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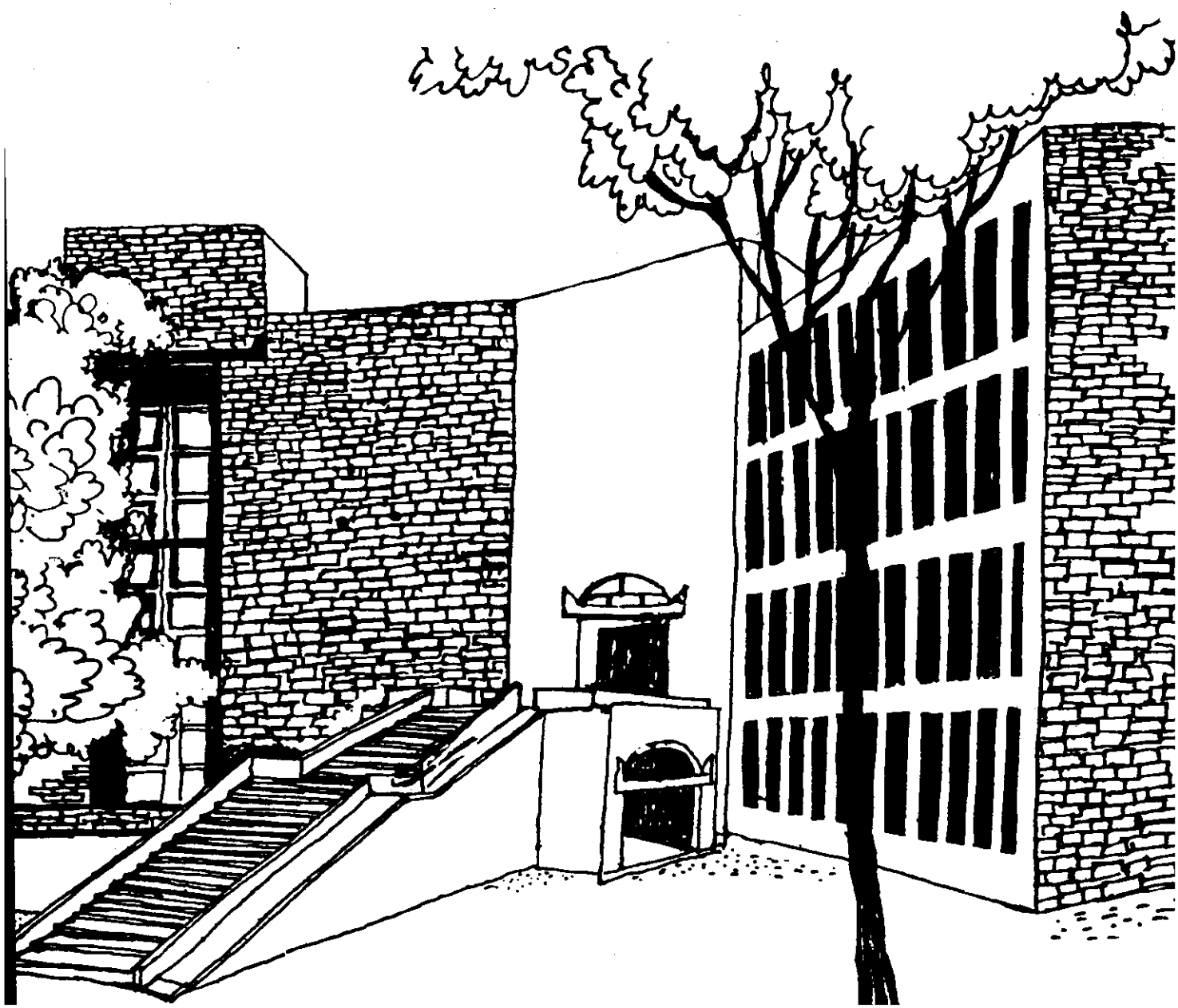

A COMPUTER BASED CREW SCHEDULING SYSTEM FOR FREIGHT TRAINS IN INDIAN RAILWAYS

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A Computer Based Crew Scheduling System for Freight Trains in Indian Railways

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ABSTRACT

This paper describes the design and implementation of an online PC-based crew allocation and management system for freight trains on Indian Railways. The software allows different rules to be used for calling the crew so that equity in duty hours is achieved. A computer network between the various bases of a planning region can solve the problem of imbalances in crew availability. The software also reduces a lot of data redundancy because it can integrate well with other systems.

INTRODUCTION

Crew management is an important aspect in the management of Indian Railways. The total manpower costs form 46 percent of the total expenses [1]. Of the total manpower, a critical category is the moving crew, whose salaries amount to ten percent of the total man power expenses. The moving crew can be categorized into drivers, assistants, guards, ticket examiners, coach attendants, catering staff etc. Of these, while drivers, assistants, and guards are used by both freight and passenger trains, the others are meant for only passenger trains. Further, the drivers, assistants, and guards are separate for freight and passenger trains. In this paper, we focus on freight train crew, and highlight a PC-based system for drivers.

The management of driver scheduling for freight trains is complicated because freight trains in Indian Railways do not have a schedule associated with their running. A freight train is formed at its origin when the required load is ready. It is then dynamically scheduled from station to station based on availabilty of path, and on the priorities between various trains, till it reaches its destination.

Along its run, depending on the duty hours and other regulations, the driver changes at designated stations known as bases.

At each base, as the departure of a freight train becomes known, which happens usually three hours in advance, an important decision to be made is which driver is to be called for duty. The main considerations that govern this decision are cost and equity. Further, the driver must be familiar with the territory under consideration, and should be qualified to handle the specific type of traction being used.

At a base, the decisions on crew duties are made in an office called *lobby office*. After deciding the driver to be called for duty, the lobby office supervisor conveys this decision to the concerned driver through a courier called a *call-boy*. However, a few of the drivers are required to report for duty on their own at pre-specified times, without being called by the call-boy. This is necessitated because: (i) there is a need for manning local movements which arise quite frequently, and (ii) some drivers stay far away from the lobby office. The PC-based system of this paper does not consider such drivers.

CONTEXT DESCRIPTION

Crew organization in Indian Railways

The Indian Railways, consisting of 62,400 route kilometers, is the largest system in the world under a single management. According to the 1990-91 statistics, the Indian Railways operated 245 million freight train kilometers, providing an output of 236 billion net ton-kilometers. The total staff employed is 1.65 million, of which 0.1 million constitute the moving crew. The Indian Railways is divided into nine regional operating zones which are further divided into a total of 54 divisions.

Each division is responsible for the overall crew management, which is executed through the crew bases under its charge. Each driver is assigned his permanent quarters at one of the crew bases, which is called his home base. Figure-1 shows the map of crew bases of a typical division. Apart from helping the bases coordinate among themselves, the divisional office computes and disburses the fortnightly pay of the drivers. The division is also responsible for deciding the number of drivers to be assigned to each base and for transferring drivers from one base to another.

Hours of Employment Regulations

The hours of employment regulations (HOER) [2] which directly affect the scheduling of drivers have been extracted and interpreted as follows:

1. The duty hours of a crew include 'signing-on time', 'signing-off time', engine attendance time and train attendance time. Such times are specific to each terminal station.

2. A crew, by plan should not be put on duty for more than ten hours at a stretch. If the duration of a crew duty happens to exceed ten hours at a stretch (due to unforeseen circumstances), the crew can claim a rest after working for 12 hours, provided a notice of two hours is given for bringing in a relief crew.

3. Total regular duty hours for a crew should not exceed 104 hours over a fortnight, defined from the midnight of a Saturday-Sunday to the midnight of the Saturday-Sunday two weeks later. Excess duty hours are paid on overtime basis.

4. Rest hours should be provided after each duty as follows:
(a) At headquarters (crew base): If the duty has been less than or equal to eight hours, the crew is eligible for a rest of at least 12 hours. If the duty has exceeded eight hours, the crew is eligible for a rest of at least 16 hours.
(b) At other stations: The crew is eligible for as much rest as the duty hours that the crew has just had, subject to a maximum of eight hours.

5. In addition to the rests described above, a crew is also eligible for long rests. A long rest should be given only at the headquarters station and should always include a full night in bed (21.00 hours to 6.00 hours). As far as possible, it should be given atleast once in ten days. A crew is entitled to five long rests of 22 hours or four long rests of 30 hours each in a month.

6. A crew should not have to work in the night (any time between 21.00 hours and 6.00 hours) for more than six nights consecutively. A crew should come to headquarters at least once in three or four days.

7. If a crew is not provided at least one hour rest, then the crew is treated as if on continuous duty.

8. If a crew is required for duty before the expiry of the rest period, the crew is entitled for a breach of rest allowance.

Structure of pay

A driver's monthly pay consists of three basic components:

1. Basic pay. This consists of basic salary and other usual allowances, such as dearness allowance, which depend on the basic salary.

2. Overtime pay. This is computed using the total number of hours on duty spent by the driver in each fortnight. The number of hours put in by a driver

in excess of 104 hours is considered to be overtime. For overtime calculation, if a driver reports sick, or is on training, he is given 8 hours credit per day.

3. Breach of rest allowance. A driver is eligible for this, if at the end of a duty, the rest that he is given is less than what is specified in the HOER, and when he is not given enough number of long rests in a month.

MANUAL SYSTEM

Registers and documents

In the current manual system [3], the decision on duty assignments is aided by the following registers and documents maintained at the lobby office:

1. Sign-on register. Whenever a driver reports for duty at a lobby office, he is required to go through some checks, after which entries are made in this register along with the clock time. This time is usually fifteen minutes prior to the estimated time of departure of the train to which he is assigned.

2. Sign-off register. Whenever a driver finishes his duty, he signs off by entering the clock time. For home based drivers, decisions regarding long rest, leave etc. are taken at this time.

3. Engine ticket. While on duty, a driver, along with the guard, fills a document called an engine ticket, also known as combined train report (CTR). Each ticket contains a record of a duty, with starting and ending times, and information on extraordinary delays. An example engine ticket is shown in Figure-2. Each time a driver comes back to his home base, he hands in the engine ticket(s) since the last sign-on at his home base.

4. Progressive hours register. After a sign-off at the home base, the duty hours logged by the driver are entered into this register to calculate the fortnightly running total.

5. Availability register. The available time of a driver is computed by adding the rest hours to the sign-off time. The names are entered in this register in the order of available time.

6. Leave register. This register contains information on the leave availed, including the official leave for training, by the home based drivers.

Priorities

If more than one driver is available at the required time, the following priority scheme is followed in duty assignment: (i) drivers returning from leave or training, (ii) non-home based drivers, (iii) home based drivers in order of availability, and sometimes in increasing order of progressive hours.

Coordination between bases

The crew assignment decisions are taken at a base independent of the status of crew at other bases. When the distribution of drivers is very uneven resulting in breach of rest at a base, some coordination is attempted to move drivers as passengers from a surplus base to a deficit base.

NEED FOR COMPUTERIZED SYSTEM

The following problems in the current manual system necessitate a computerized system for managing the driver assignments:

1. There is a perceived inequity in duty assignments, especially in terms of overtime earnings. Such perceptions are caused by the vulnerability of the manual system to malpractices, stakes associated with overtime earnings, and actual instances of unfair duty assignments. The availability register is open to manipulation, and sick leave to misuse.

2. The driver history is not immediately accessible for long rest decision during sign-off. This leads to improper spacing of long rests, endangering operational safety, and leading to breach of rest. The driver's tendency is to avoid long rests, as a long rest cuts into his overtime earnings.

3. The same information has to be entered in multiple registers, sometimes with computations, leading to inconsistencies across registers.

4. The salary payments have a long lead time due to the gathering of data from different home bases and the manual processing involved.

A COMPUTERIZED SYSTEM

We describe below the design of a PC-based stand alone system to be used by the supervisor of a lobby office.

1. Main menu. The various menu options provided are: (i) File maintenance, (ii) Sign-on, (iii) Sign-off, (iv) Select a driver, (v) Enquiries, (vi) Leave details, (vii) Report generation, (viii) Fortnightly housekeeping, and (ix) Monthly housekeeping. Selection of a menu item causes a corresponding software routine to be executed. As an example, the pseudocode for the sign-off option is shown in Figure-3.

2. Data files. The following data files are maintained by the computerized system:

S.No.	Name of File	Major Contents
1	Names	Driver number, name, other master data
2	Sign-on	Driver number, time of sign-on
3	Sign-off	Driver number, time of sign-off
4	Progressive Hrs	Driver number, hrs in current trip, total hrs so far in the fortnight
5	Long rest	Driver number, starting time, ending time of the rest
6	Long leaves	Driver number, starting and ending times of leave
7	Engine tickets	Driver number, sign-on time, station name, sign-off time, station name
8	Availability	Driver number, time from which available

3. Priority rules. The system provides flexibility in prioritizing drivers for duty assignment. This is achieved by providing the option of sorting the drivers in the availability register according to different rules:

(i) first available rule,

(ii) lowest progressive hours rule,

(iii) a combination of rules (i) and (ii), for example rule (i) in the first week of a fortnight, and rule (ii) in the second week,

(iv) rule (i) subject to a driver not exceeding 104 hours of duty in the fortnight.

While the above rules provide considerable flexibility in duty assignment, the selection rule cannot differ from duty to duty arbitrarily. A rule, once chosen, should be used consistently over a period of time, except in case of emergencies. A log of the decisions along with the context is maintained for subsequent analysis and management control.

4. Validation checks. Various validation checks are incorporated to trap the data entry errors. Some of these are checks on clock time, identification codes, and range checks on duty hours. Checks are also provided on change of status of a driver to ensure that procedures are followed properly. For example, two successive sign-off or sign-on transactions for the same driver are not permitted.

5. Reports. Apart from answering queries, the system has options to produce periodic reports like driver histories, crew utilization, transaction logs and summaries.

While the system is designed to work as an online transaction processing system, especially in a high traffic lobby office, the option to enter some of the data in a batch mode is also provided.

A NETWORKED SYSTEM

The design described above does not effectively solve the problem of coordination between bases. Hence, a network based system is designed [4]. Here, the various lobby office computers are connected as nodes in a wide area network along with the computer in the divisional office, using the advanced communication technology that the Indian Railways are currently investing in.

The major consequence of this network is data sharing between all the bases and divisional office, enabling queries on drivers resting at other bases, decisions on better operational distribution of drivers, and quicker processing of payroll. This also facilitates better operational decisions, especially from the perspective of point #6 of HOER, which requires monitoring of the driver's night duties and period for return to headquarters.

The queries and data updating would be governed by a system of privileges provided to different classes of users.

LONG TERM DECISIONS IN CREW MANAGEMENT

While the software addresses operational decisions, there are significant long term crew management decisions that have important implications. Some of these are:

1. Location of bases
2. Number of crew at each base
3. Formulation of HOER
4. Sharing of drivers on a section between bases and between divisions

These decisions require the use of models, in which the operational decision making could be an embedded part.

CONCLUSIONS

1. The above software has been used in training programmes for railway officials to demonstrate the application of computers in crew management. Its implementation is under consideration by one of the zonal railways.

2. The software provides good management information, like identification of sections where the ten hour duty limit is violated often, or the crew is under utilized because of short duty durations, or variations between different drivers in running time on the same section, or drivers consistently earning overtime. These help in planning and long term decisions.

3. Due to slight variations in crew management practices between zones, the software needs to be tailored to the specific requirements of a zone. For example, not all priority rules would be administratively permissible in a zone. Similarly, marginal differences could exist in the computation of allowances.

4. The Indian Railways are embarking on the implementation of an operational information system (OIS) over their entire network. A crew scheduling system, if integrated with the OIS, would result in improved resource planning and utilization.

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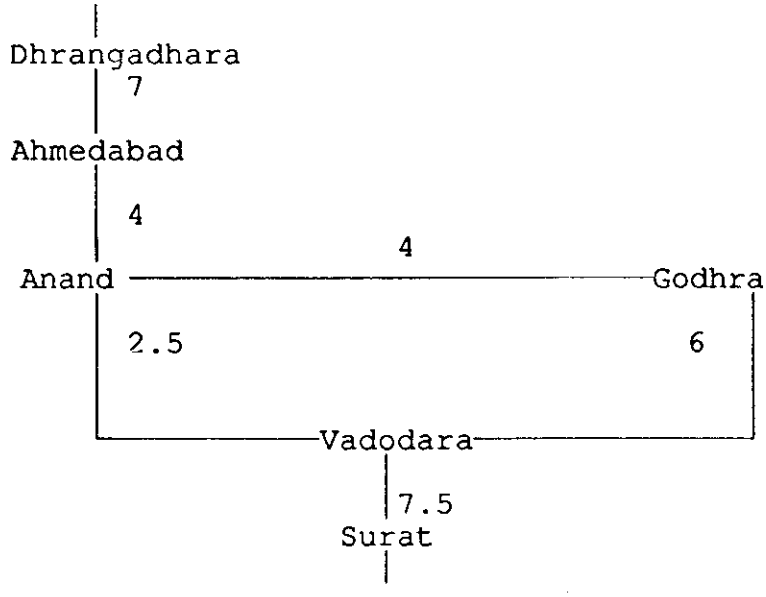

1. The numbers along the arcs are average travel times in hours.

2. Anand is generally not used as a crew change point for Ahmedabad-Vadodara trains.

3. Except for the section between Dhrangadhara and Ahmedabad, all other sections are electrified.

Figure 1. Map of crew bases of a typical division, Vadodara.

Engine No.:		Class of Engine:		Home Shed:	
Train No:		Service:		Date:	
From Station:		To Station:			
How employed on previous trip:					
Name of Guard:		Staff No:		HQR:	
Name of Driver:		Staff No:		HQR:	
Name of Assistant:		Staff No:		HQR:	
STATION	ARRIVAL	DEPARTURE	REASON FOR DETENTION		

Notes:
1. '*' indicates travel from the previous station as a passenger
2. In the case of first station, only departure time is given. In the case of last station, only arrival time is given.

Time on duty (Hrs):	Drivers special report
Time off duty (Hrs):	
Duty time (Hrs):	
Special duty:	
To be filled in by the divisional office:	
Came on duty:	Kms/trip allowance:
Went off duty:	Allowance in kms:
Time on duty:	Special compensatory allowance:
Allowance:	Overtime allowance:
	Breach of rest allowance:

Figure 2. A proforma engine ticket.

```
BEGIN
    Accept the Driver-number and head quarter code of the driver
    IF the head quarters is Ahmedabad THEN
        Retrieve the latest sign-on details of this driver
        IF sign-on details are not valid THEN
            Display error message
            Stop
        ELSE
            Obtain Total-hrs of the driver from Progressive-hrs register
            WHILE the engine ticket has one more segment to be entered
                Accept sign-on and sign-off data of next segment
                Hours-worked <-- sign-off time - sign-on time
                Total-hrs <-- Total-hrs + Hours-worked
            ENDWHILE
            Append the Sign-off data of the last segment of engine ticket
                                        to sign-off register
            Update Progressive-hrs Register with Total-hrs of this driver
            IF hours-worked <= 8 THEN
                REST <- 8 hrs
            ELSE
                REST <- 16 hrs
            ENDIF
            Available-time <-- Sign-off time + REST
            Display all long rest details of this driver for this month
            IF the driver wants long rest now THEN
                Find the duration of long rest
                Available-time <-- Sign-off time + long rest duration
            ENDIF
            Append to Availability register this drivers avilable-time
        END IF
    ELSE
        Accept sign-off details for the segment of trip just completed
        IF hours-worked <= 8 THEN
            REST <-- hours-worked
        ELSE
            REST <-- 8 hrs
        ENDIF
        Available-time <-- Sign-off time + REST
        Append to availabilty register this drivers available-time
    ENDIF
END
```

Figure 3. Pseudocode for sign-off transaction.