COMP23420 Software Engineering

Semester 2

Driver Scheduling and Rostering

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Lecture Overview

- Your team project is about developing a Integrated Bus Management System (**IBMS**) for a bus company
- You need to know:
  - What are driver scheduling and driver rostering?
  - How do they work?
- So that you can design & implement these requirements into your system

- This lecture introduces to you the processes & concepts of driver scheduling and driver rostering

What are driver scheduling & rostering?

To ensure every bus has a driver to drive at all times when buses are in services

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And …

To make sure buses are running on time

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What we passengers can see

Stockport — East Didsbury — Rusholme — Manchester 42

Mondays to Fridays

Stockport, Bus Station	0616	0636	0656	0711	0724	0743	0801	0821	0847	0910	0936	0956	1016		1516	1532	1550	1610	1630
Didsbury Rd/Mauldeth Rd	0622	0642	0702	0717	0732	0751	0809	0829	0855	0918	0942	1002	1022	and	1522	1539	1558	1618	1638
East Didsbury, Parrs Wood	0628	0648	0708	0723	0740	0800	0818	0838	0904	0927	0947	1007	1027	every	1527	1547	1607	1627	1647
Didsbury, School Lane	0633	0653	0713	0728	0747	0807	0825	0845	0909	0932	0952	1012	1032	20	1532	1552	1612	1632	1652
Fallowfield, Friendship Inn	0643	0703	0723	0739	0759	0819	0837	0857	0921	0943	1003	1023	1043	mins	1543	1603	1623	1643	1703
Rusholme, Platt Lane	0648	0708	0729	0746	0806	0826	0844	0904	0928	0948	1008	1028	1048	until	1548	1608	1628	1648	1708
University of Mcr, Phoenix	0658	0718	0739	0756	0816	0836	0856	0916	0938	0958	1018	1038	1058		1558	1618	1638	1658	1718
Piccadilly Gardens	0708	0728	0749	0808	0828	0848	0908	0928	0948	1008	1028	1048	1108		1608	1628	1648	1708	1728

Stockport, Bus Station	1650	1710	1730	1750	1812	1836	1856	1916	1936	1955	2025	2055	2125	2155	2225	2255	2325		
Didsbury Rd/Mauldeth Rd	1658	1718	1738	1758	1819	1842	1902	1922	1942	2001	2031	2101	2131	2201	2231	2301	2331		
East Didsbury, Parrs Wood	1707	1727	1747	1807	1827	1847	1907	1927	1947	2006	2036	2106	2136	2206	2236	2306	2336		
Didsbury, School Lane	1712	1732	1752	1812	1832	1852	1912	1932	1952	2011	2041	2111	2141	2211	2241	2311	2341		
Fallowfield, Friendship Inn	1723	1743	1803	1823	1843	1903	1923	1943	2003	2022	2052	2122	2152	2222	2252	2322	2352		
Rusholme, Platt Lane	1728	1748	1808	1828	1848	1908	1928	1948	2008	2027	2057	2127	2157	2227	2257	2327	2357		
University of Mcr, Phoenix	1738	1758	1818	1838	1856	1916	1936	1956	2016	2035	2105	2135	2205	2235	2305	2335	0005		
Piccadilly Gardens	1748	1808	1828	1846	1904	1924	1944	2004	2024	2043	2113	2143	2213	2243	2313	2343	0013		

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What we passengers can see

Service route

Bus number (service number)

Stockport — East Didsbury — Rusholme — Manchester 42

Mondays to Fridays

Service days

Stockport, Bus Station	06					0743	0801	0821	0847	0910	0936	0956	1016		1516	1532	1550	1610	1630
Didsbury Rd/Mauldeth Rd	0622	0642	0702	0717	0732	0751	0809	0829	0855	0918	0942	1002	1022	and	1522	1539	1558	1618	1638
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Piccadilly Gardens	0708	0728	0749	0808	0828	0848	0908	0928	0948	1008	1028	1048	1108		1608	1628	1648	1708	1728

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Bus stops

Arrival times

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But behind the scene

Driver scheduling & rostering is an integral part of public transport planning processes:

- **Timetabling:** producing bus timetables
- **Bus scheduling**: allocating buses to bus timetables
- **Driver scheduling**: assigning driver duties to buses
- **Driver rostering**: assigning real drivers to duties.

Your team project assumes the first two processes have already been done and focuses on the last two processes.

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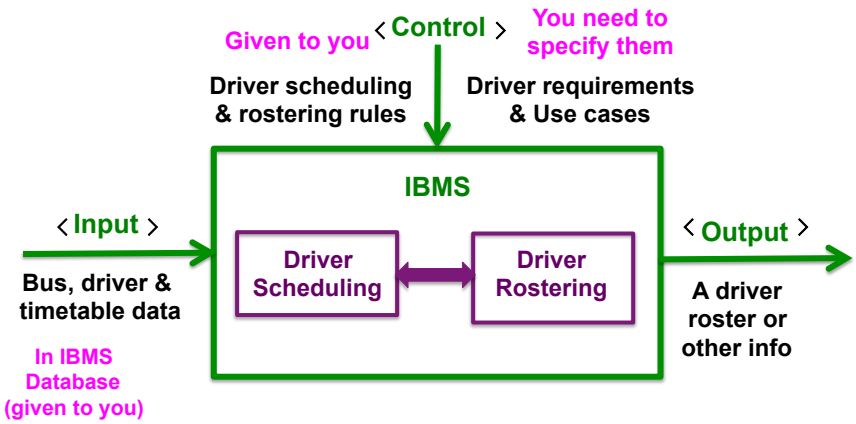
The scope of your project



Your project is about developing driver scheduling & rostering as well as some associated use cases!

More precisely:

IBMS should have the following functionality:

1. Implement **a set of use cases** to find out driver information, bus information or timetable information (database queries) (Iterations 1 & 3)
2. Produce **a set of driver duties** according to the scheduling rules (Iteration 2)
3. Produce **a driver roster** by allocating real drivers to these duties according to the rostering rules & driver requirements (Iteration 2)

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Which Use Cases?

1. *"Driver Requesting Holidays"* (Iteration 1)
2. For the remaining use cases: read Team Project Handbook (esp. Iteration 3 for clues)
3. Don't tell others ☺

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Today's tasks

Work on a simple driver scheduling & rostering problem

We are given:

- A bus schedule (timetabled buses)
- A set of driver scheduling rules
- A set of driver rostering rules

Our tasks are:

1. To find a driver schedule (driver scheduling)
2. To find a driver roster for one week (driver rostering)

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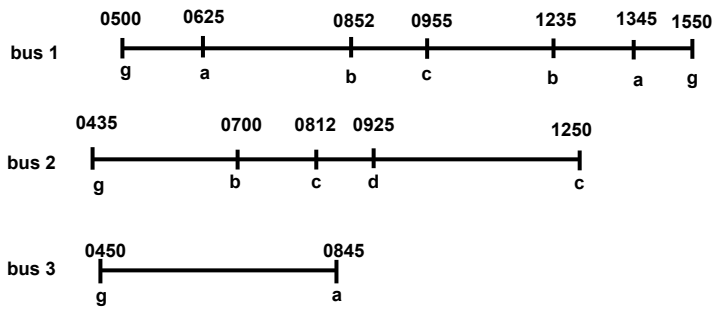
A bus schedule



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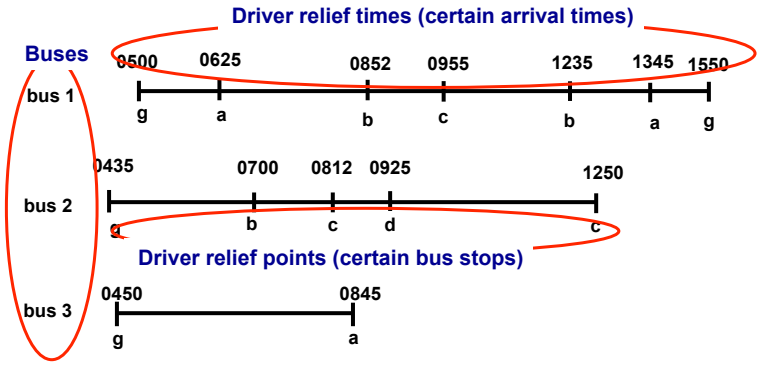
Bus schedule information



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Driver scheduling rules

1. The maximum continuing working time for a **normal duty** without a break is 4.30 hrs whereas the minimum time is 2 hrs
2. The maximum meal break time for a **normal duty** is 60 mins whereas the minimum time is 30 mins
3. The maximum duration of a **normal duty** is 8.30 hrs
4. The maximum continuing working time for a **split duty** without a break is 6 hrs, whereas the minimum time is 3 hrs
5. The maximum break time for a **split duty** is 3 hrs
6. The maximum duration of a **split duty** is 12.00 hrs

Driver rostering rules

1. There can be no more than 50 hours driven by any one driver in any one week.
2. A driver may specify up to two resting days for each week in which they will not be available for work.

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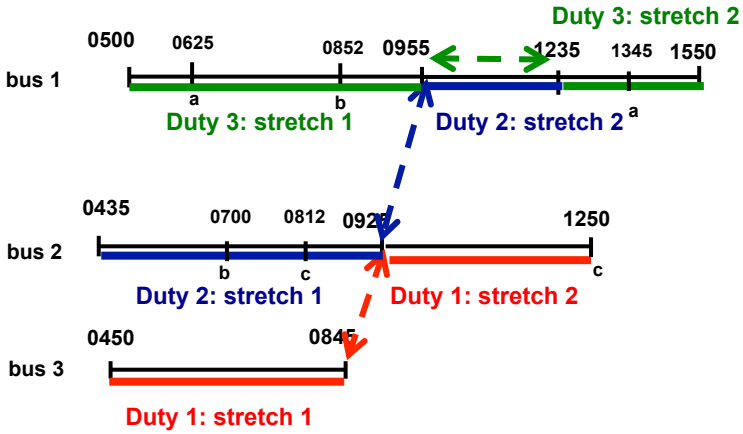
Task 1: find a driver schedule

Objective: To minimize the number of driver duties required to cover the bus schedule (hence the total cost of duties).

How do we achieve this objective?

1. Use a simple algorithm called “heuristics”
2. Find driver duties one by one, respecting the scheduling rules

Task 1: find a driver schedule (cont.)



duty 1 & duty 2: normal duty
duty 3: split duty

Task 2: find a driver roster

Objective: To minimise the number of drivers required to cover the driver schedule (hence the total cost of drivers).

COMP26912 will help you in this task where rostering will be one of the examples

A simple method is used today:

1. Calculate the total number of duty hours for each duty for a week
2. Allocate these hours evenly to available drivers, respecting the rostering rules
3. For each day, the number of duties suggests that at least the same number of drivers are required.

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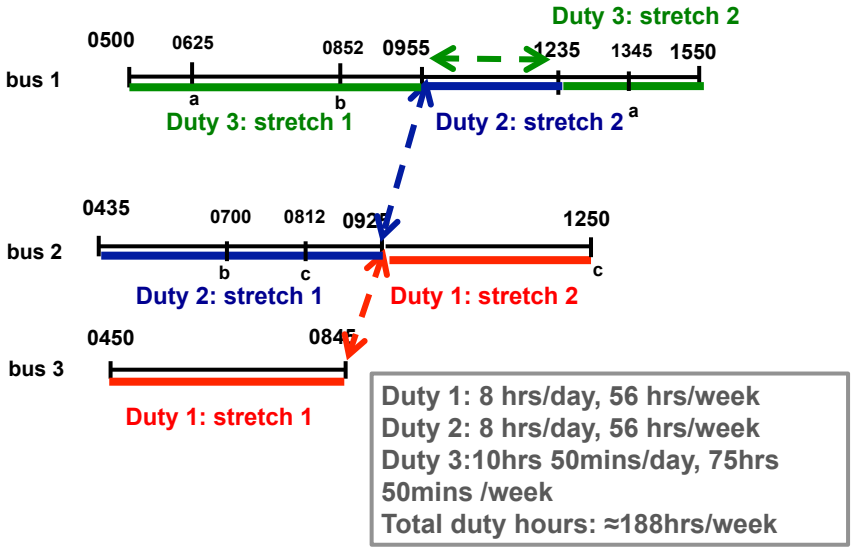
Task 2: find a driver roster (cont.)



Duty 1: 8 hrs/day, 56 hrs/week
Duty 2: 8 hrs/day, 56 hrs/week
Duty 3:10hrs 50mins/day, 75hrs 50mins /week
Total duty hours: ≈188hrs/week

Task 2: find a driver roster (cont.)

Rostering rules:

1. There can be no more than 50 hours driven by any one driver in any one week.
2. A driver may specify up to two resting days for each week in which they will not be available for work.

- Rule 1 means that a minimum number of 188/50 ≈ 4 drivers are needed for any one week
- Rule 2 means that each driver may work up to 5 days a week
- Since each day we need 3 drivers to cover all duties
- A crude roster will need a maximum of 6 drivers: 3 for week days and 3 for weekend

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Further help to your project

The remaining slides are for your self study.

You need to understand:

- Which rules are driver scheduling rules for IBMS
- Which are driver rostering rules for IBMS
- What makes a good roster
- Why driver scheduling is hard

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Driver scheduling rules for IBMS

1. The maximum driving time for any driver in any one day is 10 hours.
2. A driver can drive for a maximum of 5 hours at any one time and must have a break of at least one hour. Breaks can only be taken at the bus depot.
3. A driver duty consists of one period of up to 5 hours driving time, or two such periods with a 1 hour break between them.
4. Time spent with the bus whilst not actually moving counts as driving time for the driver (that is, while responsible for the bus).
5. If a bus is available, it is available for the whole day.

Rostering rules for IBMS

1. There is a sufficiency of fuelled buses available for the roster.
2. A roster is generated for each week based upon the timetable for that week.
3. There can be no more than 50 hours driven by any one driver in any one week.
4. A driver may specify up to two resting days for each week in which they will not be available for work. (We assume not all drivers will choose the same two days.)

Rostering rules for IBMS (cont.)

5. Drivers can normally take 25 days of holidays a year – this is in addition to the two resting days a week they specified.
6. If a driver requests holidays, he or she should specify the intended starting date and the finishing date.
7. During Sundays and public holidays when fewer buses are in operation, it is possible for more than 10 drivers to request the holidays for the same period.

Some Criteria for a Good Roster

1. Rostering should maximise the amount of time a driver actually drives during a duty whilst not violate rules for driver breaks.
2. The number of drivers used in a roster is minimised.
3. The number of days worked per week per driver is minimised.
4. The allocation of hours in a week to drivers is fair.
5. The use of buses should be balanced to give each bus a roughly equal workload in any one roster.

Driver scheduling is hard

- It is a combinatory problem (NP Hard)
  - There are numerous ways to cover the same piece of bus work, which potentially results in a very large number of valid duties.
  - Computationally intractable
- It is a constraint satisfaction problem (CSP)
  - There is a large set of scheduling constraints that must be met.

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Questions?