

# Database-Driven Optimization for Community Aid Organizations: Enhancing Resource Allocation and Engagement at ICNA Relief

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## Abstract

During my 2022 summer internship at ICNA Relief, a non-profit dedicated to aiding the underprivileged and disaster-affected, I identified operational inefficiencies in resource allocation and community outreach. The reliance on registration forms for clients and volunteers, coupled with Excel spreadsheets for tracking inventories and donations, hindered their ability to optimize processes. Armed with my newly acquired knowledge of database systems from class, I resolved to design and implement a comprehensive relational database that could centralize information, allowing for more effective resource allocation and community engagement. To achieve this, I utilized ER diagrams to design a relational database to centralize donor, volunteer, client, inventory, donation, and event data. Applying SQL functionalities, including joins, subqueries, and aggregates, I developed complex queries to identify total donation amounts, top donors, percentage of donations from top donors, and volunteers with the most hours donated per interest. These insights enable ICNA Relief to recognize top contributors, target fundraising efforts to increase contributions, and strategically assign volunteers to areas where their skills and contributions are impactful. Additionally, I implemented triggers for real-time updates of essential inventories during events. These features streamlined ICNA Relief's processes, preventing data loss from outdated tracking methods. This database-driven solution exemplifies a transformative approach, fostering efficient resource allocation and robust community engagement at ICNA Relief, aligning seamlessly with the organization's commitment to making a positive impact.

## Background

In my internship at ICNA Relief last summer, I discovered a passion for volunteering in social service programs, witnessing firsthand the dedication of the staff in addressing the immediate needs of individuals facing crises, such as house fires. Inspired by the organization's commitment to community welfare, I recognized the potential to enhance their mission by leveraging data-driven solutions. This led to the conceptualization of a project aimed at designing and implementing a comprehensive database to identify organizational flaws, expand volunteer participation, and strategically deploy resources.

While the staff at ICNA Relief is dedicated to identifying people in need, organizing events, recruiting volunteers, and attracting donations, they still rely on registration forms for clients and volunteers, coupled with Excel spreadsheets for tracking inventories and donations,

hindering their ability to optimize processes. As highlighted by Antoine in his article, "What Can a Nonprofit Database Do for Your Organization?" [1] and articulated by C. J. Date in the renowned book "An Introduction to Database Systems,"[2] transitioning to a relational database solution presents numerous advantages. Firstly, it allows for centralized storage of data, providing a single point of access for all relevant information, including client details, volunteer records, inventory levels, and donation history. This minimizes the need to navigate through multiple forms and spreadsheets. Secondly, it makes retrieving specific information more efficient. Queries can be formulated to extract precise data, reducing the time and effort required to locate critical details compared to manual searches in forms or spreadsheets. Thirdly, it enforces data integrity through constraints and relationships and ensures that information is accurate and consistent, reducing the likelihood of errors compared to manual data entry in forms or spreadsheets. Additionally, it also supports automation through triggers. This enables the automation of repetitive tasks, such as updating inventory levels after distribution via food pantry events, reducing manual effort and improving efficiency compared to manual tracking in Excel spreadsheets.

In addition, I sought to address specific challenges in resource allocation, volunteer deployment, and fundraising efforts. For instance, implementing triggers to identify top volunteers and highlighting high-status donors in real time on social media aimed to recognize and incentivize contributions. Moreover, the database would aid in identifying overlooked donation items, allowing for targeted fundraising efforts to address specific needs.

### **Approach**

In implementing the database for ICNA Relief, I followed a systematic approach to ensure an effective and comprehensive solution. The foundation of the project was built on principles from renowned database design methodologies and best practices, incorporating key design choices to address the unique needs of ICNA Relief's operations.

The initial phase involved gathering requirements by understanding ICNA Relief's existing workflows, pain points, and aspirations for improvement based on my experience working for the organization last summer. This information served as a basis for the Entity-Relationship (ER) modeling process. Utilizing ER diagrams, I delineated the relationships between various entities such as clients, volunteers, donors, inventory items, donations, and events to capture all relevant information seamlessly.

When determining the attributes for each entity, I not only gathered basic information, such as age, gender, and full name for Staff, Volunteers, and Clients, but also added attributes to tailor the specific requirements for each entity. For example, I included an income attribute for Clients to determine their eligibility for food pantry programs and a Has\_children attribute to ensure they receive essentials tailored to their needs. I also added Hours\_worked to the entity connecting volunteers to events to enable users to efficiently retrieve their volunteer hours without searching through spreadsheets. For Donation, Essentials and Distributes entities,

attributes to quantify the items were added in order to identify resource shortage, ensuring optimal operation across the organization.

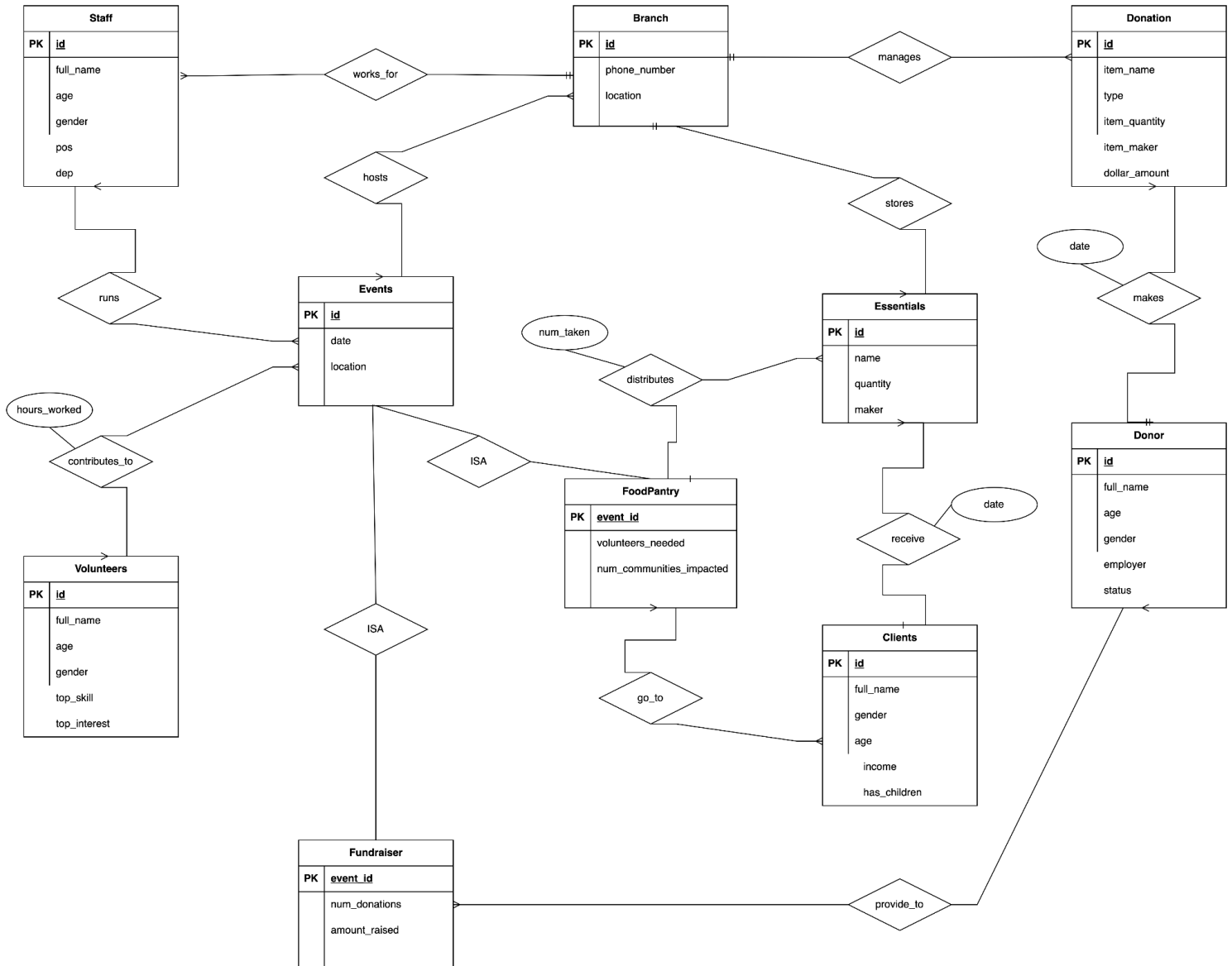
For the database implementation, I used Structured Query Language (SQL) to create tables, define relationships, and formulate complex queries. I leveraged SQL's powerful functionality, including joins, subqueries, and aggregates, to develop intricate queries for extracting valuable insights, such as identifying top donors, the expertise of volunteers, and the statuses of top donors. In some cases, I created views for complex queries and queried on top of those views to produce the desired results. For instance, to find Volunteers with the Most Hours Donated in Each Interest, I first created a view to retrieve the total hours worked for each volunteer, a view to rank all volunteers based on hours worked categorized by their interest, and then wrote a query to retrieve the top volunteer with the most hours donated in each interest.

To ensure data integrity and consistency, I incorporated constraints within the database schema, such as PRIMARY key, FOREIGN key, and CHECK constraints. These design choices aimed to minimize errors and discrepancies in the data, providing a reliable foundation for decision-making. Additionally, I implemented triggers to automate specific tasks, such as updating inventory levels when donors contribute items or items are distributed during food pantry events. This automation streamlines processes, eliminates potential discrepancies caused by manual updates, and enhances overall efficiency, potentially yielding substantial cost savings for the organization.

Throughout the implementation process, I referred to established database design principles outlined in reputable sources such as "Database System Concepts" by Abraham Silberschatz, Henry F. Korth, and S. Sudarshan [3], and "SQL Performance Explained" by Markus Winand [4]. By drawing on these authoritative references, I ensured that the design choices made during implementation align with industry standards and best practices.

## Results

### Entity-Relationship (ER) Modeling



ER Diagram of ICNA Relief

### Relational schemas:

1. Branch(Branch\_id, Phone\_number, Location)
2. Staff(Staff\_id, Full\_name, Age, Gender, Pos, Dep)
3. Donation(Donation\_id, Type, Dollar\_amount, Item\_name, Item\_quantity, Item\_maker)
4. Essentials(Essentials\_id, Name, Maker, Quantity)
5. Donor(Donor\_id, Full\_name, Age, Gender, Employer, Status)

6. Events(Event\_id, Date, Location)
7. Fundraiser(Event\_id, Num\_donations, Amount\_raised)
8. FoodPantry(Event\_id, Volunteers\_needed, Num\_communities\_impacted)
9. Clients(Client\_id, Full\_name, Age, Gender, Has\_children, Income)
10. Volunteers(Volunteer\_id, Full\_name, Age, Gender, Top\_skill, Top\_interest)
11. Works\_For(Branch\_id, Staff\_id)
12. Stores(Branch\_id, Essentials\_id)
13. Manages(Branch\_id, Donation\_id)
14. Makes(Donation\_id, Donor\_id, Date)
15. Hosts(Branch\_id, Event\_id)
16. Runs(Staff\_id, Event\_id)
17. Contribute(Volunteer\_id, Event\_id, Hours\_worked)
18. Go\_To(Event\_id, Client\_id)
19. Receive(Essentials\_id, Client\_id, Date)
20. Provide\_To(Event\_id, Donor\_id)
21. Distributes(Event\_id, Essentials\_id, Num\_taken)

**Create Table Commands with Constraints** (Note: Only included create table commands for tables relevant to the queries, views, and triggers developed for this project; skipped the rest for space-saving purposes)).

1. CREATE TABLE Donation (
   
        Donation\_id INT,
   
        Type VARCHAR(20),
   
        Item\_name VARCHAR(30),
   
        Item\_quantity INT,
   
        Item\_maker VARCHAR(60),
   
        Dollar\_amount FLOAT,
   
        Donor\_id INT,
   
        PRIMARY KEY (Donation\_id),
   
        FOREIGN KEY (Donor\_id) REFERENCES Donor(Donor\_id)
   
);
2. CREATE TABLE Essentials (
   
        Essential\_id INT,
   
        Name VARCHAR(30),
   
        Quantity INT,
   
        Maker VARCHAR(60),
   
        PRIMARY KEY (Essential\_id)
   
);

3. CREATE TABLE Donor (  
    Donor\_id INT,  
    Full\_name VARCHAR(30),  
    Age INT,  
    Gender CHAR(1) CHECK (Gender IN ('M', 'F')),  
    Employer VARCHAR(30),  
    Status VARCHAR(10),  
    PRIMARY KEY (Donor\_id)  
);
4. CREATE TABLE Contribute (  
    Volunteer\_id INT,  
    Event\_id INT,  
    Hours\_worked FLOAT,  
    PRIMARY KEY (Volunteer\_id, Event\_id),  
    FOREIGN KEY (Volunteer\_id) REFERENCES Volunteers(Volunteer\_id),  
    FOREIGN KEY (Event\_id) REFERENCES Events(Event\_id)  
);
5. CREATE TABLE Events (  
    Event\_id INT,  
    Date DATETIME,  
    Location VARCHAR(50),  
    PRIMARY KEY (Event\_id)  
);
6. CREATE TABLE Volunteers (  
    Volunteer\_id INT,  
    Full\_name VARCHAR(30),  
    Age INT,  
    Gender CHAR(1) CHECK (Gender IN ('M', 'F')),  
    Top\_skill VARCHAR(30),  
    Top\_interest VARCHAR(30),  
    PRIMARY KEY (Volunteer\_id)  
);
7. CREATE TABLE Distributes (  
    Event\_id INT,  
    Essential\_id INT,  
    Num\_taken INT,  
    PRIMARY KEY (Event\_id, Essential\_id),  
    FOREIGN KEY (Event\_id) REFERENCES FoodPantry(Event\_id),  
    FOREIGN KEY (Essential\_id) REFERENCES Essentials(Essential\_id)  
);

```

8. CREATE TABLE FoodPantry (
    Event_id INT,
    Volunteers_needed INT,
    Num_communities_impacted INT,
    PRIMARY KEY (Event_id)
);

```

### Complex Queries and Views:

#### 1. Total donation amount for each donor

```

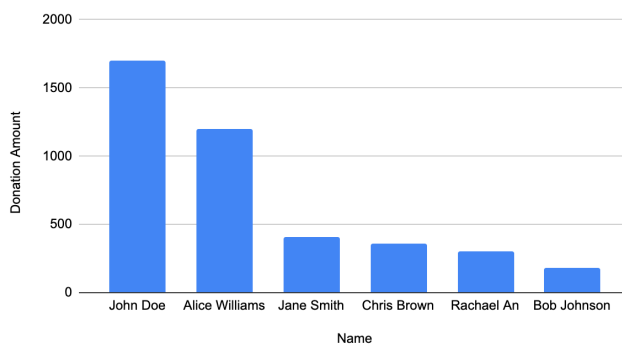
SELECT
    d.Donor_id,
    d.Full_name,
    SUM(do.Dollar_amount) AS total_donation_value
FROM
    Donor d
JOIN Donation do ON d.Donor_id = do.Donor_id
GROUP BY
    d.Donor_id, d.Full_name

```

Total donation amount for each donor

|   | Donor_id | Full_name      | total_donation_value |
|---|----------|----------------|----------------------|
| 1 | 1        | John Doe       | 1700.0               |
| 2 | 2        | Jane Smith     | 410.0                |
| 3 | 3        | Bob Johnson    | 180.0                |
| 4 | 4        | Alice Williams | 1200.0               |
| 5 | 5        | Chris Brown    | 360.0                |
| 6 | 6        | Rachael An     | 300.0                |

Donor Contribution Amounts



2. Top 5 donors based on the total value of their donations

```
SELECT
    d.Donor_id,
    d.Full_name,
    SUM(do.Dollar_amount) AS total_donation_value
FROM
    Donor d
JOIN Donation do ON d.Donor_id = do.Donor_id
GROUP BY
    d.Donor_id, d.Full_name
ORDER BY
    total_donation_value DESC
LIMIT 5
```

3. Percentage of Donations from Top Donors

```
CREATE VIEW TopDonors AS
    SELECT
        Donor_id,
        SUM(Dollar_amount) AS total_donation
    FROM
        Donation
    GROUP BY
        Donor_id
    ORDER BY
        total_donation DESC
    LIMIT 5;

WITH TotalSum AS (
    SELECT SUM(Dollar_amount) AS overall_sum
    FROM Donation
)

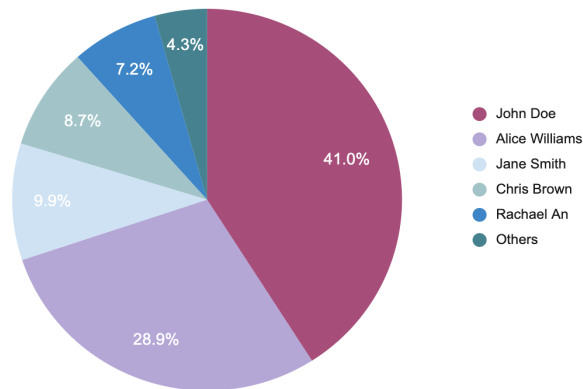
SELECT
    Td.Donor_id,
    Td.total_donation,
    td.total_donation / ts.overall_sum * 100 AS percentage_of_total_donation
FROM
    TopDonors td
CROSS JOIN
    TotalSum ts
```



#### Percentage of total donation among top 5 donors

|   | Donor_id | total_donation | percentage_of_total_donation |
|---|----------|----------------|------------------------------|
| 1 | 1        | 1700.0         | 40.9638554216867             |
| 2 | 4        | 1200.0         | 28.9156626506024             |
| 3 | 2        | 410.0          | 9.87951807228916             |
| 4 | 5        | 360.0          | 8.67469879518072             |
| 5 | 6        | 300.0          | 7.2289156626506              |

Distribution of the Contribution Amounts Among All Donors



#### 4. Find Volunteers with the Most Hours Donated in Each Interest

CREATE VIEW TotalHoursWorked AS

```

SELECT
    Volunteer_id,
    SUM(Hours_worked) AS total_hours_worked
FROM
    Contribute
GROUP BY
    Volunteer_id;
```

CREATE VIEW VolunteerRank AS

```

SELECT
    V.Volunteer_id,
    V.Full_name,
    V.Top_interest,
    RANK() OVER (PARTITION BY v.Top_interest ORDER BY
thw.total_hours_worked DESC) AS
    rank
FROM
    Volunteers v;
```

JOIN

TotalHoursWorked thw ON v.Volunteer\_id = thw.Volunteer\_id;

SELECT

Vr.Volunteer\_id,  
Vr.Full\_name,  
Vr.Top\_interest,  
Vr.rank

FROM

VolunteerRank vr

WHERE

vr.rank = 1;

Volunteers table

|   | Volunteer_id | Full_name        | Age     | Gender | Top_skill      | Top_interest             |
|---|--------------|------------------|---------|--------|----------------|--------------------------|
|   | Filter       | Filter           | Filt... | Filter | Filter         | Filter                   |
| 1 | 1            | Eleanor Johnson  | 30      | F      | Programming    | Community Service        |
| 2 | 2            | Sebastian Miller | 25      | M      | Marketing      | Environment Conservation |
| 3 | 3            | Isabella Garcia  | 35      | F      | Graphic Design | Animal Welfare           |
| 4 | 4            | Xavier Smith     | 28      | M      | Event Planning | Healthcare               |
| 5 | 5            | Olivia Martinez  | 32      | F      | Data Analysis  | Healthcare               |

Top interests as: community service, environment conservation, animal welfare, healthcare

TotalHoursWorked view

|   | Volunteer_id | total_hours_worked |
|---|--------------|--------------------|
|   | Filter       | Filter             |
| 1 | 1            | 31.5               |
| 2 | 2            | 8.0                |
| 3 | 3            | 25.0               |
| 4 | 4            | 9.0                |
| 5 | 5            | 11.0               |

List in no particular order

### VolunteerRank view

|   | Volunteer_Id | Full_name        | Top_interest             | rank   |
|---|--------------|------------------|--------------------------|--------|
|   | Filter       | Filter           | Filter                   | Filter |
| 1 | 3            | Isabella Garcia  | Animal Welfare           | 1      |
| 2 | 1            | Eleanor Johnson  | Community Service        | 1      |
| 3 | 2            | Sebastian Miller | Environment Conservation | 1      |
| 4 | 5            | Olivia Martinez  | Healthcare               | 1      |
| 5 | 4            | Xavier Smith     | Healthcare               | 2      |

Rankings of volunteers in each interest

Find Volunteers with the Most Hours Donated in Each Interest

|   | Volunteer_Id | Full_name        | Top_interest             | rank |
|---|--------------|------------------|--------------------------|------|
| 1 | 3            | Isabella Garcia  | Animal Welfare           | 1    |
| 2 | 1            | Eleanor Johnson  | Community Service        | 1    |
| 3 | 2            | Sebastian Miller | Environment Conservation | 1    |
| 4 | 5            | Olivia Martinez  | Healthcare               | 1    |

### Triggers to automate tasks:

1. Trigger for Donor Status Update Based on Total Donation

```
CREATE TRIGGER donor_status
```

```
AFTER INSERT
```

```
ON Donation FOR EACH ROW
```

```
BEGIN
```

```
-- Update the Donor table based on the calculated total donation
```

```
UPDATE Donor
```

```
SET Status =
```

```
CASE
```

```
WHEN (
```

```
    SELECT SUM(Dollar_amount)
```

```
    FROM Donation
```

```
    WHERE Donor_id = NEW.Donor_id
```

```
) > 1000 THEN 'Gold'
```

```
WHEN (
```

```
    SELECT SUM(Dollar_amount)
```

```
    FROM Donation
```

```
    WHERE Donor_id = NEW.Donor_id
```

```
) > 500 THEN 'Silver'
```

```
ELSE 'Bronze'
```

```
END
```

```
WHERE Donor_id = NEW.Donor_id;
END;
```

Donation table

|    | Donation_id | Type       | Item_name       | Item_quantity | Item_maker     | Dollar_amount | Donor_id |
|----|-------------|------------|-----------------|---------------|----------------|---------------|----------|
|    | Filter      | Filter     | Filter          | Filter        | Filter         | Filter        | Filter   |
| 1  | 1           | Monetary   | NULL            | NULL          | NULL           | 100.0         | 1        |
| 2  | 2           | In-kind    | Clothes         | 10            | Fashion Co.    | NULL          | 2        |
| 3  | 3           | Monetary   | NULL            | NULL          | NULL           | 200.0         | 2        |
| 4  | 4           | In-kind    | Books           | 20            | Book World     | 100.0         | 1        |
| 5  | 5           | Monetary   | NULL            | NULL          | NULL           | 150.0         | 2        |
| 6  | 6           | Monetary   | NULL            | NULL          | NULL           | 120.0         | 3        |
| 7  | 7           | In-kind    | Electronics     | 5             | Tech Solutions | 1000.0        | 4        |
| 8  | 8           | In-kind    | Food            | 30            | Grocery Mart   | 180.0         | 5        |
| 9  | 9           | In-kind    | Clothes         | 20            | Fashion World  | 1500.0        | 1        |
| 10 | 10          | Essentials | Toothpaste      | 30            | Colgate        | 60.0          | 3        |
| 11 | 11          | Essentials | Toilet paper    | 30            | Colgate        | 60.0          | 2        |
| 12 | 12          | Toys       | Stuffed animals | 10            | Build a Bear   | 200.0         | 4        |
| 13 | 13          | Self-care  | Face masks      | 30            | Malle          | 180.0         | 5        |
| 14 | 14          | Furniture  | Chairs          | 1             | Malle          | 100.0         | 6        |
| 15 | 15          | Toys       | Stuffed animals | 10            | Build a Bear   | 200.0         | 6        |

Donor table - Donor status was updated based on contribution amounts

|   | Donor_id | Full_name      | Age     | Gender | Employer        | Status |
|---|----------|----------------|---------|--------|-----------------|--------|
|   | Filter   | Filter         | Filt... | Filter | Filter          | Filter |
| 1 | 1        | John Doe       | 35      | M      | ABC Corporation | gold   |
| 2 | 2        | Jane Smith     | 28      | F      | XYZ Industries  | bronze |
| 3 | 3        | Bob Johnson    | 45      | M      | LMN Company     | bronze |
| 4 | 4        | Alice Williams | 32      | F      | PQR Enterprises | gold   |
| 5 | 5        | Chris Brown    | 40      | M      | UVW Corporation | bronze |
| 6 | 6        | Rachael An     | 20      | F      | Smith College   | bronze |

## 2. Trigger for Update Essentials Quantity After Donation Insert

```
CREATE TRIGGER after_donation_insert
```

```
AFTER INSERT
```

```
ON Donation FOR EACH ROW
```

```
BEGIN
```

```
    UPDATE Essentials
```

```
    SET Quantity = Quantity + NEW.Item_quantity
```

```
    WHERE Name = NEW.Item_name AND Maker = NEW.Item_maker;
```

END;

Essentials table BEFORE donation

|   | Essential_Id | Name            | Quantity | Maker        |
|---|--------------|-----------------|----------|--------------|
|   | Filter       | Filter          | Filter   | Filter       |
| 1 | 1            | Toothpaste      | 110      | Colgate      |
| 2 | 2            | Tollet paper    | 80       | Bounty       |
| 3 | 3            | Stuffed animals | 1        | Bulld a Bear |

A new donation is inserted into Donation table

|    |    |      |                 |    |              |       |   |
|----|----|------|-----------------|----|--------------|-------|---|
| 15 | 15 | Toys | Stuffed animals | 10 | Bulld a Bear | 200.0 | 6 |
|----|----|------|-----------------|----|--------------|-------|---|

10 stuffed animals by the build a bear brand were donated by donor #6

Essentials table AFTER donation was inserted

|   | Essential_Id | Name            | Quantity | Maker        |
|---|--------------|-----------------|----------|--------------|
|   | Filter       | Filter          | Filter   | Filter       |
| 1 | 1            | Toothpaste      | 110      | Colgate      |
| 2 | 2            | Tollet paper    | 80       | Bounty       |
| 3 | 3            | Stuffed animals | 11       | Bulld a Bear |

After: 10 stuffed animals added to essentials inventory

3. Trigger for Update Essentials Quantity After Food Pantry Event Insert

CREATE TRIGGER after\_food\_pantry\_event\_delete

AFTER INSERT

ON Distributes FOR EACH ROW

BEGIN

    UPDATE Essentials

    SET Quantity = Quantity - NEW.Num\_taken

    WHERE Essential\_id = NEW.Essential\_id;

END;

Essentials table BEFORE food pantry event

|   | Essential_Id | Name            | Quantity | Maker        |
|---|--------------|-----------------|----------|--------------|
|   | Filter       | Filter          | Filter   | Filter       |
| 1 | 1            | Toothpaste      | 110      | Colgate      |
| 2 | 2            | Tollet paper    | 80       | Bounty       |
| 3 | 3            | Stuffed animals | 11       | Bulld a Bear |

Distributes table (20 rolls of toilet paper were distributed during the food pantry event #1)

|   | Event_id | Essential_id | Num_taken |
|---|----------|--------------|-----------|
|   | Filter   | Filter       | Filter    |
| 1 | 1        | 1            | 30        |
| 2 | 2        | 2            | 20        |
| 3 | 2        | 1            | 20        |
| 4 | 1        | 2            | 20        |

Essentials table AFTER food pantry event #1 was inserted into Distributes table

|   | Essential_id | Name            | Quantity | Maker        |
|---|--------------|-----------------|----------|--------------|
|   | Filter       | Filter          | Filter   | Filter       |
| 1 | 1            | Toothpaste      | 110      | Colgate      |
| 2 | 2            | Toilet paper    | 60       | Bounty       |
| 3 | 3            | Stuffed animals | 11       | Build a Bear |

After: 20 rolls of toilet paper taken from inventory

### Conclusions and future directions

In summary, the results obtained from the implemented database system at ICNA Relief suggest a significant improvement in resource allocation, volunteer deployment, and fundraising efforts. The streamlined processes and efficient data management lead to enhanced community engagement, more targeted support, and improved recognition of top contributors. The advantages of centralized storage, efficient data retrieval, and automation through triggers are effective in minimizing errors and discrepancies, contributing to overall organizational efficiency.

This database-driven system allows ICNA Relief to gain valuable insights into resource allocation and engagement, such as donor contribution amounts and ranks of volunteers in their respective interests. These newly gained insights will enable the organization to gauge donor interests, volunteer skills, and launch targeted fundraising, allocating resources to serve the community more effectively.

However, while the current approaches have addressed the identified challenges, the project has the potential for further exploration and expansion. In future directions, I aim to explore additional avenues to provide more details in answering questions about the most common items contributed by donors, the most in-demand essentials in the community, and the common demographics of their clients. This information will enable the organization to tailor its services to fit the needs of customers by purchasing in-demand items or launching targeted fundraising efforts, thereby further enhancing the goal of making a positive impact. As the organization grows larger, the system should also scale and adapt to align with the dynamic requirements of ICNA Relief's community service initiatives.

## References

- [1] Antoine, “What Can a Nonprofit Database Do for Your Organization?” [Online]. Available: <https://www.springly.org/en-us/blog/nonprofit-database/>. [Accessed Dec. 12, 2023].
- [2] C. J. Date, *An Introduction to Database Systems, Volume 1*, Addison-Wesley Publishing Company, 1975.
- [3] A. Silberschatz, H. Korth, and S. Sudarshan, *Database System Concepts*. McGraw-Hill, New York, 6 edition, (2010).
- [4] M. Winand, *SQL Performance Explained: Everything Developers Need to Know about SQL Performance*. M. Winand, 2012.