distributed among them. One popular approach is the creation of *data ware-houses*, where information from many legacy databases is copied periodically, with the appropriate translation, to a central database. Another approach is the implementation of a mediator, or "middleware," whose function is to support an integrated model of the data of the various databases, while translating between this model and the actual models used by each database.

1.2 Overview of a Database Management System

In Fig. 1.1 we see an outline of a complete DBMS. Single boxes represent system components, while double boxes represent in-memory data structures. The solid lines indicate control and data flow, while dashed lines indicate data flow only. Since the diagram is complicated, we shall consider the details in several stages. First, at the top, we suggest that there are two distinct sources of commands to the DBMS:

1. Conventional users and application programs that ask for data or modify data.

2. A *database administrator*: a person or persons responsible for the structure or *schema* of the database.

1.2.1 Data-Definition Language Commands

The second kind of command is the simpler to process, and we show its trail beginning at the upper right side of Fig. 1.1. For example, the database administrator, or *DBA*, for a university registrar's database might decide that there should be a table or relation with columns for a student, a course the student has taken, and a grade for that student in that course. The DBA might also decide that the only allowable grades are A, B, C, D, and F. This structure and constraint information is all part of the schema of the database. It is shown in Fig. 1.1 as entered by the DBA, who needs special authority to execute schema-altering commands, since these can have profound effects on the database. These schema-altering data-definition language (DDL) commands are parsed by a DDL processor and passed to the execution engine, which then goes through the index/file/record manager to alter the *metadata*, that is, the schema information for the database.

1.2.2 Overview of Query Processing

The great majority of interactions with the DBMS follow the path on the left side of Fig. 1.1. A user or an application program initiates some action, using the data-manipulation language (DML). This command does not affect the schema of the database, but may affect the content of the database (if the