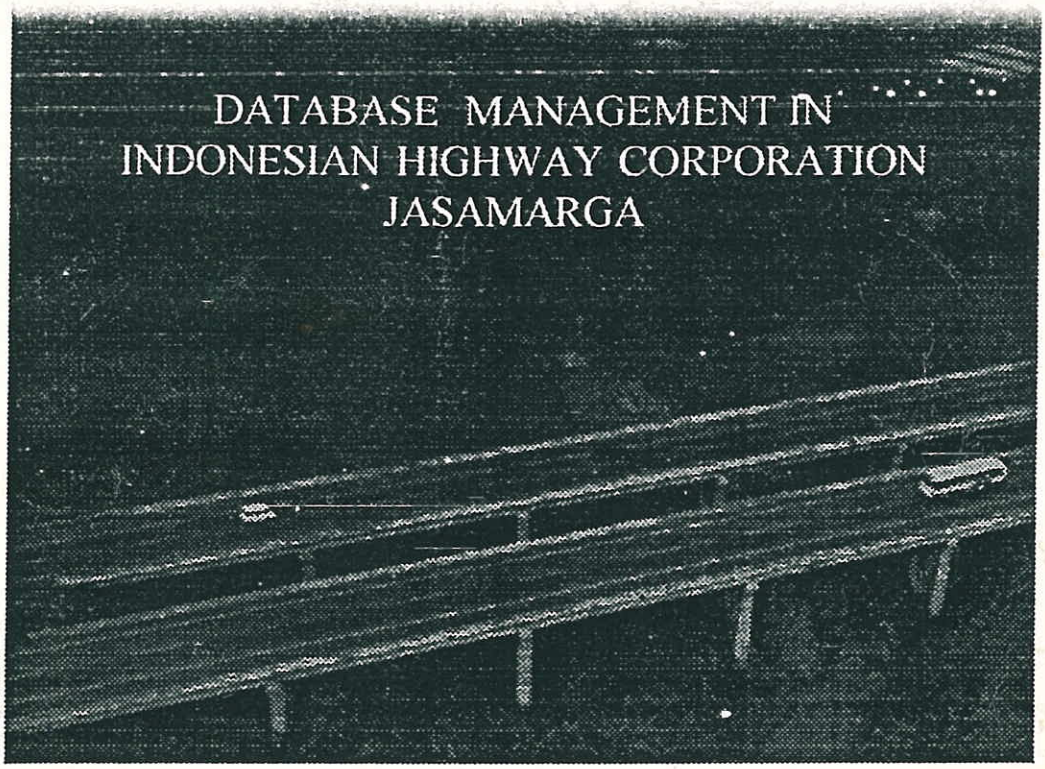
Database Management Paper



by:

Stepan Babayan
James High
Abdul Kamarzuki
Irwan Prasetyo

May 4, 1995

Carnegie Mellon University
John Heinz III School of Public Policy and Management

Description of Organization

The Indonesian Highway Corporation (JASAMARGA) plays two important roles, first as a provider of a vital national good (the expressways), and second as a profit-maximizing enterprise. The performance is determined by the length of toll roads, toll revenue, total assets, and profit.

The company's funds are derived from toll revenues, the issuance the of bonds and foreign loans. These funds remain insufficient to finance the construction of new toll roads given the increasing demand.

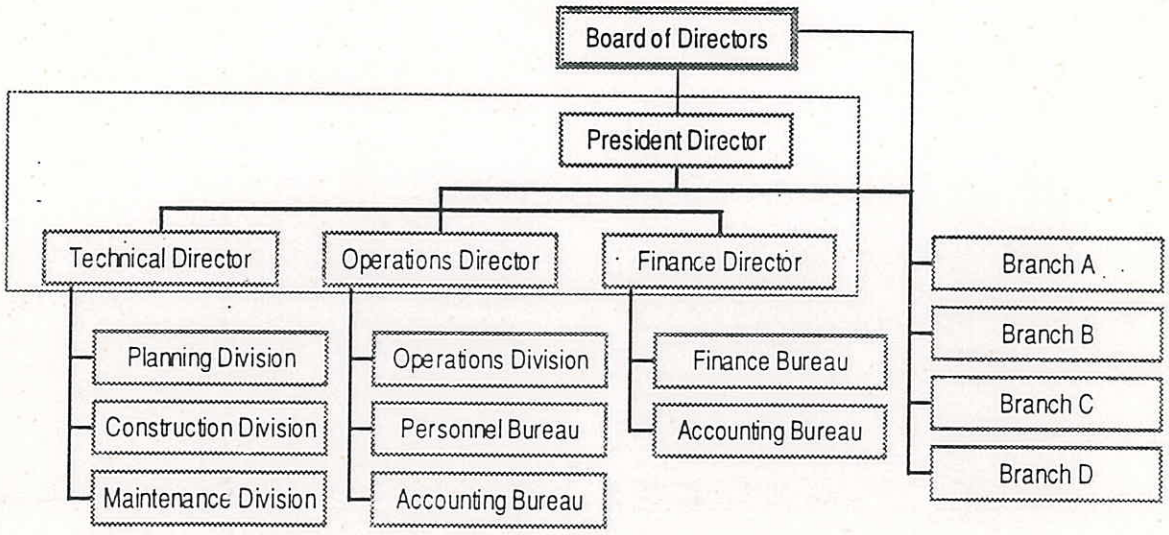
Traffic growth in Indonesia, especially in urban areas, is 9-10 % per year, but the infrastructure growth is much slower.

JASAMARGA has 11 branch and regional offices spread throughout the islands. Each branch office is in charge of maintaining a road link with on/off ramps, and toll gates. Each branch has an average of 6 gates (one gate has both a destination gate and an origin gate).

Daily traffic is counted at the toll gates. Traffic is defined by vehicle type: Passenger Car, Bus, and Heavy Truck. Each vehicle type is charged a respective toll fee.

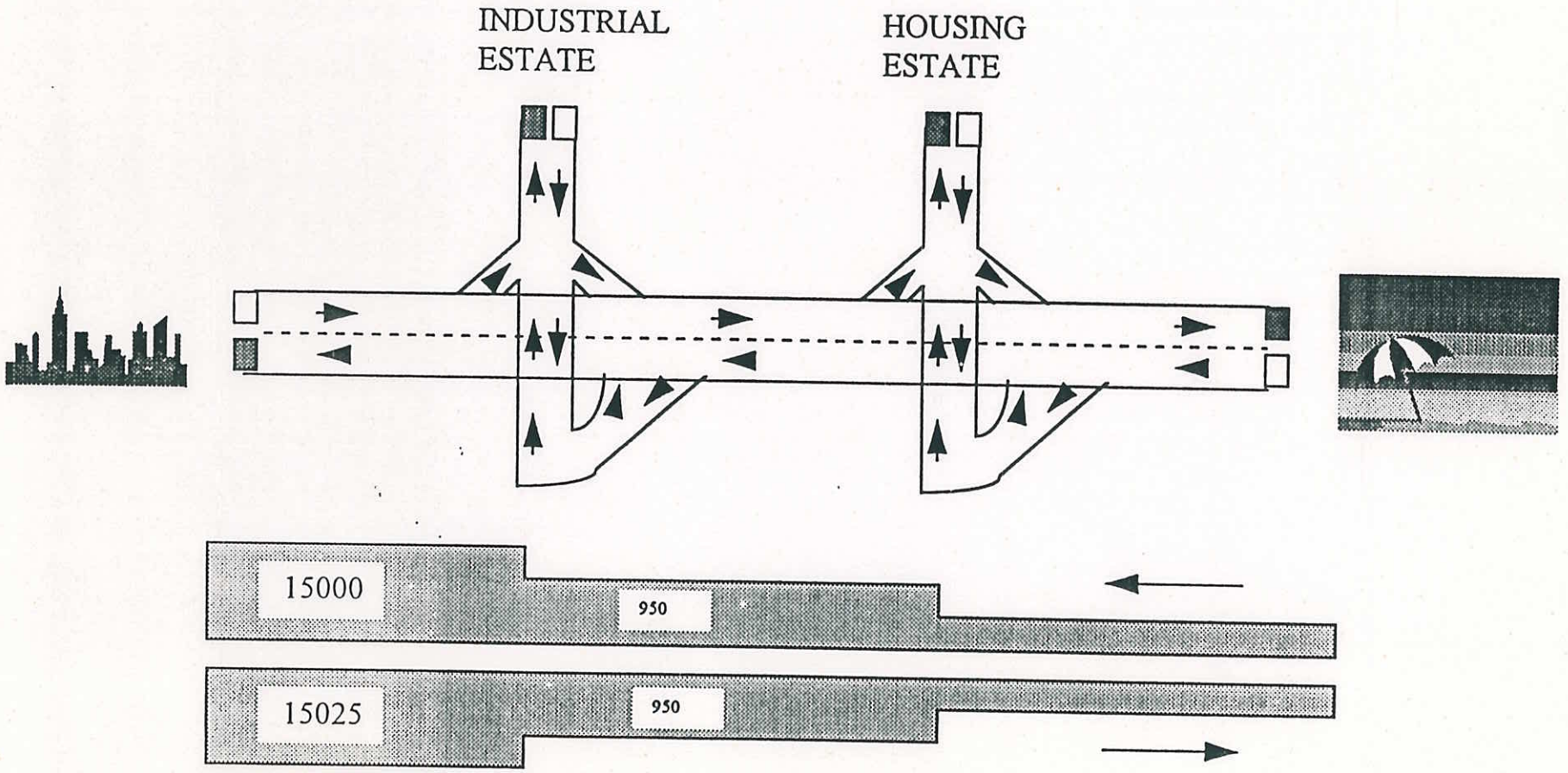
Branch offices are responsible for the revenues it collects and the daily traffic conditions. Every week each branch office makes a report to the head office.

JASAMARGA ORGANIZATION CHART



Current System

AVERAGE DAILY TRAFFIC IN NOVEMBER 94



Traffic counting is done both electronically and manually. The electronic data is for cross-checking the manual data. At the end of their shift the operators count and classify the ticket that they received according to the vehicle, count the revenues and report to the branch office. After have been checked, the data is sent to central office.

ŝ{3∂Bϕ+■af;M

Current Status

Currently, traffic and revenues are counted on a daily basis. The passengers take a ticket at an origin gate and pay at a destination gate. The operator in the origin gate will give a ticket to the passenger. The ticket contains the location of the origin gate and the type of vehicle. For example, an operator will give a red ticket for a passenger car (P/C), a green ticket for a bus, and a yellow one for a truck.

At the destination gate the passenger will give the ticket to the operator in the toll booth. The ticket will show from where the vehicle came. The passenger of the vehicle will pay a certain amount of money according to the origin and destination gates, and the type of the vehicle.

Traffic counting is done manually. At the end of their shifts the operators count and classify the tickets that they received according to the vehicle, count the revenues and report to the branch office.

The branch office will collect and compile the data from the gates daily. They will compile the average daily traffic (ADT) every week and send it to the head office. The head office will compile all the data from all the branches and produce a monthly report of traffic conditions.

The schema of the reports is graphically shown in figure 1.

The current report as shown in figure 1 is basically a monthly report of average daily traffic conditions, so the pattern does not really reflect the actual traffic pattern when it is in rush hour, weekend, and holiday seasons and other special periods or conditions.

Problem Definition

Traffic growth on a provincial expressway is unpredictable and depends on the physical development of the areas surrounding the expressway (i.e. real estate, industrial estate, harbor, airport, tourism area and others).

Because traffic is unpredictable, JASAMARGA finds great difficulty in accommodating the flow of traffic. Traffic jams occur in the suburban gates that are experiencing rapid development, and in the gates located in the Central Business District area. For example at the gates in the southern part of Jakarta, the capital city, the average daily traffic is around 45,000 vehicles.

In order to predict traffic flows, JASAMARGA needs to have a database system that can provide information about current traffic conditions to track and forecast the number of gates required at a given time on a given day.

Rationale for new system

Because of the rapid growth in expressway traffic, JASAMARGA requires accurate present and historical traffic data in order to predict the growth due to road expansion, toll

plaza width expansion, and traffic light arrangements. In this proposal, traffic is counted on an hourly basis, which is technically possible because of new technologies developed to count the traffic.

Counting traffic on an hourly basis is a better representation of the flow data that is needed to show the need for traffic management, road widening, gate expansion and other developments.

The Objectives of The New System

The objective of the new system is to provide an improved database management system, that can provide more accurate traffic condition information. The new system can also answer queries that are needed for planning, operational, and financial purposes.

The new system will answer the following queries:

For Planning Purpose : to plan for future development

How many vehicles passed a particular gate in a particular road link during any specified time period ?

- What is the weekly traffic fluctuation in a road link ?
- What is the traffic condition on Saturday and Sunday at a particular gate ?
- What is the traffic condition during rush hours ; morning 7 - 9 a.m., afternoon 12 - 2 p.m., and evening 5 - 7 p.m. ?
- What is the average travel time for a vehicle from Gate A to Gate B?.
- What is the average travel time for the traffic flow from Gate A to Gate B?.

For Operation and Maintenance Purpose : to perform road overlay, and to install signs, etc.

- What are the low traffic periods for a particular road link?

For Financial Purpose:

- How much is the total revenue of the company per year ?
- How much is the revenue at one gate during a given time period ?

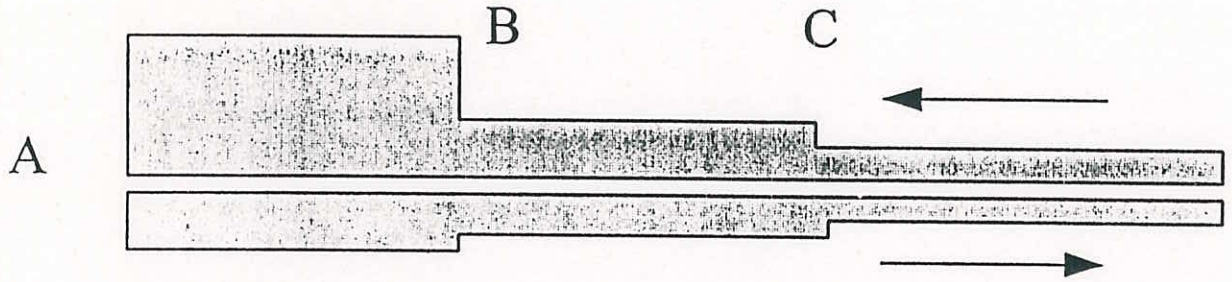
Potential Users

The Planning Division

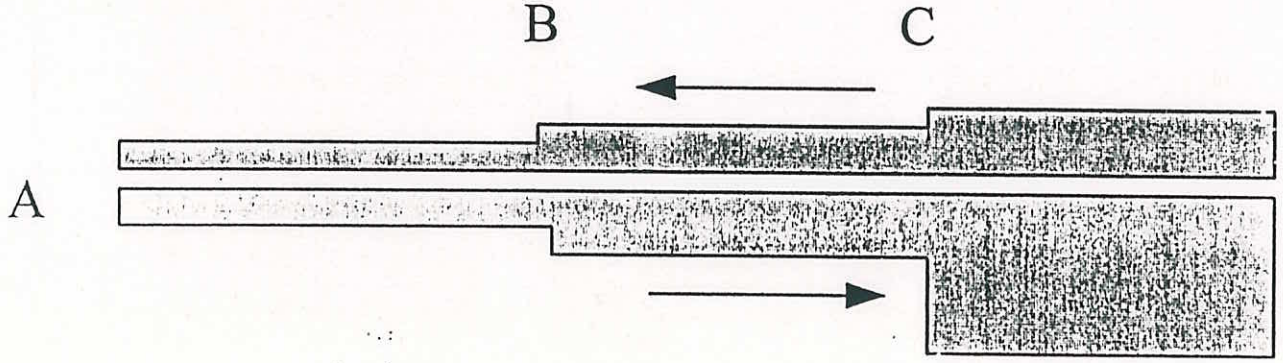
The Planning Division can use the database for developing facilities to accommodate the traffic. The database is very useful for forecasting traffic growth, thus the Planning Division can use data collected form the database to prepare for traffic fluctuations.

Proposed System

AVERAGE TRAFFIC FLOW AT 7 - 9 AM IN JUNE, 19



AVERAGE DAILY TRAFFIC FLOW ON WEEKENDS IN JU E, 1995



TRAFFIC VOLUME (Number of Vehicles)

The Operation Division

The Operation Division can use the database to plan operations in personnel management, traffic management.

The Finance Division

The Finance Division can use the database for reporting the revenue, as well as to control for the collection of revenue. This database can be useful for forecasting future revenue.

The implementation of the new system

The E-R diagram for our system is shown in figure 1. In this report we will take as an example a system for one branch office. We have five base relations in the system. The example of the tables is shown in Appendix A.

Sources of Information & Data

The information about traffic conditions and revenues will be provided by the branch offices on an hourly basis to the head office.

The data will be entered from the gates in each branch office. The proposed system will use a magnetic card. At the origin gate an operator will give the passenger a card that consists of information about origin gate location, type of vehicle, and time entering the gate.

At the destination gate, the passenger will give the card to the operator in the booth. The operator will slide the card across a computing device and the computer will record the information,

- time leaving the gate,
- determines the toll fee, travel time and sends it to the branch office main data base.

Each information will be recorded in a table which called TICKET in the branch office database.

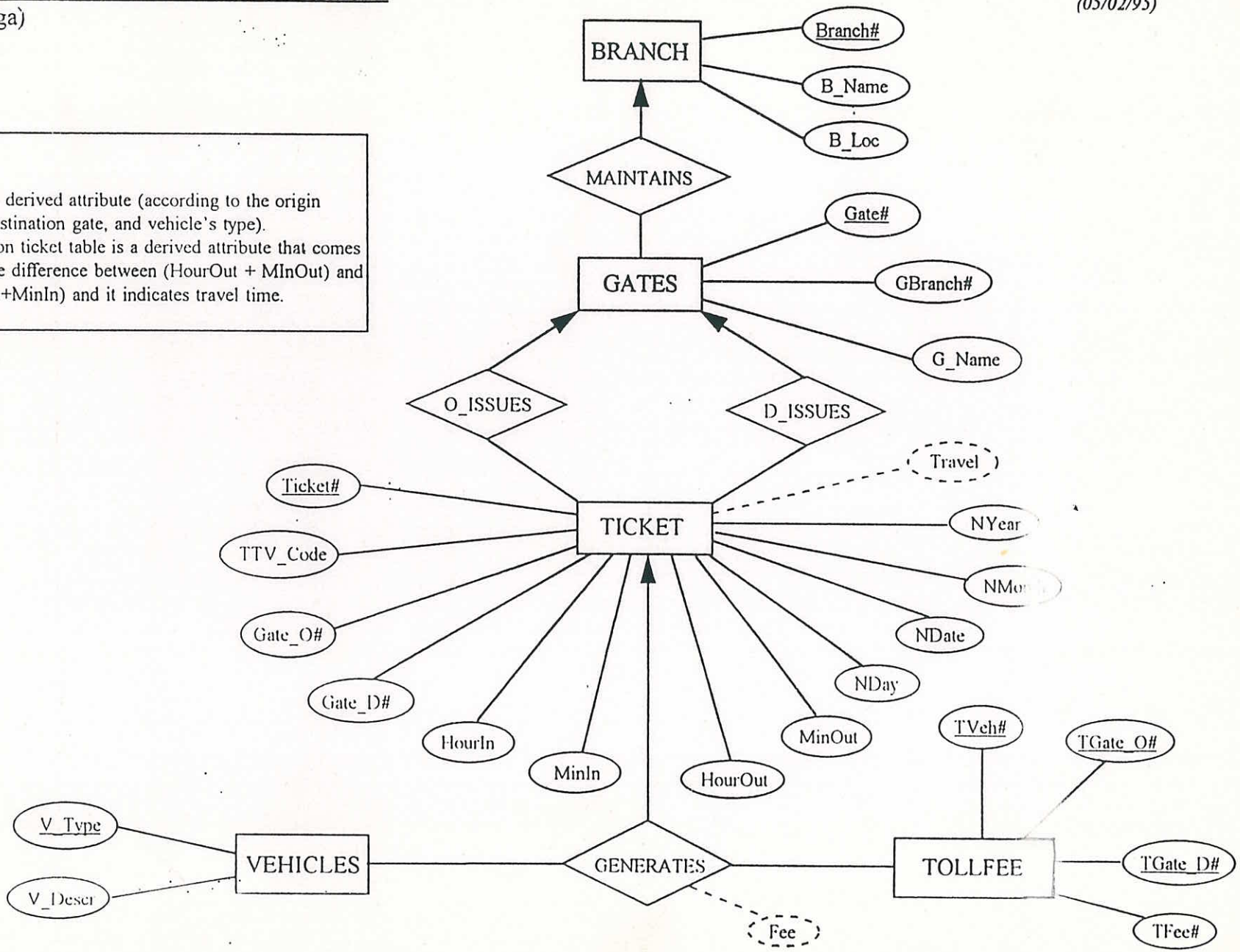
HIGHWAY CORPORATION ER-DIAGRAM :

(Jasamarga)

Last Version
(05/02/95)

Notes :

- Fee is a derived attribute (according to the origin gate, destination gate, and vehicle's type).
- Travel on ticket table is a derived attribute that comes from the difference between (HourOut + MInOut) and (HourIn+MinIn) and it indicates travel time.



Preface

Requirements and Constraints

The organization wants to keep track of the amount of traffic in each individual branch through a traffic count. This is done by recording the number of tickets issued for each type of vehicle and the origin/destination of said vehicle.

Branches have many gates. Any particular gate is assigned to exactly one branch.
Gates will issue a ticket that specifies a unique ticket number and gate number.

A gate may issue or receive many tickets.

Each gate has a unique gate number and gate name.

The fee charged is according to the destination gate (represented in our database as Gate_D#), the origin gate (represented in our database as Gate_O#), and the vehicle type(represented V_Type).

The Vehicles that enter the toll system are assigned exactly one ticket and ticket number.

Tickets may be assigned by many gates (origin gates), according to vehicle type, time in, time out, day, date, month, year, travel (a trigger attribute), and fee.

The Generates relation is a trigger that provides the fee for each ticket.

Each ticket has a unique ticket number.

The TollFee table specifies the fee (represented by Tfee) for each link of the destination and origin gates based on the type of vehicle.

Each toll fee has a unique composite key consisting of vehicle type (Tveh#), origin gate (TGate_O#), and the destination gate (TGate_D#).

Assumptions

All branches under this organization have more than one gate and each gate can be named as either an origin or destination gate, depending on the direction the vehicle is traveling when it comes to a gate.

The organization needs the vehicles to be placed in one of three types: passenger car, truck, or bus.

The fees are determined by the Board of Directors of the organization.

The example of the TICKET table is shown as follows

TICKET(Ticket#,Gate_O#,Gate_D#,nyear,nmonth,ndate,nday,hourin,minin,ttv_code,hourout,minout, fee,travel)

1	A	D	95	4	2	Saturday	BUS	6
2	A	D	95	4	5	Tuesday	TRC	7
3	A	D	95	4	12	Tuesday	BUS	6
4	B	A	95	4	24	Monday	CAR	3
5	B	A	95	4	24	Monday	BUS	3

TICKET#	HOURIN	MININ	HOUROUT	MINOUT	TTV_CODE	TRAVEL
1	22	0	23	30	BUS	90
2	13	20	14	10	TRC	50
3	12	0	12	45	BUS	45
4	1	0	1	15	CAR	15
5	1	30	1	50	BUS	20

The attribute **Fee** is a triggered attribute. The fee will show up if the input to Gate_O#, Gate_D# and ttv_code have been made.

The attribute **Travel** also is a trigerred attribut. The travel will show up if the input to Hourin,Minin,Hourout,Minout have been made.

The TICKET table will be sent to the head office and the database administrator in the head office will compile the data to an hourly basis table. The SQL program that can convert the TICKET table is as follows:

```
SQL> get  a:central;
  1  insert into central(nyear,nmonth,ndate,hourin,go#,gd#,nday,traffic,revenue,avtravel)
  2  select
     nyear,nmonth,ndate,hourin,gate_o#,gate_d#,nday,count(TTV_CODE),sum(FEE),
     avg(TRAVEL)
  3  from ticket
  4* group by nyear,nmonth,ndate,hourin, gate_o#,gate_d#,nday
5
```

The result of the compilation is:

REPORT TO HEAD OFFICE

From Branch Name : JAKARTA

Table Name : Central

GO	GD	NYEAR	NMONTH	NDATE	NDAY	HOURIN	TRAFFIC	REVENUE	AVTRAVEL
A	D	95	4	2	Friday	22	1	6	90
A	D	95	4	5	Monday	13	1	7	50
A	D	95	4	12	Tuesday	12	1	6	45
B	A	95	4	24	Monday	1	3	9	15
C	A	95	4	24	Monday	2	2	11	35

etc...

After the report to central has been made the Central Database Administrator will collect all the data from the branches. The CDBA will grant the read and select option of Central Table to all divisions and they can make query based on what they need. For example to answer the queries that are mentioned below.

SQL Queries and Views Created for Project

The sql queries and commands used to produce this information are in italics.

For Planning Purposes:

- How many vehicles left the road system through a particular destination gate (where A is the destination gate) during any specified time period?

```
SQL> get a:quest1;
 1 select gd#,nyear,nmonth,ndate,nday,hourin,traffic
 2 from central
 3 where gd# = 'A'
 4 and nday = 'Monday'
 5* and hourin between 1 and 3
 6 ;
```

GD	NYEAR	NMONTH	NDATE	NDAY	HOURIN	TRAFFIC
A	95	4	24	Monday	1	3
A	95	4	24	Monday	2	2

- What is the weekly traffic fluctuation in a particular road link (for example, road link where the origin is D and the destination gate is A) during a specified time period?

```
SQL> ;
  1  select go#, gd#, ndate, sum(traffic)
  2  from central
  3  where go# = 'D' and gd# = 'A'
  4  and ndate between 24 and 30
  5* group by go#,gd#,ndate;

SQL> start a:quest2;

GO GD   NDATE SUM(TRAFFIC)
-- -- ------- ------------
D  A     24          5
D  A     25          1
```

- What are the traffic conditions on Wednesday and Thursday?

```
SQL> get   a:quest3;
  1  select go#, gd#, ndate, nday, hourin, traffic
  2  from central
  3  where hourin between 7 and 9
  4* and   (nday = 'Wednesday' or nday = 'Thursday')
SQL> start a:quest3;
  5 ;

GO GD   NDATE NDAY       HOURIN TRAFFIC
-- -- ------- ---------- ------- -------
C  D      27  Thursday         9       1
D  B       3  Wednesday        9       1
```

- What is the traffic condition during rush hours: morning 0700-0900 ?

```
SQL> get   a:quest4;
  1  select go#, gd#, nmonth,ndate,nday,hourin, traffic
  2  from central
  3  where
  4  (hourin between 7 and 9)
  5* ;
```

SQL> start a:quest4;

GO	GD	NMONTH	NDATE	NDAY	HOURIN	TRAFFIC
D	A	4	24	Monday	8	1
D	A	4	24	Monday	9	1
C	D	4	27	Thursday	9	1
D	B	5	3	Wednesday	9	1

For Operation and Maintenance Purposes:

- What are the low traffic periods for a particular road link (origin gate C and destination gate A)?

```
SQL> get  a:quest5;
  1  select go#, gd#, hourin, traffic
  2  from central
  3  where go# = 'C' and gd# = 'A'
  4  and traffic  <= (select min(traffic)
  5                  from central
  6                  where go# = 'C' and gd# = 'A'
  7*                 group by go#, gd#)
  8  ;
```

GO	GD	HOURIN	TRAFFIC
C	A	19	1
C	A	10	1

For Financial Purposes:

- How much is the total revenue of the branch for a particular year?

```
SQL> get  a:quest6;
  1  select nyear, sum(revenue)
  2  from central
  3  where nyear = 95
  4* group by nyear;
```

SQL> start a:quest6;

NYEAR SUM(REVENUE)
------ -----------

- How much revenue is collected at a particular gate at different time periods?

SQL> get a:quest7;
1 select gd#, hourin, sum(revenue)
2 from central
3 where gd# = 'A' and (hourin between 12 and 19)
4 group by gd#, hourin;*
SQL> start a:quest7;

GD HOURIN SUM(REVENUE)
-- ------- -----------
A 13 7
A 14 6
A 15 5
A 19 6

For Safety and Planning Purposes:

- What is the average travel time between all road links?

SQL> start a:quest8;

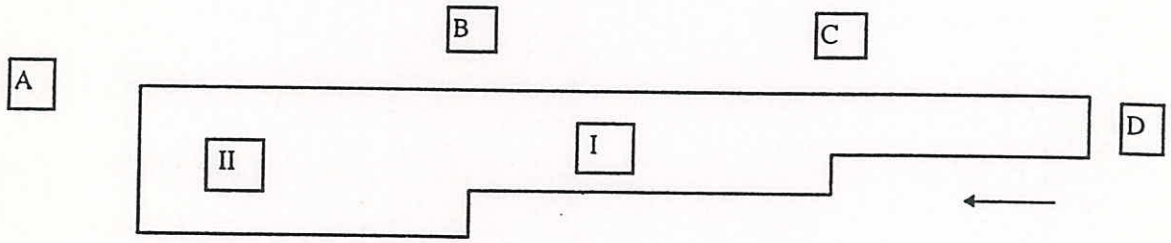
SQL> get a:quest8;
1 select gate_o#, gate_d#, avg(travel)
2 from ticket
3 group by gate_o#, gate_d#;*
SQL> start a:quest8;

GA GA AVG(TRAVEL)
-- -- -----------
A C 42.6667

A D	59.4444
B A	15
B C	41.6667
B D	46
C A	46.25
C B	35
C D	165
D A	56.875
D B	18.3333

10 rows selected.

To support the graphical report as shown figure 1



For example we want to know the total traffic in one day that passed a segment from **B --> C**
then SQL example is shown below:

I. segment B--->C

```
1 select sum(traffic)
2 from central
3 where ((GD# ='A' and GO# = 'D')
4 or (GD# = 'B' and GO# = 'D')
5 or (GD# = 'B' and GO# = 'C'))
6 and NDATE = 24
7 and NMONTH = 4
8 and NYEAR = 95
9* and HOURIN between 0 and 24
10 ;
```

```
SUM(TRAFFIC)
------ ------
     5
```

and for the total traffic that passed the link B--->A

II. segment B---->A

```
2 from central
3 where GD# ='A'
4 and NDATE = 24
5 and NMONTH = 4
6 and NYEAR = 95
7* and HOURIN between 0 and 24
8 ;
```

SUM(TRAFFIC)

10

SQL> spool off

Security, Integrity, and Domain Constraint

The Security :

The prime security system component that needs to be addressed in this database system is the providing of a password for each user who will need to access the data.
The potential user in this database system are:

- Toll booth operators who will enter the raw data.
- The branch database officer (BDO) who will need the data for each gate and perform a compilation of all data before sending the data to the central database officer (CDO) or those persons who sit in the information system division.
- The central database officer will be able to send information to divisions that request this information.
- The Financial Division will receive information about the revenues that were generated from collected toll fees.
- The Planning Division will need traffic information which contains the number of vehicles that use the toll road in a particular time, and the road link (origin gate B destination gate A) used.

- The operation division head of the Information System Division will need both the traffic information and financial information.
- The board of Directors who are responsible for determining the toll fee rates and the type of vehicles allowed to enter the toll fee system.

The Security on the database system level:

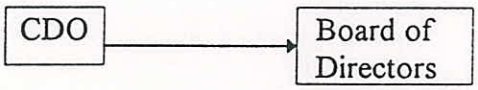
- Provide the user with a "personilized" model of the database, for example:

- The BDO will be able to create and provide queries in order to compile different types of data. Give read, update index, resource, alteration, and drop authorizations to the CDO, especially the authorization to use the Ticket table.
- The CDO willbe able to update, create and delete the data and also to grant and revoke the authorizations for all other users excluding toll booth operators.
- Toll booth operators will be given the insert authorization from the BDO for just the ticket table which allows insertion of new data but not modification of existing data. The only data that may be able to be inserted are *Gate_O#*, *HourIn*, *MinIn*, and *TTV_Code*.
- The financial division will be given authorization to read the financial information views that are created by joining the ticket, and tollfee tables by creating queries.
- The planning division will be given the read authorization for the traffic information view which contains the information of the total number of vihicles for every hour, minute, date, day, year, and gate.
- Operation division will be given the read authorization for the traffic information view that contains the information on the total number of vihicles per hour, minute, date, day, year, gate, and also the financial inforamtion view. And he will be given also an update, index, resource, and alteration authorizations for the vihicles, branch, and gates tables.
- The Board of Directors will be given the read authorization of financial and traffic information views, and the read, insert, update, and delete authorizations associated with the tollfee table.

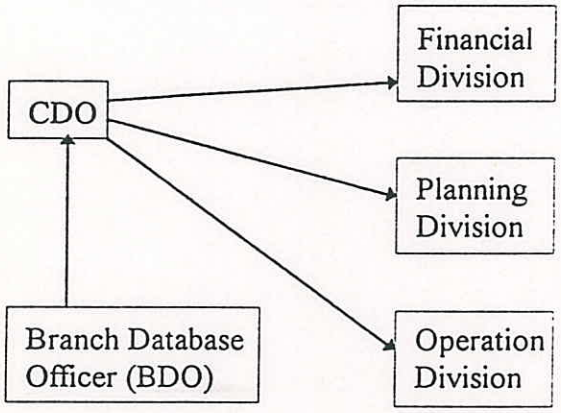
All the authorizations above can be seen through diagrams as follow :

a. Insert authorization on ticket table:

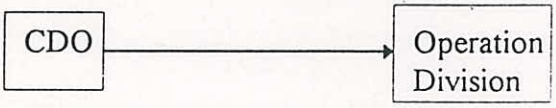
b. Insert and update authorizations on tollfee table :



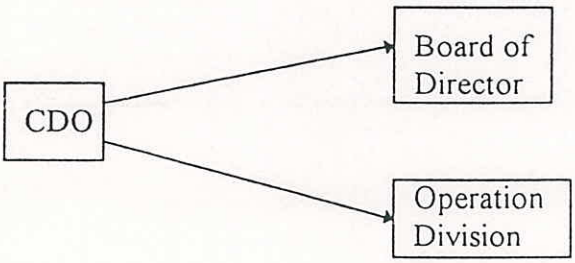
c. Read authorization on ticket table :



d. Read, update, and insert authorization for gates and branch tables :



e. Read, update, insert, and delete authorizations for vehicles table :



b. The security on the physical aspect :
The location of the computer system must be physically secured and would have to be close to the information system's officers in order to repair systems failures.

c. The security on the human side :
Issuing authorizations must be done in a discriminating manner to reduce the chance of an authorized user from providing systems access to an intruder in exchange for a bribe or other favors. Users should only be able to use information pertinent to their position.
Providing the forms that contain some restrictions on the inputting of data, such as providing the pop-up form, should also provide a function inside the attribute to prevent the user from creating the wrong calculations when inputting data.

The Integrity :

The integrity constraints that need to be developed in the database are:

a. Functional dependencies(see the chart towards the end of the paper).

b. Value restriction and in this case:
- The HOURIN and HOUROUT numbers should be in the range of 000 and 2300 hours.
- The MININ and MINOUT numbers should be in the range of 0 and 59 minutes.

The relational database's integrity that needs to be developed in the database are:

a. Entity integrity that will:
- Prevent attributes BRANCH#, GATE#, TICKET# V_TYPE, TVEH#, TGATE_O#, and TGATE_D# from having null values.

b. Referential Integrity will make these constraints:
- The Gate_O# in the ticket table shall appear also as a GATE# in gates table.
- The Gate_D# in the ticket table shall appear also as a GATE# in gates table.
- The TTV_CODE in the ticket table shall appear also as a V_TYPE in vehicles table.
- The TVEH#, TGATE_O#, and TGATE_D# in the TollFee table have to be identical to V_TYPE of the vehicles table, and GATE# of the gates table, respectively.

- The GBRANCH# that appears in the Gates table should be identical to the BRANCH# attribute in the branch table.
- The Fee attribute in the Generates table should be identical to the TFEE# in the TollFee table.

c. Domain Integrity will make the following constraints:

- HOUROUT and MINOUT should be greater than HOURIN and MININ in the ticket table.
- The Travel attribute in the Ticket table comes from the difference between HOUROUT, MINOUT and HOURIN, MININ (by building the trigger).
- Fee is the derived attribute that is created by building a trigger to match the vehicle type, gate-origin, and gate-destination attributes that exist in the ticket and TollFee tables. In this case, this trigger function will restricting the fee to be in the range of $2.00 and $7.00.

The Security and Integrity Implementation:

1. Trigger :

   a. The trigger command that needs to be used in order to get the fee data :

```
begin
select tollfee.tfee
into :trifee.fee
from TollFee
where tollfee.tveh# = :trifee.ttv_code
and tollfee.tgate_o# = :trifee.gate_o#
and tollfee.tgate_d# = :trifee.gate_d#:
end:
```

   b. The trigger command that needs to be used in order to get the travel data :

```
procedure travel_time is
begin
:travel := (:hourout*60 +:minout) - (:hourin*60 +:minin):
end:
```

2. Authorization :

   a. The command to insert authorization on ticket table:

```
grant insert *
on ticket
to toll_booth_operators
with grant option:
```

b. The command for inserting and updating the authorization on TollFee table:

*grant insert *, update **
on TollFee
to board_of_director
with grant option:

c. The command for read authorization on ticket table:

*grant read **
on ticket
to financial_division, planning_division, operation_division
with grant option:

d. The command for read, update, and insert authorization for gates and branch tables:

*grant read *, update *, insert **
on gates, branch
to operation_division
with grant option:

e. The command for read, update, insert and delete authorization for vehicles table:

*grant read *, update *, insert *, delete **
on vehicles
to board_of_director, operation_division
with grant option:

Management Issues to be Considered

If the database development plan is implemented the responsibilities, requirements and the workload of the database manager will increase. It will also require time and resources to train all the personnel who will use the system. All of the branch offices will require a new position of branch office database administrator. All branch offices will be responsible for storing and compiling data collected from the gates. The branch database officer will be responsible for sending the information to the central database in the head office. The branch and central database officer will coordinate the inserting and the deleting of tables if there are new changes or developments. For example:

- new gates
- new toll fees
- new classifications for vehicles.

Every year, the central database officer will compile and store the hourly data for every branch. This will require the stockpiling of an enormous amount of data.

For this project the use of a magnetic ticket is highly recommended. Though this is an expensive way to replace hand held documents, it is an essential item in order to supply database managers with timely information. This will also prevent a long queue at the gates.

The most difficult employees to manage are the toll both operatorsbecause they located at remote sites, a reasonable distance from the branch offices. Plus, it is possible for them to make errors such as:

- Entering the wrong vehicle code
- Collecting the wrong amount of money.

Contributions, advantages and limitations of the design and implemented system

The average travel time does not represent the actual traffic conditions. Vehicles may stop in a rest area, skewing the travel time between gates. Calculating the travel time will be more accurate at branches without rest areas.

As stated before, the new system will increase the timeliness of data received from the branches. The information on our database would be very useful to policy organizations that record the migration of citizens, and the efficiency of the present infrastructure.

The most pressing limitation is the capacity and cost of storing such an immense amount of data. It would most likely require several mainframes (and they are very expensive) to handle the transport and handling of such a large amount of data.

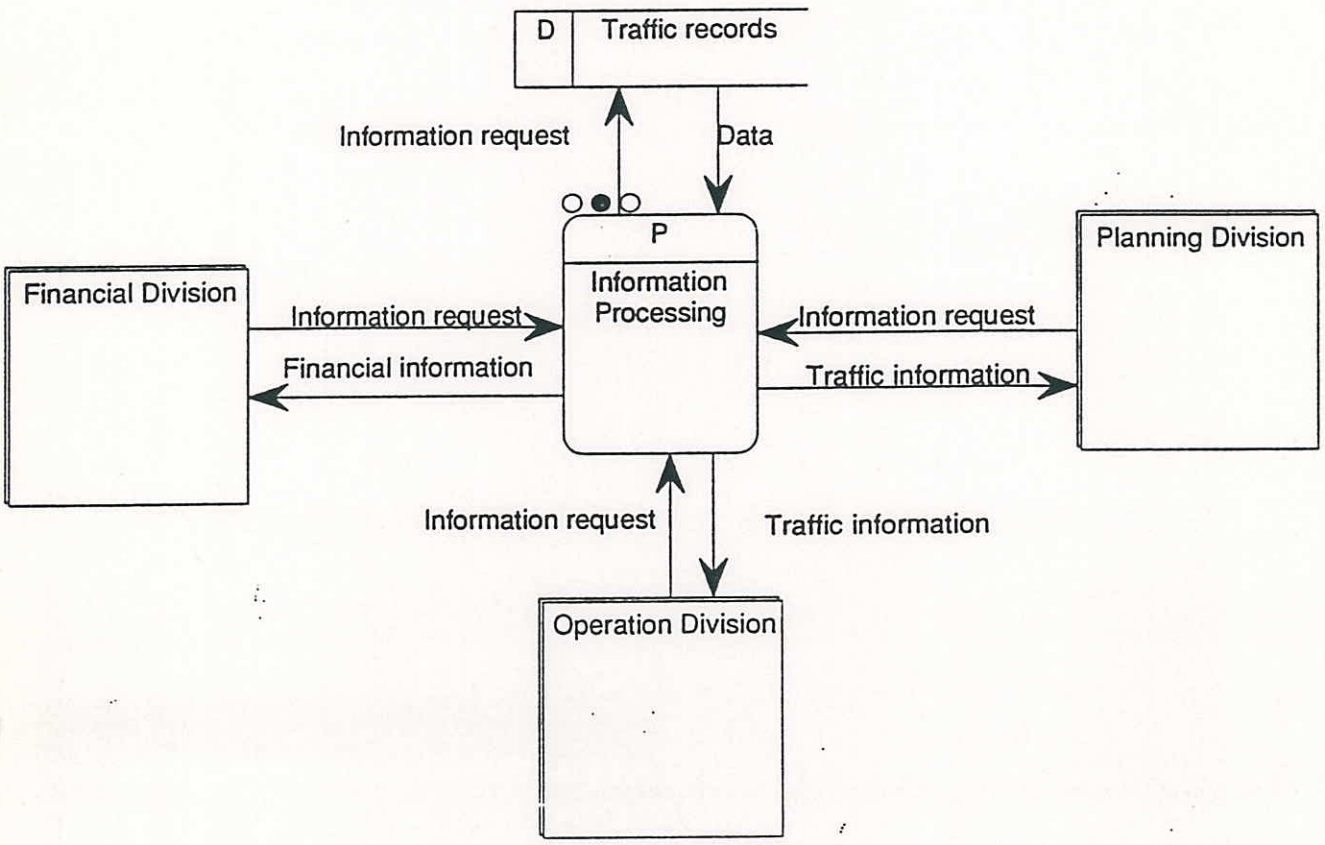
Possible future extensions

- If the road capacity data for each link is already stored, then it can be collaborated into this system. The future system can show which link has experienced over capacity. This will support the decision to widen roads or increase traffic management. This requires a table of each link with it's maximum capacity.

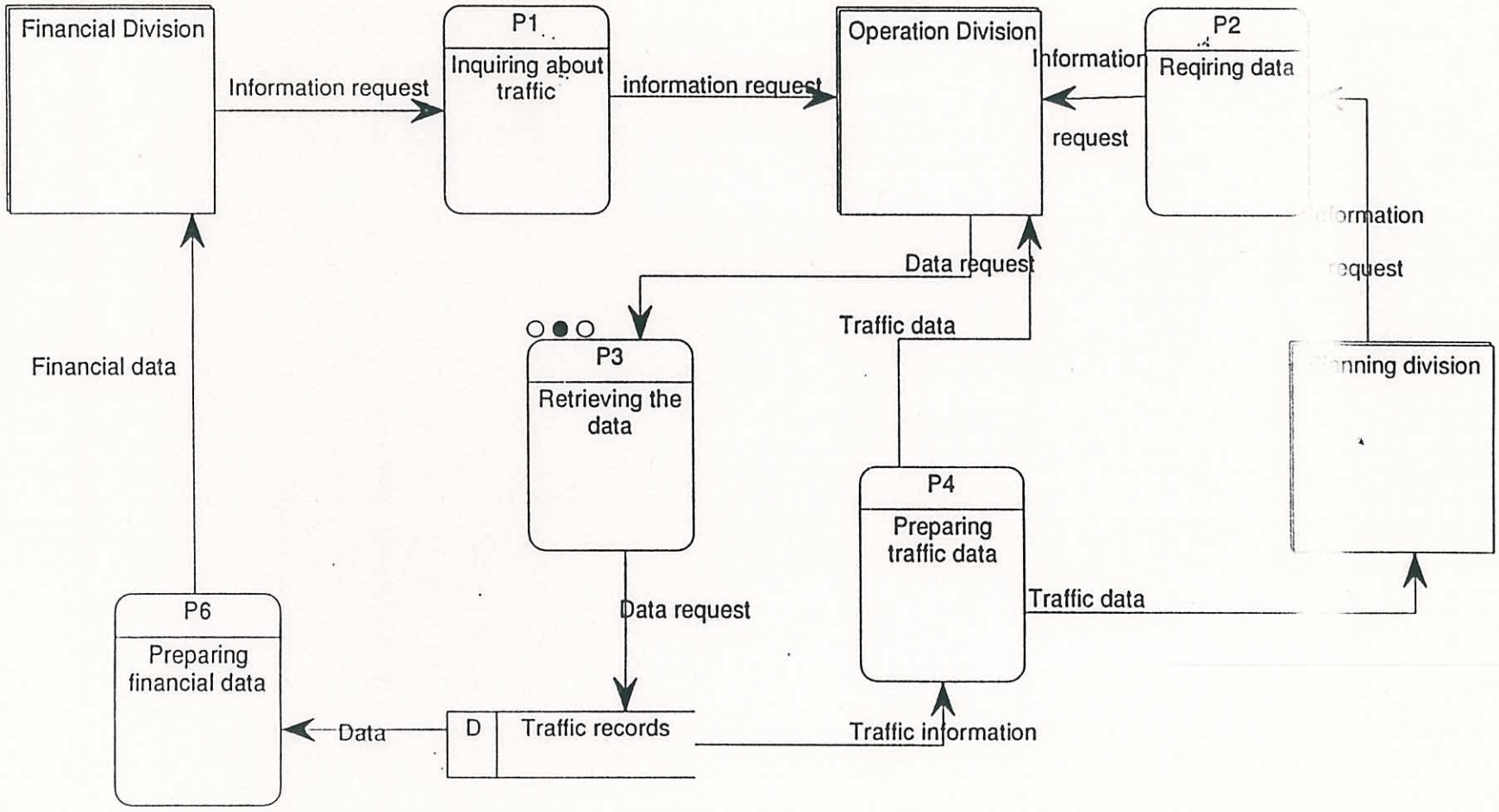
- If the data concerned with the length of each link and the speed limit is established then it can be collaborated into the system. The system will have the minimum travel speed or the minimum travel time information for each link. If a vehicle is traveling faster than the minimum travel time for a venicle going the speed limit, the authorities can fine the vehicle. So this system will also enforced the speed limits of the roads.

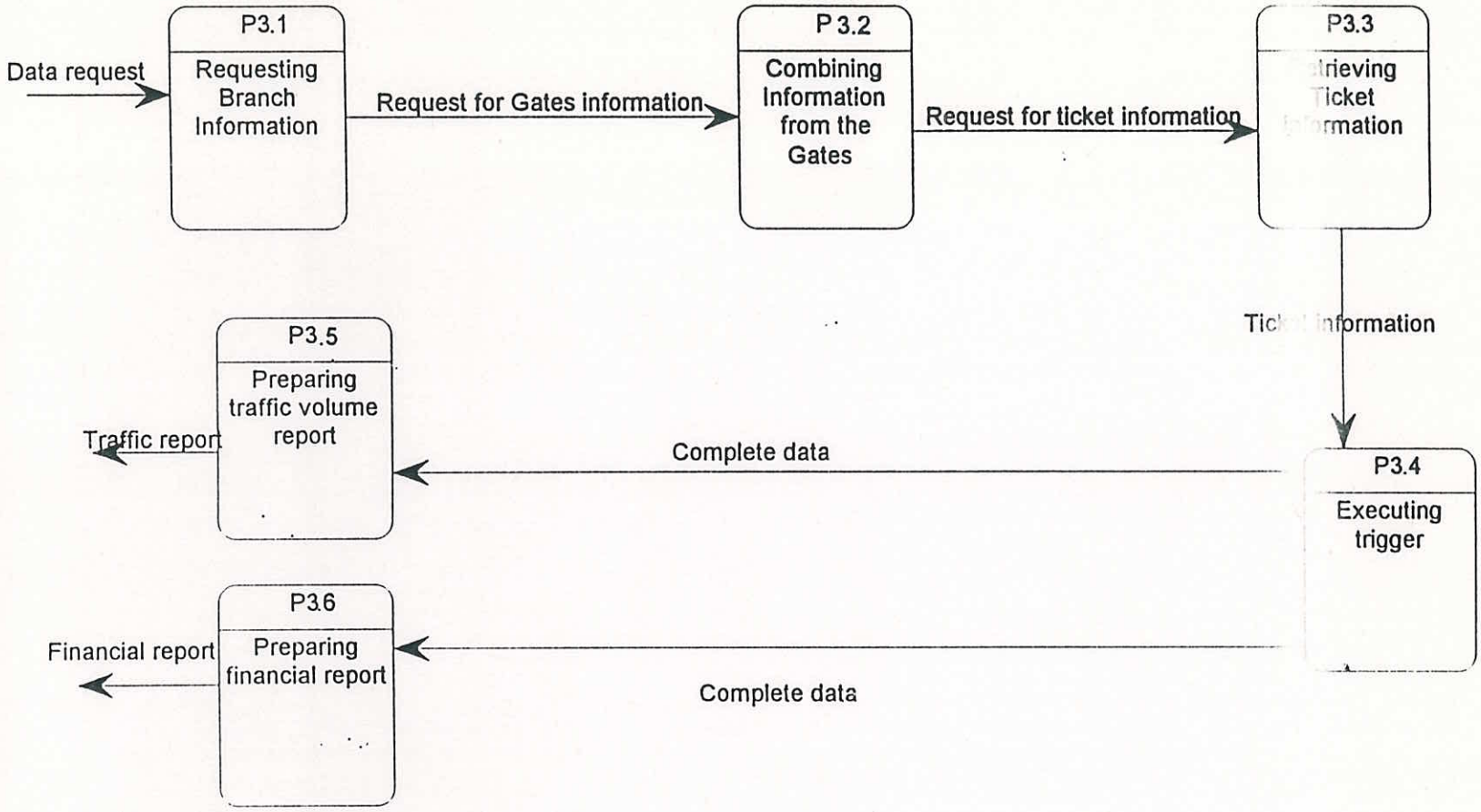
The structure of table needed for future need:
LINK_INFORMATION
(Gate_O#,Gate_D#,
Length,CapacityperDay,Capacityperhour,SpeedLimit,MinimumTravelTime)

Context level Diagram



Interaction between divisions





Assumptions

Process 3 combines "Ticket" information from a gate
Process 4 ticket information activates trigger and displays the complete data

Normalized Relational Schema

Branch (Branch#, B_loc, B_Name)
Maintains (Gate#, Branch#)
Gates (Gate#, G_Branch#, G_Name)
O_Issues (OGate_O#, OTicket#, OHourIn, OMinIn)
D_Issues (DGate_D#, DTicket#, DHourOut, DMinOut)
Ticket (Ticket#, TTV_Code, Gate_O#, Gate_D#, HourIn, HourOut, NDate, NDay, NYear, NMonth, MinOut, MinIn, Travel)
Generates (GV_Code, GGate_D#, GGate_O#, GTicket#, GFee)
Vehicles V_Code, V_Descr)
Toll Fee (TGate_O#, T, Gate_D#, TV_Code, Tfee#)

Final Tables

Branch (Branch#, B_loc, B_Name)
Gates (Gate#, G_Branch#, G_Name)
Ticket (Ticket#, TTV_Code, Gate_O#, Gate_D#, HourIn, HourOut, NDate, NDay, NYear, NMonth, MinOut, MinIn, Travel)
Generates (GV_Code, GGate_D#, GGate_O#, Gticket#, GFee)
Vehicles V_Type, V_Descr)
Toll Fee (TGate_O#, TGate_D#, TV_Code, TFee#)

Relations Maintains, O_Issues, and D_Issues were dropped because of redundant attributes.

Functional Dependencies

These functional dependencies are in a lossless dependency preserving relationship. Plus, these functional dependencies are in Third Normal Form.

Set of all attributes {(Branch#, B_loc, B_Name, Gate#, G_Name, Gate_O#, Gate_D#, V_Code, HourIn, HourOut, NDate, NDay, NYear, Nmonth, MinOut, MinIn, V_Descr, Ticket# Tfee#)} *Their foreign keys appear per the names assigned on the ER diagram.*

1) Ticket# --> TTV_Code Gate_O# Gate_D# HourIn HourOut NDate NDay NYear NMonth MinOut MinIn Travel

2) Gate# --> GBranch# G_Name

3) V_Type --> V_Descr

4) TGate_O# TGate_D# TVeh# --> TFee#

5) G_Name Branch# --> B_Loc B_Name

Dropped because of partial dependency and redundancy. (6) GV_ Code GTicket# GGate_D# GGate_O# --> GFee)

Tables:		Attribute	Type & Size	Domain
Branch (table)				
Primary-Key	Branch#			
Foreign-Key	None			
		Branch#	Number 7	Branch#-Domain
		B_loc	Char 15	B-loc-Domain
Gates (table)				
Primary-Key:	Gate#			
Foreign-Key	GBranch# (Branch table)			
		Gate#	Number 2	Gate#-Domain
		G_Name	Char 15	G_Type-Domain
		GBranch#	Number 1	Branch#-Domain
Generates (table)				
Primary-Key:	GTicket			
	GV_Code			
	GGate_D#			
	GGate_O#			
Foreign-Key:	GGate_D# (Ticket table)			
	GGate_O# (Ticket table)			
	GV_Code (Vehicles tables)			
	GTicket# (Ticket table)			
	GFee (Ticket table)			
		GGate_O#	Char 2	GGate_O#-Domain
		GTicket	Number 5	GTicket-Domain
		GGate_D#	Char 2	GGate_D#-Domain
		GFee	Number 7	GFee-Domain
		GV_Code	Char 4	GV_Code-Domain
Ticket (table)				
Primary Key:	Ticket#			
Foreign-Key:	TTV_Code (Vehicles table)			
		Ticket#	Number 5	Ticket#-Domain
		TTV_Code	Char 4	TTV_Code-Domain
		Gate_O#	Char 2	Gate_O#-Domain
		Gate_D#	Char 2	Gate_D#-Domain
		HourIn	Number 2	HourIn-Domain
		HourOut	Number 2	HourOut-Domain
		MinIn	Number 2	MinIn-Domain
		NDate	Number 2	NDate-Domain
		NDay	Char 8	NDay-Domain
		NMonth	Number 2	NMonth-Domain
		NYear	Number 2	NYear-Domain
		MinOut	Number 2	MinOut-Domain
		Travel	Number 3	Travel-Domain
Vehicles (table)				
Primary-Key	V_Type			
Foreign-Key	None			
		V_Descr	Char 50	V_Descr-Domain
		V_type	Char 10	V_type-Domain
TollFee (table)				
ary-Key:	TVeh#			
	TGate_O#			
	TGate_D#			
Foreign-Key	TVeh# (Vehicles table)			
	TGate_O# (Ticket table)			
	TGate_D# (Ticket table)			
		TVeh#	Char 10	TVeh#-Domain
		TGate_O#	Char 10	TGate_O#-Domain
		TGate_D#	Char 10	TGate_D#-Domain
		TFee	Number 7	TFee-Domain

Data Dictionary

- **Branch** Office in charge of maintaining the gates in a particular region
- **Branch#** This attribute is used to identify a particular branch. Attribute.
- **GBranch#** This attribute is used to identify a particular branch. Foreign key. Attribute.
- **B_Name** Shows name of the branch. Attribute.
- **B_loc** Provides location of branch. Attribute.
- **Gates** Are the gates, either origin or destination gates, assigned to a certain branch. Attribute.
- **Gate#** This attribute is used to identify a particular gate. Attribute.
- **G_loc** Shows location of gate. Attribute.
- **Ticket#.** This is the receipt that vehicle operators receive at a origin gate and turn into a destination gate in order to pay a toll fee. Attribute.
- **GTicket#** This is the receipt that vehicle operators receive at a origin gate and turn into a destination gate in order to pay a toll fee. Foreign key. Attribute.
- **Vehicle** This entity represents the vehicles that are tolled through the gates and constitute the traffic calculated on the expressway. Attribute
- **TV_Code** This attribute is used to identify a particular vehicle that enters through an origin gate. For example, it is either a passenger car, a truck or a bus. Foreign key. Attribute.
- **TTV_Code** This attribute is used to identify a particular vehicle that enters through an origin gate. For example, it is either a passenger car, a truck or a bus. Foreign key. Attribute.
- **V_Descr** This element provides a description of the vehicle. Attribute.
- **V_Type.** This attribute tells you what type of vehicle this is. For example, it is either a passenger car, a truck or a bus. Attribute.
- **Gate_O#** This attribute is used to identify a particular origin gate. Attribute.
- **Ticket#** This attribute is used to identify the ticket assigned to a vehicle. It is assigned at an origin gate. Attribute.
- **Gate_D#** This attribute is used to identify a particular destination gate. Attribute.
- **TFee#** This is the amount that the vehicle operator must pay at a destination gate. Foreign key. Attribute.
- **NDate** Provides information concerning the date a ticket was issued. Attribute.
- **NDay** Provides information concerning the day a ticket was issued. Attribute.
- **NMonth** Provides information concerning the month a ticket was issued. Attribute.
- **NYear** Provides information concerning the year a ticket was issued. Attribute.
- **Toll fee** The cost that is assessed at the destination gate. Entity.
- **TVeh#** This number is assigned to a certain vehicle that enters an origin gate. Attribute.
- **TGate_O#** This attribute is used to identify a particular origin gate. Foreign key. Attribute.
- **TGate_D#** This attribute is used to identify a particular destination gate. Foreign key. Attribute.
- **Fee** This is the amount that the vehicle operator must pay at a destination gate. Attribute.
- **O_Issues** This relation shows the branches that issues tickets. Relation.
- **D_Issues** This relation shows the branches that receives the tickets and fees. Relation.
- **Maintains** This relation demonstrates that vehicles that enter into our highway system must take (get) a ticket and pay a fee. Ternary relation.
- **HourIn.** The hour that a vehicle enters the highway toll system. Attribute.
- **OHourIn.** The hour that a vehicle enters the highway toll system. Foreign key. Attribute.
- **HourOut.** The hour that a vehicle exits the highway toll system. Attribute.
- **DHourOut.** The hour that a vehicle exits the highway toll system. Foreign key. Attribute.
- **MinIn** The minute that a vehicle enters the high way toll system. Attribute.
- **OMinIn.** The minute that a vehicle enters the high way toll system. Foreign key. Attribute.
- **MinOut.** The minute that a vehicle exits the high way toll system. Attribute.
- **DMinOut.** The minute that a vehicle exits the high way toll system. Foreign key. Attribute.
- **Central.** A compiled table.
- **Travel.** Distance between origin and destination gates. Attribute.

APPENDIX A
LIST OF TABLES

TICKET

TICKET#	Gate_o#	Gate-d#	NYEAR	NMONTH	NDATE	NDAY	TTV_	TFEE#
2	A	D	95	4	5	Tuesday	TRC	7
3	A	D	95	4	12	Tuesday	BUS	6
4	B	A	95	4	24	Monday	CAR	3
5	B	A	95	4	24	Monday	BUS	3
6	B	A	95	4	24	Monday	CAR	3
7	C	A	95	4	24	Monday	TRC	6
8	C	A	95	4	24	Monday	BUS	5
9	D	A	95	4	24	Monday	TRC	7
10	D	A	95	4	24	Monday	CAR	5
11	D	A	95	4	24	Monday	BUS	6
12	D	A	95	4	24	Monday	TRC	7
13	D	A	95	4	24	Monday	CAR	5
14	D	B	95	4	25	Tuesday	TRC	4
15	D	A	95	4	25	Tuesday	CAR	5
16	A	D	95	4	25	Tuesday	BUS	6
17	B	C	95	4	25	Tuesday	CAR	2
18	B	C	95	4	25	Tuesday	TRC	3
19	C	D	95	4	27	Thursday	CAR	3
20	C	B	95	4	27	Thursday	BUS	3
21	A	D	95	4	27	Thursday	BUS	6
22	C	A	95	4	27	Thursday	TRC	6
23	B	C	95	5	1	Monday	CAR	2
24	B	D	95	5	1	Monday	CAR	3
25	A	C	95	5	1	Monday	TRC	6
26	D	A	95	5	1	Monday	BUS	6
27	B	D	95	5	2	Tuesday	BUS	3
28	C	A	95	5	2	Tuesday	TRC	6
29	A	D	95	5	2	Tuesday	CAR	5
30	A	D	95	5	2	Tuesday	CAR	5
31	C	B	95	5	2	Tuesday	CAR	2
32	D	A	95	5	2	Tuesday	TRC	7
33	D	B	95	5	3	Wenesday	CAR	3
34	D	B	95	5	3	Wenesday	BUS	3
35	A	C	95	5	4	Thursday	TRC	6
36	A	D	95	5	5	Friday	TRC	7

36 rows selected.

TICKET

TICKET#	HOURIN	MININ	HOUROUT	MINOUT	TTV_CODE	TRAVEL
1	22	0	23	30	BUS	90
2	13	20	14	10	TRC	50
3	12	0	12	45	BUS	45
4	1	0	1	15	CAR	15
5	1	30	1	50	BUS	20
6	1	45	1	55	CAR	10
7	2	30	2	55	TRC	25
8	2	45	3	30	BUS	45
9	4	0	5	0	TRC	60
10	6	15	7	10	CAR	55
11	7	30	8	30	BUS	60
12	8	30	9	30	TRC	60
13	9	15	10	0	CAR	45
14	14	30	15	0	TRC	30
15	15	15	16	30	CAR	75
16	17	0	18	0	BUS	60
17	17	0	17	45	CAR	45
18	20	0	21	0	TRC	60
19	9	45	12	30	CAR	165
20	10	30	11	30	BUS	60
21	17	15	18	30	BUS	75
22	19	0	20	15	TRC	75
23	10	20	10	40	CAR	20
24	12	0	12	40	CAR	40
25	12	15	12	58	TRC	43
26	14	20	15	10	BUS	50
27	10	10	11	2	BUS	52
28	10	20	11	0	TRC	40
29	12	0	13	0	CAR	60
30	12	10	12	55	CAR	45
31	12	30	12	40	CAR	10
32	13	40	14	30	TRC	50
33	9	20	9	35	CAR	15
34	10	11	10	21	BUS	10
35	14	2	14	27	TRC	25
36	10	0	11	0	TRC	60

TOLLFEE

ODI#	TGATE_O#	TGATE_D#	TVEH#	TFEE#
1	A	B	CAR	3
2	A	C	CAR	4
3	A	D	CAR	5
4	B	A	CAR	3
5	B	C	CAR	2
6	B	D	CAR	3
7	C	A	CAR	4
8	C	B	CAR	2
9	C	D	CAR	3
10	D	A	CAR	5
11	D	B	CAR	3
12	D	C	CAR	3
13	A	B	BUS	3
14	A	C	BUS	5
15	A	D	BUS	6
16	B	A	BUS	3
17	B	C	BUS	3
18	B	D	BUS	3
19	C	A	BUS	5
20	C	B	BUS	3
21	C	D	BUS	3
22	D	A	BUS	6
23	D	B	BUS	3
24	D	C	BUS	3
25	A	B	TRC	4
26	A	C	TRC	6
27	A	D	TRC	7
28	B	A	TRC	4
29	B	C	TRC	3
30	B	D	TRC	4
31	C	A	TRC	6
32	C	B	TRC	3
33	C	D	TRC	4
34	D	A	TRC	7
35	D	B	TRC	4
36	D	C	TRC	4

36 rows selected.

GATE

GA	G_NAME	GBRANCH#
A	JAKARTA CITY	1
B	HOUSING ESTATE	1
C	INDUSTRIAL	1
D	TOURISM RESORT	1

VEHICLE

V_TYPE	V_DESCR
CAR	non commercial vehicle
TRC	freight carrying commercial vehicle
BUS	Commercial passanger carrying vehicle

REPORT TO CENTRAL

CENTRAL

GO	GD	NYEAR	NMONTH	NDATE	NDAY	HOURIN	TRAFFIC	REVENUE	AVTRAVEL
A	D	95	4	2	Friday	22	1	6	90
A	D	95	4	5	Monday	13	1	7	50
A	D	95	4	12	Tuesday	12	1	6	45
B	A	95	4	24	Monday	1	3	9	15
C	A	95	4	24	Monday	2	2	11	35
D	A	95	4	24	Monday	4	1	7	60
D	A	95	4	24	Monday	6	1	5	55
D	A	95	4	24	Monday	7	1	6	60
D	A	95	4	24	Monday	8	1	7	60
D	A	95	4	24	Monday	9	1	5	45
D	B	95	4	25	Tuesday	14	1	4	30
D	A	95	4	25	Tuesday	15	1	5	75
A	D	95	4	25	Tuesday	17	1	6	60
B	C	95	4	25	Tuesday	17	1	2	45
B	C	95	4	25	Tuesday	20	1	3	60
C	D	95	4	27	Thursday	9	1	3	165
C	B	95	4	27	Thursday	10	1	3	60
A	D	95	4	27	Thursday	17	1	6	75
C	A	95	4	27	Thursday	19	1	6	75
B	C	95	5	1	Monday	10	1	2	20
A	C	95	5	1	Monday	12	1	6	43

B	D	95	5	1	Monday	12	1	3	40
D	A	95	5	1	Saturday	14	1	6	50
B	D	95	5	2	Tuesday	10	1	3	52
C	A	95	5	2	Tuesday	10	1	6	40
A	D	95	5	2	Sunday	12	1	5	45
A	D	95	5	2	Tuesday	12	1	5	60
C	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D	A	95	5	2	Tuesday	13	1	7	50
D	B	95	5	3	Wenesday	9	1	3	15
D	B	95	5	3	Wenesday	10	1	3	10
A	C	95	5	4	Thursday	14	1	6	25
A	D	95	5	5	Monday	10	1	7	60

APPENDIX B
FORMS, TRIGGERS

======== TRIFEE ========

TICKET#

GATE_O#

GATE_D#

HOURIN

MINOUT

NDAY

NDATE

NMONTH

NYEAR

TTV_CODE

TRAVEL

FEE

nt: *0

<Replace>

****

13:32 3 May 1995 TRIGGERS Report for Application:TICKET

****

Application: TICKET
Owner: SB93

****

* 13:32 3 May 1995 TRIGGERS Report for Application:TICKET Field: TTV_CODE
*

****

Block name: trifee

Field: TTV_CODE

Trigger Name: POST-CHANGE Style: V3 Hide: No Description:

Comment:

```
select tollfee.tfee#
into :trifee.fee
from tollfee
where tollfee.tveh# =:trifee.ttv_code
and tollfee.tgate_o# =:trifee.gate_o#
and tollfee.tgate_d# =:trifee.gate_d#;
exception
when no_data_found then
  message ('Invalid Data Please Re-enter.');
  raise form_trigger_failure;
end;

travel_time;
```

block name with base table ticket

1978

****

* 13:44 3 May 1995 PROCEDURES Report for Application: TICKET

*

****

Application: TICKET
Owner: SB93

Procedure Name: travel_time

```
procedure travel_time is
begin
:travel := (:hourout*60+:minout) -(:hourin*60+:minin);
end;
```

APPENDIX C
REPORTS

REPORTS

This system generates two types of reports that are needed by users, the Revenue report for the Finance Division and the Traffic Volume report for divisions that need planning and operational reports (Please see the reports shown in this section of the report). These are only examples of many types of reports that can be generated for queries that are concerned with financial, planning and operational information

The financial report attached shows the total revenues collect on the given time and dates. The traffic report shows the amount of time it took any type of vehicle to go from one origin gate to a destination gate.