

SQL Test Case Generation Using Multi-Objective Optimization

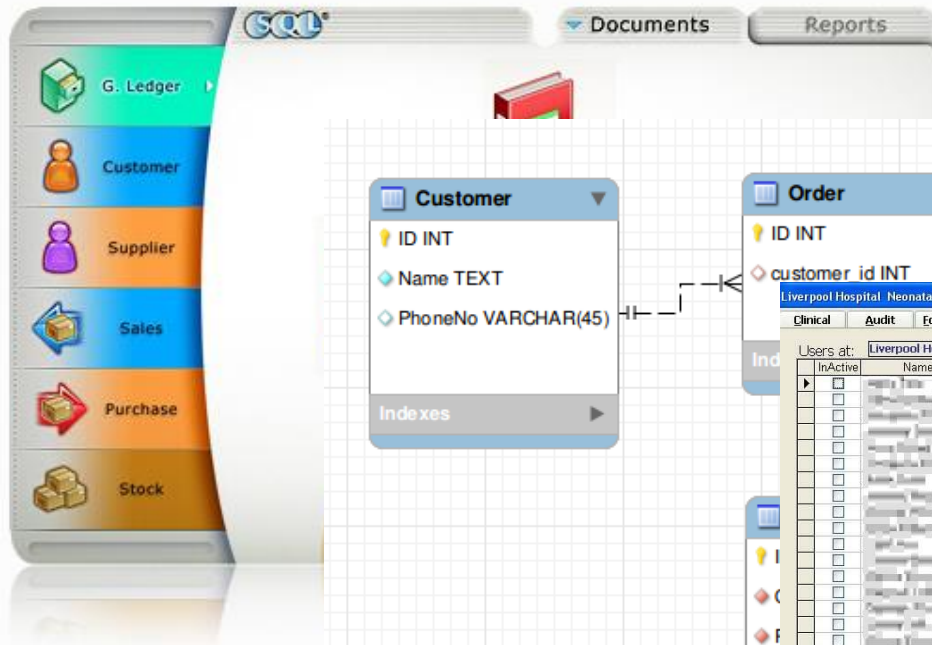


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Liverpool Hospital Neonatal Database

Clinical Audit Followup Reports Admin

Users at: Liverpool Hospital Server: Liverpool Hospital

| InActive | Name | Job | List | Username | Password | changed | Clinical | FUP | Reports | NICUS | Lock | Admin |
|--------------------------|-------------------------|-----|------|----------|----------|------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| <input type="checkbox"/> | Registered Nurse | | | | ***** | 23/08/2007 | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | Database consultant | | | | **** | 19/12/2007 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| <input type="checkbox"/> | Neonatal Resident | | | | ***** | 11/02/2008 | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | Registered Nurse | | | | ***** | 18/07/2007 | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | Neonatal Registrar | | | | ***** | 24/01/2008 | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | Registered Nurse | | | | ***** | 15/08/2007 | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | Home Support Nurse | | | | ***** | 8/01/2007 | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | Registered Nurse | | | | ***** | 16/07/2007 | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | Neonatal Registrar | | | | ***** | 19/02/2008 | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | Clinical Co-ordinator | | | | ***** | 14/06/2007 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| <input type="checkbox"/> | Registered Nurse | | | | ***** | 13/08/2007 | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | Registered Nurse | | | | ***** | 20/02/2008 | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | Ward Clerk | | | | ***** | 13/06/2007 | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | Clinical Nurse Educator | | | | ***** | 17/08/2007 | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | Registered Nurse | | | | ***** | 13/07/2007 | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | Registered Nurse | | | | ***** | 13/07/2007 | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | Secretary | | | | ***** | 7/11/2007 | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | Registered Nurse | | | | ***** | 13/07/2007 | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | Neonatal Registrar | | | | ***** | 24/01/2008 | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | Physiotherapist | | | | ***** | 16/07/2007 | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

Record: 1 of 106

New Users will be linked with the hospital listed above - each staff member must have a server unique username even if they are not given a password

Hospital Defaults Advanced Local form

Beds Table Ian Callender Logged on at 10:53 01/03/08

Consultant Table Log Off / Switch User

Give Feedback SQL Executor Logbook EXIT Neonatal Database

SELECT items .* **FROM** invoice

JOIN items **ON** invoice.id = items.invoiceid

WHERE amount > 1000 **OR** taxfree = 1

How should we test this query?

“



Search-based Test Data Generation for SQL Queries

Jeroen Castelein et al. ICSE 18'



Search-based Test Data Generation for SQL Queries

(Jeroen Castelein et al. ICSE 18')

- ✓ Modeled the problem of test data generation for SQL queries as a **search-based problem**.
- ✓ Implemented three different search approaches in tool, named ***EvoSQL***
(random search, biased random search, genetic algorithms)
- ✓ Executed on 2,135 queries extracted from 4 software systems



Fitness Function

```
SELECT *  
FROM Cars  
JOIN Tires  
ON Cars.tire_id = Tires.id  
WHERE model = 'Ferrari'
```

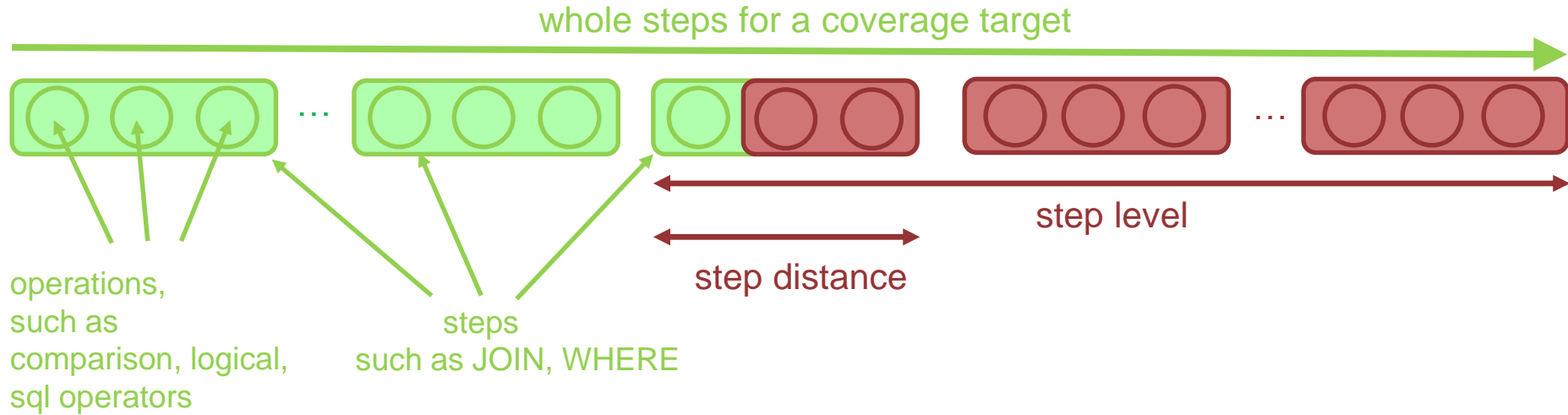
Step 1

Step 2

If Step 1 doesn't produce an output,
database stops its execution before proceeding to Step 2



Fitness Function



$$\text{Fitness function} = \text{step level} + \text{step distance}$$

Problem: Inefficiency of single-target strategy

- 1. The order of each coverage target is not optimized*
- 2. Inefficient allocation of the budget might happen, such as infeasible coverage target.*

Solution

Multi-Objective Optimization!



“



Multi-Objective Optimization

```
SELECT * FROM Product WHERE (Category = 'Toy' )
```



Multi-Objective Optimization

```
SELECT * FROM Product WHERE (Category = 'Toy' )
```

| id | category |
|----|----------|
| 1 | Toy |
| 2 | Food |
| 3 | Car |

Product



Multi-Objective Optimization

```
SELECT * FROM Product WHERE (Category != 'Toy' )
```

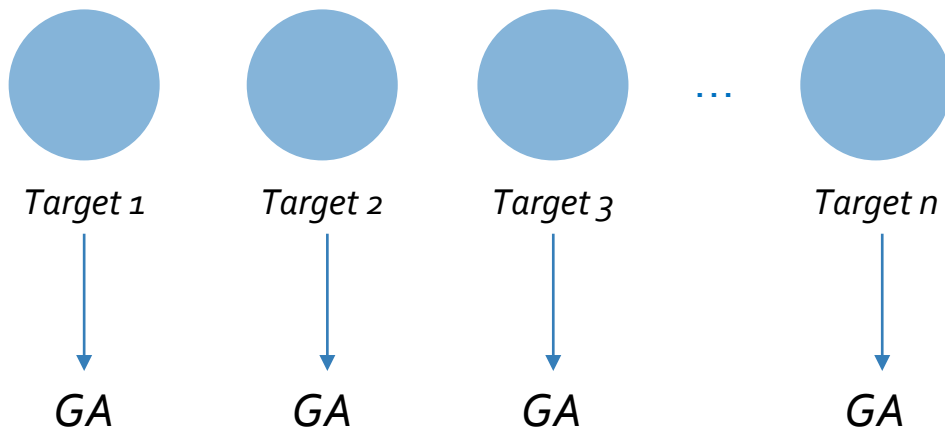
| id | category |
|----|----------|
| 1 | Toy |
| 2 | Food |
| 3 | Car |

Product



Multi-Objective Optimization

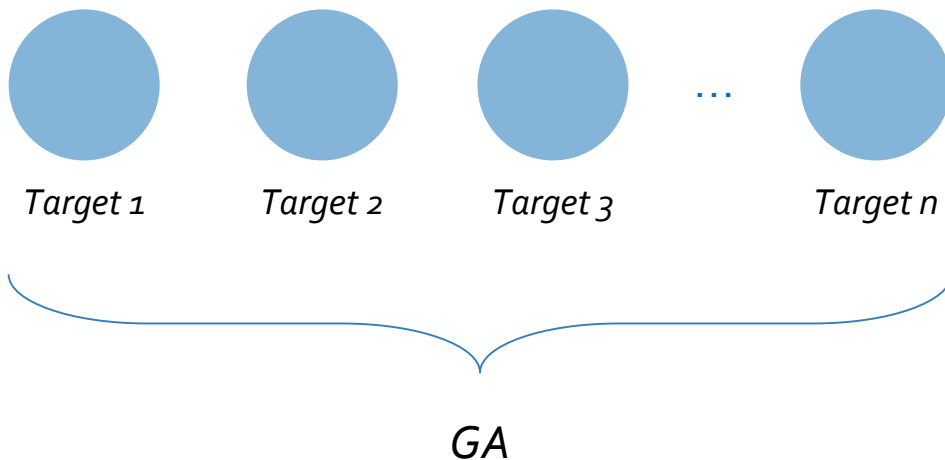
Challenge 1. The order of each coverage target being executed is not optimized





Multi-Objective Optimization

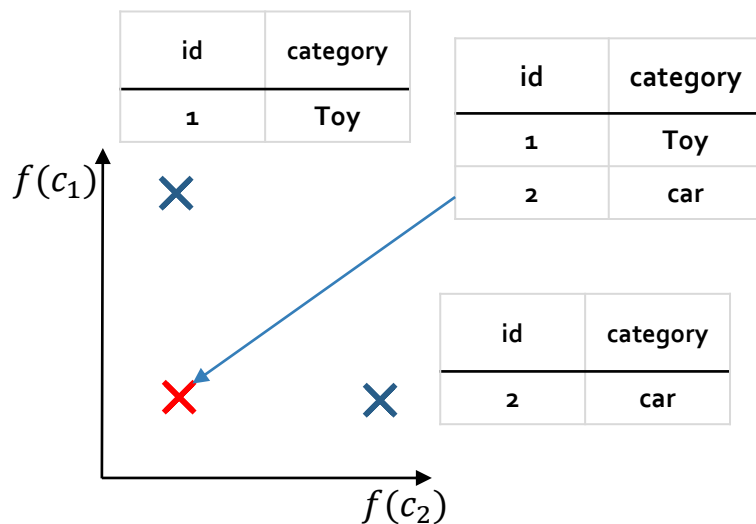
Challenge 1. The order of each coverage target being executed is not optimized





Multi-Objective Optimization

SELECT * FROM Product WHERE (Category = 'Toy')



$$\begin{cases} \min & f(c_1, t) & c_1 : \textit{WHERE Category} = \textit{'Toy'} \\ \min & f(c_2, t) & c_2 : \textit{WHERE Category} \neq \textit{'Toy'} \end{cases}$$



Multi-Objective Optimization

Challenge 2. Inefficient allocation of the budget might happen, such as infeasible coverage target.

" $A > 10$ and $A < 10$ "? \rightarrow infeasible, no solution from GA

$$\left\{ \begin{array}{lll} \min & f(c_1, t) & f(c_1, t) \Rightarrow \text{feasible} \\ \min & f(c_2, t) & f(c_2, t) \Rightarrow \text{Infeasible} \\ & \dots & \dots \\ \min & f(c_m, t) & f(c_m, t) \Rightarrow \text{feasible} \end{array} \right.$$

Solution from EvoSQL is to manually remove infeasible coverage targets.



Our Expectation

- ✓ Our MOO version can solve more complex queries simultaneously compared to single-objective strategy.
- ✓ Each solution is guided by hinting the similar solution from other coverage target.
- ✓ It doesn't consume improper budget for handling the infeasible coverage target .

Questions?

Thanks for your attention!



“

A vertical grey line extends downwards from the bottom of the yellow circle.