To: Whom It May Concern

From: Alejandro Andrade, Kyle Salitrik

Subject: Nurse Scheduling Database Final Design and Queries

Date: December 1, 2017

The purpose of the following document is to explain in depth a database for a nursing care assistance hospital or clinic. Such database was created to solve the problem of scheduling each shift and combining the available resources to meet the working constraints of each nurse.

The database model and the select examples give an overview of the relationship and capabilities of the data. It is important that data can get increasingly big and processing the select queries can exponentially increase in run time. Thus, this document also explains how the database is internally optimized to avoid long run time processing through indexing techniques. The data model that will be referenced throughout the document is attached at the end of the document.

Table Specifications

This section contains the specifications for each table used in the relational model.

Address

The address table contains the information for an address, with each address being linked to an employee by their employee ID. This allows the database to handle employees with multiple addresses without wasting space by having multiple address fields per employee.

Field	Type	Null	Key	Default	Extra
address_ID	int(11)	NO	PRI	NULL	auto_increment
emp_ID	int(11)	YES	MUL	NULL	
street1	char(50)	YES		NULL	
street2	char(50)	YES		NULL	
city	char(50)	YES		NULL	
state	char(50)	YES		NULL	
zip	char(50)	YES		NULL	

Certification

Each certification is linked to a role by the role ID and an employee by their employee ID. This implementation allows an employee to have multiple registered certifications.

Field	Type	Null	Key	Default	Extra
cert_ID	int(11)	NO	PRI	NULL	auto_increment
emp_ID	int(11)	YES	UNI	NULL	
role_ID	int(11)	YES	MUL	NULL	

Role

The role table contains the description of each role (RN, LPN, etc) in order to save storage space by preventing repeated copies of the data.

Field	Type	Null	Key	Default	Extra
role_ID	int(11)	NO	PRI	NULL	auto_increment
role	char(50)	NO		NULL	

Department

The department table contains the department name and number of beds as well as the maximum and minimum amount of staff necessary.

Field	Type	Null	Key	Default	Extra
dept_ID	int(11)	NO	PRI	NULL	auto_increment
min_staff	int(11)	NO		0	
max_staff	int(11)	NO		100	
beds	int(11)	NO		0	
dept_name	char(50)	NO		NULL	

Department Need

The department need table is linked to the week, day, shift time, department, and roles by their respective IDs. A single department need record contains the role and number of personnel needed for a particular shift on a particular day.

Field	Type	Null	Key	Default	Extra
need_ID	int(11)	NO	PRI	NULL	auto_increment
week_ID	int(11)	YES	MUL	NULL	
day_ID	int(11)	YES	MUL	NULL	
time_ID	int(11)	YES	MUL	NULL	
dept_ID	int(11)	YES	MUL	NULL	
role_ID	int(11)	YES	MUL	NULL	
need	int(11)	YES		NULL	
day	date	YES		NULL	

Employee

The employee table contains personal and financial information for each employee. The home department of the employee may be filled out, if applicable, via a foreign key to the department table.

Field	Type	Null	Key	Default	Extra
emp_ID	int(11)	NO	PRI	NULL	auto_increment
home_dept	int(11)	YES	MUL	NULL	
fname	char(50)	NO		NULL	
mname	char(50)	YES		NULL	
lname	char(50)	YES		NULL	
ssn	char(12)	YES		NULL	
phone1	char(13)	YES		NULL	
phone2	char(13)	YES		NULL	
start_date	datetime	NO		CURRENT_TIMESTAMP	
end_date	date	YES		NULL	
full_time	tinyint(1)	NO		0	
salaried	tinyint(1)	NO		0	
hourly_pay	double	NO		0	

Shift

The shift table contains entries for a specific shift for a specific employee on a specific day. The table is linked to the employee, department, shift time, week, day, and shift status tables by their respective foreign keys. The pay modifier may be adjusted to increase the employee's shift pay if they are called in or work a special shift such as a holiday.

Field	Type	Null	Key	Default	Extra
shift_ID	int(11)	NO	PRI	NULL	auto_increment
emp_ID	int(11)	NO	MUL	NULL	
dept_ID	int(11)	NO	MUL	NULL	
time_ID	int(11)	NO	MUL	NULL	
week_ID	int(11)	NO	MUL	NULL	
day_ID	int(11)	NO	MUL	NULL	
status_ID	int(11)	YES	MUL	NULL	
pay_modifier	double	YES		NULL	
day	date	YES		NULL	

Shift Status

The shift status table contains information with common notes for a shift, such as someone calling off, requesting the shift off, requesting to be staffed for the shift or being called in.

Field	Type	Null	Key	Default	Extra
status_ID	int(11)	NO	PRI	NULL	auto_increment
status	char(50)	YES		NULL	

Shift Time

The shift times table contains the hospital's current shift schedules.

Field	Type	Null	Key	Default	Extra
time_ID	int(11)	NO	PRI	NULL	auto_increment
shift_start	time	NO		NULL	
shift_end	time	NO		NULL	
shift_length	int(11)	YES		NULL	

Week

The week table was created to easily access shifts by week, as it serves only to be used in the shift as a foreign key for this purpose.

Field	Type	Null	Key	Default	Extra
week_ID	int(11)	NO	PRI	NULL	auto_increment
start_date	date	NO		NULL	
end_date	date	NO		NULL	

Weekday

The weekday table contains the days of the week as text in order to save on data storage and time costs of re-writing the names of each day repeatedly.

Field	Type	Null	Key	Default	Extra
day_ID	int(11)	NO	PRI	NULL	auto_increment
day_name	char(10)	YES		NULL	

Desired Queries

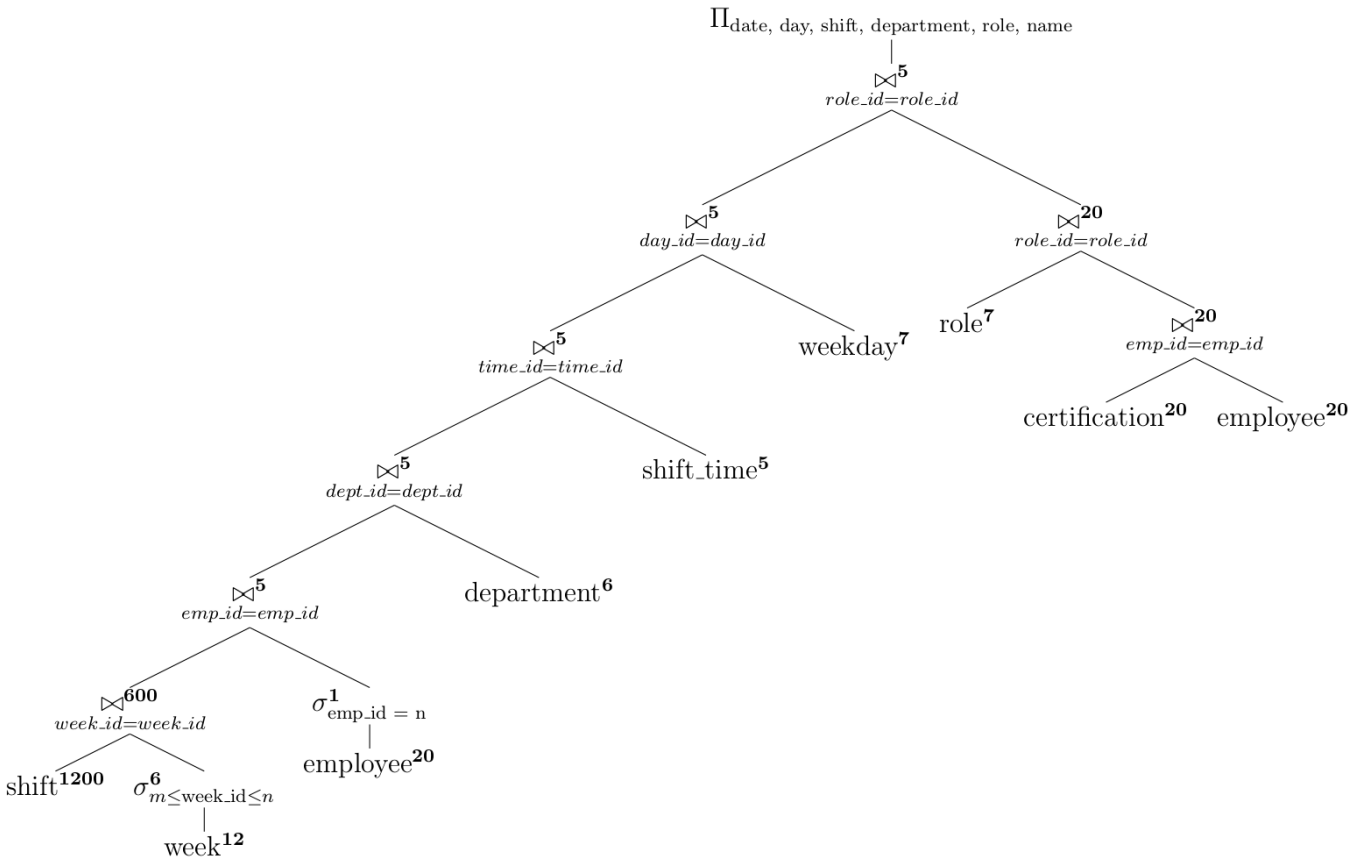
Within this section all queries are explained, the MySQL query itself is given, indexing is discussed and one weeks worth of sample data is provided. If the sample data exceeded 100 lines, the result was truncated to 100 lines for brevity.

Query 1

The first query is designed to return a single employee's schedule for any given 6 week period. It shall return the week start date, day of week, shift, department, and role for the employee. The input parameters to the query are the start week, end week, and ID of the employee in question.

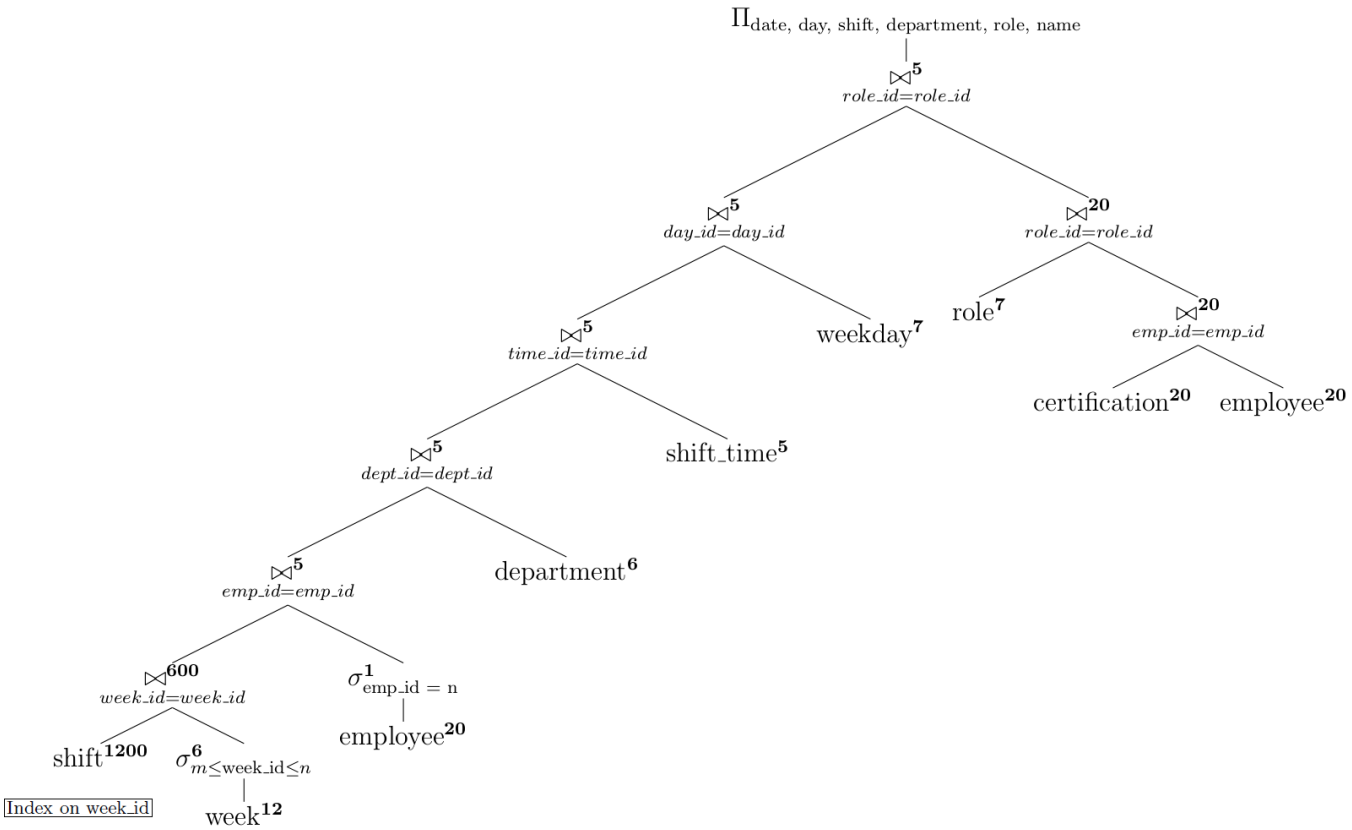
MySQL Query

```
SELECT
   shift.day,
   weekday.day_name,
   shift_time.shift_start,
   shift_time.shift_end,
   employee.fname,
   employee.lname,
   department.dept_name,
   role.role
FROM shift, week, weekday, shift_time, department, role, certification, employee
WHERE shift.day_ID = weekday.day_ID
      AND shift.time_ID = shift_time.time_ID
      AND shift.dept_ID = department.dept_ID
      AND shift.week_ID = week.week_ID
      AND shift.emp_ID = employee.emp_ID
      AND employee.emp_ID = certification.emp_ID
      AND certification.role_ID = role.role_ID
      AND employee.emp_ID = 1
      AND week.week_ID >= 1
      AND week.week_ID <= 6;
```



For the first query, the best table to index is Shift on shift_id and week_id. This index is chosen because the shift table will be the second largest table in the database (only department_need will be larger) and the ability to quickly find the desired weeks for the employee's schedule. This will narrow down the number of records to a maximum of 30 times the number of employees, and has the following costs.

- Week Between Dates: T0 = O(W)
- Shift-Week Join: T1 = O(S*T0)
- Employee Equal to N: O(E)
- T1-Emp Join: T2 = O(SW) because there will only be 1 employee
- T2-Department Join: T3 = O(T2 D)
- T3-Time Join: T4 = O(T3 Time)
- T4-Weekday Join: T4 = O(T4 Weekday)
- Certification-Employee Join: T5 = O(C * E)
- T5-Role Join: T6 = O(T5 R)
- T4-T6 Join: T7 = O(T4 * T6)



Using the indexes stated has the following effect on the query execution time:

- Week Between Dates: T0 = O(W)
- Shift-Week Join: T1 = O(S*T0) $\rightarrow$ O(S*log T0)
- Employee Equal to N: O(E)
- T1-Emp Join: T2 = O(SW) because there will only be 1 employee
- T2-Department Join: T3 = O(T2 D)
- T3-Time Join: T4 = O(T3 Time)
- T4-Weekday Join: T4 = O(T4 Weekday)
- Certification-Employee Join: T5 = O(C * E)
- T5-Role Join: T6 = O(T5 R)
- T4-T6 Join: T7 = O(T4 * T6)

Example Data

day	day_name	shift_start	shift_end	fname	lname	dept_name	role
2017−10−06	FRI	07:00:00	15:00:00	Adam	Apple	OR	NP
2017−10−09	MON	07:00:00	15:00:00	Adam	Apple	OR	NP
2017−10−11	WED	07:00:00	15:00:00	Adam	Apple	ICU	NP
2017−10−13	FRI	07:00:00	15:00:00	Adam	Apple	ICU	NP
2017−10−26	THU	07:00:00	15:00:00	Adam	Apple	PSYCH	NP
2017−10−27	FRI	07:00:00	15:00:00	Adam	Apple	ICU	NP
2017−11−03	FRI	07:00:00	15:00:00	Adam	Apple	ICU	NP
2017−10−30	MON	07:00:00	15:00:00	Adam	Apple	QUAR	NP
2017−11−06	MON	07:00:00	15:00:00	Adam	Apple	ICU	NP
2017−10−05	THU	15:00:00	23:00:00	Adam	Apple	MAT	NP
2017−10−19	THU	15:00:00	23:00:00	Adam	Apple	ICU	NP
2017−10−20	FRI	15:00:00	23:00:00	Adam	Apple	OR	NP

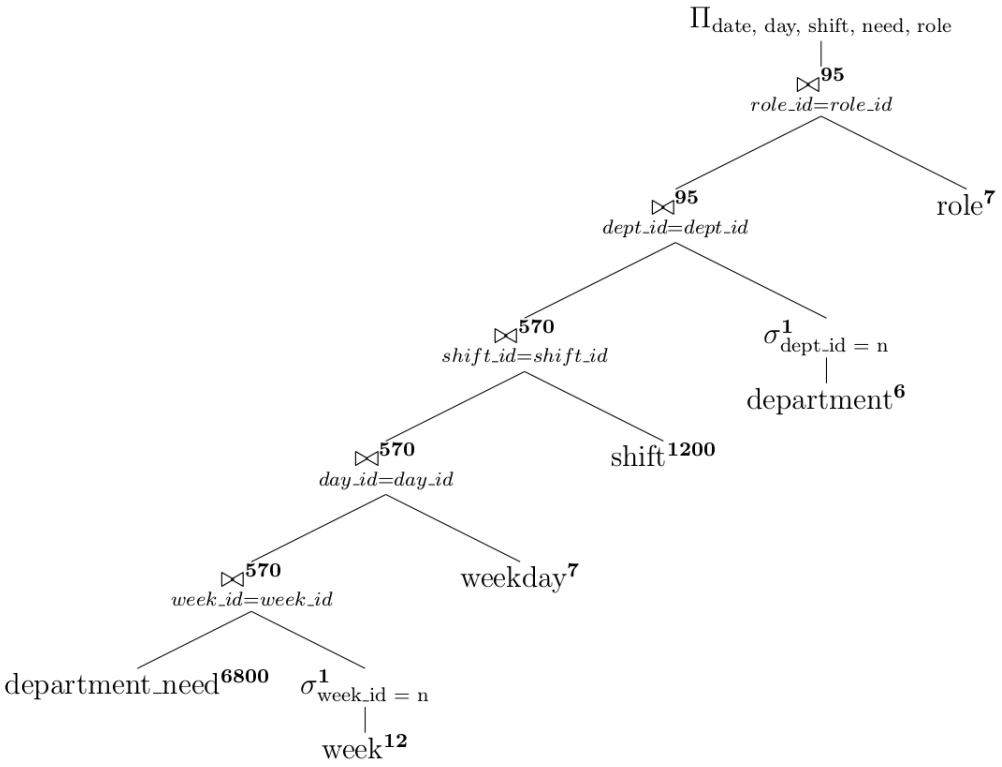
2017-10-16	MON	15:00:00	23:00:00	Adam	Apple	QUAR	NP
2017-11-10	FRI	15:00:00	23:00:00	Adam	Apple	QUAR	NP
2017-11-07	TUE	15:00:00	23:00:00	Adam	Apple	QUAR	NP
2017-10-04	WED	23:00:00	07:00:00	Adam	Apple	OR	NP
2017-10-23	MON	23:00:00	07:00:00	Adam	Apple	MAT	NP
2017-10-31	TUE	23:00:00	07:00:00	Adam	Apple	QUAR	NP
2017-10-07	SAT	07:00:00	19:00:00	Adam	Apple	MAT	NP
2017-10-01	SUN	07:00:00	19:00:00	Adam	Apple	MAT	NP
2017-10-15	SUN	07:00:00	19:00:00	Adam	Apple	ICU	NP
2017-10-22	SUN	07:00:00	19:00:00	Adam	Apple	MAT	NP
2017-11-04	SAT	07:00:00	19:00:00	Adam	Apple	OR	NP
2017-11-11	SAT	07:00:00	19:00:00	Adam	Apple	MAT	NP
2017-11-05	SUN	07:00:00	19:00:00	Adam	Apple	ER	NP
2017-10-14	SAT	19:00:00	07:00:00	Adam	Apple	ER	NP
2017-10-08	SUN	19:00:00	07:00:00	Adam	Apple	QUAR	NP
2017-10-21	SAT	19:00:00	07:00:00	Adam	Apple	ICU	NP
2017-10-28	SAT	19:00:00	07:00:00	Adam	Apple	ER	NP
2017-10-29	SUN	19:00:00	07:00:00	Adam	Apple	PSYCH	NP

Query 2

Query 2 returns a department's need for a single week including the week's start date, day of week, shift start time, shift end time, and needs per role per shift. The query can be tuned by changing the department ID and week ID.

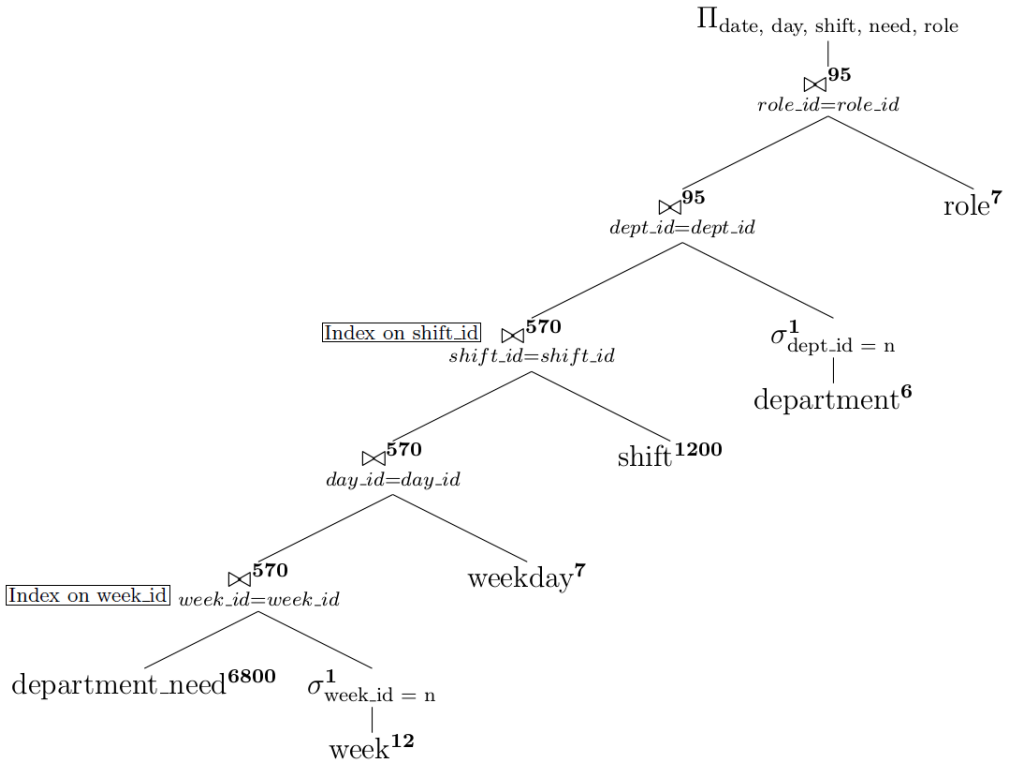
MySQL Query

```
SELECT
   department_need.day,
   weekday.day_name,
   shift_time.shift_start,
   shift_time.shift_end,
   department.dept_name,
   role.role,
   department_need.need
FROM department_need, week, weekday, shift_time, department, role
WHERE department_need.week_ID = 1
       AND department.dept_ID = 1
       AND department_need.week_ID = week.week_ID
       AND department_need.day_ID = weekday.day_ID
       AND department_need.time_ID = shift_time.time_ID
       AND department_need.dept_ID = department.dept_ID
       AND department_need.role_ID = role.role_ID;
```



For the second query the process is much similar to query one. The difference is that the table that is getting joined for the following select query is the departments table. Following the above principle one can optimize the run-time of the query by indexing shifts on shift_id and department_id to optimize the given big-O runtimes.

- Week Equals: T0 = O(W)
- Need-Week Join: T1 = O(N*T0)
- T1-Weekday: T2 = O(T1 Weekday)
- T2-Shift: T3 = O(T2 S)
- T3-Department: T4 = O(T3 D)
- T4-Role: T5 = O(T4 R)



Creating the indexing described above yields log(N) access for both the shifts and department tables, providing a significant speed up because these two tables will be the largest within the database. The optimized runtime changes are shown below:

- Need-Week Join: T1 = O(N*W) → O(log(N) * W)
- T1-Weekday: T2 = O(T1 Weekday)
- T2-Shift: T3 = O(T2 Shift) → O(T2 log(S))
- T3-Department: T4 = O(T3 D)
- T4-Role: T5 = O(T4 R)

Example Data

day	day_name	shift_start	shift_end	dept_name	role	need
2017−10−02	MON	07:00:00	15:00:00	ER	RN	2
2017−10−03	TUE	07:00:00	15:00:00	ER	RN	2
2017−10−04	WED	07:00:00	15:00:00	ER	RN	2
2017−10−05	THU	07:00:00	15:00:00	ER	RN	3
2017−10−06	FRI	07:00:00	15:00:00	ER	RN	2
2017−10−02	MON	15:00:00	23:00:00	ER	RN	2
2017−10−03	TUE	15:00:00	23:00:00	ER	RN	2
2017−10−04	WED	15:00:00	23:00:00	ER	RN	2
2017−10−05	THU	15:00:00	23:00:00	ER	RN	3
2017−10−06	FRI	15:00:00	23:00:00	ER	RN	3
2017−10−02	MON	23:00:00	07:00:00	ER	RN	2
2017−10−03	TUE	23:00:00	07:00:00	ER	RN	3
2017−10−04	WED	23:00:00	07:00:00	ER	RN	2
2017−10−05	THU	23:00:00	07:00:00	ER	RN	3
2017−10−06	FRI	23:00:00	07:00:00	ER	RN	3
2017−10−01	SUN	07:00:00	19:00:00	ER	RN	3
2017−10−07	SAT	07:00:00	19:00:00	ER	RN	3
2017−10−01	SUN	19:00:00	07:00:00	ER	RN	2
2017−10−07	SAT	19:00:00	07:00:00	ER	RN	2

2017-10-02	MON	07:00:00	15:00:00	ER	LPN	2
2017-10-03	TUE	07:00:00	15:00:00	ER	LPN	2
2017-10-04	WED	07:00:00	15:00:00	ER	LPN	3
2017-10-05	THU	07:00:00	15:00:00	ER	LPN	2
2017-10-06	FRI	07:00:00	15:00:00	ER	LPN	3
2017-10-02	MON	15:00:00	23:00:00	ER	LPN	3
2017-10-03	TUE	15:00:00	23:00:00	ER	LPN	2
2017-10-04	WED	15:00:00	23:00:00	ER	LPN	2
2017-10-05	THU	15:00:00	23:00:00	ER	LPN	2
2017-10-06	FRI	15:00:00	23:00:00	ER	LPN	3
2017-10-02	MON	23:00:00	07:00:00	ER	LPN	2
2017-10-03	TUE	23:00:00	07:00:00	ER	LPN	2
2017-10-04	WED	23:00:00	07:00:00	ER	LPN	3
2017-10-05	THU	23:00:00	07:00:00	ER	LPN	3
2017-10-06	FRI	23:00:00	07:00:00	ER	LPN	2
2017-10-01	SUN	07:00:00	19:00:00	ER	LPN	2
2017-10-07	SAT	07:00:00	19:00:00	ER	LPN	3
2017-10-01	SUN	19:00:00	07:00:00	ER	LPN	3
2017-10-07	SAT	19:00:00	07:00:00	ER	LPN	2
2017-10-02	MON	07:00:00	15:00:00	ER	NP	2
2017-10-03	TUE	07:00:00	15:00:00	ER	NP	3
2017-10-04	WED	07:00:00	15:00:00	ER	NP	3
2017-10-05	THU	07:00:00	15:00:00	ER	NP	2
2017-10-06	FRI	07:00:00	15:00:00	ER	NP	2
2017-10-02	MON	15:00:00	23:00:00	ER	NP	2
2017-10-03	TUE	15:00:00	23:00:00	ER	NP	3
2017-10-04	WED	15:00:00	23:00:00	ER	NP	3
2017-10-05	THU	15:00:00	23:00:00	ER	NP	3
2017-10-06	FRI	15:00:00	23:00:00	ER	NP	3
2017-10-02	MON	23:00:00	07:00:00	ER	NP	2
2017-10-03	TUE	23:00:00	07:00:00	ER	NP	2
2017-10-04	WED	23:00:00	07:00:00	ER	NP	2
2017-10-05	THU	23:00:00	07:00:00	ER	NP	3
2017-10-06	FRI	23:00:00	07:00:00	ER	NP	2
2017-10-01	SUN	07:00:00	19:00:00	ER	NP	2
2017-10-07	SAT	07:00:00	19:00:00	ER	NP	3
2017-10-01	SUN	19:00:00	07:00:00	ER	NP	3
2017-10-07	SAT	19:00:00	07:00:00	ER	NP	2
2017-10-02	MON	07:00:00	15:00:00	ER	CNS	3
2017-10-03	TUE	07:00:00	15:00:00	ER	CNS	2
2017-10-04	WED	07:00:00	15:00:00	ER	CNS	3
2017-10-05	THU	07:00:00	15:00:00	ER	CNS	2
2017-10-06	FRI	07:00:00	15:00:00	ER	CNS	2
2017-10-02	MON	15:00:00	23:00:00	ER	CNS	2
2017-10-03	TUE	15:00:00	23:00:00	ER	CNS	3
2017-10-04	WED	15:00:00	23:00:00	ER	CNS	3
2017-10-05	THU	15:00:00	23:00:00	ER	CNS	2
2017-10-06	FRI	15:00:00	23:00:00	ER	CNS	2
2017-10-02	MON	23:00:00	07:00:00	ER	CNS	3
2017-10-03	TUE	23:00:00	07:00:00	ER	CNS	3
2017-10-04	WED	23:00:00	07:00:00	ER	CNS	3
2017-10-05	THU	23:00:00	07:00:00	ER	CNS	2
2017-10-06	FRI	23:00:00	07:00:00	ER	CNS	2
2017-10-01	SUN	07:00:00	19:00:00	ER	CNS	3
2017-10-07	SAT	07:00:00	19:00:00	ER	CNS	2
2017-10-01	SUN	19:00:00	07:00:00	ER	CNS	3
2017-10-07	SAT	19:00:00	07:00:00	ER	CNS	3
2017-10-02	MON	07:00:00	15:00:00	ER	NA	3
2017-10-03	TUE	07:00:00	15:00:00	ER	NA	3
2017-10-04	WED	07:00:00	15:00:00	ER	NA	3
2017-10-05	THU	07:00:00	15:00:00	ER	NA	2
2017-10-06	FRI	07:00:00	15:00:00	ER	NA	2
2017-10-02	MON	15:00:00	23:00:00	ER	NA	2
2017-10-03	TUE	15:00:00	23:00:00	ER	NA	3
2017-10-04	WED	15:00:00	23:00:00	ER	NA	2
2017-10-05	THU	15:00:00	23:00:00	ER	NA	3
2017-10-06	FRI	15:00:00	23:00:00	ER	NA	2
2017-10-02	MON	23:00:00	07:00:00	ER	NA	2
2017-10-03	TUE	23:00:00	07:00:00	ER	NA	3
2017-10-04	WED	23:00:00	07:00:00	ER	NA	2
2017-10-05	THU	23:00:00	07:00:00	ER	NA	2
2017-10-06	FRI	23:00:00	07:00:00	ER	NA	2

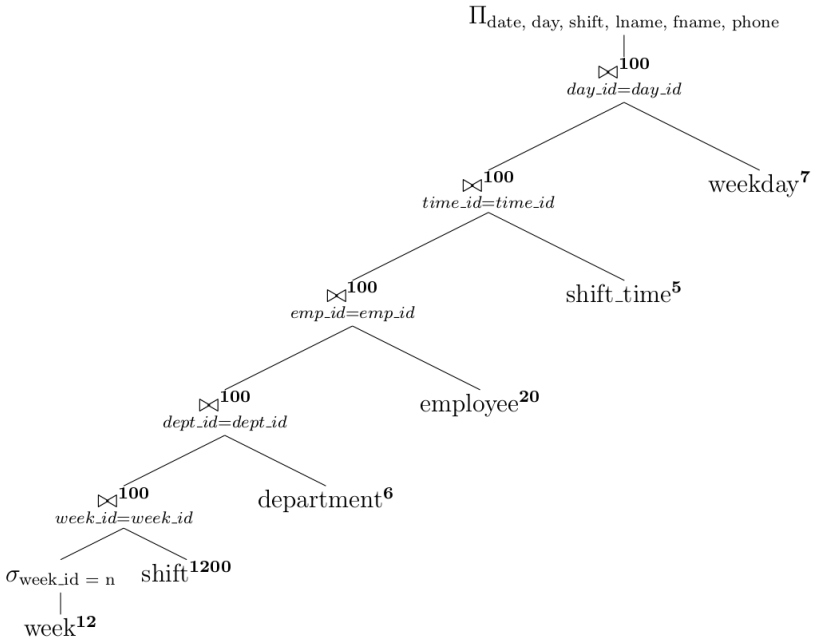
```
| 2017-10-01 | SUN | 07:00:00 | 19:00:00 | ER | NA | 3 |
| 2017-10-07 | SAT | 07:00:00 | 19:00:00 | ER | NA | 2 |
| 2017-10-01 | SUN | 19:00:00 | 07:00:00 | ER | NA | 2 |
| 2017-10-07 | SAT | 19:00:00 | 07:00:00 | ER | NA | 2 |
```

Query 3

Query 3 will give a single department's schedule for a specified week, ordered by the employee's names. Included information shall contain the start date of the week, the day of the week, shift start and end times, the employee's name, and their phone number. The department and week ID values will need to be changed in order to get the desired data.

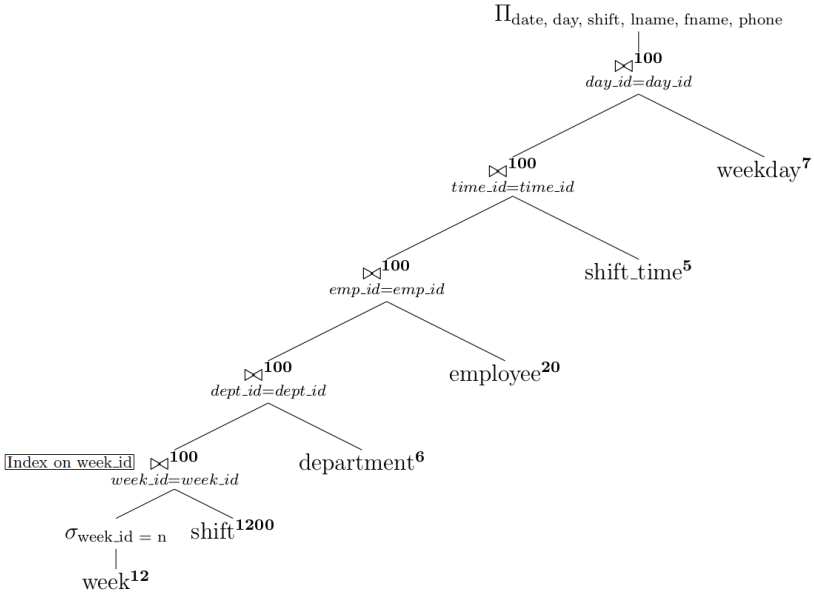
MySQL Query

```
SELECT
   department.dept_name,
   employee.fname,
   employee.lname,
   employee.phone1,
   shift.day,
   weekday.day_name,
   shift_time.shift_start,
   shift_time.shift_end
FROM department, week, employee, shift, shift_time, weekday
WHERE week.week_ID = 1
      AND shift.emp_ID = employee.emp_ID
      AND shift.dept_ID = department.dept_ID
      AND shift.time_ID = shift_time.time_ID
      AND shift.week_ID = week.week_ID
      AND shift.day_ID = weekday.day_ID;
```



For the third query a similar index scheme will be implemented on the shift table between the shift.week_id and week.week_id. The largest amount of comparisons occur during this table join. The time complexities for the joins are shown in the following list.

- Week = N: T1 = O(Week)
- T1-Shift Join: T2 = O(T1 S)
- T2-Department Join: T3 = O(T2 D)
- T3-Employee Join: T4 = O(T3 E)
- T4-Shift Time Join: T5 = O(T4 ST)
- T5-Weekday Join: T6 = O(T5 WD)



The third query would experience the largest enhancement in the join between the tables from O(m*n) to O(log(m*n)+c) due to the ability to conduct a binary search on the values corresponding to the correct week ID for both tables and a linear search to find the beginning and end of that week.

- Week = N: T1 = O(Week)
- T1-Shift Join: T2 = O(T1 S) →O(T1 log(S))
- T2-Department Join: T3 = O(T2 D)
- T3-Employee Join: T4 = O(T3 E)
- T4-Shift Time Join: T5 = O(T4 ST)
- T5-Weekday Join: T6 = O(T5 WD)

Example Data

dept_name	fname	lname	phone1	day	day_name	shift_start	shift_end
OR	Adam	Apple	000−000−0001	2017−10−06	FRI	07:00:00	15:00:00
PSYCH	Derek	Davis	000−000−0004	2017−10−05	THU	07:00:00	15:00:00
QUAR	Evan	Elliott	000−000−0005	2017−10−05	THU	07:00:00	15:00:00
MAT	Evan	Elliott	000−000−0005	2017−10−03	TUE	07:00:00	15:00:00
MAT	Frank	Farris	000−000−0006	2017−10−02	MON	07:00:00	15:00:00
PSYCH	George	Grant	000−000−0007	2017−10−03	TUE	07:00:00	15:00:00
QUAR	George	Grant	000−000−0007	2017−10−02	MON	07:00:00	15:00:00

QUAR	Hank	Hamill	000-000-0008	2017-10-05	THU	07:00:00	15:00:00
PSYCH	Jack	Joplin	000-000-0010	2017-10-05	THU	07:00:00	15:00:00
QUAR	Kevin	Keller	000-000-0011	2017-10-04	WED	07:00:00	15:00:00
ER	Mark	Morris	000-000-0013	2017-10-05	THU	07:00:00	15:00:00
ER	Mark	Morris	000-000-0013	2017-10-06	FRI	07:00:00	15:00:00
QUAR	Mark	Morris	000-000-0013	2017-10-03	TUE	07:00:00	15:00:00
OR	Orval	Obrian	000-000-0015	2017-10-02	MON	07:00:00	15:00:00
OR	Orval	Obrian	000-000-0015	2017-10-05	THU	07:00:00	15:00:00
ICU	Peter	Parker	000-000-0016	2017-10-05	THU	07:00:00	15:00:00
ER	Quinn	Quarrick	000-000-0017	2017-10-02	MON	07:00:00	15:00:00
MAT	Quinn	Quarrick	000-000-0017	2017-10-06	FRI	07:00:00	15:00:00
QUAR	Robert	Rodgers	000-000-0018	2017-10-05	THU	07:00:00	15:00:00
MAT	Robert	Rodgers	000-000-0018	2017-10-06	FRI	07:00:00	15:00:00
OR	Tom	Tarantino	000-000-0020	2017-10-05	THU	07:00:00	15:00:00
MAT	Adam	Apple	000-000-0001	2017-10-05	THU	15:00:00	23:00:00
OR	Charles	Chaplan	000-000-0003	2017-10-04	WED	15:00:00	23:00:00
OR	Charles	Chaplan	000-000-0003	2017-10-06	FRI	15:00:00	23:00:00
QUAR	Derek	Davis	000-000-0004	2017-10-03	TUE	15:00:00	23:00:00
MAT	Evan	Elliott	000-000-0005	2017-10-06	FRI	15:00:00	23:00:00
QUAR	Frank	Farris	000-000-0006	2017-10-05	THU	15:00:00	23:00:00
ER	Frank	Farris	000-000-0006	2017-10-06	FRI	15:00:00	23:00:00
QUAR	George	Grant	000-000-0007	2017-10-06	FRI	15:00:00	23:00:00
ICU	Hank	Hamill	000-000-0008	2017-10-06	FRI	15:00:00	23:00:00
MAT	Ivan	Ikarov	000-000-0009	2017-10-03	TUE	15:00:00	23:00:00
ER	Ivan	Ikarov	000-000-0009	2017-10-06	FRI	15:00:00	23:00:00
PSYCH	Jack	Joplin	000-000-0010	2017-10-03	TUE	15:00:00	23:00:00
OR	Jack	Joplin	000-000-0010	2017-10-02	MON	15:00:00	23:00:00
ICU	Kevin	Keller	000-000-0011	2017-10-06	FRI	15:00:00	23:00:00
ER	Lenny	Landman	000-000-0012	2017-10-06	FRI	15:00:00	23:00:00
PSYCH	Lenny	Landman	000-000-0012	2017-10-02	MON	15:00:00	23:00:00
ER	Lenny	Landman	000-000-0012	2017-10-04	WED	15:00:00	23:00:00
ER	Nick	Norton	000-000-0014	2017-10-05	THU	15:00:00	23:00:00
ER	Nick	Norton	000-000-0014	2017-10-04	WED	15:00:00	23:00:00
PSYCH	Nick	Norton	000-000-0014	2017-10-02	MON	15:00:00	23:00:00
QUAR	Orval	Obrian	000-000-0015	2017-10-06	FRI	15:00:00	23:00:00
QUAR	Peter	Parker	000-000-0016	2017-10-03	TUE	15:00:00	23:00:00
MAT	Peter	Parker	000-000-0016	2017-10-06	FRI	15:00:00	23:00:00
OR	Sam	Saville	000-000-0019	2017-10-03	TUE	15:00:00	23:00:00
OR	Tom	Tarantino	000-000-0020	2017-10-06	FRI	15:00:00	23:00:00
OR	Adam	Apple	000-000-0001	2017-10-04	WED	23:00:00	07:00:00
MAT	Brad	Baker	000-000-0002	2017-10-04	WED	23:00:00	07:00:00
PSYCH	Brad	Baker	000-000-0002	2017-10-02	MON	23:00:00	07:00:00
OR	Brad	Baker	000-000-0002	2017-10-06	FRI	23:00:00	07:00:00
OR	Charles	Chaplan	000-000-0003	2017-10-03	TUE	23:00:00	07:00:00
MAT	Derek	Davis	000-000-0004	2017-10-04	WED	23:00:00	07:00:00
PSYCH	Frank	Farris	000-000-0006	2017-10-04	WED	23:00:00	07:00:00
OR	Hank	Hamill	000-000-0008	2017-10-03	TUE	23:00:00	07:00:00
OR	Hank	Hamill	000-000-0008	2017-10-04	WED	23:00:00	07:00:00
ER	Ivan	Ikarov	000-000-0009	2017-10-05	THU	23:00:00	07:00:00
PSYCH	Jack	Joplin	000-000-0010	2017-10-04	WED	23:00:00	07:00:00
PSYCH	Kevin	Keller	000-000-0011	2017-10-03	TUE	23:00:00	07:00:00
QUAR	Mark	Morris	000-000-0013	2017-10-04	WED	23:00:00	07:00:00
MAT	Peter	Parker	000-000-0016	2017-10-04	WED	23:00:00	07:00:00
ICU	Quinn	Quarrick	000-000-0017	2017-10-05	THU	23:00:00	07:00:00
MAT	Quinn	Quarrick	000-000-0017	2017-10-03	TUE	23:00:00	07:00:00
PSYCH	Robert	Rodgers	000-000-0018	2017-10-03	TUE	23:00:00	07:00:00
ICU	Sam	Saville	000-000-0019	2017-10-05	THU	23:00:00	07:00:00
ICU	Sam	Saville	000-000-0019	2017-10-04	WED	23:00:00	07:00:00
PSYCH	Tom	Tarantino	000-000-0020	2017-10-04	WED	23:00:00	07:00:00
PSYCH	Tom	Tarantino	000-000-0020	2017-10-02	MON	23:00:00	07:00:00
MAT	Adam	Apple	000-000-0001	2017-10-07	SAT	07:00:00	19:00:00
MAT	Adam	Apple	000-000-0001	2017-10-01	SUN	07:00:00	19:00:00
MAT	Charles	Chaplan	000-000-0003	2017-10-01	SUN	07:00:00	19:00:00
ER	Derek	Davis	000-000-0004	2017-10-07	SAT	07:00:00	19:00:00
OR	Evan	Elliott	000-000-0005	2017-10-01	SUN	07:00:00	19:00:00
QUAR	Evan	Elliott	000-000-0005	2017-10-07	SAT	07:00:00	19:00:00
PSYCH	George	Grant	000-000-0007	2017-10-01	SUN	07:00:00	19:00:00
ICU	George	Grant	000-000-0007	2017-10-07	SAT	07:00:00	19:00:00
PSYCH	Ivan	Ikarov	000-000-0009	2017-10-07	SAT	07:00:00	19:00:00
OR	Lenny	Landman	000-000-0012	2017-10-07	SAT	07:00:00	19:00:00
ER	Lenny	Landman	000-000-0012	2017-10-01	SUN	07:00:00	19:00:00
ER	Mark	Morris	000-000-0013	2017-10-01	SUN	07:00:00	19:00:00

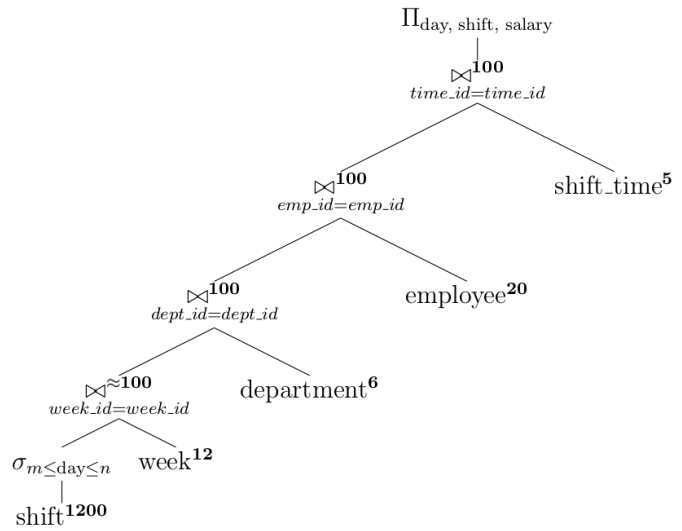
OR	Nick	Norton	000-000-0014	2017-10-01	SUN	07:00:00	19:00:00
ER	Nick	Norton	000-000-0014	2017-10-07	SAT	07:00:00	19:00:00
ICU	Orval	Obrian	000-000-0015	2017-10-01	SUN	07:00:00	19:00:00
MAT	Orval	Obrian	000-000-0015	2017-10-07	SAT	07:00:00	19:00:00
PSYCH	Robert	Rodgers	000-000-0018	2017-10-07	SAT	07:00:00	19:00:00
OR	Sam	Saville	000-000-0019	2017-10-07	SAT	07:00:00	19:00:00
QUAR	Tom	Tarantino	000-000-0020	2017-10-07	SAT	07:00:00	19:00:00
OR	Brad	Baker	000-000-0002	2017-10-07	SAT	19:00:00	07:00:00
PSYCH	Brad	Baker	000-000-0002	2017-10-01	SUN	19:00:00	07:00:00
PSYCH	Charles	Chaplan	000-000-0003	2017-10-07	SAT	19:00:00	07:00:00
MAT	Derek	Davis	000-000-0004	2017-10-01	SUN	19:00:00	07:00:00
PSYCH	Frank	Farris	000-000-0006	2017-10-01	SUN	19:00:00	07:00:00
ICU	Hank	Hamill	000-000-0008	2017-10-01	SUN	19:00:00	07:00:00
PSYCH	Ivan	Ikarov	000-000-0009	2017-10-01	SUN	19:00:00	07:00:00
PSYCH	Jack	Joplin	000-000-0010	2017-10-07	SAT	19:00:00	07:00:00
QUAR	Kevin	Keller	000-000-0011	2017-10-07	SAT	19:00:00	07:00:00
PSYCH	Kevin	Keller	000-000-0011	2017-10-01	SUN	19:00:00	07:00:00
ER	Peter	Parker	000-000-0016	2017-10-01	SUN	19:00:00	07:00:00
QUAR	Quinn	Quarrick	000-000-0017	2017-10-01	SUN	19:00:00	07:00:00
QUAR	Robert	Rodgers	000-000-0018	2017-10-01	SUN	19:00:00	07:00:00
ER	Sam	Saville	000-000-0019	2017-10-01	SUN	19:00:00	07:00:00

Query 4

Query 4 will return an employee's pay rate, department, shift start, and shift end times per shift when given a range of dates sorted by date and then shift start time. The total cost per shift shall be calculated by the data parser supplied by you.

MySQL Query

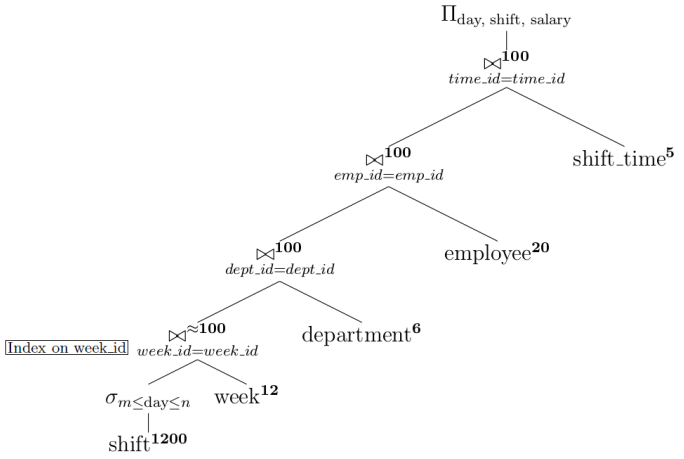
```
SELECT
   department.dept_name,
   employee.fname,
   employee.lname,
   shift.day,
   shift_time.shift_start,
   shift_time.shift_end,
   employee.hourly_pay,
   shift_status.status
FROM department, employee, shift, shift_time, week, shift_status
WHERE shift.day >= '2017-10-01'
      AND shift.day <= '2017-10-05'
      AND shift.emp_ID = employee.emp_ID
      AND shift.dept_ID = department.dept_ID
      AND shift.time_ID = shift_time.time_ID
      AND shift.week_ID = week.week_ID
      AND shift.status_ID = shift_status.status_ID;
```



Query 4 will also benefit from an index on the shift table between the shift.week_id and week.week_id. Again, the largest amount of comparisons occur during this table join. The time complexities for the joins are shown in the following list.

- Shift Between Days: T1 = O(S)
- T1-Week Join: T2 = O(T1 W)
- T2-Department Join: T3 = O(T2 D)
- T3-Employee Join: T4 = O(T3 E)
- T4-Shift Time Join: T5 = O(T4 ST)

.



For the fourth query, selecting the shifts between date ranges is the only step involving large amounts of data to compare. Indexing this first step would be the most beneficial to the query execution and would result in the new execution time below.

- Shift Between Days: T1 = O(S) $\rightarrow$ O(log(S))
- T1-Week Join: T2 = O(T1 W)
- T2-Department Join: T3 = O(T2 D)
- T3-Employee Join: T4 = O(T3 E)
- T4-Shift Time Join: T5 = O(T4 ST)

Example Data

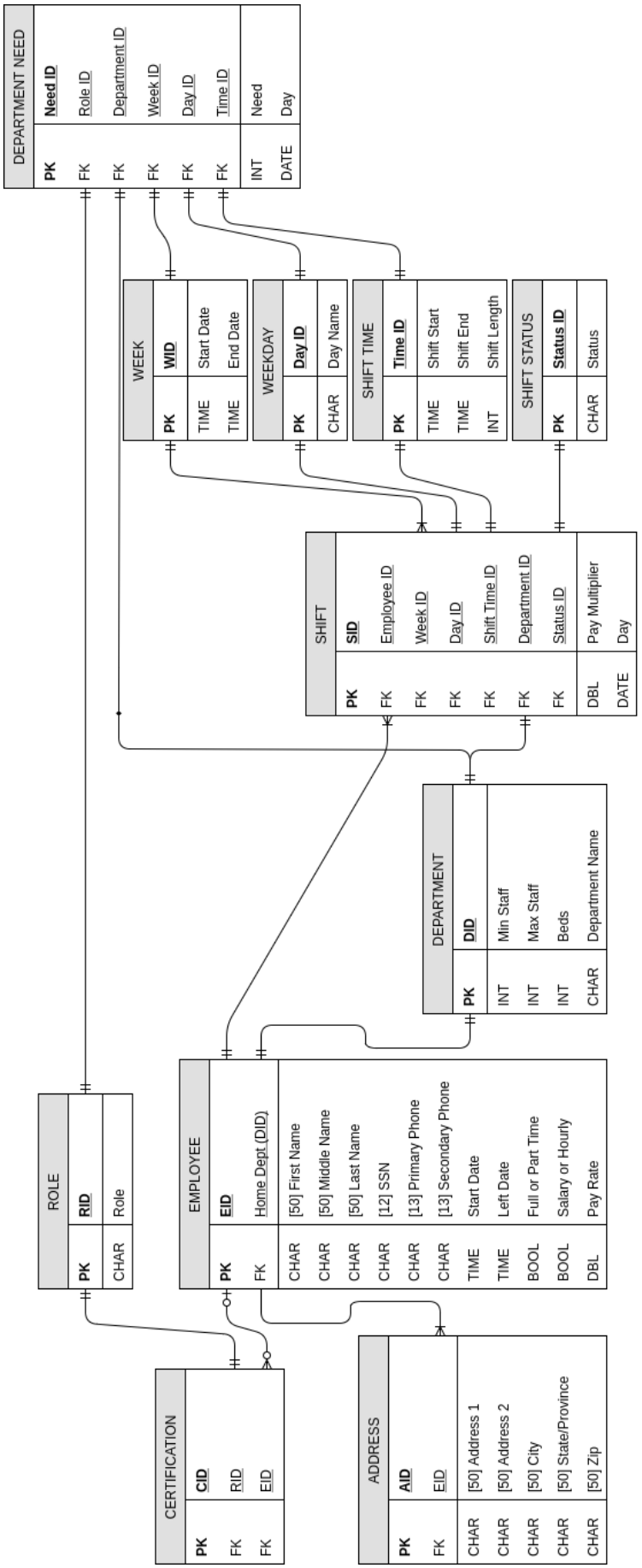
dept_name	fname	lname	day	shift_start	shift_end	hourly_pay	status
OR	Adam	Apple	2017-10-04	23:00:00	07:00:00	22.5	CallIn
MAT	Adam	Apple	2017-10-05	15:00:00	23:00:00	22.5	CallOff
MAT	Adam	Apple	2017-10-01	07:00:00	19:00:00	22.5	ReqIn
MAT	Brad	Baker	2017-10-04	23:00:00	07:00:00	15	CallOff
PSYCH	Brad	Baker	2017-10-02	23:00:00	07:00:00	15	CallIn
PSYCH	Brad	Baker	2017-10-01	19:00:00	07:00:00	15	ReqIn
OR	Charles	Chaplan	2017-10-04	15:00:00	23:00:00	37	CallOff
OR	Charles	Chaplan	2017-10-03	23:00:00	07:00:00	37	ReqIn
MAT	Charles	Chaplan	2017-10-01	07:00:00	19:00:00	37	ReqOff
MAT	Derek	Davis	2017-10-01	19:00:00	07:00:00	40	CallIn
PSYCH	Derek	Davis	2017-10-05	07:00:00	15:00:00	40	CallOff
MAT	Derek	Davis	2017-10-04	23:00:00	07:00:00	40	ReqOff
QUAR	Derek	Davis	2017-10-03	15:00:00	23:00:00	40	CallOff
OR	Evan	Elliott	2017-10-01	07:00:00	19:00:00	21	ReqOff
QUAR	Evan	Elliott	2017-10-05	07:00:00	15:00:00	21	ReqOff
MAT	Evan	Elliott	2017-10-03	07:00:00	15:00:00	21	CallOff
PSYCH	Frank	Farris	2017-10-01	19:00:00	07:00:00	32	CallIn
MAT	Frank	Farris	2017-10-02	07:00:00	15:00:00	32	CallIn
QUAR	Frank	Farris	2017-10-05	15:00:00	23:00:00	32	ReqIn
PSYCH	Frank	Farris	2017-10-04	23:00:00	07:00:00	32	CallOff
PSYCH	George	Grant	2017-10-01	07:00:00	19:00:00	19	ReqOff
PSYCH	George	Grant	2017-10-03	07:00:00	15:00:00	19	ReqIn
QUAR	George	Grant	2017-10-02	07:00:00	15:00:00	19	CallIn
OR	Hank	Hamill	2017-10-03	23:00:00	07:00:00	21	CallOff
OR	Hank	Hamill	2017-10-04	23:00:00	07:00:00	21	ReqOff
ICU	Hank	Hamill	2017-10-01	19:00:00	07:00:00	21	CallIn
QUAR	Hank	Hamill	2017-10-05	07:00:00	15:00:00	21	ReqIn
ER	Ivan	Ikarov	2017-10-05	23:00:00	07:00:00	24	ReqIn
PSYCH	Ivan	Ikarov	2017-10-01	19:00:00	07:00:00	24	ReqIn
MAT	Ivan	Ikarov	2017-10-03	15:00:00	23:00:00	24	CallOff
PSYCH	Jack	Joplin	2017-10-03	15:00:00	23:00:00	21	CallOff
PSYCH	Jack	Joplin	2017-10-05	07:00:00	15:00:00	21	CallIn
PSYCH	Jack	Joplin	2017-10-04	23:00:00	07:00:00	21	ReqOff
OR	Jack	Joplin	2017-10-02	15:00:00	23:00:00	21	ReqIn
PSYCH	Kevin	Keller	2017-10-03	23:00:00	07:00:00	20	ReqOff
PSYCH	Kevin	Keller	2017-10-01	19:00:00	07:00:00	20	CallOff
QUAR	Kevin	Keller	2017-10-04	07:00:00	15:00:00	20	ReqIn
PSYCH	Lenny	Landman	2017-10-02	15:00:00	23:00:00	17	CallIn
ER	Lenny	Landman	2017-10-01	07:00:00	19:00:00	17	CallOff
ER	Lenny	Landman	2017-10-04	15:00:00	23:00:00	17	ReqOff
ER	Mark	Morris	2017-10-05	07:00:00	15:00:00	32	CallOff
ER	Mark	Morris	2017-10-01	07:00:00	19:00:00	32	ReqIn
QUAR	Mark	Morris	2017-10-03	07:00:00	15:00:00	32	CallOff
QUAR	Mark	Morris	2017-10-04	23:00:00	07:00:00	32	CallOff
ER	Nick	Norton	2017-10-05	15:00:00	23:00:00	23	CallOff
ER	Nick	Norton	2017-10-04	15:00:00	23:00:00	23	ReqOff
OR	Nick	Norton	2017-10-01	07:00:00	19:00:00	23	CallIn
PSYCH	Nick	Norton	2017-10-02	15:00:00	23:00:00	23	CallIn
ICU	Orval	Obrian	2017-10-01	07:00:00	19:00:00	30	CallOff
OR	Orval	Obrian	2017-10-02	07:00:00	15:00:00	30	ReqOff
OR	Orval	Obrian	2017-10-05	07:00:00	15:00:00	30	CallIn
ER	Peter	Parker	2017-10-01	19:00:00	07:00:00	39	CallIn
QUAR	Peter	Parker	2017-10-03	15:00:00	23:00:00	39	CallIn
MAT	Peter	Parker	2017-10-04	23:00:00	07:00:00	39	ReqIn
ICU	Peter	Parker	2017-10-05	07:00:00	15:00:00	39	CallIn
ICU	Quinn	Quarrick	2017-10-05	23:00:00	07:00:00	15	ReqIn
QUAR	Quinn	Quarrick	2017-10-01	19:00:00	07:00:00	15	ReqIn
ER	Quinn	Quarrick	2017-10-02	07:00:00	15:00:00	15	CallIn
MAT	Quinn	Quarrick	2017-10-03	23:00:00	07:00:00	15	ReqOff
PSYCH	Robert	Rodgers	2017-10-03	23:00:00	07:00:00	17	ReqIn
QUAR	Robert	Rodgers	2017-10-05	07:00:00	15:00:00	17	ReqIn
QUAR	Robert	Rodgers	2017-10-01	19:00:00	07:00:00	17	ReqOff
ICU	Sam	Saville	2017-10-05	23:00:00	07:00:00	38	CallIn
ER	Sam	Saville	2017-10-01	19:00:00	07:00:00	38	ReqOff
OR	Sam	Saville	2017-10-03	15:00:00	23:00:00	38	CallIn
ICU	Sam	Saville	2017-10-04	23:00:00	07:00:00	38	CallOff

PSYCH	Tom	Tarantino	2017-10-04	23:00:00	07:00:00	27	CallOff
OR	Tom	Tarantino	2017-10-05	07:00:00	15:00:00	27	ReqOff
PSYCH	Tom	Tarantino	2017-10-02	23:00:00	07:00:00	27	ReqIn

Final Notes

In closing, the supplied data model, table structures, and queries will return the data required by the specification documents. The indexes implemented should provide a considerable performance enhancement as the database grows. Output returned by the MySQL queries shall be parse-able by the program supplied by your company in order to create the desired output formats.

Data Model


DEPARTMENT NEED
PK Need ID
FK Role ID
FK Department ID
FK Week ID
FK Day ID
FK Time ID
INT Need
DATE Day
WEEK
PK WID
TIME Start Date
TIME End Date
WEEKDAY
PK Day ID
CHAR Day Name
SHIFT TIME
PK Time ID
TIME Shift Start
TIME Shift End
INT Shift Length
SHIFT STATUS
PK Status ID
CHAR Status
SHIFT
PK SID
FK Employee ID
FK Week ID
FK Day ID
FK Shift Time ID
FK Department ID
FK Status ID
DBL Pay Multiplier
DATE Day
DEPARTMENT
PK DID
INT Min Staff
INT Max Staff
INT Beds
CHAR Department Name
ROLE
PK RID
CHAR Role
EMPLOYEE
PK EID
FK Home Dept (DID)
CHAR [50] First Name
CHAR [50] Middle Name
CHAR [50] Last Name
CHAR [12] SSN
CHAR [13] Primary Phone
CHAR [13] Secondary Phone
TIME Start Date
TIME Left Date
BOOL Full or Part Time
BOOL Salary or Hourly
DBL Pay Rate
CERTIFICATION
PK CID
FK RID
FK EID
ADDRESS
PK AID
FK EID
CHAR [50] Address 1
CHAR [50] Address 2
CHAR [50] City
CHAR [50] State/Province
CHAR [50] Zip