with the referential integrity constraints:

StudentNumber in GRADE_1 must exist in StudentNumber in STUDENT
Professor in CLASS_PROFESSOR must exist in Professor in PROFESSOR
(ClassName, Section, Term) in GRADE_1 must exist in (ClassName, Section, Term) in CLASS_PROFESSOR

Next, consider what happens if more than one professor teaches a section of a class. In that case, the only change is to make Professor part of the primary key of CLASS_PROFESSOR. Thus, the new relation is:

CLASS_PROFESSOR_1 (<u>ClassName</u>, <u>Section</u>, <u>Term</u>, *Professor*)

Class sections that have more than one professor will have multiple rows in this table—one row for each of the professors.

This example shows how normalization problems can become more complicated than simple examples might indicate. For large commercial applications that potentially involve hundreds of tables, such problems can sometimes consume days or weeks of design time.

BTW

In the interest of full disclosure, if professors can teach more than one class, then GRADE has what is called a **multivalued dependency.** We do not discuss such dependencies in depth in this book. We will revisit them in Chapter 5 (page 261–262) when we review normal forms in that chapter. If you want to learn about them, see one of the more advanced texts mentioned in the footnote on page 72 and also see exercises 2.40 and 2.41.

THE ACCESS WORKBENCH

Section 2

Working with Multiple Tables in Microsoft Access

In Chapter 1's "The Access Workbench," we learned how to create Microsoft Access 2010 databases, tables, forms, and reports. However, we were limited to working with only one table. In this section, we will:

- See examples of the modification problems discussed in Chapters 1 and 2.
- Work with multiple tables.

We will continue to use the WMCRM database we created in Chapter 1's section of "The Access Workbench." At this point, you have created and populated (which means you have inserted the data into) the CONTACT table. Figure AW-2-1 shows the contacts that have been made with each customer. Note that there is no CustomerID 2—this is because we deleted and reentered the data for Jessica Christman.

Possible Modification Problems in the WMCRM Database

FIGURE AW-2-1

CONTACT Data

CustomerID	Date	Type	Remarks
1	7/7/2012	Phone	General interest in a Gaea.
1	7/7/2012	Email	Sent general information.
1	7/12/2012	Phone	Set up an appointment.
1	7/14/2012	Meeting	Bought a HiStandard.
3	7/19/2012	Phone	Interested in a SUHi, set up an appointment.
1	7/21/2012	Email	Sent a standard follow-up message.
4	7/27/2012	Phone	Interested in a HiStandard, set up an appointment.
3	7/27/2012	Meeting	Bought a SUHi.
4	8/2/2012	Meeting	Talked up to a HiLuxury. Customer bought one.
3	8/3/2012	Email	Sent a standard follow-up message.
4	8/10/2012	Email	Sent a standard follow-up message.
5	8/15/2012	Phone	General interest in a Gaea.

We know from the topics covered in this chapter that we really need a separate table to store the CONTACT data, but in order to illustrate the modification problems discussed in Chapter 1 let us combine it into one table with the data already in CUSTOMER. This table is available in the file WMCRM-Combined-Data.accdb, which is available at the Web site for this book (**www.pearsonhighered.com/kroenke**). We will use this database to see modification problems in non-normalized tables and then build the correctly normalized tables in the actual WMCRM database.

We will need to start Microsoft Access 2010, open the WMCRM-Combined-Data .accdb file, and take a look at the WMCRM-Combined-Data database.

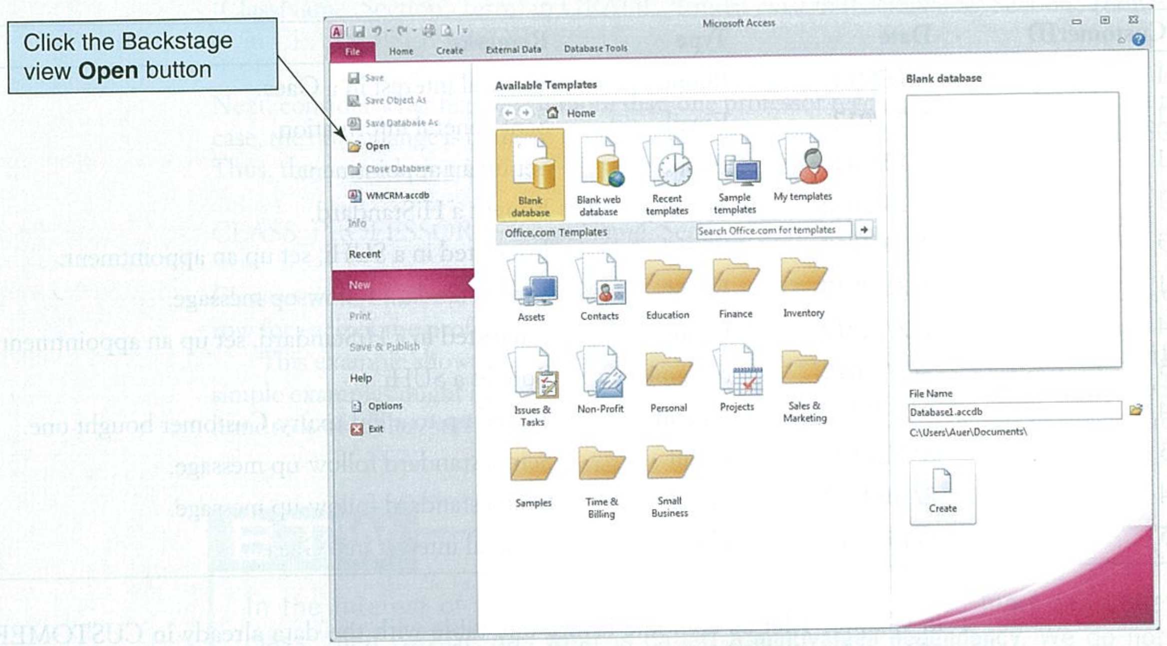
Opening an Existing Microsoft Access Database

1. Select **Start | All Programs | Microsoft Office | Microsoft Access 2010**. The Microsoft Access 2010 window appears with the Backstage view displayed, as shown in Figure AW-2-2.
   - **NOTE:** The menu command or icon location used to start Microsoft Access 2010 may vary, depending on the operating system and how Microsoft Office is installed on the computer you are using.
2. Click the **Open** button to display the Open dialog box, as shown in Figure AW-2-3.
3. Browse to the **WMCRM-Combined-Data.accdb** file, click the file name to highlight it, and then click the **Open** button.
4. The **Security Warning** bar appears with the database. Click the Security Warning bar's **Enable Content** button to select this option.
5. In the Navigation Pane, double-click the **CUSTOMER_CONTACT** table object to open it.
6. Click the **Shutter Bar Open/Close** button to minimize the Navigation Pane.
7. The CUSTOMER_CONTACT table appears in Datasheet view, as shown in Figure AW-2-4. Note that there is one line for each contact, which has resulted in the duplication of basic customer data. For example, there are five sets of basic data for Ben Griffey.
8. Close the CUSTOMER_CONTACT table by clicking the document window's **Close** button.
9. Click the **Shutter Bar Open/Close** button to expand the Navigation Pane.

(Continued)

FIGURE AW-2-2

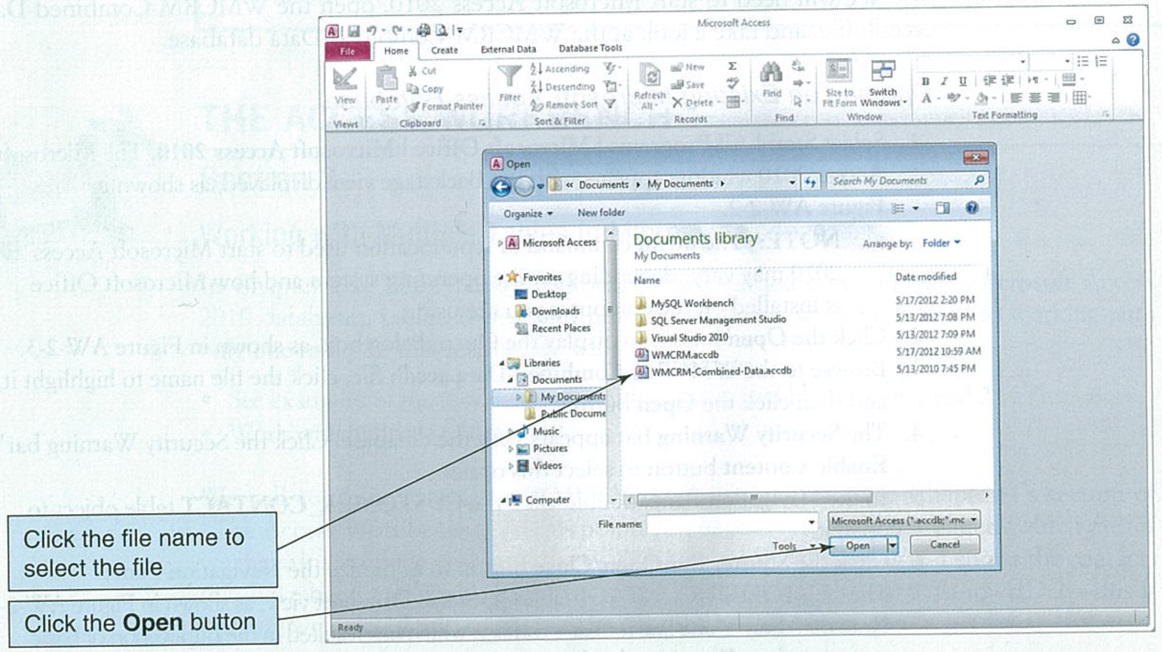
The Microsoft Access 2010 File Menu



Click the Backstage view **Open** button

FIGURE AW-2-3

The Open Dialog Box



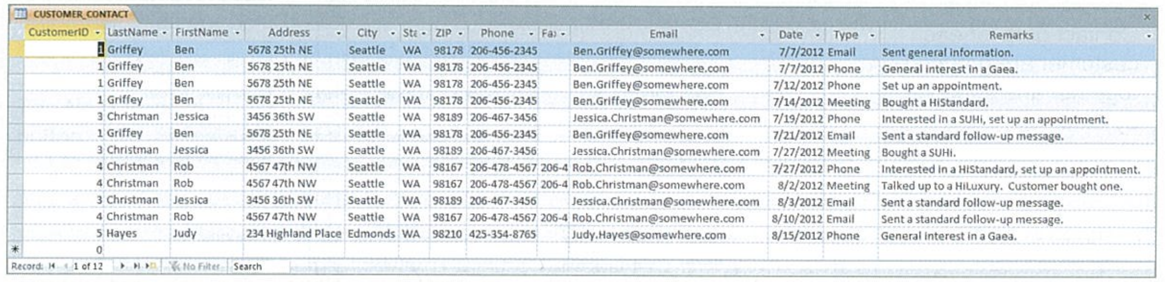
Click the file name to select the file

Click the **Open** button

10. In the Navigation Pane, double-click the **Customer Contact Data Input Form** object to open it. The Customer Contact Data Input Form appears, as shown in Figure AW-2-5. Note that the form displays all the data for one record in the CUSTOMER_CONTACT table.
11. Close the Customer Contact Data Input Form by clicking the document window's **Close** button.

FIGURE AW-2-4

The CUSTOMER_CONTACT Table



CUSTOMER_CONTACT

CustomerID	LastName	FirstName	Address	City	Sta	ZIP	Phone	Fa	Email	Date	Type	Remarks
1	Griffey	Ben	5678 25th NE	Seattle	WA	98178	206-456-2345		Ben.Griffey@somewhere.com	7/7/2012	Email	Sent general information.
1	Griffey	Ben	5678 25th NE	Seattle	WA	98178	206-456-2345		Ben.Griffey@somewhere.com	7/7/2012	Phone	General interest in a Gaea.
1	Griffey	Ben	5678 25th NE	Seattle	WA	98178	206-456-2345		Ben.Griffey@somewhere.com	7/12/2012	Phone	Set up an appointment.
1	Griffey	Ben	5678 25th NE	Seattle	WA	98178	206-456-2345		Ben.Griffey@somewhere.com	7/14/2012	Meeting	Bought a HiStandard.
3	Christman	Jessica	3456 36th SW	Seattle	WA	98189	206-467-3456		Jessica.Christman@somewhere.com	7/19/2012	Phone	Interested in a SUHi, set up an appointment.
1	Griffey	Ben	5678 25th NE	Seattle	WA	98178	206-456-2345		Ben.Griffey@somewhere.com	7/21/2012	Email	Sent a standard follow-up message.
3	Christman	Jessica	3456 36th SW	Seattle	WA	98189	206-467-3456		Jessica.Christman@somewhere.com	7/27/2012	Meeting	Bought a SUHi.
4	Christman	Rob	4567 47th NW	Seattle	WA	98167	206-478-4567	206-4	Rob.Christman@somewhere.com	7/27/2012	Phone	Interested in a HiStandard, set up an appointment.
4	Christman	Rob	4567 47th NW	Seattle	WA	98167	206-478-4567	206-4	Rob.Christman@somewhere.com	8/2/2012	Meeting	Talked up to a HiLuxury. Customer bought one.
3	Christman	Jessica	3456 36th SW	Seattle	WA	98189	206-467-3456		Jessica.Christman@somewhere.com	8/3/2012	Email	Sent a standard follow-up message.
4	Christman	Rob	4567 47th NW	Seattle	WA	98167	206-478-4567	206-4	Rob.Christman@somewhere.com	8/10/2012	Email	Sent a standard follow-up message.
5	Hayes	Judy	234 Highland Place	Edmonds	WA	98210	425-354-8765		Judy.Hayes@somewhere.com	8/15/2012	Phone	General interest in a Gaea.
0												

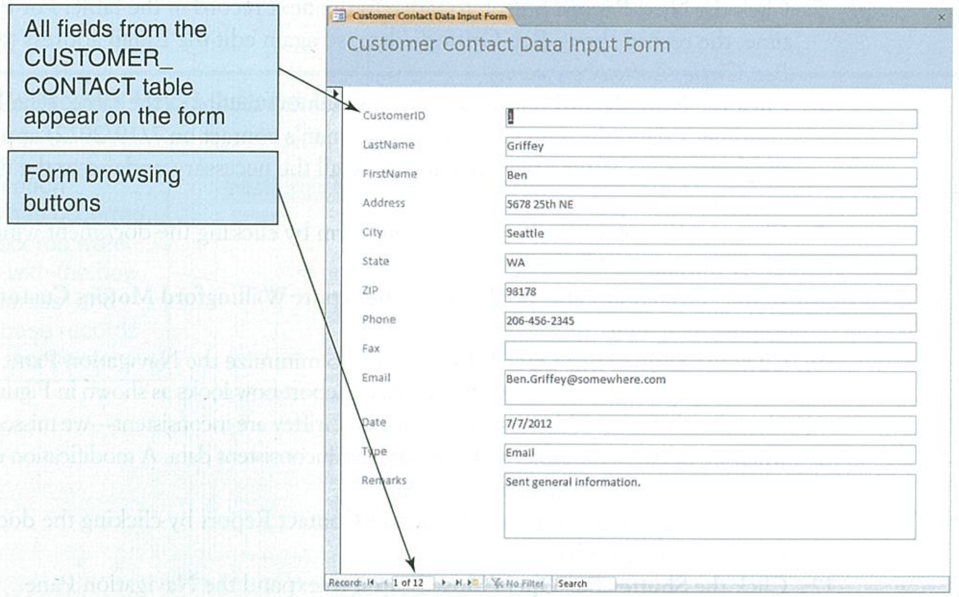
Record: 1 of 12 No Filter Search

12. In the Navigation Pane, double-click the **Wallingford Motors Customer Contact Report** to open it.
13. Click the **Shutter Bar Open/Close** button to minimize the Navigation Pane.
14. The Wallingford Motors Customer Contact Report appears, as shown in Figure AW-2-6. Note that the form displays the data for all contacts in the CUSTOMER_CONTACT table, sorted by CustomerNumber and Date. For example, all the contact data for Ben Griffey (who has a CustomerID of 1) is grouped at the beginning of the report.
15. Close the Wallingford Motors Customer Contact Report by clicking the document window's **Close** button.
16. Click the **Shutter Bar Open/Close** button to expand the Navigation Pane.

Now, assume that Ben Griffey has changed his email address from Ben.Griffey@somewhere.com to Ben.Griffey@elsewhere.com. In a well-formed relation, we would have to make this change only once, but a quick examination of Figures AW-2-4 through AW-2-6 shows that Ben Griffey's email address appears in multiple records.

FIGURE AW-2-5

The Customer Contact Data Input Form



All fields from the CUSTOMER_CONTACT table appear on the form

Form browsing buttons

Customer Contact Data Input Form

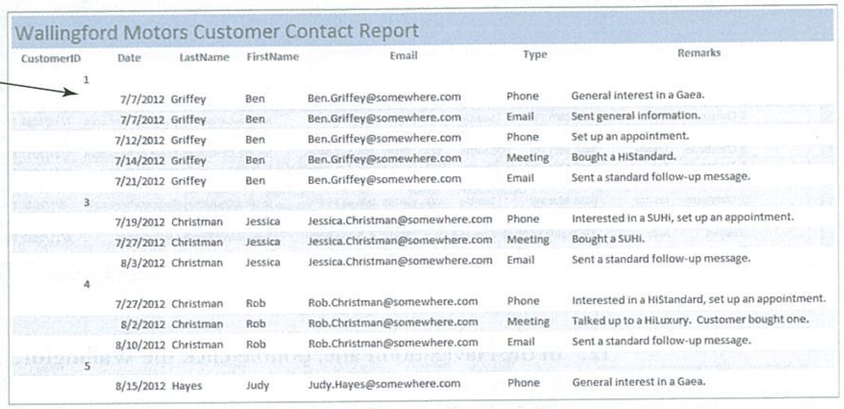
CustomerID	1
LastName	Griffey
FirstName	Ben
Address	5678 25th NE
City	Seattle
State	WA
ZIP	98178
Phone	206-456-2345
Fax	
Email	Ben.Griffey@somewhere.com
Date	7/7/2012
Type	Email
Remarks	Sent general information.

Record: 1 of 12 No Filter Search

(Continued)

FIGURE AW-2-6

The Wallingford Motors Customer Contact Report



Contact data for each customer are grouped together and sorted by date

Wallingford Motors Customer Contact Report

CustomerID	Date	LastName	FirstName	Email	Type	Remarks
1						
	7/7/2012	Griffey	Ben	Ben.Griffey@somewhere.com	Phone	General interest in a Gaea.
	7/7/2012	Griffey	Ben	Ben.Griffey@somewhere.com	Email	Sent general information.
	7/12/2012	Griffey	Ben	Ben.Griffey@somewhere.com	Phone	Set up an appointment.
	7/14/2012	Griffey	Ben	Ben.Griffey@somewhere.com	Meeting	Bought a HiStandard.
	7/21/2012	Griffey	Ben	Ben.Griffey@somewhere.com	Email	Sent a standard follow-up message.
3						
	7/19/2012	Christman	Jessica	Jessica.Christman@somewhere.com	Phone	Interested in a SUHi, set up an appointment.
	7/27/2012	Christman	Jessica	Jessica.Christman@somewhere.com	Meeting	Bought a SUHi.
	8/3/2012	Christman	Jessica	Jessica.Christman@somewhere.com	Email	Sent a standard follow-up message.
4						
	7/27/2012	Christman	Rob	Rob.Christman@somewhere.com	Phone	Interested in a HiStandard, set up an appointment.
	8/2/2012	Christman	Rob	Rob.Christman@somewhere.com	Meeting	Talked up to a HiLuxury. Customer bought one.
	8/10/2012	Christman	Rob	Rob.Christman@somewhere.com	Email	Sent a standard follow-up message.
5						
	8/15/2012	Hayes	Judy	Judy.Hayes@somewhere.com	Phone	General interest in a Gaea.

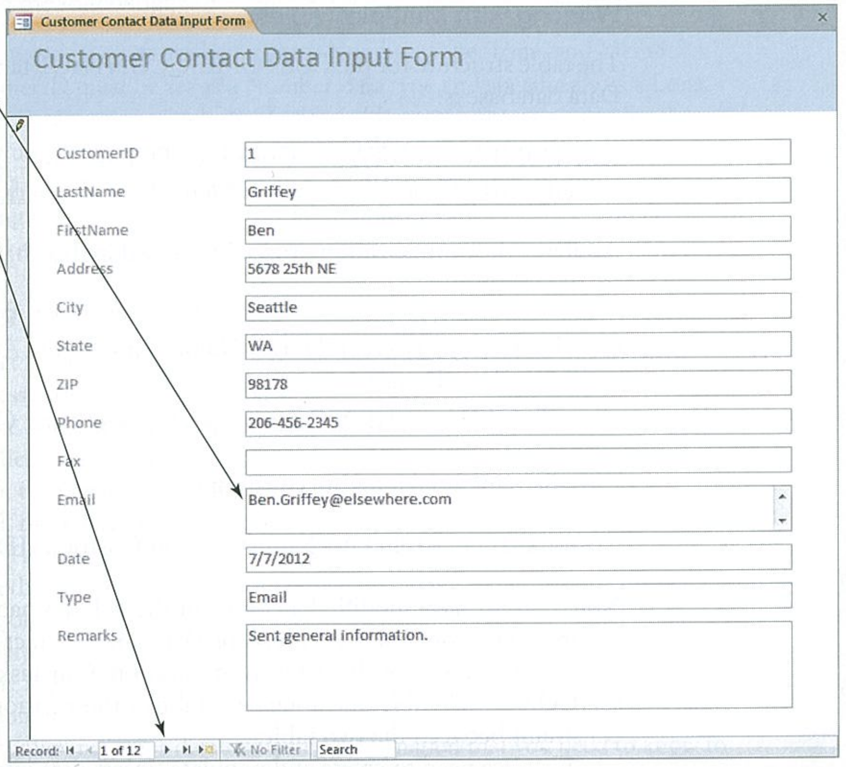
We therefore have to change it in every record to avoid update problems. Unfortunately, it is easy to miss one or more records, especially in large tables.

Updating Ben Griffey's Email Address

1. In the Navigation Pane, double-click the *Customer Contact Data Input Form* object to open it. Because Ben Griffey is the customer in the first record, his data is already in the form.
2. Edit the **Email** address to read *Ben.Griffey@elsewhere.com*, as shown in Figure AW-2-7.
3. Click the **Next Record** button to move to the next record in the table. Again, the record shows Ben Griffey's data, so again edit the **Email** address to read *Ben.Griffey@elsewhere.com*.
4. Click the **Next Record** button to move to the next record in the table. For the third time, the record shows Ben Griffey's data, so again edit the **Email** address to read *Ben.Griffey@elsewhere.com*.
5. Click the **Next Record** button to move to the next record in the table. For the fourth time, the record shows Ben Griffey's data, so again edit the **Email** address to read *Ben.Griffey@elsewhere.com*.
6. Click the **Next Record** button to move to the next record in the table. Finally, another customer's data (the data for Jessica Christman's contact on 7/19/2012) appears in the form, so we assume that we have made all the necessary updates to the database records.
7. Close the Customer Contact Data Input form by clicking the document window's **Close** button.
8. In the Navigation Pane, double-click the report **Wallingford Motors Customer Contact Report** to open it.
9. Click the **Shutter Bar Open/Close** button to minimize the Navigation Pane.
10. The Wallingford Motors Customer Contact Report now looks as shown in Figure AW-2-8. Note that the email addresses shown for Ben Griffey are inconsistent—we missed one record when we updated the table, and now we have inconsistent data. A modification error—in this case an update error—has occurred.
11. Close the Wallingford Motors Customer Contact Report by clicking the document window's **Close** button.
12. Click the **Shutter Bar Open/Close** button to expand the Navigation Pane.

FIGURE AW-2-7

The Customer Contact Data Input Form with the Updated Email Address



The email address has been updated

The **Next Record** button

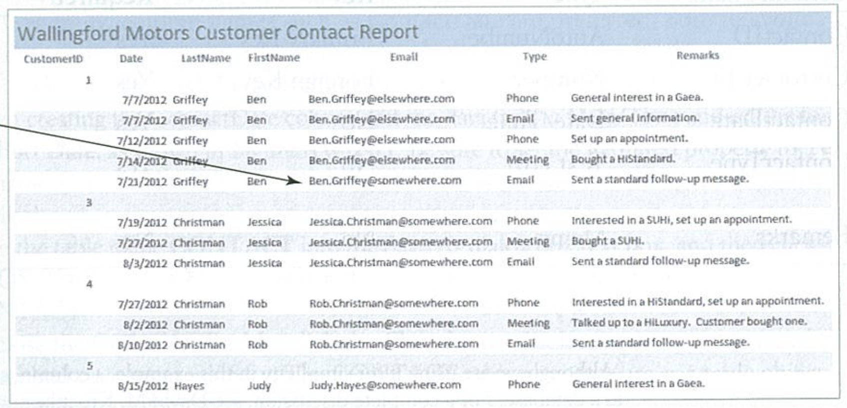
Customer Contact Data Input Form

CustomerID	1
LastName	Griffey
FirstName	Ben
Address	5678 25th NE
City	Seattle
State	WA
ZIP	98178
Phone	206-456-2345
Fax	
Email	Ben.Griffey@elsewhere.com
Date	7/7/2012
Type	Email
Remarks	Sent general information.

This simple example shows how easily modification problems can occur in tables that are not normalized. With a set of well-formed, normalized tables, this problem would not have occurred.

FIGURE AW-2-8

The Updated Wallingford Motors Customer Contact Report



A modification problem has occurred. Not all records were updated with the new email address, and the database records are now inconsistent

Wallingford Motors Customer Contact Report

CustomerID	Date	LastName	FirstName	Email	Type	Remarks
1						
	7/7/2012	Griffey	Ben	Ben.Griffey@elsewhere.com	Phone	General interest in a Gaea.
	7/7/2012	Griffey	Ben	Ben.Griffey@elsewhere.com	Email	Sent general information.
	7/12/2012	Griffey	Ben	Ben.Griffey@elsewhere.com	Phone	Set up an appointment.
	7/14/2012	Griffey	Ben	Ben.Griffey@elsewhere.com	Meeting	Bought a HiStandard.
	7/21/2012	Griffey	Ben	Ben.Griffey@somewhere.com	Email	Sent a standard follow-up message.
3						
	7/19/2012	Christman	Jessica	Jessica.Christman@somewhere.com	Phone	Interested in a SUHi, set up an appointment.
	7/27/2012	Christman	Jessica	Jessica.Christman@somewhere.com	Meeting	Bought a SUHi.
	8/3/2012	Christman	Jessica	Jessica.Christman@somewhere.com	Email	Sent a standard follow-up message.
4						
	7/27/2012	Christman	Rob	Rob.Christman@somewhere.com	Phone	Interested in a HiStandard, set up an appointment.
	8/2/2012	Christman	Rob	Rob.Christman@somewhere.com	Meeting	Talked up to a HiLuxury. Customer bought one.
	8/10/2012	Christman	Rob	Rob.Christman@somewhere.com	Email	Sent a standard follow-up message.
5						
	8/15/2012	Hayes	Judy	Judy.Hayes@somewhere.com	Phone	General interest in a Gaea.

(Continued)

Closing the WMCRM-Combined-Data Database

1. Click the **Close** button to close the database and exit Microsoft Access.

Working with Multiple Tables

The table structure for the CUSTOMER_CONTACT table in the WMCRM-Combined-Data database is:

CUSTOMER_CONTACT (CustomerID, LastName, FirstName, Address, City, State, ZIP, Phone, Fax, Email, Date, Type, Remarks)

Applying the normalization process discussed in this chapter, we will have the following set of tables:

CUSTOMER (CustomerID, LastName, FirstName, Address, City, State, ZIP, Phone, Fax, Email)

CONTACT (ContactID, *CustomerID*, ContactDate, ContactType, Remarks)

with the referential integrity constraint:

CustomerID in CONTACT must exist in CustomerID in CUSTOMER

Note that we have modified a couple of the column names in the CONTACT table—we are using ContactDate instead of Date and ContactType instead of Type. We will discuss the reason for this later in this section. Our task now is to build and populate the CONTACT table and then to establish the relationship and referential integrity constraint between the two tables.

First, we need to create and populate (insert data into) the CONTACT table, which will contain the columns and column characteristics shown in the table in Figure AW-2-9.[6] The CustomerID column appears again in CONTACT, this time designated as a foreign key. As discussed in this chapter, the term **foreign key** designates this column as the link to the CUSTOMER table. The value in the CustomerID column of CONTACT tells which customer was contacted. All we have to do is look up the value of CustomerID in the CUSTOMER table.

FIGURE AW-2-9

Database Column Characteristics for the CONTACT Table

Column Name	Type	Key	Required	Remarks
ContactID	AutoNumber	Primary Key	Yes	Surrogate Key
CustomerID	Number	Foreign Key	Yes	Long Integer
ContactDate	Date/Time	No	Yes	Short Date
ContactType	Text (10)	No	Yes	Allowed values are Phone, Fax, Email, and Meeting
Remarks	Memo	No	No	

[6] Although we are using it for simplicity in this example, a column, such as Remarks, can cause problems in a database. For a complete discussion, see David M. Kroenke and David J. Auer, *Database Processing: Fundamentals, Design, and Implementation*, 12th edition (Upper Saddle River, NJ: Prentice Hall, 2012).

Note that when we build the CONTACT table there is no "foreign key" setting. We will set up the database relationship between CUSTOMER and CONTACT after we have finished building the CONTACT table.

Note the following:

- Some new data types are being used: Number, Date/Time, and Memo.
- CustomerID must be set as a Number data type and specifically as a Long Integer data type to match the data type Microsoft Access creates for the AutoNumber data type in the CUSTOMER table.
- The Type column has only four allowed values: Phone, Fax, Email, and Meeting. For now, we can simply input only these data values. You will learn how to enforce the data restriction for this column in Chapter 3.

Creating the CONTACT Table

1. Select **Start | All Programs | Microsoft Office | Microsoft Access 2010**. The Microsoft Access 2010 window appears.
2. In the quick access list of database files, click **WMCRM.accdb**. The database file opens in Microsoft Access.
3. Click the **Create** command tab.
4. Click the **Table Design** button.
5. The Table1 tabbed document window is displayed in Design view. Note that along with the Table1 window a contextual tab named Table Tools is displayed and that this tab adds a new command tab and ribbon, named Design, to the set of command tabs displayed.
6. Using the steps we followed to create the CUSTOMER table in Chapter 1's section of "The Access Workbench," begin to create the CONTACT table. The following steps detail only new information that you need to know to complete the CONTACT table.
   - **NOTE:** When creating the CONTACT table, be sure to enter appropriate comments in the Description column.
7. When creating the CustomerID column, set the data type to **Number**. Note that the default Field Size setting for Number is Long Integer, so no change is necessary. Be sure to set the Required property to **Yes**.
8. After creating the ContactID column, set it as the primary key of the table.
9. When creating the ContactDate column, start by using the column name **Date**. As soon as you enter the column name and try to move to the Data Type column, Microsoft Access displays a dialog box, warning you that Date is a reserved word, as shown in Figure AW-2-10. Click the **Cancel** button, and change the column name to **ContactDate**.
   - **NOTE:** Normally, you should avoid reserved words such as Date and Time. Generally, column names such as ContactDate are preferred, both to avoid reserved words and to clarify exactly which date you are referring to, and that is why we changed the column names in the CONTACT table.
10. When creating the ContactDate column, set the data type to **Date/Time** and set the format to **Short Date**, as shown in Figure AW-2-11. Be sure to set the Required property to **Yes**.
11. To name and save the CONTACT table, click the **Save** button in the Quick Access Toolbar.
12. Type the table name **CONTACT** into the Save As dialog box text box, and then click the **OK** button. The table is named and saved, and it now appears with the table name CONTACT.
13. To close the CONTACT table, click the **Close** button in the upper-right corner of the tabbed document window. The CONTACT table now appears as a table object in the Navigation Pane.

(Continued)