Automating Bed Assignment with Artificial Intelligence Solver

An AI-based Approach to Improve Bed Management

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Introduction

SGH Bed Management Unit (BMU), which is currently staffed by 23 operators across all shifts, utilises Bed Management System (BMS) to assign beds. BMS heavily relies on staff decision-making for bed assignments (refer to *Figure 1*). While BMS features an Intelligent Matching Engine to recommend bed allocation, it lacks the capability to consider ringfenced beds and assignment priority.

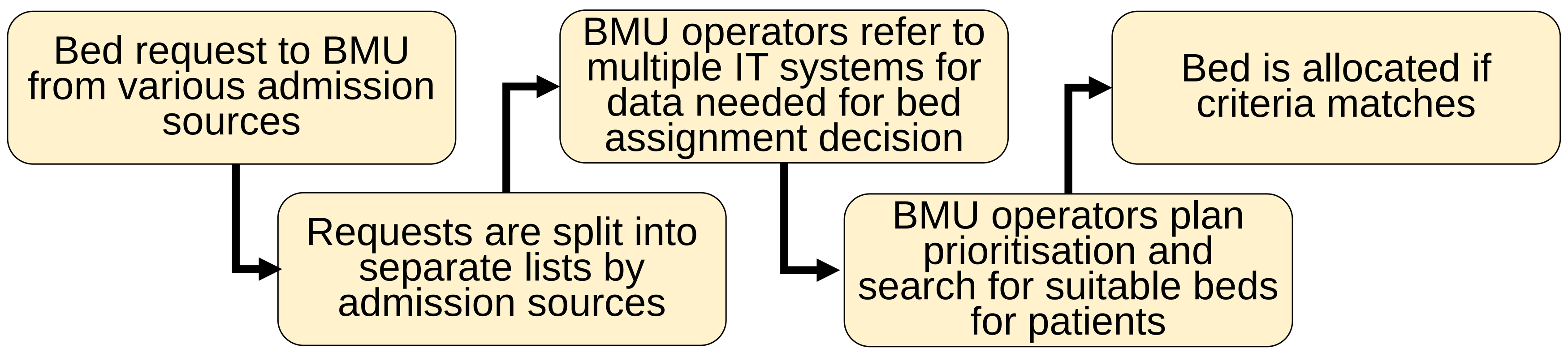

Figure 1: *Current Bed Assignment Workflow*

To address this limitation, BMU embarked on a project to develop a prototype AI-based constraint solver model (AI-solver) to assist with bed assignments for simpler cases, enabling staff to allocate more time to complex situations.

Objectives

The primary objective of the project is to develop a standalone prototype AI-based constraint solver model that can recommend bed assignments with a comparable, if not better, performance than BMU operators. Performance is defined as right-siting rate and waiting time for a bed.

The longer term objective is to develop and implement an AI-solver that improves the productivity of BMU operators by automating the labour-intensive tasks of bed prioritisation and assignment, while ensuring operational adaptability for scenarios such as a pandemic where bed configurations and assignment priorities rapidly change.

Methodology

The AI-solver was developed using RedHat OptaPlanner, and the model was designed based on BMU's operating processes with the prevailing bed assignment policies corresponding to the simulation period. Scenarios were selected to simulate both COVID-19 and post-COVID-19 periods with historically high Bed Occupancy Rates (BOR) at 99% for four simulation runs (refer to *Figure 2*).

Weighted rules were created (limited to 10 due to funding constraints) to set constrains for the purpose of policy adherence relating to gender- and ward-specific settings, together with bed overflow algorithm and other patient prioritisation matrices. Thereafter, the AI-solver was tasked with bed allocation (based on available bed supply) for the patient backlog at the Department of Emergency Medicine (DEM) (average of 59 patients on peak days), as well as business-as-usual (BAU) incoming patients from all admission sources (average of 152 patients per day), with some patients excluded (limited rules).

Run	Year	Month	DEM Patient Backlog	Bed Occupancy Rate (BOR)	BAU Bed Request	Covid-19
1	2021	December	59	99%	168	Yes
2	2021	December	51	99%	138	Yes
3	2022	November	61	99%	157	Post-Covid-19
4	2022	November	65	99%	147	Post-Covid-19

Figure 2: *Test Parameters*

BMU evaluated the AI-solver's ability to right-site patients and optimise bed allocation using various prioritisation matrices, bed matching algorithms, and patient attributes such as admission source, patient condition, time of day, waiting time, and patient choice class (refer to *Figure 3*).

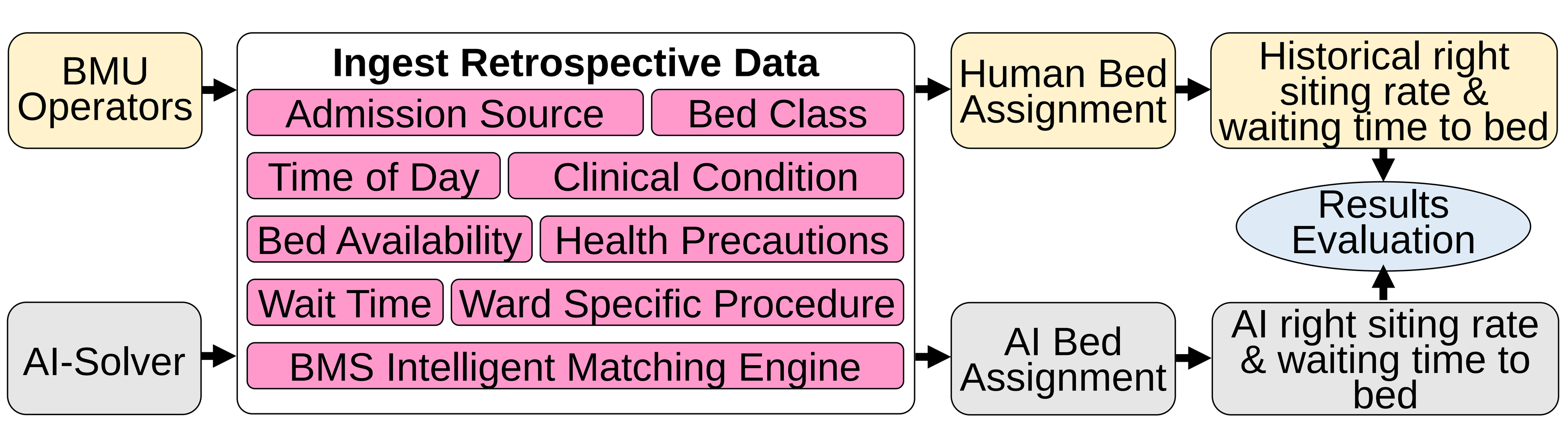

Figure 3: *Overview of the Evaluation Method*

Results

The AI-solver demonstrated flexibility in prioritising patient groups and effectively right-siting patients by adjusting rules or weights based on the hospital's needs. Right-siting and waiting time for a bed were compared against historical results for assessment, and the AI-solver performed satisfactorily in both aspects for both COVID-19 and post-COVID-19 periods.

The results showed that the AI-solver's performance was not inferior to that of a BMU operator. The AI-solver had an average patient right-siting accuracy of ~65%, compared to ~63% to a BMU Operator (refer to *Figure 4a*).

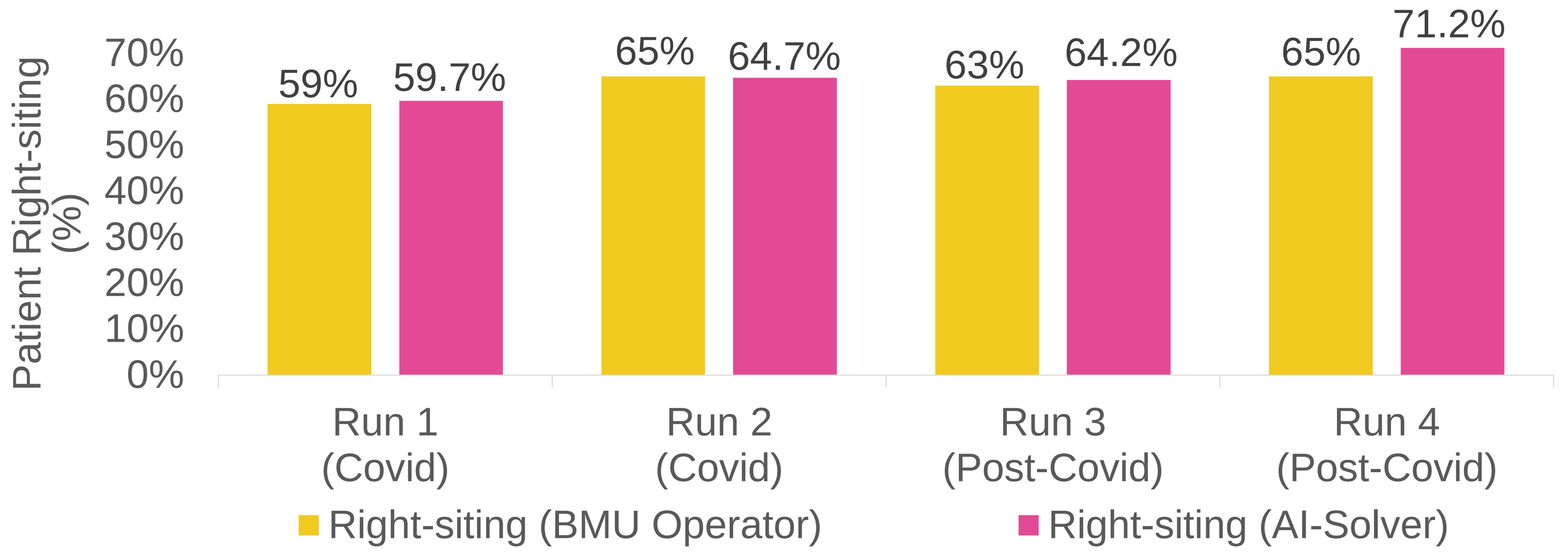

Figure 4a: *Patient Right-siting Comparison*

Also, the AI-solver's patients had an average waiting time of ~16.5 hours to receive a bed, compared to ~19 hours to a BMU Operator (refer to *Figure 4b*).

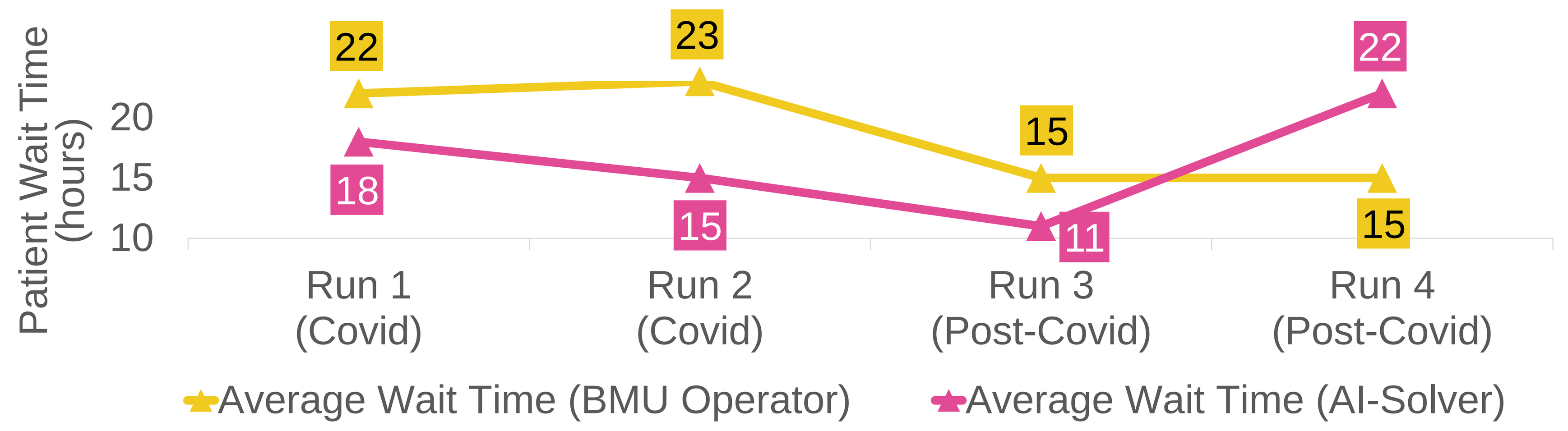

Figure 4b: *Patient Wait Time Comparison*

In Run 4 (*Figure 4a & 4b*), the AI-solver was deliberately adjusted to prioritise right-siting over waiting time to test its flexibility. The results indicated that it was able to achieve better right-siting rate by compromising waiting time to bed. Additionally, the AI-solver showcased its ability to prioritise patients based on the time of day and admission source, ensuring that patients requiring a bed by a specific time were given priority during specific periods.

Conclusion

The AI-solver has produced promising results by recommending appropriate bed assignments during high-demand periods while also offering flexibility to accommodate the hospital's requirements. Automation can alleviate labour-intensive operations and future-proof operations during a pandemic. Such a solution would allow BMU to operate without needing to increase manpower to cope with increasing bed demand. The protoype study highlights the value of AI-based solutions in addressing complex healthcare management challenges.

Next Step

BMU plans to refine the AI-solver and implement in its current workflow in a limited capacity. In addition, BMU plans to layer on a prediction module that can forecast bed demand and estimate bed supply by predicting patient discharges, allowing for proactive adjustments in bed assignments and resource allocation (refer to *Figure 5*). This would not only benefit the hospital but also greatly assist BMU operators in efficiently managing bed availability and patient flow.

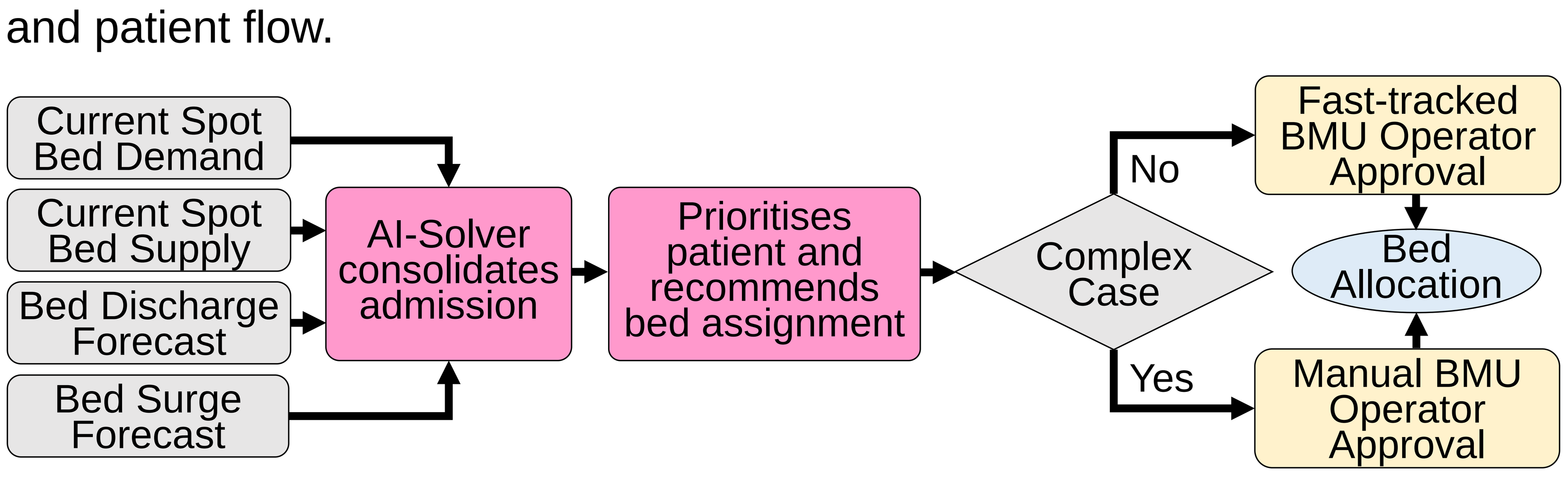

Figure 5: *Future State Bed Assignment Workflow*