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A RANDOMIZED CONSTRAINT-BASED APPROACH FOR FAIR EXAMINATION INVIGILATOR SCHEDULING WITH ROOM AND PARTNER REPETITION AVOIDANCE

Automatic Examination Invigilator Duty List Generator

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Abstract : The preparation of examination invigilation duty rosters is a constrained administrative task in which faculty availability, room requirements, previous duty counts, room repetition, partner repetition, examination sessions, and special responsibilities must be considered simultaneously. This paper presents an implemented Python-based, menu-driven Automatic Examination Invigilator Duty List Generator that addresses these requirements through database-backed management and a randomized constraint-based allocation strategy. Eligible faculty are prioritized according to previous guard counts, while the generator attempts to avoid repeated room assignments and repeated invigilator partnerships. A candidate allocation is checked incrementally, and unsuccessful partial allocations are discarded through backtracking-style retry. The implementation permits up to 1000 candidate combinations per generation attempt and allows the examination cell to request an alternative combination. The system also provides role-based authentication, faculty and room management, examination validation, reserve-invigilator selection, printable guard-list generation, and an at-a-glance workload report. Validation using actual institutional examination output for the Odd Semester January 2026 examination demonstrates the practical operation of the system. The generated at-a-glance report contains 20 faculty records across eight examination dates and fourteen sessions, with 141 recorded duty assignments. A sample guard-list output for 27 January 2026 contains 18 invigilator assignments across nine rooms and one reserve invigilator. The results indicate that the proposed approach can produce usable schedules while improving workload visibility and reducing avoidable allocation repetition.

Index Terms - examination invigilation, constraint-based scheduling, faculty allocation, room repetition avoidance, partner repetition avoidance, backtracking, Python, database, guard list.

I. INTRODUCTION

Examination invigilation scheduling is a recurring administrative problem in educational institutions. A duty roster must assign eligible faculty members to examination rooms and sessions while satisfying operational requirements and institutional rules. Manual preparation becomes difficult as the number of faculty members, rooms, examination sessions, and special responsibilities increases. In addition to ensuring sufficient invigilators, the examination cell may need to consider previous duty counts, previous room assignments, repeated invigilation partners, faculty availability, and reserve requirements.

The present work develops an Automatic Examination Invigilator Duty List Generator to address this problem as a practical constraint-based scheduling task. The implemented system is Python-based and menu-driven, with database storage for users, examinations, faculty, rooms, and generated guard lists. The central allocation mechanism gives higher priority to faculty members with lower previous guard counts and then searches for room and partner combinations that satisfy the applicable constraints.

A key characteristic of the problem is that all constraints may not be simultaneously satisfiable. For example, with a small set of rooms and faculty members, avoiding both room repetition and repeated invigilator pairs can become impossible even when the total number of available invigilators is sufficient. Therefore, the proposed implementation does not depend on a single random choice. It generates candidate combinations, checks constraints, and retries with alternative combinations when necessary.

II. OBJECTIVES AND MAJOR FEATURES

The objectives of the implemented system are to automate the preparation of examination duty lists, reduce the workload of the examination cell, distribute duties more evenly, prioritize faculty members with fewer previous duties, reduce unnecessary room and partner repetition, maintain centralized records, support authorized access, generate reserve assignments, and produce printable and consolidated reports.

Table 1. Major system features

Feature	Purpose
Faculty management	Add, display, update and maintain faculty eligibility/status information.
Room management	Maintain room number, capacity, status and invigilator requirement.
Examination management	Create examinations, validate date overlap and maintain ongoing/completed status.
Automatic allocation	Select eligible faculty and construct room-wise duty combinations.
Constraint checking	Check availability, current-session selection, room repetition and partner repetition.
Alternative combinations	Allow the user to reject a proposed combination and request another.
Reserve selection	Select a reserve invigilator using predefined priority levels.
PDF/report generation	Generate printable guard lists and an at-a-glance workload report.

III. SYSTEM DESIGN AND METHODOLOGY

The system combines authentication, database management, examination and room management, scheduling, constraint validation, reserve selection, and report generation in one application. The workflow begins with authentication and role verification, continues through faculty and room preparation, and ends with generation, acceptance, storage, and reporting of the selected duty list.

3.1 User Authentication and Role-Based Access

Users enter a registered username or email ID and password. The credentials are checked against the database. If the password is incorrect, the implementation provides an OTP-based password-reset path using the registered email address. After successful login, the User Type is checked. Administrators receive an additional option to create users, while normal users proceed to the homepage. This separation restricts administrative functions to authorized users.

3.2 Database Design

Table 2. Database entities and principal fields

Entity	Principal information
User	User ID, name, email, password and user type
Examination	Exam ID, name, semester, start date, end date and status
Faculty	Faculty ID, name, department, guard count, responsibility, selection status, previous room and partner
Guard List	Examination date, time and invigilation/guarding details
Examination Room	Room ID, room number, capacity, status and invigilator requirement

3.3 Faculty Eligibility and Examination Management

Faculty status determines whether a member is eligible for normal invigilation. The implementation uses status values for unavailable faculty, normally available faculty, Chief/Exam In-Charge, Assistant Exam In-Charge, Exam Cell Member, Group D Staff, and Reserve Invigilator. Before a duty list is generated, the system considers only the appropriate eligible faculty. Examination creation also checks for overlapping periods. When a new examination is created, the previous examination is marked completed, the new examination is marked ongoing, and an examination folder is created. Guard-list generation is restricted to the ongoing examination.

3.4 Guard-List Generation

Generation begins by identifying the ongoing examination, eligible faculty, allocated rooms, and the number of invigilators required for each room. The system first verifies that the total number of eligible faculty is sufficient for the current room requirements. If the available number is insufficient, generation is stopped and the user is informed that more invigilators are required.

IV. CONSTRAINT-BASED GUARD LIST GENERATION ALGORITHM

4.1 Faculty Selection Rule

Faculty members with lower previous guard counts receive higher priority. Once a faculty member is selected for the current examination session, that member is not selected again for another room in the same session. This rule supports a more balanced distribution of duties.

4.2 Room Repetition Constraint

The system stores previous guarding-room information for faculty members. During a new allocation it attempts to assign a different room when alternatives are available. This is a soft operational constraint rather than an absolute prohibition, because limited rooms or faculty availability can make repetition unavoidable.

4.3 Invigilator Partner Repetition Constraint

Previous guarding-partner information is also retained. The generator attempts to avoid assigning the same pair together repeatedly when alternative combinations are available. As with room repetition, the objective is to reduce avoidable repetition rather than claim that repetition can never occur.

4.4 Backtracking and Randomized Combination Search

The central allocation process works incrementally. A room is selected, an eligible faculty member is considered, and the candidate is checked against the relevant constraints. A valid partial assignment is temporarily retained. If a later room cannot be assigned without violating the constraints, the partial allocation is discarded and another combination is tried. The implementation can attempt up to 1000 combinations in one generation attempt. If a suitable arrangement is found earlier, the search stops; otherwise the last generated arrangement can be presented to the user, who may accept it or request regeneration.

This strategy is similar to constraint-satisfaction search with randomized candidate selection and backtracking-style reallocation. It is more appropriate for the practical problem than selecting faculty completely at random because the search explicitly evaluates the constraints that matter to the examination cell.

4.5 Time Complexity

In real-world examination scheduling, all constraints cannot always be satisfied simultaneously. With limited rooms and faculty members, avoiding both room repetition and invigilator-partner repetition may become difficult, even when sufficient invigilators are available. Therefore, random selection alone will not be sufficient, and the system will generate and check alternative combinations. The system will give higher preference to avoiding recently assigned rooms. If room repetition becomes unavoidable, a faculty member will have a lower chance of being assigned to the room they have just invigilated, while a room they have not invigilated for several days will have a higher chance of being selected. This will help distribute room assignments more fairly. The system can generate and check up to 1000 random invigilation duty combinations in a single attempt. It will stop immediately if it finds a valid and unique arrangement before reaching 1000 attempts. If no suitable arrangement is found within 1000 attempts, the system will display the last generated arrangement. The user can either accept it or select Regenerate to start another set of up to 1000 combinations.

Time Complexity

If one attempt takes approximately O(RF) where R is the number of exam room required and F is the number of invigilators required, then 1000 attempts require:

O(1000RF)

Since 1000 is a constant, the theoretical Big-O complexity remains:

O(RF)

V. RESERVE INVIGILATOR AND REPORT GENERATION

5.1 Reserve Invigilator Selection

After the final guard-list combination is accepted, the system selects a reserve invigilator using a three-level priority rule. First, it checks for a faculty member with Reserve Status = 6. If no designated reserve is available, it checks for an eligible faculty member who was not selected in the current session. If neither condition is satisfied, no reserve is assigned.

5.2 Guard List PDF

The generated guard list contains the examination name, semester, examination date and time, room numbers, and assigned invigilator names. The printable format also provides signing areas for the Chief Examination In-Charge, Assistant CIC, and Exam Cell Member. This converts the database allocation into an operational document that can be distributed to faculty members.

5.3 At-a-Glance Report

The at-a-glance report consolidates faculty names, total guard counts, dates, sessions, and assigned rooms. It provides the examination cell with a quick way to inspect workload distribution across the complete examination period and to identify whether individual faculty members have received substantially different numbers of duties.

VI. IMPLEMENTATION RESULTS AND DISCUSSION

The final implementation was evaluated using actual output generated for the External Theoretical Examination (Odd Semester January 2026). The at-a-glance report covers eight examination dates—13, 14, 15, 16, 17, 19, 20 and 27 January 2026—and fourteen session columns. It records 20 faculty members and a total of 141 duty assignments. The observed duty counts range from 1 to 11, while twelve faculty members have totals between 9 and 11. The output therefore provides direct evidence that the application can maintain and summarize a complete multi-session duty schedule rather than only generating an isolated allocation.

Table 3. Summary of actual at-a-glance output

Evaluation item	Observed output
Examination	External Theoretical Examination (Odd Sem Jan, 2026)
Dates represented	8 dates (13–27 January 2026, excluding non-exam dates shown)
Sessions represented	14 session columns
Faculty records in at-a-glance report	20
Total recorded duty assignments	141
Minimum individual total	1
Maximum individual total	11
Faculty with 9–11 duties	12 of 20

The distribution should not be interpreted as proof that every faculty member was equally available throughout the examination. The source output itself contains faculty with very different totals, which is consistent with the system's eligibility and special-responsibility rules. The important result is that the application records these differences systematically and exposes them through the consolidated report. The first twelve higher-count faculty members are concentrated in the 9–11 range, showing a relatively narrow spread among that group, while several other records contain only one or three assignments.

6.1 Sample Guard-List Validation

A detailed guard-list PDF for 27 January 2026 provides a second form of validation. The session is 11:00–13:30 and contains 18 normal invigilator assignments distributed as two invigilators across each of nine rooms: S_01, S_03, S_06, S_10, T_02, T_06, T_07, F_09 and F_03. The same output also identifies one reserve invigilator, demonstrating that the reserve-selection stage is integrated with the final operational roster.

Table 4. Sample generated guard list for 27 January 2026

Room	Invigilators
S_01	Abhijit ; Titas
S_03	Anupam; Amartya
S_06	Debolina; Sristita
S_10	Kedarnath; Sneha
T_02	Manisha; Sutapa
T_06	Sadananda; Sourav
T_07	Sanat; Soma
F_09	Mainak; Kinkar
F_03	Surajit; Abhijit
Reserve	Indrajit Santra

The sample is operationally usable because every listed room has the required pair of invigilators, a reserve is explicitly identified, and the document contains an examination-cell responsibility section for CIC, Assistant CIC, members and floor in-charge. This confirms that the project output is not limited to an internal algorithmic representation; it produces a document suitable for examination-cell administration.

6.2 Discussion of Constraint Behaviour

The actual at-a-glance report contains some repeated room assignments for individual faculty members. This is important because it demonstrates the intended nature of the constraints: room repetition and partner repetition are treated as avoidable preferences when alternatives exist, not as absolute restrictions under every possible condition. The implementation therefore prioritizes feasibility and complete room coverage while attempting to improve variety. This is a practical trade-off for institutional scheduling, were insufficient faculty, limited rooms, or special responsibilities can make perfect constraint satisfaction impossible. Some faculty members have limited invigilation duties due to absence or examination-cell responsibilities and are assigned duties only when there is a shortage of invigilators.

The result also illustrates why the combination-search mechanism is valuable. A single random assignment can create a conflict late in the allocation sequence. The backtracking-style retry can discard the problematic partial assignment and search for another combination. The user can additionally regenerate the roster if the first feasible combination is not operationally preferred.

VII. ADVANTAGES AND TECHNICAL SIGNIFICANCE

1. Automates a repetitive examination-cell activity and reduces manual allocation effort.
2. Prioritizes faculty with fewer previous duties for more balanced workload distribution.
3. Checks faculty sufficiency before starting generation.
4. Reduces avoidable room and invigilator-partner repetition.
5. Prevents a selected faculty member from receiving multiple room duties in the same session.
6. Provides alternative combinations instead of forcing a single fixed roster.
7. Maintains centralized database records and role-based access.
8. Provides reserve invigilator selection using explicit priority rules.
9. Produces printable guard-list PDFs and a consolidated at-a-glance report.

The technical significance of the project lies in treating invigilation allocation as a constraint-based scheduling problem rather than as simple record entry. The algorithm combines priority-based faculty selection, randomized candidate generation, constraint checking, partial-assignment rollback, and bounded retry. Together with database management and automated reporting, these components form an end-to-end examination-invigilation management application.

VIII. CONCLUSION

This paper presented the implemented Automatic Examination Invigilator Duty List Generator, a Python-based system for automating examination invigilation scheduling. The system integrates authentication, faculty and room management, examination scheduling, database storage, constraint-based allocation, reserve selection, guard-list PDF generation, and workload reporting.

The core allocation mechanism prioritizes faculty members with lower previous guard counts and attempts to reduce repeated room assignments and repeated invigilator partnerships. When constraints conflict, the implementation searches alternative combinations through randomized candidate generation and backtracking-style retry, with a maximum of 1000 attempts per generation cycle. The actual Odd Semester January 2026 outputs demonstrate that the system can generate multi-session schedules, detailed room-wise guard lists, reserve assignments, and a consolidated workload report. The results support the practical usefulness of the approach for institutional examination management.

Future enhancement can focus on stronger quantitative optimization, such as explicit weighted penalties for room and partner repetition, richer availability calendars, larger-scale benchmark datasets, and formal comparison with deterministic constraint solvers. Such extensions could further improve fairness while preserving the practical usability of the present application.

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