Making the Most of SQL-SELECT

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VFP's SQL-SELECT command lets you look at data in many ways, but getting the results you want can be difficult. This session looks at queries beyond the basics and shows you how to make sure that what you get is what you meant. It also covers performance and optimization issues, including a look at the VFP function that reports on query optimization.

This session assumes some familiarity with the SQL-SELECT command. It's focused on VFP's native SQL-SELECT command, not client-server queries.

Getting the right join

While some queries (such as those used to collect information for a picklist) involve only a single table, most queries use two or more tables. Joining more than two tables introduces a variety of issues.

The JOIN clause

When a query includes more than one table, you need to specify how records from the tables are to be matched up to produce the result set. This is called *joining* the tables. The JOIN sub-clause of SQL-SELECT's FROM clause is used for this purpose. (JOIN was added in VFP 5. Prior to that, joins had to be placed in the WHERE clause.)

A join has two parts: the pair of tables to be joined, and the condition for matching records. The syntax looks like this:

```
<Table1> JOIN <Table2> ON <expression>
```

The expression following the ON clause can be more complex than a simple comparison. For example, if the criteria for joining two tables involve multiple fields, you can use AND and OR to combine multiple comparisons. (Another type of complex condition is discussed below.)

VFP provides two ways to specify joins when more than two tables are involved in a query. The first, called *nested* syntax, lists all the tables first, then lists all the join conditions. In nested syntax, the last two tables listed are joined first, using the innermost join condition. Then, the next-to-last table listed is joined with the result of the first join, using the second join condition, and so forth.

For example, using VFP's TasTrade sample data, the FROM clause of a query involving the Customer, Orders, and Order_Line_Items tables might look like this:

```
FROM Customer ;
  JOIN Orders ;
    JOIN Order_Line_Items ;
    ON Orders.Order_Id = Order_Line_Items.Order_Id ;
  ON Customer.Customer_Id = Orders.Customer_Id
```

Orders and Order_Line_Items are joined first, using the condition Orders.Order_Id = Order_Line_Items.Order_Id. Then Customer is joined to the result using the condition Customer.Customer_Id = Orders.Customer_Id. Nested syntax works best when the tables in the query have a hierarchical relationship.

The alternative to nested syntax, called *sequential* syntax, lists the joins one at a time. Each time JOIN is specified to add a table, it's followed by ON, which tells how to join that table to the results so far. Here's the same join, using the sequential syntax:

```
FROM Customer ;
  JOIN Orders ;
    ON Customer.Customer_Id = Orders.Customer_Id ;
  JOIN Order_Line_Items ;
    ON Orders.Order_Id = Order_Line_Items.Order_Id
```

This time, Customer and Orders are joined first, using the condition Customer.Customer_Id = Orders.Customer_Id. Then Order_Line_Items is joined with the result, based on the condition Orders.Order_Id = Order_Line_Items.Order_Id. With all this in mind, let's move on to more complicated situations.

Multiple Unrelated Siblings

Writing a join condition is usually easy when the relationship among the tables is strictly hierarchical (parent-child-grandchild); either nested or sequential syntax can be used, as in the examples above. But when a table has multiple child tables and the child tables aren't related to each other, things start to get interesting.

Again using the TasTrade data, consider a query in which you want to find out the employee who took an order and the shipper used to send the order. (Perhaps you want to determine whether an employee appears to be steering business to a particular shipper.) In this situation, the Orders table is the parent and the Employee and Shippers tables are the children. So, the natural way to write this query is:

```
SELECT Shippers.Company_Name, ;
       Orders.Order_Id, ;
       Employee.Last_Name ;
   FROM Orders ;
     JOIN Shippers ;
       JOIN Employee ;
       ON Orders.Employee_Id = Employee.Employee_Id ;
     ON Shippers.Shipper_Id = Orders.Shipper_Id
```

Unfortunately, this query doesn't work. When you run it, one of two things happens. If the Orders table is already open, the query runs, but the results contain the same employee in each row rather than the one associated with the order. If the Orders table is not open before the query is run, the error "SQL: Column 'EMPLOYEE_ID' is not found." appears. The problem is that VFP attempts to join Shippers and Employee using the innermost condition:

```
Orders.Employee_Id=Employee.Employee_Id
```

When Orders isn't open, that triggers an error. When Orders is open, VFP's behavior is much more dangerous: it takes the current value of Orders.Employee_Id and plugs that into the join.

There are several ways to get the right results. You can use nested syntax by listing the tables in a different order:

```
SELECT Shippers.Company_Name, ;
       Orders.Order_Id, ;
       Employee.Last_Name ;
   FROM Shippers ;
     JOIN Orders ;
       JOIN Employee ;
       ON Orders.Employee_Id = Employee.Employee_Id ;
     ON Shippers.Shipper_Id = Orders.Shipper_Id
```

In this case, Orders has been moved to the middle of the relationship. While this query gives the right results, to a reader, it implies a parent-child-grandchild relationship from Shippers to Orders to Employees (technically, it specifies that Shippers is to be joined with the result of joining Orders and Employee). Similarly, the next version, also using the nested syntax, suggests a relationship between Shippers and Employee:

```
SELECT Shippers.Company_Name, ;
       Orders.Order_Id, ;
       Employee.Last_Name ;
   FROM Shippers ;
     JOIN Employee;
       JOIN Orders;
       ON Orders.Employee_Id = Employee.Employee_Id ;
     ON Shippers.Shipper_Id = Orders.Shipper_Id
```

Fortunately, the sequential syntax makes it easier to deal with non-hierarchical relationships. You can get the right answer and have readable code:

```
SELECT Shippers.Company_Name, ;
       Orders.Order_Id, ;
       Employee.Last_Name ;
   FROM Orders;
     JOIN Shippers;
       ON Shippers.Shipper_Id = Orders.Shipper_Id;
     JOIN Employee ;
       ON Orders.Employee_Id = Employee.Employee_Id
```

As the number of tables involved in a query increases, the value of having both the nested and sequential syntaxes for joins becomes apparent, especially because you can mix the two in a single query. This query extracts the customer name, shipper, order date, and each product in an order:

```
SELECT Customer.Company_Name, ;
       Shippers.Company_Name, ;
       Orders.Order_Date, ;
       Products.English_Name ;
  FROM Customer ;
    JOIN Orders ;
      JOIN Order_Line_Items ;
        JOIN Products ;
        ON Order_Line_Items.Product_Id = ;
           Products.Product_Id ;
      ON Orders.Order_Id = Order_Line_Items.Order_Id ;
    ON Customer.Customer_Id = Orders.Customer_Id ;
    JOIN Shippers ;
      ON Orders.Shipper_Id = Shippers.Shipper_Id
```

Nested joins are used to move from Customer down to Products, where a hierarchical relationship exists. Then the sequential syntax tells VFP to join that result with Shippers.

Don't use the Query Designer and View Designer for complex queries

The Query Designer (QD) and View Designer (VD) are good tools for learning basic query syntax and for setting up simple views. Unfortunately, their ability to handle anything out of the ordinary is limited.

The order of joins produced by the QD/VD for a multi-table query is related to the order in which tables are added. The tools can't evaluate the information given and determine the right order for the joins. For example, the QD/VD is unable to produce a query that can extract the customer name, employee name and shipper for an order in TasTrade, regardless of the order in which tables are added and even if you help it out along the way by specifying appropriate join conditions.

In addition, the QD/VD always uses the nested syntax for joins. So, even when it works, the queries can be difficult to read and maintain.

The Membership data set

While the TasTrade data provided with VFP presents some interesting challenges, such as the multiple unrelated siblings problem, other complex queries are best demonstrated by a different database. Many of the examples below use the membership database described here.

This database (called Membership) represents part of the data for an organization like a YMCA that offers activities for adults, children and families. Typically, organizations like this provide membership and registration discounts for multiple family members, so data needs to be maintained at both the individual and family levels. The key table in this database is Person – each record represents one person:

```
Field Name   Type        Width   Description
IPERSONID    Integer     4       Primary key
CFIRSTNAME   Character   12      First Name
CLASTNAME    Character   20      Last Name
DBIRTHDATE   Date        8       Birthdate
IEMERGFK     Integer     4       Person key for Emergency Contact
IFAMILYFK    Integer     4       Family key
```

Person contains two foreign keys. iEmergFK is a pointer back into the person table for this person's emergency contact. iFamilyFK links the person to his or her family.

The Family table contains one record for each family and tracks address.

```
Field Name   Type        Width   Description
IFAMILYID    Integer     4       Primary key
MADDRESS     Memo        4       Street address
CCITY        Character   15      City
CSTATEPROV   Character   12      State/Province
CPOSTCODE    Character   9       Postal Code
CCOUNTRY     Character   12      Country – probably not really needed
```

One of the more challenging aspects of tracking people these days is managing phone numbers. The Membership database uses two tables for the task. Each record in Phone contains information about a single phone number. HasPhone links phones to people, in a many-to-many relationship. Phone has this structure:

```
Field Name    Type         Width   Description
IPHONEID      Integer      4       Primary Key
CAREACODE     Character    3       Area code
CNUMBER       Character    7       Phone number
CEXTENSION    Character    5       Extension
```

The link table, HasPhone, has this structure:

```
Field Name    Type         Width   Description
IHASPHONEID   Integer      4       Primary key
IPERSONFK     Integer      4       Foreign key to Person
IPHONEFK      Integer      4       Foreign key to Phone
CTYPE         Character    1       Type of phone
```

The last field, cType, contains a one-character code indicating the type of phone: "H" for home, "W" for work, "F" for work fax, "M" for mobile and "X" for home fax. While a production application might link to a look-up table for those values, that approach adds complexity that makes the examples below hard to understand.

The Membership database is on the conference CD.

Table: Join thyself

Using the same table for a person and his or her emergency contact raises an interesting question. How do you extract that information? The answer is what's known as a *self-join*, in which the same table appears more than once in a query.

To create a self-join, you open the table more than once and give it a different alias each time. The term *local alias* is used for an alias that's created and used within a query. Here's a FROM clause that assigns the local alias Cust to the Customer table:

```
FROM Customer Cust ;
  JOIN Orders ;
    ON Cust.Customer_Id = Orders.Customer_Id
```

As the example suggests, when a table has a local alias, you must use that alias each time you refer to the table; you cannot use the actual table name.

As with any other join, a self-join needs an appropriate condition that indicates which records to match up. Here's a self-join that produces a list of people showing their names and the names of their emergency contacts.

```
SELECT Person.cFirstName, Person.cLastName, ;
       Emerg.cFirstName AS cEmergFirstName, ;
       Emerg.cLastName AS cEmergLastName;
    FROM Person ;
        JOIN Person Emerg ;
          ON Person.iEmergFK = Emerg.iPersonId ;
    INTO CURSOR Contacts
```

The query also shows how to assign a field name to a field in the result. The AS keyword indicates that the preceding expression should be given the field name following. In the example, where several fields in the query have the same name, this technique prevents VFP from attaching a suffix ("_a", "_b") to distinguish them. (That is, without AS, the fields in the result would be cFirstName_a, cLastName_a, cFirstName_b, cLastName_b.) AS is also useful when you have computed fields in a query.

A self-join isn't limited to just multiple instances of the same table. Here's a more complex query that extracts the phone numbers of the emergency contact as well. Note that, in this case, the result may contain multiple records for a given person, if there are multiple phones on file for the person's emergency contact.

```
SELECT Person.cFirstName, Person.cLastName, ;
       Emerg.cFirstName AS cEmergFirstName, ;
       Emerg.cLastName AS cEmergLastName, ;
       Phone.cAreaCode, Phone.cNumber, ;
       Phone.cExtension, HasPhone.cType;
    FROM Person ;
        JOIN Person Emerg ;
          ON Person.iEmergFK = Emerg.iPersonId ;
        JOIN HasPhone ;
          ON Emerg.iPersonId = HasPhone.iPersonFK ;
        JOIN Phone ;
          ON HasPhone.iPhoneFK = Phone.iPhoneId ;
    ORDER BY 2, 1 ;
    INTO CURSOR Contacts
```

Adding outer joins to the mix

The queries above all use *inner joins*, in which only those records that match in the joined tables appear in the result. Any record in one table that has no counterpart in the table to which it's being joined is omitted. FoxPro has included inner joins since SQL SELECT was first added to the language and all of the queries above can be written with join conditions in the WHERE clause rather than using the newer JOIN syntax.

However, many useful queries include the unmatched records in the result instead of omitting them. These queries are called *outer joins*. There are three types - they differ in which tables contribute unmatched records to the result. A *left outer join* includes unmatched records from the first (left) table listed in the join. Correspondingly, a *right outer join* includes unmatched records from the second (right) table listed. A *full outer join* includes unmatched records from both tables. No matter which type of outer join is used, any fields in the result that come from unmatched records are filled with null values (.NULL.).

The words "inner" and "outer" are usually omitted when talking about joins, so you'll hear people refer to joins (that is, inner joins), left joins, right joins and full joins. Similarly, the INNER and OUTER keywords of SELECT are optional.

Each join in the FROM clause is considered separately for the purposes of distinguishing inner and outer joins and determining whether an outer join is left, right or full. So a single query may contain a left join, two inner joins and a full join, for instance.

As with inner joins, a two-table outer join is pretty simple to assemble. Going back to the TasTrade data, here's a query that shows each company and the date of its most recent order. Every customer is included, even if it's never placed an order.

```
SELECT Customer.Company_Name, MAX(Orders.Order_Date) AS dMostRecent;
   FROM Customer ;
      LEFT JOIN Orders ;
        ON Customer.Customer_Id = Orders.Customer_ID ;
   GROUP BY 1 ;
   INTO CURSOR MostRecentOrder
```

This is a left join, so all Customer records are included, but some Orders records could be omitted. (In this example, omitted Orders records would be a sign of trouble since every Orders record should be associated with a Customer record.) The Order_Date field is drawn from Orders; it's filled with .NULL. for any company with no orders on file.

When more than two tables are involved, it gets a little more complex. Sometimes, you have to use an outer join in a situation that doesn't appear to need it, so that records already added via an outer join stay in the data set.

Returning to the Membership database, suppose we want to get a list of people and their phone numbers. If every person were required to provide a phone number, this would be easy. There are several ways to write the query. Here's one that works:

```
SELECT cFirstName, cLastName, cAreaCode, cNumber, cExtension ;
   FROM Person ;
      JOIN HasPhone ;
        ON Person.iPersonId = HasPhone.iPersonFK ;
      JOIN Phone ;
        ON HasPhone.iPhoneFK = Phone.iPhoneId ;
   INTO CURSOR PhoneList
```

However, anybody with no phone records falls out of the result set. To include everyone, we need to use an outer join:

```
SELECT cFirstName, cLastName, cAreaCode, cNumber, cExtension ;
   FROM Person ;
      LEFT JOIN HasPhone ;
        ON Person.iPersonId = HasPhone.iPersonFK ;
      LEFT JOIN Phone ;
        ON HasPhone.iPhoneFK = Phone.iPhoneId ;
   INTO CURSOR PhoneList
```

In this case, we do an outer join from Person to HasPhone, which makes sure that all the people are included. Then we do another outer join between that result and Phone. The second outer join may seem extraneous, since every HasPhone record has a matching Phone record. But the results of the first join includes some records with null data for the HasPhone part, so the outer join is needed to keep those records from falling out.

For this example, there are some alternatives that let you dispense with the second outer join. Any version that does the join between HasPhone and Phone before the join to Person will work. Here's a query using the nested syntax that needs only one outer join:

```
SELECT cFirstName, cLastName, cAreaCode, cNumber, cExtension ;
   FROM Person ;
      LEFT JOIN HasPhone ;
```

```
      JOIN Phone ;
        ON HasPhone.iPhoneFK = Phone.iPhoneId ;
      ON Person.iPersonId = HasPhone.iPersonFK ;
   INTO CURSOR PhoneList
```

With sequential syntax, putting the Phone-HasPhone join first would also work.

The moral of the story is that you need to consider the order in which you're asking VFP to join the tables (logically – the actual execution order may be different; see "Testing Optimization" below). Once records are added via an outer join, be careful not to push them back out with a later inner join.

Combining outer joins with filters

Outer joins can be used like any other joins and mixed with other query clauses. However, there's a subtle trap when filtering data in a query that involves outer joins. It's possible for the filter to interfere with the join. Suppose we want to get a list of all people and their home phone numbers. Since not everyone has a phone number in the system, an outer join is needed. Here's a first attempt:

```
SELECT cFirstName, cLastName, cAreaCode, cNumber, cExtension ;
   FROM Person ;
      LEFT JOIN HasPhone ;
        ON Person.iPersonId = HasPhone.iPersonFK ;
      LEFT JOIN Phone ;
        ON HasPhone.iPhoneFK = Phone.iPhoneId ;
   WHERE HasPhone.cType = "H" ;
   INTO CURSOR HomePhones
```

However, this query doesn't work because at least conceptually, joins are performed before filters. So, the query does an outer join that includes at least one record for each person, then it filters out those records where the phone type isn't "H". So people with no phones get filtered right back out. (.NULL. = "H" is not true.)

The problem occurs when the filter directly impacts the outer join, that is, when it changes the set of records that are added to the result by the outer join. If the filter is based on a field or fields from the "all" table, the one for which all records are included in the result, there's no issue. But when the filter affects the "some" table, as above, there can be trouble. The solution, in general, is to move the filter into the join clause. Here's a query that lists everyone, providing the home phone if it's available.

```
SELECT cFirstName, cLastName, cAreaCode, cNumber, cExtension ;
   FROM Person ;
      LEFT JOIN HasPhone ;
        ON Person.iPersonId = HasPhone.iPersonFK ;
           AND HasPhone.cType = "H" ;
      LEFT JOIN Phone ;
        ON HasPhone.iPhoneFK = Phone.iPhoneId ;
   INTO CURSOR HomePhones
```

Here, the join itself filters out all phone records not for home phones, then the outer join adds a dummy record for each person without a home phone.

In some cases, the filtering problem can be quite complex and requires restructuring the query to make sure that the right set of records is created. Putting the filter at the right point in the join sequence may involve trying lots of variations.

As noted above, not every filter condition needs to move into the JOIN clause. If the filter doesn't impact the outer join, it can remain in the WHERE clause. Filters that specifically should eliminate outer joined records can also go into the WHERE clause. For example, suppose we want a list of children including their home phones, if available. This query does the trick.

```
SELECT cFirstName, cLastName, cAreaCode, cNumber, cExtension ;
   FROM Person ;
      LEFT JOIN HasPhone ;
        ON Person.iPersonId = HasPhone.iPersonFK ;
           AND HasPhone.cType = "H" ;
      LEFT JOIN Phone ;
        ON HasPhone.iPhoneFK = Phone.iPhoneId ;
   WHERE dBirthdate > GOMONTH(DATE(), -18*12 ) ;
   INTO CURSOR HomePhones
```

There's an additional caution about mixing filters with outer joins. Fields that are .NULL. because the record was added by an outer join test as less than actual values. That means those records show up on the "less than" list, but not the "greater than" list. This example is a little unnatural, but demonstrates the point. The query looks for everyone whose home phone is in the 609 area code, but whose work phone has an area code less than 609:

```
SELECT cFirstName, cLastName, ;
       HomePhone.cAreaCode AS HomeAC, ;
       HomePhone.cNumber AS HomeNumber, ;
       WorkPhone.cAreaCode AS WorkAC, ;
       WorkPhone.cNumber AS WorkNumber ;
   FROM Person ;
      LEFT JOIN HasPhone HasHome ;
        ON Person.iPersonID = HasHome.iPersonFK ;
           AND HasHome.cType = "H" ;
      LEFT JOIN Phone HomePhone ;
        ON HasHome.iPhoneFK = HomePhone.iPhoneID ;
      LEFT JOIN HasPhone HasWork ;
        ON HasWork.iPersonFK = Person.iPersonID;
          AND HasWork.cType = "W" ;
      LEFT JOIN Phone WorkPhone ;
        ON HasWork.iPhoneFK = WorkPhone.iPhoneID ;
   WHERE HomePhone.cAreaCode = "609" ;
     AND WorkPhone.cAreaCode < "609"
```

When you run the query, it turns up everyone living in the 609 area code with a work area code less than 609, as well as those living in 609 who have no work phone listed. That's not unreasonable, but if you turn the condition around and test:

```
WorkPhone.cAreaCode >= "609"
```

the records without a work phone don't show up. The issue is that filtering occurs against the source tables, not the intermediate result. In the source data, cAreaCode is empty, and an empty value is less than any specific value. The solution is to also test using EMPTY()

– specify EMPTY(WorkPhone.cAreaCode) if you want to include the dummy records or NOT EMPTY(WorkPhone.cAreaCode) to exclude them.

```
SELECT cFirstName, cLastName, ;
       HomePhone.cAreaCode AS HomeAC, ;
       HomePhone.cNumber AS HomeNumber, ;
       WorkPhone.cAreaCode AS WorkAC, ;
       WorkPhone.cNumber AS WorkNumber ;
   FROM Person ;
      LEFT JOIN HasPhone HasHome ;
        ON Person.iPersonID = HasHome.iPersonFK ;
           AND HasHome.cType = "H" ;
      LEFT JOIN Phone HomePhone ;
        ON HasHome.iPhoneFK = HomePhone.iPhoneID ;
      LEFT JOIN HasPhone HasWork ;
        ON HasWork.iPersonFK = Person.iPersonID;
           AND HasWork.cType = "W" ;
      LEFT JOIN Phone WorkPhone ;
        ON HasWork.iPhoneFK = WorkPhone.iPhoneID ;
   WHERE HomePhone.cAreaCode = "609" ;
     AND (WorkPhone.cAreaCode < "609" OR EMPTY(WorkPhone.cAreaCode)) ;
   INTO CURSOR LivesIn609
```

The most important thing to remember about using filters with outer joins is that the interactions are complex and you should test each query with a small, diverse data set before feeling confident that your queries work.

Counting with Outer Joins

Returning to the TasTrade data, suppose we want to count the number of orders placed by each customer and include 0 for any customer who hasn't ordered. Here's a first attempt:

```
SELECT Company_Name, COUNT(*) AS OrderCount;
  FROM Customer ;
    LEFT JOIN Orders ;
      ON Customer.Customer_Id = Orders.Customer_Id ;
  GROUP BY Customer.Customer_Id
```

A look at the results shows no records with OrderCount = 0. However, a look at the original data shows us that Uncle's Food Factory doesn't have any orders. Why does it contain 1 for OrderCount?

To see why, you have to understand the way the aggregate functions (COUNT(), SUM(), AVG(), MIN() and MAX()) and the GROUP BY clause work. First, the query performs joins and filtering and produces an intermediate result. The GROUP BY clause is applied to that intermediate result with the functions performed against those records. COUNT(*) indicates that we want the number of records in the group. Since every customer is included in the intermediate result, there's at least one record per customer, even though it may not be the result of a match with Orders.

The secret is to specify a field from Orders in the COUNT() function, for example, COUNT(Order_Id). The Order_Id field for the unmatched records contains .NULL. – null values are ignored by the aggregate functions. So, to count the number of orders per customer, we use:

```
SELECT Company_Name, COUNT(Order_Id) AS OrderCount;
  FROM Customer ;
    LEFT JOIN Orders ;
    ON Customer.Customer_Id = Orders.Customer_Id ;
  GROUP BY Customer.Customer_Id
```

The other aggregate functions don't run into this problem because they always require a field name.

Special Queries

Once you have joins and filtering working together properly, there are still lots of queries that require additional special handling. This section looks at subqueries, queries involving UNIONs, and a variant of the multiple unrelated siblings problem.

Handling Multi-Step Processes

Some problems require the results of one query to be fed into another query. While it's often possible to use a series of queries in this case, sometimes it makes more sense to consolidate the process into a single command. In other cases, embedding one query in another is the only way to get the desired result with SQL commands.

A query within a query (or within another SQL command) is called a *subquery*. It computes intermediate results, which are then used in the main command. The results of the subquery are used in a comparison in the WHERE clause of the main query. Subqueries must be enclosed in parentheses and may not be nested.

A number of special operators are available to perform comparisons between expressions and subquery results, though the usual comparison operators can be used in some situations. The special operators are IN, EXISTS, ANY, SOME and ALL. IN or NOT IN are used far more than the others.

IN compares a specified field or expression to the results of a subquery and selects records for which the subquery results contain a match. NOT IN selects those records with no match in the subquery. In either case, the field list in the subquery should contain a single field or expression.

For example, to get a list of the people with no home phone number on record, you can use:

```
SELECT cFirstName, cLastName ;
   FROM Person ;
   WHERE iPersonId NOT IN ;
      (SELECT iPersonFK FROM HasPhone ;
          WHERE cType = "H") ;
   INTO CURSOR NoHomePhone
```

The subquery creates a list of ids for people with home phones. Then, the NOT IN comparison excludes anyone with a match in that list.

IN is also useful when you need to compare against computed results. However, the subquery can be pretty odd-looking in such cases. This query creates a list of the oldest member of each family.

```
SELECT cFirstName, cLastName, iFamilyFK, dBirthdate ;
  FROM Person ;
  WHERE STR(iFamilyFK) + DTOS(dBirthdate) IN ;
     ( SELECT STR(iFamilyFK) + DTOS(MIN(dBirthdate)) ;
         FROM Person ;
         WHERE NOT EMPTY(dBirthdate) ;
         GROUP BY iFamilyFK ) ;
  INTO CURSOR OldestInFamily
```

To provide the single field to match, we have to combine the family id and birth date into an expression. (It's also worth noting that, as written, this query omits families where no birth dates are available. To include those families would make the code even uglier.) In cases like this, it may make more sense to perform two queries in sequence:

```
SELECT iFamilyFK, MIN(dBirthdate) AS dBirthMin;
   FROM Person ;
   WHERE NOT EMPTY(dBirthdate) ;
   GROUP BY 1 ;
   INTO CURSOR Oldest

SELECT cFirstName, cLastName, Person.iFamilyFK, dBirthdate ;
  FROM Person ;
    JOIN Oldest ;
      ON Person.iFamilyFK = Oldest.iFamilyFK ;
         AND Person.dBirthdate = Oldest.dBirthMin ;
  INTO CURSOR OldestInFamily
```

Here, the first query creates a cursor with the family id and birth date of the oldest family member, then the second does a join to pull out the person's name.

The other subquery comparison operators are generally used less. The big reason is that subqueries using them are usually *correlated*. A correlated subquery includes one or more fields from the main query and thus must be executed for each record examined in the main query. The examples above (like most subqueries in involving IN and NOT IN) are not correlated - the subquery stands alone, so it can be executed once, then used to check each record in the main query.

EXISTS tests whether the subquery found any records at all. The main query selects those records for which the subquery produces any results. EXISTS queries, which are usually correlated, can generally be rewritten to use IN and an uncorrelated subquery.

The ALL operator is used together with a comparison operator to test whether an expression compares as specified to ALL the records in the subquery result. Similarly, ANY and SOME, which are identical, check whether the expression compares as specified to any record in the subquery result.

Consolidating Query Results

In some situations, it takes multiple queries to collect all the results, but a single result set is called for. For example, using TasTrade, we might want a list of all the companies with

which there's a business relationship (customers, suppliers and shippers), say for a holiday card list.

The UNION clause of SELECT combines the results of two (or more) separate queries into a single result set. To use UNION, the field lists of the queries must contain the same number of items and corresponding items must be the same type and size.

To create a list of all companies in TasTrade, use a query like this:

```
SELECT Company_Name ;
    FROM Customer ;
UNION ;
SELECT Company_Name ;
    FROM Supplier ;
UNION ;
SELECT Company_Name ;
    FROM Shippers ;
  INTO CURSOR AllCompanies
```

This query won't take use very far for a holiday mailing list, though, since it doesn't include addresses. The problem is that the Shippers table only has the company name and no address information. Since each query in the UNION must have a matching field list, we have to supply dummy data for fields that are missing. In this query, the empty string is substituted for the address-related fields from Shippers:

```
SELECT Company_Name, Address, City, Region, Postal_Code, Country ;
    FROM Customer ;
UNION ;
SELECT Company_Name, Address, City, Region, Postal_Code, Country ;
    FROM Supplier ;
UNION ;
SELECT Company_Name, "", "", "", "", "" ;
    FROM Shippers ;
  INTO CURSOR AllCompanies
```

The first query in the UNION determines the type and size of the fields in the result. In the example, that's no problem because the corresponding fields in the other tables are the same size or smaller. But, in some cases, fields in the first query must be adjusted to make sure all the data will fit. Use functions like SPACE() and PADR() to ensure that character fields are large enough for all the possible entries. For numeric fields, use a template of 0's plus decimal point, if appropriate. For example, to leave space for a field with 4 digits to the left and 2 digits to the right of the decimal point, use the value 0000.00 rather than just 0. For date fields, substitute the empty date, {}. You can even supply an empty memo field by creating a cursor with a single memo field, adding one record, then adding that cursor to the list of tables in the query.

Here, an empty memo field is added to each record in the list of companies. Since Dummy contains only one record, there's no need for a join condition.

```
CREATE CURSOR Dummy (mMemo M)
INSERT INTO Dummy VALUES ("")

SELECT Company_Name, Address, City, Region, Postal_Code, Country, ;
       mMemo ;
   FROM Customer, Dummy ;
```

```
UNION ;
SELECT Company_Name, Address, City, Region, Postal_Code, Country, ;
       mMemo ;
   FROM Supplier, Dummy ;
UNION ;
SELECT Company_Name, "", "", "", "", "", mMemo ;
   FROM Shippers, Dummy ;
 INTO CURSOR AllCompanies

USE IN Dummy
```

Adding a field in every query in the UNION like this is an unusual (and useless) case, but the technique is quite handy when one query in a UNION involves a memo and others don't.

Keep in mind that all clauses except ORDER BY and INTO apply to individual queries in the UNION. ORDER BY and INTO, which can be considered "post-processing" clauses, affect the query as a whole.

Another thing that affects the query as a whole are the optional ALL and DISTINCT keywords. By default, VFP performs all the queries and dumps all the results into one set, then it removes any exact duplicates. Adding the DISTINCT keyword after UNION does the same thing. The ALL keyword tells VFP not to do so, but to keep all the records.

Multiple Unrelated Siblings Redux – Multiple Detail Bands

The problem of a single parent with multiple child tables comes up with a different spin when you consider reporting. A typical requirement is to have a report that shows the parent, then has information about one kind of child record, then information about the next kind of child, and so forth. In other words, the goal is to have a report that appears to have multiple details bands.

The Visual FoxPro Report Designer doesn't natively support such reports. But a creative query, together with some Report Designer cleverness, can trick VFP into doing the job.

Consider a "customer profile" report for TasTrade. The report shows customer information, then a list of employees the customer has dealt with, then a list of all the products the customer has ever ordered. The report also includes the total value of the orders placed through the employee and the total of the orders for each item.

The first step is to gather the data into a single cursor. The key to doing so is UNION. Use one query to collect the employee data, a second to collect product data, and UNION to produce a single result set. An extra field is added to identify the source of each record.

Here's the query that assembles the information. The cType field contains "E" for records originating in the Employee table and "P" for records originating in the Products table. The query organizes the report in customer order. Within each customer, employee information comes first, then product information.

```
SELECT Customer.Customer_Id, Company_Name, ;
       PADR(TRIM(Last_Name) + ", " + First_Name, 40) AS cName, ;
       SPACE(50) AS cEngName, ;
```

```
       SUM(Quantity * Unit_Price) AS nTotal, ;
       "E" AS cType ;
    FROM Customer ;
      JOIN Orders ;
        JOIN Order_Line_Items ;
          ON Orders.Order_ID = Order_Line_Items.Order_ID ;
        ON Customer.Customer_ID = Orders.Customer_ID ;
      JOIN Employee ;
        ON Orders.Employee_ID = Employee.Employee_ID ;
    GROUP BY 1, 2, 3 ;
UNION ALL ;
SELECT Customer.Customer_ID, Customer.Company_Name, ;
       Products.Product_Name AS cName, ;
       Products.English_Name AS cEngName, ;
       SUM(Quantity * Order_Line_Items.Unit_Price) AS nTotal, ;
       "P" AS cType ;
    FROM Customer ;
      JOIN Orders ;
        JOIN Order_Line_Items ;
          JOIN Products ;
            ON Order_Line_Items.Product_ID = Products.Product_ID ;
          ON Orders.Order_ID = Order_Line_Items.Order_ID ;
        ON Customer.Customer_ID = Orders.Customer_ID ;
    GROUP BY 1, 2, 3 ;
  ORDER BY 2, 6, 3 ;
  INTO CURSOR CustomerProfile
```

To create a report for this cursor, add two groups. The outer group is based on Customer_ID and is set to start every group on a new page. The inner group is based on cType. Figure 1 shows the report in the Report Designer.

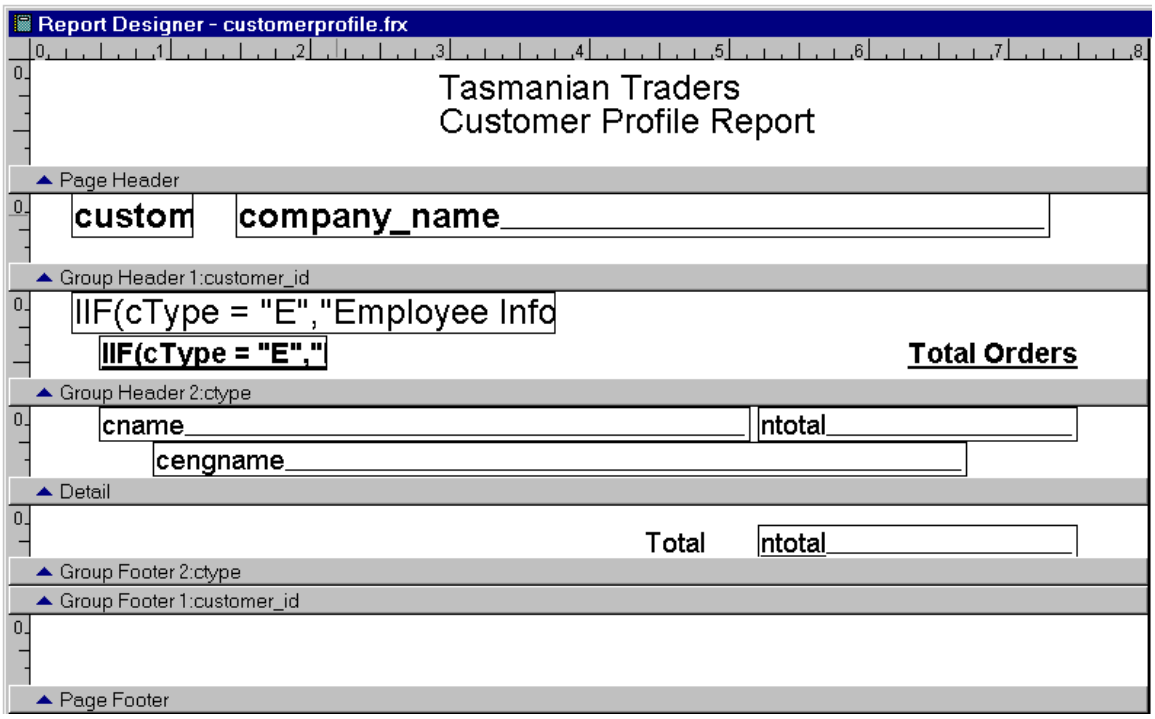


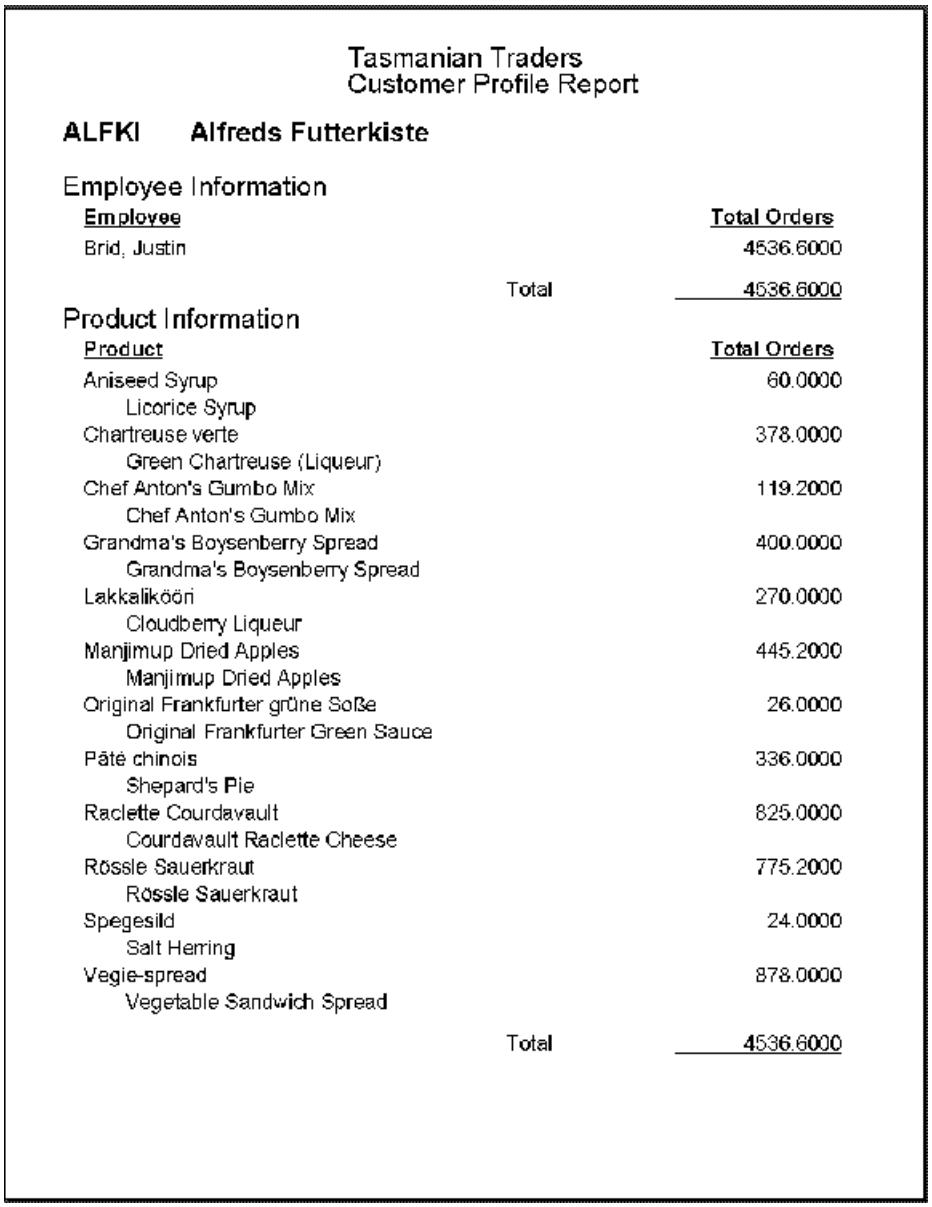
Figure 1 Reporting on Multiple Unrelated Siblings – The second grouping distinguishes employee information from product information.

In the report itself, IIF() and the Print When dialog are used to print the right information for each section of the report. For example, in the group header for cType, the heading for the two sections of the report uses IIF() to decide what to print:

```
IIF(cType = "E","Employee Information", "Product Information")
```

The cEngName field, which contains the English name of products, is set to remove blank lines, so the line containing that field disappears entirely in the Employee section of the report.

Figure 2 shows one page of the sample report.



Tasmanian Traders
Customer Profile Report

ALFKI Alfreds Futterkiste

Employee Information

Employee		Total Orders
Brid, Justin		4536.6000
	Total	4536.6000

Product Information

Product	Total Orders
Aniseed Syrup Licorice Syrup	60.0000
Chartreuse verte Green Chartreuse (Liqueur)	378.0000
Chef Anton's Gumbo Mix Chef Anton's Gumbo Mix	119.2000
Grandma's Boysenberry Spread Grandma's Boysenberry Spread	400.0000
Lakkalikööri Cloudberry Liqueur	270.0000
Manjimup Dried Apples Manjimup Dried Apples	445.2000
Original Frankfurter grüne Soße Original Frankfurter Green Sauce	26.0000
Pâté chinois Shepard's Pie	336.0000
Raclette Courdavault Courdavault Raclette Cheese	825.0000
Rössle Sauerkraut Rössle Sauerkraut	775.2000
Spegesild Salt Herring	24.0000
Vegie-spread Vegetable Sandwich Spread	878.0000
Total	4536.6000

Figure 2 Customer Profile Report – Using a clever query and some reporting tricks, you can create reports that appear to have multiple detail bands.

This technique is most useful when the child tables are fairly similar in structure, but with liberal use of IIF() and Print When can be used in many situations.

Improving Query Performance

There are a number of things you can do to optimize the performance of your queries (many of them will improve the speed of your Xbase code as well). In addition, VFP5 and later make it easier to see what part of a query needs improvement.

Having the right tags

FoxPro's Rushmore optimization system is based on using available index tags to avoid reading records from the disk. When tags are available, FoxPro reads the (smaller) index files instead of the data and creates a list of records that meet the specified conditions. Then, only those records are retrieved.

In some cases, tags exist to optimize some conditions, but not others, so FoxPro handles the optimizable conditions first, then performs a sequential search through the records that meet those conditions to test the others. (Actually, sometimes FoxPro creates its own temporary index tags for those conditions, but this is still slower than having the tag in the first place.)

Obviously, the more of your conditions FoxPro can optimize by using existing tags, the faster your queries will run.

What makes a condition optimizable? In filters, it's a tag whose key *exactly* matches the left-hand side of the condition. The word "exactly" is important here. If the left-hand side is sort of like the key, it's not good enough. For example, if you have an index on UPPER(LastName), a condition of LastName = "Smith" can't be optimized. You need to use UPPER(LastName) = "SMITH" instead.

For filters, placing the optimizable expression on the left-hand side is also important. Given the same tag on UPPER(LastName), the condition "SMITH" = UPPER(LastName) in the WHERE clause is *not* optimized.

Joins also need an exact match to the tag – a tag on UPPER(LastName) won't optimize a join condition based on LastName. However, there may be tags for each side of the condition. The rule is that only one index tag is applied, but you can't predict which one it is. If only one table involved has an appropriate tag, that one is used, but if both tables have tags, VFP decides which one helps more. Sometimes, VFP rejects all available tags and creates its own.

Deletion status counts

FoxPro's two-stage deletion process (DELETE a record now and it's marked for removal at the next PACK) can have an effect on optimization. The SET DELETED command

determines whether deleted records are included in query results or not. When DELETED is ON, records marked for deletion are filtered out.

The key word is "filtered." Removal of deleted records works just like a filter condition. With no help from you, each record's deleted status is checked sequentially. The process can be optimized, however, by providing an index tag with a key of DELETED(), as follows:

```
INDEX ON DELETED() TAG IsDeleted
```

Keep in mind that it doesn't matter whether any records are actually deleted or not. The issue is whether DELETED is ON or OFF. If it's ON, a tag on DELETED() helps to optimize your queries. If DELETED is OFF, the tag on DELETED() still helps if you include a WHERE condition of DELETED() or NOT DELETED() in your query. (See "Too much of a good thing" below for a situation where a tag on DELETED() can hurt more than help.)

Memory matters – a lot

While testing query speed for this session, I ran into a problem. I didn't see the results I expected. Generally, adding a tag on a field used in a join or filter sped things up, but not by orders of magnitude, as I'd expected. A tag on DELETED() sometimes seemed to slow things down very slightly, not speed them up. I asked someone else to test and he got similar results.

I knew I'd tested these rules in the past and seen tremendous differences. What was going on in this case? The other tester and I both had enormous quantities of memory and a large page file (in NT 4) which meant that big tables could be kept in memory and even huge ones could be moved in and out of memory without much difficulty. In this situation, using optimizable expressions didn't matter much and, in fact, as the number of tags grew so that the index file took up more room, things could slow down (even without the issue of network traffic).

How can you deal with this if you don't know how capable users' machines will be? The slowdowns from additional tags, when they occurred, were tiny while the potential gains from adding tags are huge. So the lesson is clearly to add the tags. Users on loaded machines won't notice the difference, but users on low-end machines will appreciate all optimization.

The other lesson is that, as Microsoft, and Fox Software before them, have been telling us for a long time, memory is perhaps *the* most important factor in how fast FoxPro processes data.

However, FoxPro can have too much memory, too. When VFP starts, it grabs a chunk of memory to work with, usually about half of the available memory. (You can check with SYS(3050,1).) Since other things are running at the same time (at least Windows, often much more), and those applications need memory as well, VFP can end up swapping data out to disk rather than using only actual, physical memory. VFP knows how to manage the memory it's been allocated extremely efficiently, but writing to disk is always slow.

Mac Rubel has done extensive testing in this area. His results are documented in a series of *FoxPro Advisor* articles. In general, it's wise to use SYS(3050) to *lower* VFP's memory allocation so that it only works with physical memory. On a 64MB machine, I find that VFP's performance is maximized by setting the memory allocation around 24MB with a call like this SYS(3050, 1, 24000000).

Too much of a good thing

It also turns out that too many tags or the wrong tags can be a bad thing. When VFP uses a tag to optimize, it has to load a portion of the index into memory. The amount of the index that gets loaded is related to the index expression and, most importantly, to how balanced the values of that expression are. If 90% of the records in the table meet the specified condition, 90% of the index must be loaded. With large tables, this can cause serious slowdowns, especially when working across a network.

The solution is to consider the distribution of values when deciding whether to create a tag for a particular expression. If the values are widely distributed, a tag is likely to help. If most records have the same value, the tag may do more harm than good. (For more information about this problem, see the article "Rushmore: More is Less" in the May 1999 *FoxPro Advisor*.)

It's all in where you put it

SQL-SELECT has two clauses that filter data: WHERE and HAVING. A good grasp of the English language might lead us to believe that these are synonyms, but SQL is not English, and mixing these two indiscriminately is a sure-fire disaster in the making! It's not obvious where a particular condition should go at first glance. But getting it wrong can lead to a significant slowdown.

Here's why. The conditions in WHERE filter the original data. Existing index tags are used to speed things up as much as possible. This produces an intermediate set of results. HAVING operates on the intermediate results, with no tags in sight. So, by definition, HAVING is slower than WHERE, if a query is otherwise constructed to be optimized.

Suppose you want to find all families in the Membership database whose postal code is between 19000 and 19999. This query, with the filter in WHERE, is optimizable:

```
SELECT * ;
   FROM Family ;
   WHERE BETWEEN(cPostCode,"19000","19999") ;
   INTO CURSOR FamiliesInZone
```

If we move the filter to the HAVING clause, the query can't be fully optimized:

```
SELECT * FROM Family ;
   HAVING BETWEEN(cPostCode,"19000","19999") ;
   INTO CURSOR FamiliesInZone
```

When should you use HAVING? When you group data with GROUP BY and want to filter on aggregate data formed as a result of the grouping rather than on the raw data. For example, if you group customers by country, counting the number in each, and you're

interested only in countries with three or more customers, put the condition COUNT(*) >= 3 in the HAVING clause:

```
SELECT Country, CNT(*) ;
   FROM Customer ;
   GROUP BY Country ;
   HAVING CNT(*) > 3 ;
   INTO CURSOR CountriesThreeOrMore
```

There's a simple rule of thumb: Don't use HAVING unless you also have a GROUP BY. That doesn't cover all the cases, but it eliminates many mistakes. To make the rule complete, remember that a condition in HAVING should contain one of the aggregate functions (COUNT, SUM, AVG, MAX or MIN) or a field that was named with AS and uses an aggregate function.

Testing Optimization

Until VFP5, the only way to figure out whether a query was fully optimized was to test it, over and over, until you found the fastest arrangement. Getting it right was difficult since test data sets are often smaller than the actual data to be used and many factors can impact the speed of an operation. (In addition, the memory issues above – "Memory matters – a lot" – can make it very hard to tell which version will really be faster on a user's machine.)

Starting with VFP5, it's much easier to see whether a query is fully optimized and, if not, what parts are and are not optimized. The SYS(3054) function controls a feature called SQL ShowPlan. There are three settings:

- SYS(3054,0) - turn off SQL ShowPlan.
- SYS(3054,1) - turn on SQL ShowPlan for filters only.
- SYS(3054,11) - turn on SQL ShowPlan for filters and joins.

In VFP5, issuing SYS(3054) immediately produces a message in the active window, indicating the ShowPlan state. This message was removed in VFP6. Instead, the function returns, as a character string, the setting you pass it.

The output from the function (described below) also appears in the active window. You can send all the messages elsewhere using SET ALTERNATE and prevent it from appearing by defining and activating a window off-screen.

One warning. Don't turn SYS(3054) on while you're running actual timing tests. The function slows things down and interferes with the results, so perform the two kinds of tests separately.

Checking Filters for Optimization

For filters, SQL ShowPlan shows two kinds of information. First, it indicates which tags are being used to filter the table. Then, it provides an assessment of optimization for the table: none, partial or full.

Here's a simple query involving the Tastrade Customer table:

```
SELECT Customer.Company_Name ;
  FROM Customer ;
  WHERE Company_Name="H" ;
  INTO CURSOR Test
```

ShowPlan provides the following information:

```
Rushmore optimization level for table customer: none
```

A look at the tags for Customer shows that, while there's a tag called Company_Na, the key for it is UPPER(Company_Name). A slight change to the query:

```
SELECT Customer.Company_Name ;
  FROM Customer ;
  WHERE UPPER(Company_Name)="H" ;
  INTO CURSOR Test
```

gives us this ShowPlan output:

```
Using index tag Company_na  to rushmore optimize table customer
Rushmore optimization level for table customer: full
```

Matching the tag takes the query from totally unoptimized to fully optimized.

Be aware that ShowPlan indicates an optimization level of none for a table that's not filtered in the query. For example, for this query:

```
SELECT Customer.Company_Name, Orders.Order_Cate ;
  FROM Customer ;
    JOIN Orders ;
      ON Customer.Customer_Id = Orders.Customer_Id ;
  WHERE UPPER(Company_Name)="H" ;
  INTO CURSOR Test
```

the filter-only version of ShowPlan gives this feedback:

```
Using index tag Company_na  to rushmore optimize table customer
Rushmore optimization level for table customer: full
Rushmore optimization level for table orders: none
```

The optimization level for Orders is none because there are no filters on Orders to be optimized.

ShowPlan lets us see the effect of a tag for DELETED() as well (even when our timing tests don't). SET DELETED ON and run the query above and ShowPlan gives:

```
Using index tag Company_na  to rushmore optimize table customer
Rushmore optimization level for table customer: partial
Rushmore optimization level for table orders: none
```

The optimization level for Customer is now partial because of the implied filter created by SET DELETED. Add a tag based on DELETED() and the ShowPlan output becomes:

```
Using index tag Company_na  to rushmore optimize table customer
Using index tag Isdel to rushmore optimize table customer
Rushmore optimization level for table customer: full
Rushmore optimization level for table orders: none
```

The new tag helps to optimize the query.

Checking Joins for optimization

When ShowPlan is enabled for joins as well as filters, the output also includes one line for each join, indicating how it was optimized, if at all. The output even includes lines for any missing join conditions, indicating that a Cartesian join was used. (A Cartesian join is one in which every record of one table is matched with every record of another table.)

Here's the join portion of the ShowPlan output for the simple query above:

```
Joining table customer and table orders using index tag Customer_I
```

It indicates which tables were joined and which tag, if any, was used to join them. At most one tag is used even if both tables have appropriate tags. VFP decides which tag to use, if multiple tags are available.

If no tag is available, the ShowPlan output says "using temp index". Sometimes, ShowPlan says it's using a temporary index even when one table has a tag that applies. It appears that this happens when the tables are of very different sizes and only the smaller table has a tag. VFP decides that creating a temporary tag for the larger table is more efficient than using the existing tag of the smaller table.

For multi-table joins, the order in which join information appears indicates the order in which the joins are actually being performed. This order may be quite different from the logical order of the joins described above. For example, this query:

```
SELECT customer.company_name, ;
       orders.order_date, ;
       order_line_items.quantity, ;
       products.English_name ;
  FROM customer ;
    JOIN orders ;
      JOIN order_line_items ;
        JOIN products ;
        ON order_line_items.product_id = ;
           products.product_id ;
      ON orders.order_id = order_line_items.order_id ;
    ON customer.customer_id = orders.customer_id
```

produces the following ShowPlan output:

```
Rushmore optimization level for table customer: none
Rushmore optimization level for table orders: none
Rushmore optimization level for table order_line_items: none
Rushmore optimization level for table products: none
Joining table customer and table orders using index tag Customer_i
Joining intermediate result and table order_line_items using index tag
Order_id
Joining table products and intermediate result using temp index
```

The tables here are joined in exactly the reverse order from what we'd expect based on the structure of the query. The sizes of the tables and the tags available lead the VFP engine to believe this is the optimal join order. (Optimization of filter conditions is none for all tables because the query contains no filter conditions.)

For optimization, it doesn't matter whether you use nested and sequential joins. It appears that FoxPro uses the syntax to understand the desired result, but then joins the tables in the most efficient order.

Adding an outer join changes the optimization result. If we make the join between Customer and Orders in the example above into a left outer join so all customers appear in the result, ShowPlan produces this output:

```
Rushmore optimization level for table orders: none
Rushmore optimization level for table order_line_items: none
Rushmore optimization level for table products: none
Joining table orders and table order_line_items using index tag
Order_id
Joining table products and intermediate result using temp index
Rushmore optimization level for table customer: none
Rushmore optimization level for intermediate result: none
Joining table customer and intermediate result using temp index
```

With outer joins involved, the nested vs. sequential issue is a little more significant since FoxPro can no longer rearrange the joins as it pleases. However, my tests show that the join syntax used makes little difference in most cases. However, when tables of vastly different sizes are involved in an outer join, the choice of syntax might make a difference since it may determine the order in which the tables are actually joined.

Using ShowPlan information

The output from ShowPlan can help us to optimize queries. The simplest case, of course, is to add a tag or modify a condition so that it uses an existing tag, as in the UPPER(Company_Name) example above.

However, there are times when you know more about your data than VFP does. In such cases, you may want to insist that joins be performed in a certain order. The FORCE clause of SELECT (added in VFP 5) lets you specify that joins must be performed in the order listed rather than having the optimizer try to figure out the best choice. You can also use parentheses around join clauses to force some joins to be performed before others.

You can also use FORCE when you've determined the optimal order for joins. Arrange the query so that the joins are listed in that order and add the FORCE clause to prevent the VFP engine from trying to figure out which way to do things. This saves the time the optimizer would require to figure out which order to use.

Optimization *can* be a problem

One of the ways VFP (and earlier versions of FoxPro) optimizes queries is by taking a shortcut. If a query is fully optimizable, involves a single table, has no calculated fields and no grouping, and puts its results in a cursor, VFP simply filters the source table. This saves the time needed to actually create the cursor. You can tell when VFP has done so by checking DBF() for the result cursor. For example, with DELETED OFF, the following query:

```
SELECT First_Name, Last_Name ;
```

```
  FROM Employee ;
    WHERE Group_Id = "     3" ;
  INTO CURSOR Group3
```

creates a cursor which is simply a filtered view of the Employee table. Checking DBF("Group3") produces something like:

```
H:\MSDN\VS6\98VS\1033\SAMPLES\VFP98\TASTRADE\DATA\EMPLOYEE.DBF
```

Cursors that are really filtered tables can't be used in certain operations and can give bad results in others. In addition, VFP doesn't remember to apply a filter of DELETED()=.F. to the original table when a query is run with DELETED ON and no real cursor is created. If DELETED is subsequently turned OFF, the filtered cursor contains the deleted records of the original that otherwise meet its criteria. This can give wrong results.

In FoxPro 2.x and VFP 3.0x, the only solution was to force the query to be less than fully optimizable. In VFP5 and later, the NOFILTER clause forces VFP to create a "real" cursor. For example, after executing:

```
SELECT First_Name, Last_Name ;
  FROM Employee ;
    WHERE Group_Id = "     3" ;
  INTO CURSOR Group3 NOFILTER
```

a check of DBF("Group3") shows a temporary file such as:

```
C:\TEMP\08334986.TMP
```

Because of the bug involving deleted records, it's best to use NOFILTER any time VFP might fail to create a real cursor. Make exceptions only when the speed gain from filtering far outweighs the risk of mishandling deleted records.

Summary

SQL-SELECT provides an extremely powerful mechanism for collecting data. Getting started with simple queries is easy. But complex queries call for a methodical approach with plenty of testing along the way. SYS(3054) provides a means for understanding what's going on under the hood and tuning queries for optimal performance.

With the tools available and some practice, anyone can make the most of SQL-SELECT.

Acknowledgements

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Some of the material in these notes is excerpted from *Hacker's Guide to Visual FoxPro 6.0* by Tamar E. Granor and Ted Roche, Hentzenwerke Publishing, 1998.