We shall examine in this chapter:

- Examples of database information systems.
- We then examine in detail three commonly used methods for organising and storing and retrieving data within information systems:
  1. Flat-file databases (including non-computer examples),
  2. Relational databases, and
  3. Hypermedia or hypertext.
- Finally we consider issues related to the use of information systems and databases.

EXAMPLES OF DATABASE INFORMATION SYSTEMS

In this section we examine three examples of database information systems:

- A school timetable system holding information on teachers, subjects, classrooms and students.
- The Roads and Traffic Authority holding information on vehicles and holders of driver’s licences.
- Video stores holding information on borrowers and videos.

For each example we identify the system’s environment/boundaries, purpose, participants, data/information, information technology and information processes. We describe the flow of data/information through each system using data flow diagrams. Our aim is to gain an overall view of each system’s components and how they work together to achieve the system’s purpose.

SCHOOL TIMETABLE SYSTEM

Environment/Boundaries

In this example we consider a school’s timetable system as a complete system, however in our particular example it is actually a subsystem within the larger school administration system. School admin systems perform many functions, one of these functions being the maintenance of the school’s timetable. The larger administration system forms part of the environment within which the timetable system operates – an entity on the context diagram for the school timetable system.

The larger school administration system provides and obtains data via an interface crossing a boundary to the timetable system – represented by data flows in both directions on the school timetable context diagram (Fig 2.1). For example teacher and student names move from the larger system to the timetable system. The teachers and students personal details, including their names, are maintained somewhere else within the larger system. Note that individual student and teacher timetables can be edited or even removed from within the timetable system, however personal student and teacher details cannot be removed from within the timetable system. The timetable system also provides data to other parts of the larger administration system via queries. For example information on each student’s subjects is output from the timetable system to the larger system to enable subject fees to be charged, Board of Studies reports to be prepared, student reports to be produced, etc.

Fig 2.1

Context diagram for a school timetable system (without data flows labeled).
The actual teachers and students are also present within the timetable system’s environment. Both teachers and students provide data to the system – teachers indicate classes they wish to teach and students provide subject selections. Conversely both receive their personal timetables from the system. Hence the teachers and students form external entities on the school timetable context diagram (see Fig 2.1).

The final entity is the administration staff. This includes office staff, the deputy, the principal and others who may need to locate particular teachers and students during the school day. Note that these people are also likely to be participants and also users within the system.

The context diagram in Fig 2.1 above graphically describes the environment in terms of data/information flowing into and out of the school timetable system. However, the environment includes more than just the entities shown on a context diagram – it includes everything that influences or is influenced by the system. The environment includes physical components that affect the system such as the network connections along which data moves and the power supply to the hardware. It is likely that the timetable system operates and shares hardware, and some software that is part of the larger admin system – if this is the case then this information technology is also part of the timetable system’s environment.

**Environment**
The circumstances and conditions that surround an information system. Everything that influences or is influenced by the system.

**GROUP TASK Discussion**
Why do you think personal student details are maintained outside the timetable system? Discuss.

**Purpose**
The purpose fulfils the needs of those for whom the system is created. A school’s timetable must therefore fulfil the primary needs for teachers and students to know where to go and what to do at all times. Other people within the school, such as admin staff on behalf of parents, need to be able to locate individual teachers or students at any time. Furthermore the larger school admin system needs various different forms of information from the timetable systems to achieve its purpose.

The purpose of a school timetable system is therefore to:
- provide accurate details to each teacher and student with regard to where and what they should be doing throughout each school day.
- enable the location of any teacher or student to be accurately determined at any time throughout each school day.
- provide flexible retrieval methods so timetable data in various forms can be provided to the school’s administration system.

Notice that the purpose is not to ensure students and teachers are in the correct place at the correct time; rather its task is to provide the information to enable this to occur. Clearly an information system cannot hope to force students to be in class, on time, every time!

**GROUP TASK Discussion**
In reality, is there really a difference between needs and the system’s purpose? Discuss.
**Data/information**

In our timetable example we have already mentioned much of the data/information entering and leaving the school timetable system. The following table summarises the data/information mentioned throughout our discussion so far:

<table>
<thead>
<tr>
<th>Data/Information</th>
<th>External Entity</th>
<th>Source OR Sink</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Names</td>
<td>School Admin System</td>
<td>✓</td>
</tr>
<tr>
<td>Student Names</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subject Selections</td>
<td>Students</td>
<td>✓</td>
</tr>
<tr>
<td>Student Timetables</td>
<td>Students</td>
<td>✓</td>
</tr>
<tr>
<td>Class Selections</td>
<td>Teachers</td>
<td>✓</td>
</tr>
<tr>
<td>Teacher Timetables</td>
<td>Teachers</td>
<td>✓</td>
</tr>
<tr>
<td>Teacher Name</td>
<td>Admin Staff</td>
<td>✓</td>
</tr>
<tr>
<td>Student Name</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Update Details</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher Location</td>
<td>Admin Staff</td>
<td>✓</td>
</tr>
<tr>
<td>Student Location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timetable Query</td>
<td>School Admin System</td>
<td>✓</td>
</tr>
<tr>
<td>Query Results</td>
<td>School Admin System</td>
<td>✓</td>
</tr>
</tbody>
</table>

The details from the above table form the basis for labelling each of the data flows on the context diagram (see *Fig 2.2*). Notice that data flow arrows pointing to an external entity indicate sinks, whilst arrows from an external entity and towards the school timetable system indicate sources of data. In this example all the external entities are both sources and sinks – they both provide data to and receive data from the system.

![Context diagram for a school timetable system.](image)

Consider the following:

To produce information requires data to be analysed and processed. Hence an examination of the final information output from a system is critical when identifying the data that must enter the system. Note that if we were developing a new system a series of verifiable requirements would be created that aim to ensure the system’s purpose is realised – many of these requirements would specify the precise nature of the information produced by the system.

**GROUP TASK Activity**

Examine your own personal school timetable and discuss the data required by your school’s timetable system to produce your timetable.
Participants

Participants are those people who perform or initiate the information processes – therefore they are part of the information system. Within our timetable system the primary participants are the administration staff, including those teachers who create and update the timetable. For example office staff probably perform most of the bulk data entry of student subject selections. The teachers who create the timetable analyse the number of students selecting each course to decide on the number of classes that will operate. They also analyse the different combinations of subject selections to best place each class so that the maximum number of students and teacher selections are satisfied. In most timetable systems these processes are accomplished using a combination of manual and computer based processes.

Consider the following:

Users are not the same as participants, however users can be participants and participants can be users – somewhat confusing! A user is someone who provides data to the system and/or receives information from the system but they need not be part of the system. In general, users who are not participants are indirect users.

GROUP TASK Discussion

In some school timetable systems the students are both users and participants, whilst in most schools students are indirect users but not participants. Identify and describe possible differences in these systems that make this possible.

Information technology

Much of the information technology used within this particular school timetable system is common to the larger school administration system. The following table details the general nature of the hardware and software used:

<table>
<thead>
<tr>
<th>Description</th>
<th>Purpose</th>
<th>Part of larger Admin System</th>
<th>Hardware</th>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>File server with RAID1</td>
<td>Physical data storage</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>SQL Server DBMS</td>
<td>Provide access/security of data</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Personal computers</td>
<td>Execute software that queries the timetable database</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Laser Printers</td>
<td>Fast printing of student and teacher timetables</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>LAN</td>
<td>Provide connectivity between server and personal computers</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Timechart</td>
<td>Dedicated software application for constructing the timetable</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>SAS Timetable module</td>
<td>Application which performs all timetable processes during the school year.</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
</tr>
</tbody>
</table>
Information Processes

The school timetable system is composed of five processes:

1. The creation of the timetable, which includes the collection of subject selections from students and class selections from teachers. This process results in the initial timetable that is used at the start of the school year.

2. Generating student timetables, which involves querying the timetable database and formatting then printing all individual student timetables.

3. Generating teacher timetables, which involves querying the timetable database and formatting then printing all individual teacher timetables.

4. Locating teachers or students includes collecting the student or teachers name and then querying the timetable to determine their location at the current time.

5. Executing SQL (Structured Query Language) statements of various types on the timetable database. The resulting data (if any) from the query being returned to the querying process. This process is used by each of the other processes apart from during the creation of the initial timetable.

The data flow diagram in Fig 2.3 is a decomposition of the context diagram to describe these five processes.

GROUP TASK Discussion

Three significant software tools are itemised in the table on the previous page. Decide which software tool is most likely to accomplish each process on the above DFD.

GROUP TASK Activity

Choose process 2, 3, 4 or 5 on the above DFD. Decompose this process further based on your school’s timetable system.
THE ROADS AND TRAFFIC AUTHORITY HOLDING INFORMATION ON VEHICLES AND HOLDERS OF DRIVER'S LICENCES

Environment/Boundaries
The Roads and Traffic Authority (RTA) is a NSW statutory authority responsible for managing the road network to ensure efficient traffic flows and improved road safety. This includes building new roads and improving and maintaining existing roads. The RTA is also responsible for testing and licensing drivers and registering and inspecting vehicles – it is this area of responsibility that we shall consider.

In 2005 the RTA operated 131 motor registries, a customer call centre located in Newcastle and approximately 80-90 other centres that are either mobile or operate as agencies within regional areas. In NSW there are more than 4.5 million licensed drivers and a similar number of vehicles requiring yearly registration. The RTA operates a system called DRIVES (Driver Vehicle System) that processes all registration and licence transactions.

The context diagram in Fig 2.4 above describes the significant external entities that either provide or obtain data from DRIVES. For example customers provide their personal details in the form of various “proof of identity” documents when they apply for a driver’s licence. Other areas of government, including other sections of the RTA, are able to access DRIVES – for instance statistics on the number of vehicles registered in particular suburbs assists when planning upgrades to the road system or other infrastructure.

GROUP TASK Activity
Classify each of the external entities on the context diagram in Fig 2.4 as either a source and/or a sink.

Purpose
The purpose of DRIVES includes:
- Maintaining accurate records of all licence and vehicle registrations within NSW.
- Assigning demerit points to licence holders as a consequence of infringements.
- Ensuring the privacy of customer’s personal details.
- Providing information to other government departments.

GROUP TASK Activity
Briefly discuss how each data flow on the context diagram in Fig 2.4 assists DRIVES to achieve its purpose.
Data/Information
Details of each data flow on the DRIVES context diagram in Fig 2.4 follow:

<table>
<thead>
<tr>
<th>Data/Information</th>
<th>Detailed Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Details</td>
<td>Name, address, photograph and proof of identity documents.</td>
</tr>
<tr>
<td>Payments</td>
<td>Credit card numbers, details for EFTPOS transaction, cash.</td>
</tr>
<tr>
<td>Licence</td>
<td>NSW photo licence.</td>
</tr>
<tr>
<td>Registration Papers</td>
<td>NSW vehicle registration papers.</td>
</tr>
<tr>
<td>Rego Number</td>
<td>Licence plate number used as a unique identifier to determine the vehicle’s registered owner.</td>
</tr>
<tr>
<td>Infringement Details</td>
<td>Type of infringement and date/time together with the driver’s licence number and other personal details. Also includes the vehicle’s details.</td>
</tr>
<tr>
<td>Enquiry</td>
<td>Various authorised queries for information from the DRIVES database.</td>
</tr>
<tr>
<td>Response</td>
<td>Information returned from DRIVES in response to an enquiry.</td>
</tr>
<tr>
<td>Vehicle Registration Details</td>
<td>Vehicle dealers submit personal details of each car purchaser together with the vehicle’s details for each car sold.</td>
</tr>
<tr>
<td>CTP Green Slip Details</td>
<td>Insurance companies inform the RTA directly each time a Green Slip is issued.</td>
</tr>
<tr>
<td>Inspection Certificate Details</td>
<td>Pink slip and blue slip details either on paper certificates or transmitted electronically to RTA.</td>
</tr>
</tbody>
</table>

Participants
Most of the information processing within DRIVES is performed by RTA staff, hence these are the most significant participants within the system. The system also allows many of the other users to enter data directly into the system – when this occurs then those people are also participants.

Examples where people other than RTA staff are participants include:
- myRTA website which allows customers to perform a range of transactions online including renewing their registration, changing address and checking their demerit points.
- Dealer online (DOL) system that enables motor vehicle dealers to register vehicles and transfer registrations using the Internet.
- E-safety check system which allows registered vehicle inspectors to electronically transmit pink slip details to the RTA.
- Employees of CTP Green Slip insurers transmit details of each paid Green Slip directly to the RTA system.

Information Technology
The NSW RTA has outsourced responsibility and provision of its data management technology to Fujitsu since 1997. Fujitsu manages the entire NSW RTA information technology environment, which includes DRIVES. The main data centre is currently located in Ultimo (an inner Sydney suburb) where both application software and data is hosted on Sun Fire™ E6900 servers – two of these servers hosting DRIVES. Together these servers support approximately 5500 client computers in some 220 locations throughout the state. The current contract with Fujitsu includes detailed specifications including reliability, response times and recovery times. The E6900 servers assist in this regard as they include inbuilt redundancy for most of their components.
Currently (2007) the client computers used within registry offices are largely Apple G4 iMacs – these were selected because of their ergonomic design and their ability to integrate easily within the Unix-based network. The DRIVES software is a custom application that processes licence and registration data held in an Oracle database accessed via the Sun E6900 servers. Each motor registry workstation includes the iMac computer, a printer, EFTPOS terminal and access to at least one digital camera. The DRIVES software is an integrated application capable of processing EFTPOS transactions, capturing photos and producing licences and of course accessing the main Oracle database.

### GROUP TASK Research
Determine the basic specifications of the Sun Fire™ E6900 server and Oracle’s database system.

### GROUP TASK Discussion
Brainstorm possible reasons why the RTA has outsourced responsibility and provision of its data management technology.

### Information Processes
Some of the information processes performed by DRIVES include:
- Renewing vehicle registrations. This includes generating and posting renewal notices, receiving pink and green slip details, processing payments and approving renewals.
- Editing registration details. Includes change of ownership and/or address, collecting stamp duty payments, verifying personal details and creating registration records for new vehicles.
- Issuing new and renewed licences. Includes testing, processing payments, taking photos, verifying personal details and producing photo licences.
- Retrieving and transmitting details of the registered owner of vehicles to police.
- Issuing licence suspension notices when twelve or more demerit points are accumulated within a period of 3 years.

### GROUP TASK Discussion
Brainstorm a list of other information processes performed by DRIVES.

### Consider the following decision table for renewing vehicle registrations:

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current CTP Green Slip</td>
<td></td>
</tr>
<tr>
<td>Pink Slip Passed</td>
<td></td>
</tr>
<tr>
<td>Payment Approved</td>
<td></td>
</tr>
</tbody>
</table>

### GROUP TASK Activity
Convert the above decision table into an equivalent decision tree.
VIDEO STORES HOLDING INFORMATION ON BORROWERS AND VIDEOS

HSC style question

A small video store records details of its customers and the videos and DVDs they have borrowed using vStore – a software application connected to a database. The store has a single personal computer attached to a cash drawer, bar code scanner and printer. The owner of the store uses the computer to generate various financial and statistical reports from the database. The sales staff use the computer when enrolling new members, processing sales and entering returned movies.

The customers are provided with a membership card that includes a barcode representing their membership number. Similarly each video and DVD has a sticker with a unique barcode. A separate EFTPOS machine is used to process all non-cash payments.

(a) Identify each of the following components in the context of the above information system.

- **Purpose**
- **Participants**
- **Data/information**
- **Information technology**

(b) Draw a data flow diagram to describe the information system, including the following:

- **external entities**
- **information processes mentioned above**
- **data flows**

**Suggested Solution**

(a) **Purpose**
- To maintain accurate records of members and the videos and DVDs they borrow and subsequently return including payments made.
- Produce financial and statistical reports for the owner.

**Participants**
- Owner when generating reports.
- Sales staff enrolling new members, processing sales and entering returned movies.

**Data/information**
- Customer details including their membership number.
- Details of each video including a unique number/barcode for each.
- Borrowing details including membership number, date borrowed, date for return, unique number for each video and DVD borrowed and payment.
- Financial and statistical reports.
- EFTPOS details including details from customer’s EFT cards and approval from bank.

**Information Technology**
- vStore software, PC, cash drawer, bar code scanner and printer.
- EFTPOS machine, including its connection to bank.