



# QUANTUMDB

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Relational Databases

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01

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## **INSPIRATION & OVERVIEW**

Papers Used,  
Relational Databases

02

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## **BASIC QUERIES**

SEARCH, INSERT,  
DELETE

03

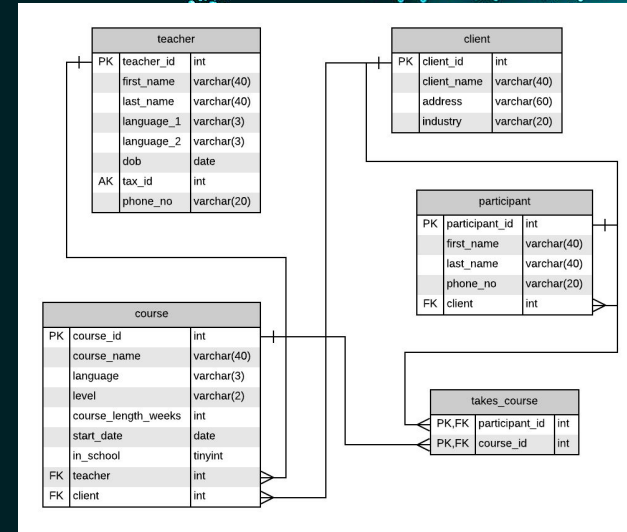
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## **ADVANCED QUERIES**

NATURAL JOIN,  
CROSS JOIN

# INSPIRATION & OVERVIEW

- Derived from Gueddena et al. 2010 and 2014
- Based on classical relational databases
- Goal:** Attempt to replicate in quantum environment



```
SELECT DISTINCT Name AS DepartmentName
,PERCENTILE_CONT(0.5) WITHIN GROUP (ORDER BY ph.Rate)
OVER (PARTITION BY Name) AS MedianCont
,PERCENTILE_DISC(0.5) WITHIN GROUP (ORDER BY ph.Rate)
OVER (PARTITION BY Name) AS MedianDisc
FROM HumanResources.Department AS d
INNER JOIN HumanResources.EmployeeDepartmentHistory AS dh
ON dh.DepartmentID = d.DepartmentID
INNER JOIN HumanResources.EmployeePayHistory AS ph
ON ph.BusinessEntityID = dh.BusinessEntityID
WHERE dh.EndDate IS NULL;
```

DepartmentName	MedianCont	MedianDisc
Document Control	16.8269	16.8269
Engineering	34.375	32.6923
Executive	54.32695	48.5577
Facilities and Maintenance	9.25	9.25
Finance	19	19.00
Human Resources	17.42785	16.5865

# Creating the Quantum Table

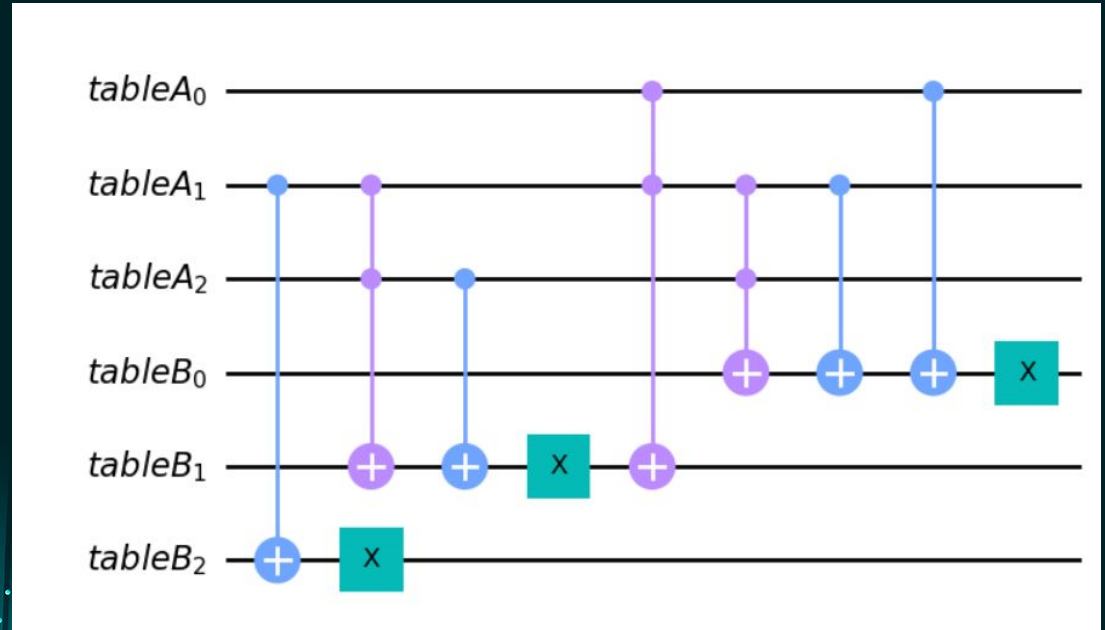
DepNum	$K^1$	DepName	$D_1^1$
27	0	Sales	7
10	1	Engineering	6
14	2	Clerical	2
6	3	Marketing	1
19	4	Finance	5
42	5	Management	4
37	6	Service	3
2	7	NULL	0

- DepNum and DepName are stored classically
- $K^1$  and  $D_1^1$  are the quantum mappings



# Creating the Quantum Table

DepNum	$K^1$	DepName	$D_1^1$
27	0	Sales	7
10	1	Engineering	6
14	2	Clerical	2
6	3	Marketing	1
19	4	Finance	5
42	5	Management	4
37	6	Service	3
2	7	NULL	0



# SQL → QQL: Creating Queries

Biggest component of most queries: **Grover's Algorithm**

## Current Available Query Tools in QQL

- **SELECT**
- **INSERT**
- **DELETE**
- **NATURAL JOIN**
- **CROSS JOIN**

# SELECT

## Stage 1: Preparation

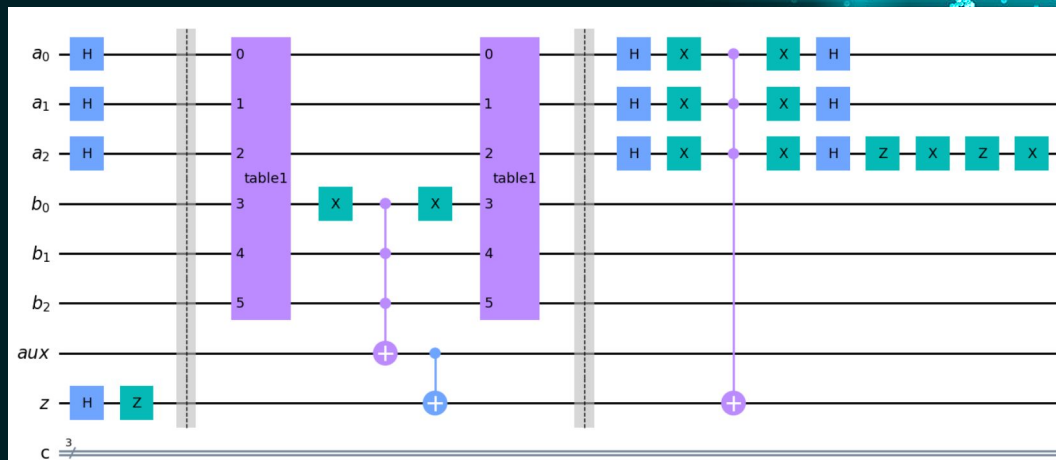
- Superpose states
- Prepare auxiliary

## Stage 2: The Oracle

- Use table to encode
- Retrieve value
- Reset state

## Stage 3: Diffusion

- Apply the  $W$  operator
- Repeat  $M = \lfloor \frac{\pi}{4} \sqrt{N} \rfloor$  times



# INSERT

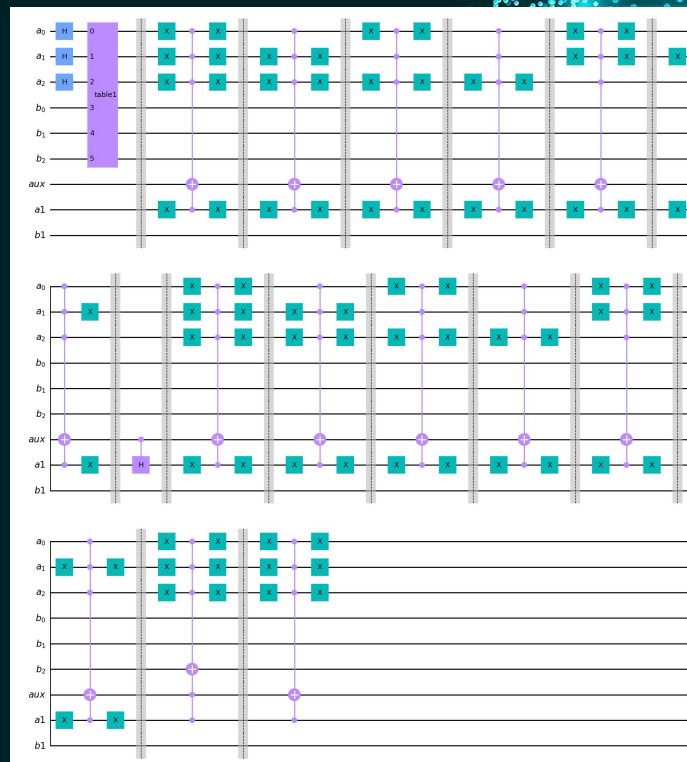
Find optimal states to insert:

$$S = \min(N_+, 2^n - N);$$

where

$$N_+ = \left(\frac{4}{\pi} \left(\left\lfloor \frac{\pi}{4} \sqrt{N} \right\rfloor + 1\right)\right)^2 - N$$

- Control  $[0, 1, \dots, S]$  states to auxiliary
- Apply controlled Hadamard
- Apply mapping and reset

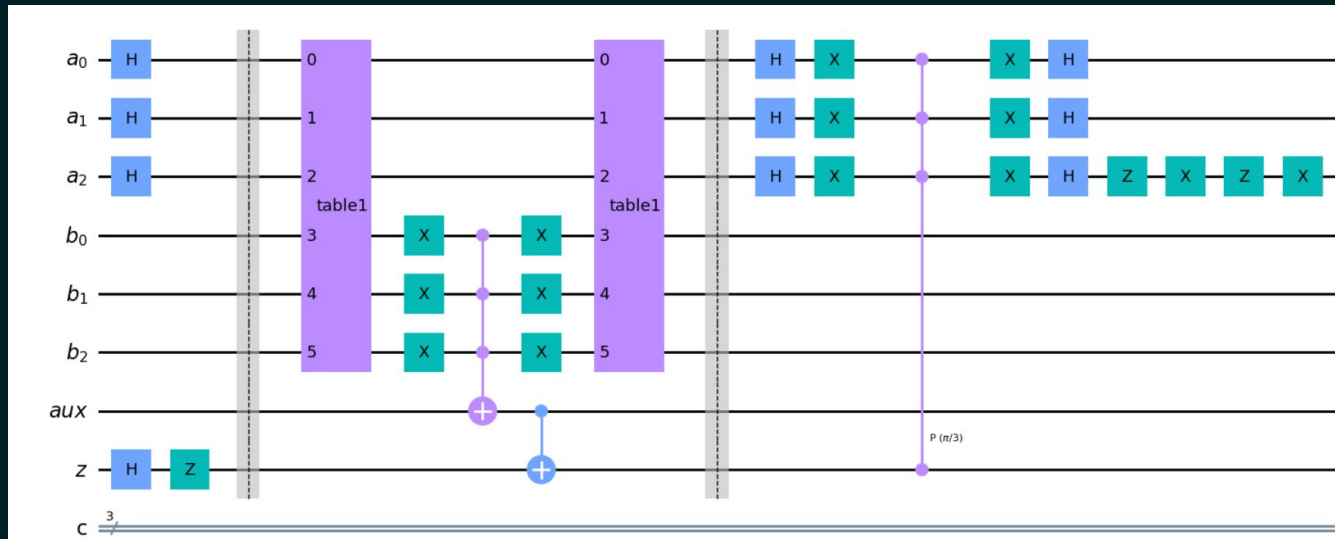




# DELETE

Essentially same as SELECT operation

- Oracle represents states to keep
- Apply  $\pi/3$  phase for optimal deletion (Y. Liu and G.L.Long, 2007)



# ADVANCED QUERIES / JOINS

ITEM_ID	ITEM_NAME	ITEM_UNIT	COMPANY_ID
1	Cheex Mix	Pcs	16
6	Cheez-It	Pcs	15
2	BN Biscuit	Pcs	15
3	Mighty Munch	Pcs	17
4	Pot Rice	Pcs	15
5	Jaffa Cakes	Pcs	18
7	Salt n Shake	Pcs	-

COMPANY_ID	COMPANY_NAME	COMPANY_CITY
18	Order All	Boston
15	Jack Hill Ltd	London
16	Akias Foods	Delhi
17	Foodies	London
19	sip-n-Bite	New York

**\*\* Same column came once**

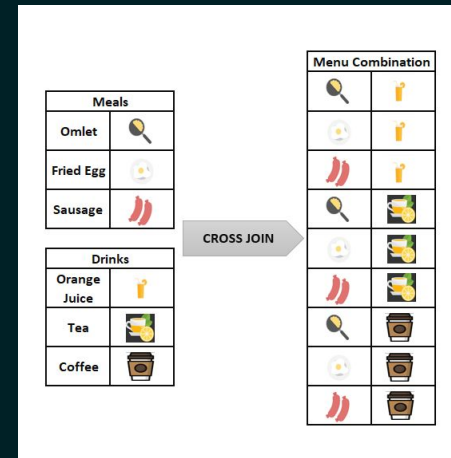
COMPANY_ID	ITEM_ID	ITEM_NAME	ITEM_UNIT	COMPANY_NAME	COMPANY_CITY
16	1	Cheex Mix	Pcs	Akias Foods	Delhi
15	6	Cheez-It	Pcs	Jack Hill Ltd	London
15	2	BN Biscuit	Pcs	Jack Hill Ltd	London
17	3	Mighty Munch	Pcs	Foodies	London
15	4	Pot Rice	Pcs	Jack Hill Ltd	London
18	5	Jaffa Cakes	Pcs	Order All	Boston

## NATURAL JOIN

Most optimal join based on columns

## CROSS/CARTESIAN JOIN

Cartesian product of two tables



# NATURAL JOIN

Semantics in QQL:

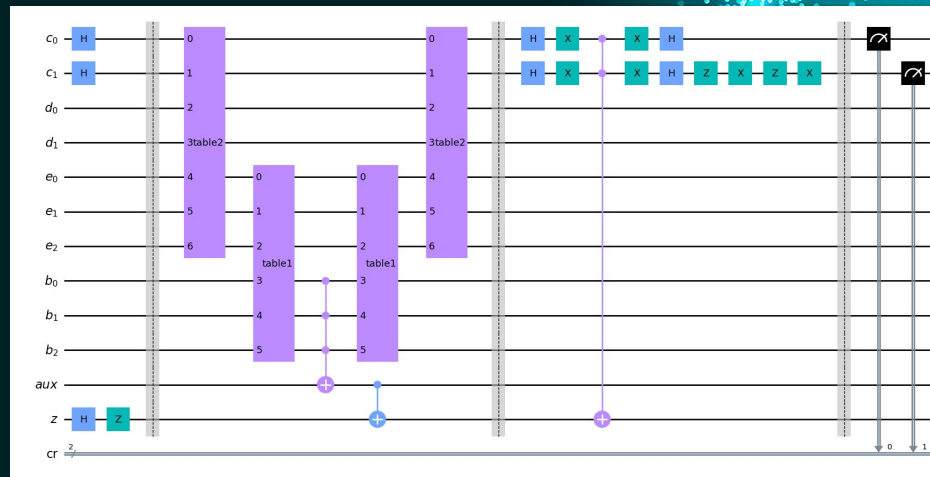
```
SELECT  $|K^2\rangle$ 
FROM  $|T_1\rangle$ 
NATURAL JOIN  $|T_2\rangle$ 
WHERE  $|D_1^1\rangle = |7\rangle$ 
```

**Oracle:**

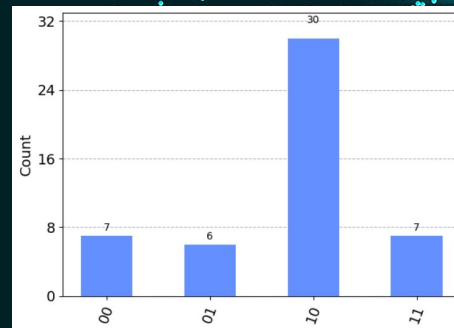
- Links table 1 and 2
- Apply checker C-not

- **Diffuse and Repeat**  
 $M = \lfloor \frac{\pi}{4} \sqrt{N} \rfloor$  times

EmpNum	$K^2$	EmpName	$D_1^2$	DepNum	$F^2$	DepName	$D_1^1$
315	0	Albert	3	37	6	Service	3
90	1	Brian	0	2	7	Entertainment	0
123	2	Craig	1	27	0	Sales	7
204	3	Oliver	2	37	6	Service	3



**Only 50 shots!**



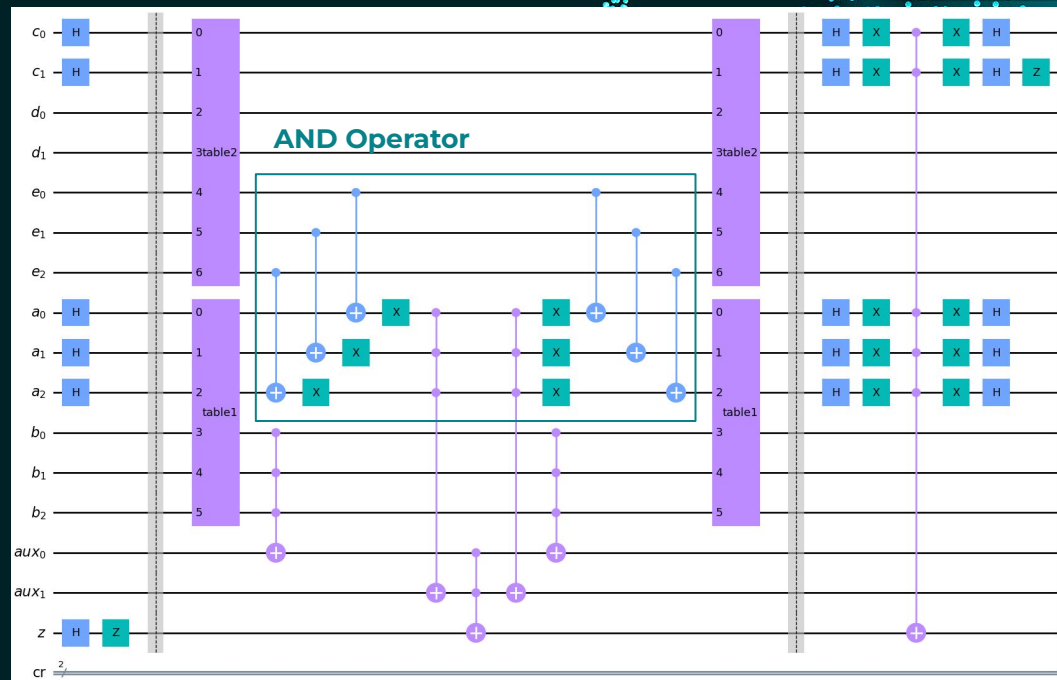
# CROSS JOIN

Semantics in QQL:

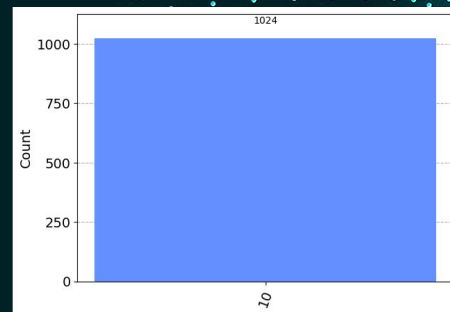
```
SELECT  $|K^2\rangle$ 
FROM  $|T_1\rangle$ 
CROSS JOIN  $|T_2\rangle$ 
WHERE ( $|D_1^1\rangle = |7\rangle$ )
AND ( $|K^1\rangle = |F^2\rangle$ )
```

**Oracle:**

- AND operator links table 1 and 2
- Apply checker C-not
- **Diffuse and Repeat**  
 $M = \lfloor \frac{\pi}{4} \sqrt{N} \rfloor$  times



**High  
Certainty!**





# Thank you!

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Any Questions?