

Chemical and Inventory Management System
SoFab Inks
Team 3

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1 Introduction/Executive Summary

1.1 Introducing SoFab Inks

SoFab Inks is a chemical manufacturing startup that was spun-out from the University of Louisville, Conn Center for Renewable Energy Research with support from the US DoE. SoFab inks focuses on accelerating the commercialization of Perovskite Solar Cells through the development and manufacturing of functionalized inks that improve cell efficiency, reduce module cost, and enable scalable manufacturing. [1]

1.2 SoFab Inks Inventory Management Problem

SoFab Inks is doing important work in the field of solar cell technology, helping to drive humanity towards a cleaner, more energy abundant future. The problem, however, is that the team currently faces issues with managing inventory. These challenges prevent SoFab's talented team from working on the most important aspects of their work. These challenges include expending valuable energy on menial tasks like locating inventory, managing a growing number of shipments manually, scouring inventory entries found across several Google Sheets or handwritten labels to pinpoint important product information, and more.

To aid SoFab in these challenges, this semester Team 3 was tasked with developing a more efficient method of managing inventory items. To accomplish this, the team employed various existing software solutions, including database software, CRUD¹ user interface software, and solutions to containerize this software together into one package. The team also developed custom software to provide features not available in the existing software solutions.

CAC 3. Communicate effectively in a variety of professional contexts

2 System Description

The following sections describe the specifications that were formulated as a result of communication between Team 3 and the SoFab Inks team.

¹Database term for Create, Read, Update, Delete.

2.1 Needs Assessment/System Requirements

Following assignment to this project, the team assembled and met virtually with the SoFab Inks team for brief self-introductions, an overview of the current issues facing SoFab, and to gain an initial insight of what the SoFab team was looking for in a solution to these issues.

The SoFab team described the current state of inventory management at the company which included problems such as shipments arriving to incorrect customers, an inability to pinpoint important information about products as they progressed through the manufacturing process, and difficult to track remaining volumes of chemical products. In these discussions, SoFab also emphasized the importance of a solution begin *simple and easy-to-use*. As the team is primarily constructed of chemical engineers or business people, technology was not a strength.

The company also made it clear that the ability to generate item labels for internal tracking of should be a priority. These labels would allow members of their team to easily scan a barcode to view the details of an item. Finally, it was also made clear that the company also desired the ability to generate shipment labels for their products as well. These labels would differ slightly from their internal tracking label counterparts with the inclusion of chemical hazard information. This information would be included as a way to reduce harm for customers handling SoFab's chemicals upon receipt.

After this initial discussion, Team 3 began to brainstorm potential solutions to the problems presented. Immediately, 3 main pieces of software jumped out at the team as critical pieces to what would be the final product.

1. **A Database System** - In order to move the company away from the usage of Google Sheets and toward a more efficient, safe and redundant, user-friendly solution, Team 3 knew it would be necessary to select an existing database software solution. While the team was unsure of what specific solution would be chosen, it was sure that one of these solutions would be required.
2. **A User-Friendly Database Interface** - While a database solution would be an incredible improvement on its own, it would be useless to the SoFab team if there were not a simple and easy way to interact with the underlying data. Again, the team was unsure of what specific solution would be chosen, but a few requirements from discussions with SoFab were clear.
 - **Clean, Simple, Easy-to-Use** - As previously discussed, SoFab was clear that a simple and easy-to-use solution was of paramount importance for the day-to-day usage of the product.

- **Free and Open-Source** - While this requirement was not mentioned in the initial discussions with SoFab, this requirement jumped out as important to Team 3 because this would help to avoid incurring additional costs beyond the development cost that SoFab had already paid.
3. **Software to Generate Internal and Shipment Labels** - After discussing the need for barcode and label generation software, the team found that it would likely be necessary to build custom software to meet the needs of the client. The requirements were quite specific, and would not be available in any existing commercial product. These requirements certainly would not be made available in any *free and open-source* software.

2.2 Initial System Specification

Following the identification of the 3 main categories of software that would comprise the solution to SoFab’s inventory management problems, Team 3 dove into research of each individual component to identify optimal selections.

2.2.1 Selecting a Database

Firstly, it was important for Team 3 to become familiar with existing solutions that were **free and open-source**. This required conducting research on computer-science related websites and forums, and more general forums like Reddit. While a site like Reddit may not always be the most reliable source of information, it could provide a general sense of what people feel about particular software and how easy it is work with.

Many databases fulfilling the free and open-source requirement were identified, including: PostgreSQL, MySQL, MariaDB, and SQLite. As many options were available to select from, it was important to look beyond this requirement and investigate technical specifications of these solutions. During this time it was discovered that **PostgreSQL** had several technical benefits over more popular rivals. PostgreSQL boasts of being a fully **ACID** compliant database system. With features such as *Write-Ahead Logging*, which writes transactions to a log file to avoid pushing a full table(s) every time a transaction is committed, *Multi-version Concurrency Control* which the PostgreSQL documentation describes as

“This means that while querying a database each transaction sees a snapshot of data (a database version) as it was some time ago, regardless of the current state of the underlying data. This protects the transaction from viewing inconsistent data that could be caused

by (other) concurrent transaction updates on the same data rows, providing transaction isolation for each database session.”[2]

Furthermore, PostgreSQL utilizes its *Write-Ahead Log* to implement *Point-in-Time Recovery* without the need of complete backup. Additionally, since the Write-Ahead Log contains all transactions since the previous system backup, one can return to the exact state of **any point in time** between the most recent backup version and the current version. Team 3 felt that these benefits would be incredibly beneficial for SoFab’s new database, which would be the central hub containing the whereabouts and remaining inventory of their lab. This database would also contain important product information which if lost or damaged could have severe consequences for their business.

Beyond technical considerations, ease of use was of great consideration when selecting a database, and luckily, PostgreSQL benefits from being very easy-to-use. PostgreSQL has an additional software called **PgAdmin4**, a project led by a core developer of PostgreSQL! This software integrates very well with PSQL² This software provides a GUI that allows developers to interact with the database, run queries, add and edit tables, view ERDs³ for tables, and much more. This would simplify team members development tasks significantly and enable faster production.

For the reasons stated above, PostgreSQL was selected as the database software of choice for this project.

2.2.2 Selecting an Interface

2.2.3 A Language for Custom Software

(External design document) EAC 1. Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics and CAC 1. Analyze a complex computing problem and to apply principles of computing and other relevant disciplines to identify solutions)

2.3 Final Specifications

(finalized internal design document) EAC 1. Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics and CAC 1. Analyze a complex computing problem and to apply principles of computing and other relevant disciplines to identify solutions and

²PSQL is short for PostgreSQL.

³ERD stands for entity relationship diagrams.

CAC 6. Apply computer science theory and software development fundamentals to produce computing-based solutions)

2.4 System Diagrams

Detail all interfaces between the environment and the components EAC 2. Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors)

2.5 Hardware Overview Diagram

CAC 2. Design, implement, and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program's discipline)

2.6 Software Overview Diagram

CAC 2. Design, implement, and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program's discipline)

2.7 Economical, Technical, and Time Constraints

3 Detailed Implementation

3.1 Hardware Detailed Implementation

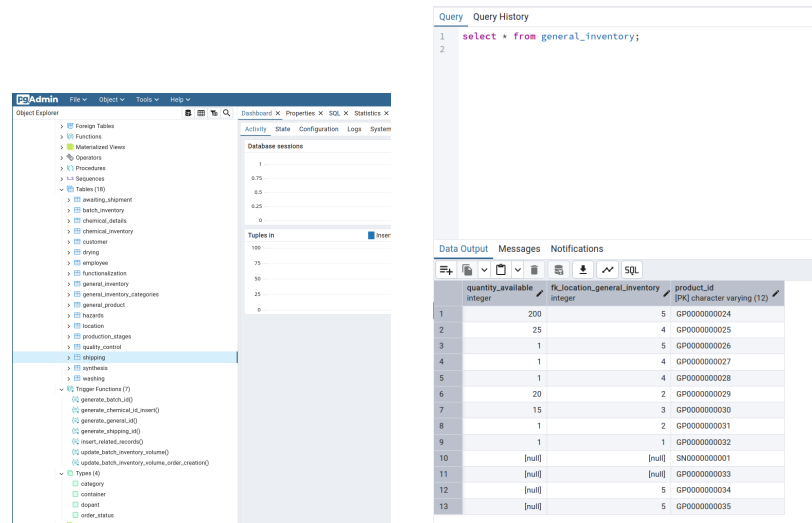
3.2 Software Detailed Implementation

3.2.1 Docker-Compose

3.2.2 PostgreSQL

3.2.3 PgAdmin4

3.2.4 Budibase



(a) Viewing existing tables in PgAd- (b) Running PostgreSQL queries inside
min interface. of PgAdmin4.

Figure 1

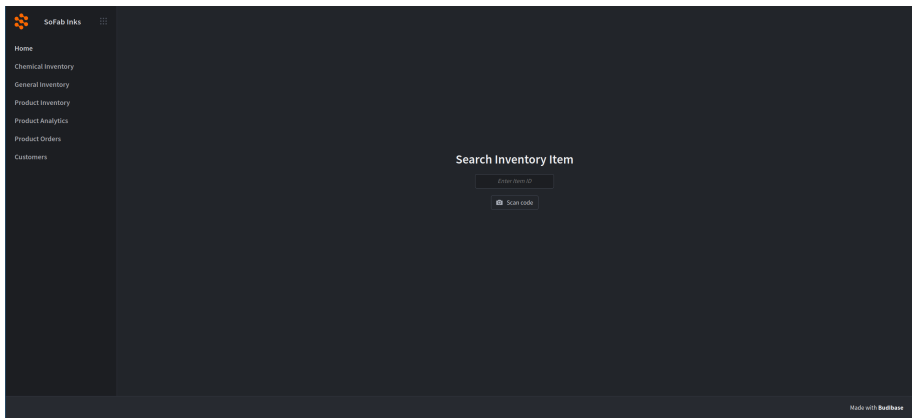


Figure 2: Budibase home page. Global search that searches all types of inventory via QR code or direct ID entry.

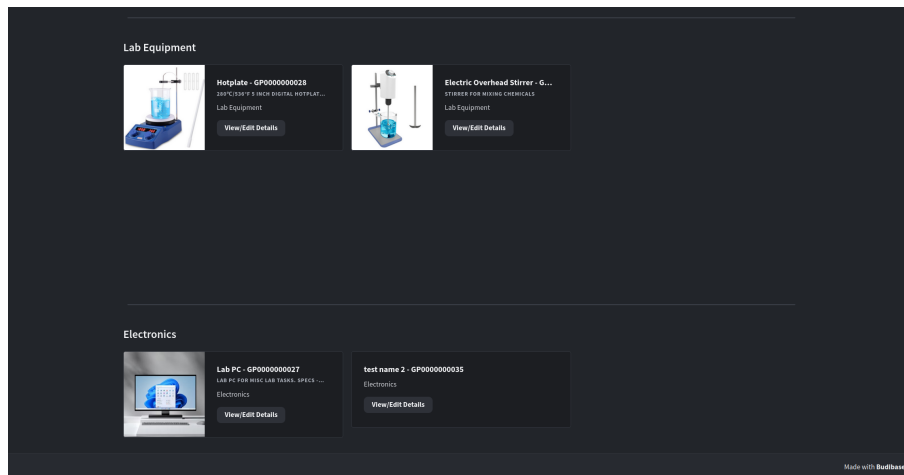


Figure 3: Budibase general inventory page. Keep track of general lab items.

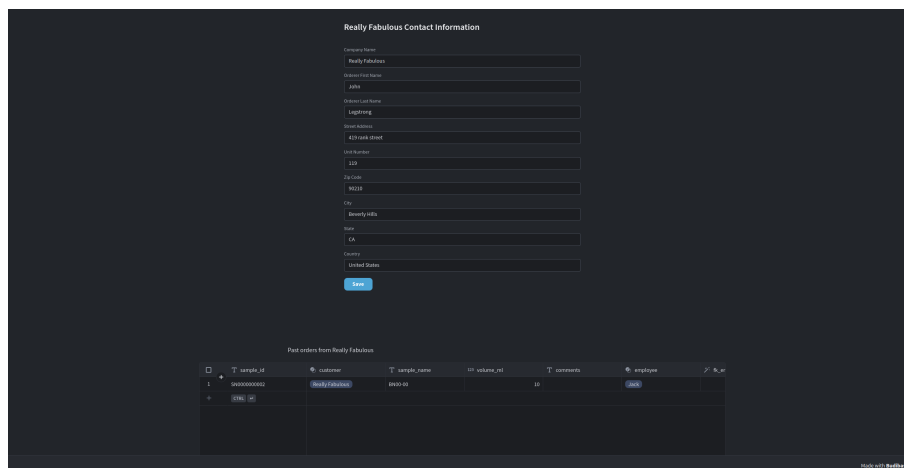


Figure 4: Keep track of customer information with Budibase. View customer information or view all orders originating from a customer

3.2.5 Python Database Insertion/Label Generation

```
1 class App(Tk):
2     def __init__(self, controller):
3         # initializing the Tk class instance
4         super().__init__()
5
6         self.title("SoFab_Inventory_Managment_System")
7
8         self.style = Style(theme="darkly")
9
10        self.controller = controller
11        self.controller.set_view(self)
12
13        self.notebook = ttk.Notebook()
14        self.notebook.pack(fill="both", expand=True)
15        self.notebook.bind("<<NotebookTabChanged>>", self.
            on_tab_selection)
16
17        # filling the notebook (top tabs) with frames
18
19        item_type_tables = self.controller.
            get_item_type_tables()
```

```
1 class HazardPrecautionFrame(tk.Frame):
2     def __init__(self, parent, controller, warning_dict,
3         images=False):
4         super().__init__(parent)
```

```
1 def generate_checkboxes(self, images=False):
2     self.checkboxes_frame = tk.Frame(self)
3     self.checkboxes_frame.grid(row=0, column=0)
4
5     for item in self.warning_items:
6         if images:
7             image = Image.open(item[1])
8             resized_image = image.resize((100, 100), Image.
                LANCZOS)
9             image = ImageTk.PhotoImage(resized_image)
10            item = item[0]
11        else:
12            image = None
13        var = tk.BooleanVar()
14        checkbox = ttk.Checkbutton(
15            self.checkboxes_frame,
16            text=item,
17            image=image,
18            compound="left",
19            variable=var,
```

```

20         command=lambda var=var: self.parent.
           update_text_box(),
21     )
22     checkbox.image = image
23
24     checkbox.pack(anchor="w", fill="x")

```

EAC 1. Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics and EAC 2. Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors, and CAC 6. Apply computer science theory and software development fundamentals to produce computing-based solutions)

4 Test/Evaluation Experimental Procedure and Analysis of Results

EAC 6. Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions)

5 Societal Impact of Project/Legal and Ethical Considerations

include legal and ethical considerations

CAC 4. Recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles)

6 Contribution of Project to Society/Expected Effects

CAC 4. Recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles)

7 Engineering Standards, Constraints, and Security

EAC 1. Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors)

8 Conclusions

9 Recommendations for Future Work

References

- [1] SofaBinks. (n.d.). About SofaBinks. Retrieved November 29, 2024, from <https://www.sofabinks.com/about>
- [2] PostgreSQL Global Development Group, *MVCC: Multi-Version Concurrency Control*, PostgreSQL 7.1 Documentation, <https://www.postgresql.org/docs/7.1/mvcc.html>, Accessed on: November 27, 2024.

Appendices

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