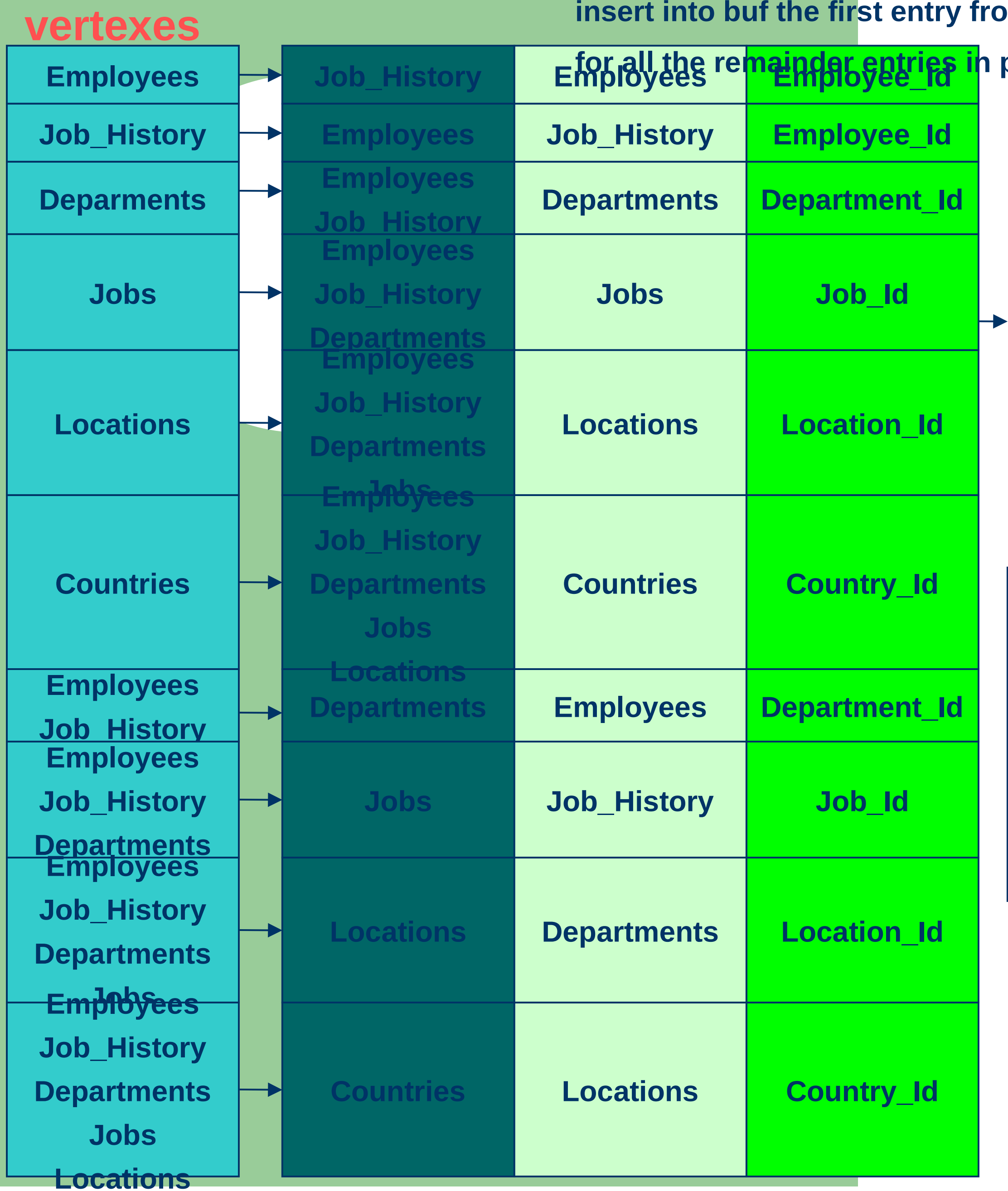
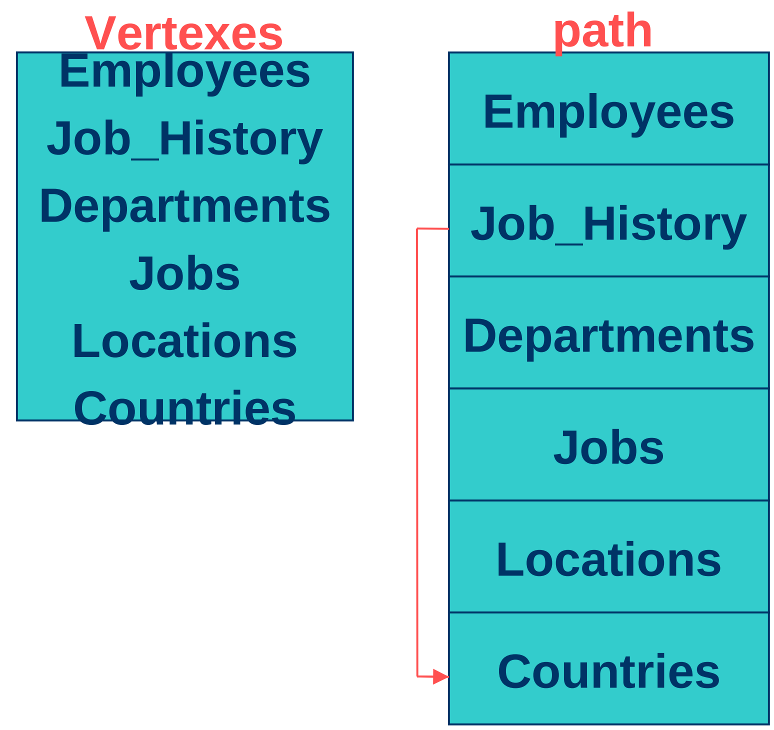
> Insert NodesList[$T_{[buf]}$] = $T_{[buf]}$





Join Path List

Employees	Job_History	Employees	Employee_Id
Job_History	Employees	Job_History	Employee_Id
Deparments	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

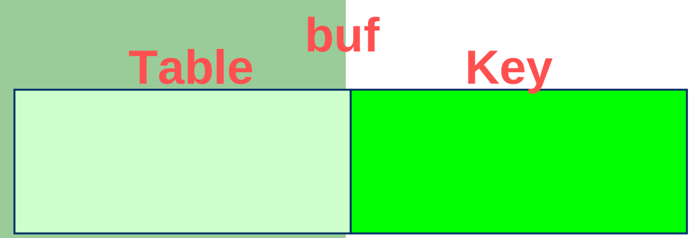
for every buf.Table = T_k do

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

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

buf.Table = T_l

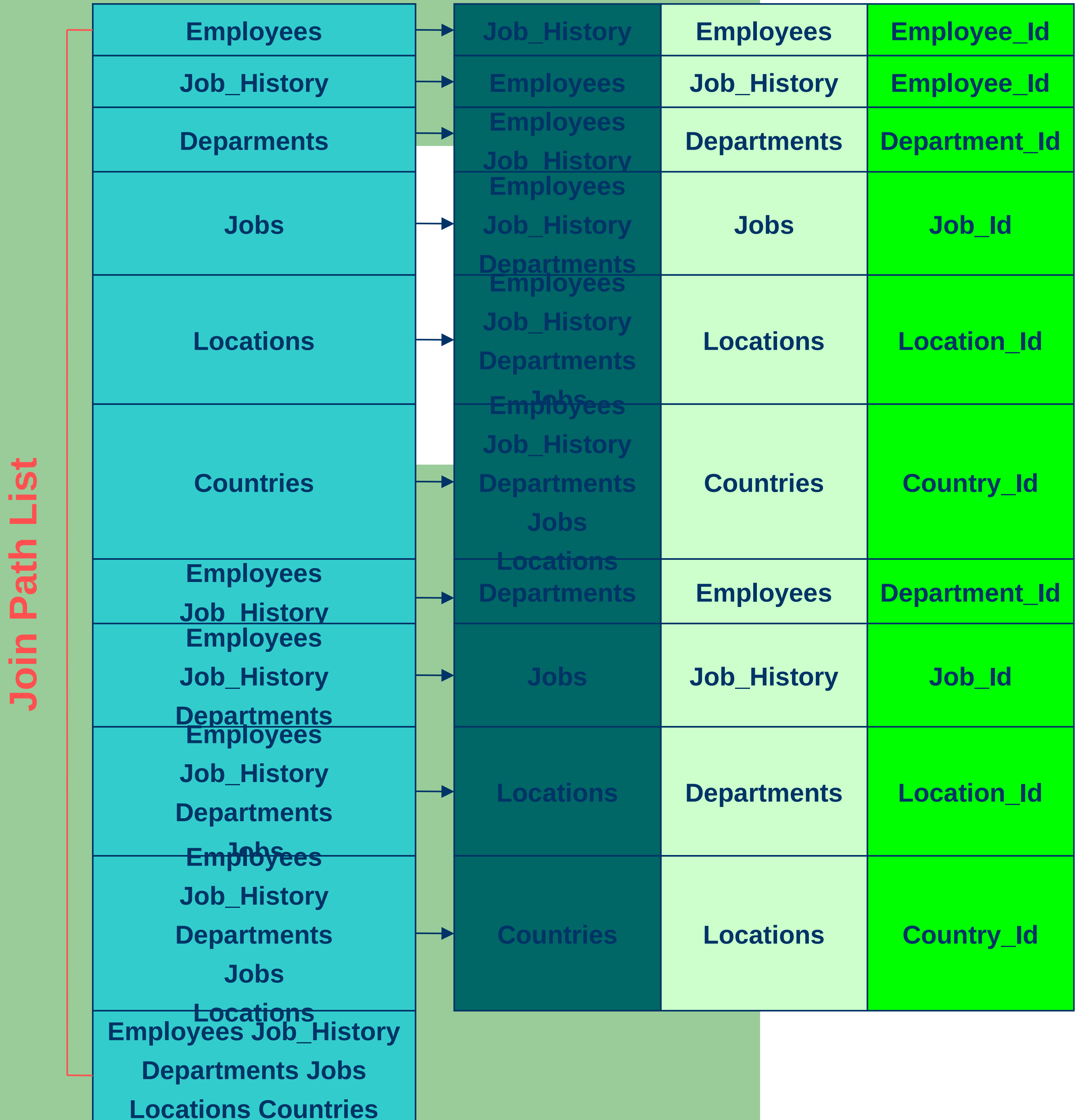
buf.key = Key($T_{[i]}$)



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
      InheritedKey($T_{[i]}$) += buf.key
- if T_l is the table from which comes Key($T_{[i]}$) then
  - buf.Table = T_l
  - buf.key = Key($T_{[i]}$)


Join Path List
Employees
Job_History
Employees
Employee_Id
Job_History
Employees
Job_History
Employee_Id
Deparments
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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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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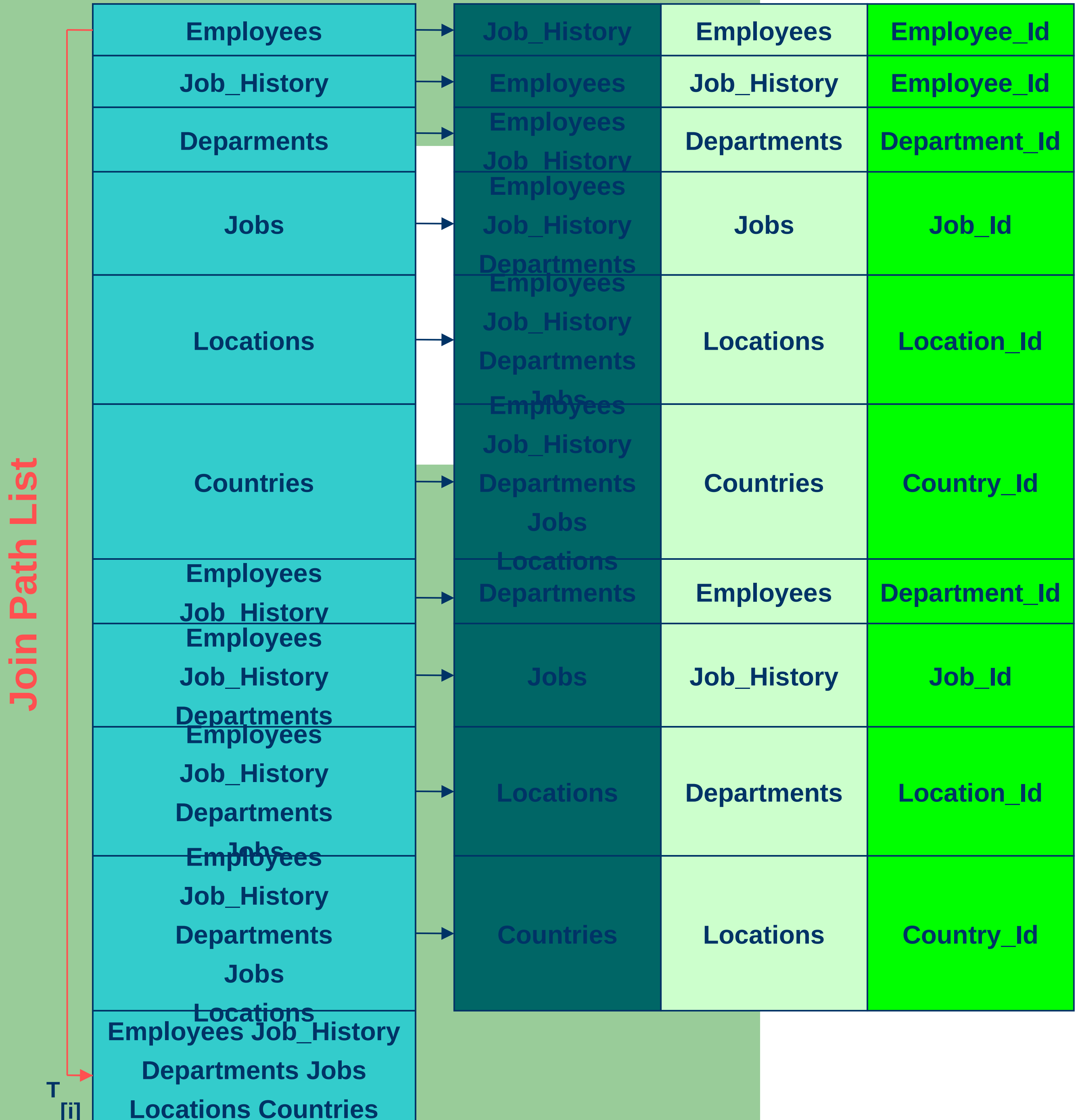
buf.key = Key($T_{[i]}$)



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

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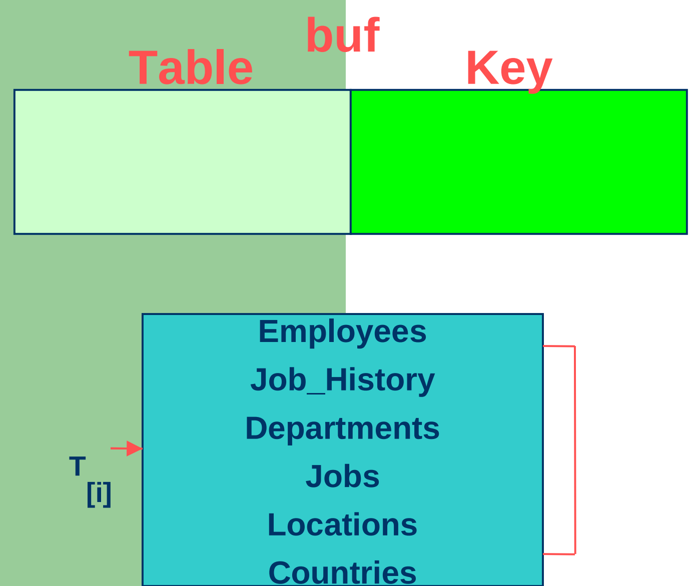
buf.key = Key($T_{[i]}$)



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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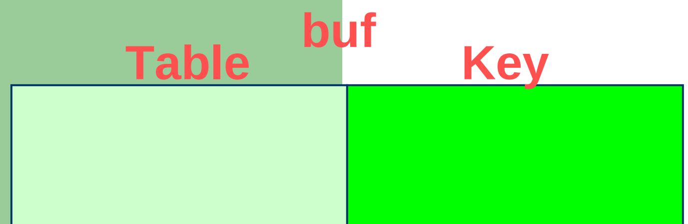

create a structure buf with 2 fields: Table and Key

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

take one T_k at a time

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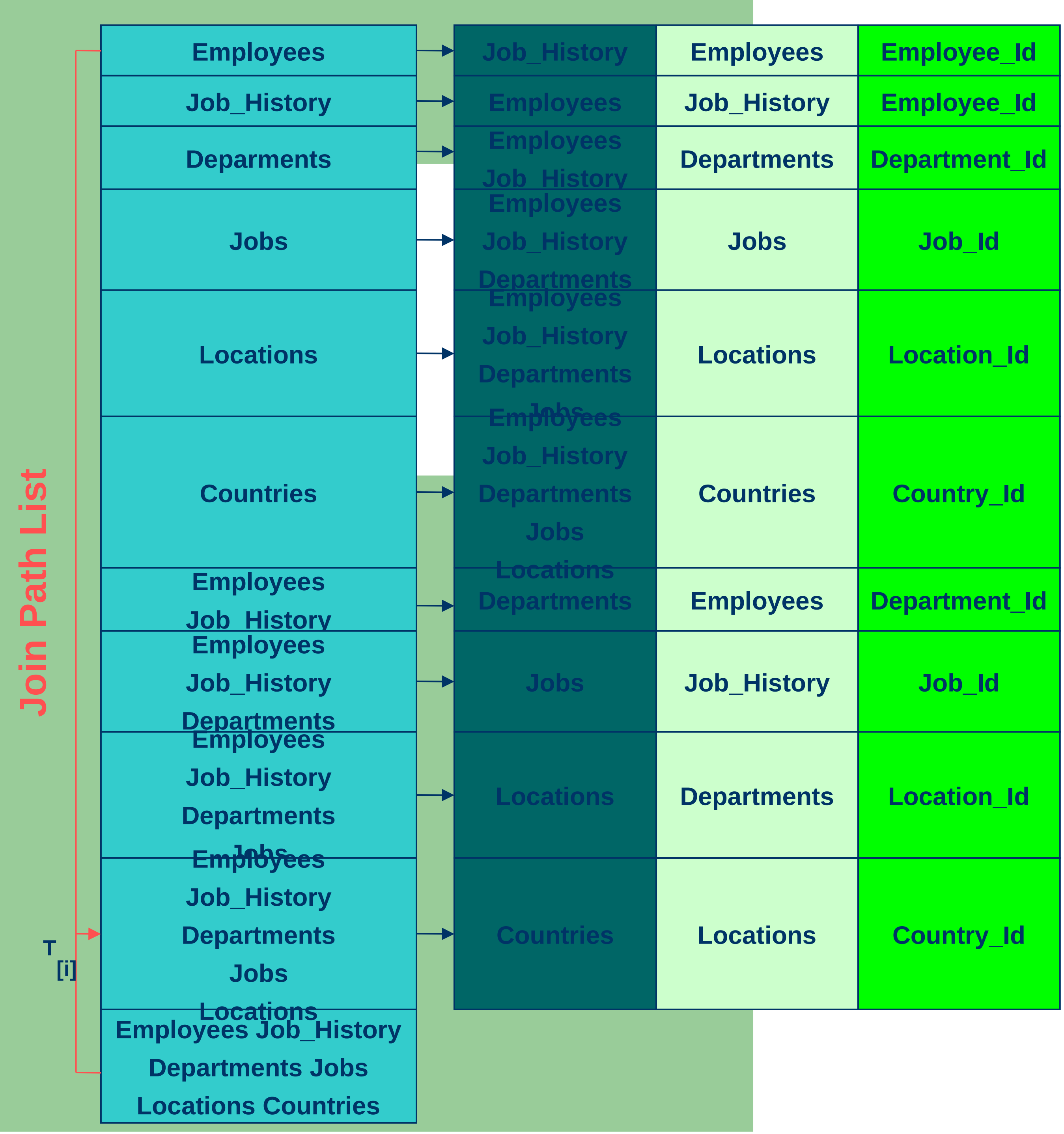
Join Path List
Employees
Job_History
Departments
Jobs
Locations
Countries
Employees Job_History
Employees Job_History Departments
Employees Job_History Departments Jobs
Employees Job_History Departments Jobs Locations
Employees Job_History Departments Jobs Locations Countries
T [i]
Job_History | Employees | Employee_Id
Employees | Job_History | Employee_Id
Employees Job_History | Departments | Department_Id
Employees Job_History Departments | Jobs | Job_Id
Employees Job_History Departments Jobs | Locations | Location_Id
Employees Job_History Departments Jobs Locations | Countries | Country_Id
Departments | Employees | Department_Id
Jobs | Job_History | Job_Id
Locations | Departments | Location_Id
Countries | Locations | Country_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
InheritedKey($T_{[i]}$) += buf.key

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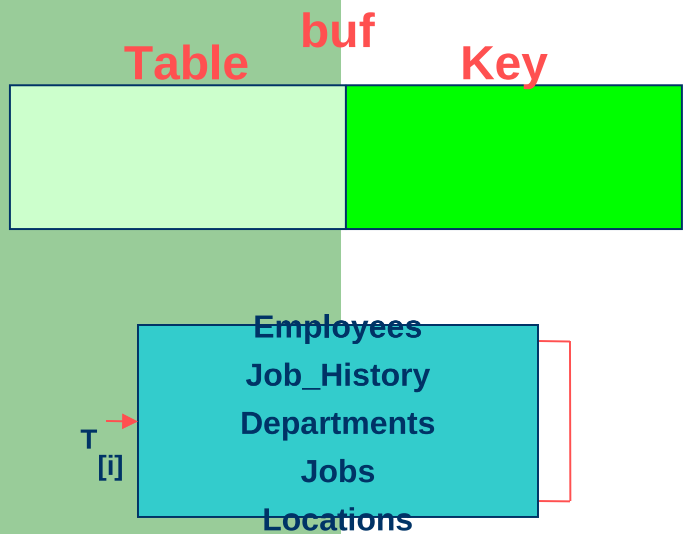
buf.Table = T_l

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

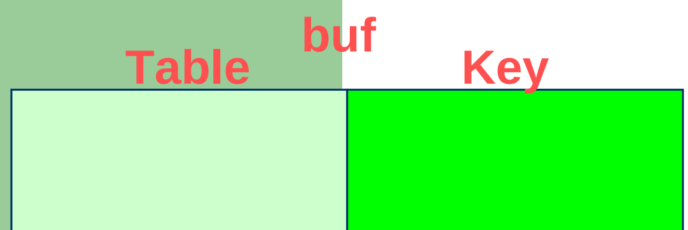
        for every buf.Table = T_k do

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

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

        buf.Table = T_l

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



create a structure buf with 2 fields: Table and Key

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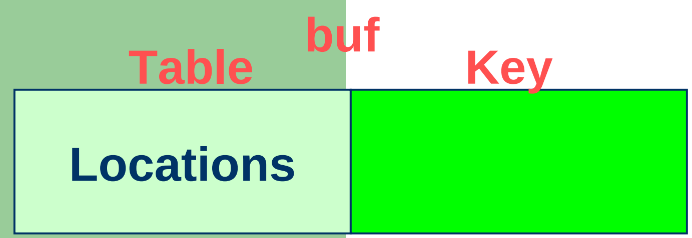

create a structure buf with 2 fields: Table and Key

for all the tables in JoinPathList going downward do

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id

Employees
Job_History
Departments
Jobs
Locations

$T_{[i]}$

T_l

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_l

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
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
$T_{[i]}$ 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

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

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id

$T_{[i]}$

Employees
Job_History
Departments
Jobs

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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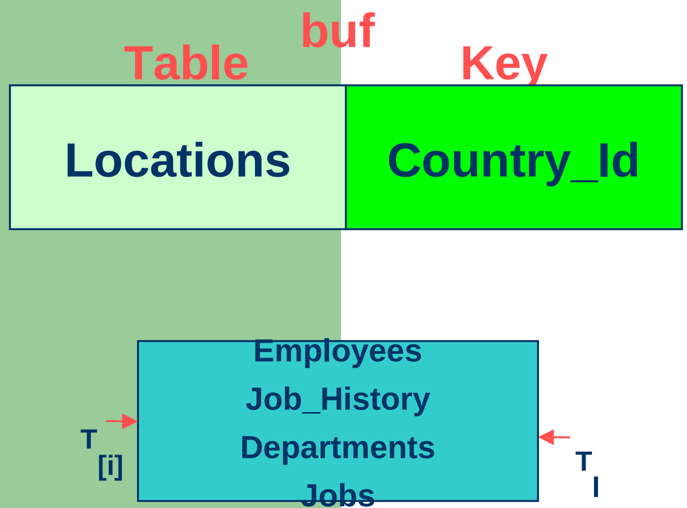

create a structure buf with 2 fields: Table and Key

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
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

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buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id

$T_{[i]}$

Employees
Job_History
Departments
Jobs

T_l

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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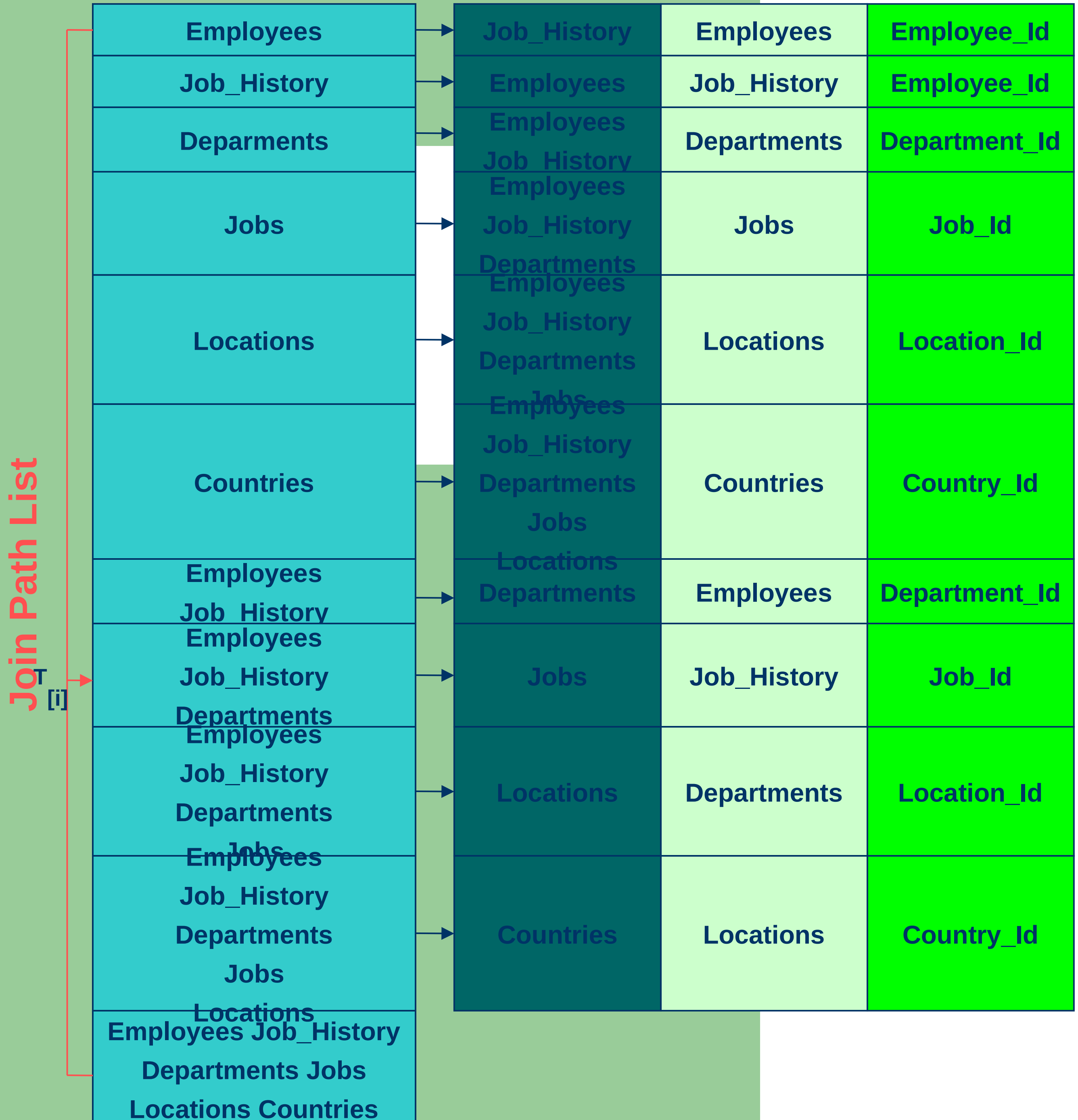

Join Path List
T
[i]
Employees
Job_History
Departments
Jobs
Locations
Countries
Employees Job_History
Employees Job_History Departments
Employees Job_History Departments Jobs
Employees Job_History Departments Jobs Locations
Employees Job_History Departments Jobs Locations Countries
Job_History
Employees
Employees Job_History
Employees Job_History Departments
Employees Job_History Departments Jobs
Employees Job_History Departments Jobs Locations
Departments
Jobs
Locations
Countries
Employees
Job_History
Departments
Jobs
Locations
Countries
Employees
Job_History
Departments
Locations
Employee_Id
Employee_Id
Department_Id
Job_Id
Location_Id
Country_Id
Department_Id
Job_Id
Location_Id
Country_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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take one T_k at a time

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id

T[i] → 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

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

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

buf

Table	Key
Locations	Country_Id
Departments	Location_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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buf.key = Key($T_{[i]}$)

buf

Table	Key
Locations	Country_Id
Departments	Location_Id

create a structure buf with 2 fields: Table and Key

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buf

Table	Key
Locations	Country_Id
Departments	Location_Id

create a structure buf with 2 fields: Table and Key

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buf

Table	Key
Locations	Country_Id
Departments	Location_Id

create a structure buf with 2 fields: Table and Key

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buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id

T[i] → Employees
Job_History
Departments ← 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

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buf

Table	Key
Locations	Country_Id
Departments	Location_Id

create a structure buf with 2 fields: Table and Key

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buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id

T[i]

Employees
Job_History
Departments

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

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Join Path List
T[i]
Employees
Job_History
Departments
Jobs
Locations
Countries
Employees Job_History
Employees Job_History Departments
Employees Job_History Departments Jobs
Employees Job_History Departments Jobs Locations
Employees Job_History Departments Jobs Locations Countries
Job_History
Employees
Employees Job_History
Employees Job_History Departments
Employees Job_History Departments Jobs
Employees Job_History Departments Jobs Locations
Departments
Jobs
Locations
Countries
Employees
Job_History
Departments
Jobs
Locations
Countries
Employees
Job_History
Departments
Locations
Employee_Id
Employee_Id
Department_Id
Job_Id
Location_Id
Country_Id
Department_Id
Job_Id
Location_Id
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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InheritedKey($T_{[i]}$) += buf.key

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id

$T_{[i]}$ → Employees / Job_History / Departments ← T_l

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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buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	

$T_{[i]}$

Employees
Job_History
Departments

T_l

create a structure buf with 2 fields: Table and Key

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buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id

$T_{[i]}$ →

Employees
Job_History
Departments

← T_l

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

    buf.Table = T_l

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

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

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id

$T_{[i]}$

Employees

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

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id

$T_{[i]}$

Employees

Job_History

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

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

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id

Employees
Job_History

$T_{[i]}$

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

buf.Table = T_l

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

buf

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

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id

$T_{[i]}$

Employees
Job_History

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

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

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

buf.Table = T_l

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

buf

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 inT[i] do
        take one Tk at a time
        for every buf.Table = Tk do
            if (buf.key != Key(T[i]) ) and (buf.Key not in InheritedKey(T[i])) then
            InheritedKey(T[i])  += buf.key
    if Tl is the table from which comes Key(T[i]) then
        buf.Table = Tl
        buf.key = Key(T[i])
```


Join Path List
T [i]
Employees
Job_History
Departments
Jobs
Locations
Countries
Employees Job_History
Employees Job_History Departments
Employees Job_History Departments Jobs
Employees Job_History Departments Jobs Locations
Employees Job_History Departments Jobs Locations Countries
Job_History
Employees
Employees Job_History
Employees Job_History Departments
Employees Job_History Departments Jobs
Employees Job_History Departments Jobs Locations
Departments
Jobs
Locations
Countries
Employees
Job_History
Departments
Jobs
Locations
Countries
Employees
Job_History
Departments
Locations
Employee_Id
Employee_Id
Department_Id
Job_Id
Location_Id
Country_Id
Department_Id
Job_Id
Location_Id
Country_Id
Job_History
Departments
Job_Id
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

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id

Employees
Job_History

$T_{[i]}$

T_l

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id
Employees	

Employees
Job_History

$T_{[i]}$ T_l

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

buf.Table = T_l

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

buf

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

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

    buf.Table = T_l

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

Join Path List
T[i]
Employees
Job_History
Departments
Jobs
Locations
Countries
Employees Job_History
Employees Job_History Departments
Employees Job_History Departments Jobs
Employees Job_History Departments Jobs Locations
Employees Job_History Departments Jobs Locations Countries
Job_History
Employees
Employees Job_History
Employees Job_History Departments
Employees Job_History Departments Jobs
Employees Job_History Departments Jobs Locations
Departments
Jobs
Locations
Countries
Employees
Job_History
Departments
Jobs
Locations
Countries
Employees
Job_History
Departments
Locations
Employee_Id
Employee_Id
Department_Id
Job_Id
Location_Id
Country_Id
Department_Id
Job_Id
Location_Id
Country_Id
Job_History
Departments
Job_Id
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

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

buf.Table = T_l

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

buf

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 inT[i] do
                take one Tk at a time
                for every buf.Table = Tk do
                        if (buf.key != Key(T[i]) ) and (buf.Key not in InheritedKey(T[i])) then
                        InheritedKey(T[i])  += buf.key
        if Tl is the table from which comes Key(T[i]) then
                buf.Table = Tl
                buf.key = Key(T[i])
```

buf

Table	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

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

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

        buf.Table = T_l

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

buf

Table	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

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

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

    buf.Table = T_l

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

buf

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

buf.Table = T_l

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


Join Path List
T
[i]
Employees
Job_History
Departments
Jobs
Locations
Countries
Employees Job_History
Employees Job_History Departments
Employees Job_History Departments Jobs
Employees Job_History Departments Jobs Locations
Employees Job_History Departments Jobs Locations Countries
Job_History
Employees
Employees Job_History
Employees Job_History Departments
Employees Job_History Departments Jobs
Employees Job_History Departments Jobs Locations
Departments
Jobs
Locations
Countries
Employees
Job_History
Departments
Jobs
Locations
Countries
Employees
Job_History
Departments
Locations
Employee_Id
Employee_Id
Department_Id
Job_Id
Location_Id
Country_Id
Department_Id
Job_Id
Location_Id
Country_Id
Job_History
Departments
Job_Id
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

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id
Employees	Department_Id

$T_{[i]}$ Locations

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

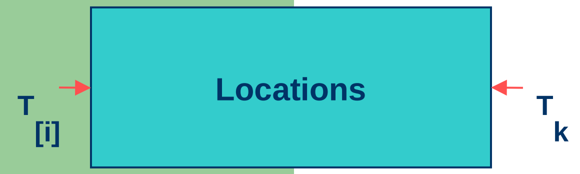
if T_l is the table from which comes Key($T_{[i]}$) then

buf.Table = T_l

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

buf

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

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

        buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id
Employees	Department_Id

$T_{[i]}$ **Locations** 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

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

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

buf.Table = T_l

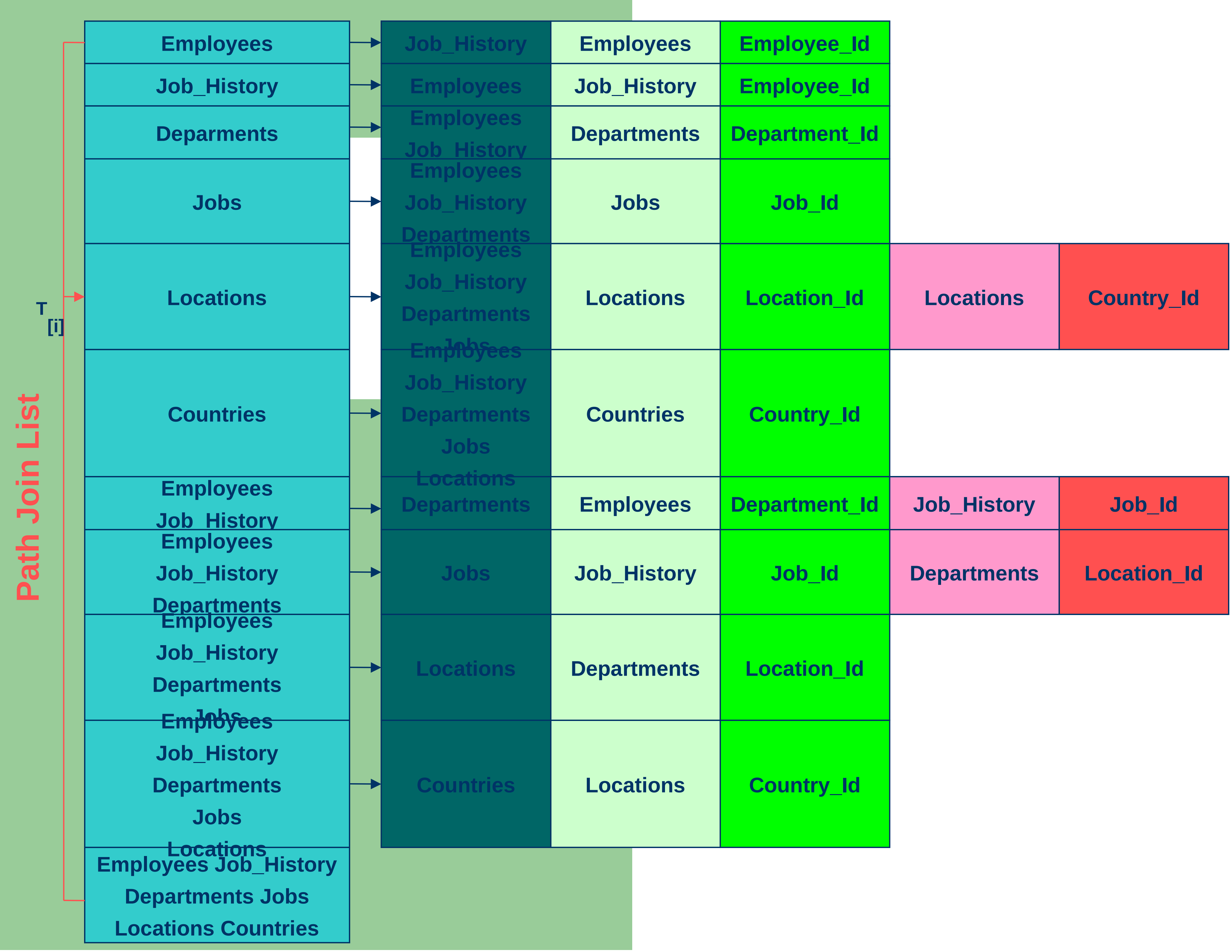
buf.key = Key($T_{[i]}$)

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id
Employees	Department_Id

$T_{[i]}$ Locations 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 inT[i] do
        take one Tk at a time
        for every buf.Table = Tk do
            if (buf.key != Key(T[i]) ) and (buf.Key not in InheritedKey(T[i])) then
            InheritedKey(T[i])  += buf.key
    if Tl is the table from which comes Key(T[i]) then
        buf.Table = Tl
        buf.key = Key(T[i])
```



Path Join List
T
[i]
Employees
Job_History
Departments
Jobs
Locations
Countries
Employees Job_History
Employees Job_History Departments
Employees Job_History Departments Jobs
Employees Job_History Departments Jobs Locations
Employees Job_History Departments Jobs Locations Countries
Job_History
Employees
Employees Job_History
Employees Job_History Departments
Employees Job_History Departments Jobs
Employees Job_History Departments Jobs Locations
Departments
Jobs
Locations
Countries
Employees
Job_History
Departments
Jobs
Locations
Countries
Employees
Job_History
Departments
Locations
Employee_Id
Employee_Id
Department_Id
Job_Id
Location_Id
Country_Id
Department_Id
Job_Id
Location_Id
Country_Id
Locations
Job_History
Departments
Country_Id
Job_Id
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

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id
Employees	Department_Id

$T_{[i]}$ → Locations

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

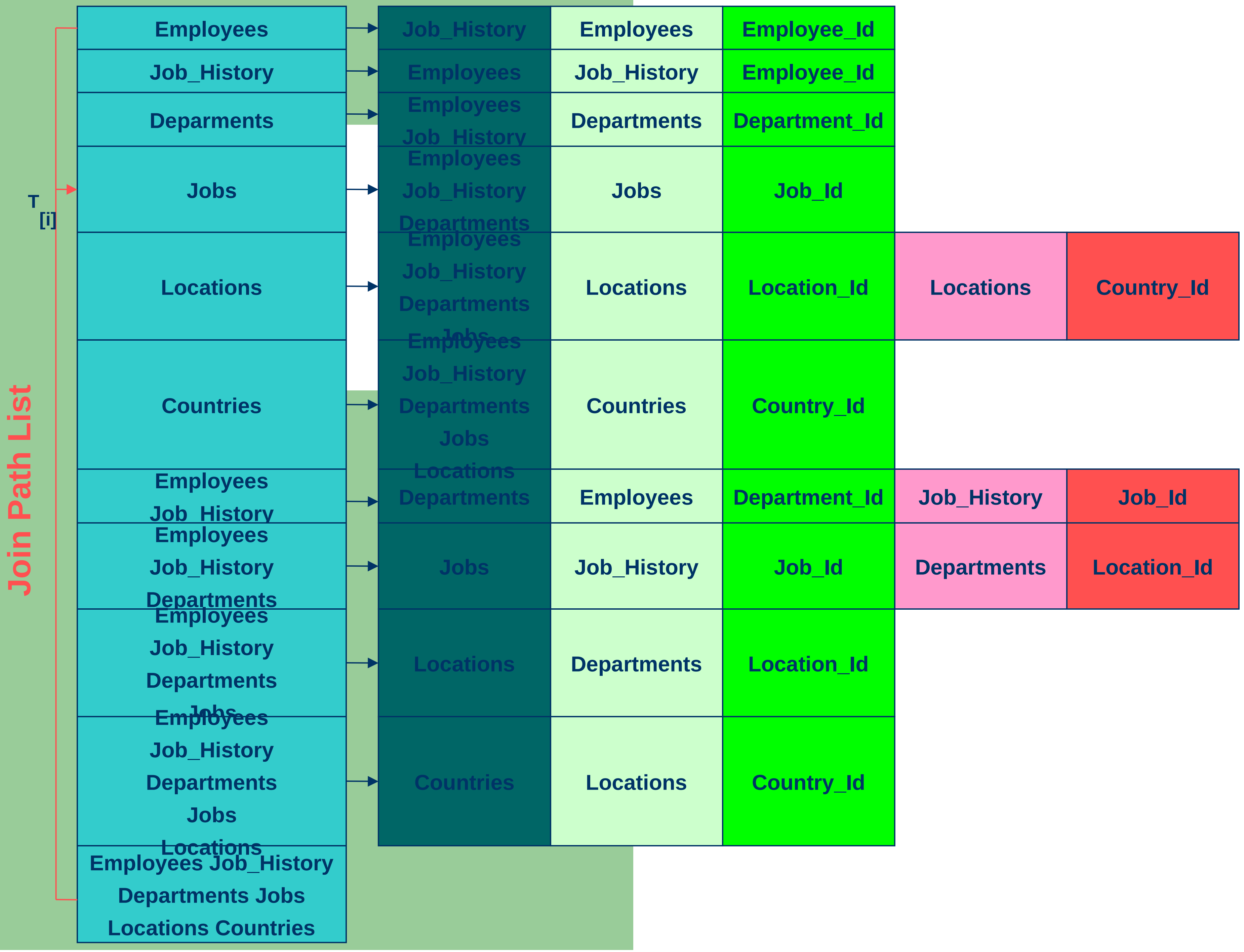
for every buf.Table = T_k do

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

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

buf.Table = T_l

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



Join Path List
T [i]
Employees
Job_History
Departments
Jobs
Locations
Countries
Employees Job_History
Employees Job_History Departments
Employees Job_History Departments Jobs
Employees Job_History Departments Jobs Locations
Employees Job_History Departments Jobs Locations Countries
Job_History
Employees
Employees Job_History
Employees Job_History Departments
Employees Job_History Departments Jobs
Employees Job_History Departments Jobs Locations
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Job_History
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Locations
Employee_Id
Employee_Id
Department_Id
Job_Id
Location_Id
Country_Id
Department_Id
Job_Id
Location_Id
Country_Id
Locations
Job_History
Departments
Country_Id
Job_Id
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

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id
Employees	Department_Id

$T_{[i]}$

Jobs

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

    buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id
Employees	Department_Id

$T_{[i]}$ Jobs 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

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

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id
Employees	Department_Id

$T_{[i]}$ Jobs 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

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

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id
Employees	Department_Id

$T_{[i]}$ → Jobs

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

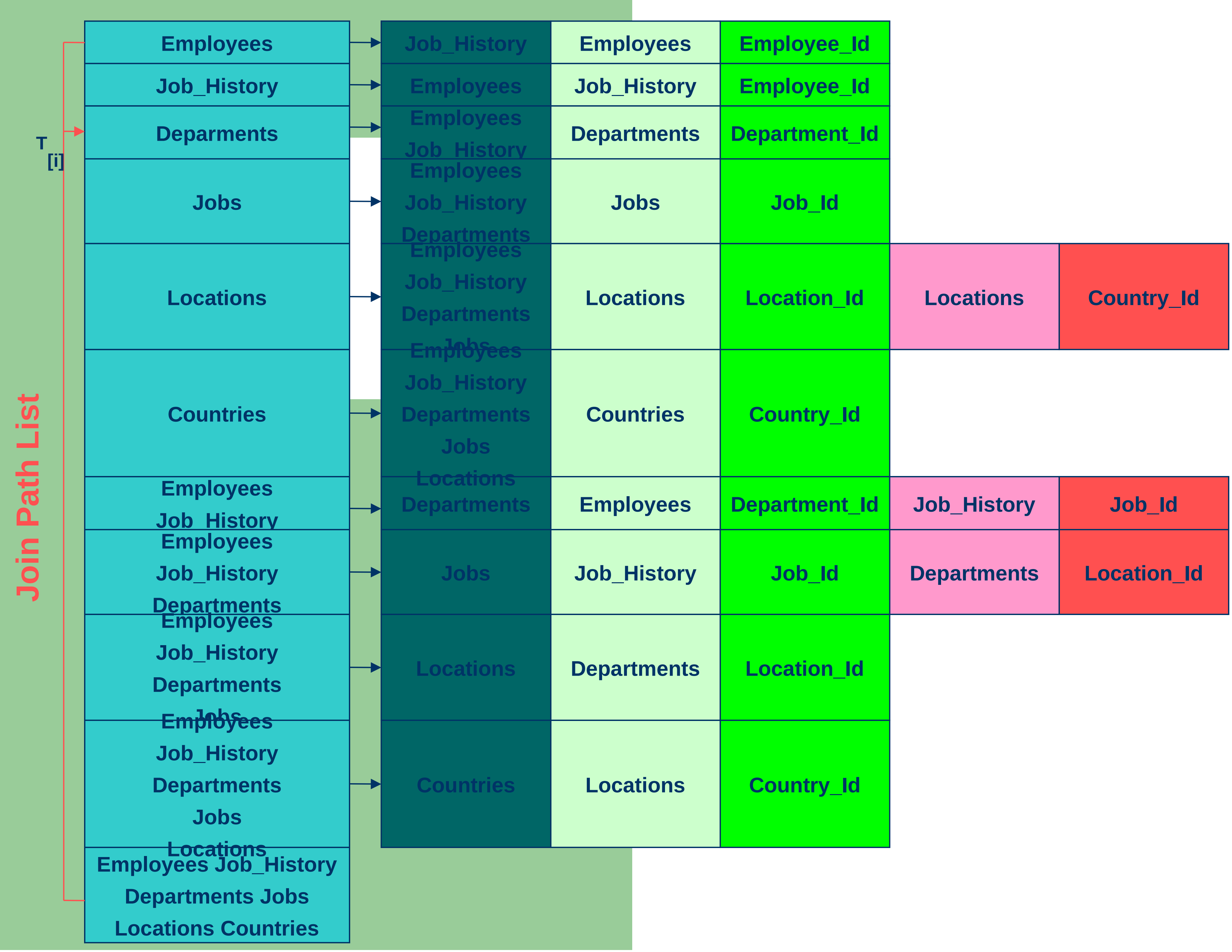
for every buf.Table = T_k do

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

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

buf.Table = T_l

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


Join Path List
T
[i]
Employees
Job_History
Departments
Jobs
Locations
Countries
Employees Job_History
Employees Job_History Departments
Employees Job_History Departments Jobs
Employees Job_History Departments Jobs Locations
Employees Job_History Departments Jobs Locations Countries
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Department_Id
Job_Id
Location_Id
Country_Id
Locations
Country_Id
Job_History
Job_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

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id
Employees	Department_Id

$T_{[i]}$ Deparments

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

buf

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

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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

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id
Employees	Department_Id

$T_{[i]}$ Deparments 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

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

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id
Employees	Department_Id

$T_{[i]}$ Deparments T_k

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

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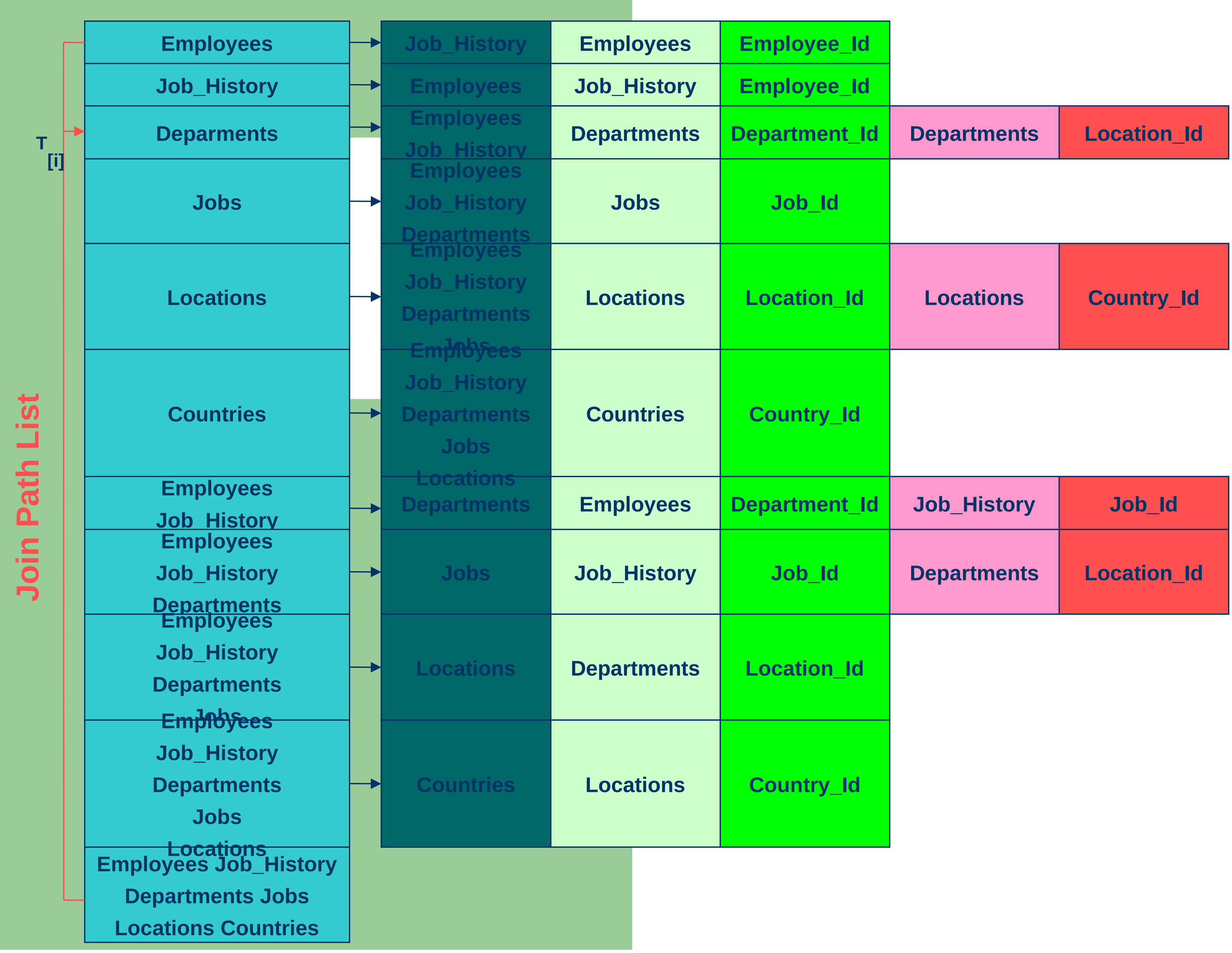
buf.key = Key($T_{[i]}$)



Join Path List
T
[i]
Employees
Job_History
Departments
Jobs
Locations
Countries
Employees Job_History
Employees Job_History Departments
Employees Job_History Departments Jobs
Employees Job_History Departments Jobs Locations
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Employee_Id
Employee_Id
Department_Id
Job_Id
Location_Id
Country_Id
Department_Id
Job_Id
Location_Id
Country_Id
Departments
Locations
Job_History
Departments
Location_Id
Country_Id
Job_Id
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

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id
Employees	Department_Id

$T_{[i]}$ → Deparments

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

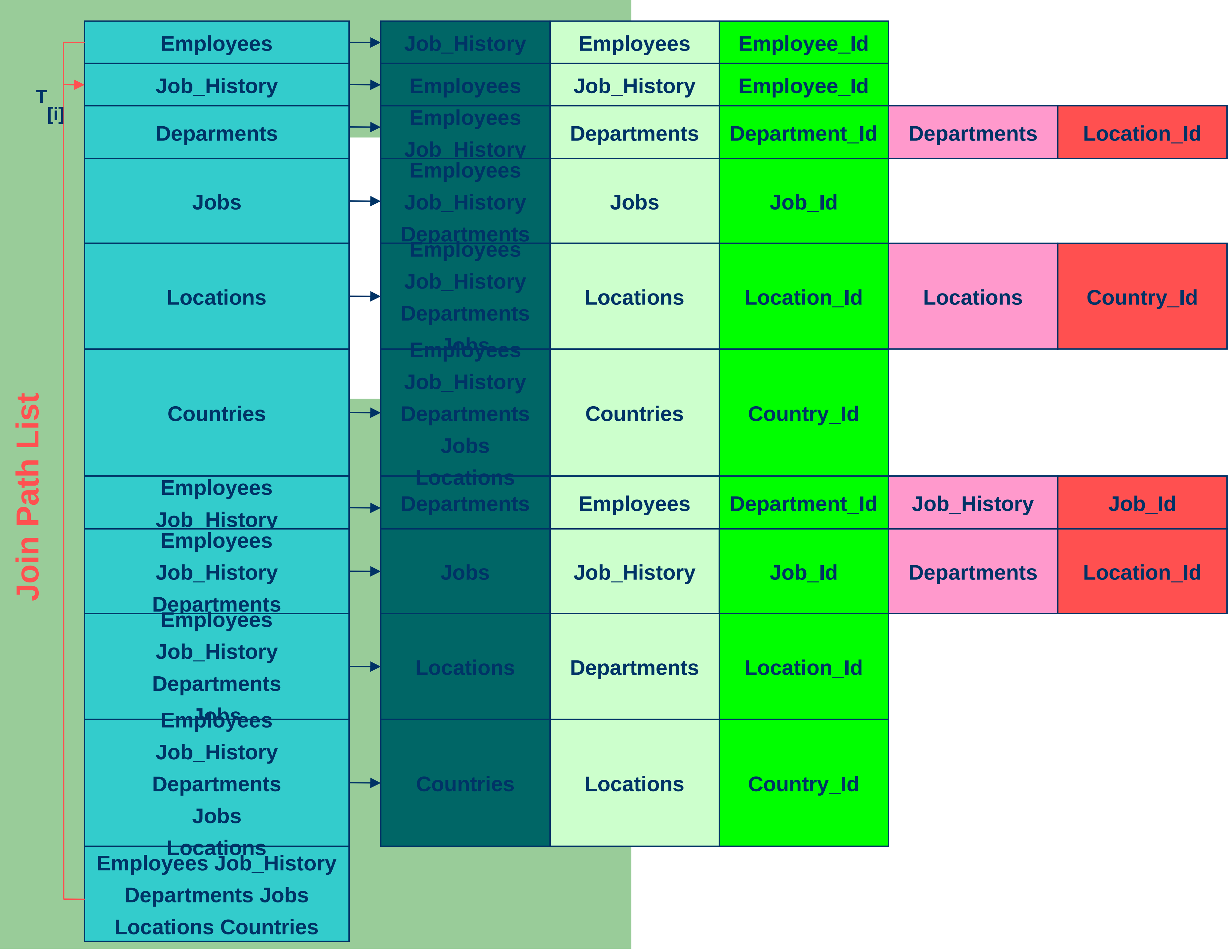
for every buf.Table = T_k do

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

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

buf.Table = T_l

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


Join Path List
T
[i]
Employees
Job_History
Departments
Jobs
Locations
Countries
Employees Job_History
Employees Job_History Departments
Employees Job_History Departments Jobs
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Employee_Id
Employee_Id
Department_Id
Job_Id
Location_Id
Country_Id
Department_Id
Job_Id
Location_Id
Country_Id
Departments
Locations
Job_History
Departments
Location_Id
Country_Id
Job_Id
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

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id
Employees	Department_Id

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

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id
Employees	Department_Id

$T_{[i]}$ → **Job_History** ← 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

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

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id
Employees	Department_Id

$T_{[i]}$ Job_History 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

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

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id
Employees	Department_Id

$T_{[i]}$ → Job_History ← 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

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

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

        buf.Table = T_l

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

Join Path List
T [i]
Employees
Job_History
Departments
Jobs
Locations
Countries
Employees Job_History
Employees Job_History Departments
Employees Job_History Departments Jobs
Employees Job_History Departments Jobs Locations
Employees Job_History Departments Jobs Locations Countries
Job_History
Employees
Employees Job_History
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Job_Id
Location_Id
Country_Id
Job_History
Departments
Locations
Job_History
Departments
Job_Id
Location_Id
Country_Id
Job_Id
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

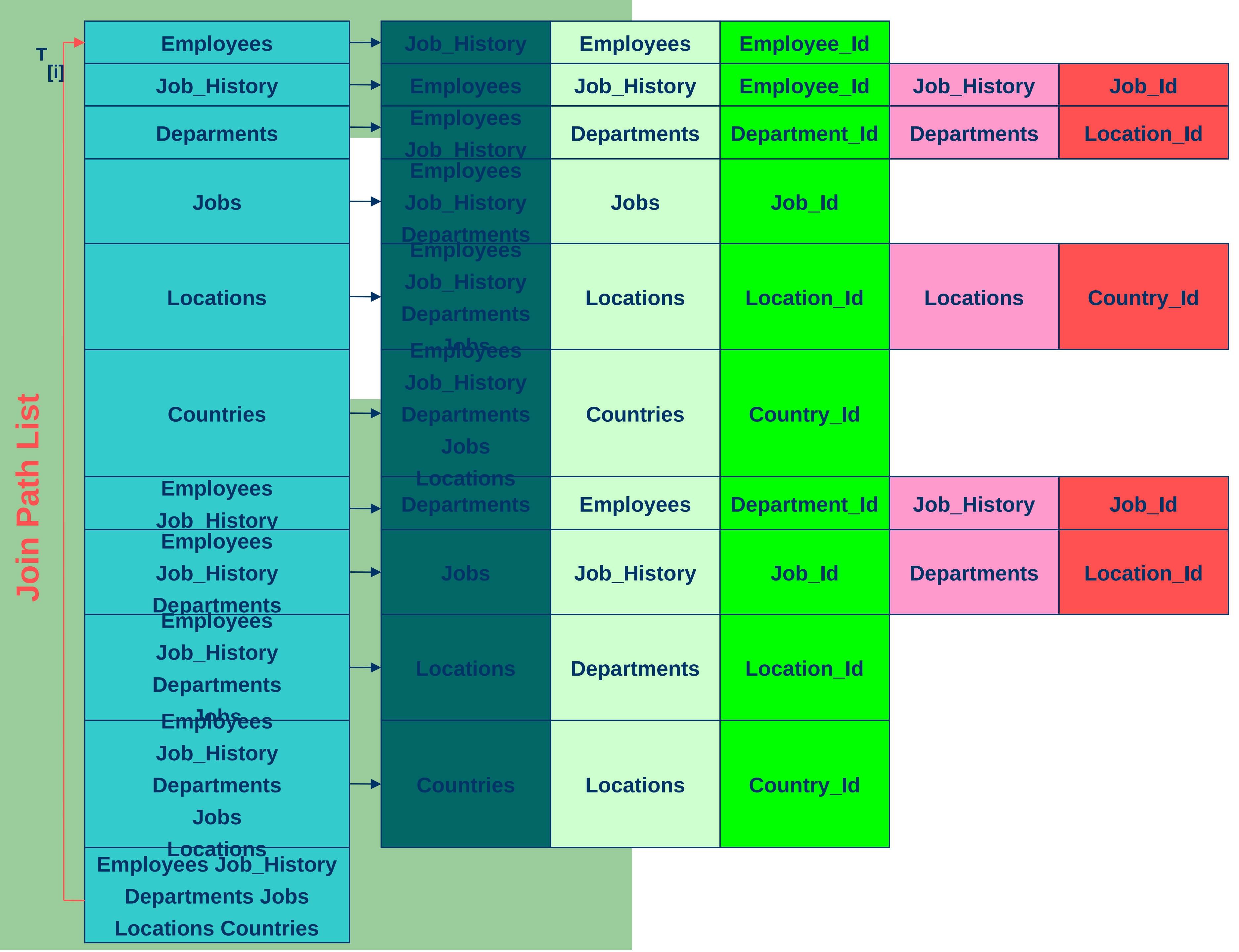
for every buf.Table = T_k do

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

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

buf.Table = T_l

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


Join Path List
T
[i]
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
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Job_Id
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Country_Id
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Country_Id
Employees Job_History
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Job_Id
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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
InheritedKey($T_{[i]}$) += buf.key

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id
Employees	Department_Id

$T_{[i]}$ → 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

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

buf.Table = T_l

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

buf

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

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

buf.Table = T_l

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

buf

Table	Key
Locations	Country_Id
Departments	Location_Id
Job_History	Job_Id
Employees	Department_Id

$T_{[i]}$ Employees 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

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

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

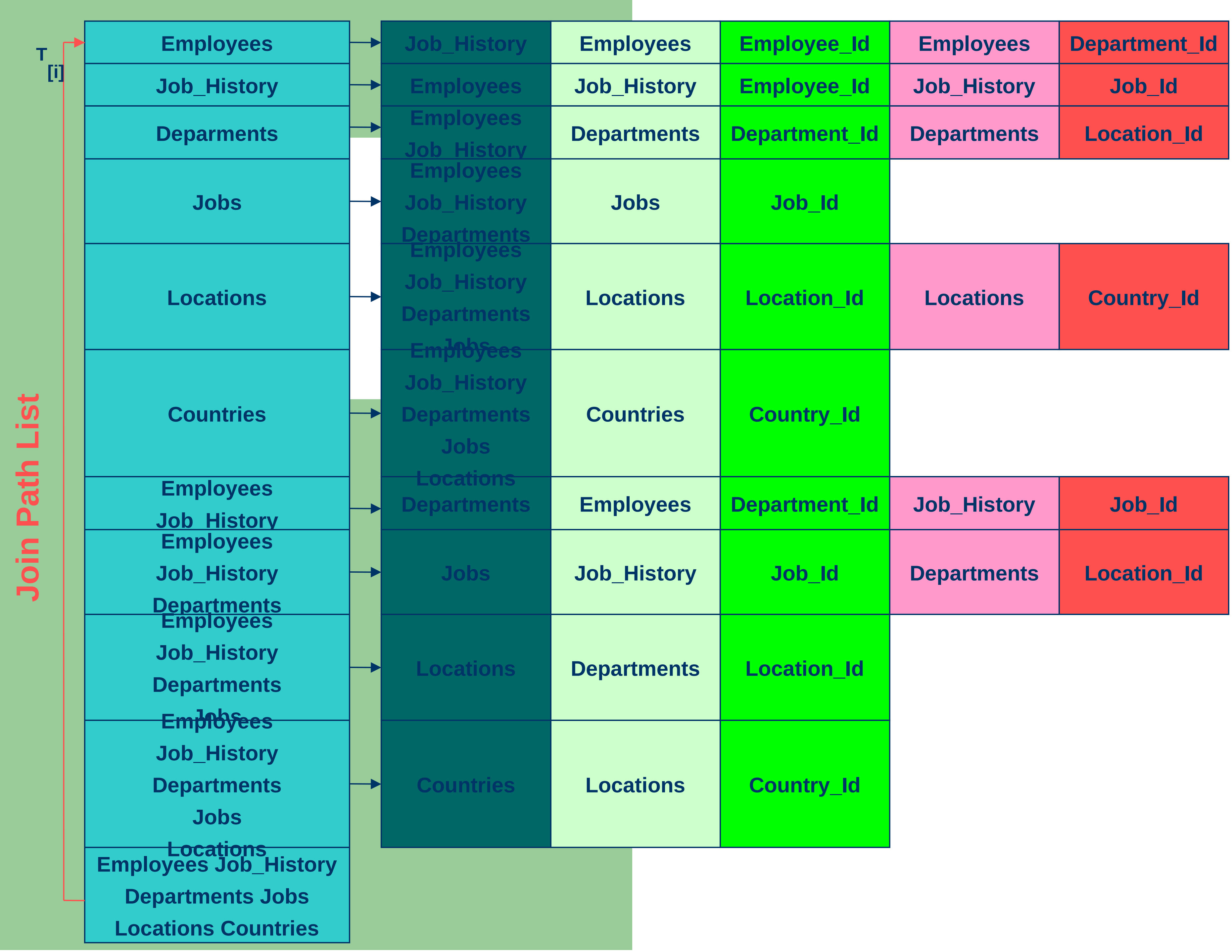
buf.Table = T_l

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

buf

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 inT[i] do
                take one Tk at a time
                for every buf.Table = Tk do
                        if (buf.key != Key(T[i]) ) and (buf.Key not in InheritedKey(T[i])) then
                        InheritedKey(T[i])  += buf.key
        if Tl is the table from which comes Key(T[i]) then
                buf.Table = Tl
                buf.key = Key(T[i])
```



Join Path List
T [i]
Employees
Job_History
Employees
Employee_Id
Employees
Department_Id
Job_History
Employees
Job_History
Employee_Id
Job_History
Job_Id
Departments
Employees Job_History
Departments
Department_Id
Departments
Location_Id
Jobs
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Locations
Employees Job_History Departments Jobs
Locations
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Locations
Country_Id
Countries
Employees Job_History Departments Jobs Locations
Countries
Country_Id
Employees Job_History
Departments
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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

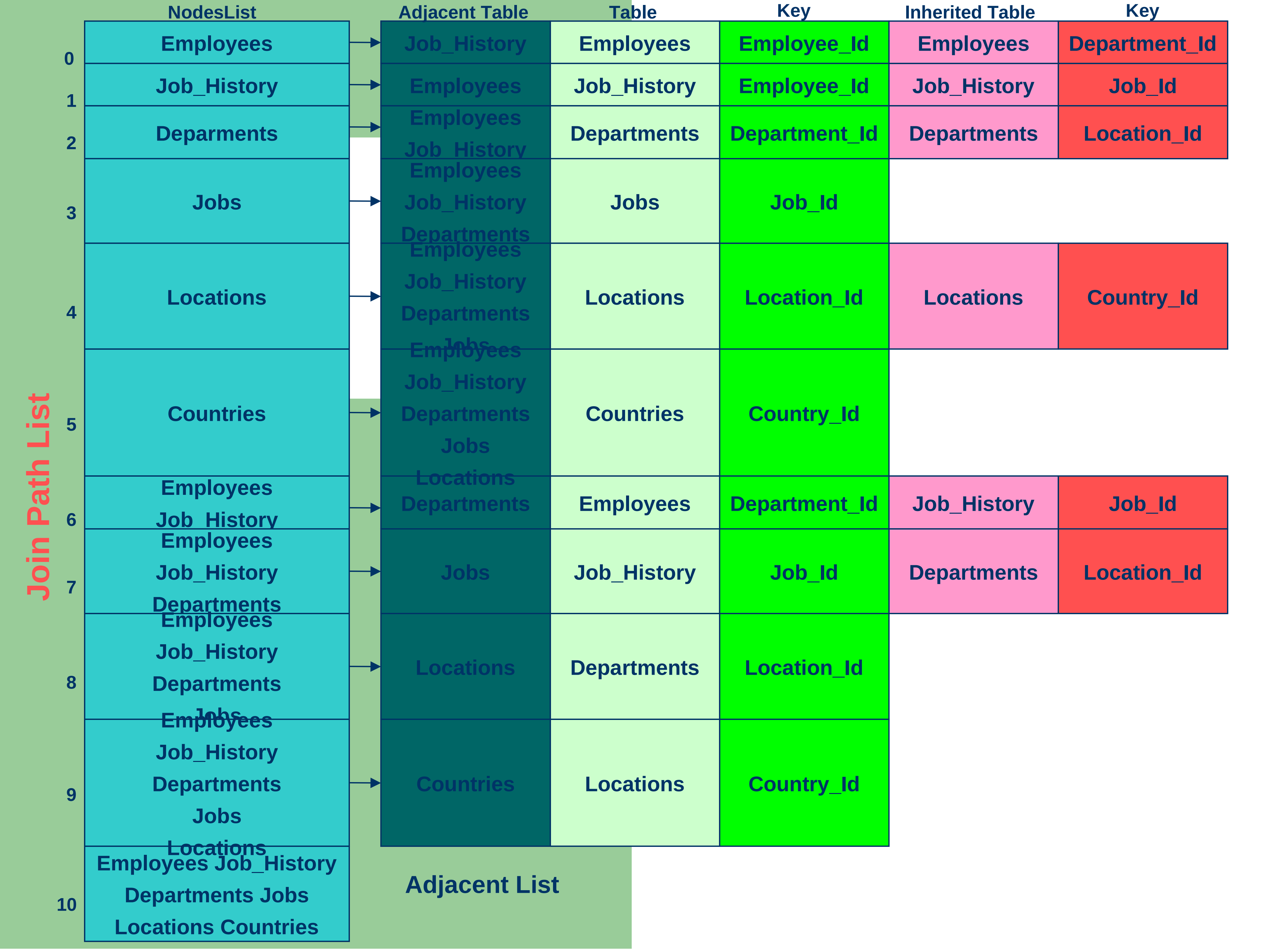
        for every buf.Table = T_k do

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

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

        buf.Table = T_l

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


NodesList
Adjacent Table
Table
Key
Inherited Table
Key
Join Path List
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
Employees Job_History 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

Give a general name for the $B^{\bowtie}$Tree.

Give for every entry in the JoinPathList a B^{+}Tree index with name as the $B^{\bowtie}$Tree + the PathJoinList entry number.

About the last virtual table, it index has no keys, it works because we consider pairs of < keys, Data Pointers > 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. When comes a key it would be inserted in the last page.

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.

Define a Create Join Index (IndexName, Eventual columns for the last virtual table representing tables in join)

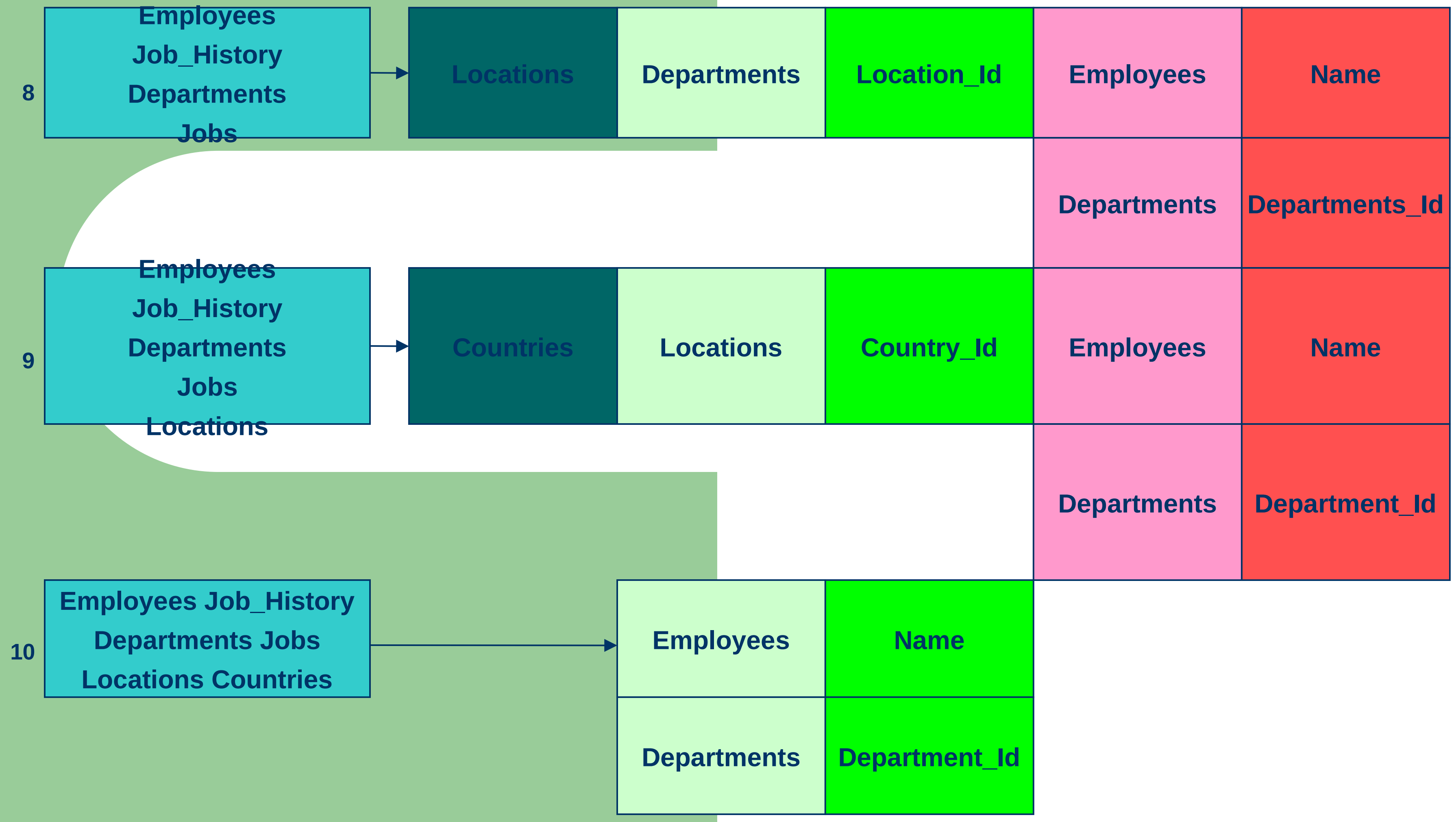
Implementation:

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.

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

Join Path List

	NodesList	Adjacent Table	Table	Key	Inherited Table	Key
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	Deparments	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
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

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, Inheritred Key> in the adjacent list of the node

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 AddJoinKey (T_i, Keys, InheritedKeys, 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 ($T_{[i]}$, [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($B^+Tree(T_{[k]})$, $Keys_{[i]}$)

AddJoinKey ($T_{[i]}$, [DP_i])

In the same fashion when using an ordinary B^+Tree and one row get inserted, so we check the definition of the B^+Tree to get the necessary keys from the row to insert them, with B^{Join}Tree we check the definition to get the keys and the inherited keys.

Call AddjoinKey(T_i,[keys],[DP_i])

Employees table

	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

	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

	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

	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

	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

	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

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

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)

0	Employees	Job_History	Employees	Employee_Id	Employees	Department_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)

0	Employees	Job_History	Employees	Employee_Id	Employees	Department_Id

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)

	EMPLOYEE_ID	NAME	EMAIL	PHONE_NUMBER	HIRE_DATE	JOB_ID	SALARY	DEPARTMENT_ID
DP_{i0}	101	Mark Stench	mstench	233-4268	12/02/1998	FI_MGR	60000	FIN

Keys

Row R_m

Inherited Keys

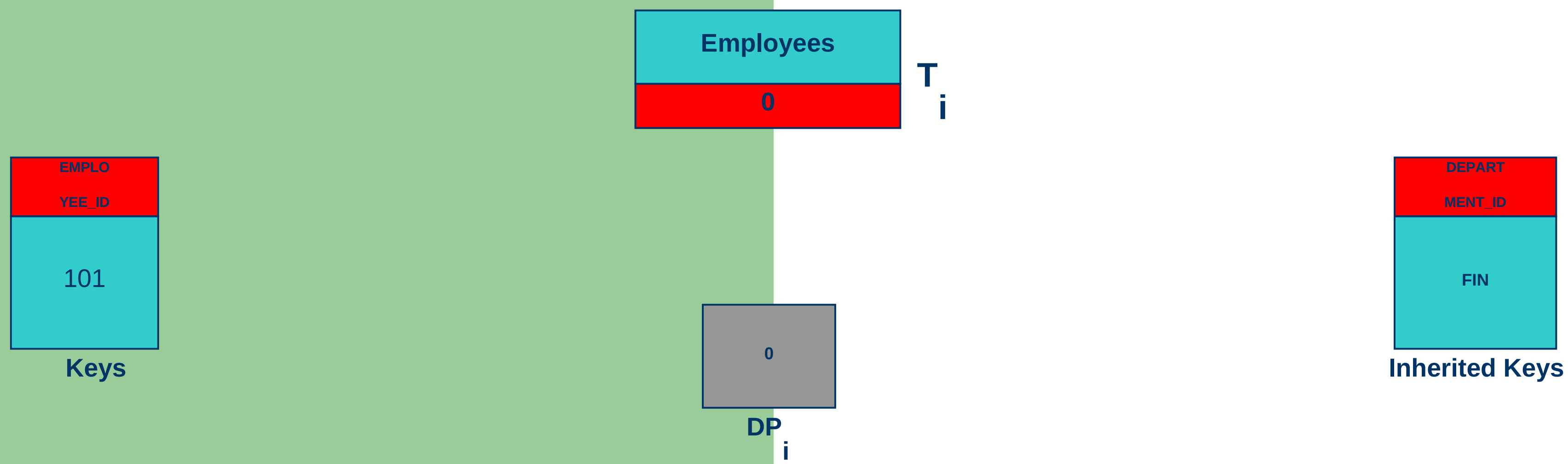
insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

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)



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($T_{[k]}$,$Keys_{[k]}$,$InheritedKeys_{[k]}$,$[DP_k]$)

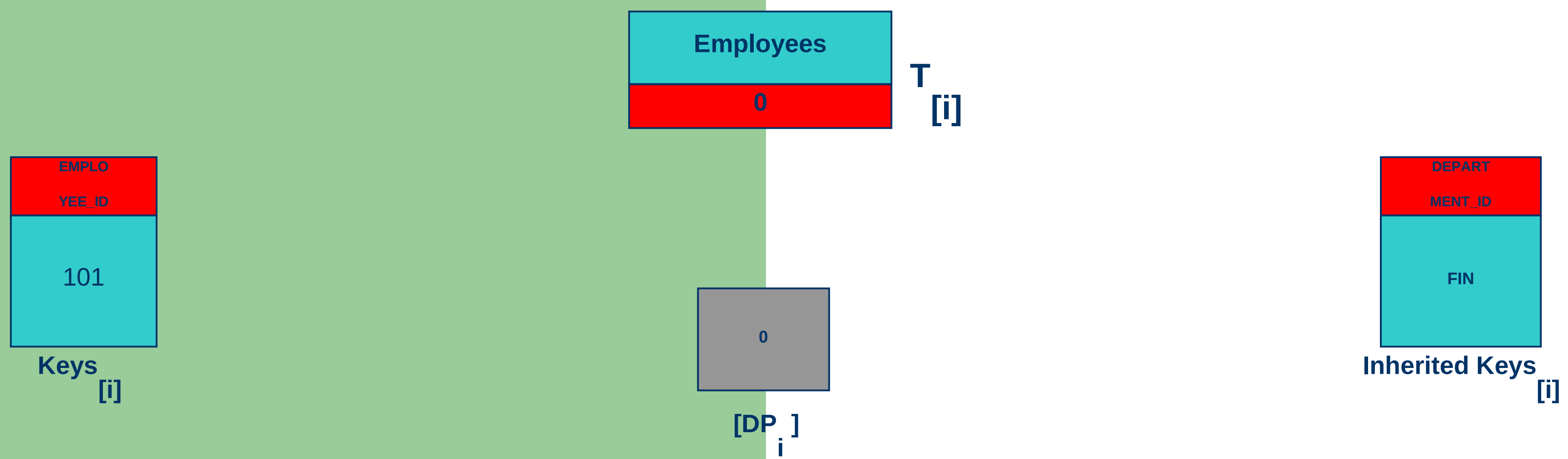
locate the entry of $T_{[ik]}$ in JoinPathList

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

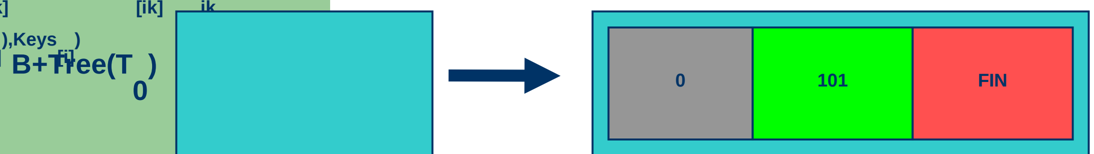
from $keys_{[i]}$, $InheritedKeys_{[i]}$, $Keys_{[k]}$ & $InheritedKeys_{[k]}$ get the keys & Inherited keys of $T_{[ik]}$

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])
```




```
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($T_{[k]}$),Keys$_{[i]}$)

0	Employees	Job_History	Employees	Employee_Id	Employees	Department_Id

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),Keys)

1	Job_History	Employees	Job_History	Employee_Id	Job_History	Job_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(T_1)

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: FALS`E

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

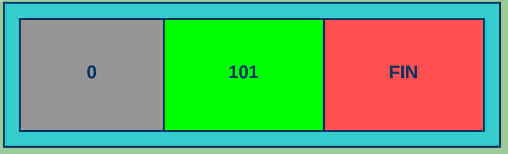
from its adjacentList, locate the definition of Keys & Inherited Keys

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_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
101	12/16/1998	12/15/1999	AC_AUD	ACC

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)

1 Job_History → Employees | Job_History | Employee_Id | Job_History | 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)

1 Job_History → Employees | $\underbrace{\text{Job\_History | Employee\_Id}}_{\text{Keys}}$ | $\underbrace{\text{Job\_History | Job\_Id}}_{\text{Inherited Keys}}$

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)

DP_{i0}

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

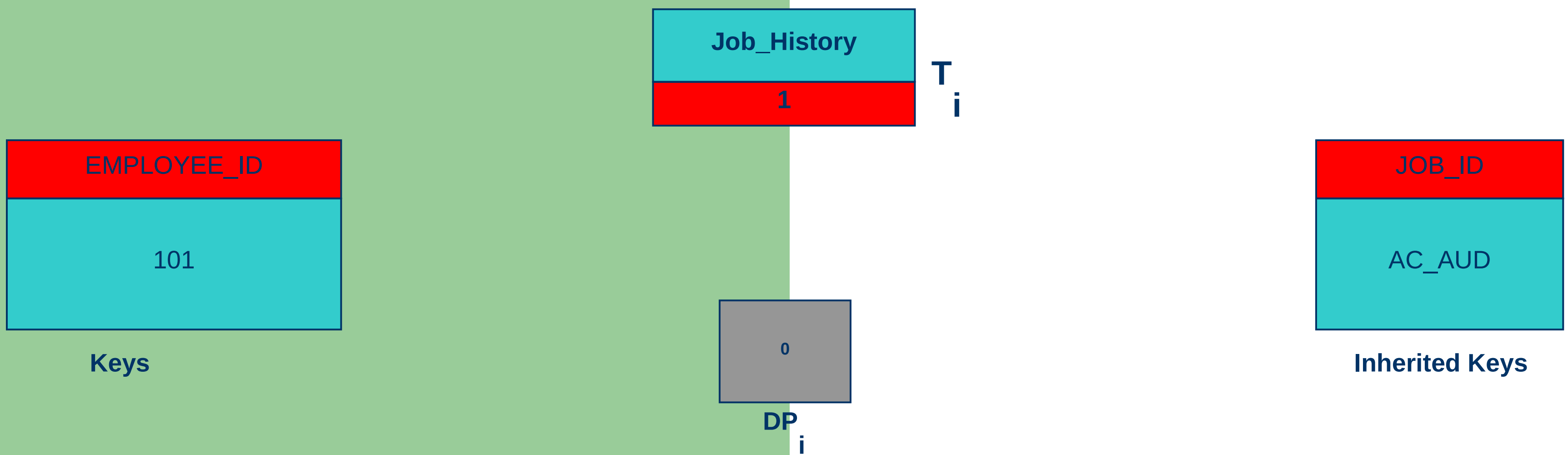
insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

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)



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($T_{[k]}$,$Keys_{[k]}$,$InheritedKeys_{[k]}$,$[DP_k]$)

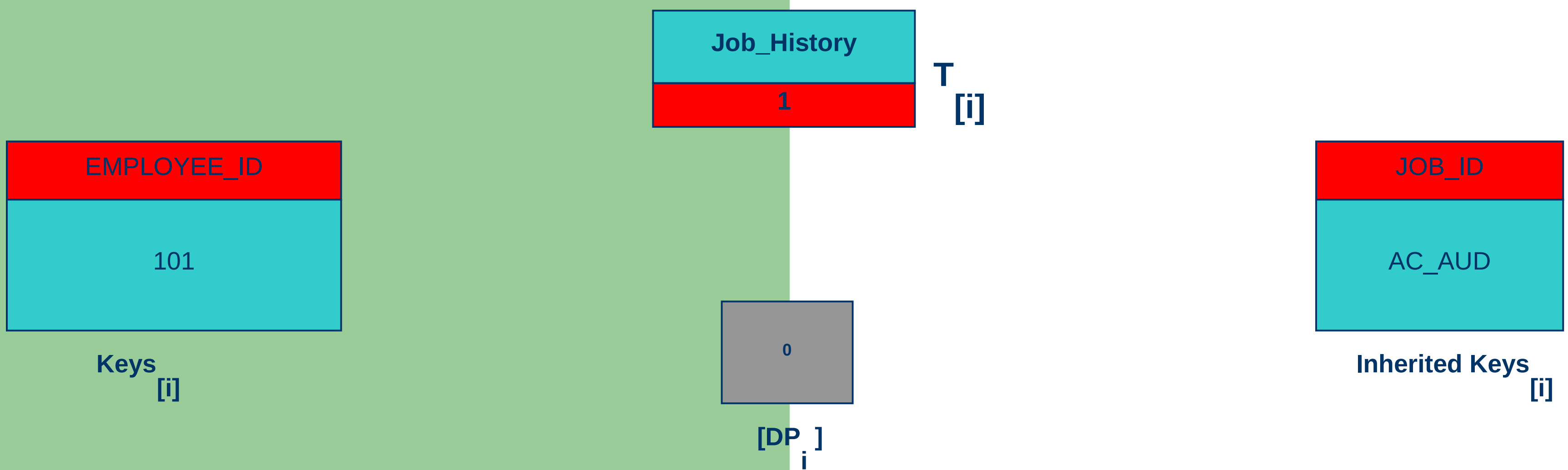
locate the entry of $T_{[ik]}$ in JoinPathList

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 $T_{[ik]}$

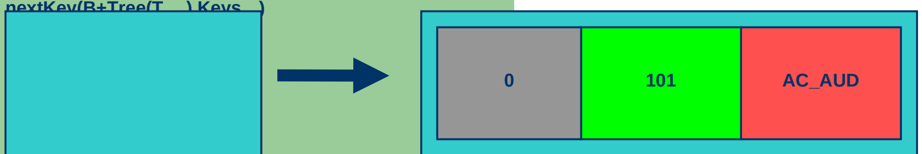
call AddJoinKey($T_{[ik]}$,$Keys_{[ik]}$,$InheritedKeys_{[ik]}$,$[DP_{ik}]$)

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



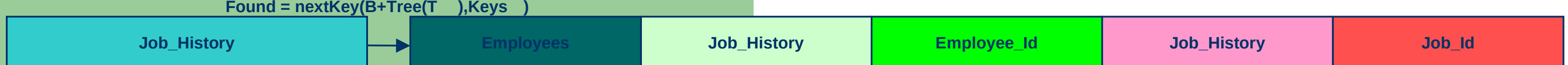
```
addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DPi])
    call addKey(B+Tree(T[i]),Keys[i],InheritedKeys[i],[DPi])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
        Found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

B+Tree(T_1)




```
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 ),Keys )
```


1



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($T_{[k]}$),$Keys_{[i]}$)

1	Job_History	→	Employees	Job_History	Employee_Id	Job_History	Job_Id

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($T_{[k]}$),$Keys_{[i]}$)

0	Employees	→	Job_History	Employees	Employee_Id	Employees	Department_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

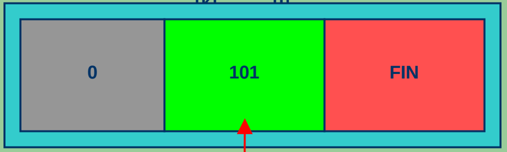
from its adjacentList, locate the definition of Keys & Inherited Keys

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(T_0)



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($T_{[k]}$),$Keys_{[i]}$)

EMPLOYEE_ID
101

$Keys_{[k]}$

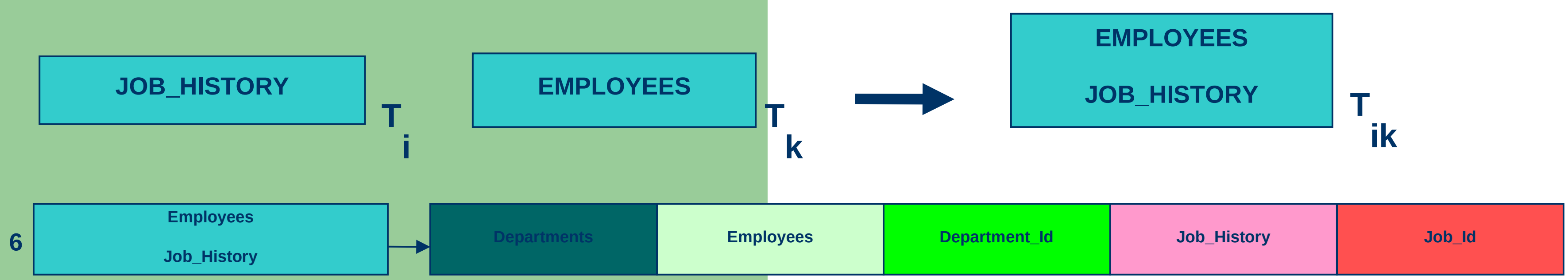
0

$[DP_k]$

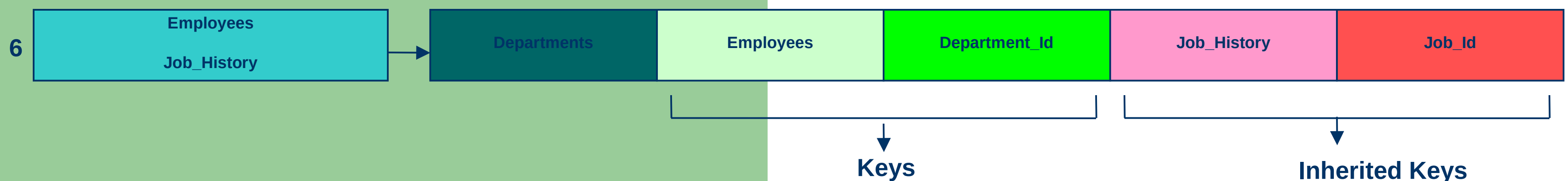
DEPARTMENT_ID
FIN

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])
```



```
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($T_{[k]}$,$Keys_{[k]}$,$InheritedKeys_{[k]}$,$[DP_k]$)

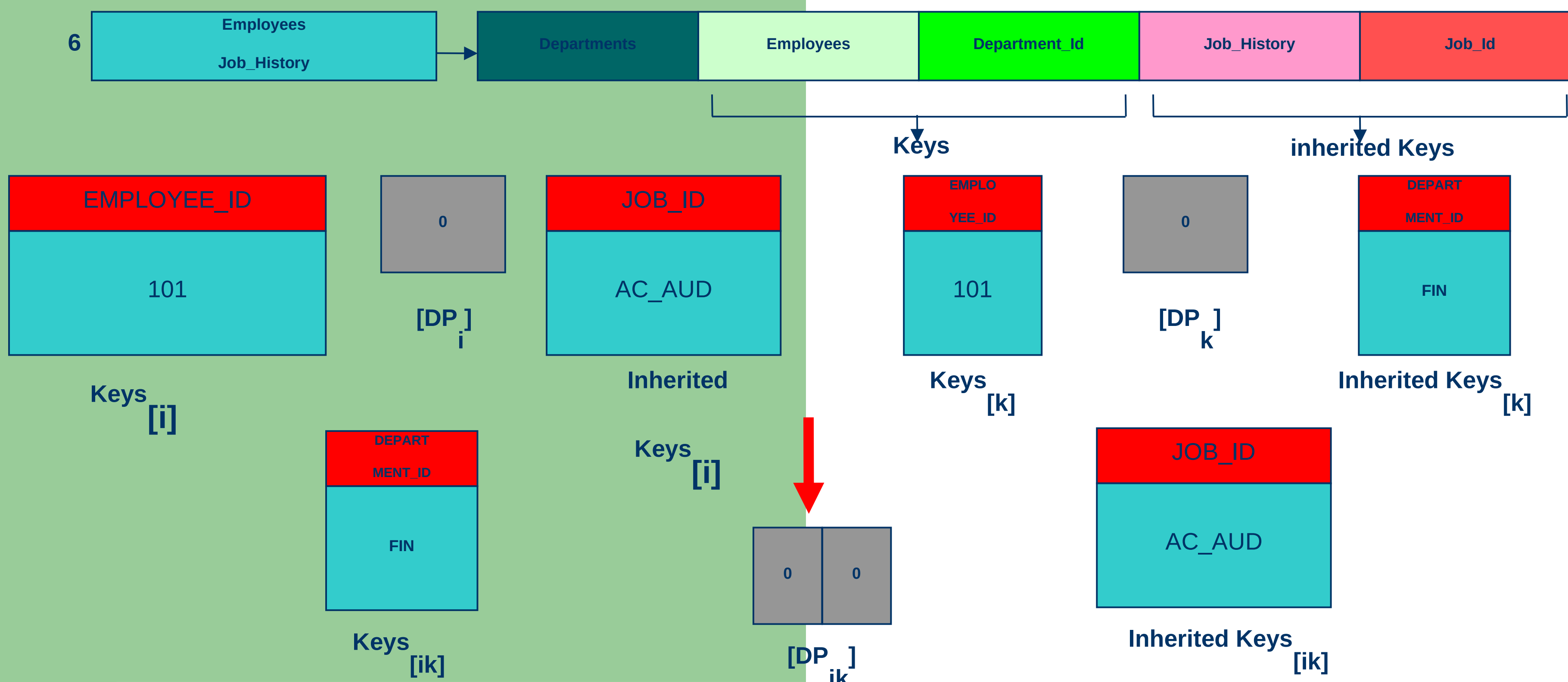
locate the entry of $T_{[ik]}$ in JoinPathList

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($T_{[k]}$),$Keys_{[i]}$)



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($T_{[k]}$,$Keys_{[k]}$,$InheritedKeys_{[k]}$,$[DP_k]$)

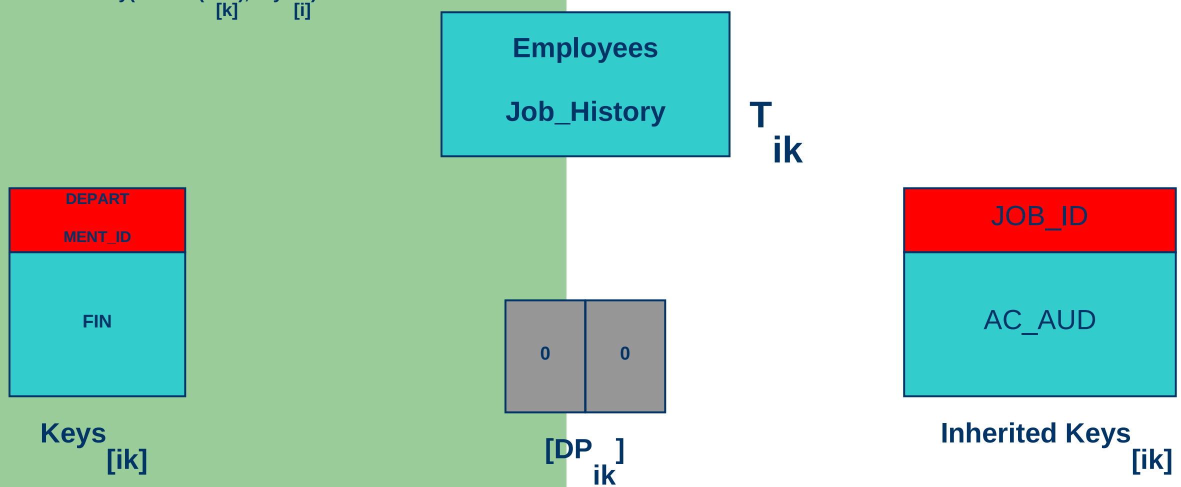
locate the entry of $T_{[ik]}$ in JoinPathList

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($T_{[k]}$),$Keys_{[i]}$)



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($T_{[k]}$,$Keys_{[k]}$,$InheritedKeys_{[k]}$,$[DP_{k}]$)

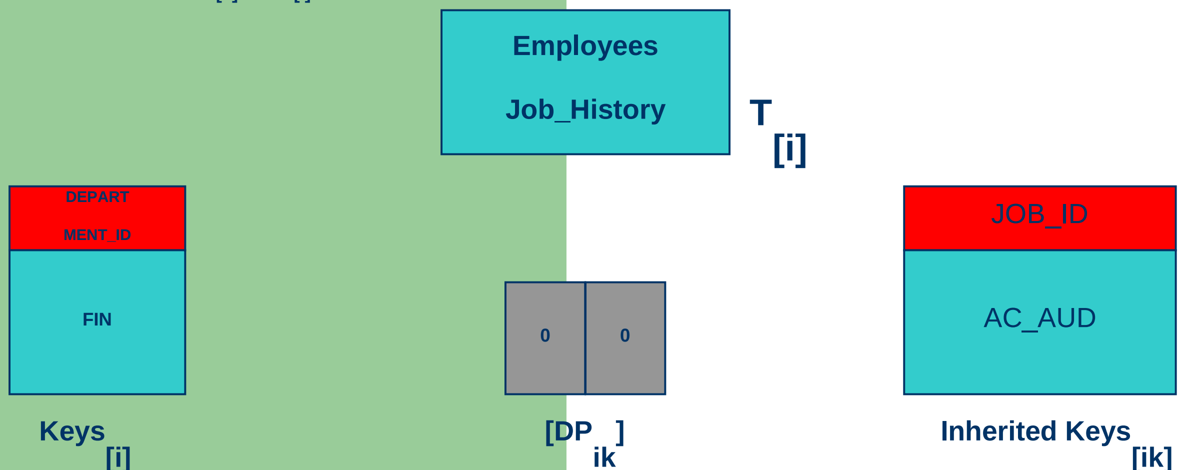
locate the entry of $T_{[ik]}$ in JoinPathList

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

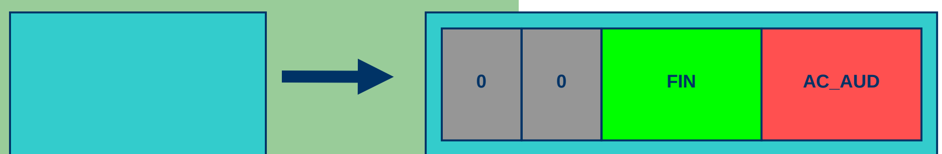
from its adjacentList, locate the definition of Keys & Inherited Keys

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_6)



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($T_{[k]}$),$Keys_{[i]}$)

6	Employees Job_History	Departments	Employees	Department_Id	Job_History	Job_Id

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($T_{[k]}$),$Keys_{[i]}$)

6	Employees Job_History	Departments	Employees	Department_Id	Job_History	Job_Id

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($T_{[k]}$),$Keys_{[i]}$)

2 Deparments | Employees Job_History | Departments | Department_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(T_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

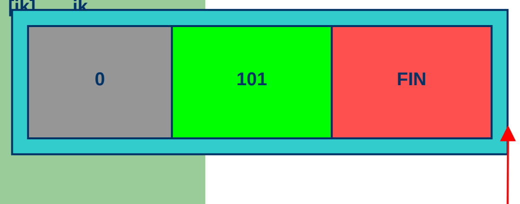
from its adjacentList, locate the definition of Keys & Inherited Keys

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(T_0)



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: FALSE

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_0)

0	101	FIN

B+Tree(T_1)

0	101	AC_AUD

B+Tree(T_6)

0	0	FIN	AC_AUD

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

LOCATION_ID	STREET_ADDRESS	POSTAL_CODE	CITY	STATE PROVINCE	COUNTRY_ID
1000	22220 Cochrane Drive	V6V 2T9	Richmond	B.C.	ca

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)

4

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

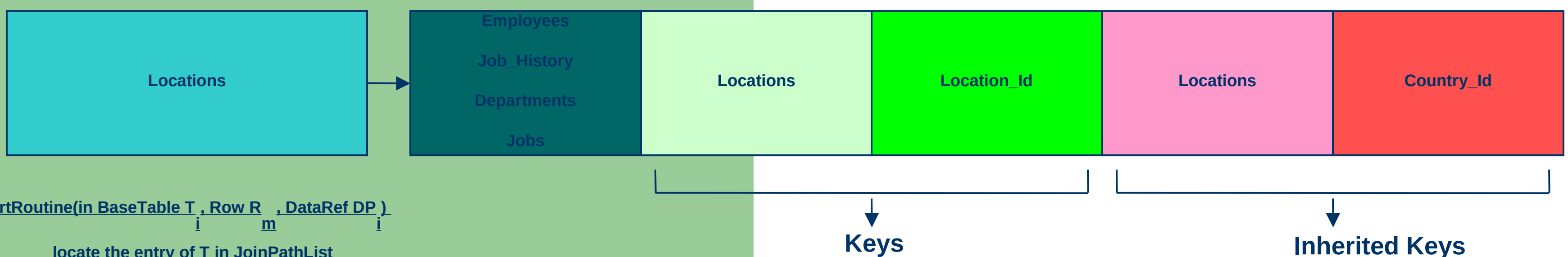
locate the entry of T_i in JoinPathList

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



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

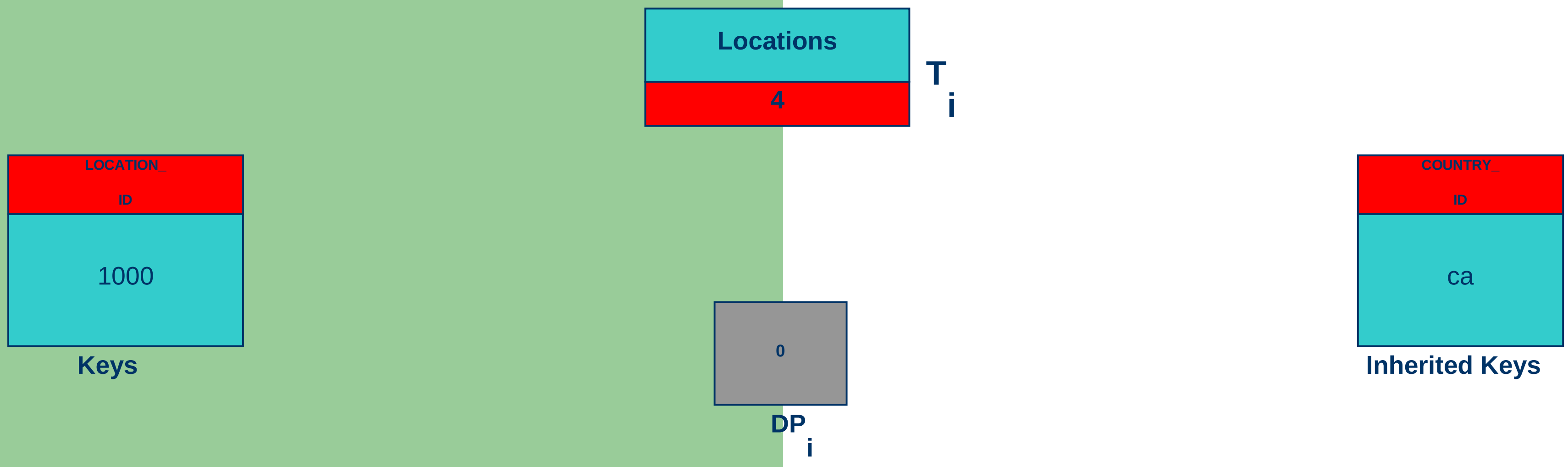
insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

locate the entry of T_i in JoinPathList

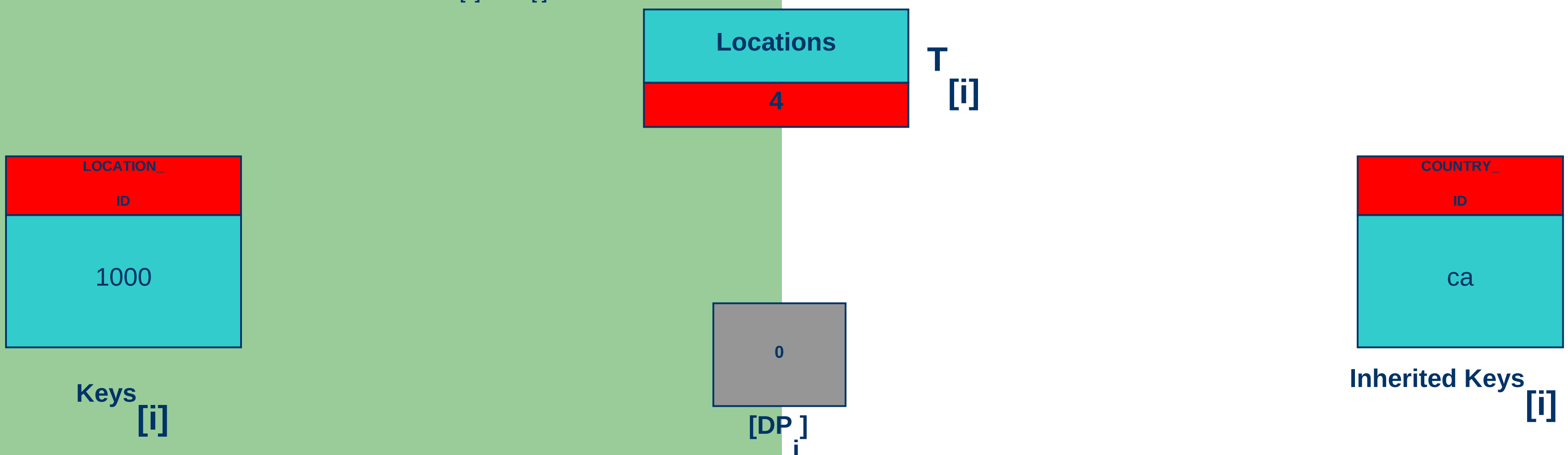
from its adjacentList, locate the definition of Keys & Inherited Keys

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

call AddJoinKey(T_i, $Keys_i$, $InheritedKeys_i$, DP_i)



```
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($T_{[k]}$),$Keys_{[i]}$)

B+Tree(T_4)

0	1000	ca

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 $T_{[ik]}$

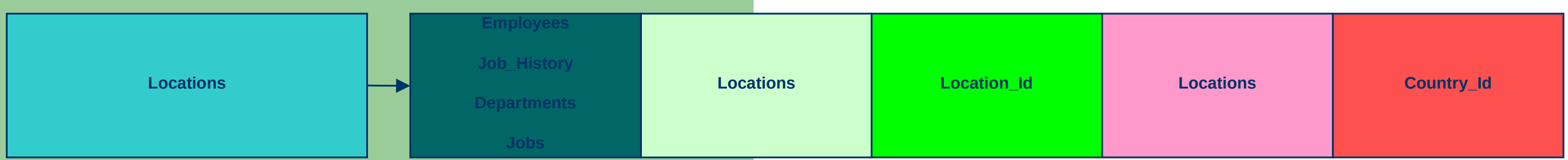
call AddJoinKey($T_{[ik]}$,$Keys_{[ik]}$,$InheritedKeys_{[ik]}$,[DP_{ik}])

Found = nextKey(B+Tree(T),Keys)

4	Locations	Employees Job_History Departments Jobs	Locations	Location_Id	Locations	Country_Id

```
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])
```

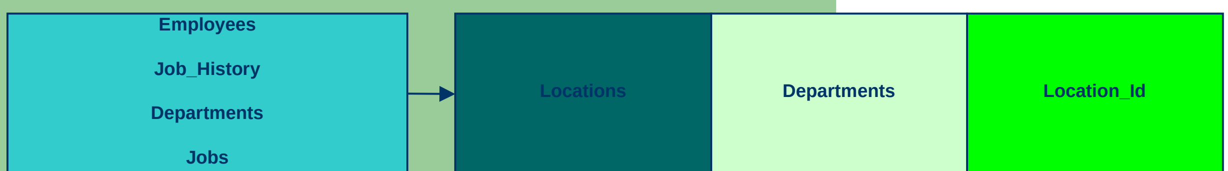
4



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])
```

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(T_8)

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)

0	101	FIN

B+Tree(T_1)

0	101	AC_AUD

B+Tree(T_4)

0	1000	ca

B+Tree(T_6)

0	0	FIN	AC_AUD

Inserting first row from table Departments

Base Table

DEPARTMENTS
2

Deparment_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

Deparment_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	Deparments	→	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	Deparments	→	Employees Job_History	Departments	Department_Id	Departments	Location_Id

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)

DP_{i0}

Deparment_Id	Department_Name	Manager_Id	Location_Id
FIN	FINANCE	101	1000

Keys

Row R_m

Inherited Keys

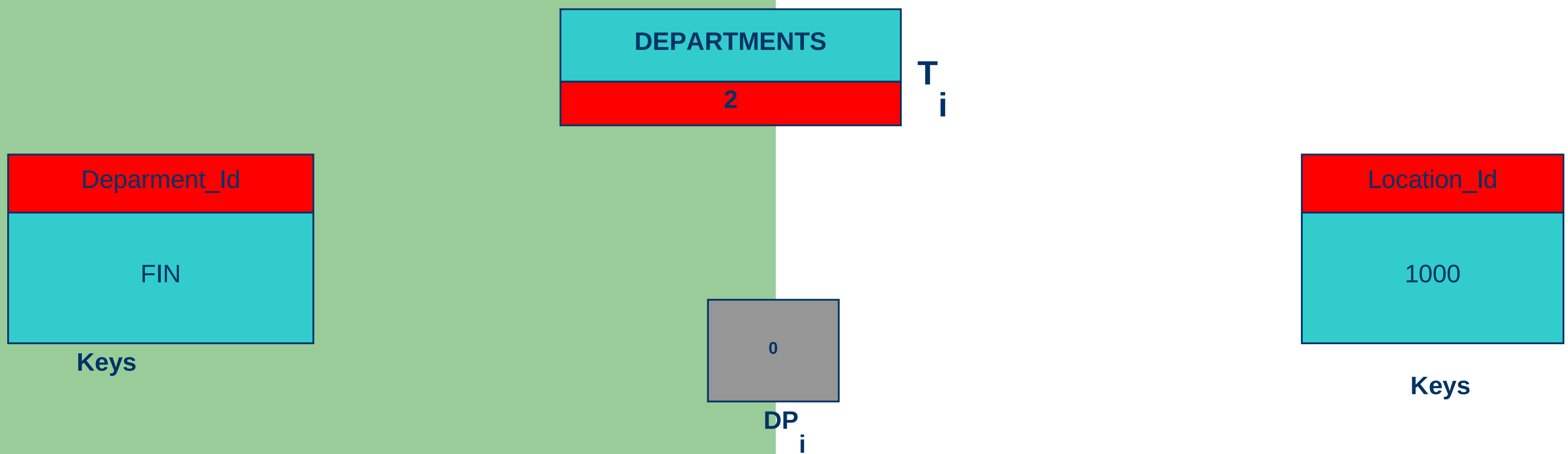
insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

locate the entry of T_i in JoinPathList

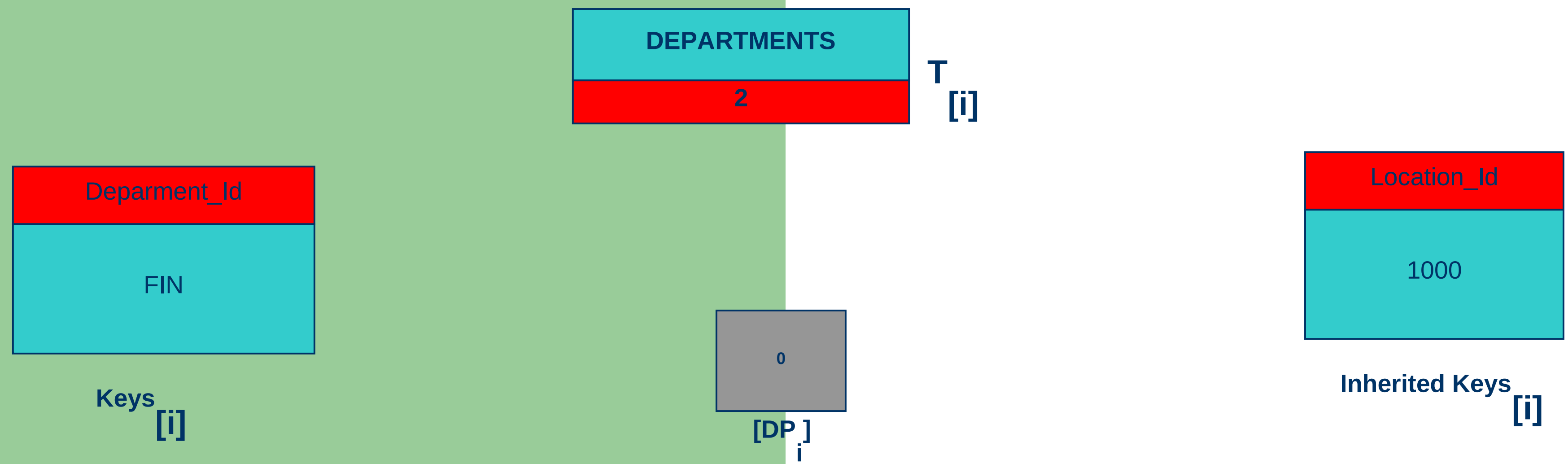
from its adjacentList, locate the definition of Keys & Inherited Keys

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

call AddJoinKey(T_i, $Keys_i$, $InheritedKeys_i$, DP_i)



```
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

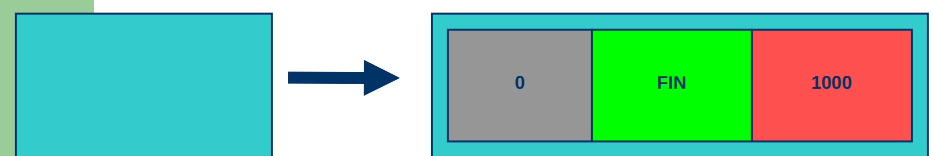
from its adjacentList, locate the definition of Keys & Inherited Keys

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($T_{[k]}$),$Keys_{[i]}$)

B+Tree(T_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($T_{[k]}$),$Keys_{[i]}$)

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($T_{[k]}$),$Keys_{[i]}$)

2	Deparments	→	Employees Job_History	Departments	Department_Id	Departments	Location_Id

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

Adjacent Table

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($T_{[k]}$),$Keys_{[i]}$)

6	Employees Job_History	→	Departments	Employees	Department_Id	Job_History	Job_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

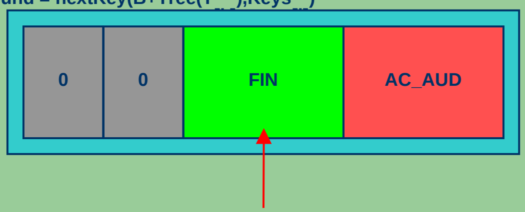
from its adjacentList, locate the definition of Keys & Inherited Keys

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(T_6)



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: TRUE

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($T_{[k]}$),$Keys_{[i]}$)

DEPARTMENT_ID
FIN

$Keys_{[k]}$

0	0

$[DP_{k}]$

JOB_ID
AC_AUD

Inherited $Keys_{[k]}$

addJoinKey(in Virtual Table $T_{[i]}$, $Keys_{[i]}$, $InheritedKeys_{[i]}$, [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])

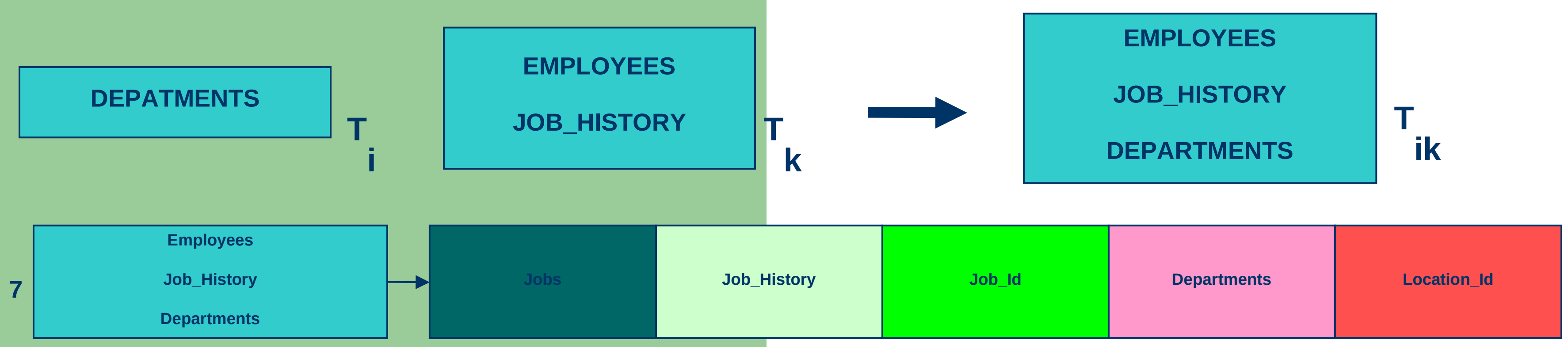
locate the entry of $T_{[ik]}$ in JoinPathList

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($T_{[k]}$,$Keys_{[k]}$,$InheritedKeys_{[k]}$,$[DP_k]$)

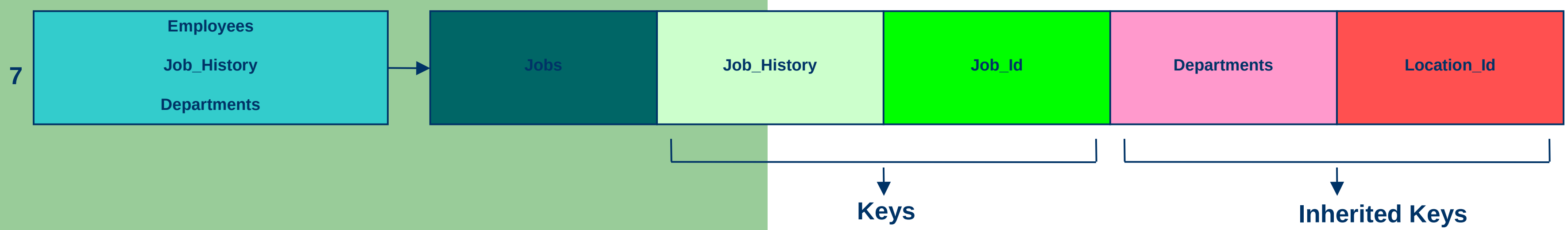
locate the entry of $T_{[ik]}$ in JoinPathList

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

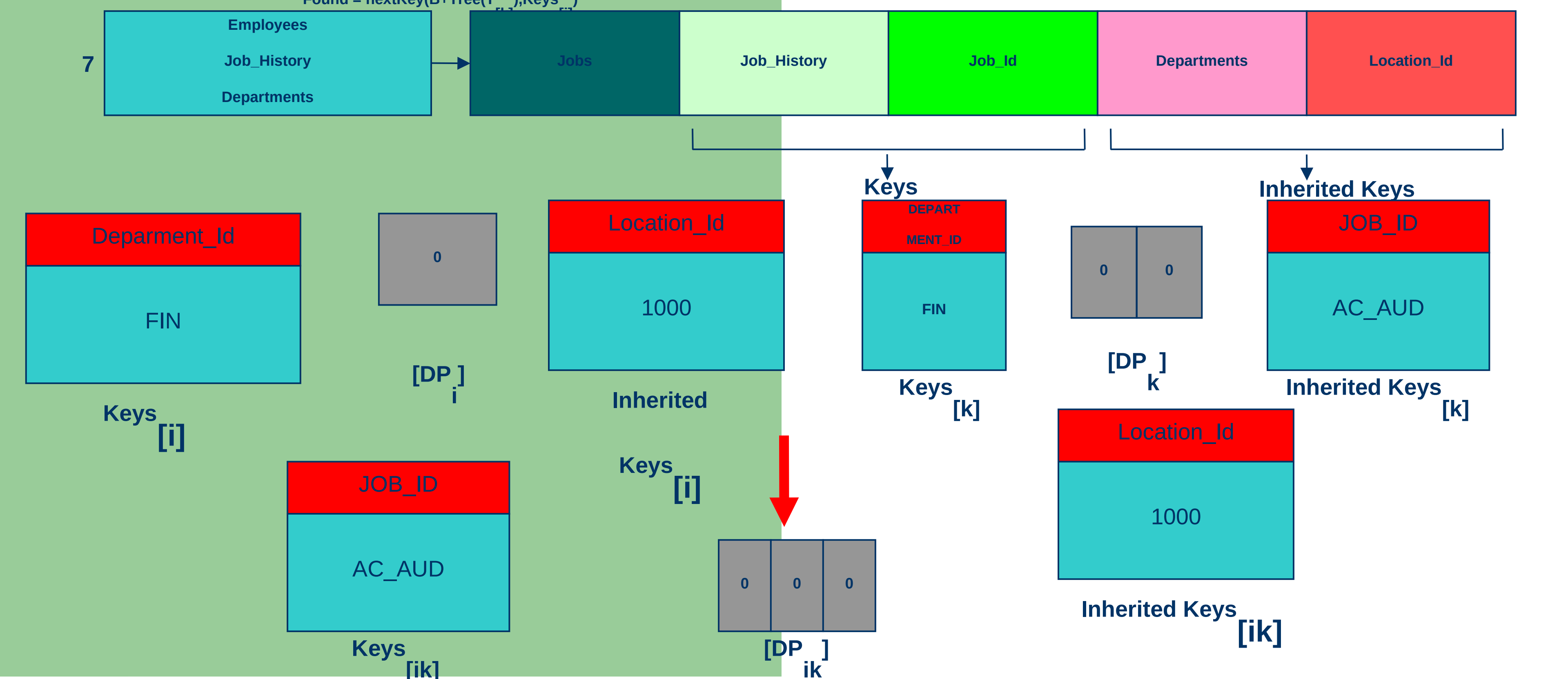
from keys$_{[i]}$, $InheritedKeys_{[i]}$, $Keys_{[k]}$ & $InheritedKeys_{[k]}$ get the keys & Inherited keys of $T_{[ik]}$

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

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



```
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[i]),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($T_{[k]}$,$Keys_{[k]}$,$InheritedKeys_{[k]}$,$[DP_k]$)

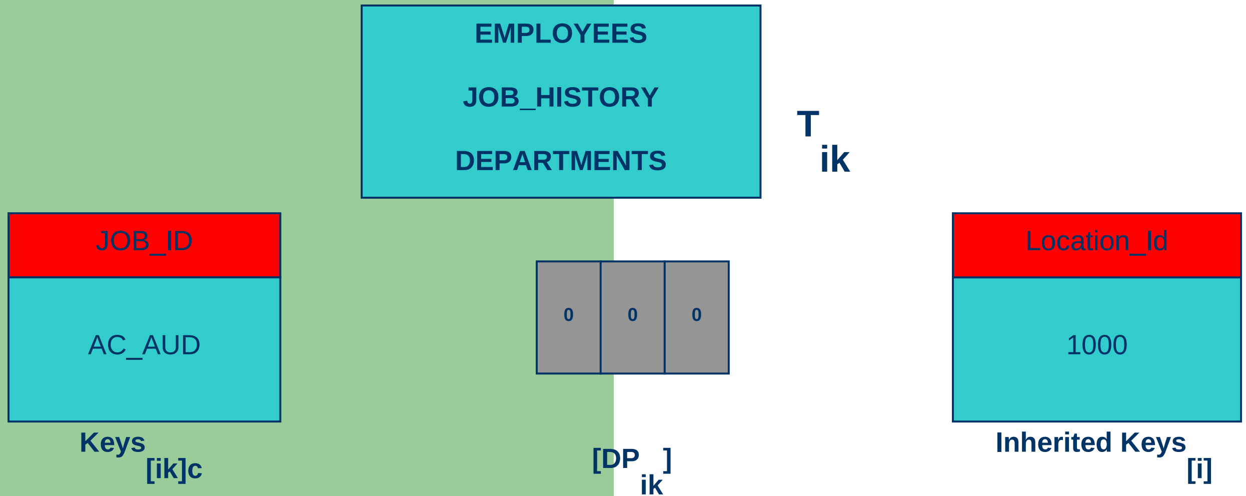
locate the entry of $T_{[ik]}$ in JoinPathList

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($T_{[k]}$,$Keys_{[k]}$,$InheritedKeys_{[k]}$,$[DP_k]$)

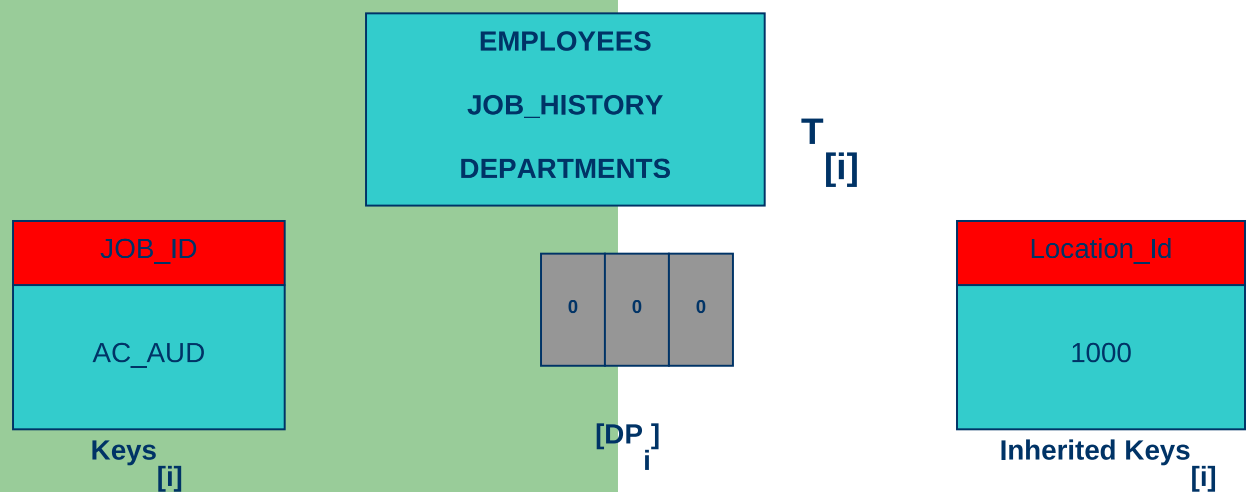
locate the entry of $T_{[ik]}$ in JoinPathList

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($T_{[k]}$),$Keys_{[i]}$)



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

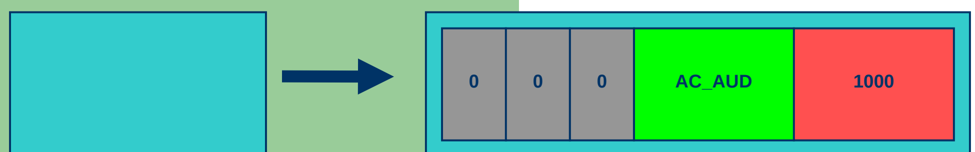
from its adjacentList, locate the definition of Keys & Inherited Keys

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}])

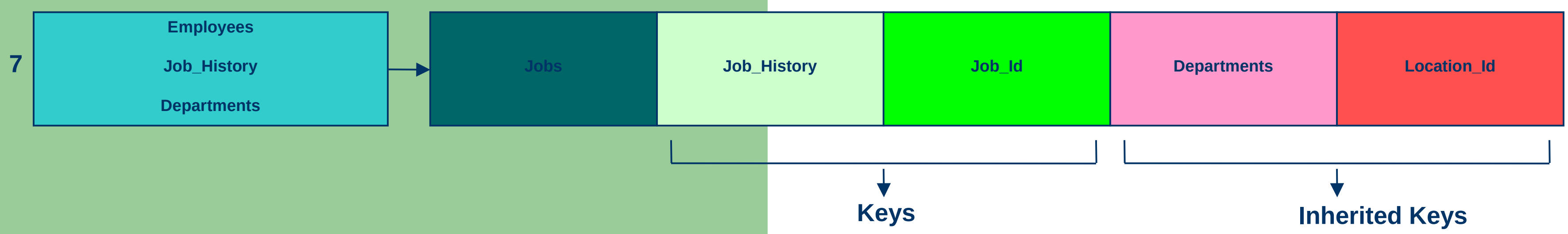
locate the entry of $T_{[ik]}$ in JoinPathList

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($T_{[k]}$),$Keys_{[i]}$)



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

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

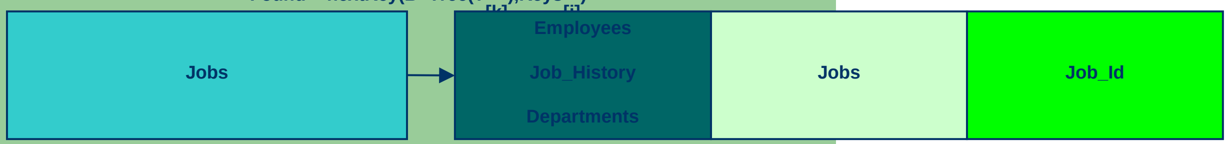
from its adjacentList, locate the definition of Keys & Inherited Keys

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($T_{[k]}$),$Keys_{[i]}$)

3



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_3)

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

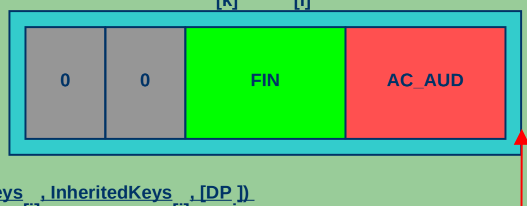
from its adjacentList, locate the definition of Keys & Inherited Keys

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(T_6)



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($T_{[k]}$,$Keys_{[k]}$,$InheritedKeys_{[k]}$,$[DP_k]$)

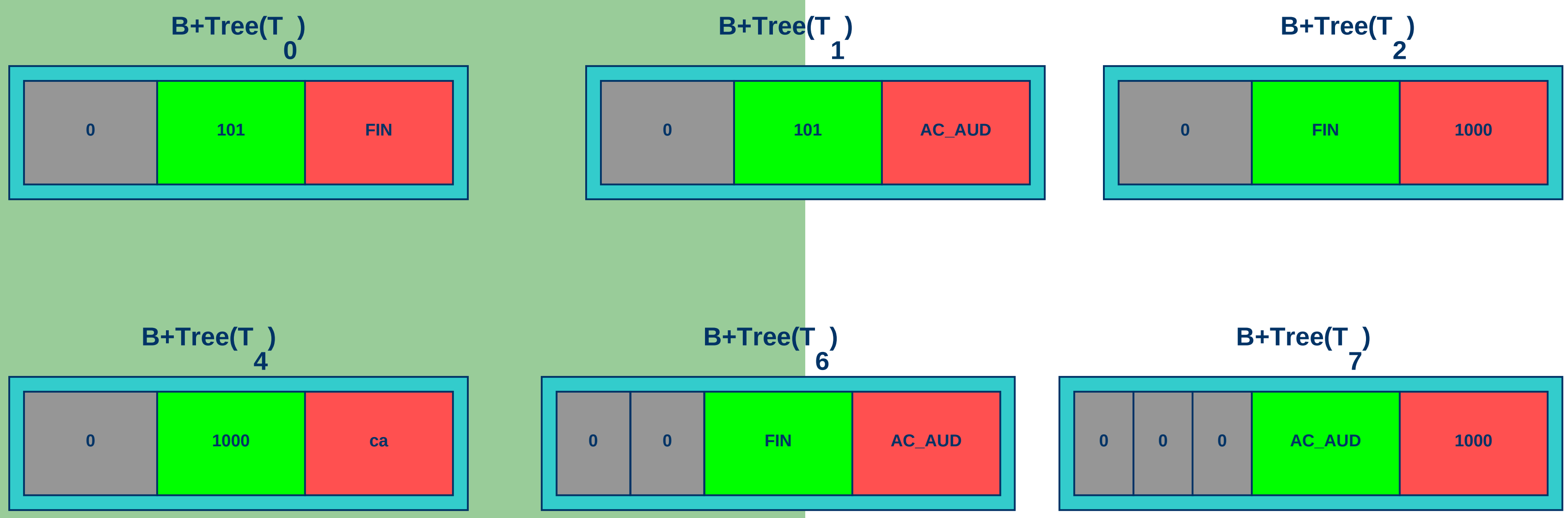
locate the entry of $T_{[ik]}$ in JoinPathList

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($T_{[k]}$),$Keys_{[i]}$)



Inserting first row from table Jobs

Base Table

JOBS
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
AC_AUD	Accounting Auditor	30000	60000

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)

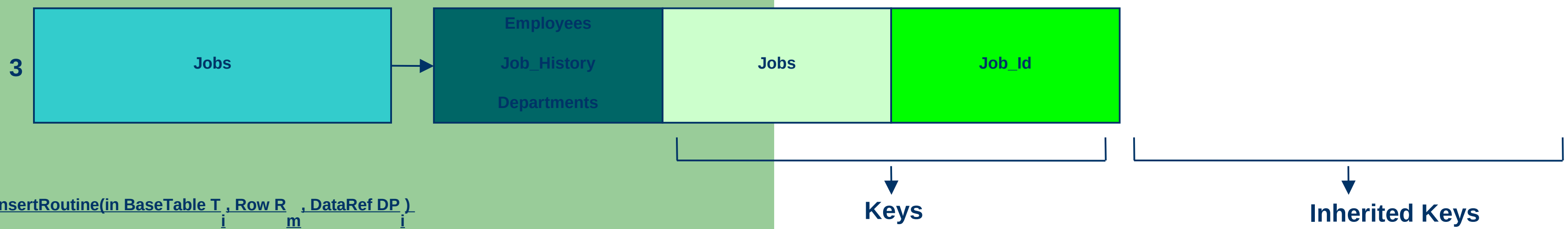
insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

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)

	JOB_ID	JOB_TITLE	MIN_SALARY	MAX_SALARY
DP_{i0}	AC_AUD	Accounting Auditor	30000	60000

Keys

Row R_m

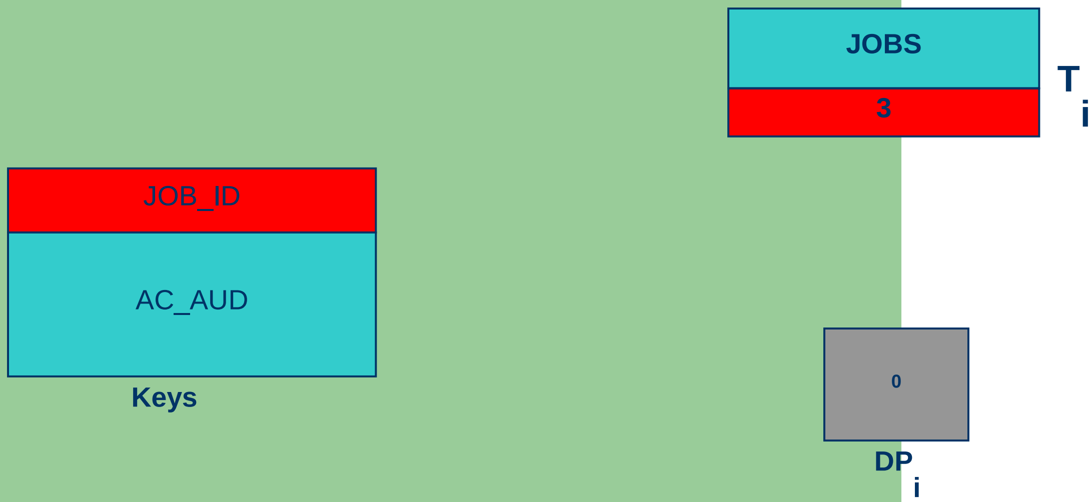
insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

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)



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($T_{[k]}$,$Keys_{[k]}$,$InheritedKeys_{[k]}$,$[DP_k]$)

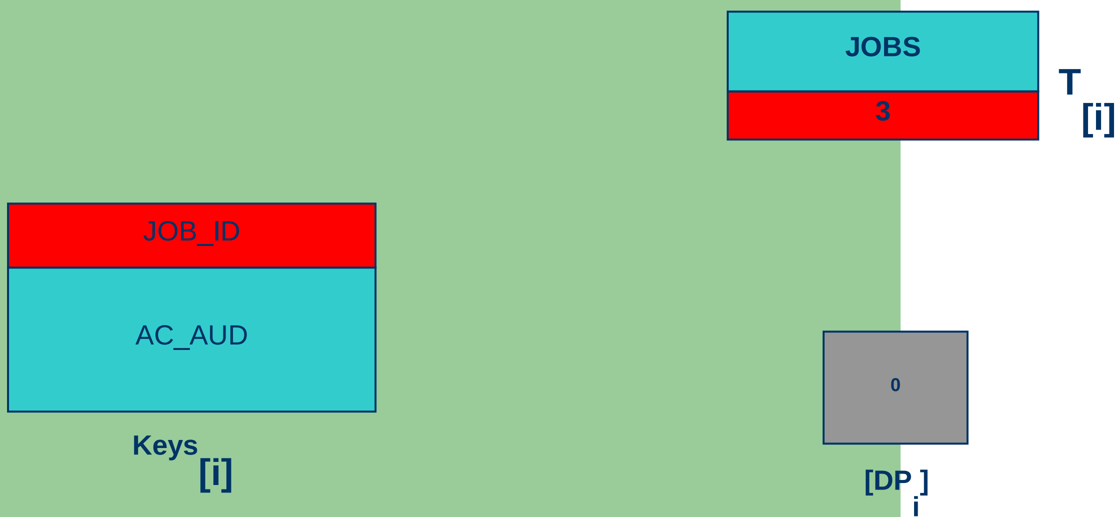
locate the entry of $T_{[ik]}$ in JoinPathList

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($T_{[k]}$),$Keys_{[i]}$)

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

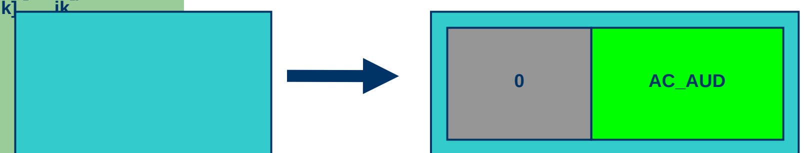
from its adjacentList, locate the definition of Keys & Inherited Keys

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

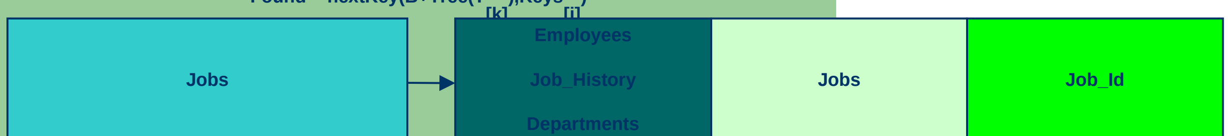
call AddJoinKey($T_{[ik]}$,$Keys_{[ik]}$,$InheritedKeys_{[ik]}$,[DP_{ik}])

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

B+Tree(T_3)



3



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

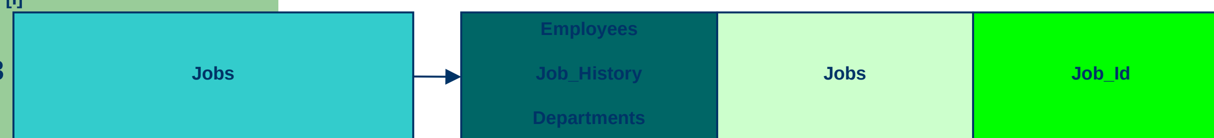
from its adjacentList, locate the definition of Keys & Inherited Keys

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



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($T_{[k]}$),$Keys_{[i]}$)

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

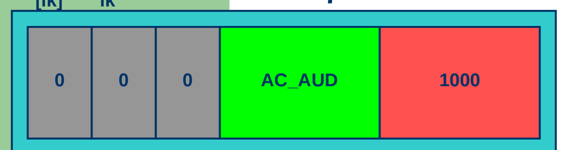
from its adjacentList, locate the definition of Keys & Inherited Keys

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$_{[i]}$)

B+Tree(T_7)



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$_k$])

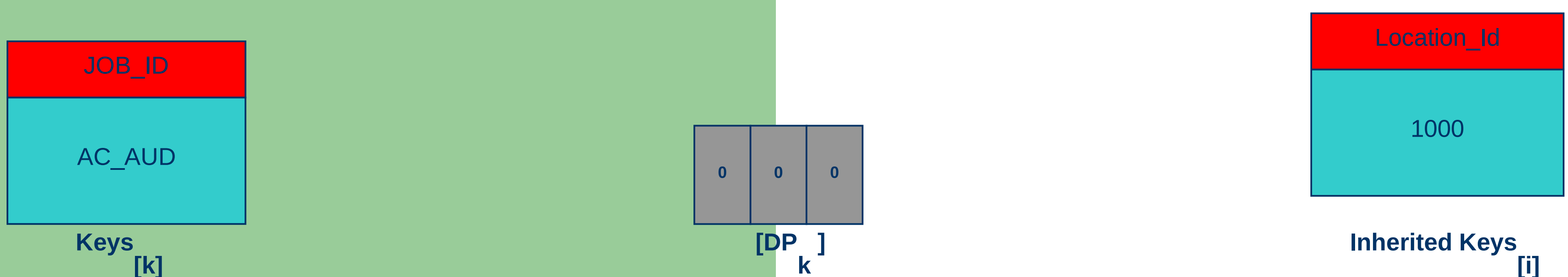
locate the entry of $T_{[ik]}$ in JoinPathList

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

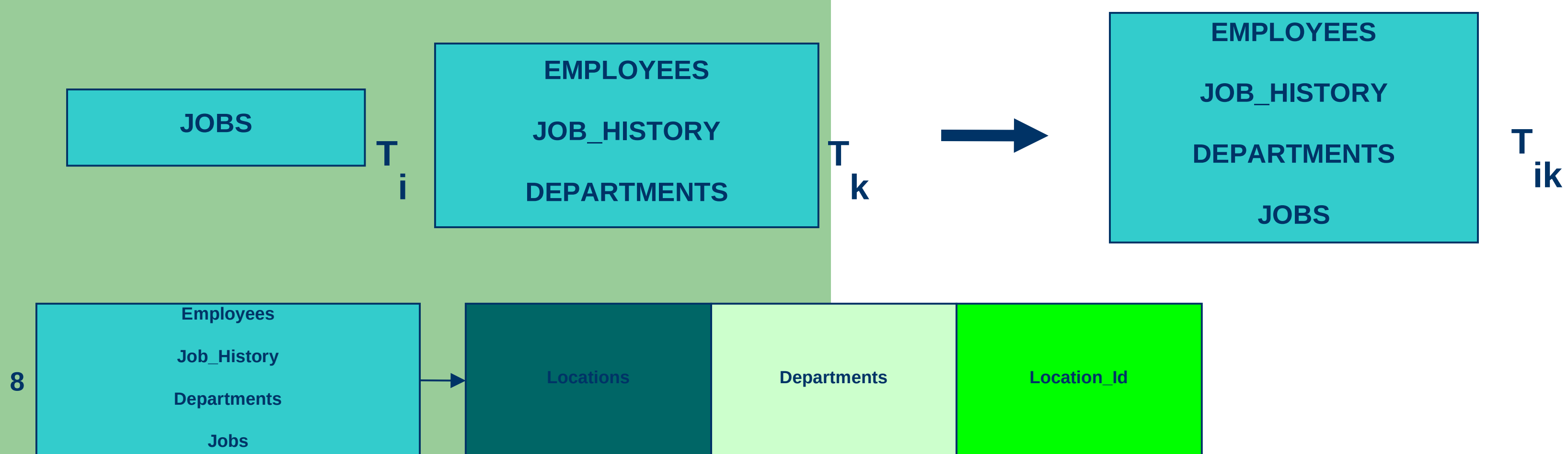
from keys$_{[i]}$, InheritedKeys$_{[i]}$, Keys$_{[k]}$ & InheritedKeys$_{[k]}$ get the keys & Inherited keys of $T_{[ik]}$

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

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

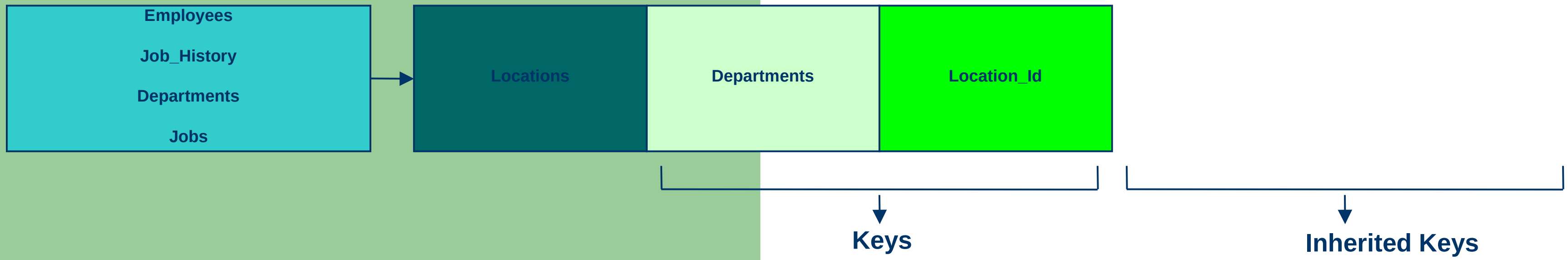


```
addJoinKey(in Virtual Table T[i], Keys[i], InheritedKeys[i], [DP i])
    call addKey(B+Tree(T[i]),Keys[i],InheritedKeys[i],[DP i])
    locate the entry of T[i] in JoinPathList
    from its adjacentList, locate the table T[k] adjacent to it
        locate the entry of T[k] in JoinPathList
       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

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($T_{[k]}$,$Keys_{[k]}$,$InheritedKeys_{[k]}$,$[DP_k]$)

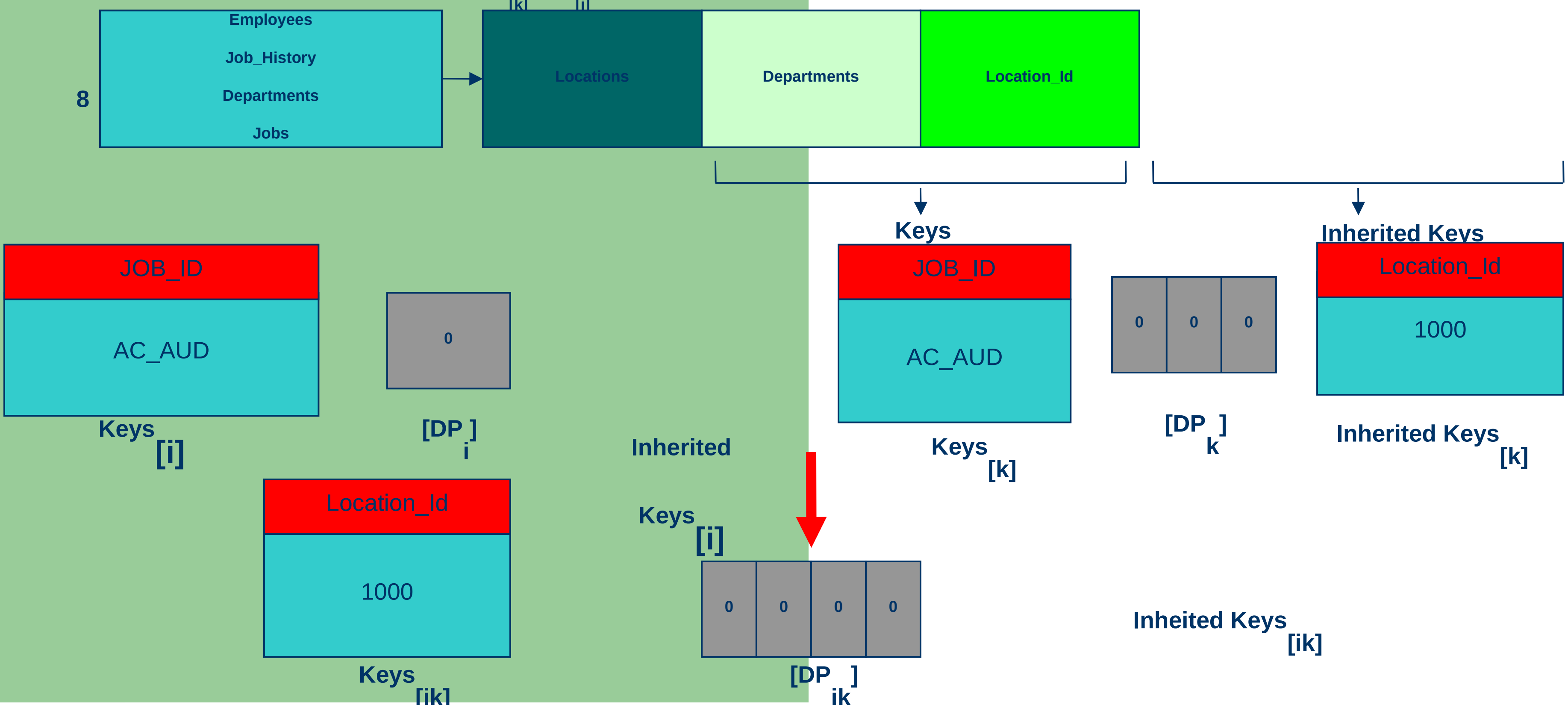
locate the entry of $T_{[ik]}$ in JoinPathList

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($T_{[k]}$),$Keys_{[i]}$)



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

T_{ik}

Location_Id

1000

$Keys_{[ik]}$

0	0	0	0

$[DP_{ik}]$

$Inherited\ Keys_{[ik]}$

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

$T_{[i]}$

Location_Id

1000

Keys$_{[i]}$

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

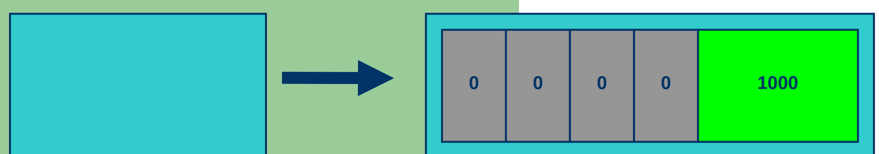
from its adjacentList, locate the definition of Keys & Inherited Keys

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])
```

8

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

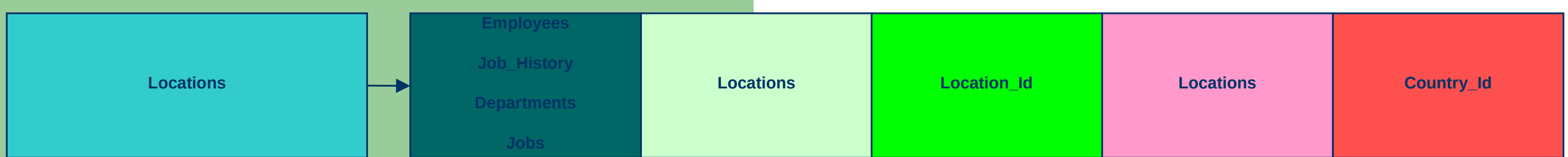
from its adjacentList, locate the definition of Keys & Inherited Keys

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

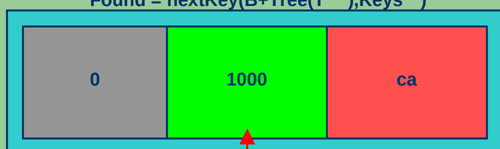
from its adjacentList, locate the definition of Keys & Inherited Keys

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),Keys)

B+Tree(T_4)



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($T_{[k]}$),$Keys_{[i]}$)

LOCATION_ID
1000

$Keys_{[k]}$

0

$[DP_k]$

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$_{[i]}$)

EMPLOYEES
JOB_HISTORY
DEPARTMENTS
JOBS

T_i

LOCATIONS

T_k

EMPLOYEES
JOB_HISTORY
DEPARTMENTS
JOBS
LOCATIONS

T_{ik}

9

Employees
Job_History
Departments
Jobs
Locations

Countries	Locations	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$_k$])

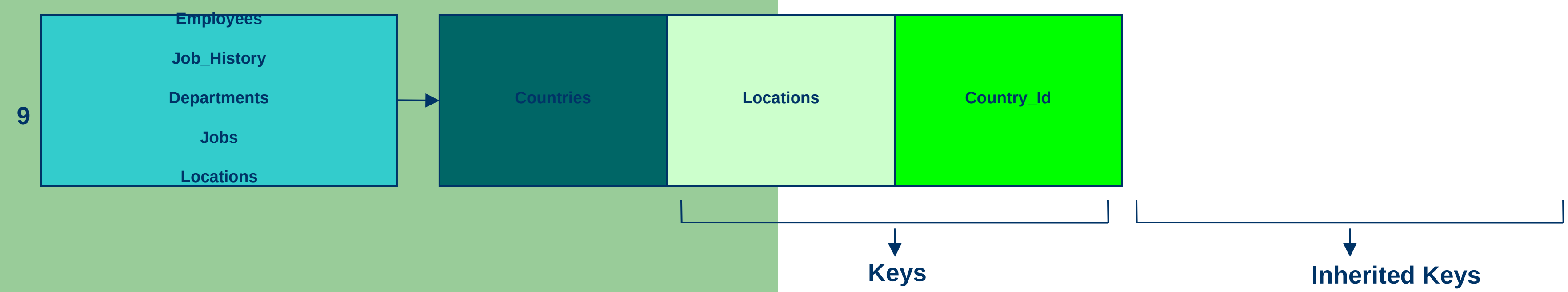
locate the entry of $T_{[ik]}$ in JoinPathList

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($T_{[k]}$),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($T_{[k]}$),$Keys_{[k]}$,$InheritedKeys_{[k]}$,$[DP_k]$)

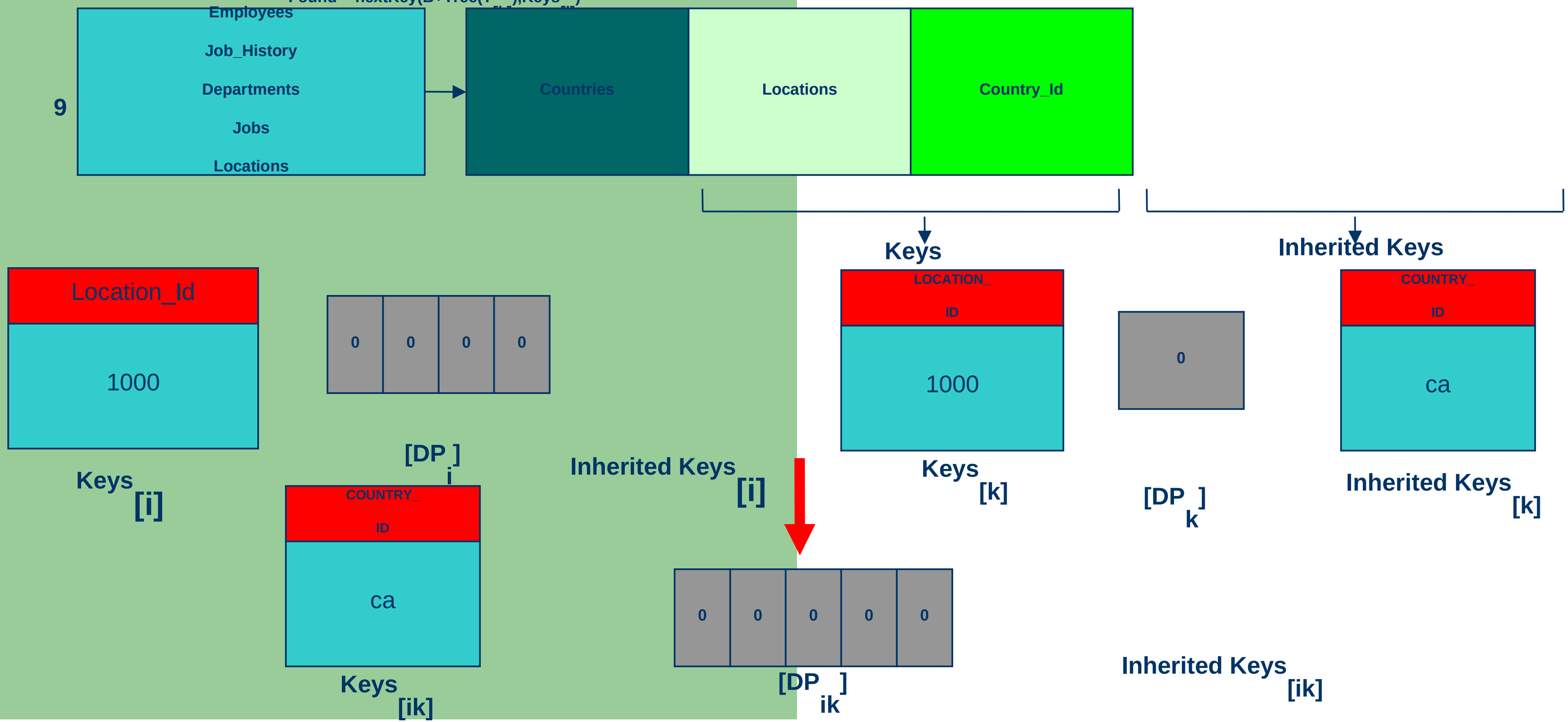
locate the entry of $T_{[ik]}$ in JoinPathList

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),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($T_{[k]}$,$Keys_{[k]}$,$InheritedKeys_{[k]}$,$[DP_k]$)

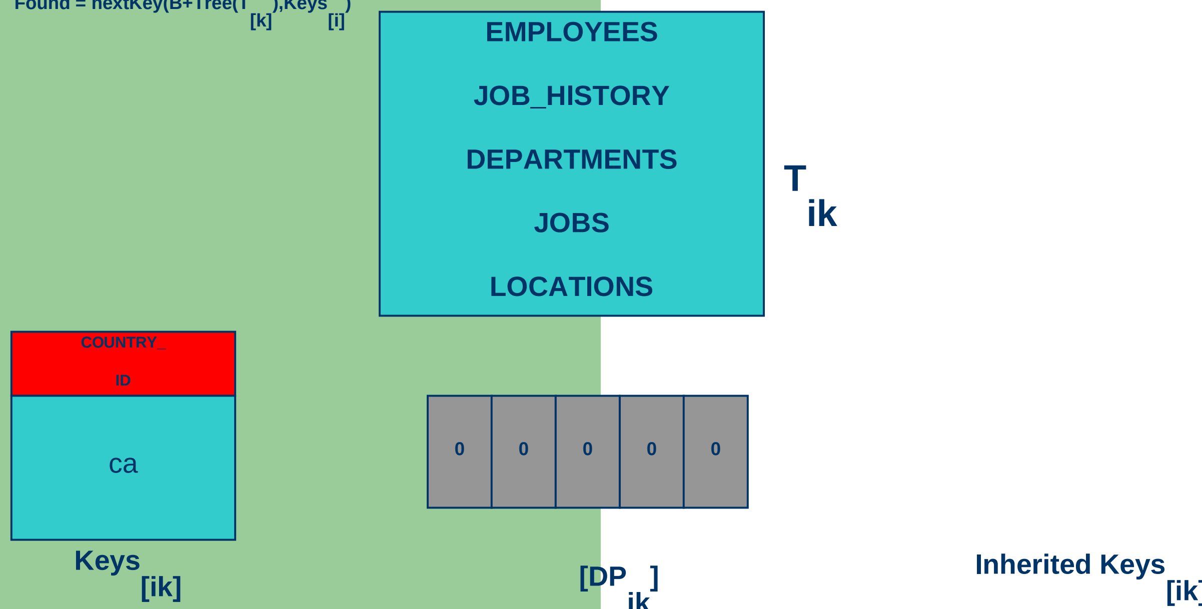
locate the entry of $T_{[ik]}$ in JoinPathList

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($T_{[k]}$),$Keys_{[i]}$)



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

$T_{[i]}$

COUNTRY_ID
ca

$Keys_{[i]}$

0	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

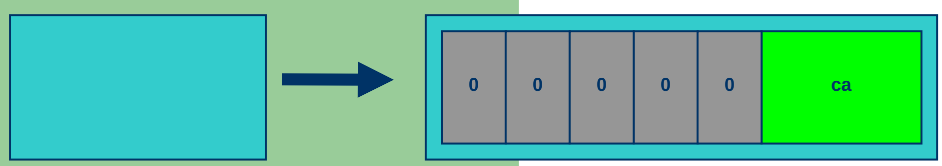
from its adjacentList, locate the definition of Keys & Inherited Keys

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_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($T_{[k]}$),$Keys_{[i]}$)

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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

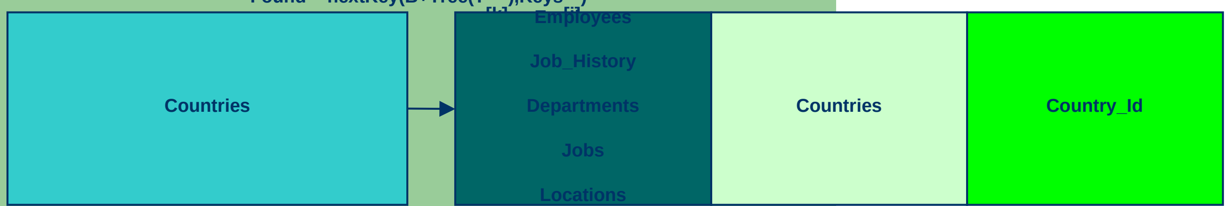
from its adjacentList, locate the definition of Keys & Inherited Keys

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($T_{[k]}$),$Keys_{[i]}$)

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($T_{[k]}$),$Keys_{[i]}$)

B+Tree(T_5)

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

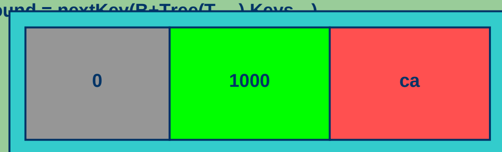
from its adjacentList, locate the definition of Keys & Inherited Keys

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),Keys)

B+Tree(T_4)



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(T_7)

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$_k$])

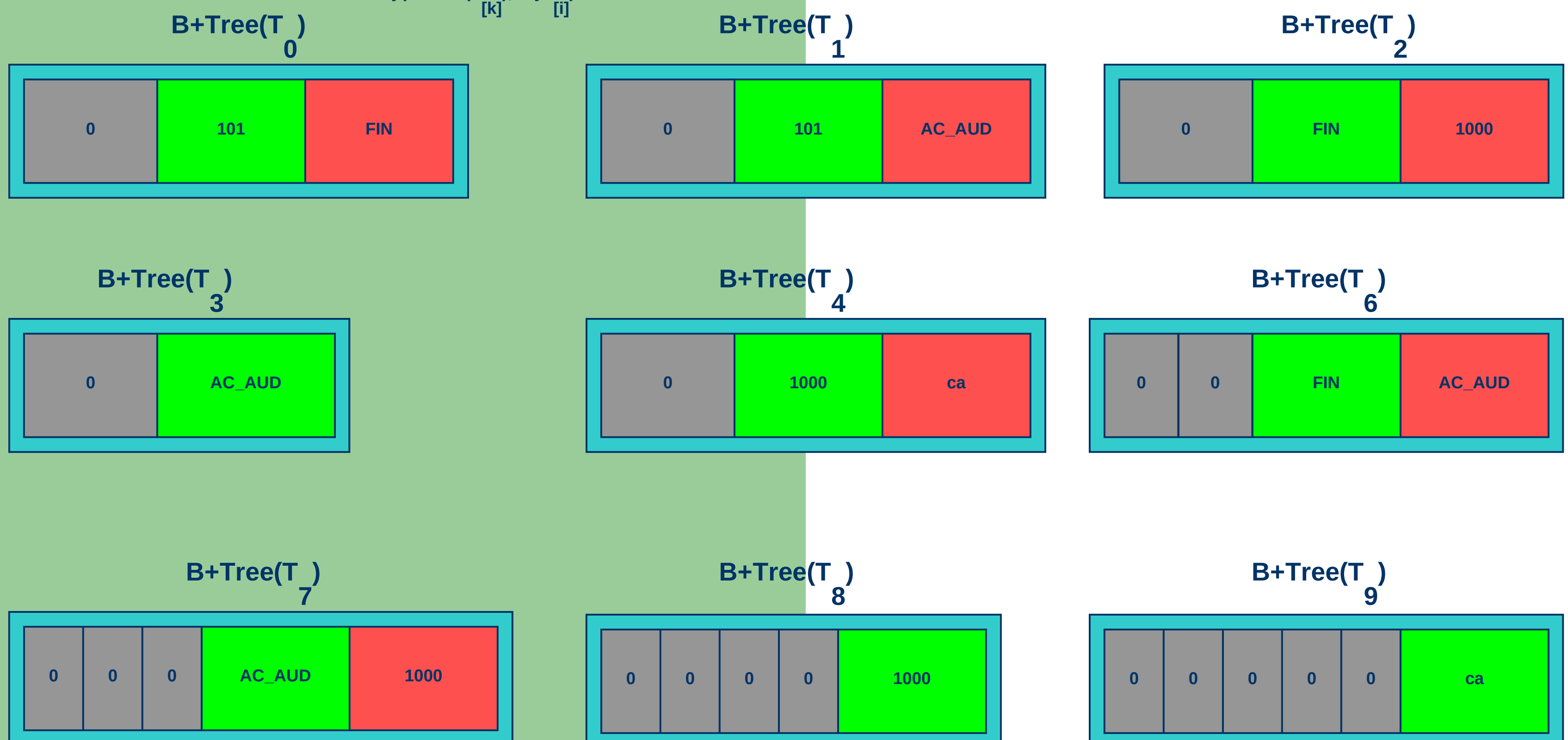
locate the entry of $T_{[ik]}$ in JoinPathList

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$_{[i]}$)



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_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

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)

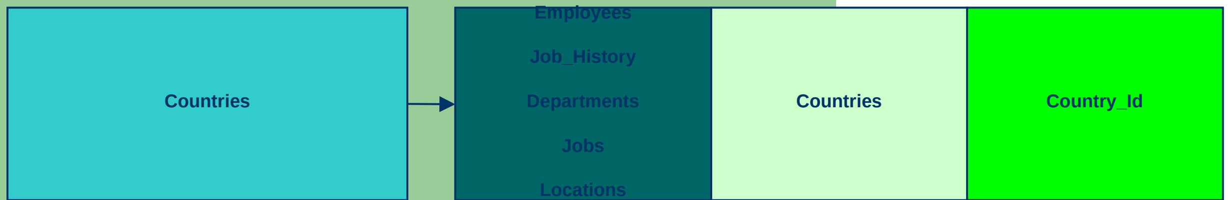
locate the entry of T_i in JoinPathList

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)

5



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)

5

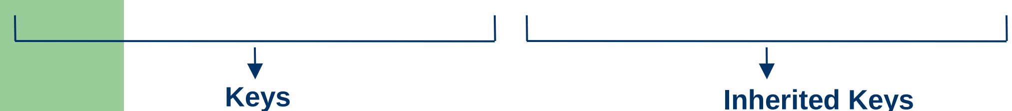
insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

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}

Country_Id	Country_Name
ca	Canada

Keys

Row R_m

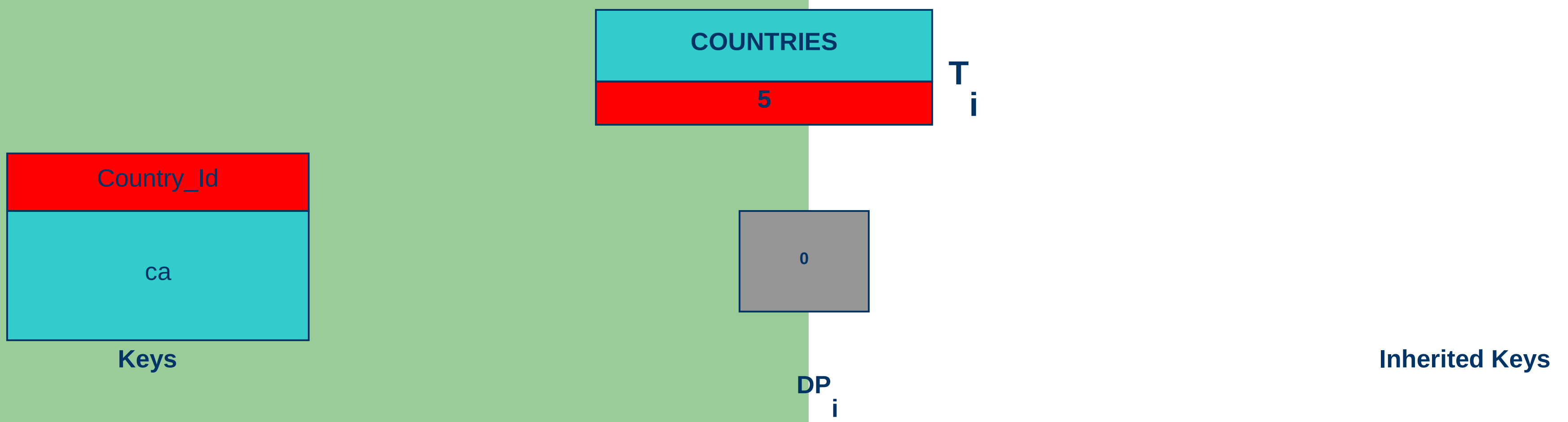
insertRoutine(in BaseTable T_i, Row R_m, DataRef DP_i)

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)



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

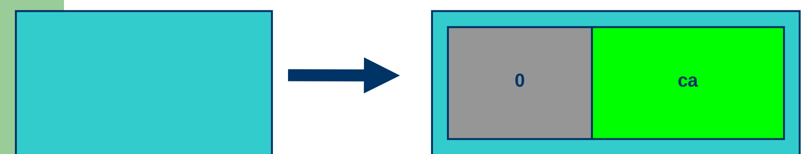
from its adjacentList, locate the definition of Keys & Inherited Keys

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

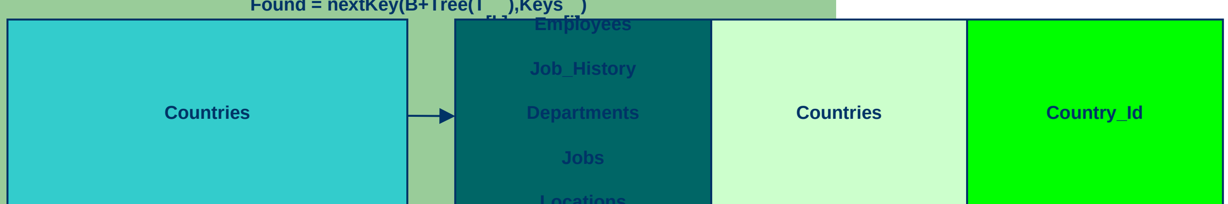
call AddJoinKey($T_{[ik]}$,$Keys_{[ik]}$,$InheritedKeys_{[ik]}$,$[DP_{ik}]$)

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

B+Tree(T_5)



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 $T_{[i]}$, $Keys_{[i]}$, $InheritedKeys_{[i]}$, $[DP_i]$)

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)

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($T_{[k]}$),$Keys_{[i]}$)

COUNTRY_ ID
ca

$Keys_{[k]}$

0	0	0	0	0

[DP_k]

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$_k$])

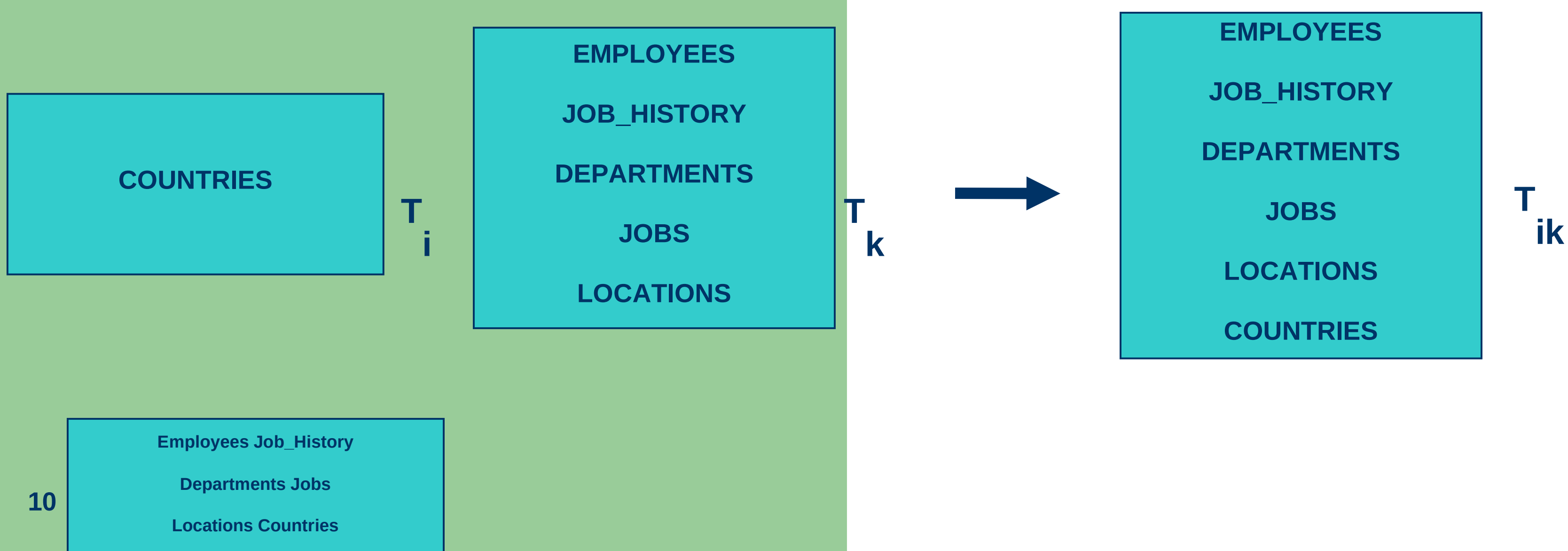
            locate the entry of $T_{[ik]}$ in JoinPathList

            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], [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

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($T_{[k]}$,$Keys_{[k]}$,$InheritedKeys_{[k]}$,$[DP_k]$)

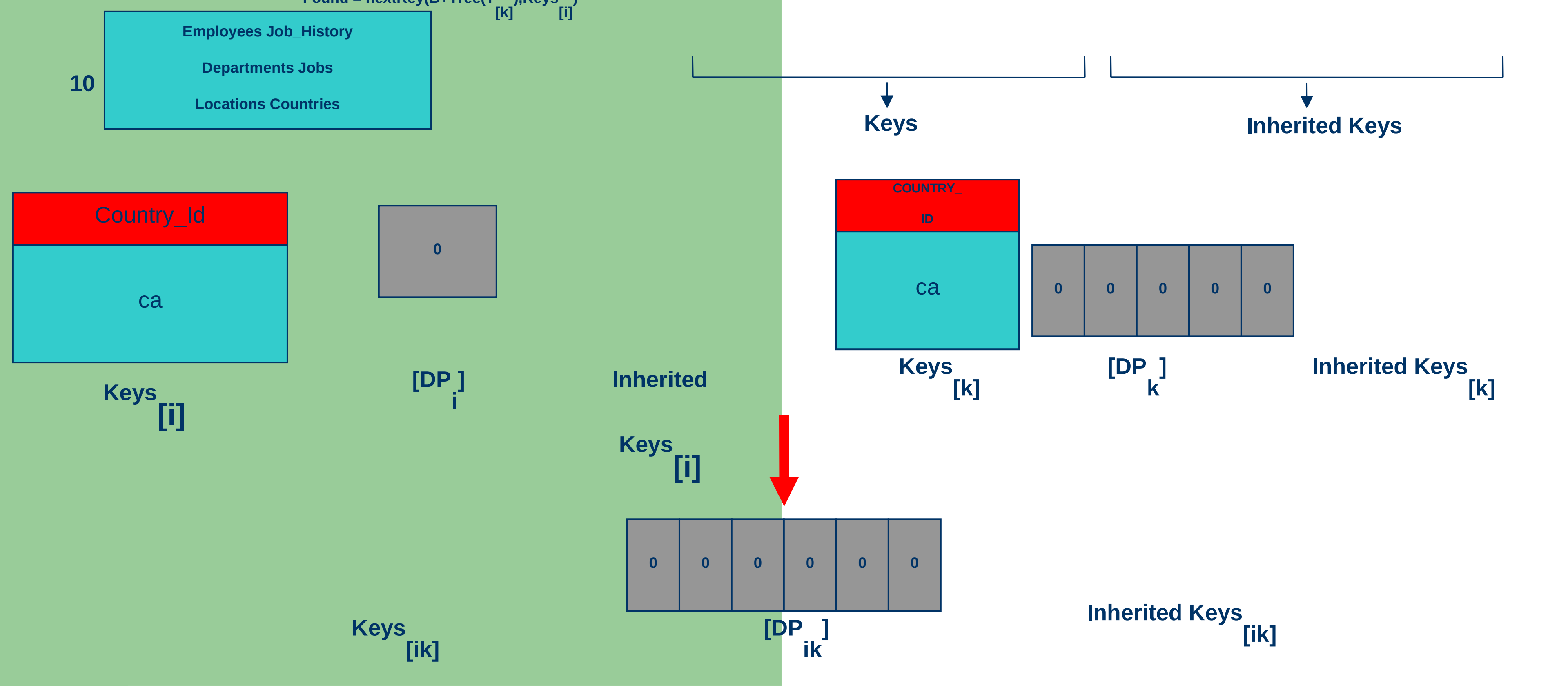
locate the entry of $T_{[ik]}$ in JoinPathList

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($T_{[k]}$),$Keys_{[i]}$)



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_{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

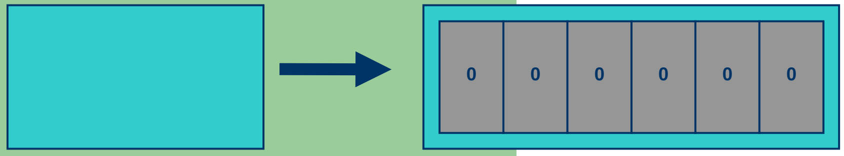
from its adjacentList, locate the definition of Keys & Inherited Keys

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$_{[i]}$, [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

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])
```

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])
```

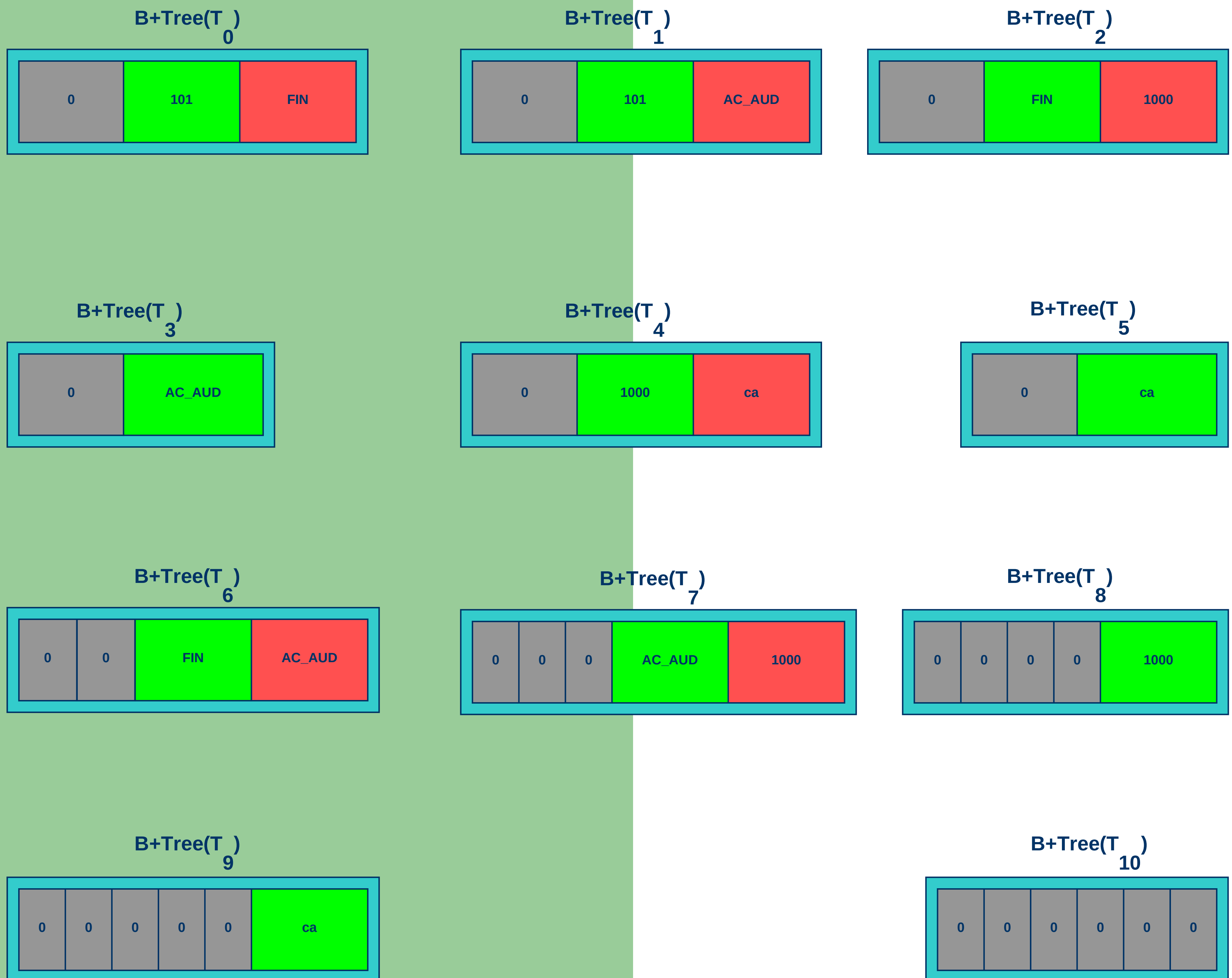
Found: FALSE

```
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])
```

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


B+Tree(T 0)
0
101
FIN
B+Tree(T 1)
0
101
AC_AUD
B+Tree(T 2)
0
FIN
1000
B+Tree(T 3)
0
AC_AUD
B+Tree(T 4)
0
1000
ca
B+Tree(T 5)
0
ca
B+Tree(T 6)
0
0
FIN
AC_AUD
B+Tree(T 7)
0
0
0
AC_AUD
1000
B+Tree(T 8)
0
0
0
0
1000
B+Tree(T 9)
0
0
0
0
0
ca
B+Tree(T 10)
0
0
0
0
0
0

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)

0	101	FIN	1	102	ACC	2	103	SAL
3	104	ACC	4	105	SAL			

B+Tree(T_1)

0	101	AC_AUD	2	101	SA_REP	1	102	AC_AUD
3	103	AC_AUD						

B+Tree(T_2)

1	ACC	1010	0	FIN	1000	2	SAL	1020

B+Tree(T_3)

0	AC_AUD
1	AC_MGR
2	FI_MGR
3	SA_MGR
4	SA_REP

B+Tree(T_4)

0	1000	ca
1	1010	me
2	1020	fr

B+Tree(T_5)

0	ca
1	fr
2	me

B+Tree(T_6)

1	1	ACC	AC_AUD
0	0	FIN	AC_AUD
0	2	FIN	SA_REP
2	3	SAL	AC_AUD

B+Tree(T_7)

0	0	0	AC_AUD	1000
2	3	2	AC_AUD	1020
1	1	1	AC_AUD	1010
0	2	0	SA_REP	1000

B+Tree(T_8)

0	0	0	0	1000
0	2	0	4	1000
1	1	1	0	1010
2	3	2	0	1020

B+Tree(T_9)

0	0	0	0	0	ca
0	2	0	4	0	ca
2	3	2	0	2	fr
1	1	1	0	1	me

B+Tree(T_{10})

0	0	0	0	0	0
0	2	0	4	0	0
1	1	1	0	1	2
2	3	2	0	2	1

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($B^+Tree(T_{[k]})$, $Keys_{[i]}$)

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 arays 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:
  - **$T_{[buf]}$ + = T_i**
  - **Insert NodesList[$T_{[buf]}$] = $T_{[buf]}$**
- 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^{Join}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 row with the lowest order tables T_0 and T_1 in this case we call recursively the insert procedure for (2*n – 1) – (n - 1) = n times.

The complexity will be:

$Ord(n * \log_m(l_i * p_i))$

Complexity of the algorithm for the other operations.

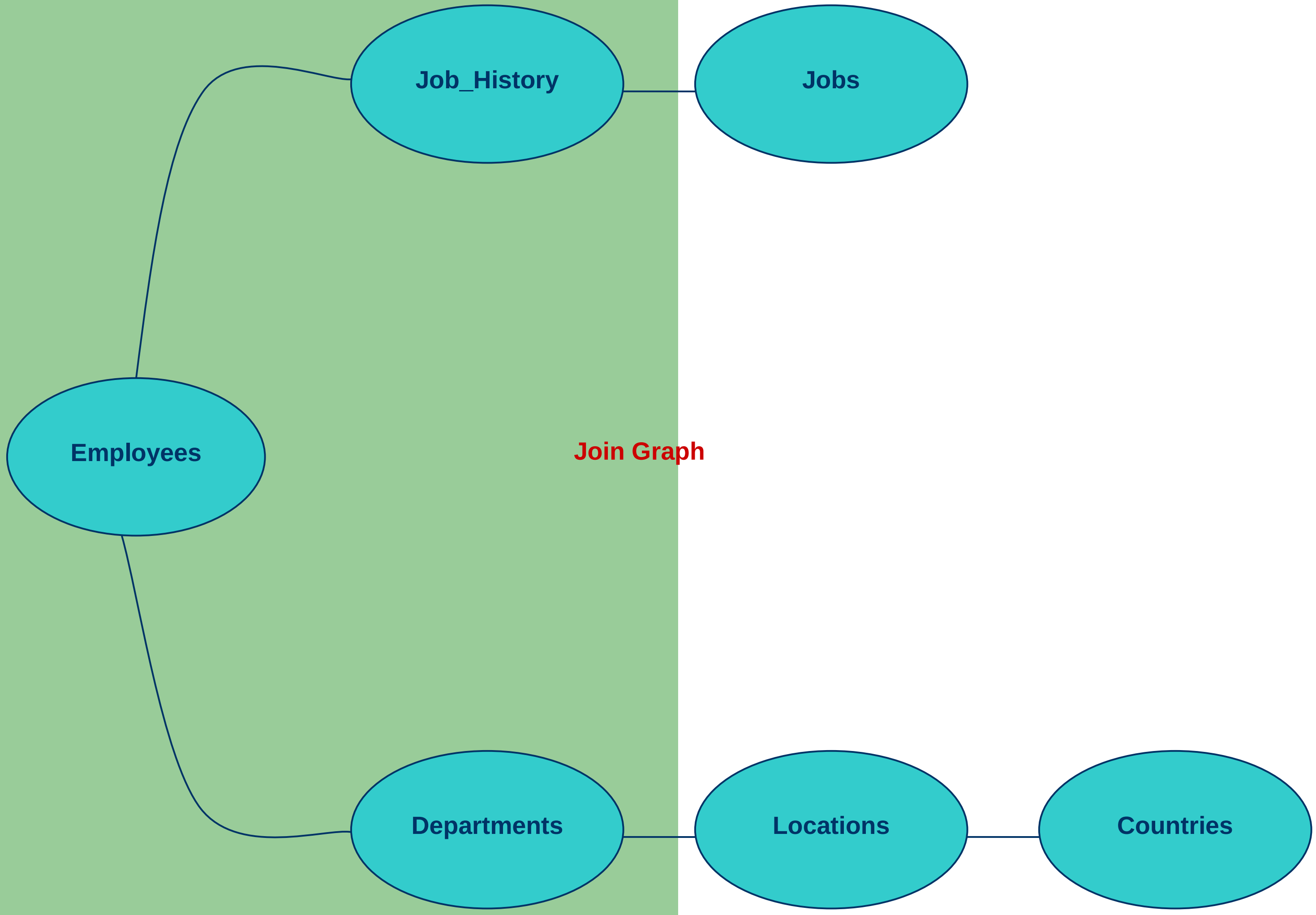
The only B^+Tree of our interest for the scan is the one with the latest index that have the join of the tables inside it.

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.

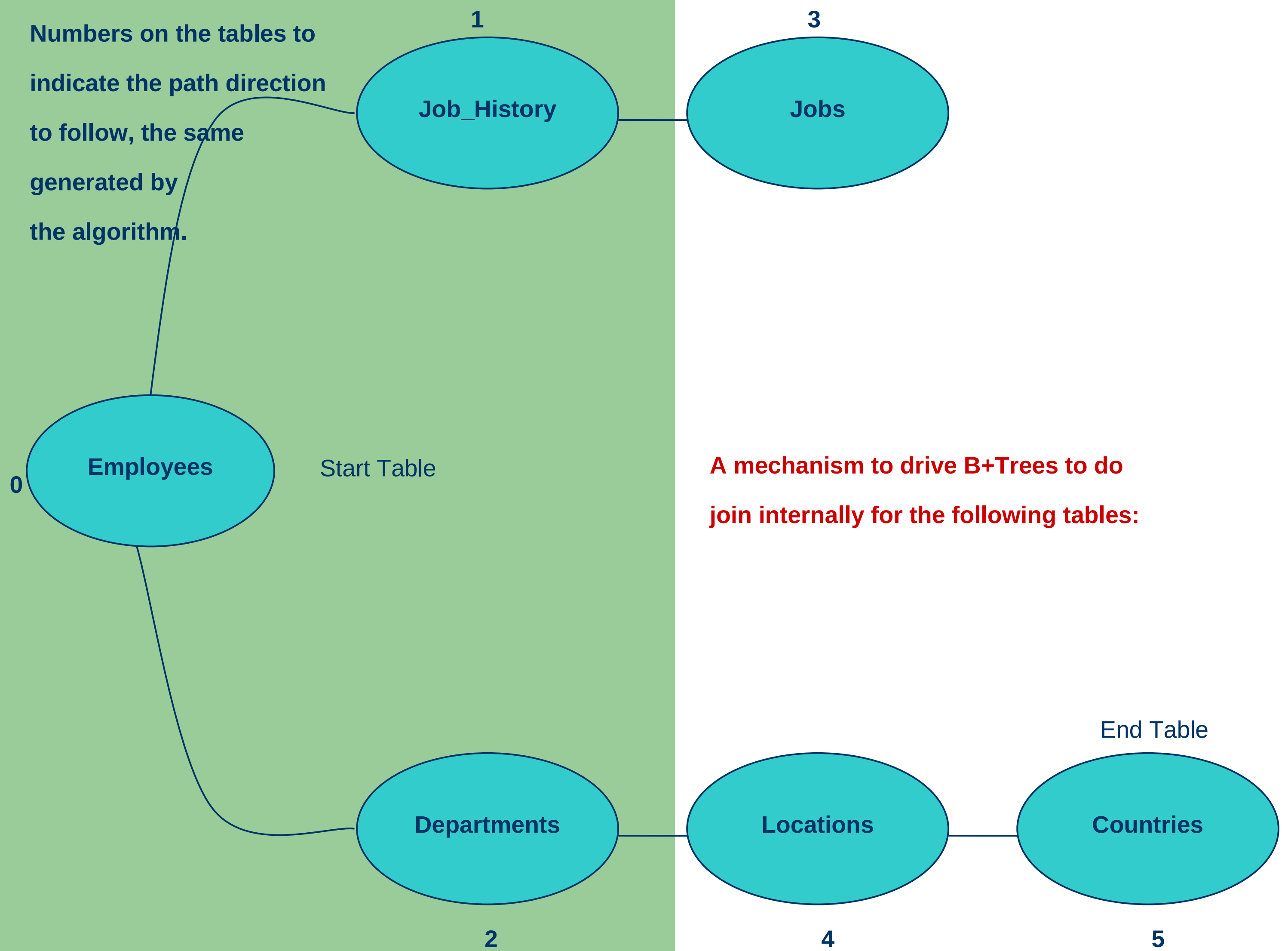
The Join Graph could be calculated easily even manually when we know which Tables are in direct join with others.



Let define a path in the Join Graph, the same path generated by the algorithm:

generateJoinPathList

Numbers on the tables to indicate the path direction to follow, the same generated by the algorithm.

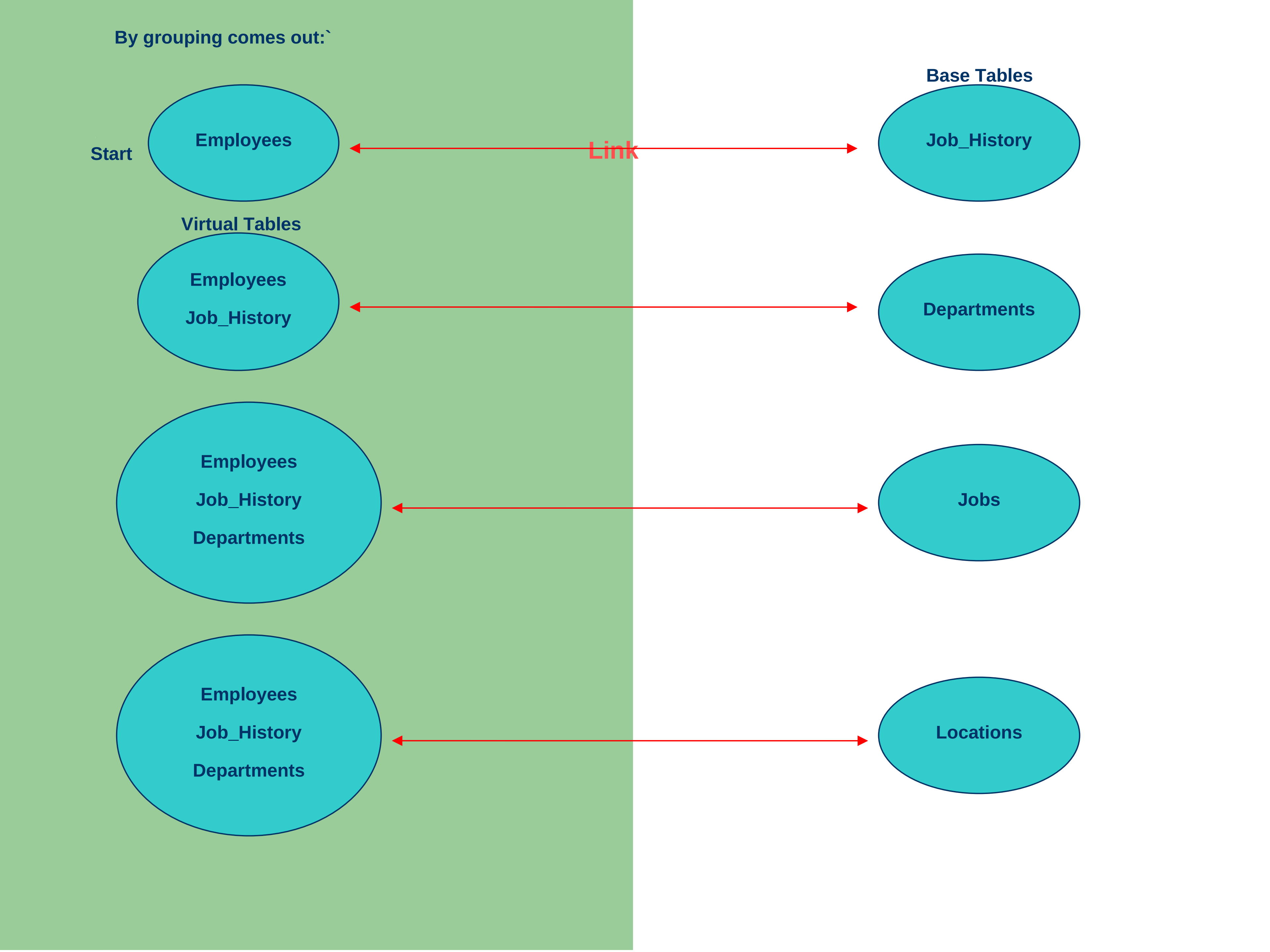


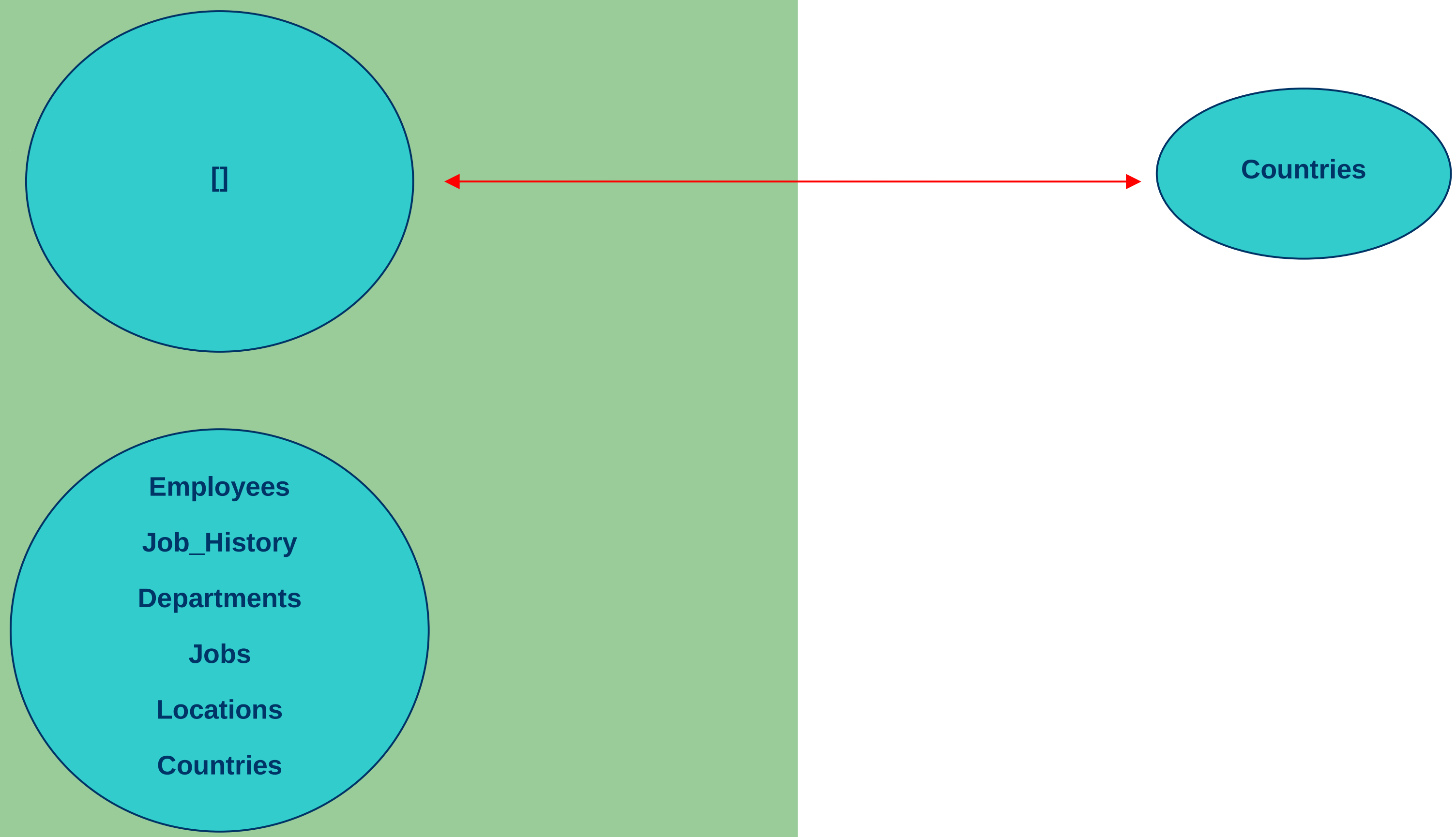
A mechanism to drive B+Trees to do join internally for the following tables:

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 and end tables.


By grouping comes out:`
Base Tables
Start
Employees
Link
Job_History
Virtual Tables
Employees
Job_History
Departments
Employees
Job_History
Departments
Jobs
Employees
Job_History
Departments
Locations



There is no restriction on how the rows from base tables get inserted (Any order with any sequence).

The only restriction is that the Data Pointers are in the same order as the virtual table in Join Path List.

If we insert for example in the B+Tree that belongs to virtual table

T[**Employees,Job_History,Departments,Jobs,Locations**]

We should insert

DP[**Employees,Job_History,Departments,Jobs,Locations**]

respectively

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.

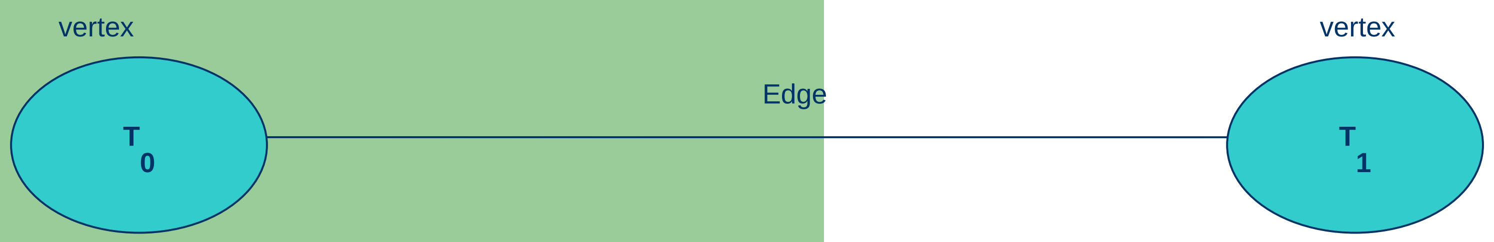
Proof of correctness.

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.

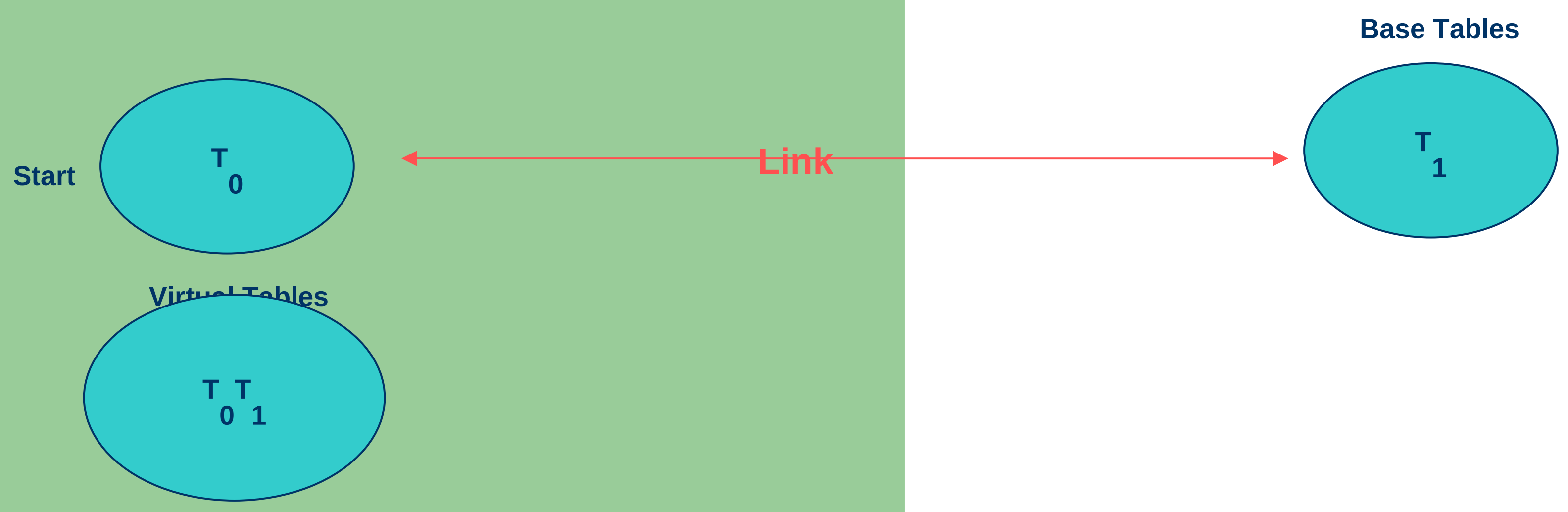
To do it, let see the correctness for 2 tables T_0 and T_1 in join together.

The join graph should be the following:

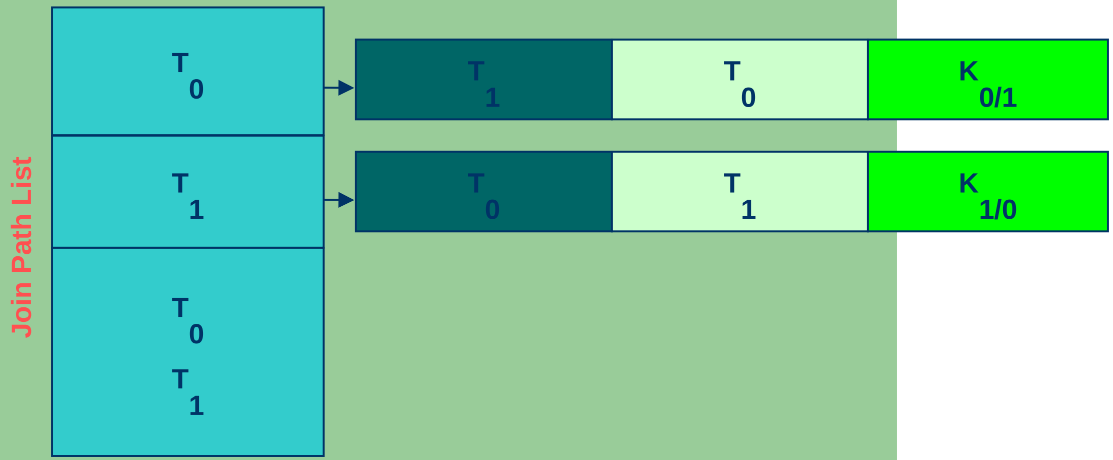


There are just 2 paths between the 2 tables: or from T_0 going toward T_1 or vice versa, let consider the former, the second case is symmetric and after all T_0 and T_1 are of arbitrarily choice.

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 key($R_{m/0}$) is inserted in the 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 B+Tree(T_0) all the keys that satisfy the join condition with the value of key($R_{n/1}$). It will get 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.

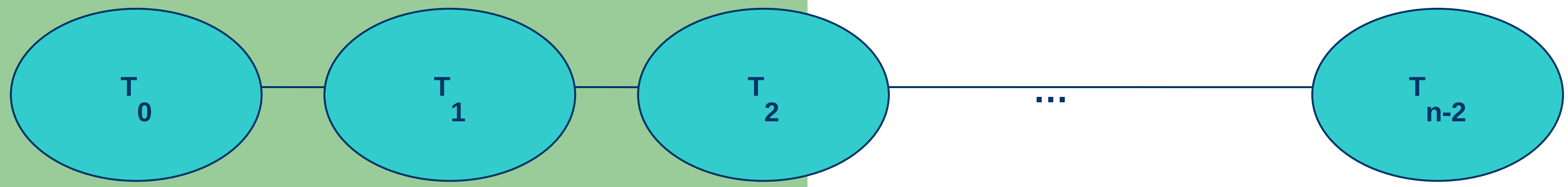
If such a couple of data pointers exist, it comes out because there is 2 keys belonging to the rows pointed by the data pointers and such keys satisfy the join condition, this is in contradiction on what we assume initially.

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 nth 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.

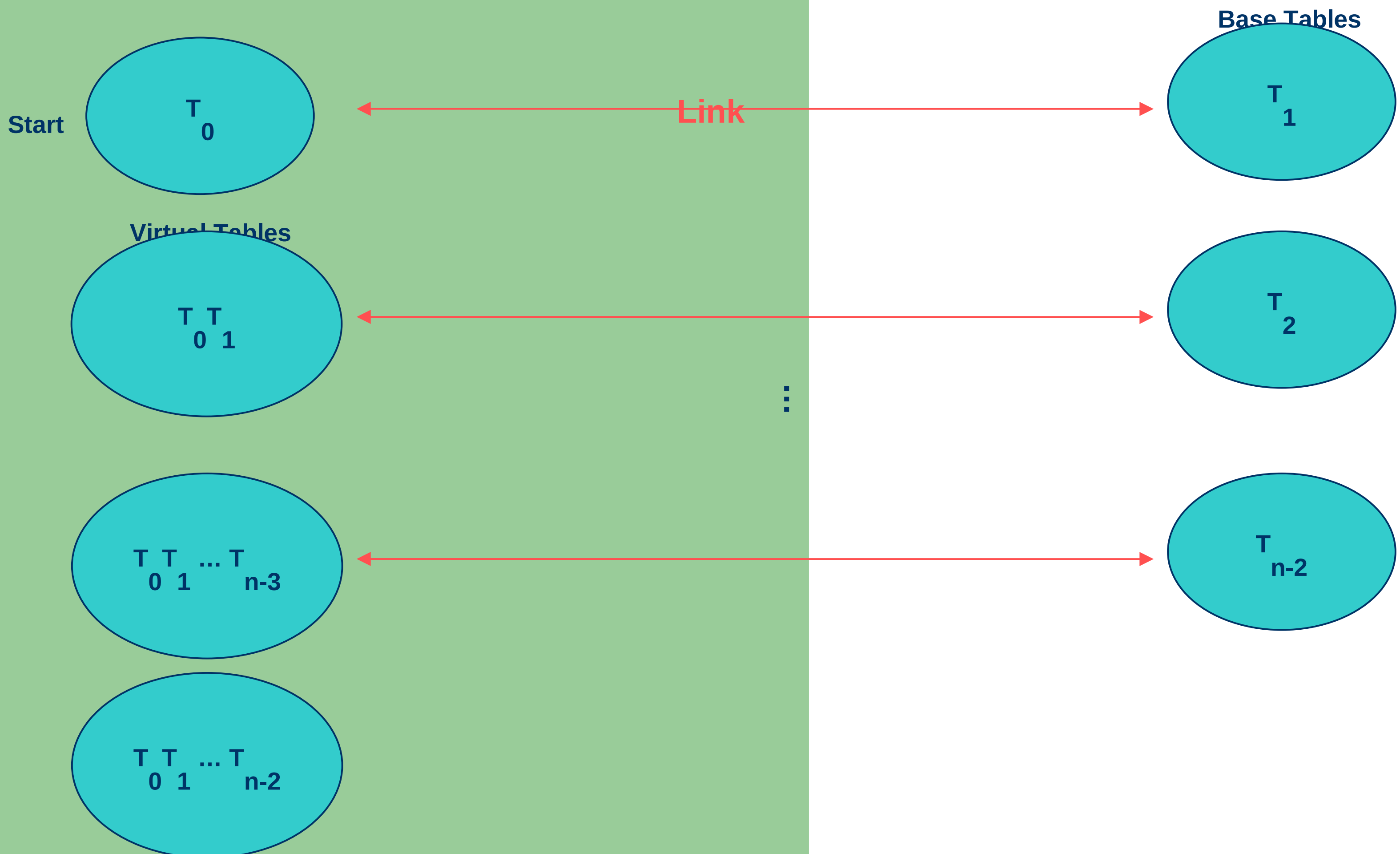
Let see first the Join Graph for the (n-1) tables and how they went in group and later what happens when we consider the nth table.

The join graph for the (n-1) tables should be the following:

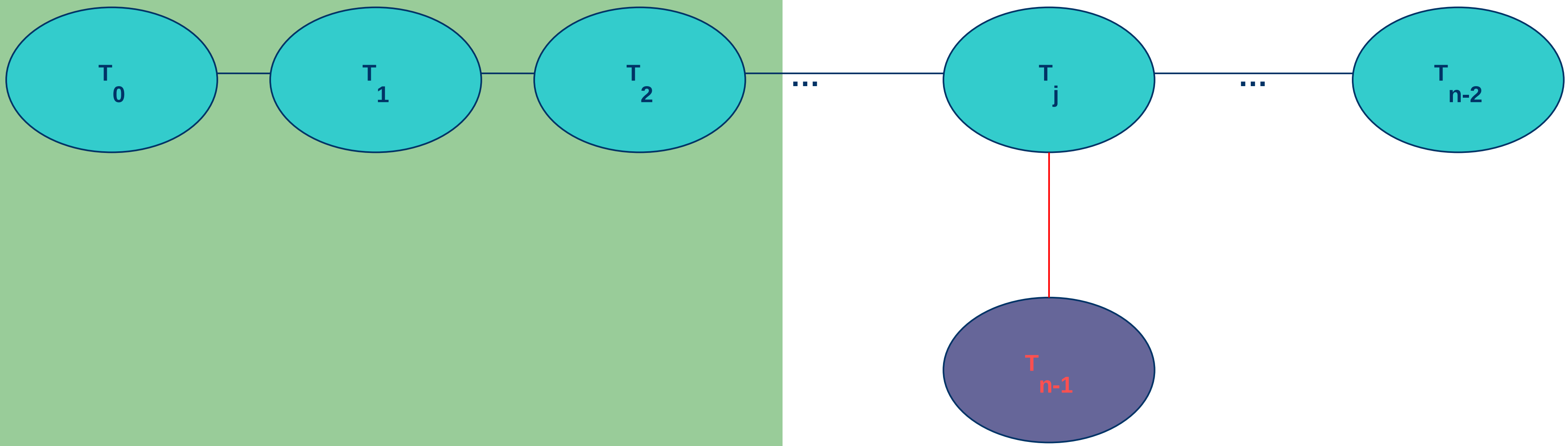


Suppose that the choice of $T_0 \dots T_{n-2}$ are in the way that the path start from T_0, continue by $T_1 \dots T_{n-3}$ till the end to arrive at T_{n-2}.

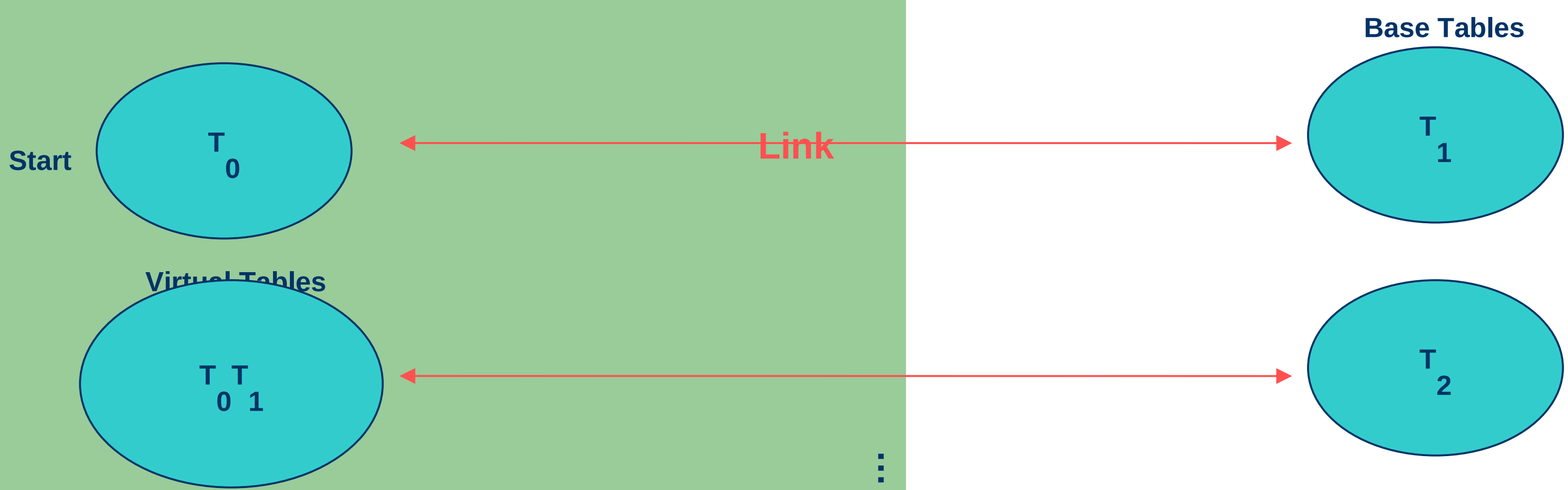
By grouping comes out:

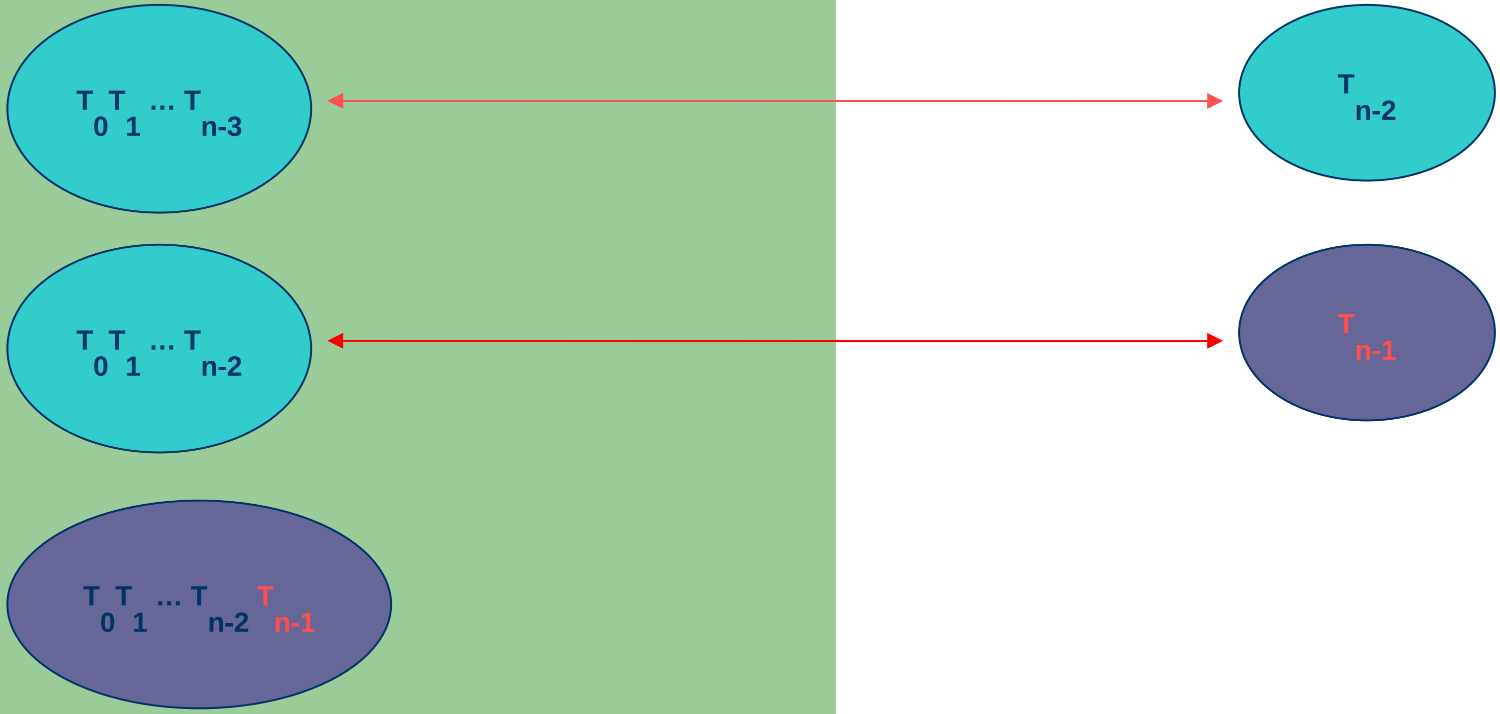


If there is one more table, the join graph would be the following:



The path should looks like this:





So if we expand the virtual table $T_0 \ldots T_{n-2}$ so the link would be just between it and the table T_{n-1}, where he common key should be from table T_j.

So we have the following situation:

Table $T_0 \ldots_{n-2}$ an expanded table from the virtual table $T_0 \ldots T_{n-2}$ 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 $T_0 \ldots_{n-2}$ 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 $T_0 \ldots_{n-2}$ 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 $T_0 \ldots T_{n-2}$ to T_j and the eventual keys from $T_0 \ldots T_{n-1}$ to some base tables in the base tables $T_0 \ldots T_{n-1}$ 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 slide 575.

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	Employees/Supervisor_Id
0	1

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	Employees/Supervisor_Id
0	1

Employees/Employee_Id
Employees/Supervisor_Id

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	Employees/Supervisor_Id
0	1

Employees/Employee_Id
Employees/Supervisor_Id

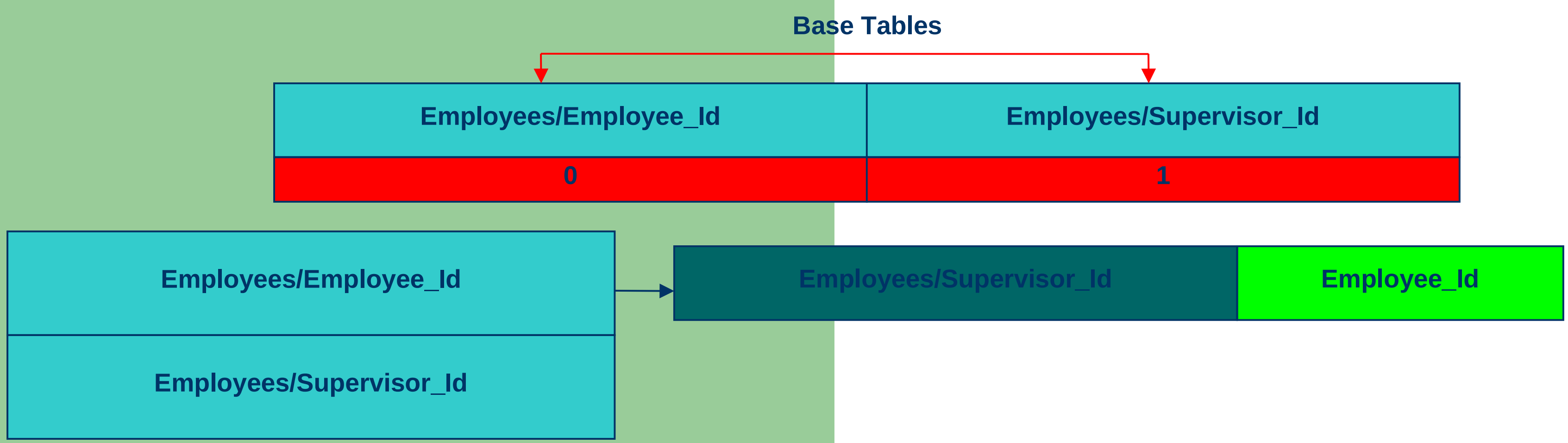
<u>generateJoinGraph (in BaseTables; out JoinGraph)</u>

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



generateJoinGraph (in BaseTables; out JoinGraph)

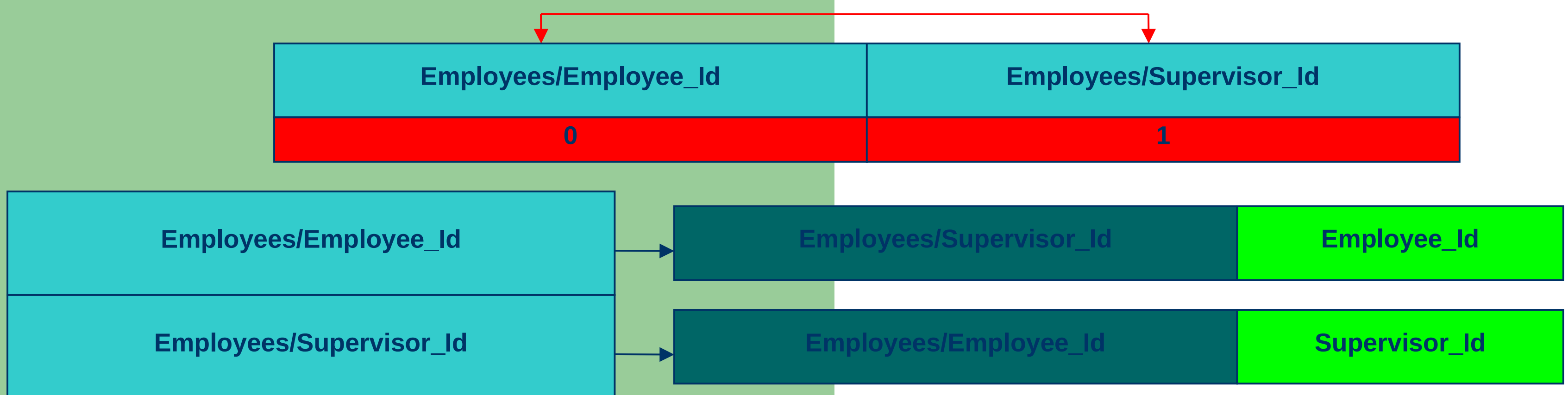
insert the base tables as vertexes of the graph

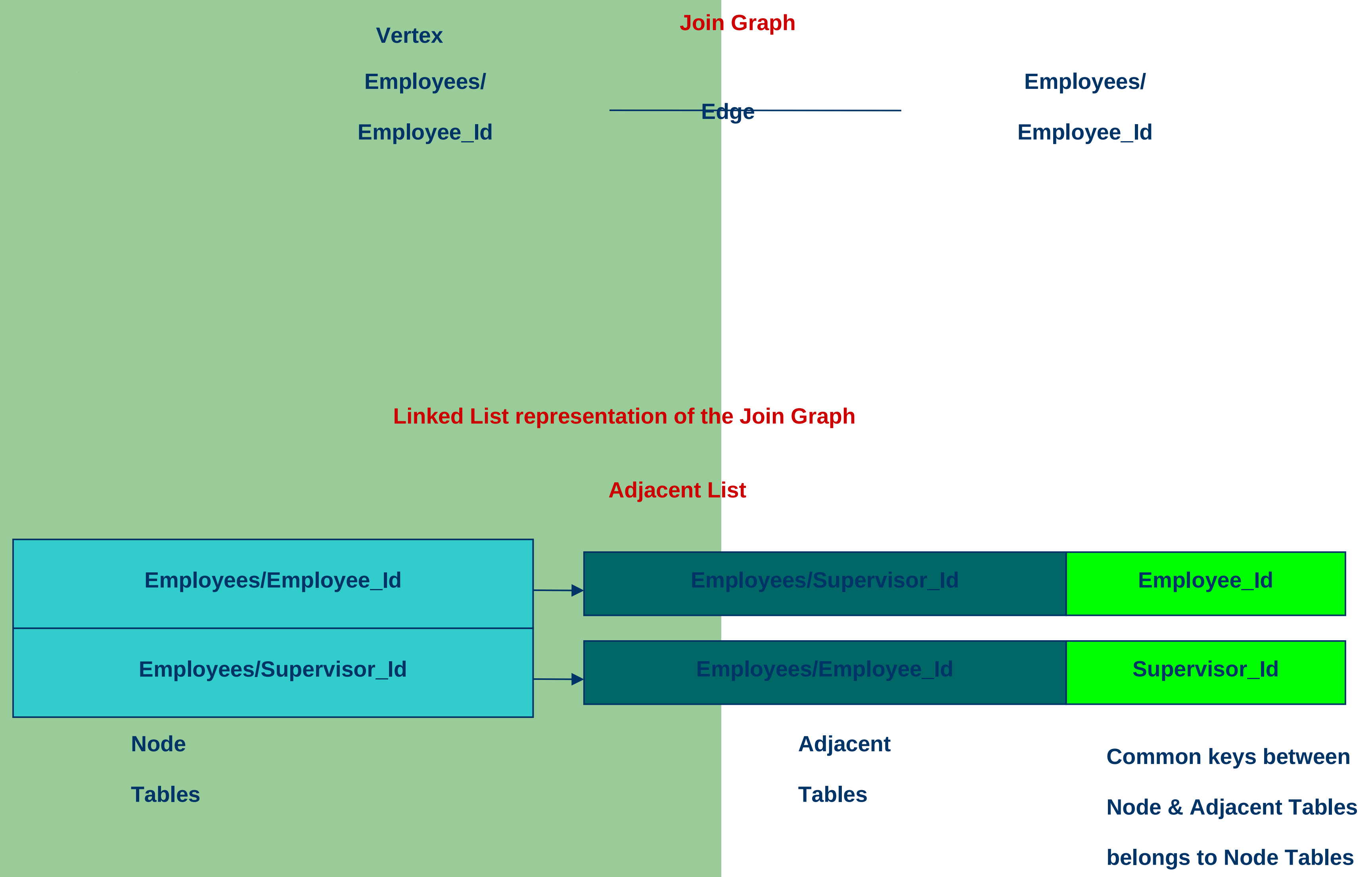
for every direct join between 2 tables of the form T_i and T_k where T_i is the table of order i and T_k is the table of order k as defined by the DBA do

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

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

Base Tables




Join Graph
Vertex
Employees/
Employee_Id
Edge
Employees/
Employee_Id
Linked List representation of the Join Graph
Adjacent List
Employees/Employee_Id
Employees/Supervisor_Id
Employees/Supervisor_Id
Employee_Id
Employees/Employee_Id
Supervisor_Id
Node
Tables
Adjacent
Tables
Common keys between
Node & Adjacent Tables
belongs to Node Tables

__generateJoinPathList (in Join Base Tables, JoinGraph; out JoinPathList)__

let $T_0 \ldots T_m$ 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

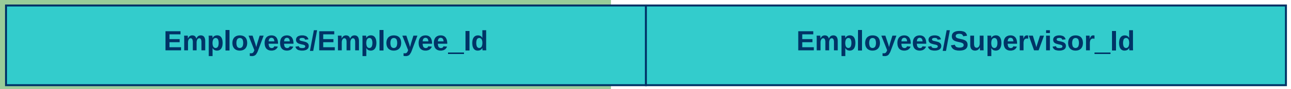
                insert Link Item into path

                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 $T_0 \ldots T_m$ 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

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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

Employees/Employee_Id	Employees/Supervisor_Id
T_0	T_1

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

```
let T_0 …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 $T_0 \ldots T_m$ be the base tables

create 2 dynamic arrays queue and path

insert T_0 into path

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            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/Employee_Id	Employees/Supervisor_Id
T_0	T_1

queue

path

Employees/Employee_Id

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/Employee_Id	Employees/Supervisor_Id
T_0	T_1

queue

Employees/Employee_Id

path

Employees/Employee_Id

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

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remove $T_{Element}$ from queue

until queue is empty

queue

Employees/Employee_Id

path

Employees/Employee_Id

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

```
let T_0 …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
Employees/Employee_Id	Employees/Employee_Id

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

let $T_0 \ldots T_m$ be the base tables

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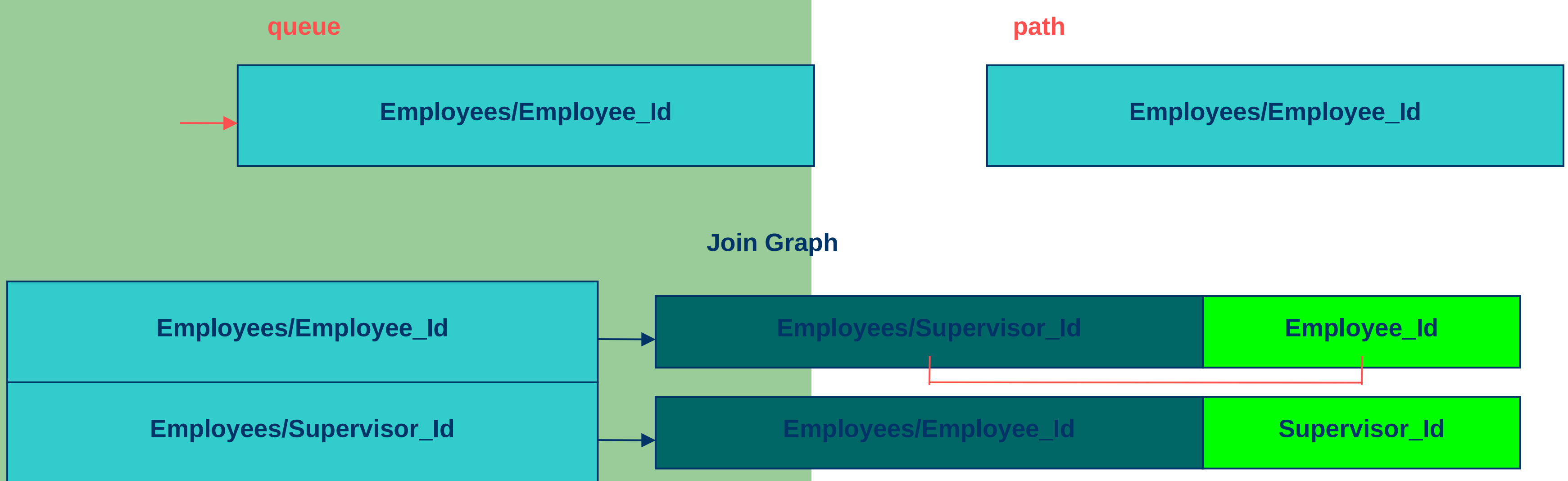

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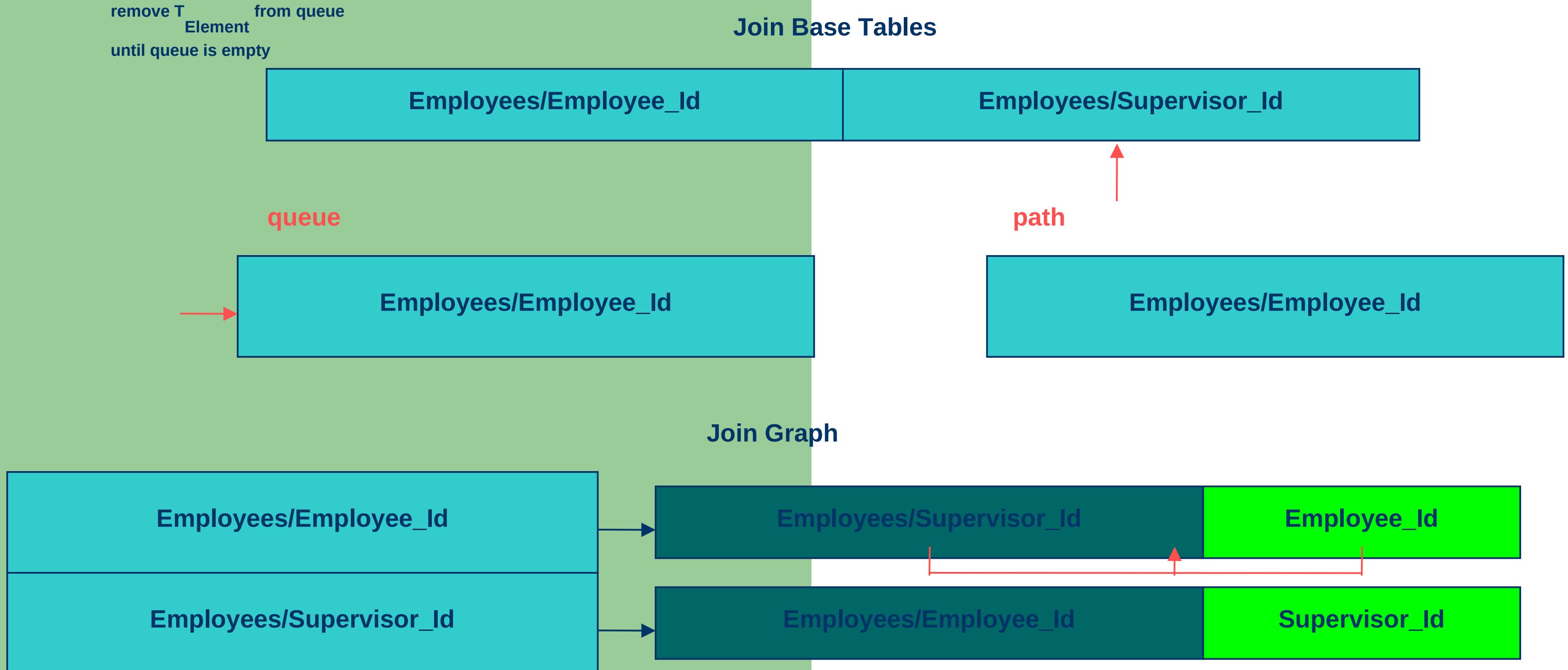

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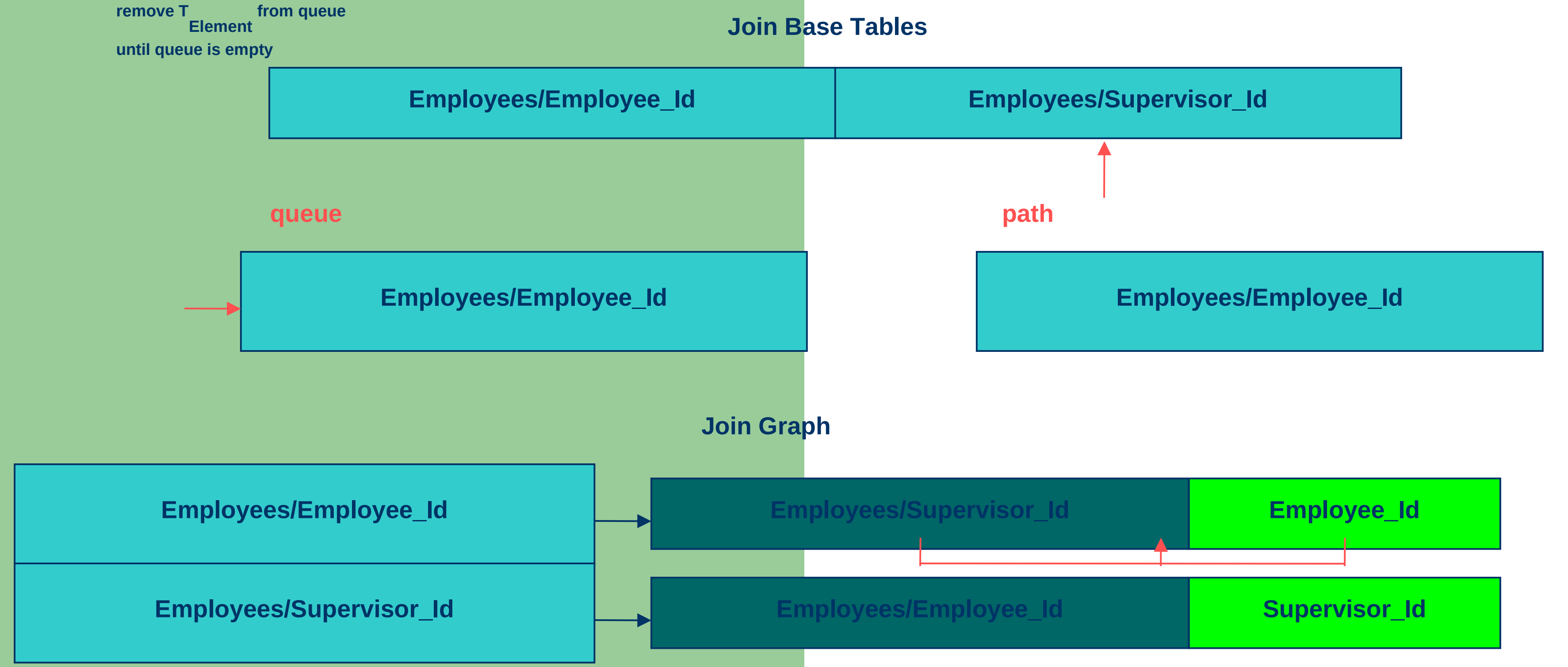
                insert Link Item into queue

    remove $T_{Element}$ from queue

until queue is empty



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

Employees/Employee_Id

path

Employees/Employee_Id
Employees/Supervisor_Id

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

let T_0 …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/Employee_Id
Employees/Supervisor_Id

path

Employees/Employee_Id
Employees/Supervisor_Id

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/Supervisor_Id

path

Employees/Employee_Id
Employees/Supervisor_Id

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

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queue

Employees/Supervisor_Id

path

Employees/Employee_Id
Employees/Supervisor_Id

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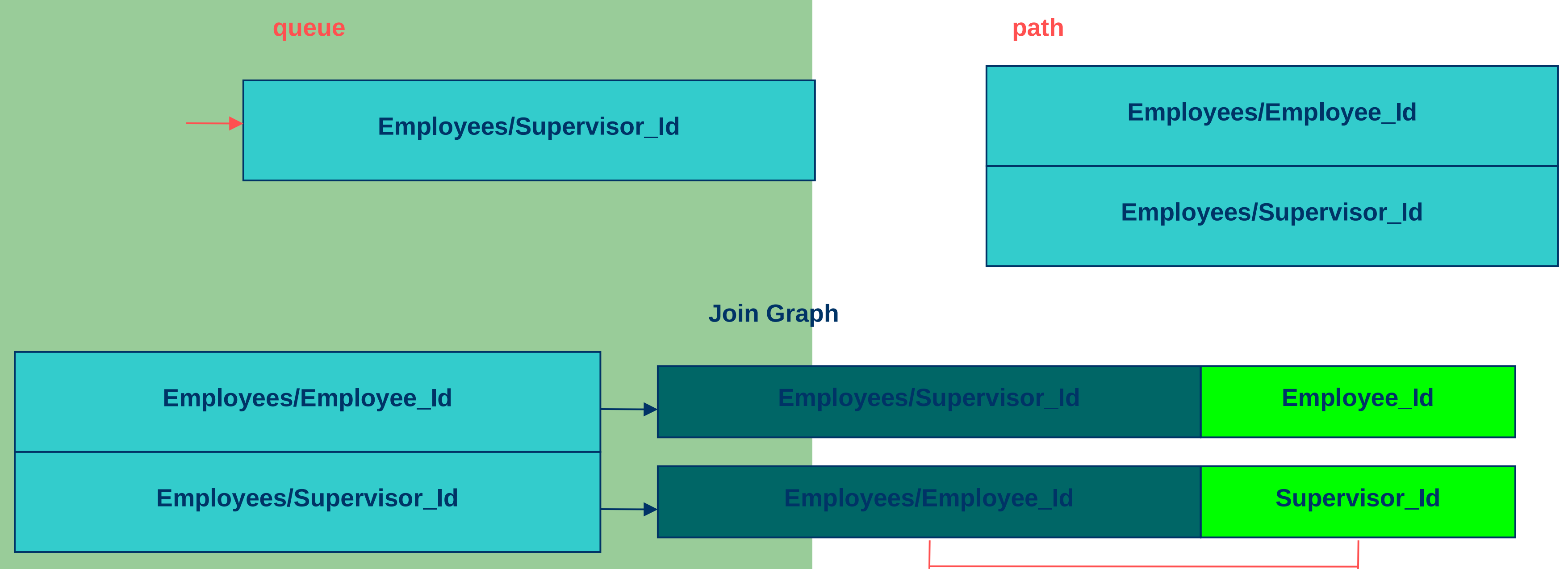

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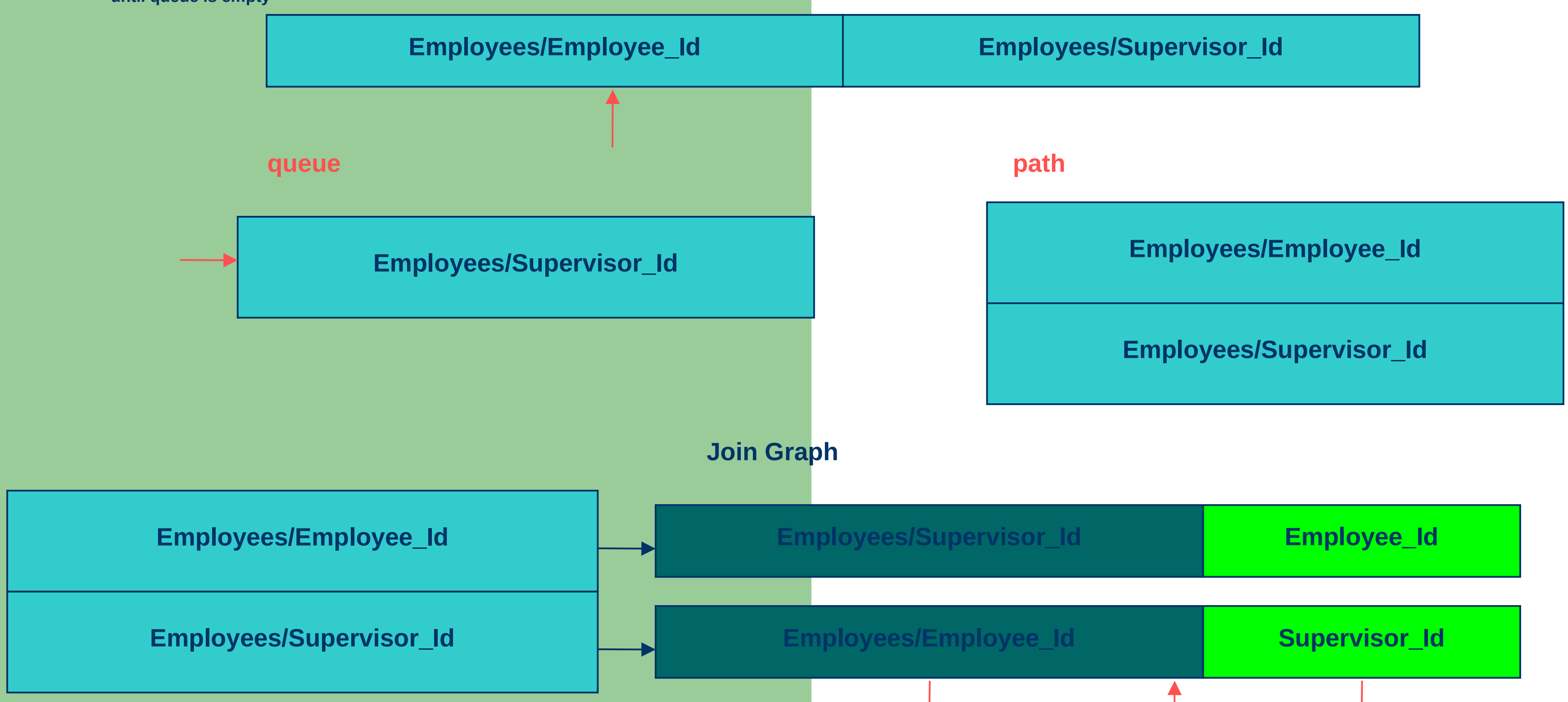

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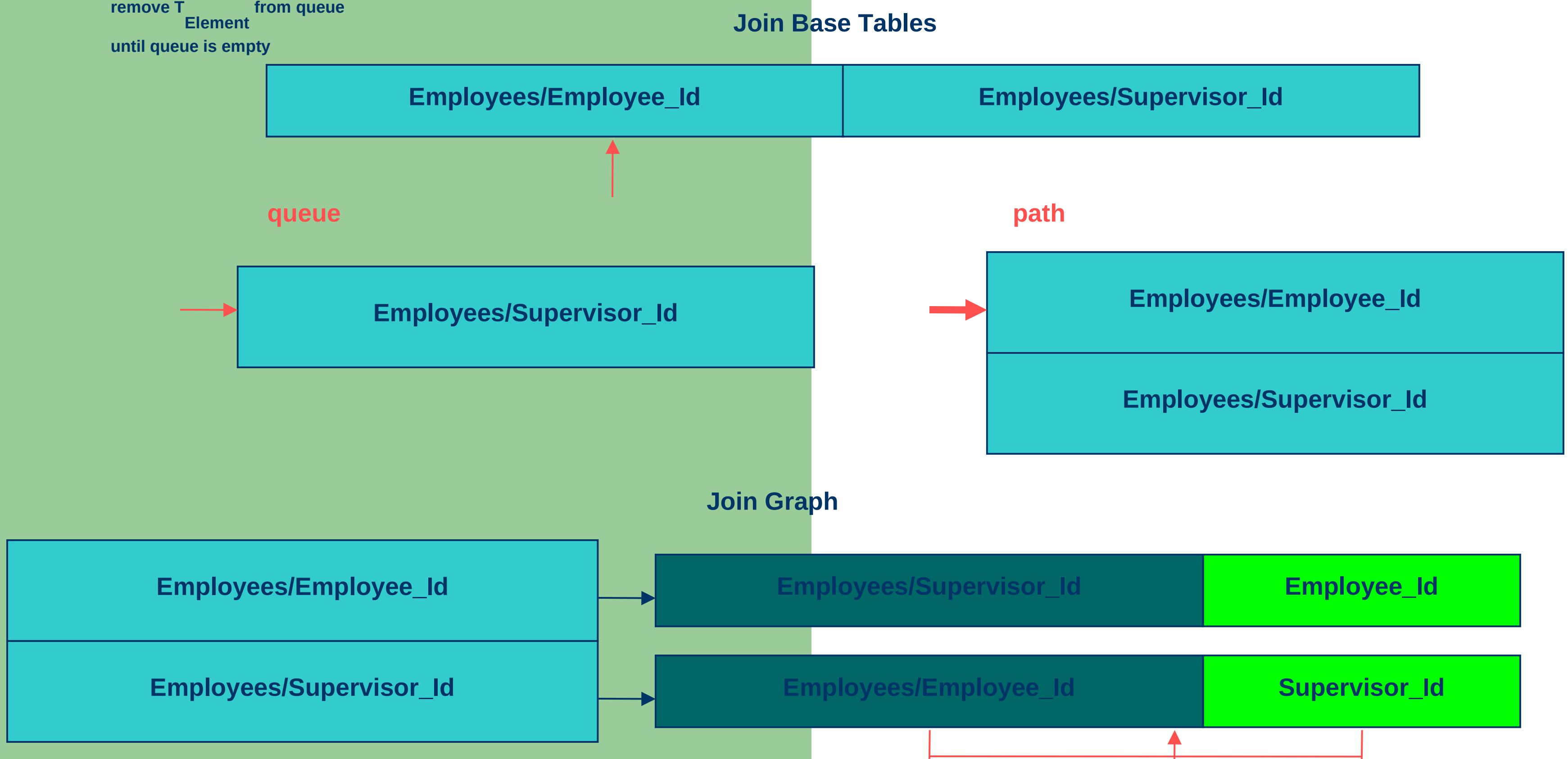
    until queue is empty



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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

queue

path

Employees/Employee_Id
Employees/Supervisor_Id

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

let T_0 …T_m be the base tables
create 2 dynamic arrays queue and path

insert T_0 into path

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    $T_{Element}$ = 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

Employees/Employee_Id
Employees/Supervisor_Id

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

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[$T_{[buf]}$] = $T_{[buf]}$

Nodes

Employees/Employee_Id
Employees/Supervisor_Id

path

Employees/Employee_Id
Employees/Supervisor_Id

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

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take one T_i at a time

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

$T_{[buf]}$ + = T_i

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

Nodes

Employees/Employee_Id
Employees/Supervisor_Id

path

Employees/Employee_Id
Employees/Supervisor_Id

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

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[$T_{[buf]}$] = $T_{[buf]}$

Nodes

Employees/Employee_Id

Employees/Supervisor_Id

path

Employees/Employee_Id

Employees/Supervisor_Id

buf

Employees/Employee_Id

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

create a local buffer buf

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

$T_{[buf]}$ + = T_i

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

Nodes

Employees/Employee_Id

Employees/Supervisor_Id

path

Employees/Employee_Id

Employees/Supervisor_Id

buf

Employees/Employee_Id

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

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[$T_{[buf]}$] = $T_{[buf]}$

Nodes

Employees/Employee_Id
Employees/Supervisor_Id

path

T_i

Employees/Employee_Id
Employees/Supervisor_Id

buf

Employees/Employee_Id

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

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

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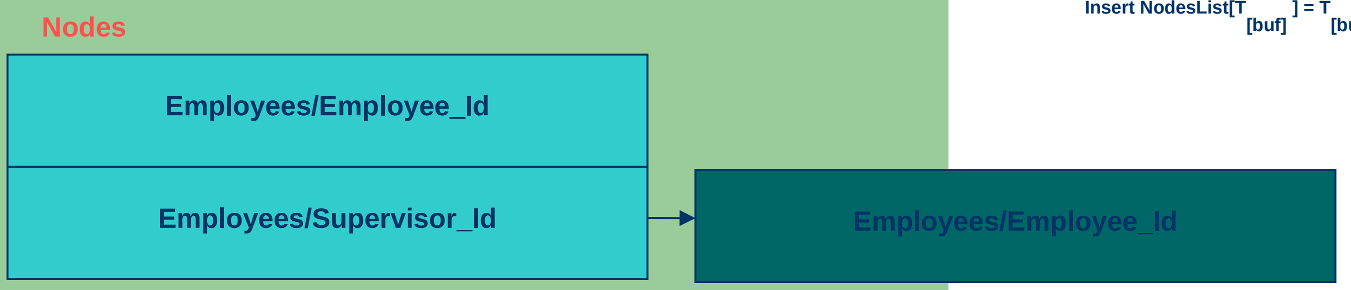
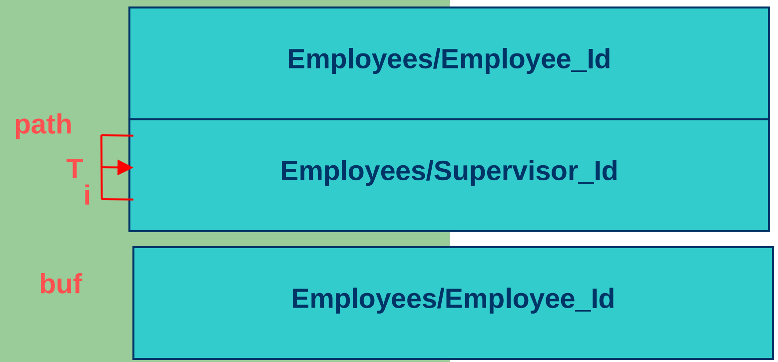
JoinPathAdjacentList($T_{[buf]}$) = T_i

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

$T_{[buf]}$ + = T_i

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





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

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

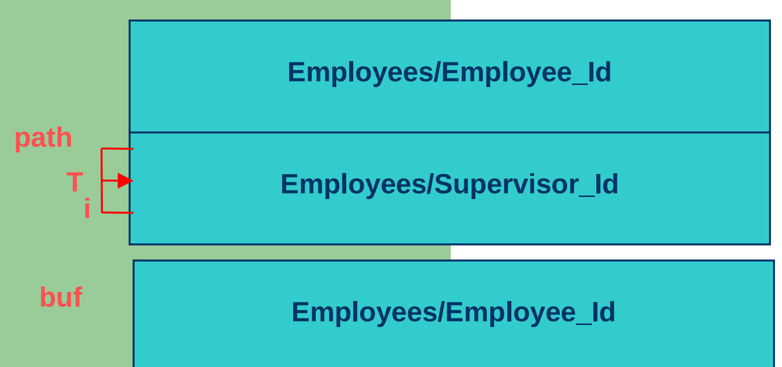
Key(T_i) = getFirstAdjacentListKey(T_i,$T_{[buf]}$)

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

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

$T_{[buf]}$ + = T_i

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



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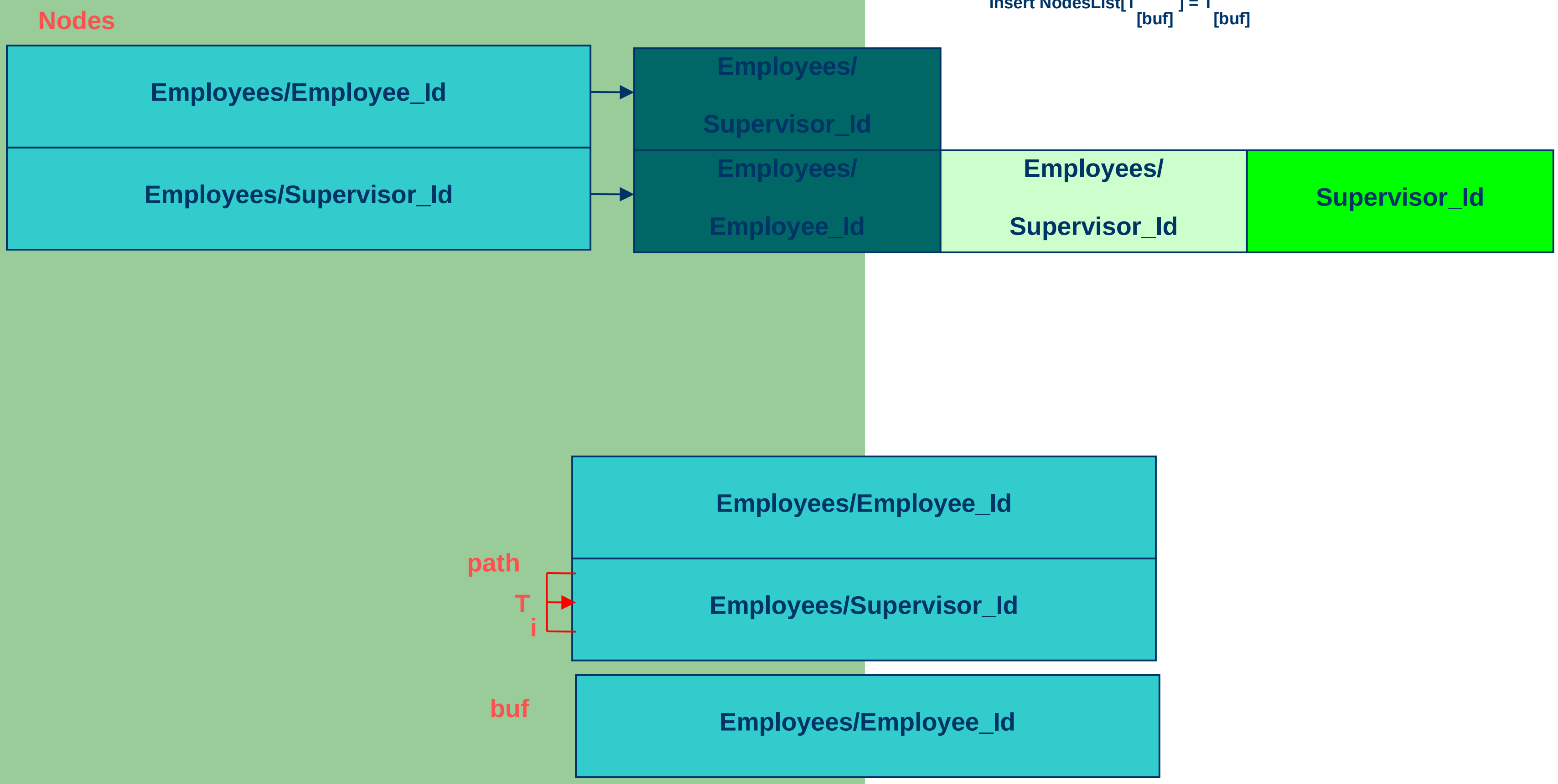
- JoinPathAdjacentList($T_{[buf]}$) = T_i
- Key($T_{[buf]}$) = getFirstAdjacentListKey ($T_{[buf]}$,T_i)
- $T_{[buf]}$ + = T_i
- Insert NodesList[$T_{[buf]}$] = $T_{[buf]}$



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

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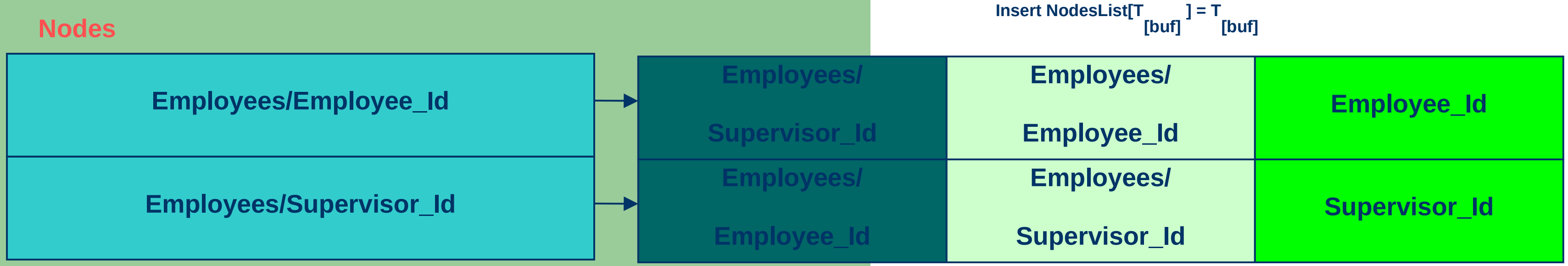
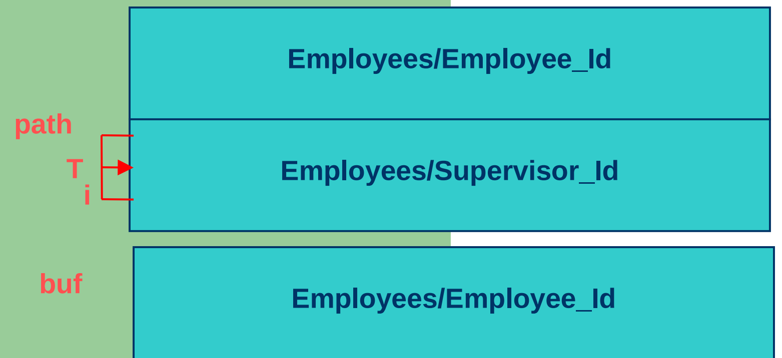
- JoinPathAdjacentList($T_{[buf]}$) = T_i
- Key($T_{[buf]}$) = getFirstAdjacentListKey ($T_{[buf]}$,T_i)
- $T_{[buf]}$ + = T_i
- Insert NodesList[$T_{[buf]}$] = $T_{[buf]}$





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

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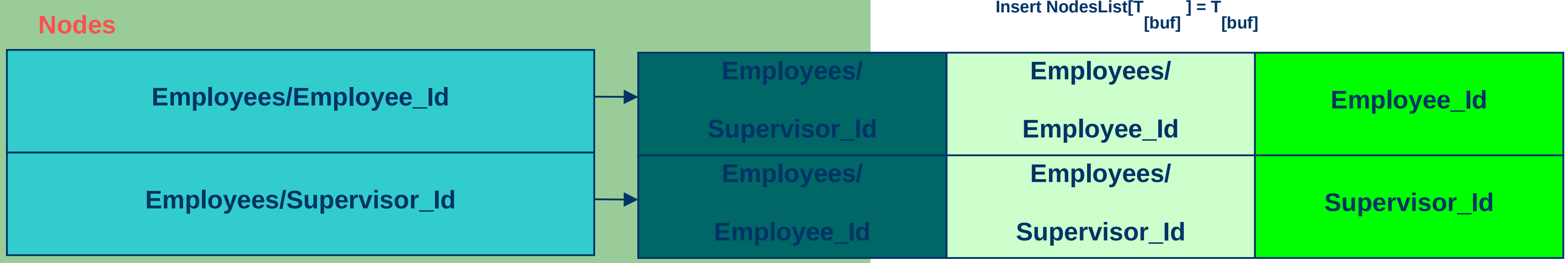
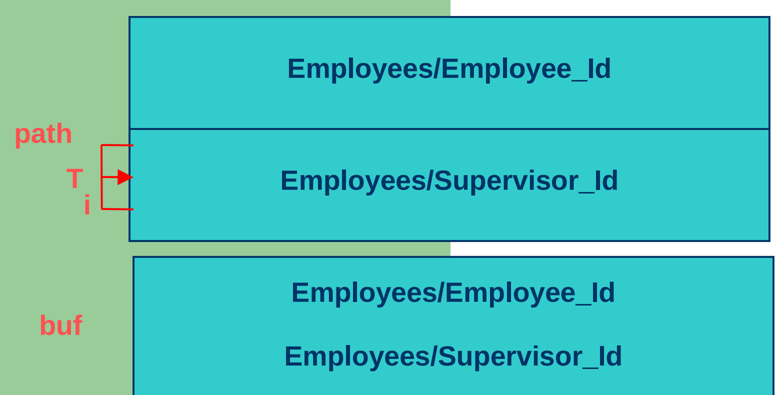
JoinPathAdjacentList($T_{[buf]}$) = T_i

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

$T_{[buf]}$ + = T_i

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





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

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

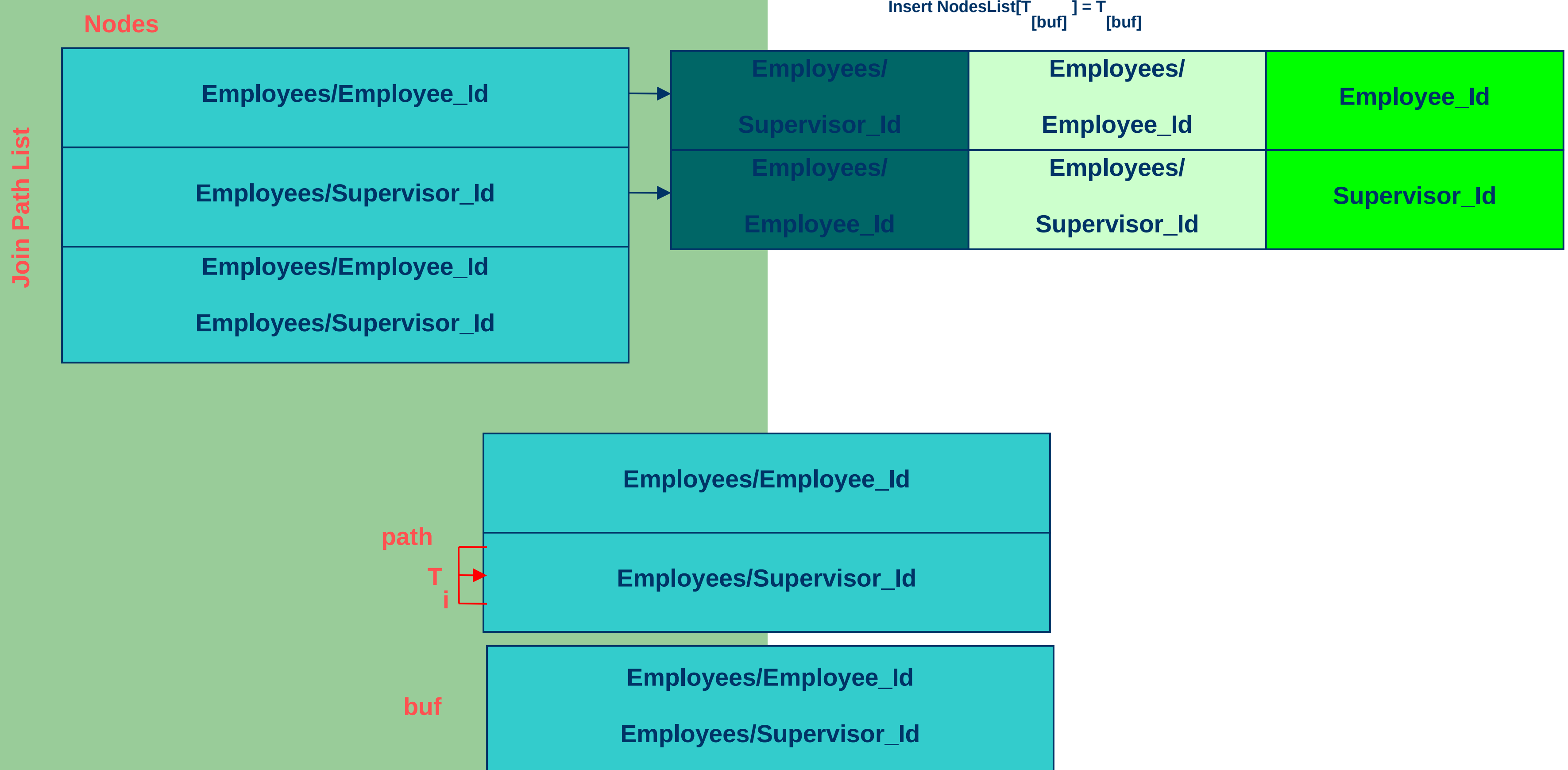
Key(T_i) = getFirstAdjacentListKey(T_i,$T_{[buf]}$)

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

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

$T_{[buf]}$ + = T_i

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



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 <Table,key> 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

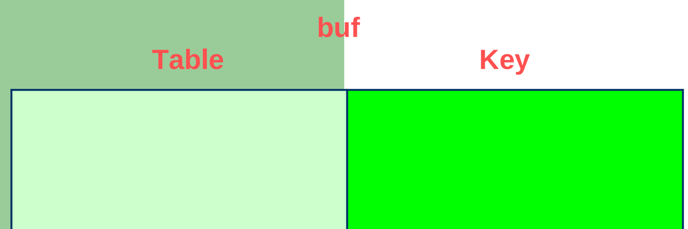
InheritedKey($T_{[i]}$) += buf_c

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_l



```
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 inT[i] do

        take one Tk at a time

        for all the couples of <Table,key> in buf do

            take one couple bufc at a time

            if (bufc.Table = Tk) then

                if (bufc != Key(T[i]) ) and (bufc not in InheritedKey(T[i])) then

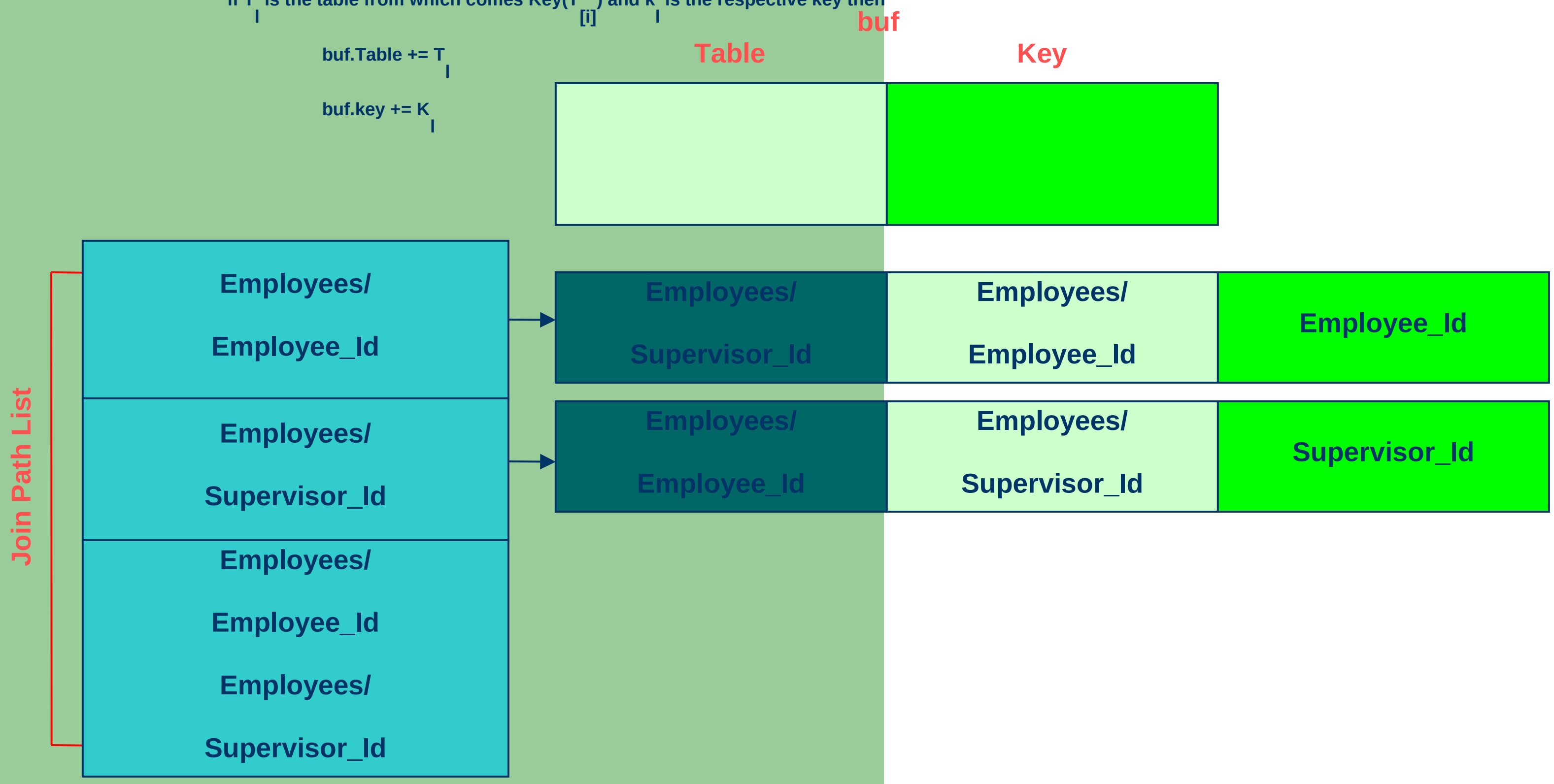
                    InheritedKey(T[i]) += bufc

    if T[i] is not a base table then

        if Tl is the table from which comes Key(T[i]) and kl is the respective key then

            buf.Table += Tl

            buf.key += Kl
```



```
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                        if (buf_c.Table = T_k) then

                                if (buf_c != Key(T[i]) ) and (buf_c not in InheritedKey(T[i])) then

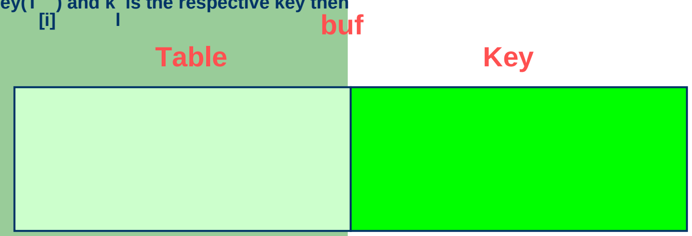
                                    InheritedKey(T[i]) += buf_c

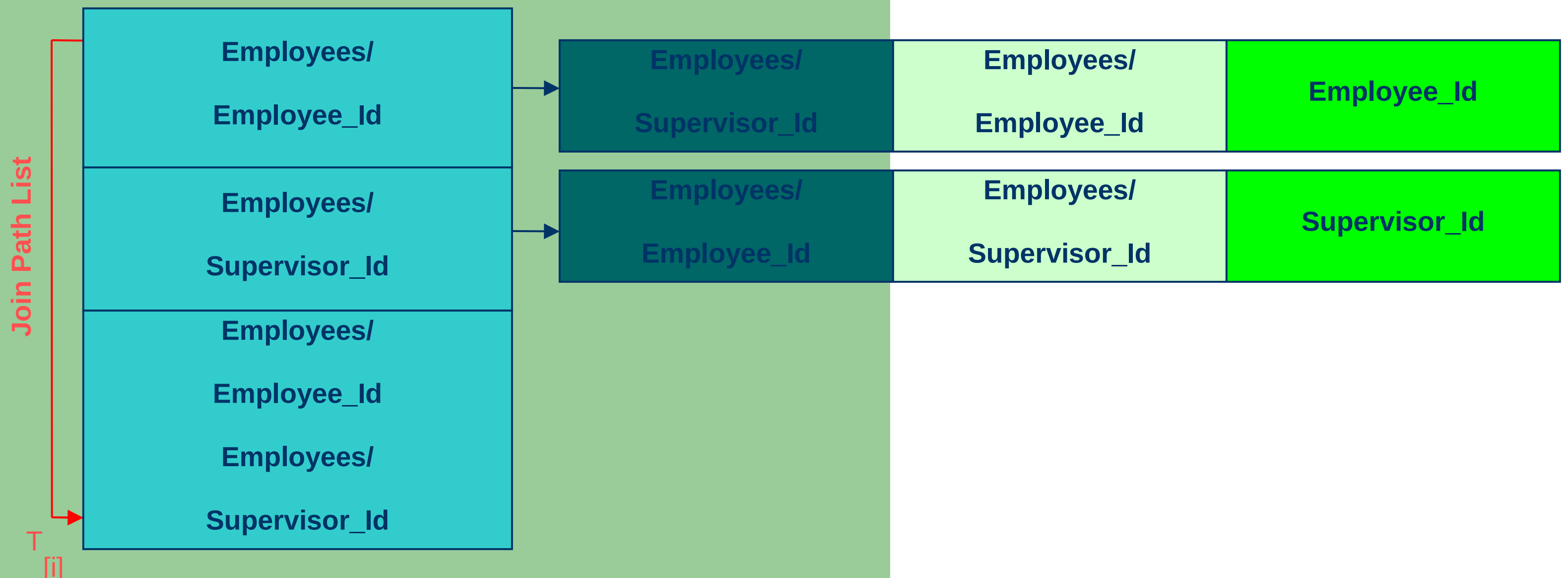
        if T[i] is not a base table then

                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_l
```





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if $T_{[i]}$ is not a base table then

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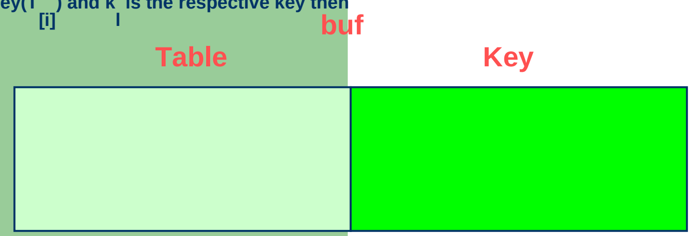

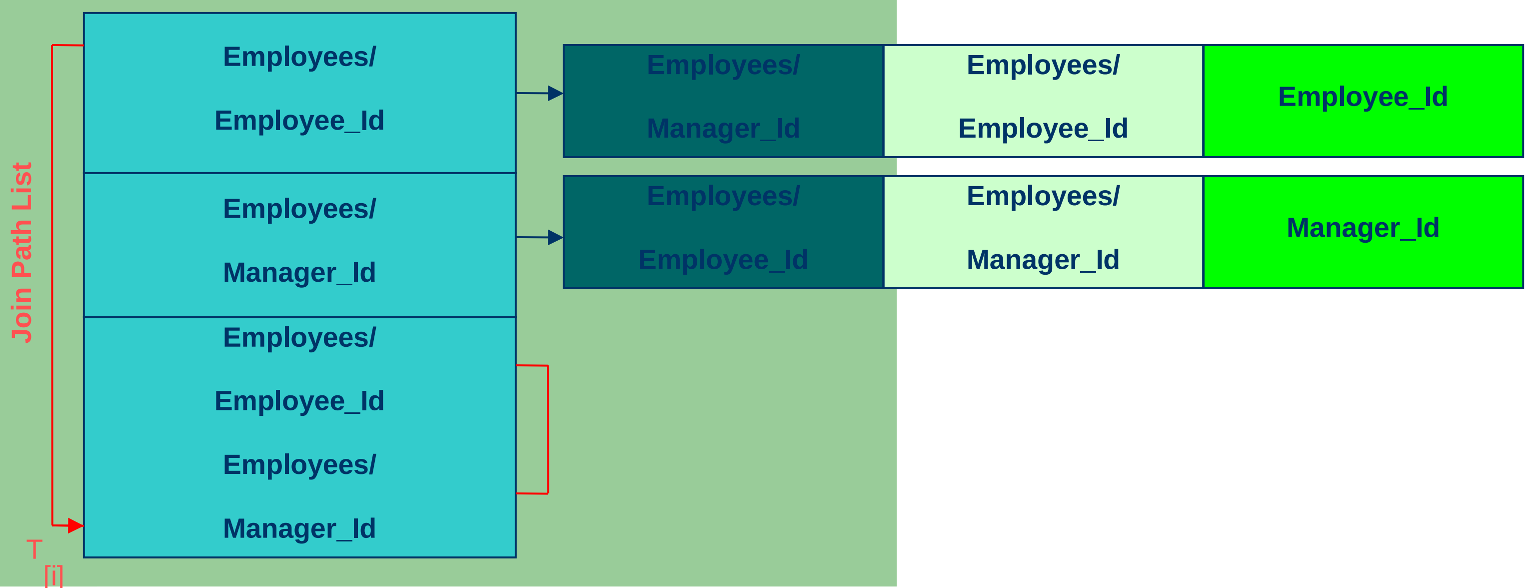

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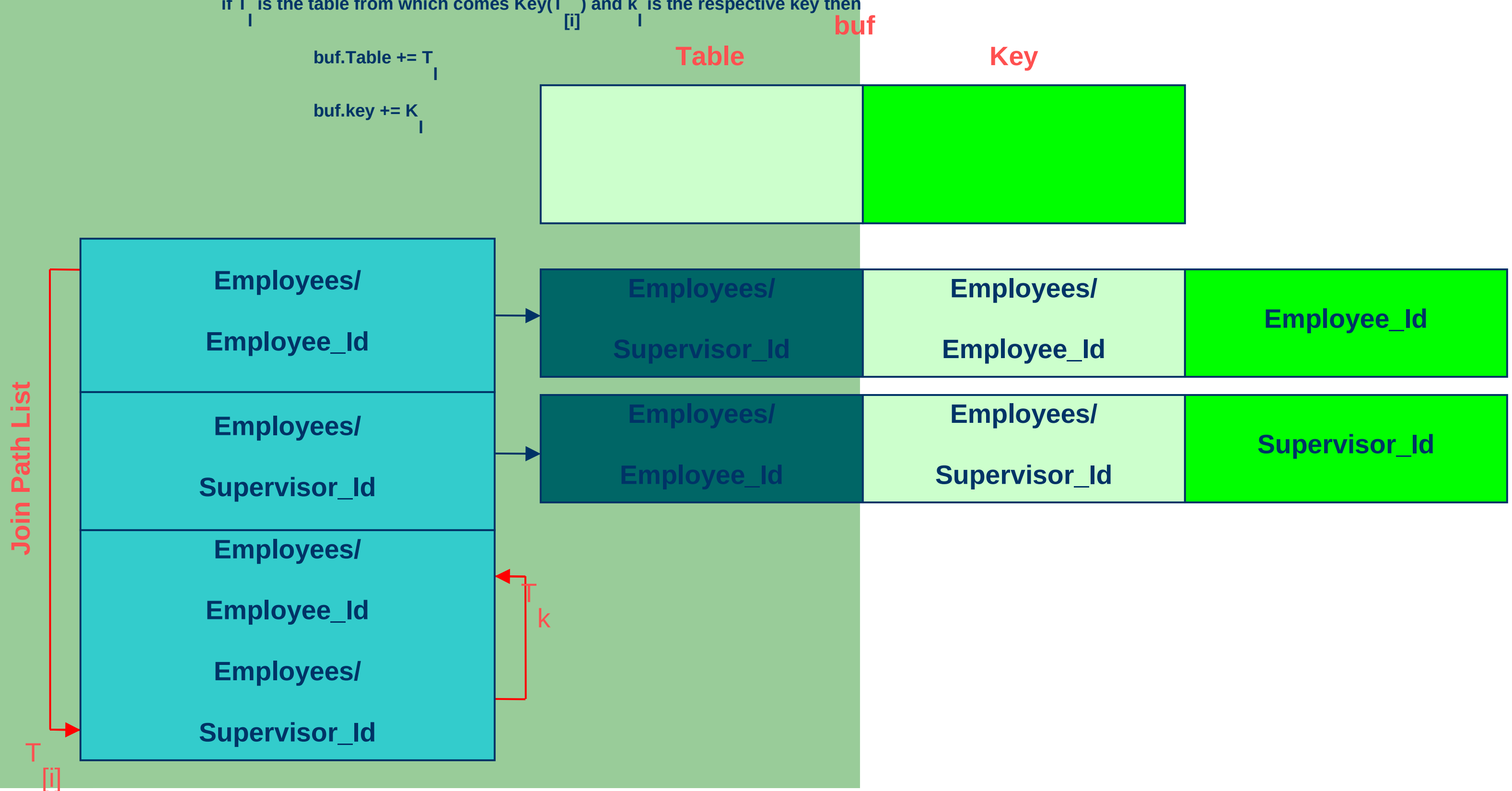

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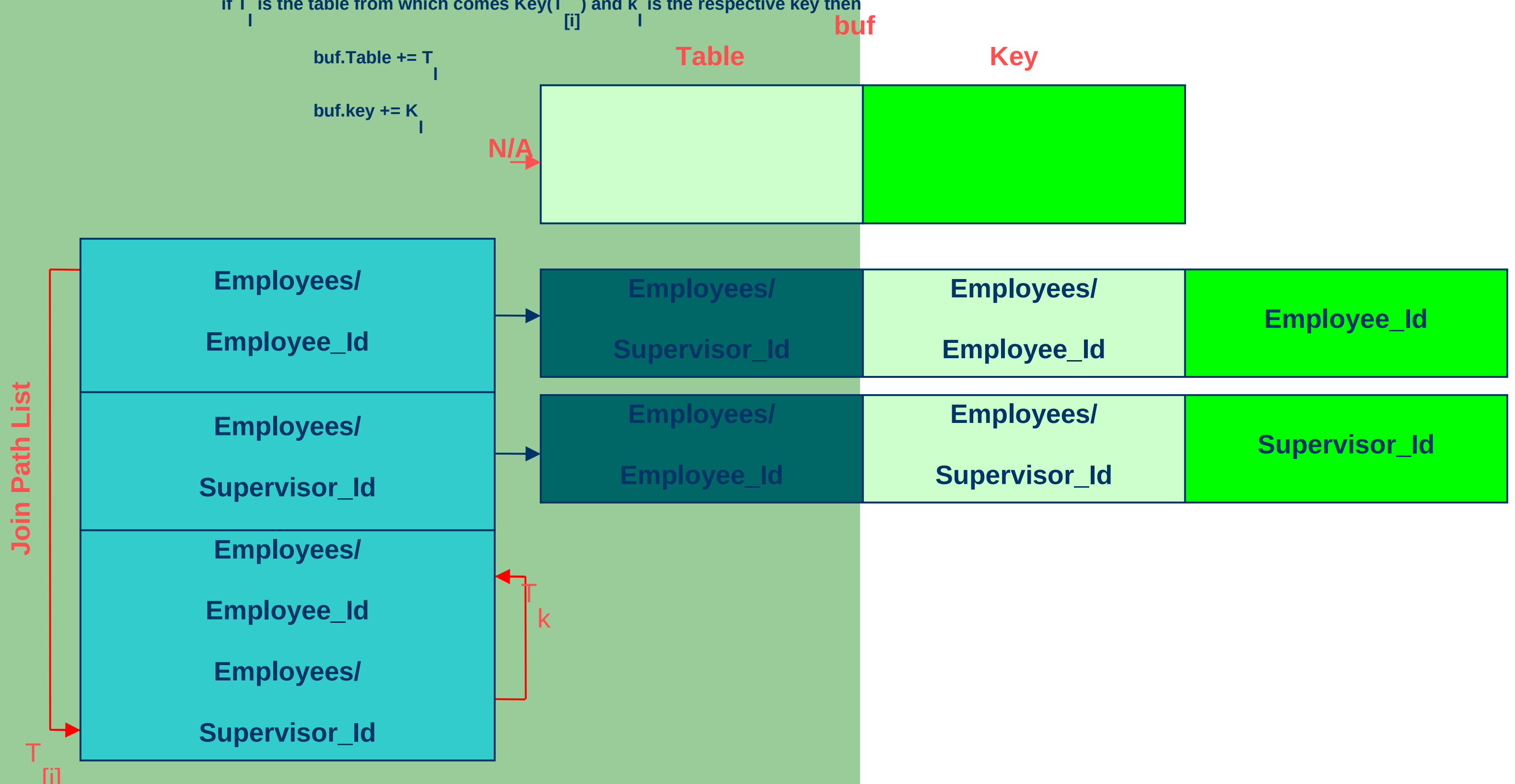

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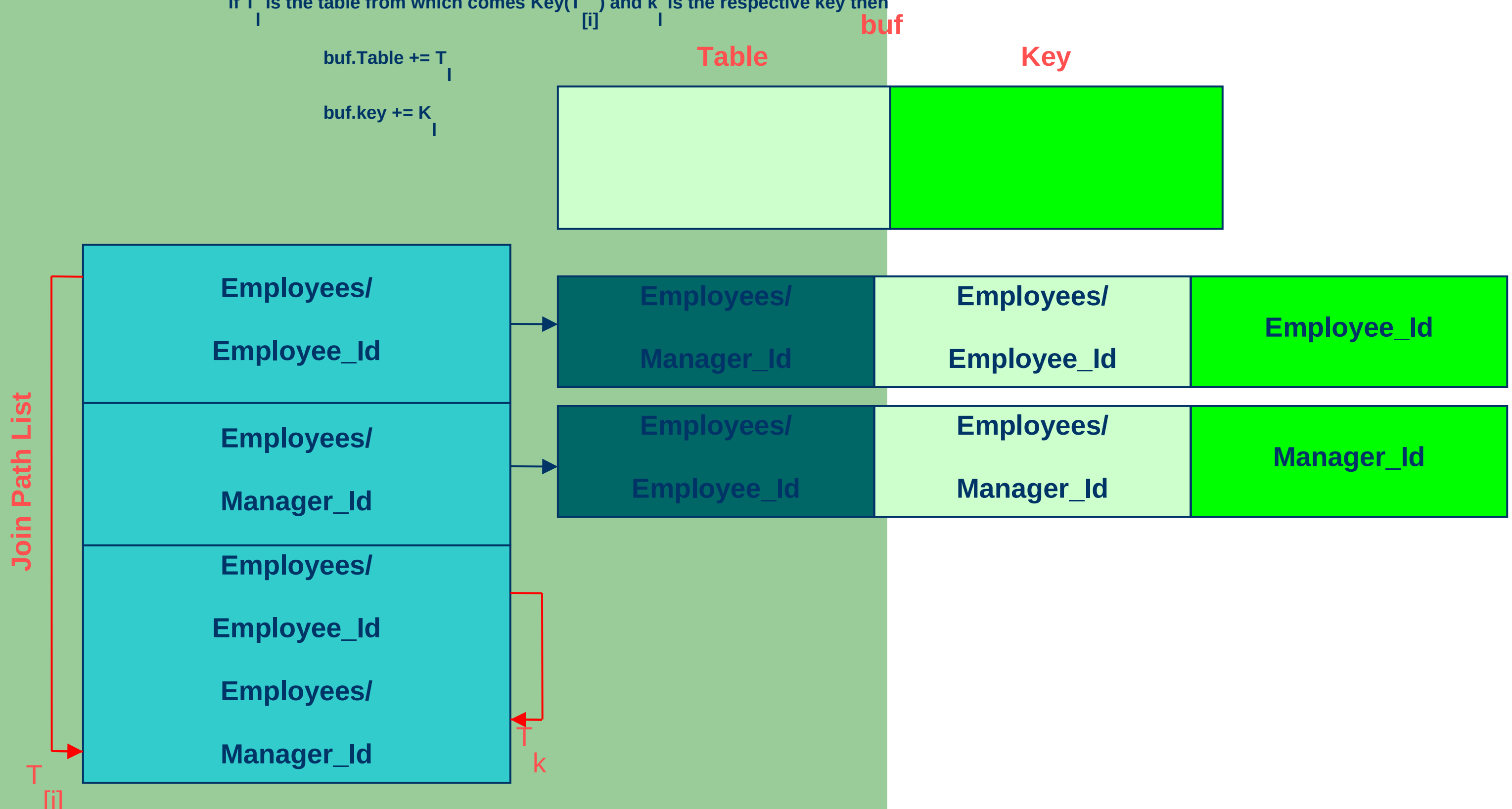

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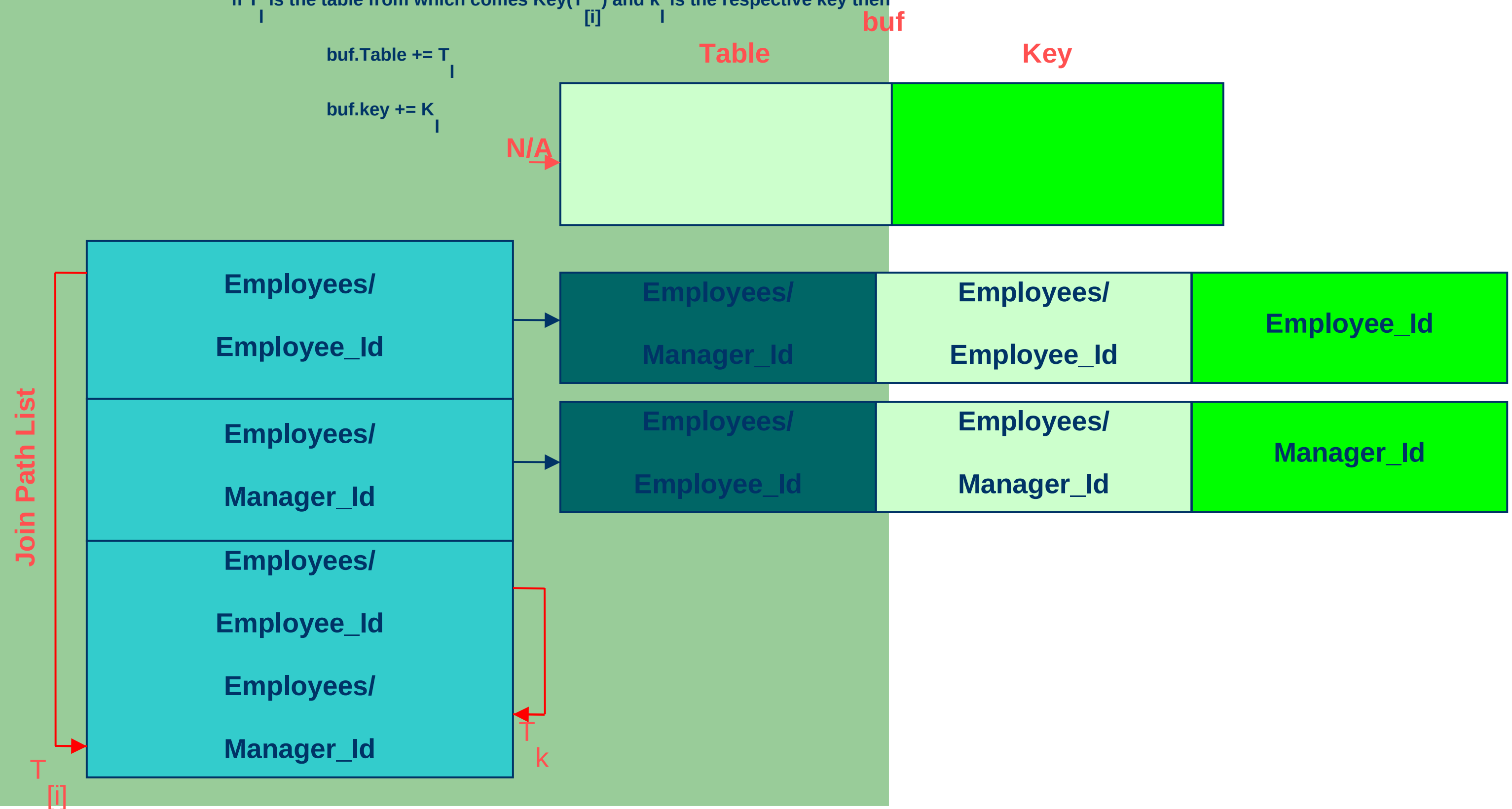

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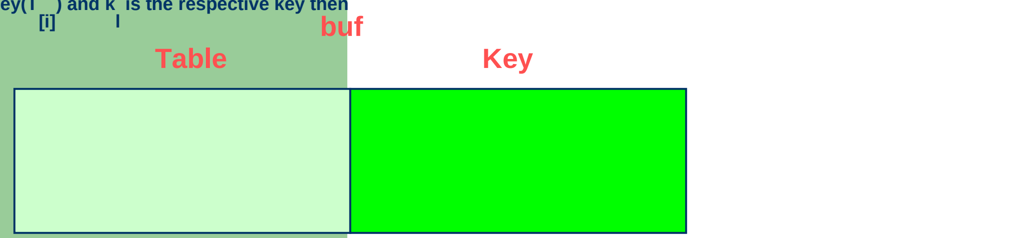

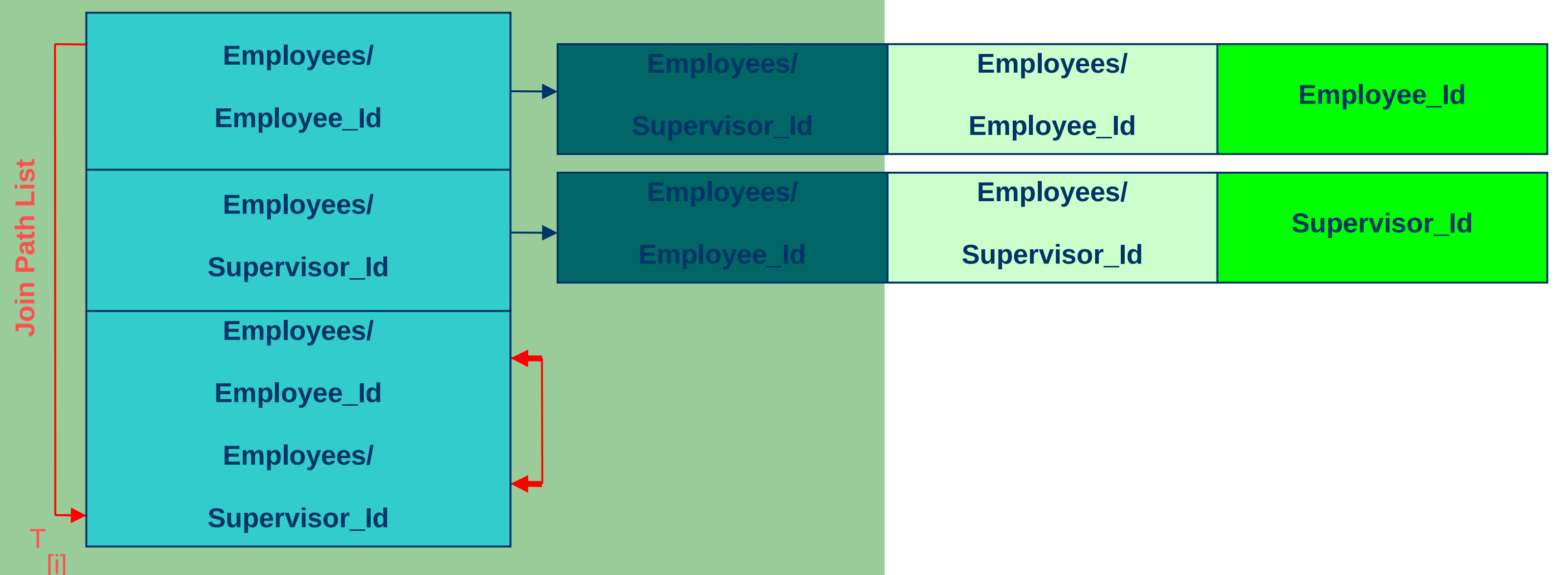

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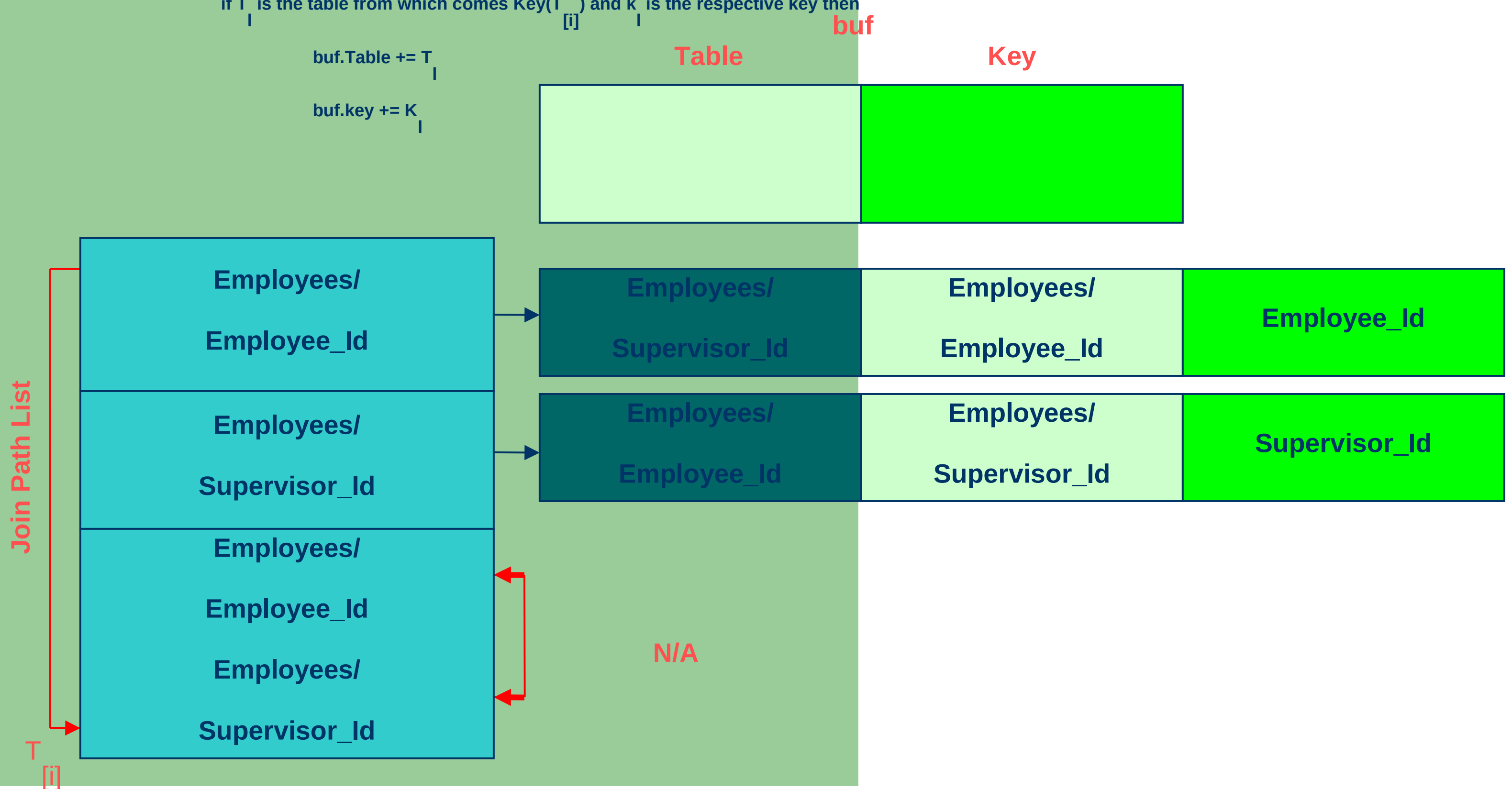

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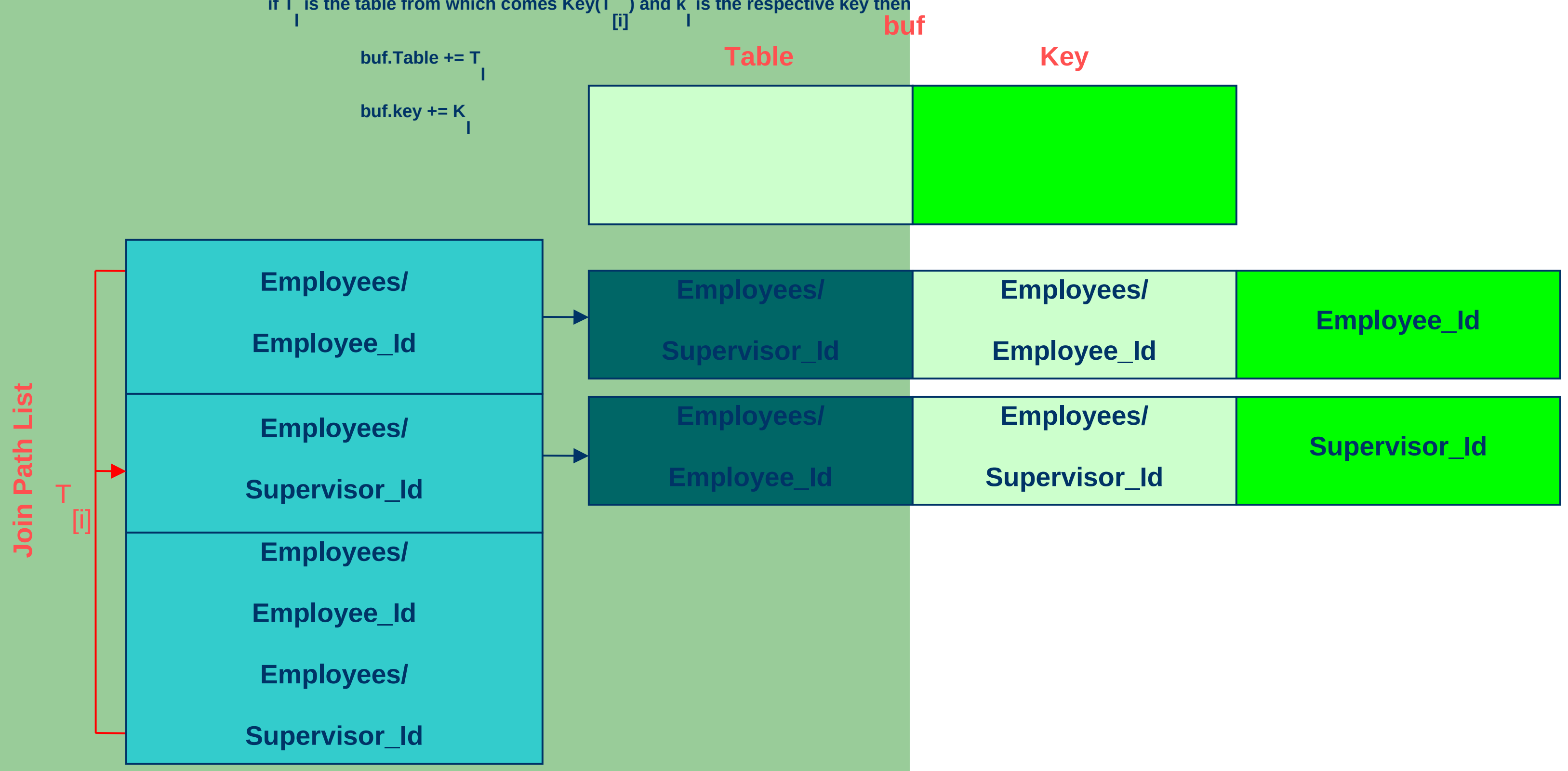

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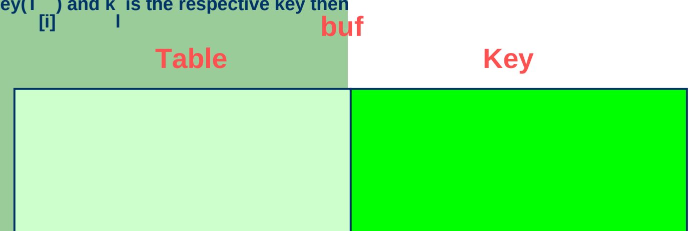

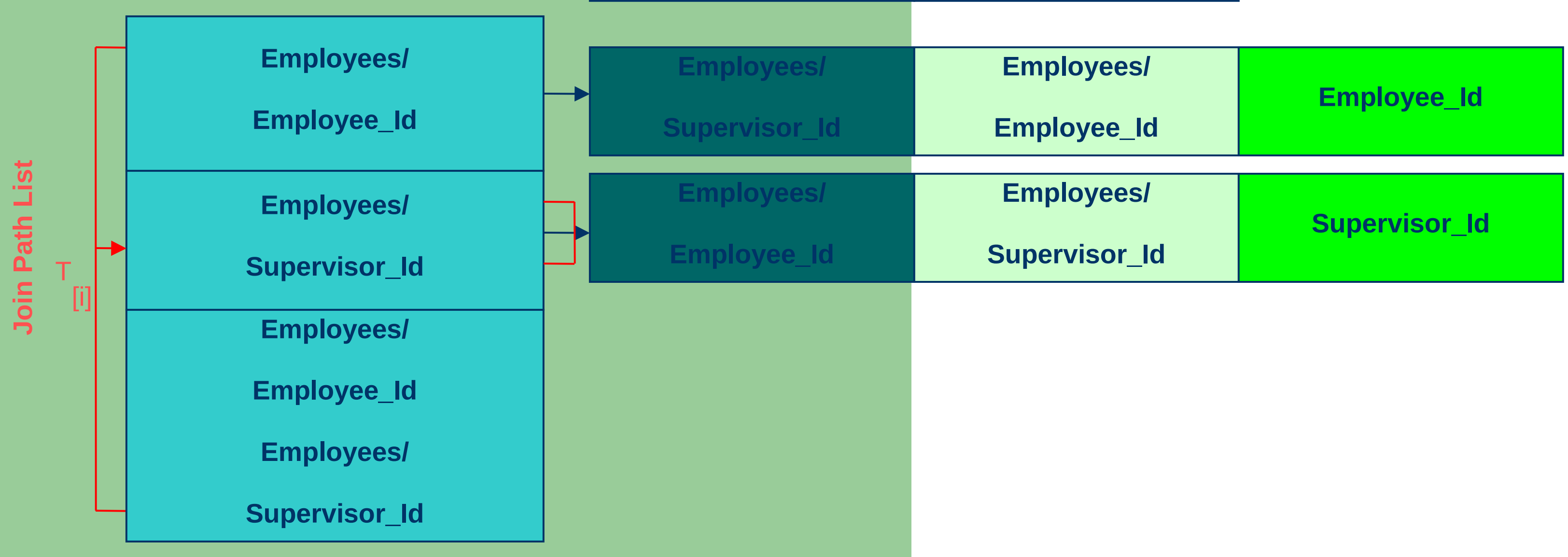

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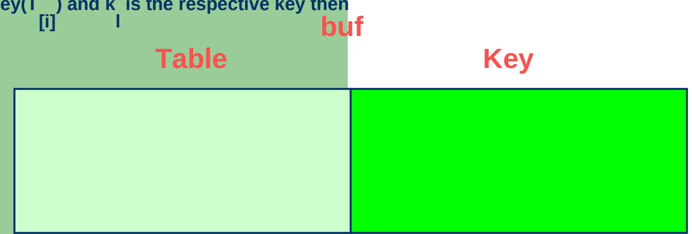

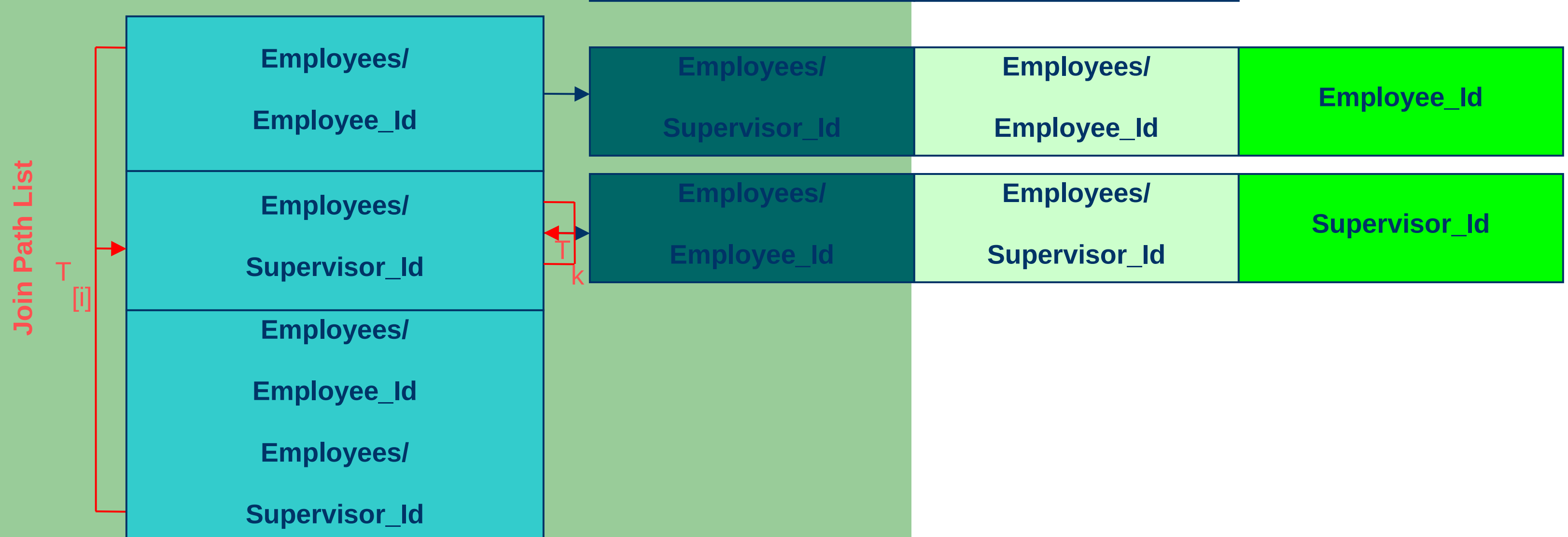

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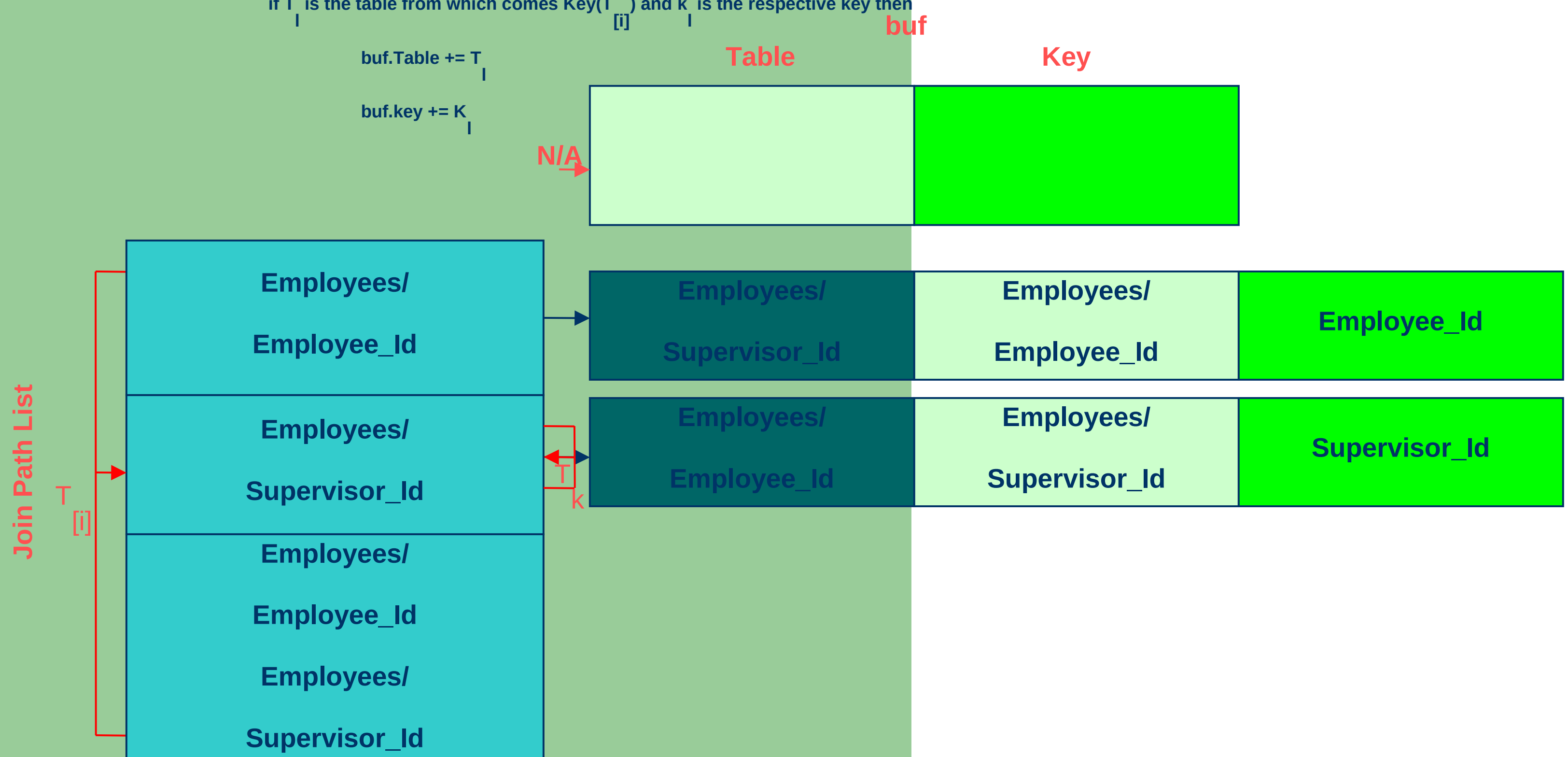

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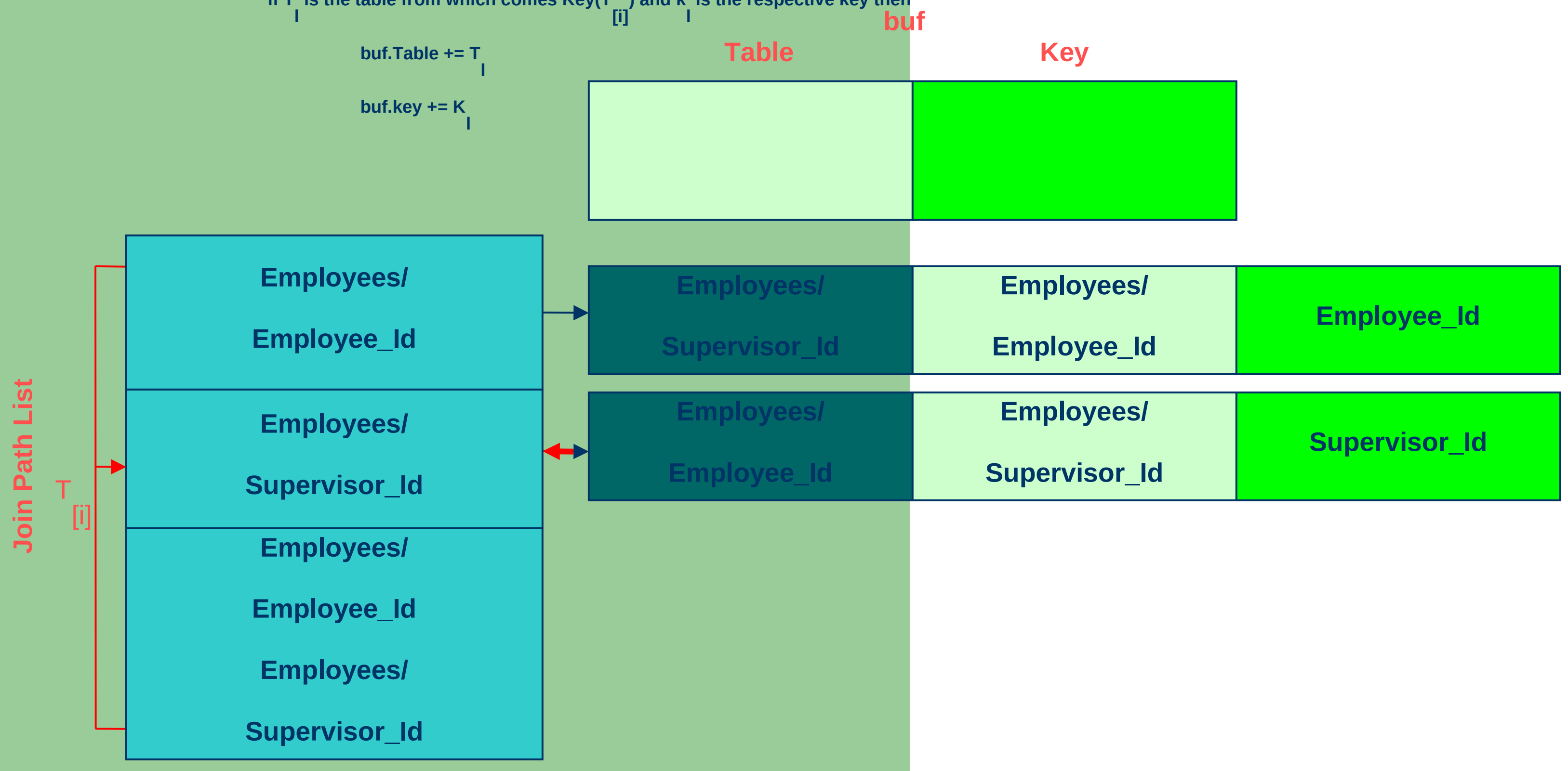

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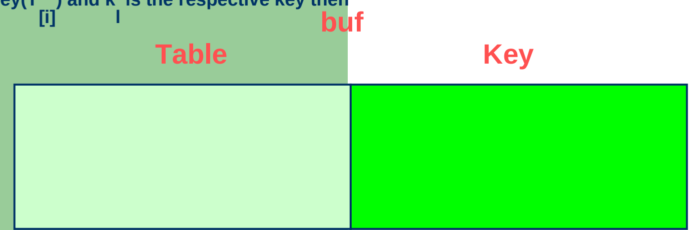

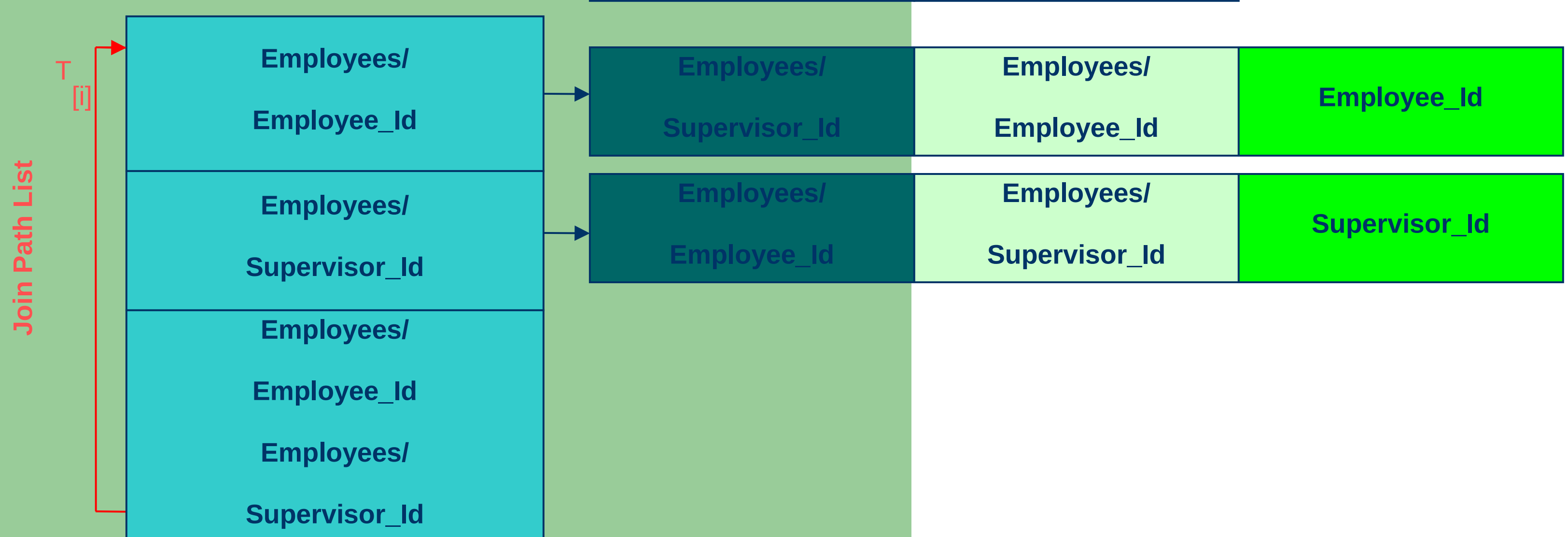

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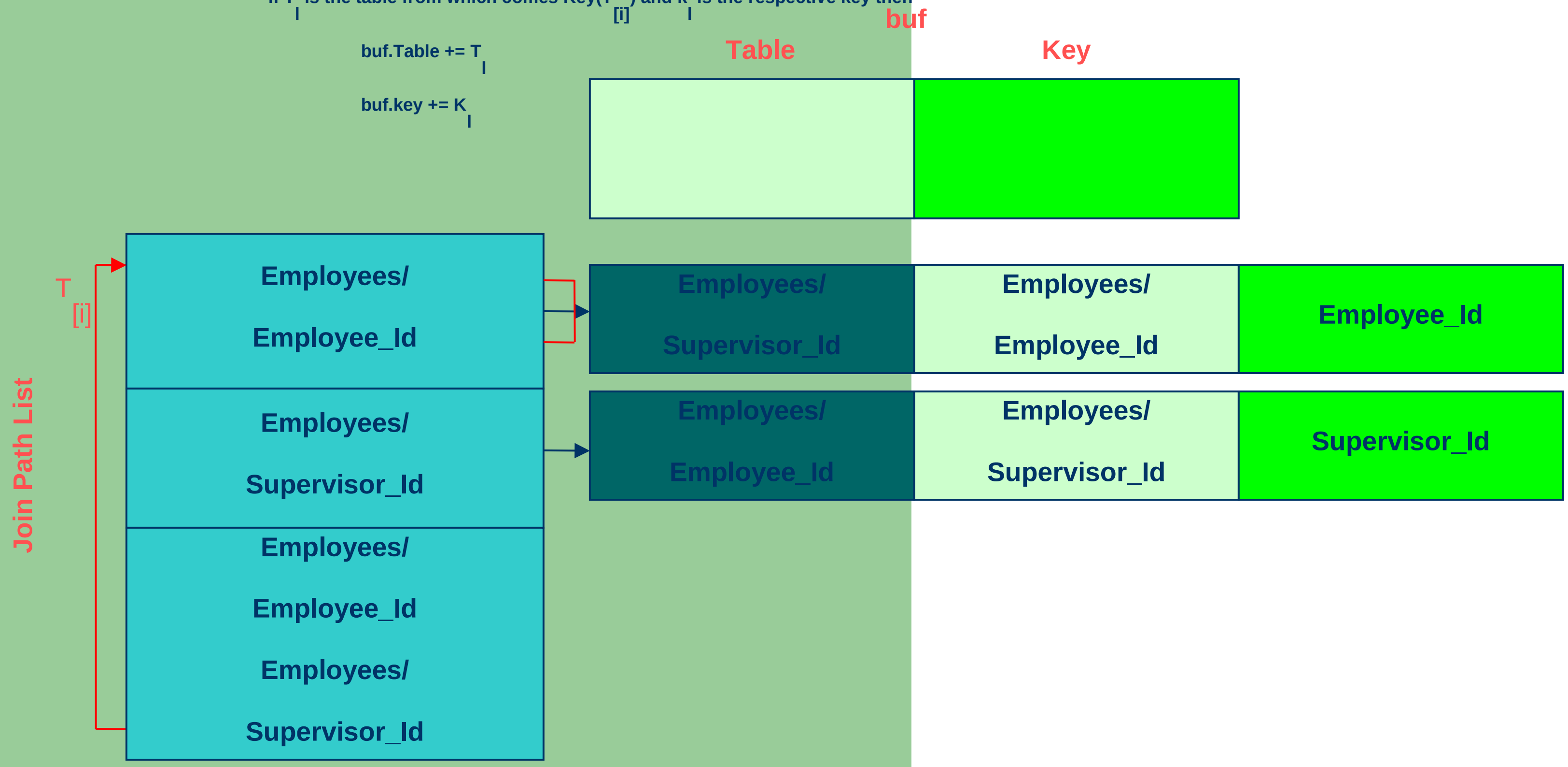

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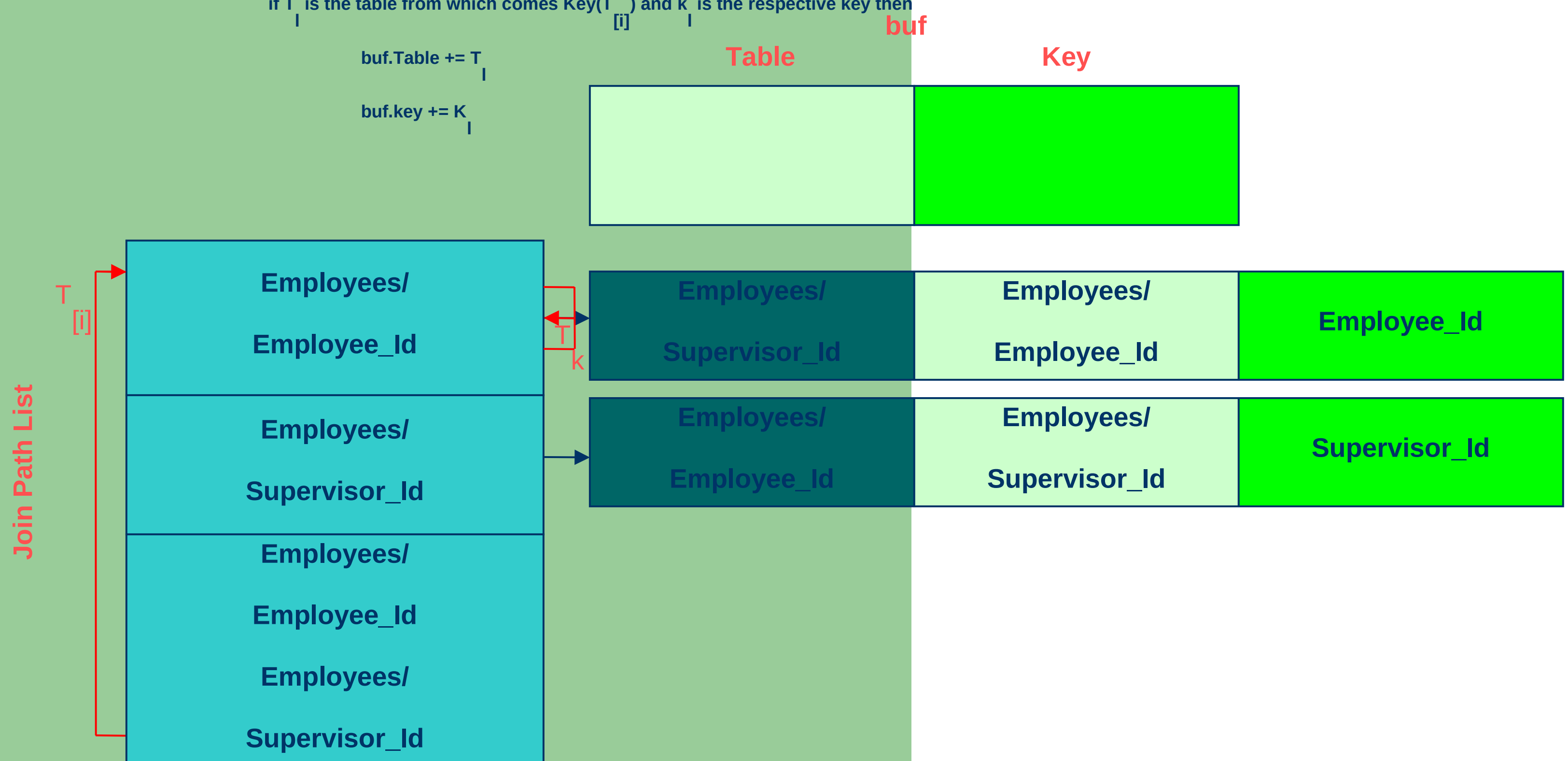

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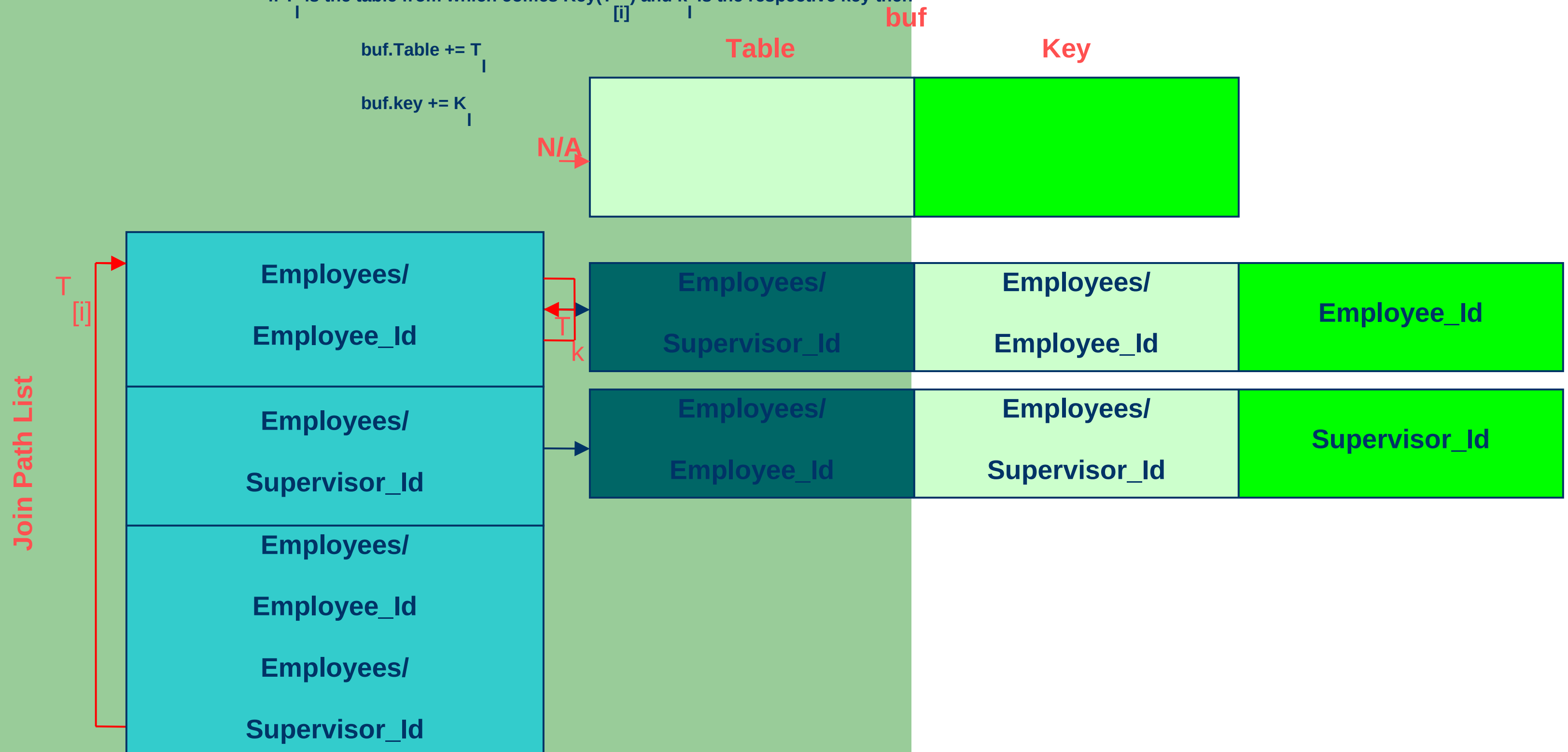

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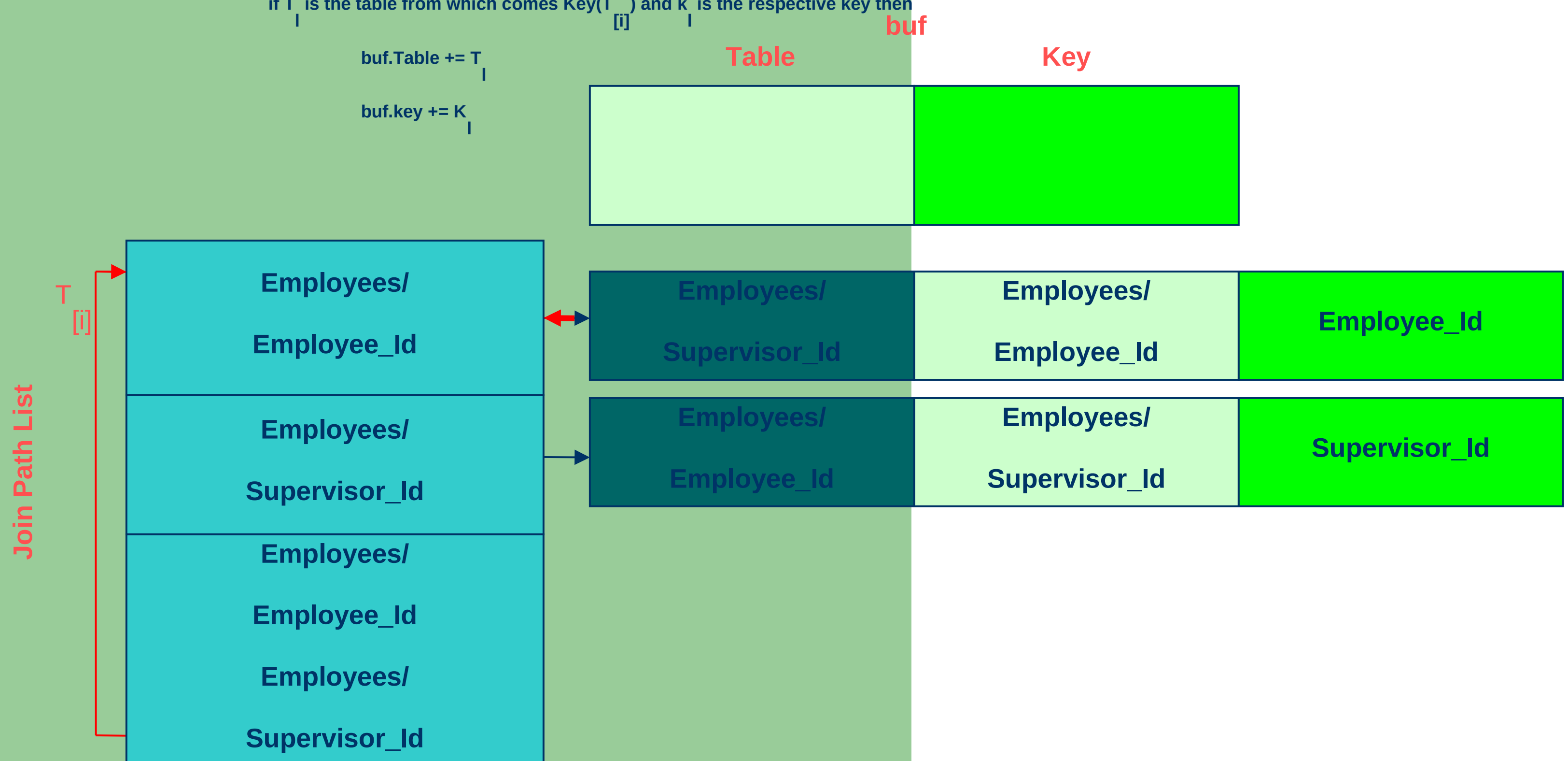

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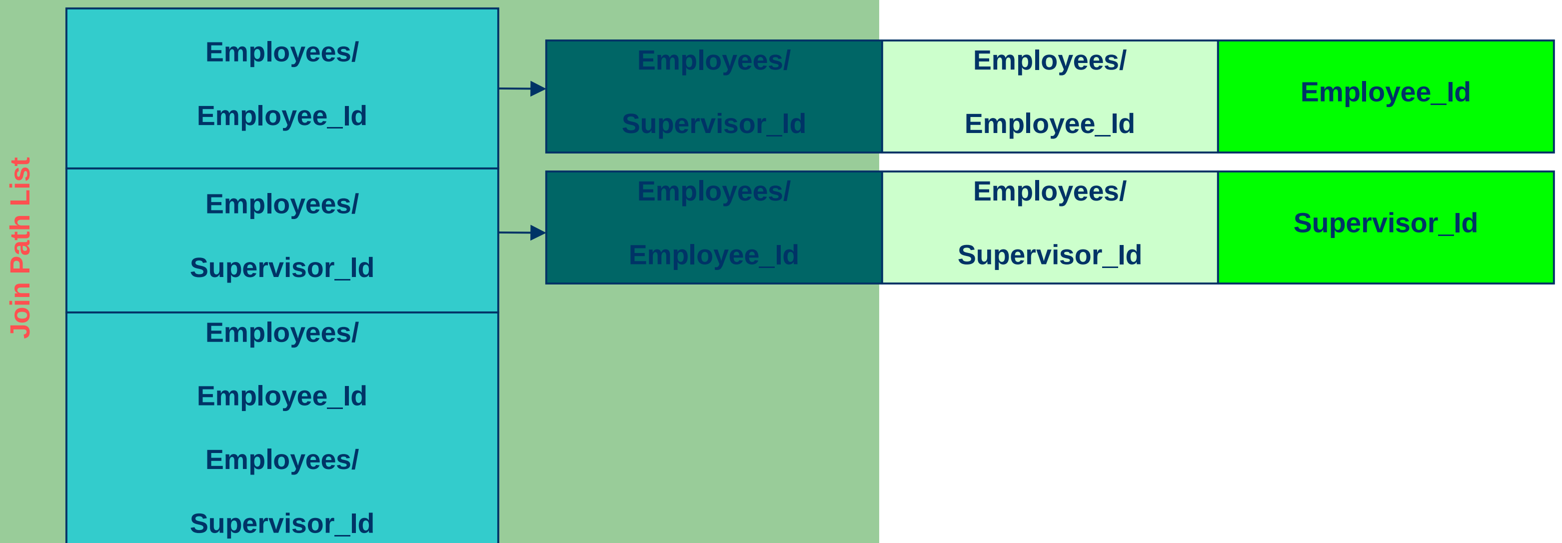

Employees table

	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

Applying the insert routine for all the rows in the table EMPLOYEES, we obtain the following indexes:

B+Tree(T_0)

0	101
1	102
2	103
3	104
4	105
5	106

B+Tree(T_1)

3	102
4	103
0	106
1	106
2	106

B+Tree(T_2)

0	5
1	5
2	5
3	1
4	2

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_o to T_i and from T_i to T_0.

The index number start always with 0.

Repeat, with T_{0i} 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.