UNIVERSITY OF PERADENIYA
Faculty of Engineering

A Project on

DEVELOPMENT OF AN ADVANCED SHIPYARD SPACE ALLOCATION AND SCHEDULING SOFTWARE FOR UNIT FABRICATION PROCESS

at

COLOMBO DOCKYARD PLC, COLOMBO 15

by

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Table of Contents

1. INTRODUCTION

In the heart of the shipbuilding industry, efficiency and precision are paramount to success. Colombo Dockyard PLC, a leading shipbuilding and repair company in Sri Lanka, faced a persistent challenge in its unit allocation process – the strategic placement of ship units within construction areas known as beds. The manual approach, relying on software like AutoCAD, led to time inefficiencies, suboptimal space utilization, and potential delays in shipbuilding projects. To address this challenge, our team from University of Peradeniya, embarked on a mission to streamline the unit allocation process, fostering collaboration between academia and industry.

This project report chronicles the development and implementation of DockBedManager, a web application that revolutionizes unit allocation at Colombo Dockyard PLC. DockBedManager automates the allocation process using the Latest Starting Method (LSD) algorithm, eliminating the need for manual calculations and reducing the risk of human error. The application incorporates a user-friendly interface, seamlessly integrates with existing shipyard systems, and provides insightful visualizations of unit allocation plans.

The report delves into the project's inception, outlining the challenges faced by Colombo Dockyard PLC and the aim behind developing DockBedManager. It details the application's design and implementation, highlighting the utilization of Python programming language, MySQL and PHP for database management and the integration of the LSD algorithm for optimization. The report showcases the application's features, including simplified data input, automated optimization, and visualized output, emphasizing its user-friendliness and effectiveness.

Figure 01: Colombo Dockyard PLC

2. PROJECT DESCRIPTION

Colombo Dockyard PLC, a leading shipbuilding and repair company in Sri Lanka, faced challenges in its unit allocation process, which involved manually allocating units to construction areas (beds) using software like AutoCAD. This manual approach led to time inefficiencies, suboptimal space utilization, and potential delays in shipbuilding projects.

To address this challenge, our team developed DockBedManager, a web application that automates the unit allocation process using the Least Starting Method (LSD) algorithm. The application incorporates a user-friendly interface, integrates with existing shipyard systems, and provides visualizations of unit allocation plans.

DockBedManager simplifies data input by allowing engineers or shipyard personnel to copy and paste unit data, which is a manual entry. Our mathematical model automatically generates the optimal sequence for starting unit fabrication processes and assigns units within the available space efficiently. A date versus bed length graph visualizes the unit allocation plan, providing a clear overview of the specific units to be assigned to particular locations at a certain time period.

The application's implementation has significantly reduced job tardiness, optimized space utilization, and enhanced productivity at Colombo Dockyard PLC. DockBedManager represents a successful collaboration between academia and industry, demonstrating the power of innovative solutions to address real-world industrial challenges.

3. PROBLEM STATEMENT

The traditional unit allocation process at Colombo Dockyard PLC, relying on manual allocation using software like AutoCAD, presented several drawbacks that hindered the company's efficiency and productivity. This manual approach, often led to several inefficiencies and limitations:

- Time-Consuming and Error-Prone: Manual allocation was time-consuming, requiring engineers to manually calculate and assign units to beds, increasing the risk of human error and delays in the shipbuilding process. This approach often takes 2 to 4 weeks to plan a six-month project, leading to delays in shipbuilding projects, impacting the overall workflow of the company, and causing a loss of money.
- Suboptimal Space Utilization: Manual allocation often results in suboptimal space utilization. Engineers had to rely on their judgment and experience to allocate units, potentially leading to wasted space and inefficient use of resources.
- Lack of Automation and Visualization: The manual process lacked automation and visualization tools, making it difficult to assess and optimize unit allocation plans quickly.

Recognizing the limitations of the manual approach, our team set out to develop an automated solution that could streamline the unit allocation sequence, optimized space allocation, reduce job tardiness, and enhance overall efficiency. We recognized that time is a crucial factor in the industry, as it represents money and delays in unit allocation could have significant financial implications.

The development of an automated solution was a significant undertaking, requiring a thorough understanding of the unit allocation process, the constraints involved, and the potential benefits of automation.

4. METHODOLOGY

In order to effectively address the challenge of streamlining the unit allocation process, we adopted a practical approach that involved direct engagement with the engineers responsible for the unit allocation and firsthand observation of the construction areas (beds) where units are assembled. We also studied past unit allocation plans and layouts from previous new ship construction projects. Afterward, the identification of essential input variables required to create a Python program was done. These variables include bed and unit dimensions, crane capacity, and sequencing, with sequencing being a particularly complex issue.

A comprehensive review of existing literature revealed various methodologies and techniques for unit allocation in the shipbuilding industry. Scheduling methods such as Critical Ratio Method (CRM), Heuristic Approaches, Linear Programming, and Latest Starting Method (LSD) have been employed to optimize resource allocation and minimize delays. Additionally, optimization algorithms have been developed to address complex sequencing constraints and maximize space utilization. For the space allocation process, 2D bin packing optimization was used to reduce waste and improve logistics efficiency.

Our team adopted a structured approach to develop the web application, encompassing data collection, algorithm selection, programming language choice, and user interface design.

5. WEB APPLICATION IMPLEMENTATION

Introducing DockBedManager, a revolutionary web application designed to streamline the unit allocation process at Colombo Dockyard PLC. On the administrative front, HTML, CSS, JavaScript, Ajax, and jQuery-powered web dashboard provides real-time insights. Python, PHP, and MySQL serve as the backbone, ensuring secure data storage and seamless communication with the web dashboard. The intuitive interface seamlessly integrates with existing shipyard systems, providing engineers and shipyard personnel with a user-friendly tool to manage unit allocation effectively.

5.1 Key features and functionalities:

- Simplified Data Input:
    - Engineers or shipyard personnel can easily copy and paste the unit data, including unit ID, length and width of the unit, weight, duration, and due date, into the user interface.
    - Eliminates the need for manual data entry and reduces the risk of errors.
- Automated Optimization:
    - The mathematical model automatically generates the optimal sequence for starting unit fabrication processes.
    - Assigns units within the available space in the most efficient manner.
- Visualized Output:
    - A date vs. bed length graph clearly displays the unit allocation plan.
    - Provides a visual representation of assigned unit locations on respective days.
- Comprehensive Coverage:
    - Displays unit allocation and sequence data for North Pier, South Pier, and Bed Number 3.
    - Provides a complete overview of unit allocation across different bed areas.

5.2 Challenges encountered and their resolutions:

- Length scale inaccuracy - Fine-tuning the linear relation between database data and UI data.
- Need of changing bed - Adding option to change move units from bed to bed.
- The packing algorithm was not 100% reliable - Adding the ability to adjust units manually.
- Need for unfixing units - Adding an unfix option for each unit.
- Need for resizing units - Adding a resize feature to the unit options.
- Need for data collection - Displaying start date and end date for the units.
- Application security - Vulnerability assessment and login system.
- Calculation time - Optimizing the algorithm.

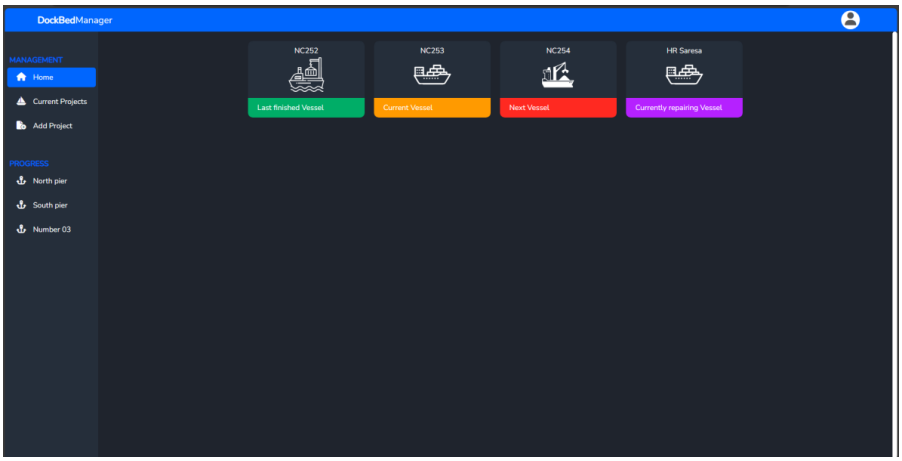

Figure 02: User Interface of DockBedManager

Figure 03: Space Allocation of Units with Time

5.3 Database infrastructure:

5.3.1 MySQL and PHP Selection Rationale

- Open-Source and Cost-Effective: MySQL and PHP are both open-source technologies, eliminating licensing costs and providing flexibility for customization and development.
- Widespread Adoption and Community Support: MySQL is a widely used relational database management system (RDBMS), ensuring compatibility with various platforms and access to extensive community support.
- PHP's Simplicity and Efficiency: PHP is a popular server-side scripting language known for its ease of use, making it suitable for rapid development and maintenance.
- Robust Data Management: MySQL's robust data management capabilities effectively handle large volumes of unit allocation data, ensuring efficient storage, retrieval, and manipulation.
- Dynamic Web Development: PHP's dynamic web development capabilities enable the creation of interactive and user-friendly interfaces for DockBedManager.
- Secure Data Handling: MySQL and PHP support secure data handling practices, including encryption and access control mechanisms, to protect sensitive unit allocation information.
- Scalability and Performance: The combination of MySQL and PHP provides a scalable and performant solution capable of handling increasing data volumes and user traffic.
- Integration with Existing Systems: MySQL and PHP can be integrated with existing shipyard systems, facilitating data exchange and streamlining the overall workflow.
- Extensive Developer Expertise: The widespread adoption of MySQL and PHP ensures access to a large pool of experienced developers for future maintenance and enhancements.

5.3.2 Database Structure and Application Support

- MySQL's relational structure and PHP's dynamic capabilities provide a robust and organized data management system, enabling efficient data handling, supporting application features, and empowering DockBedManager to optimize unit allocation at Colombo Dockyard PLC.

6. LIMITATIONS

- Packing algorithm reliability- Packing algorithm only packs according to the schedule 60%.
- UI adjustments - user interactive messages.

7. INSIGHTS AND FUTURE DEVELOPMENTS

- Advanced Visualizations and 3D Bin Packing Optimization: Introduce a time vs. length and width graph for comprehensive bed utilization analysis. Implement 3D bin packing optimization to maximize spatial efficiency. Minimize wasted space and enhance storage and logistics efficiency.
- Implementing bulk displacement function.
- Implementing custom packing algorithm which supports forbidden zones and sequence.
- Refining UI for more ergonomically aspects.
- Support for multiple projects.
- Functions to show unit wise data.
- Data export option for excel files.
- Machine Learning for Predictive Insights and Adaptive Planning.
- Real-Time Data Integration for Dynamic Adjustments: Integrate with real-time data feeds from sensors and tracking systems. Continuously update the status of units, beds, and cranes. Dynamically adjust allocation plans in response to unforeseen events.

8. CONCLUSION

In conclusion, the development and implementation of DockBedManager have successfully addressed the unit allocation challenges faced by Colombo Dockyard PLC, demonstrating the power of technology to optimize operations and enhance productivity in the shipbuilding industry.

DockBedManager's simplified data input, automated optimization algorithm, and visualized output have streamlined the unit allocation process, reducing job tardiness, optimizing space utilization, and enhancing overall efficiency. The application's user-friendly interface, seamless integration with existing shipyard systems, and compatibility with various platforms have further contributed to its success.

The insights gained from DockBedManager's implementation have paved the way for future developments, including advanced visualizations, real-time data integration, and integration with advanced planning systems. These advancements will further solidify DockBedManager as a comprehensive decision support tool, empowering Colombo Dockyard PLC to achieve new levels of efficiency and productivity in its shipbuilding operations.

The success of DockBedManager exemplifies the benefits of collaboration between academia and industry, showcasing the potential of innovative solutions to address real-world industrial challenges. As technology continues to evolve, DockBedManager is poised to play an even more significant role in optimizing shipbuilding processes and driving the industry towards greater efficiency and productivity.