RESOURCE AND PATIENT MANAGEMENT SYSTEM

BMXNet40

ADO.NET Data Access and Connectivity Utilities for RPMS Including WinForm and EHR Integration Frameworks

(BMX)

User Manual

Version 4.0
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Office of Information Technology (OIT)
Division of Information Resource Management
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Preface

This manual provides information regarding the release and installation of the BMX Version 4.0 package. BMXNET40.dll, BMXWIN40.dll, and BMXEHR40.dlls support Microsoft .NET Frameworks 2.0, 3.0, and 3.5. This manual has been updated to support:

- BMXNET40.dll, which is a rewrite of BMX supporting new context model, security features, session pooling, and misc fixes
- BMXWIN40.dll, which is framework based on BMXNET40 for writing .NET WinForm applications including standardized login and connection management dialogs
- BMXEHR40.dll, which is framework based on BMXNET40 for writing .NET components to be hosted within the EHR/VueCentric framework

The developer can also write components based on BMXNET40 that will work with both BMXWIN and BMXEHR frameworks with minimal additional effort.

1.0 Introduction

BMXNet 4.0 is intended for use by Windows software developers who are writing .NET applications and/or Electronic Health Record (EHR)/VueCentric components based on data contained in the Resource and Patient Management System (RPMS) clinical repository. BMXNET40 may be used by any kind of .NET application, including rich client, Web services, or ASP.NET.

BMXNet previously supported Windows applications written using the .NET 1.0–1.1 and .NET 2.0 in BMXNet20.dll. BMXNET40 libraries represent a leap forward in supporting EHR/VueCentric components, and incorporate many new features needed by all previously existing BMXNet20.dll-based applications.

ADO.NET defines a set of classes that enable .NET programmers to use data access services. ADO.NET is the product of the evolution of earlier legacy technologies such as ADO, OLEDB, and ODBC.

BMXNet 4.0 enables multimodal (WinForm/EHR/VueCentric) solutions by providing a runtime framework that includes a Context Model and Local Events. The Context Model supports the status, changing, and alerting of a single Patient/Visit Context.

Note: All BMXNet Classes are contained in the .NET namespace *IndianHealthService.BMXNet.*

Related Information

On-line API documentation of BMXNet Version 4.0 is included in the file BMXNET40.chm, a Microsoft Compiled Help (.chm) file. Go to http://www.ihs.gov/Cio/RPMS/index.cfm?module=home&option=softwarechoice to download the software.

Detailed information about .NET and ADO.NET can be found in the references listed in Appendix A of this document.

2.0 Orientation

The following conventions are used throughout this manual:

Code Text

Text specific to actual code is offset by a gray background with a black border, as shown in Figure 2-1.

```
aRemoteSession.TableFromRpc(“BMX DEMO”,);
```

Figure 2-1: Code text convention

Syntax Text

Text specific to SQL syntax includes an example with callouts. A table following each example explains the associated callouts. Components that make up a specific argument are indicated with a callout including the entire argument, as well as callouts for each component. For instance, in Figure 2-2, Patient.Name, VA_Patient.DOB, ‘Date of Birth’, and Patient.Age are all components of the collective select_list argument. Therefore, B refers to the select_list argument, while C, D, and E refer to the components of that argument.

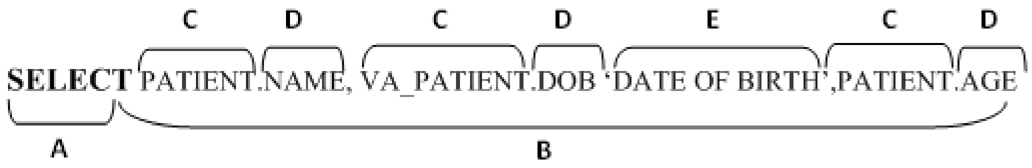

C
D
C
D
E
C
D
SELECT PATIENT.NAME, VA_PATIENT.DOB ‘DATE OF BIRTH’,PATIENT.AGE
A
B

Figure 2-2: Syntax text convention

Table 2-1: Syntax Component Convention

Section	Syntax	Description
A	SELECT	Specifies that the system should return the values by the following select_list statement.
B	select_list	Specifies which fields (columns) the system should select for the returned set. The select_list a series of expressions separated by commas.
C	table_name	Specifies from which files (tables) the FROM clause should return fields.
D	field_name	Specifies from which field (column) the FROM clause should return. The field_name is associated with the preceding table_name by using a dot (.) between the two.
E	column_alias	Specifies an alternative name to replace the column name in the query result set. For example, an alias such as “Quantity,” “Quantity to Date,” or “Qty” can be specified for a column named quantity.

3.0 Managing BMXNet Monitors

Before data can be exchanged using BMXNet, the BMXNet Monitor software must be running on the RPMS server. Management of BMXNet Monitors is accomplished via BMXNet Menu options in RPMS, as shown in the following example:

```
 EDIT Add/Edit BMXNet Monitor Entries
 STRT Start All BMXNet Monitors
 STOP Stop All BMXNet Monitors
```

Figure 3-1: Sample of BMXNet menu options

Details about each BMXNet Monitor process are stored in the BMXNET MONITOR file, which may be edited by selecting the Edit option in the BMXNet Menu, as shown in the following example:

```
Select BMXNET MONITOR PORT: 10501
PORT: 10501//
ENABLED: YES//
INTEGRATED SECURITY: YES//
SESSION NAMESPACE:
SELECT APPCONTEXT:
```

Figure 3-2: Sample of BMXNet edit option

The PORT determines the Transmission Control Protocol/Internet Protocol (TCP/IP) port on which the BMXNet monitor will listen for client connections. Be sure that other TCP/IP listeners, such as those in the XWB, CIA, and BGU namespaces, are not set up to run on the same port as any of the BMXNet Monitor entries.

The ENABLED field can be used to switch a monitor entry on or off. The switch will not take effect until BMXNet monitors are restarted.

INTEGRATED SECURITY designates whether users will be authenticated using Windows NT security. If this field is Yes, then users connecting on this monitor will be prompted only once for an Access and Verify code. Thereafter, BMXNet will automatically log the user in to RPMS based on the user’s Windows NT login. If INTEGRATED SECURITY is No, then users will be prompted for Access and Verify code at each connection.

SESSION NAMESPACE designates the namespace in which the client sessions will execute. If this field is null, client sessions will execute in the same namespace as the BMXNet Monitor is running.

APPCONTEXTS designates an optional multiple of constrained APPCONTEXTs that the port will allow. If no APPCONTEXTs are specified, then BMX clients can use any APPCONTEXT. Otherwise the BMX client is constrained to using only the explicitly specified APPCONTEXTs. This feature is useful if, for example, INTEGRATED SECURITY is only available for one specific APPCONTEXT on port 10501. Without explicitly specifying the APPCONTEXTs, users of any BMXNET-based application could manually reconfigure connection settings to access the INTEGRATED SECURITY port.

The option BMX MONITOR START should be scheduled with TaskMan to run at system startup. When this option is scheduled, all enabled BMXNet Monitors will be automatically started when TaskMan starts.

3.1 Initial Monitor Setup

Monitor Setup in Multi-Namespace Environments

BMXNET40.dll supports the use of just one BMXMON listener running in a multi-namespace environment. When an application using the BMXNET40.dll connects, the connection and access/verify process attempts to job a BMX handler in the defined server namespace. If the Server Namespace field is empty, the current namespace is implied. The handler is jobbed in the same namespace in which the BMXMON listener is running. If the Server Namespace has a value, a login is attempted based on the settings of the BMXMON monitor settings in the current namespace. That is, if the primary BMXMON supports INTEGRATED SECURITY, the jobbed namespace will try to validate the user, using the WINID instead of the access/verify process in the *namespace* defined by the Client Server Namespace field.

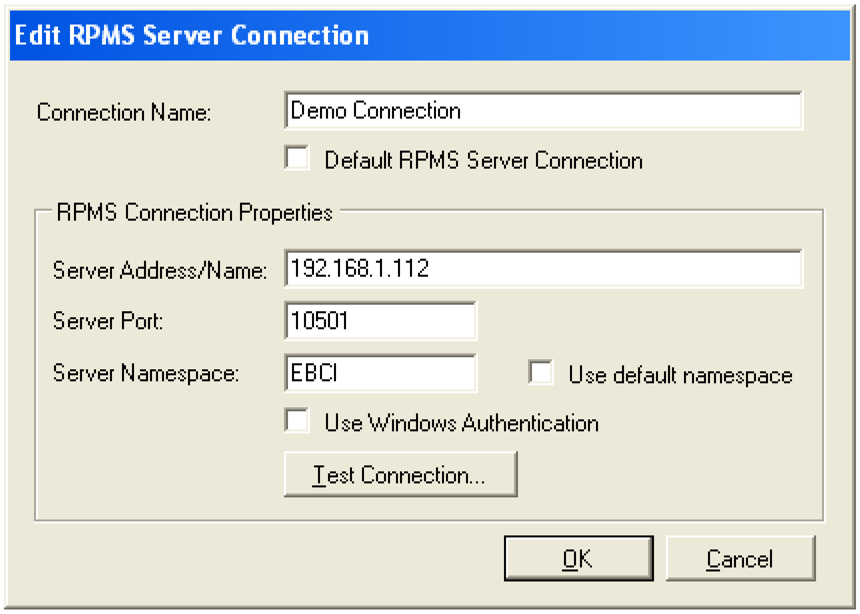
The site manager must install the BMX_0400.k KIDS software in each namespace to be accessed. The site manager should then start up one listener running in a primary namespace. All of the other namespaces *must not* have listeners using the same port address assigned and running in their BMXNET MONITOR file. If *multiple listeners* are started using the *same port address*, the RPMS system will not accept connections, and a *complete reboot of the system may be required* to correct the problem. The site manager should then assign the proper Server Namespace to the client (listener) running the application.

Multiple BMXMON listeners can be assigned to the same namespace(s) as long as there is no port number conflict. Each BMXNET MONITOR can be configured with settings for *integrated security*, *session namespace*, and *enabled.*

When restarting the BMXNET MONITOR, it is not necessary to stop monitors before restarting. If monitors are running and the option BMX MONITOR START IS SELECTED, the option will stop and restart the monitors.

Note: If the existing settings (e.g. port or namespace) have been changed, without first stopping the monitors, old monitors may continue to run.

The following screen capture shows the client server namespace entered under RPMS Connection Properties in the Server Namespace field.


Edit RPMS Server Connection

Connection Name: Demo Connection

[ ] Default RPMS Server Connection

RPMS Connection Properties

Server Address/Name: 192.168.1.112

Server Port: 10501

Server Namespace: EBCI [ ] Use default namespace

[ ] Use Windows Authentication

Figure 3-3: Example of screen used for entering a client server namespace

The dialogs implemented by the BMX WinFramework (BMXWIN40.dll) and used in WinForm applications are detailed in Section 4.0.

4.0 Connecting to RPMS Using BMXNET

In addition to data access, BMXNet also provides RPMS connectivity and user log on services. Developers will use the WinFramework and LoginProcess classes to manage the entire connection and sign-on process. The Application Program Interface (API) includes simple high-level approaches to login and low-level APIs for highly customized experiences.

Note: Developers are encouraged to use the provided WinFramework dialogs, but non-GUI APIs are available.

4.1 Using the BMXWIN WinFramework Class

Each application should create a single instance of WinFramework as the central access point to all BMXNet features and services. The LoginProcess is used to simplify the RPMS connection process by encapsulating all of the login functionality. This functionality replaces the BMXNet 2.0 *LoadConnectInfo's* support for automatic log on and the several methods to access securely cached information.

```
this.Framework = WinFramework.CreateWithNetworkBroker(true);
this.Framework.LoadSettings(…);
this.Framework.LoadConnectionSpecs(…);

LoginProcess login = this.Framework.CreateLoginProcess();

if (login.HasDefaultConnectionWithUseWindowsAuth)
{
login.AttemptWindowsAuthLogin();
}
```

Figure 4-1: Basic initialization of a WinForm application

4.1.1 Using BMXWIN Login and Connection Management Dialogs

BMXNet 4.0 includes a complete Connection Model to support BMX Net authentication, local storage, and multiconnection management.

Note: The BMXNEt 2.0 LoadConnectInfo() family of methods have been replaced by the LoginProcess and RpmsConnectionSpec classes

Logging in to RPMS with BMXNet requires two pieces of information:

1. A connection specification

2. A set of credentials

The RpmsConnectionSpec models all of the details required to find and connect to a specific RPMS database and namespace. Credentials are either a pair of Access/Verify codes or a Windows Identity that was previously established using the Windows Authentication feature.

The login API is obtained by asking the WinFramework to create a new LoginProcess. The LoginProcess supports a variety of Login dialog boxes, Connection Management dialogs, and a full API supporting both GUI and non-GUI logins.

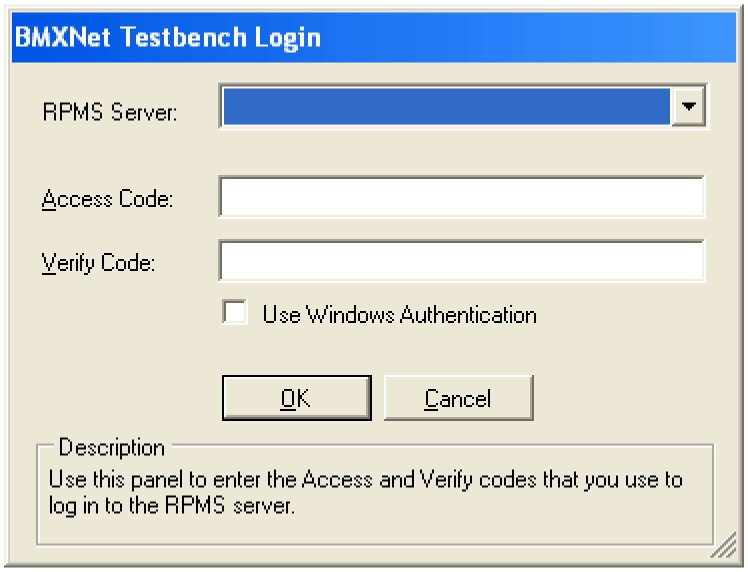
```
   LoginProcess login = this.Framework.CreateLoginProcess();

//Attempt a non-UI WindowsAuth if and only if there is a
//default connection with WindowsAuth. Of course, an application
//can set its own policy of when to AttemptWindowsAuthLogin()

if (login.HasDefaultConnectionWithUseWindowsAuth)
 {
   login.AttemptWindowsAuthLogin();
}

//If not attempted yet, i.e. skipped the AttemptWindowsAuthLogin(),
//or was unsuccessul, try and UI login

if (!login.WasLoginAttempted || !login.WasSuccessful)
 {
login.AttemptUserInputLogin(
EntryAssemblyInfo.AssemblyTitle+" Login",
3,
!this.Framework.BootStrapSettings.Get("lockedit",false),
this);
   }
```

Figure 4-2: Example of LoginProcess

The LoginProcess API explicitly notes in the method name “UserInput” if the user will be prompted with dialogs.

BMXNet 4.0 has four dialogs to support the LoginProcess:

- Login dialog box
- Server Connection Management dialog box
- Connection Specification Connection Test dialog box
- Select Division dialog box

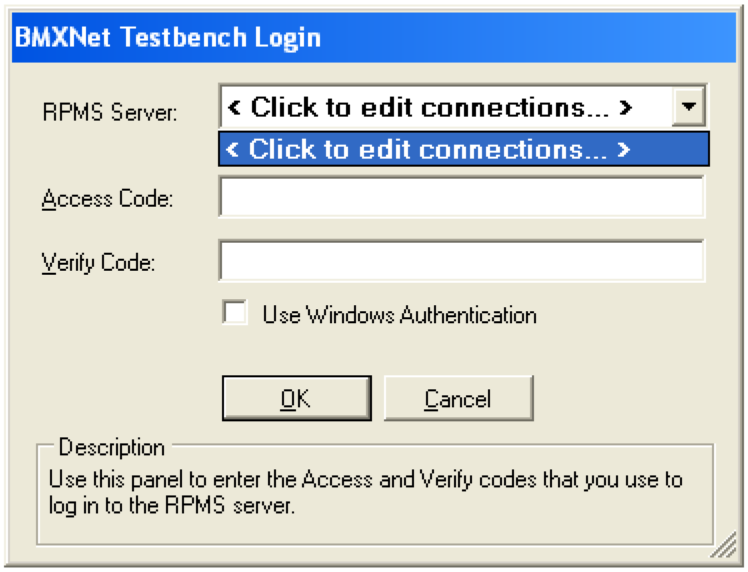


Use this panel to enter the Access and Verify codes that you use to log in to the RPMS server.

Figure 4-3: Empty Login dialog box

LoginProcess.AttemptUserInputLogin(…) supports dialog Title customization, connection management enablement, and configuration of maximum login tries.

By default, every user can edit his/her set of locally cached connection settings (Figure 4-4) by clicking in the RPMS Server field.


BMXNet Testbench Login
RPMS Server:
< Click to edit connections... >
< Click to edit connections... >
Access Code:
Verify Code:
Use Windows Authentication
OK
Cancel
Description

Use this panel to enter the Access and Verify codes that you use to log in to the RPMS server.

Figure 4-4: Connection Specification drop-down list with Connection Management navigation entry

When Connection Management is enabled, the user can select the Connection Management navigation entry in the drop-down list to open the RPMS Server Connection Management dialog box.

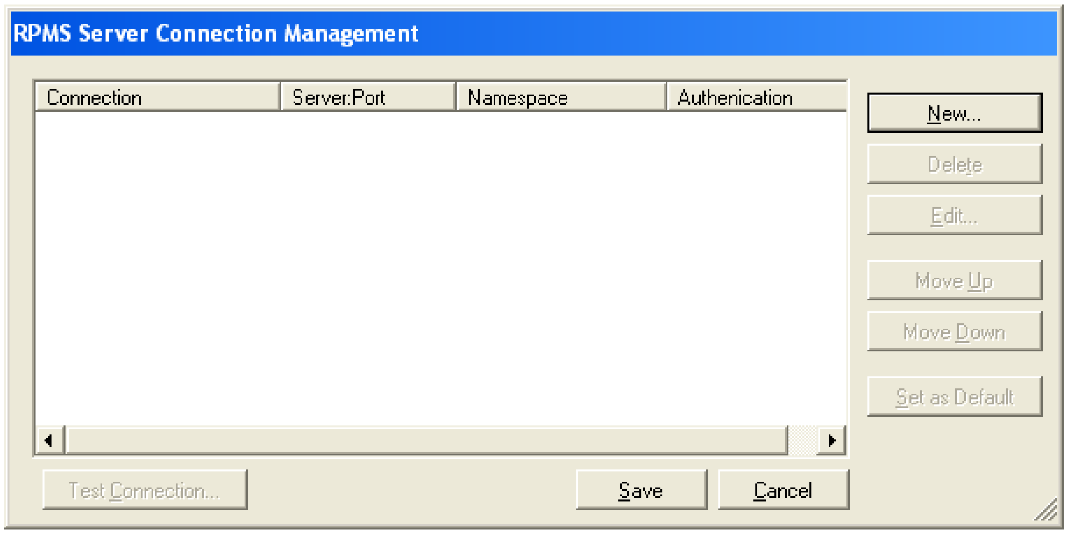
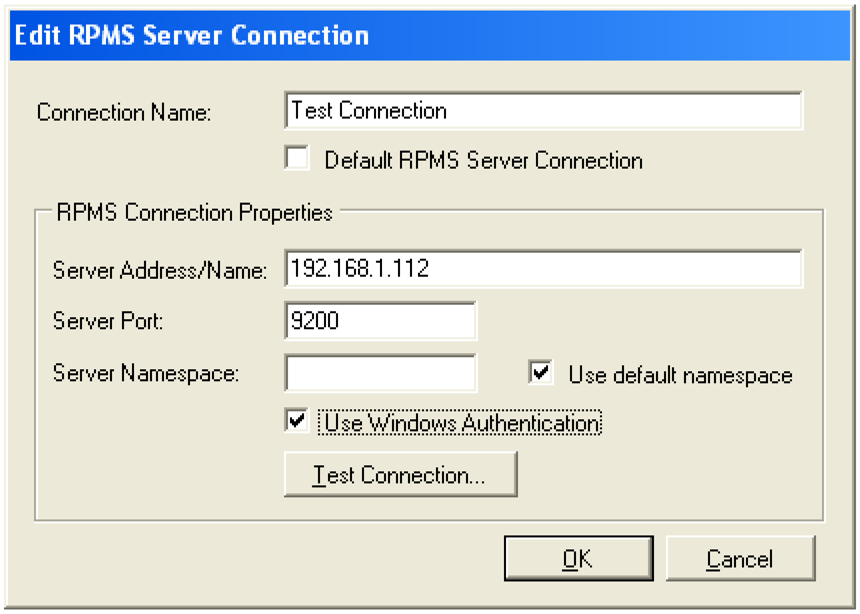


Figure 4-5: Each configuration settings file can contain multiple connection settings

The RPMS Server Connection Management dialog box allows users to create new connection specifications, and to delete, edit, change display order, and set the user’s default setting.

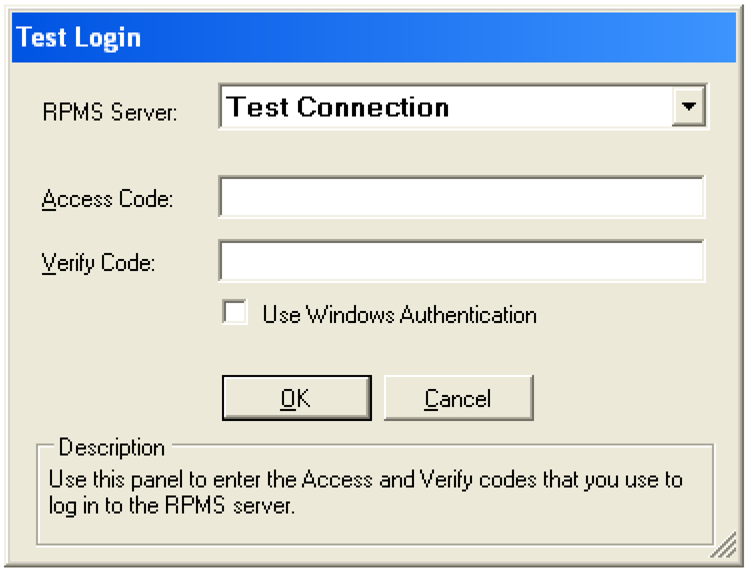
Clicking New or Edit opens the Edit RPMS Server Connection dialog box, as shown below.


Edit RPMS Server Connection
Default RPMS Server Connection
RPMS Connection Properties
Use default namespace
Use Windows Authentication
Test Connection...
OK
Cancel

Connection Name: Test Connection
Server Address/Name: 192.168.1.112
Server Port: 9200
Server Namespace:
[✓] Use default namespace
[✓] Use Windows Authentication

Figure 4-6: Connection specification property dialog box

The connection name is displayed in the Login Dialog Connection drop-down list. All fields are optional because the only sure method to test the validity of a connection specification is to use the Test Login dialog box.


Test Login

RPMS Server: Test Connection

Access Code:

Verify Code:

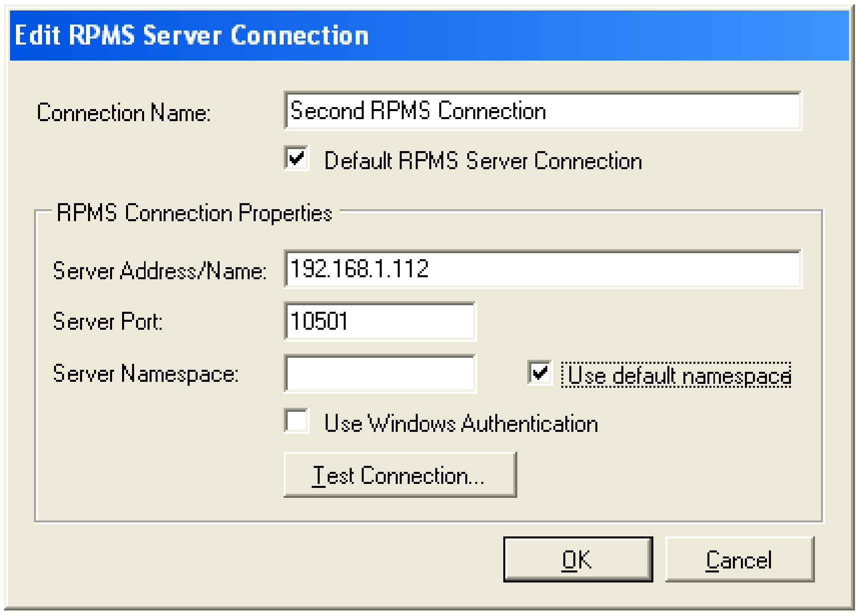
☐ Use Windows Authentication

Description
Use this panel to enter the Access and Verify codes that you use to log in to the RPMS server.

Figure 4-7: Test Login dialog box

The Test Login dialog box is similar to the Login dialog box. After the connection test, the connection to the RPMS server is closed. Any error that occurs during the use of the Login dialog box will also occur in the Test Login dialog box.

Connection testing can be performed in the Connection Specification properties dialog box or in the Connection Management dialog box by selecting a connection specification and clicking Test Connection.


Edit RPMS Server Connection

Connection Name: Second RPMS Connection

☑ Default RPMS Server Connection

RPMS Connection Properties

Server Address/Name: 192.168.1.112

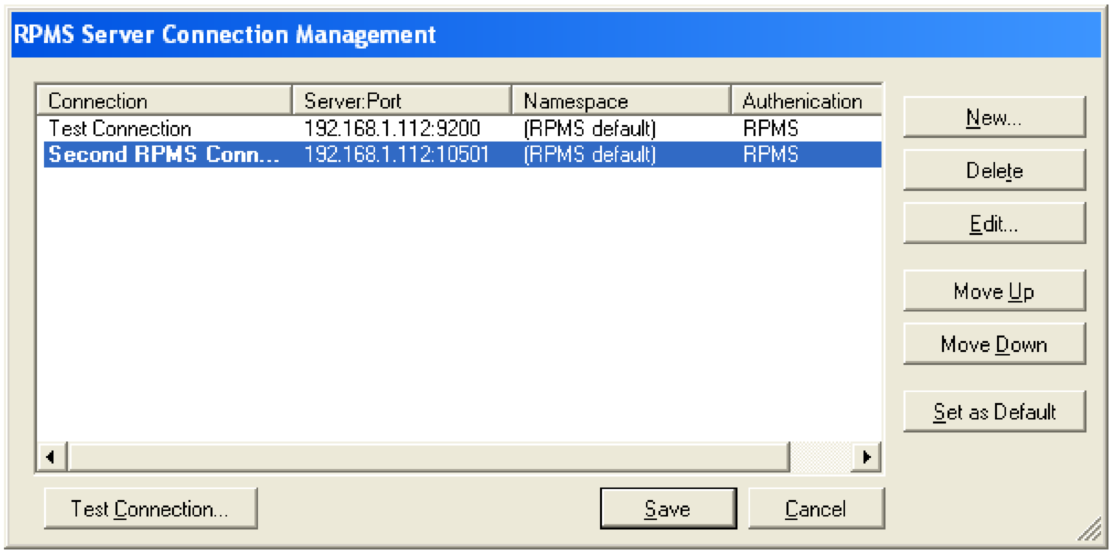
Server Port: 10501

Server Namespace: ☑ Use default namespace

☐ Use Windows Authentication

Figure 4-8: Example properties for a Server Connection

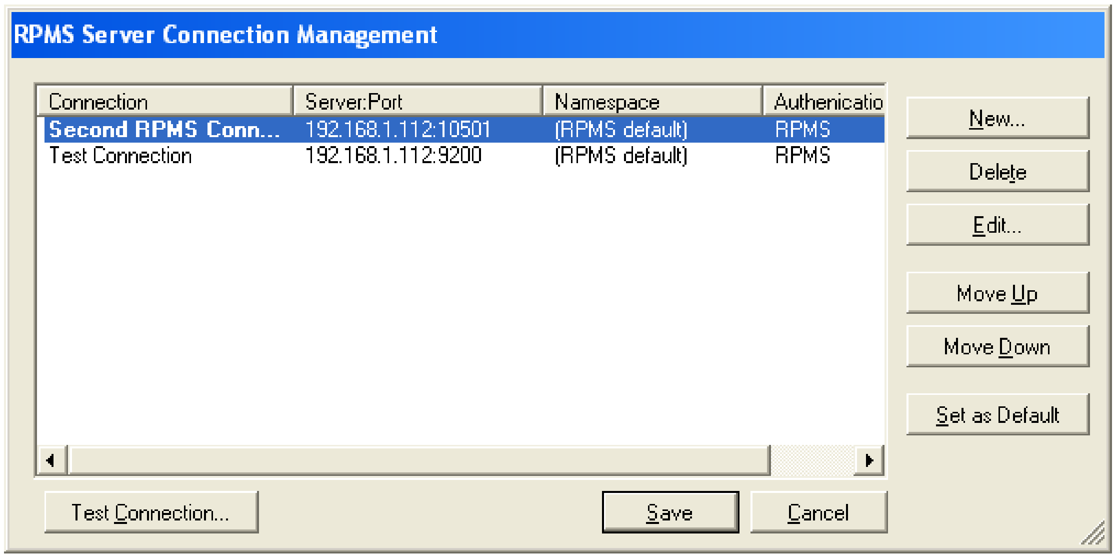
After all of the data provided for a connection specification is tested, click OK to update the RPMS Server Connection Management dialog box.


RPMS Server Connection Management

Connection	Server:Port	Namespace	Authenication
Test Connection	192.168.1.112:9200	(RPMS default)	RPMS
Second RPMS Conn...	192.168.1.112:10501	(RPMS default)	RPMS

Figure 4-9: Setting the new default connection specification in the RPMS Server Connection Management dialog

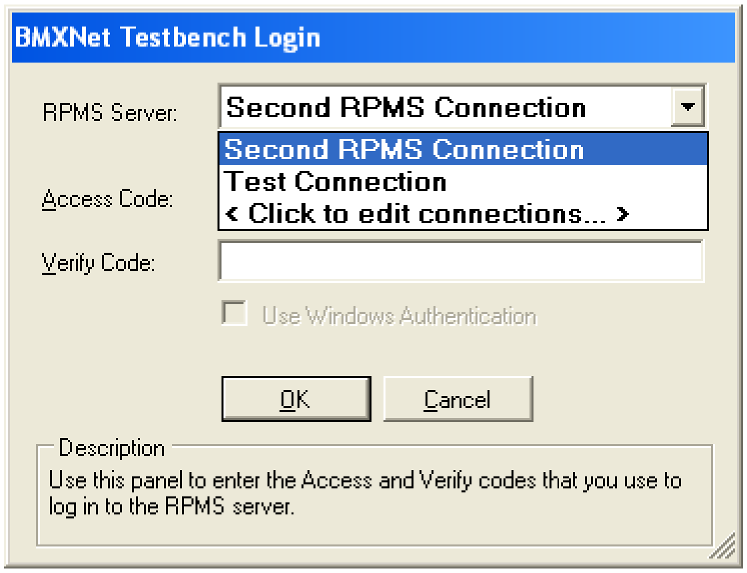
The default connection specification is displayed in **bold** (see highlighted connection in list below) and can be changed to another connection specification by selecting the connection specification and clicking Set as Default. Note the order of Second RPMS Connection and Test Connection in Figure 4-9 and Figure 4-10.


RPMS Server Connection Management

Connection	Server:Port	Namespace	Authenicatio
Second RPMS Conn...	192.168.1.112:10501	(RPMS default)	RPMS
Test Connection	192.168.1.112:9200	(RPMS default)	RPMS

Figure 4-10: Setting the order of connections in the Connection Management dialog

To change the order of connection entries, select a connection and click Move Up or Move Down until the desired order is set. After saving, the Login dialog will display the options in the new order.



Use this panel to enter the Access and Verify codes that you use to log in to the RPMS server.

Figure 4-11: Ordered connections displayed in the Login dialog

An example of disabled Connection Management for lockdown is to isolate users to a single set of connection specifications, so he/she cannot change connection specifications.

The drop-down also includes the Connection Management navigation entry. By either passing a hardcoded “False” in the AttemptUserInputLogin or by accessing the command-line settings “lockedit” (see SDK example), the user’s choices can be locked down so users cannot manage Connections.

```
/lockedit
```

Figure 4-12: Example of command line setting “lockedit”

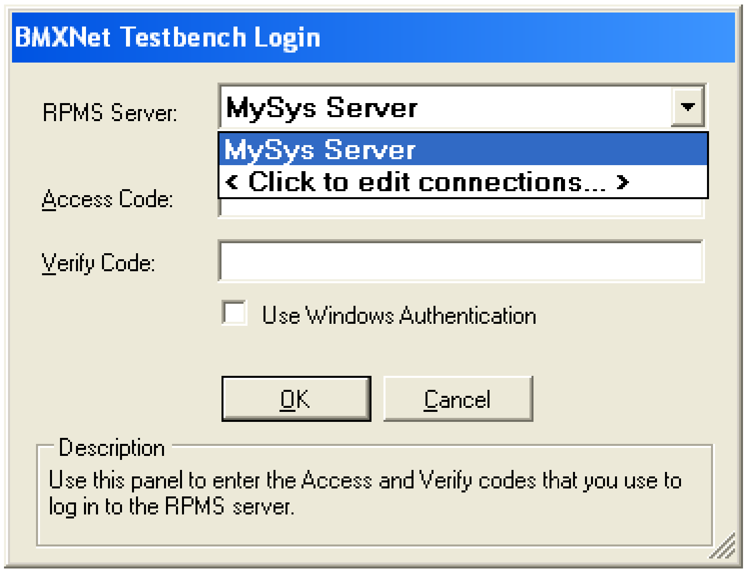

BMXNet Testbench Login
RPMS Server:
MySys Server
MySys Server
< Click to edit connections... >
Access Code:
Verify Code:
Use Windows Authentication
OK
Cancel
Description
Use this panel to enter the Access and Verify codes that you use to log in to the RPMS server.

Figure 4-13: Example of Login to RPMS Server

Command-line settings can be used for specifying the default Connection Specification.

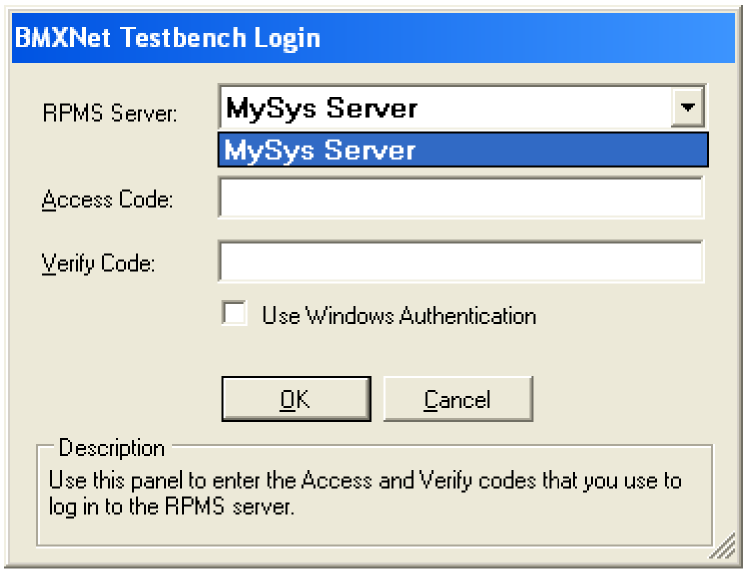
The comma-delimited arguments are:

- Server
- Port
- Display name of connection
- Name space (optional)
- Windows Authentication (set to Win)
- Receive Timeout
- Send Timeout

```
/rpms:"localhost,9201,MySys Server,EBCI,Win,5000,5000"
```

Figure 4-14: Example of RPMS Connection Specification and lockedit flag

By combining both the /rpms Connection Specification and the /lockedit flag, users can be locked down to a single connection setting.


BMXNet Testbench Login

RPMS Server: MySys Server

MySys Server

Access Code:

Verify Code:

☐ Use Windows Authentication

Description

Use this panel to enter the Access and Verify codes that you use to log in to the RPMS server.

Figure 4-15: Single connection specification lock down

Locking down is only desirable in highly managed environments with remote desktops/Terminal servers.

4.1.2 Using RpmsConnectionSpec and ConnectionSettings Programmatically

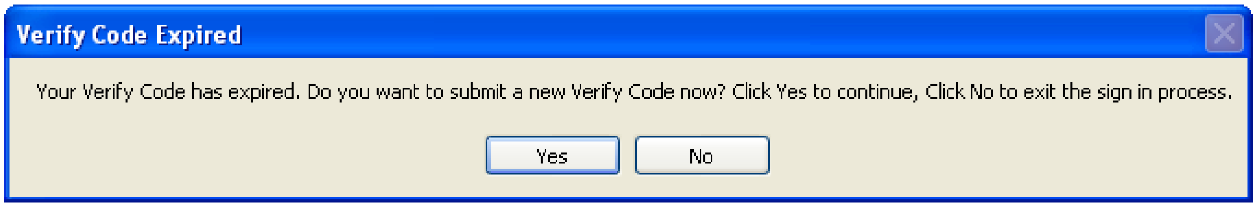
Connection settings are defined through properties of the RpmsConnectionSpec class.

```
  RpmsConnectionSpec spec = new RpmsConnectionSpec();
  spec.IsDefault = true;
  spec.Name = "My Server Spec";
  spec.NameSpace = "EBCI";
spec.Port = 9200;
  spec.Server = "localhost";
spec.UseWindowsAuthentication = true;
  spec.UseDefaultNamespace = false;
spec.ReceiveTimeout = 1000;
  spec.SendTimeout = 1000;

  this.LoginProcess.AttemptAccessVerifyLogin(spec,ACCCES11!", "VERIFY11!");
```

Figure 4-16: Example of defining connection settings in the RpmsConnectionSpec class

4.1.3 Using BMXWIN Verify Code Update Dialog to Update Verify Code When Verify Code Is Expired

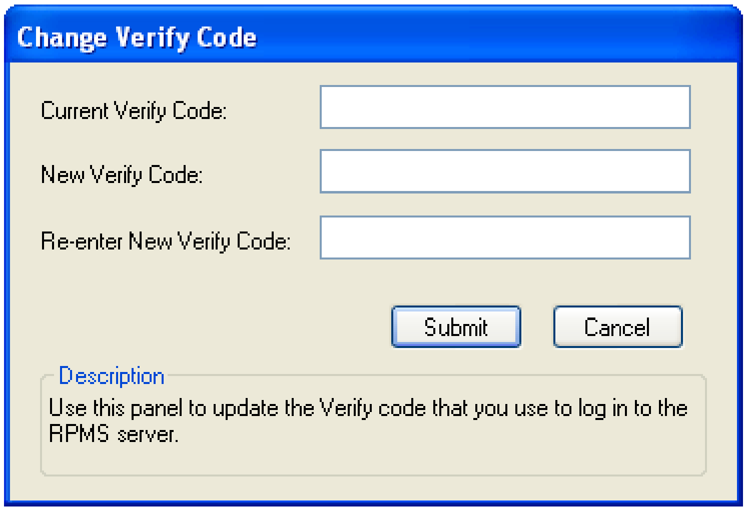
User will be prompted to update the verify code when attempting to log in to the RPMS server if the verify code is expired.


Verify Code Expired

Your Verify Code has expired. Do you want to submit a new Verify Code now? Click Yes to continue, Click No to exit the sign in process.

Figure 4-17: Verify Code Expired message

Clicking Yes opens the Change Verify Code dialog box.


Change Verify Code

Current Verify Code:

New Verify Code:

Re-enter New Verify Code:

Description

Use this panel to update the Verify code that you use to log in to the RPMS server.

Figure 4-18: Change Verify Code dialog box

The user can enter the current verify code and the new verify code with confirmation and click Submit to update the verify code. If the update is successful, the system will attempt to log the user in with the new verify code. If the update is not successful, the user will be prompted with a detailed error message and can continue trying to update the verify code.

5.0 RemoteSession: Exchanging Data with RPMS

5.1 Using BMXNet to Exchange Data with RPMS

BMXNet returns data from the Cache environment as an ADO.NET *DataTable*. An ADO.NET *DataTable* is a fundamental structure for exchanging and manipulating data in .NET applications. For example, ADO.NET *DataTables* can be used to populate data controls in .NET, and can be used as the basis for building Crystal Reports.

There are three ways to call BMXNet to retrieve a DataTable containing M data:

- By calling a *custom-written remote procedure (RPC)* registered in FileMan's REMOTE PROCEDURE file. The remote procedure's M routine must be designed to return its data in the specific format described later in this manual.
- By using a *Structured Query Language (SQL) SELECT* statement to retrieve data from VA FileMan files. BMXNet supports a subset of SQL-like statements that are useful for simple data retrieval tasks.
- By using *the BMX ADO SS* remote procedure provided with the BMXNet package to generate fully updateable ADO.NET DataTables.

Each of these three options is discussed in detail in the following pages.

Use a *custom remote procedure (RPC)* when the data retrieval task is complex or when the data to be retrieved is not stored in FileMan's files. Remote procedures can be used to update and delete FileMan data and generally to do anything that can be done in an M routine.

Use BMXNet's *SQL-like capability* to quickly retrieve a read-only DataTable without having to write an RPC call or create any other supporting file entries.

Use *BMX ADO SS* when to retrieve an updateable DataTable. *BMX ADO SS* is a generalized Remote Procedure Call, which generates an updateable DataTable. *BMX ADO SS* requires that an entry be made in the BMX ADO SCHEMA file describing the DataTable.

Complete source code for two sample applications, BMXNetTest and BMXSchemaBuilder, are distributed with BMXNet. Examine these sample applications to see different methods for connecting to RPMS, retrieving ADO.NET DataTables and populating windows controls with data retrieved from RPMS. Additionally, the sample applications can be used to create and test your own RPCs, SQL queries and schemas.

Note: The details of using ADO.NET in your Windows or Web application are beyond the scope of this document; however, there are many reference books and articles available from the Microsoft Developer's Network (MSDN) and other commercial sources that describe how to incorporate ADO.NET into applications.

5.2 RPMS Access with RemoteSession

5.2.1 RemoteSession Lifecycle

All server-side RPMS RPC calls are performed through this interface. Each instance of RemoteSession corresponds to a single job (e.g. Caché process) on RPMS. There is always one primary RemoteSession and potentially more when using RemoteSessionPool. When the primary RemoteSession is closed all secondary pooled sessions are also closed and the server broker connection is terminated.

5.2.2 RemoteSession Services

The RemoteSession interface provides access to a uniform set of services provided to a WinForm application and within the EHR/VueCentric component. The services break down into the following groups:

- Remote Procedure Calls
- Remote Data Access using ADO.NET DataTables
- Remote Events; and
- Debugging and Configuration Information

See the BMXNET.chm online documentation for API documentation and examples.

5.2.3 High-Performance RemoteSessionPools

Each BMX connection to RPMS contains a single RemoteSessionPool with at least one Session, which is the primary session. Applications that need additional server processes beyond what can be done with async commands can use the RemoteSessionPool.

Access to the RemoteSessionPool is accomplished by implementing the RemoteSessionPoolConsumer interface on the user's component/control. Secondary sessions can be opened and closed as needed. If the AvailableSessionCount is zero a null RemoteSession will be returned, so it is recommended to first check if a pool HasAvailableSessions before submitting an OpenSession() request.

RemoteSessionPool high-performance can be achieved by keeping RPMS server jobs open even after secondary sessions are closed. The pool will maintain MaxSessions number of jobs open on the server. If the application is finished with IdleSessionCount idle jobs, then TerminateIdleSessions() will release server resources and new jobs will be created on demand.

5.3 Designing RPCs and M Routines for BMXNet

M routines that return data can be created via remote procedure calls (RPCs) to use with BMXNet. These M routines must return data in a specific format in order for BMXNet to process the records into ADO.NET DataTable rows.

Generally, a BMXNet RPC must create an array, which describes the data fields and contains the data itself. The first record in the array contains schema information about the data fields, and is called the *schema record.* BMXNet uses two kinds of schema records, the *Minimum Schema Record* and the *Full Schema Record.* Use the Full Schema Record when retrieving tables that will be updated using BMX ADO SS. Use the Minimum Schema Record when retrieving static tables.

Even if no data records are returned, the RPCs must always return the schema record containing metadata, which describes DataTable columns. Subsequent records contain data organized according to the information in the schema record.

5.3.1 Minimum Schema Record

At a minimum, the schema record must contain the three elements shown in Figure 5-1 for each data field. The *Minimum Schema Record* contains enough information to create a read-only Data Table. (To create an updateable Data Table using the Full Schema Record, see Section 5.5.1.)

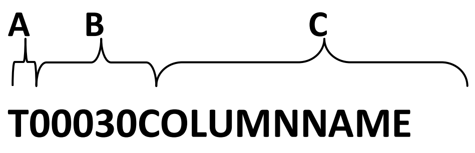


Figure 5-1: Minimum Schema illustration

The following table details the structure of the *Minimum Schema Record.*

Table 5-1: Table of Minimum Schema Record Structure

Section	Use	Description
A	Data Type	Specifies the data type of the column. Available data types are **T**ext, **N**umeric, **I**nteger, and **D**ate.
B	Column Length	Specifies the maximum length, in characters, of the column.
C	Column Name	Specifies the text name of the column.

5.3.2 BMXNet Record Structure

The record returned from a BMXNet RPC must adhere to these rules:

- BMXNet fields are delimited by the ^ character.
- BMXNet records are delimited by the ASCII character 30, which is the End-Of-Record marker.
- The entire set of records in BMXNet is terminated by the ASCII character 31, which is the End-Of-File marker.

5.3.3 Sample BMXNet RPC

Figure 5-2 shows the M code for a simple remote procedure call (BMX PATIENT DEMO) with two parameters to return a list of patients. Note the inclusion of an error trap in the routine; BMXNet RPC routines must contain a functional error trap.

```
PDEMO(BMXY,BMXPAT,BMXCOUNT)  ;EP
   ;This simple RPC demonstrates how to format data
   ;for the BMXNet ADO.NET data provider
   ;
   ;Returns a maximum of BMXCOUNT records from the
   ;VA PATIENT file whose names begin with BMXPAT
   ;
   N BMXI,BMXD,BMXC,BMXNODE,BMXDOB
   ;
   ; BMXY is passed in by reference. Set it to
;the value of the variable in which we will return our data:
   S BMXY="^TMP(BMX,"_$J_")"
   ;
   ;The first subnode of the data global contains the column header information
   ;in the form "txxxxxCOLUMN1NAME^txxxxxCOLUMN2NAME"_$C(30)
   ;where t is the column data type:
;  T for text
;  I for integer
;  N for floating point number
;  D for date/time.
   ;xxxxx is the length of the column in characters.
   ;
   S BMXI=0,BMXC=0
   S ^ TMP(BMX,$J,BMXI)="T00030NAME^T00010SEX^D00020DOB"_$C(30)
   ;
   ;You MUST set an error trap:
   S X="PDERR^BMXRPC6",@^%ZOSF("TRAP")
   ;
   ;Strip CR, LF, TAB from BMXCOUNT parameter
   S BMXCOUNT=$TR(BMXCOUNT,$C(13),"")
   S BMXCOUNT=$TR(BMXCOUNT,$C(10),"")
   S BMXCOUNT=$TR(BMXCOUNT,$C(9),"")
   ;
   ;Iterate through the global and set the data nodes:
   S:BMXPAT="" BMXPAT="A"
   S BMXPAT=$O(^DPT("B",BMXPAT),-1)
   S BMXD=0
   F S BMXPAT=$O(^DPT("B",BMXPAT)) Q:BMXPAT="" S BMXD=$O(^DPT("B",BMXPAT,0)) I +BMXD
S BMXC=BMXC+1 Q:(BMXCOUNT)&(BMXC>BMXCOUNT) D
   . Q:'$D(^DPT(BMXD,0))
   . S BMXI=BMXI+1
   . S BMXNODE=^DPT(BMXD,0)
   . ;Convert the DOB from FM date to external form
   . S Y=$P(BMXNODE,U,3)
   . I +Y X ^DD("DD")
   . S BMXDOB=Y
   . ;The data node fields are in the same order as the column header, i.e.
NAME^SEX^DOB
   . ;and terminated with a $C(30)
   . S ^ TMP(BMX,$J,BMXI)=$P(BMXNODE,U)_U_$P(BMXNODE,U,2)_U_BMXDOB_$C(30)
   ;
   ;After all the data nodes have been set, set the final node to $C(31) to indicate
   ;the end of the recordset
   S BMXI=BMXI+1
   S ^ TMP(BMX,$J,BMXI)=$C(31)
   Q
   ;
PDERR ;Error trap for PDEMO
   ;
   S ^ TMP(BMX,$J,BMXI+1)=$C(31)
   Q
```

Figure 5-2: Remote procedure call example

Figure 5-3 displays the correct format for the entry in the REMOTE PROCEDURE FILE.

```
AME: BMX DEMO       TAG: PDEMO
 ROUTINE: BMXRPC6      RETURN VALUE TYPE: GLOBAL ARRAY
```

Figure 5-3: Remote procedure file entry example

Note: Remote Procedures and the routines invoked must use a namespace set according to RPMS Standards and Conventions.

5.3.4 Invoking Remote Procedures from .NET code

Figure 5-4 demonstrates one of many ways to invoke a remote procedure in a .NET application to return a *Data Table*. The data-table can be displayed in a data grid by setting the grid's Data Source property to the data-table returned from RPMS. The grid is displayed in Table 5-2.

```
private void cmdTest1_Click_1(object sender, System.EventArgs e)
{
   try
   {
      BMXNetConnectInfo ci = new BMXNetConnectInfo();
      ci.LoadConnectInfo();
      ci.AppContext = "BMXRPC";
      BMXNetConnection conn = new BMXNetConnection(ci);
      conn.Open();
      if (conn.State != ConnectionState.Open)
      {
         throw new BMXNetException("Unable to connect to RPMS.");
      }
      BMXNetCommand cmd = (BMXNetCommand) conn.CreateCommand();
      cmd.CommandText = "BMX DEMO^S^10”
      BMXNetDataAdapter da = new BMXNetDataAdapter();
      da.SelectCommand = cmd;
      DataSet ds = new DataSet();
      da.Fill(ds,"BMXNetTable");
      dataGrid2.DataSource = ds.Tables["BMXNetTable"];
      conn.Close();
   }
   catch (Exception ex)
   {
      MessageBox.Show(ex.Message);
      return;
   }
}
```

Figure 5-4: Invoking a remote procedure in a .NET application

Table 5-2: RPC results displayed in a DataGrid

NAME	SEX	DOB
SAEL,ROBERTA	F	12/19/1954
SAEL,ROBERTA	F	12/19/1954
SELIARS,ARDEEN RENEE	F	8/18/1983
SELIARS,BILLY LEE	M	8/27/1953
SELIARS,DANIEL MICHAEL	M	5/6/1980
SELIARS,JOHN DELBERT	M	12/1/1978
SEM,ALLISON RAE	F	2/23/1966
SEM,JOHN DELBERT	M	6/28/1985
SEM,JOHNNIE	M	10/31/1927
SEM,MICHAEL JIM	M	9/16/1963
SAEL,ROBERTA	F	12/19/1954

In order for any RPC to be available to a user, four requirements must be met:

- An entry in the OPTION File (#19) which has the TYPE of "Broker (Client/Server)" must exist.
- The RPC must be entered in the RPC multiple of the OPTION.
- The user must have access to the OPTION via the RPMS menu tree either as secondary menu item.
- The AppContext property of the BMXNetConnectInfo object must be set to the name of the OPTION.

5.4 Using SQL-Like Queries to Retrieve FileMan Data

BMXNet supports a subset of SQL-like keywords to provide read access to VA FileMan files. Note the following items when creating SQL statements in BMXNet.

- Substitute the underscore character ("_") for all spaces in VA FileMan field, file, and subfile names in a BMXNet SELECT statement.
- Example: VA PATIENT must be expressed as VA_PATIENT
- The BMXNet provider recognizes the field BMXIEN as the internal entry number field of a VA FileMan file. This special field corresponds to the FileMan NUMBER field.
- Use the INTERNAL[ ] function to return the internally stored value of a VA FileMan field. This function corresponds to the VA FileMan INTERNAL() function.

5.4.1 SQL SELECT Syntax

The basic syntax of a SQL SELECT statement in BMXNet is indicated in Figure 5-5. Each component of this statement is individually addressed within Sections 5.4.1.1 - 5.4.1.5.

```
SELECT select_list
FROM table_source
[WHERE search_condition [INDEX:i]]
[MAXRECORDS:nnn]
[SHOWPLAN]
```

Figure 5-5: SQL Select Syntax

5.4.1.1 SELECT Clause

The SELECT clause specifies the columns that the system should return from the query. Figure 5-6 shows a SELECT clause example and Table 5-3 describes each component within the clause.

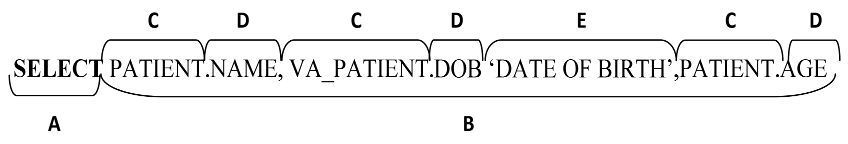

C D C D E C D
SELECT PATIENT.NAME, VA_PATIENT.DOB 'DATE OF BIRTH',PATIENT.AGE
A B

Figure 5-6: Graphic example of a SELECT Clause

Table 5-3: SELECT clause components

Section	Syntax	Description
A	SELECT	Specifies that the system should return the values by the following select_list statement.
B	select_list	Specifies which fields (columns) the system should select for the returned set. The select_list a series of expressions separated by commas.
C	table_name	Specifies from which files (tables) the FROM clause should return fields.
D	field_name	Specifies from which field (column) the FROM clause should return. The field_name is associated with the preceding table_name by using a dot (.) between the two.
E	column_alias	Specifies an alternative name to replace the column name in the query result set. For example, an alias such as “Quantity”, “Quantity to Date”, or “Qty” can be specified for a column named **quantity**

5.4.1.2 FROM Clause

The FROM clause specifies the table(s) from which the system should retrieve rows. The FROM clause is required and specifies the primary table, or FileMan file, and related tables for the SELECT clause.

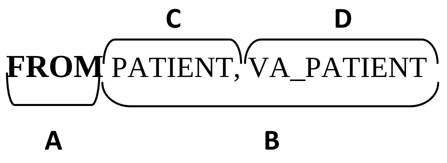


Figure 5-7: Graphic example of a FROM clause

Table 5-4: FROM clause components

Section	Syntax	Description
A	FROM	Specifies that the system should return the values from the following table_list statement.
B	table_source	Specifies from which files (tables) the FROM clause should return fields.
C	primary_table_name	The file from which the system should first retrieve data.
D	related_table_name	The file from which the system should receive data that matches the primary table.

5.4.1.3 WHERE Clause

The WHERE clause specifies search condition(s) to restrict the rows returned and to join tables in a common field.

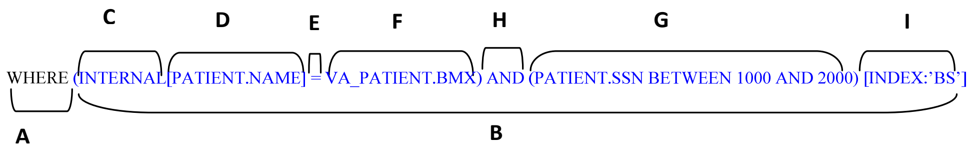

C
D
E
F
H
G
I
WHERE (INTERNAL[PATIENT.NAME] = VA_PATIENT.BMX) AND (PATIENT.SSN BETWEEN 1000 AND 2000) [INDEX:'BS']
A
B

Figure 5-8: Sample of a WHERE clause

Table 5-5: WHERE clause components

Section	Syntax	Description
A	WHERE	Specifies a search condition to restrict the rows returned.
B	search_condition	Restricts the rows returned in the result set by using predicates. There is no limit to the number of predicates that can be included in a search condition.
C	variable	Having a range of values.
D	primary_table_name	The file from which the system should first retrieve data.
E	join_type	Specifies a join using nonstandard syntax and the WHERE clause. The =* operator is used to specify a one-to-many (OTM) join. Use the OTM join to express relationship between tables A and B such that a record in table A can be referenced by a FileMan pointer field in one or more records in table B.
F	related_table_name	The file from which the system should receive data that matches the primary table.
G	Operator Arguments	A value or expression dictating the information upon which the related operator acts.
H	Operator	A symbol or word (i.e., between, and, or) that specifies which operation the systems should perform relative to the indicated operator arguments.
I	INDEX	Identifies a specific FileMan cross-reference to use when retrieving data. Always use the SHOWPLAN keyword in conjunction with the INDEX keyword to ensure that you achieve the intended result. [NOT SUPPORTED IN BMXNET VERSION 1.0]

Operators

Table 5-6 describes the WHERE clause operators that BMXNet recognizes.

Table 5-6: Available WHERE operators

Operator	Description
=	Equals
>	Greater than
<	Less than

Operator	Description
>=	Greater than or equal to
<=	Less than or equal to
<>	Not equal to
=*	One-to-many Table Join
LIKE	Pattern match. Use the % wildcard character to specify a string of zero or more characters. BMXNet currently supports use of one % character on the right side of the comparison value, e.g. LIKE 'SMITH%' will return all records beginning with the string SMITH.
BETWEEN	Specifies an inclusive range to test. BETWEEN 'value1' AND 'value2' will return all records with column values between value1 and value2, inclusive. Comparison values can be string, date, or numeric.
TEMPLATE	Records in the specified FileMan search template are returned. The syntax is: TEMPLATE[*filename*] = '*Search Template Name*'. By using the TEMPLATE keyword, complex searches can be conducted using VA FileMan or other M-based tools and the results can be displayed using common desktop applications capable of processing ADO DataTables.

Example

The following example specifies a One-to-many join, in which all the rows from **Tab2** in which **Tab2.id = Tab1.id** are included in the result set.

```
SELECT Tab1.name, Tab2.id
FROM Tab1, Tab2
WHERE Tab1.id =* Tab2.id
```

Figure 5-9: Sample of a one-to-many join

5.4.1.4 MAXRECORDSKeyword

The MAXRECORDS clause specifies the maximum number of records that the system should return. Using MAXRECORDS when designing and testing BMXNet SQL statements, could return a large number of records. Figure 5-10 represents a MAXRECORDS clause example, and Table 5-7describes each component within the clause.

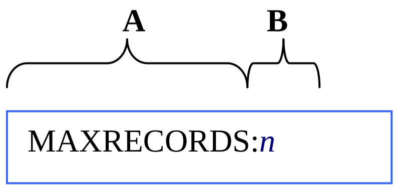


Figure 5-10: MAXRECORDS clause graphic example

Table 5-7: MAXRECORDS clause components

Section	Syntax	Description
A	MAXRECORDS	Specifies the maximum number of records to return
B	*n*	Integer number indicating the maximum records to return.

5.4.1.5 SHOWPLAN Keyword

The SHOWPLAN keyword returns the query plan, including the M code that will be executed to iterate through and retrieve the records. Use SHOWPLAN to confirm that your query statement is using a particular index. The query plan report contains at least two rows, including the *Index* row and the *Screen* row(s).

- The Index row includes the M code created by BMXNet that will execute on the RPMS server and iterate through the FileMan file.
- The Screen rows include the M code that BMXNet will execute to filter the results. The caret character i(^) n the query plan is replaced by the tilde character (~).

The following example displays a SHOWPLAN used with a WHERE clause that includes a table join and two screening filters. Table 5-8shows the index and screening that BMXNet will generate to iterate through and select the records.

```
SELECT VA_PATIENT.NAME, VA_PATIENT.SSN, PATIENT.CURRENT_COMMUNITY
FROM VA_PATIENT, PATIENT
WHERE VA_PATIENT.BMXIEN =* INTERNAL[PATIENT.NAME] AND VA_PATIENT.NAME LIKE 'DEMO%'
AND VA_PATIENT.AGE BETWEEN 15 AND 24 SHOWPLAN
```

Figure 5-11: SHOWPLAN keyword example

Table 5-8: SHOWPLAN keyword components

Item	Result
INDEX(1)	S BMXV="DELVA,STEVEN O." F S BMXV=$O(~DPT("B",BMXV)) Q:BMXV="" Q:BMXV'?1"DEMO".E Q:BMXM>BMXXMAX S D0="" F S D0=$O(~DPT("B",BMXV,D0)) Q:D0="" Q:BMXM>BMXXMAX
SCREEN	X BMXSCR("C") I 1&1&((BMXSCR("X",1)'<15)&(BMXSCR("X",1)'>24))
SCREEN(1)	X ~DD(2,.033,9.5) S X=$E(Y(2,.033,15),Y(2,.033,16),X) S Y=X,X=Y(2,.033,13),X=X<Y,Y=X,X=Y(2,.033,8),X=X-Y

Analysis of the result indicates that the query will use the "B" cross references of ^DPT and to iterate through the patient files. The screening code will execute the FileMan computed field code stored in ^DD for the AGE field and then apply the screening logic.

5.4.2 Sample BMXNet SQL Queries

Sections 5.4.2.1 - 5.4.2.4 illustrate the use of BMXNet to retrieve FileMan data using SQL SELECT statements.

5.4.2.1 Simple Select Statement Example

The following example depicts a simple Select statement.

```
SELECT NAME 'PATIENT', DOB
FROM VA_PATIENT
WHERE NAME LIKE 'DEMO%'
```

Figure 5-12: Simple SELECT statement example

Table 5-9: Results of Simple SELECT statement example

Patient	DOB
DEMO,JANICE	12/1/56
DEMO,JILL	9/1/23
DEMO,JOE	6/1/33
DEMO,JOE	3/22/54
DEMO,JOHN	2/23/44
DEMO,ONE	3/2/34
DEMO,PATIENT	4/1/56
DEMO,TEST	8/23/33
DEMO,TWO	2/1/33

5.4.2.2 Retrieving Subfield Data

When retrieving subfield data from VA FileMan, the MAXRECORDS keyword applies to the count of parent records, not to the subfields. In this example, data for two patients is returned, although one patient has more than one health record in the FACILITY multiple.

```
SELECT PATIENT.NAME 'PATIENT', PATIENT.DOB,
PATIENT.HEALTH_RECORD_NO..HEALTH_RECORD_FAC FACILITY,
PATIENT.HEALTH_RECORD_NO..HEALTH_RECORD_NO. CHART
FROM PATIENT
WHERE NAME LIKE 'WABAR,J%' MAXRECORDS:2
```

Figure 5-13: Retrieving subfield data example

Table 5-10: Results of retrieving subfield data example

Patient	Patient DOB	Facility	Chart
WABAR,JESSE Z	6/23/1923	PORTEGE EHRTEST	101875
WABAR,JESSE Z	6/23/1923	MAKE U WELL FACILITY	101876
WABAR,JUDITH Y	3/1/1982	PORTEGE EHRTEST	104047

5.4.2.3 Joining FileMan Files

The following example shows how to use a join to connect two FileMan files and to access data from each file.

```
SELECT VA_PATIENT.NAME 'NAME', VA_PATIENT.STATE 'STATE', STATE.ABBREVIATION,
VA_PATIENT.AGE 'AGE'
FROM VA_PATIENT, STATE
WHERE INTERNAL[VA_PATIENT.STATE] = STATE.BMXIEN AND VA_PATIENT.NAME LIKE 'WH%'
MAXRECORDS:5
```

Figure 5-14: Joining FileMan files

Table 5-11: Results of joining FileMan files

Patient	State	State Abbreviation	Age
WHAALAR,ALLEN	NEW MEXICO	NM	50
WHAALAR,BEVERLY A	ARIZONA	AZ	61
WHAALAR,BONNIE M	MINNESOTA	MN	44
WHAALAR,CHRISTINE M	MINNESOTA	MN	34
WHAALAR,DUSTIN B	MINNESOTA	MN	27

5.4.2.4 One-to-Many Join

The following example shows how to use a one-to-many join to retrieve data from VISIT and VISIT-related files.

```
SELECT VISIT.BMXIEN, VISIT.PATIENT_NAME, VISIT.CLINIC, V_DENTAL.BMXIEN,
V_DENTAL.SERVICE_CODE
FROM VISIT, V_DENTAL
WHERE VISIT.PATIENT_NAME LIKE 'GEGN%' AND VISIT.CLINIC = 'DENTAL' AND VISIT.BMXIEN
=* INTERNAL[V_DENTAL.VISIT]
```

Figure 5-15: Sample of a one-to-many join retrieval

Table 5-12: Results of one-to-many join retrieval

VISIT.BMXIEN	VISIT.PATIENT_NAME	V_DENTAL.SERVICE_CODE
5219	GEGNUN,BETTE A	9320
5219	GEGNUN,BETTE A	0190
5979	GEGNUN,ROBERTA J	7111

VISIT.BMXIEN	VISIT.PATIENT_NAME	V_DENTAL.SERVICE_CODE
5979	GEGNUN,ROBERTA J	0000
5979	GEGNUN,ROBERTA J	0140
5979	GEGNUN,ROBERTA J	0270
5979	GEGNUN,ROBERTA J	0270
5979	GEGNUN,ROBERTA J	0270
5219	GEGNUN,BETTE A	9320
5219	GEGNUN,BETTE A	0190
5979	GEGNUN,ROBERTA J	7111

5.5 Creating Updateable Data Tables with BMXNet

BMXNet provides a way to generate *updateable* ADO.NET DataTables from FileMan data. By using an updateable DataTable, the BMXNet developer is able to use standard *.NET* techniques in his/her Windows/Web application to access and edit FileMan data and can avoid having to write custom RPCs for these tasks.

5.5.1 The Full Schema Record

Updateable DataTables require use of the *full schema* record rather than the minimal schema record described in Section 5.3.1. While the minimal schema record contains only data type, column length and column name information, the full schema record contains sufficient metadata for BMXNet to generate fully updateable ADO.NET DataTables.

The full schema is also able to express relational joins between multiple tables. BMXNet can use this information to build ADO.NET DataRelationship objects between tables in a client ADO.NET DataSet that mirror the FileMan File relationships on the RPMS Server.

It is possible to write custom RPCs, which use full schema instead of the minimal schema. The data nodes of the returned M array take the same form regardless of whether the full or minimal schemas are used. See Section 5.2 for information on writing custom RPCs with BMXNet.

Because the full schema is complex, BMXNet provides software utilities to simplify using the full schema. Rather than writing a custom RPC, developers may define and store full schemas in the **BMX ADO SCHEMA** file. Developers may then access full schemas using the **BMX ADO SS** remote procedure call as described in Section 5.3.4.

5.5.2 Structure of BMXNet Data

Developers who use BMXNet's utilities may never need to examine records returned by BMXNet utilities in the Caché environment. However, when troubleshooting and developing it is important to understand the structure of the data returned by BMXNet's M utilities.

The BMXNet M components return data in a string delimited by ASCII 30 (EOR) characters. The ASCII 31 (EOF) character, as shown in Figure 5-16, marks the end of the entire record set.

```
SchemaRecord EOR DataRecord1 EOR DataRecord2 EOR…DataRecordN EOR EOF
```

Figure 5-16: Sample of return data in a string delimited by ASCII 30 (EOR) characters

The Schema Record may be either Full or Minimum format. (See Section 5.3.1 for structure of the minimum schema record.) The Full Schema Record consists of an **introductory section** followed by one or more **field definition sections**. Like all fields in BMXNet records, each of these sections is delimited by the caret character (^). This is a printable character: ASCI 94 [$C(94)].

```
IntroductorySection^FieldDef1^FieldDef2^…^FieldDefinitionN EOR
```

Figure 5-17: Sample of a BMXNet record

Each major section of the schema string is further subdivided into basic elements by the vertical bar character (|): ASCI 124 [$C(124)].

5.5.3 The Introductory Section of the Schema Record

The introductory section of the Schema String is contained within the first "^" piece of the schema string. This section is further subdivided by the "|" character.

Consider the following sample Introductory Section of a Schema String:

```
"@@@meta@@@BMXIEN|2160010.224||^…"
```

Figure 5-18: Sample of the introductory section of a schema string

The following use sample text from the example in Figure 5-18:

First "|" Piece: The "@@@meta@@@BMXIEN" text is a **lead tag** that tells BMXNet that this schema is a **full schema** rather than a minimal schema. If the return data contains multiple schema/data pairs to define a relational join, the lead tag delimits the boundaries of each pair.

Second "|" Piece: The "2160010.224" text is the FileMan file or sub-file number. This is the primary file/sub-file that contains the data, and it is also the starting point for inter-file navigation. In the example shown above, the second piece references a sub-file.

Third "|" Piece: This piece usually is empty. It only contains a value if (1) the record set contains data records along with a schema record, (2) data is being returned to a calling application in chunks; e.g. 50 records at a time and (3) there is more data to be passed in the next chunk. If all three of these conditions are met, then this piece contains the "seed" value that tells the retrieving routine where to start the next chunk. In other words, the seed initiates the *iteration* that generates the rows of the data table. Management of chunks and the use of seeds will be discussed in detail later.

Fourth "|" Piece: This piece is usually empty. It may contain a numeric value if the schema defines a relational join of two or more data tables. Management of relational joins will be discussed in detail later.

5.5.4 The Field Definition Section of the Schema Record

The field definition is contained in "^" pieces two through *n* of the schema record. Each "^" piece defines a specific field or column in the schema. There is no technical limit to the number of "^" pieces/field definitions that can be included in a schema record. Within each "^ piece, there are eight sub-pieces delimited by the "|" character. A field definition section contains the components shown in the following example.

```
"…^FILE#|FIELD#|DATATYPE|LENGTH|FIELDNAME|READONLY|KEYFIELD|NULLOK^"
```

Figure 5-19: Sample of components in a field definition section

Following is an example of a field definition section.

```
"…^2160010.224|.03|D|12|Birthdate|FALSE|FALSE|FALSE^…"
```

Figure 5-20: Sample of a field definition section

Refer to the example text in Figure 5-20 for the following:

First "|" Piece: This is the FileMan file or sub-file number. Typically, this number will be identical for every data element in the schema. (For example, "2160010.224")

Second "|" Piece: This is the FileMan field number. This number is different for every data element in the schema. The schema string contains at least one *virtual field number*, as described in Section 5.5.5. (For example, ".03")

Third “|” Piece: The Third “|” Piece is the ADO Data Type. See the example below:

D = Date, I = Integer, N = floating point Number, and T = Text

Fourth “|” Piece: The Fourth “|” Piece is the maximum length of the field in characters. (For example, “12”)

Fifth “|” Piece: This is the ADO DataTable Column Header. Often this is the same as the FileMan field name. (For example, “BIRTHDATE”)

Sixth “|” Piece: This is a “Read Only” flag. “TRUE” if data cannot be edited. “FALSE” if data can be updated.

Seventh “|” Piece: The Seventh “|” Piece is the “Key Field” flag. “TRUE” if this field is the key field. “FALSE” if this is not the key field. Unless this is the *.001* field (the IEN), this value will be “FALSE.”

Eighth “|” Piece: This is the “Null OK” flag. “TRUE” if value can be null. “FALSE” if data is mandatory. This piece is important because it is a potential determinant of transaction “rollback.” If the value is “FALSE” and no data value is supplied for this field, then the entire transaction will be rolled back. For example, a VISIT file entry will be rolled back if the VISIT LOCATION is not specified. If the FileMan field is “required,” this piece should be set to “FALSE.”

Like all BMXNet records, the schema record terminates with the non-printable EOR character, ASCII 30.

5.5.5 Virtual Fields

The schema may contain so-called “virtual fields.” Virtual fields do not exist in FileMan, they only exist in the ANR, but virtual fields are derived from FileMan data and data definitions. Virtual fields are always “read only,” and are always created on an ad hoc basis when the ANR is generated. Some virtual fields *must* be linked to a specific, “real” field in the schema, and all share certain naming conventions and properties. There are four types of virtual fields:

- PRIMARY KEY
- PARENT KEY.POINTER VALUE
- IDENTIFIER
- TRIGGERED

5.5.5.1 Primary Key Virtual Fields

The primary key of any FileMan file is its internal entry number (IEN). The internal entry number of the file is stored in the .001 field of the ANR.

Note: The *.001* field is *always* defined in the schema.

5.5.5.2 Parent Key Virtual Fields

Sub-File representation and management will be discussed in detail later in this document. For now, it is sufficient to know that if the ANR defines a FileMan sub-file, the IEN of the *parent* file will be stored in the .0001 field of the sub-file's ANR. If it exists, the .0001 field will always be the first field in the schema. It is followed by the .001 field.

5.5.5.3 IEN Virtual Fields

In FileMan, many data elements are stored as "pointer" values. A pointer value is an internal entry number–a primary key of another file. Even though the data elements may be stored in internal format (IEN's), data elements are displayed in external format. For example, the V MEASUREMENT file stores the patient IEN, but when measurement results are displayed, the patient's full name is shown.

Typically, when data is passed to the ANR, it is in external format. To avoid potential ambiguity, it may be useful to include the IEN along with the external value in the ANR data. A field that contains the IEN can be added to the ANRS at the last moment.

The virtual field follows a naming convention: xxIEN where xx is the field number. For example, ".04IEN" contains the internal value (IEN) of field .04.

Identifier Virtual Fields

In FileMan, certain fields are embellished with identifiers (additional pieces of information) that are included whenever the key field is displayed. For example whenever a patient name is displayed, the DOB, SSN, and chart number identifiers are automatically displayed as well. The EBCU is capable of automatically generating identifier fields for the ANR–even if those fields are *not* included in the FileMan data definition. The identifiers are included in a text string that is the value of a virtual field. The naming convention for an identifier field is: **xxIDy** where xx is the number of the field that is "identified," and y is an instance identification number. The instance identification number is necessary because there may be multiple identifier strings associated with a single field. For example "**.01ID2**" is the name of the second identifier field associated with the primary field .01.

Triggered Virtual Fields

The EBCU is capable of automatically transforming the value of one field and displaying the transformed value within another (virtual) field. For example, a date of birth could trigger an age value that is displayed in a virtual field. This functionality is similar to, but independent of, FileMan's "triggered" and computed fields. In fact FileMan's triggered/computed fields can be displayed along side the EBCU's triggered fields in the ANR. The naming convention for a triggered virtual field is xxTRIGGERy where xx is the number of the triggering field, and y is the instance identification number. The instance identification number is necessary because there may be multiple triggers associated with a single field. For example "**.01TRIGGER2**" is the name of the *second triggered* field associated with *triggering* field .01.

The following schema is used to display patient measurements. It contains virtual fields (shown in **bold**) that are automatically added to the schema by the EBCU. Virtual fields do not exist in FileMan.

```
@@@meta@@@BMXIEN|9000010.01|^
9000010.01|.001|I|10|BMXIEN|TRUE|TRUE|FALSE^
9000010.01|.01|T|30|TYPE|FALSE|FALSE|FALSE^
9000010.01|.01IEN|I|00009|TYPE_IEN|FALSE|FALSE|FALSE^
9000010.01|.02|T|30|PATIENT NAME|FALSE|FALSE|FALSE^
9000010.01|.02IEN|I|00009|PATIENT NAME_IEN|FALSE|FALSE|FALSE^
9000010.01|.02TRIGGER1|I|00003|PATIENT AGE|TRUE|FALSE|TRUE^
9000010.01|.02ID1|T|00080|PATIENT IDENTIFIERS|TRUE|FALSE|TRUE^
9000010.01|.03|T|30|VISIT|FALSE|FALSE|FALSE^
9000010.01|.03IEN|I|00009|VISIT_IEN|FALSE|FALSE|FALSE^
9000010.01|.04|T|100|VALUE|FALSE|FALSE|TRUE
```

Figure 5-21: Sample of schema displaying patient measurements

5.5.6 The BMX ADO SCHEMA File

The specification for a BMXNet schema can be stored in the **BMX ADO SCHEMA** File. Storing a schema in a standard FileMan file helps to ensure the data integrity of the schema. BMXNet contains both command-line and Windows-based utilities for creating and updating schemas in the BMX ADO SCHEMA file.

```
.01  SCHEMA NAME (RF), [0;1]
.02  FILE OR SUBFILE NUMBER (NJ22,9), [0;2]
.03  DATASET IS READ ONLY
1   FIELD NUMBER (Multiple-90093.991), [1;0]
   .01 FIELD NUMBER (MNJ22,9), [0;1]
   .02 DATA TYPE (S), [0;2]
   .03 FIELD LENGTH (F), [0;3]
   .04 COLUMN HEADER (F), [0;4]
   .05 READ ONLY (S), [0;5]
   .06 KEY FIELD (S), [0;6]
   .07 NULL ALLOWED (S), [0;7]
   .08 IEN AUTOMATICALLY INCLUDED
   .09 ALWAYS GET INTERNAL VALUE
    1 AUTO IDENTIFIER EXTR FUNCT
    2 SPECIAL UPDATE EP
```

Figure 5-22: BMX ADO SCHEMA file structure

SCHEMA NAME

The SCHEMA NAME is a brief descriptive name that tells the purpose of the schema; e.g., “VISIT FILE - ADD NEW ENTRY.” Schema entries should have a namespace according to RPMS Standards and Conventions to avoid naming issues between packages.

FILE OR SUBFILE NUMBER

The FileMan FILE OR SUBFILE NUMBER is described in the previous section.

DATASET IS READ ONLY

The DATASET IS READ ONLY has a value of “YES” or “NO.” If the value is “YES,” then *none* of the fields in the schema can be edited. This is the equivalent of the setting the READ ONLY property of every field to “TRUE” (see below). DATASET IS READ ONLY overrides all related properties.

FIELD

Field is a multiple containing all the fields represented in the schema.

FIELD NUMBER

FIELD NUMBER is the FileMan field number. Every file has a .001 field. This is a *virtual* field (one that may not actually exist in FileMan) that stores the internal entry number (IEN or unique primary key) of the record. *The .001 field is automatically inserted in the schema string by the schema generator* (see next section). If the schema describes a FileMan sub-file, a .0001 field will also be automatically added to the schema. This field contains the IEN of the entry in the parent file.

DATA TYPE

DATA TYPE contains the data type: NUMBER, INTEGER, TEXT, and DATE. Note that if the FileMan data type for the field is a pointer, and the external value is to be displayed, then the data type will be automatically converted from integer (i.e. the IEN/actual pointer value) to whatever data type is appropriate for the pointed-to field.

FIELD LENGTH

FIELD LENGTH is a number. This value is used by ADO.Net to establish its internal data definitions.

COLUMN HEADER

COLUMN HEADER is a brief descriptive name, and is typically identical to the FileMan field name. When BMXNet creates the ADO.NET DataTable, this value will be used for the ColumnName.

KEY FIELD

KEY FIELD has a value of “YES” or “NO.” The .001 field is **always** the primary key field. No other field can be the primary key field.

NULL ALLOWED

NULL ALLOWED has a value of “YES” or “NO.” If “NO,” the field is mandatory; i.e., the record will *not* be updated unless this filed has a non-null value.

IEN AUTOMATICALLY INCLUDED

IEN AUTOMATICALLY INCLUDED has a value of “YES” or “NO.” If the value is “YES,” the schema will automatically include an additional field to store the IEN of a pointer-type field. The data type of the IEN field is a number.

ALWAYS GET INTERNAL VALUE

ALWAYS GET INTERNAL VALUE has a value of “YES” or “NO.” If “YES,” the internal FileMan value will always be used along with the corresponding data type and field length for the internal value.

AUTO IDENTIFIER EXTR FUNCT

AUTO IDENTIFIER EXTR FUNCT specifies an extrinsic function entry point in the format “TAG^LINE.” If an entry point is specified, BMXNet uses this extrinsic function to automatically create an identifier field and include it in the schema. This is another virtual field not found in FileMan.

SPECIAL UPDATE EP

SPECIAL UPDATE EP specifies an entry point in the format “TAG^LINE.” If an entry point is specified, BMXNet uses the custom code in this call to file the data.

EXTR FUNCT FOR TRIGGERED VALUE

EXTR FUNCT FOR TRIGGERED VALUE specifies an entry point for creating another virtual field. The value of the triggering field is passed to this entry point and transformed. The transformed value is then passed to the virtual field. Multiple triggered fields can be produced from a single source field.

5.5.7 BMXNet Data Records

BMXNet Data Records–if present, follow the BMXNet Schema Record. Like all BMXNet records, the data record terminates with the non-printable EOR character, ASCII 30. Each data record consists of ^-delimited field data. The ^-position of the field determines which schema field it is associated with; the *n*th ^-piece of a data record corresponds to the *n+1*th ^-piece of the schema record.

The ASCII 31 EOF character terminates the last data record.

A sample BMXNet record set, including schema and data records, is shown in Figure 5-23. Note that the “^”-pieces of the schema (shown in **bold**) correspond to the “^”-pieces of each data record (shown in blue, for example “71140^3040419.09^I^1^4585^A^1”). In this example, there are seven pieces in the schema record and seven pieces in each data record. Each ^-piece corresponds to a field/column.

```
@@@meta@@@BMXIEN|9000010^9000010|.001|I|10|BMXIEN|TRUE|TRUE|FALSE^9000010|.01|D|21|T
IMESTAMP|FALSE|FALSE|FALSE^9000010|.03|T|3|TYPE|FALSE|FALSE|FALSE^9000010|05|T|30|PA
TIENT|FALSE|FALSE|FALSE^9000010|.06|T|30|FACILITY|FALSE|FALSE|FALSE^9000010|.07|T|10
|CATEGORY|FALSE|FALSE|FALSE^9000010|.08|T|30|CLINIC|FALSE|FALSE|TRUEEOR
71144^3040419.1^I^1^4585^A^1EOR
71143^3040419.1^I^1^4585^A^1EOR
71142^3040419.1^I^1^4585^A^1EOR
71141^3040419.1^I^1^4585^A^1EOR
71145^3040419.11^I^1^4585^A^1EOR
71146^3040419.12^I^1^4585^A^1EOR
71147^3040419.15^I^1^4585^A^1EOR EOF
```

Figure 5-23: Sample of BMXNet Records

5.5.8 Schema Management Utilities

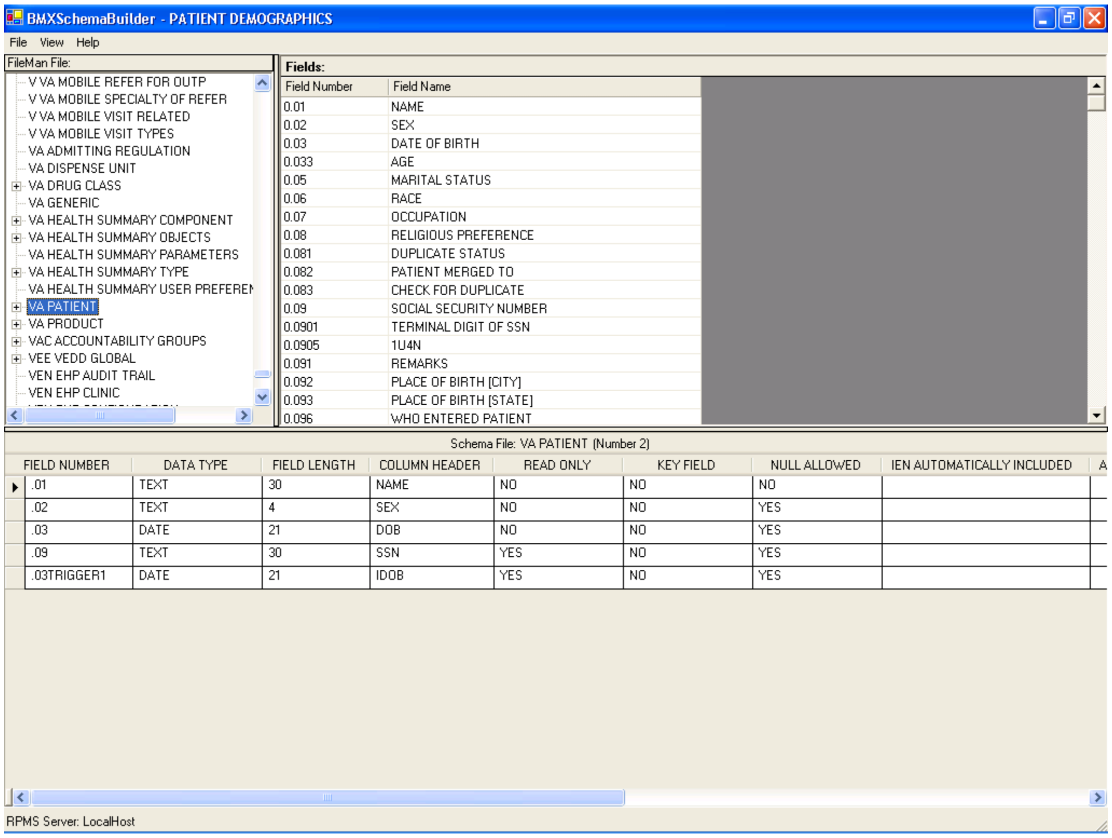
BMXNet includes two utilities for creating and editing schemas. The command-line based Schema File Updater utility is accessed at the entry point *SS^BMXADOS* on the RPMS Server. A sample session is shown in Figure 5-24.

A Windows-based utility, *BMXSchemaBuilder*, is also available and a sample screen is shown in Figure 5-25. The C# source code for BMXSchemaBuilder is included in the BMXNet package. BMXSchemaBuilder makes extensive use of BMXNet-generated ADO.NET data and is useful as a tutorial. A view of the BMXSchemaBuilder screen is displayed in Figure 5-25.

```
>D ^BMXADOS

Enter schema name: PATIENT DEMOGRAPHICS
 Are you adding 'PATIENT DEMOGRAPHICS' as
 a new BMX ADO SCHEMA (the 11TH)? y (Yes)
Select FILE: VA PATIENT

The BMX PATIENT file contains the following sub-files

1 ADMISSION DATE (2.95)
2 HEMODIALYSIS DATE (2.951)
3 TRANSFER DATE (2.96)
4 TREATING SPECIALTY (2.9501)

Is the schema linked to a sub-file in this list? No// N (No)

Select a field from this file:
1 NAME [.01]
2 SEX [.02]
3 DOB [.03]
4 PRIMARY CLINIC [.04]

Select a number from the list (1-4) or press <ENTER> to continue: 1
Column header: NAME//
Is null allowed? Yes// N (No)
Want to display identifiers with this field? No// Y (Yes)
Entry Point to generate Identifiers: DEMOGR^BMXADOX
The identifier field has been created

Select a number from the list (1-14) or press <ENTER> to continue: 2
Column header: SEX//
Is null allowed? Yes// (Yes)

Select a number from the list (1-4) or press <ENTER> to continue: 3
Column header: DOB//
Is null allowed? Yes// (Yes)

1 NAME [.01]
2 SEX [.02]
3 DOB [.03]
4 PRIMARY CLINIC [.04]
```

```
Select a field from the list: (1-4): 4
Column header: LOCAL FACILITY//
Is null allowed? Yes// (Yes)
This field is a pointer value (IEN).
Want to automatically insert the lookup value in the schema? No// Y (Yes)
Select a number from the list (1-4) or press <ENTER> to continue:
OK. A lookup field named '.04IEN' has been added to this schema!
Done!
```

Figure 5-24: Sample Schema Generator command-line


BMXSchemaBuilder - PATIENT DEMOGRAPHICS
File
View
Help
FileMan File:
V VA MOBILE REFER FOR OUTP
V VA MOBILE SPECIALTY OF REFER
V VA MOBILE VISIT RELATED
V VA MOBILE VISIT TYPES
VA ADMITTING REGULATION
VA DISPENSE UNIT
VA DRUG CLASS
VA GENERIC
VA HEALTH SUMMARY COMPONENT
VA HEALTH SUMMARY OBJECTS
VA HEALTH SUMMARY PARAMETERS
VA HEALTH SUMMARY TYPE
VA HEALTH SUMMARY USER PREFEREI
VA PATIENT
VA PRODUCT
VAC ACCOUNTABILITY GROUPS
VEE VEDD GLOBAL
VEN EHP AUDIT TRAIL
VEN EHP CLINIC
Fields:

Field Number	Field Name
0.01	NAME
0.02	SEX
0.03	DATE OF BIRTH
0.033	AGE
0.05	MARITAL STATUS
0.06	RACE
0.07	OCCUPATION
0.08	RELIGIOUS PREFERENCE
0.081	DUPLICATE STATUS
0.082	PATIENT MERGED TO
0.083	CHECK FOR DUPLICATE
0.09	SOCIAL SECURITY NUMBER
0.0901	TERMINAL DIGIT OF SSN
0.0905	1U4N
0.091	REMARKS
0.092	PLACE OF BIRTH [CITY]
0.093	PLACE OF BIRTH [STATE]
0.096	WHO ENTERED PATIENT

Schema File: VA PATIENT (Number 2)

FIELD NUMBER	DATA TYPE	FIELD LENGTH	COLUMN HEADER	READ ONLY	KEY FIELD	NULL ALLOWED	IEN AUTOMATICALLY INCLUDED	A
.01	TEXT	30	NAME	NO	NO	NO		
.02	TEXT	4	SEX	NO	NO	YES		
.03	DATE	21	DOB	NO	NO	YES		
.09	TEXT	30	SSN	YES	NO	YES		
.03TRIGGER1	DATE	21	IDOB	YES	NO	YES		

RPMS Server: LocalHost

Figure 5-25: BMXSchemaBuilder Utility

5.5.9 Using BMX ADO SS to Retrieve Updateable FileMan DataTables

BMXNet supplies the BMX ADO SS remote procedure call to allow developers to retrieve updateable DataTables using schemas stored in the BMX ADO SCHEMA file. *BMX ADO SS* takes up to three parameters and is invoked from *.NET* in the same fashion as other custom RPCs described in Section 5.3.4. Use syntax as demonstrated in the following example.

```
BMX ADO SS^SIEN^DAS^VSTG
```

Figure 5-26: BMX ADO SS Syntax

Note: Internally, the BMX ADO SS remote procedure invokes M routine SS^BMXADO. It is useful when developing and testing schemas to call SS^BMXADO directly from the M command line, and then inspect the resulting output array. In this case, an additional parameter, the OUT parameter, is used as the first parameter. This parameter should be passed by reference using the "dot syntax." OUT does not have to have a value when the call is made. When the call is completed, OUT will contain a text string that is a closed global reference to the location where the output array is stored.

5.5.9.1 BMX ADO SS Parameter 1: SIEN

This is the IEN (or, alternatively, an unambiguous name) of an entry in the BMX ADO SCHEMA file. The schema that is referenced here determines the scope and format (column definitions) of the resulting record set. Of the three parameters that can be passed to BMX ADO SS, this is the only one that is required to have a value. If DAS and VSTG are undefined, then the resulting record set will contain **only** the schema string and **no data**.

5.5.9.2 BMX ADO SS Parameter 2: DAS

DAS stands for "DA String." FileMan references internal entry numbers with the local variable "DA". The value of DAS is null unless the record set includes data. Even then, the DAS will be null unless (1) the record set is a continuation of a previous request and/or (2) the record set is connected to a sub-file.

If the schema is attached to a top level file (i.e., not a sub-file) the DAS will be a single integer corresponding to the FileMan internal entry number (IEN), specifically, the *DA value* of the *last record* in the previous record set in a continuation process. In this instance, the DAS is a "seed." It initiates the iteration, but the record associated with IEN is not actually included in the continuation record set.

Here is an example of a continuation request: the client asks for a list of all patients and the list is to be delivered 50 names at a time by IEN. Assume there are 185 patients with contiguous IENs. Starting with IEN=1, it will take four calls to SS^BMXADO to deliver the entire list. Since iteration starts at the beginning, the initial value of the seed (DAS) should be null. For the second call, the seed will have a value of 50 because record #50 was the last IEN accessed during the first pass. The seed of the third call will be 100. The seed of the fourth and last call will be 150. On the last call, only 35 names will be returned.

If the schema is attached to a sub-file, the DAS will be comma-delimited string of integers corresponding to the DA array. The first integer is the IEN of the top-most file; the second integer is the IEN of the first level descendant file, and so on. The last integer is the IEN of an entry in the sub-file. The last IEN will be null (or have a value of zero) unless the record set is part of a continuation process. Thus, the DAS “6,2,7” corresponds to “DA(2),DA(1),DA” where DA(2)=6, DA(1)=2, and DA=7. Do not confuse the DAS with the IENS string utilized by FileMan client server calls. The IENS string is in ascending order (child to parent) while the DAS is in descending order (parent to child).

Example of a continuation DAS (i.e., a “seed”): “7”

Example of a DAS for a sub-file: “6,2,” (Note the terminal comma)

Example of a DAS for a sub-file seed: “6,2,7”

5.5.9.3 BMX ADO SS Parameter 3: VSTG

VSTG stands for “View String.” This parameter is null unless the result set includes data (i.e. a “view”). The VSTG is a “~” (tilde) delimited string with nine pieces. *Within* some of these pieces, there may be additional delimitated data using the “ |” or “,“ characters. *The purpose of the VSTG is to drive the Iterator:* the MUMPS code that populates the rows of the result set. From a functional perspective, the *Iterator* is an IEN generator. It identifies a series of IENs for the home file (or sub-file) specified by the schema.

Note: In general, the Iterator controls the searching and sorting, and the schema controls the formatting.

In most cases, the Iterator will use an index specified in the VSTG. The VSTG may also specify where the iteration is to *start* and *stop* as well as the *maximum* number, if records are to be delivered in one chunk (as part of a continuation process). The VSTG also has a flag to determine is the values in the dataset are in internal or external format. In some cases, non-standard iteration is required or complex filters must be applied to the iteration process. To accommodate this requirement, the VSTG can reference *special entry points* and parameters to be passed to custom coded iteration subroutines. Finally, the BMX ADO SS is capable of generating *multiple record sets* in one pass, if a *relational join* connects the records. The VSTG can contain information to initiate the join(s).

The general structure of the VSTG is shown in Figure 5-27.

```
INDEX~START~STOP~MAX~FORMAT~TAG~ROUTINE~PARAM~JOIN
```

Figure 5-27: VSTG Structure

Remember, VSTG is a parameter that is passed to BMX ADO SS, so it may *not* contain the “^” character.

VSTG Piece 1: INDEX

This is the FileMan index that cycles the iterator. If null, the iterator will cycle by IEN. BMX ADO SS understands all common indices used in PCC including “B,” “AA,” “AC,” “AD,” etc.

In most cases the data type of START and STOP must correspond to the data type of the field associated with the index. For example, if we are dealing with the “B” index of the PATIENT file, the data type for START and STOP must be text. There is one important exception. If a DINUM relationship exists between the home file and another (reference) file, the data type can correspond to the data type of the *.01* field of the reference file. For example, suppose you specify the “B” index of the PATIENT FILE (9000001). The .01 field is a number, not a name – actually it is a pointer value or IEN. *However,* because the pointer value is DINUM’d to the VA PATIENT file, you *can* use text values for START and STOP. BMX ADO SS will automatically determine it should use the “B” index of the VA PATIENT file to drive the iteration, so text values are acceptable in this instance.

If the “AA” index is used, the START and STOP parameters must be dates in external format (e.g., “1/25/04”) AND the PARAM parameter must conform to the following conventions. Determine if the home file has a two level or a three level “AA” index. The VISIT file has a two level “AA” index: patient IEN, and inverse date. The V MEASUREMENT file has a three level “AA” index: patient IEN, measurement type IEN, and inverse date.

For a two level index PARAM will contain “PATIENT IEN|SORT ORDER.” SORT ORDER can have a value of “C” for chronological or “R” for reverse chronological. For example: “4591|R” means “iterate chronologically through a date range for patient # 4591.”

For a three level “AA” index, PARAM will contain “PATIENT IEN|ENTITY TYPE IEN|SORT ORDER” Example: “4591|2|R” means do reverse chronological iteration for patient #4591 and entity type #2. Entity type is typically specified by its internal entry number. An accent grave may be placed before this number (e.g., “4591|`2|R”), but this is not required. The second piece can also be a text string, as long as this string is an unambiguous lookup value in the file that stores the type. For example, 4591|**WT**|R would specify that WEIGHTS are to be returned in the record set.

VSTG Piece 2: START

This is the first lookup value to be used by the Iterator (i.e., the first value that can be used with specified index). START is not a “seed” value because it may actually be included in the iteration. The seed is contained in the DAS parameter. START is used only once, to initiate the iteration. If the developer defines MAX, subsequent fetches will use the last IEN delivered as the seed for the next iteration. The value of START must always precede the value of STOP or the VSTG will be rejected as invalid by BMX ADO SS.

VSTG Piece 3: STOP

This is the last lookup value allowed for the Iterator (the last value used in specified index). The value of STOP may be included in the data set, but no values that follow STOP will be included.

VSTG Piece 4: MAX

This is the maximum number of records returned in the result set in a single chunk. It is independent of START and STOP. If MAX is not specified, it defaults to a value of 100. In certain instances, MAX is ignored. If multiple record sets are returned in a single transaction because the VSTG specifies a join, MAX will be applied to the primary record set but not to any of the related record sets. BMX ADO SS will return as many related record sets as necessary to complete the joins for the primary file. MAX is also ignored when a custom-coded iterator is used.

VSTG Piece 5: FORMAT

If this parameter has a value of “I” (Internal), all values in the result set will be returned in internal FileMan format.

VSTG Piece 6: TAG

If a custom coded subroutine is to be used for iteration, TAG will contain the name of the entry point *line*.

VSTG Piece 7: ROUTINE

If a custom coded subroutine is to be used for iteration, ROUTINE will contain the name of the entry point *routine*.

VSTG Piece 8: PARAM

When Tag and Routine are not null, PARAM may contain a string that is passed to TAG^ROUTINE to invoke the custom iterator. Custom iterators can be used whenever there are *complex* or *unusual sorting/filtering requirements* for the data rows. For example, if TAG=”EN”, ROUTINE = “ABC”, BMX ADO SS translates this to D EN^ABC(PARAM).

PARAM can also contain information for use with the “AA” index.

VSTG Piece 8: JOIN

In the context of relational tables, a “join” means that a data value in one table can be used to unambiguously look up an entry in another table. In this way, data elements from rows in two different tables can be joined together, thus creating a “virtual record” that can be viewed and edited. For example, it may be useful to join information from a patient measurements file and a patient registration file so that clinical and demographic information can be viewed together. In FileMan, joins are accomplished via pointers and sub-files.

ADO.Net follows a **Master File – Details File** model for managing joins. The master file is a core “reference” or “foundation” file like the PATIENT file or VISIT file. A details file contains information that extends or embellishes the contents of the master file (e.g., a patient problem list file or a patient insurance coverage file). In FileMan, at least one field in the details file must point to its master file. From here on, the Master/Details terminology will be used to refer to the primary file and the secondary file that is joined to it. In the ADO environment, the flow of a join is always from master table to details table. Consequently, the BMX ADO SS is limited to “master-to-detail” joins. Other types of joins are possible, but these are not supported by BMX ADO SS because of the limitations of ADO. More information on join limitations will be presented later.

In BMX ADO SS, a join is defined by a four piece, comma-delimited string. The *first piece* is the IEN of the details schema that is associated with the details file.

The *second piece* is a specific field identifier in the *master* schema that is used to initiate the join. (The master schema has already been defined by the SIEN parameter.) The data value of this field can be used to do an unambiguous lookup in the details file. In the case of a "sub-file join," where a parent file is "joined" to its sub-file (described in detail below), the second piece will contain the text string "SUB."

The *third piece* contains the field identifier in the details schema that is used to complete the join. In the case of a sub-file join, this piece is null.

The *fourth piece* contains special iterator instructions for generating data rows. In fact, the fourth piece is a nested view string (a VSTG within a VSTG). The first two comma-delimited pieces of the join string are mandatory. The third piece is mandatory if the join is standard (i.e., not a sub-file join). The fourth piece (nested VSTG) is optional. See below for join syntax.

```
schema_ien, master_field_number, details_field_number, view_string
```

Figure 5-28: Join Syntax

```
…|4,.05,.02,
```

Figure 5-29: Example standard join

Figure 5-29 is an example of a **standard join**. In the simplest case, only the first three pieces of the join instruction string are specified. Here "4" is the IEN of the schema attached to the details file, ".05" is the field number of the master file that is used to complete the join, and ".02" is the field in the details file that completes the join. No special iterator is needed, so the fourth piece is null. Two result sets will be returned in this transaction. The first record set contains the schema and data records from the master file. The second record set contains the schema and "joined" data records from the details file.

The next example shows the join instruction string for a **sub-file join**. Schema 5 is associated with a sub-file of the master file. The third piece is null because this is a sub-file. No special iterator is used to view the sub-file, so the fourth piece is null.

```
…|5,SUB,,
```

Figure 5-30: Example sub-file join

The next example demonstrates the use of a *nested VSTG.*

```
…|6,.001,.02IEN,AA~1/1/1988~12/31/1988~~~~~|WT|R
```

Figure 5-31: Example nested VSTG

Schema 6 is associated with a details file, e.g., V MEASUREMENTS. The join is made via a link between the .001 field (IEN) of the master file (e.g., the PATIENT file) and the ".02IEN" field of the details file. The fourth piece specifies that the iterator for generating the detail data rows will use the "AA" index, and will limit the output to weights ("WT") entered in 1988. The detail data rows will sort in reverse ("R") chronological order.

It is possible to define more than one join in a VSTG (i.e., *the master file can be joined to multiple details files in the same transaction*). This is called a **compound join**. To accomplish this, the join segment is subdivided into multiple pieces by conforming to the following convention: each three-piece set of join instructions must be separated by the text string "@JOIN@". Standard joins and sub-file joins can be mixed in any order within a compound join. Figure 5-32, shows an example of a compound join string.

```
…|6,.001,.02IEN,AA~1/1/1988~12/31/1988~~~~~|WT|R@JOIN@7,.001,.02IEN,AA~1/1/1960~6/30
/2004~~~~~|C
```

Figure 5-32: Example compound join

In this case, *three* result sets will be returned in the transaction: the first for the master schema and its associated data records; the second for the details schema #6 and its associated data records; and the third for details schema #7 and its associated data records.

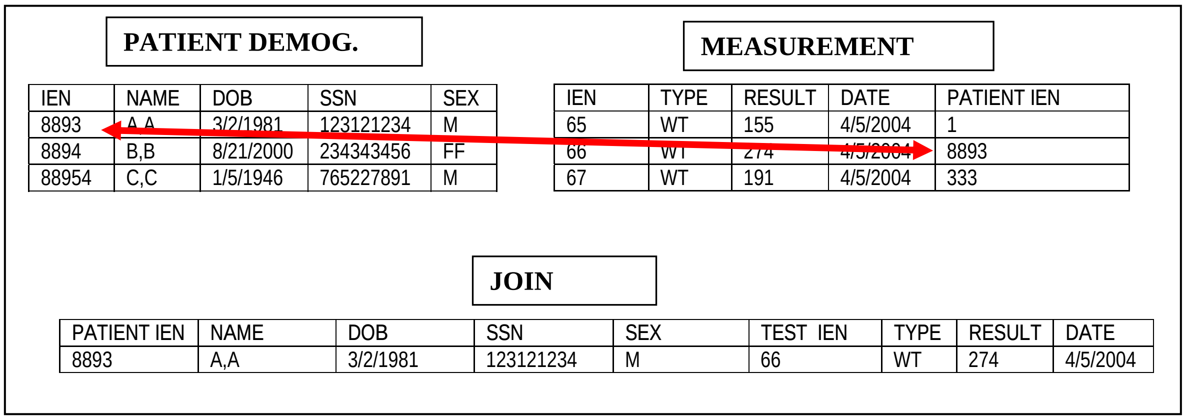
5.5.10 Detailed BMX ADO SS Examples

5.5.10.1 Standard Join

In a standard join, the value of a data element in the primary file is the IEN (.001 field) of an unambiguous IEN (primary key) in a second file. When BMX ADO SS is instructed to perform a standard join, it generates multiple record sets in a *single transaction.* The output contains the record set for the primary file as well as the record sets of any secondary files that are joined to it. The record sets of the secondary files contain only those records that are required to complete the join to the data rows the primary file.

Note: Extended joins (i.e., joins that require simultaneous traversal of *three* or more tables) are not supported in this version of BMXNet.

Suppose there are two schemas: a primary schema called PATIENTS and a secondary schema called MEASUREMENTS. The PATIENTS schema is associated with a file (table) called PATIENT DEMOGRAPHICS and the MEASUREMENTS schema is associated with a file (table) called MEASUREMENTS. Assume that there is a PATIENT IEN field in the MEASUREMENTS file. This field always contains a valid IEN of a record in the PATIENT file. The IEN is also contained in the *.001* field (the key field) of the PATIENT file. The IEN value can be used to join the two schemas/files together. See the following examples.



PATIENT DEMOG.

IEN	NAME	DOB	SSN	SEX
8893	A,A	3/2/1981	123121234	M
8894	B,B	8/21/2000	234343456	FF
88954	C,C	1/5/1946	765227891	M

MEASUREMENT

IEN	TYPE	RESULT	DATE	PATIENT IEN
65	WT	155	4/5/2004	1
66	WT	274	4/5/2004	8893
67	WT	191	4/5/2004	333

JOIN

PATIENT IEN	NAME	DOB	SSN	SEX	TEST IEN	TYPE	RESULT	DATE
8893	A,A	3/2/1981	123121234	M	66	WT	274	4/5/2004

Figure 5-33: Example of standard join

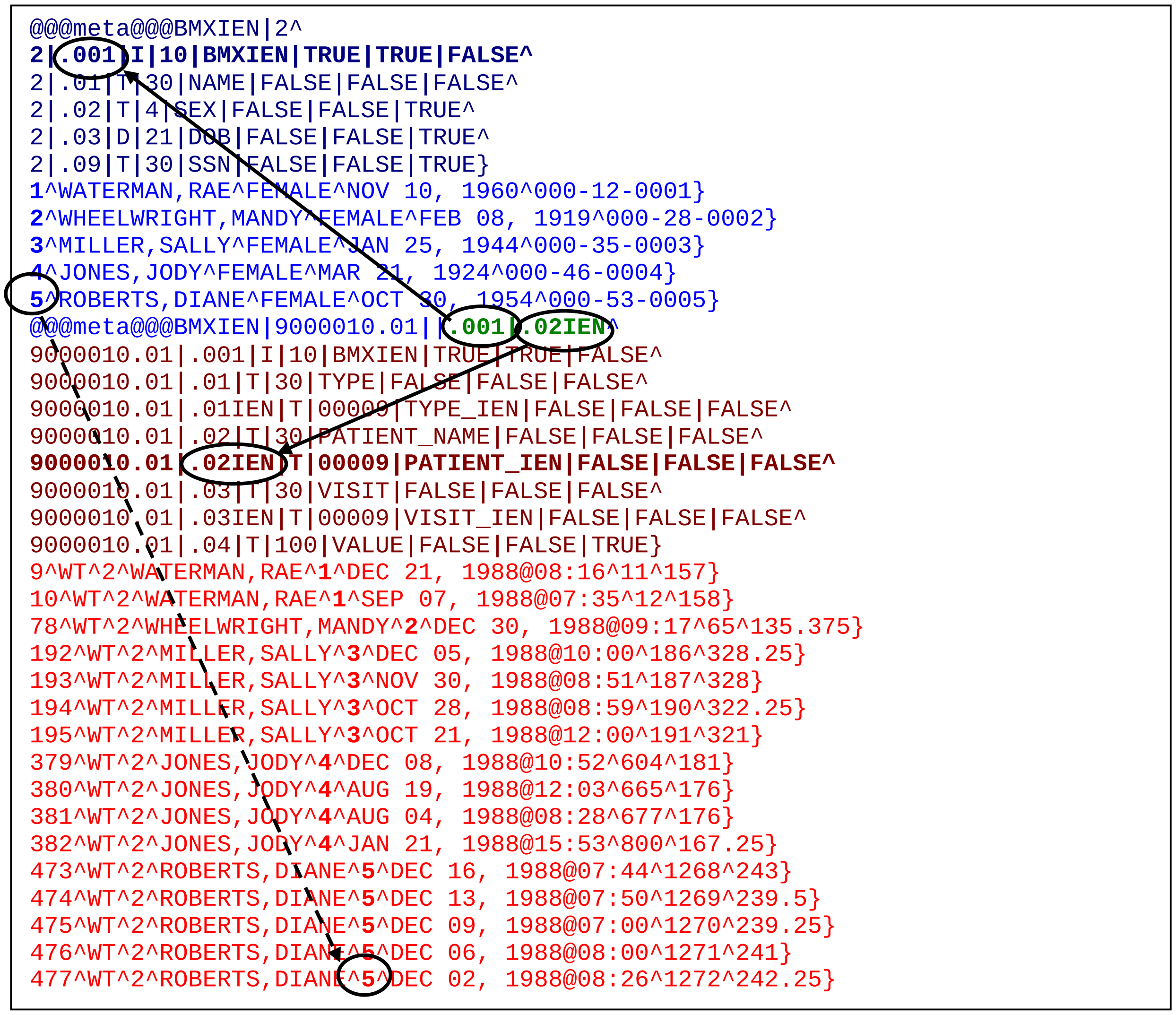
In the next example, M code produces a standard join as well as the result set.

```
S SIEN1=1 ; SIEN1 = THE IEN OF THE MASTER SCHEMA (PATIENT)
S SIEN2=2 ; SIEN2 = THE IEN OF THE DETAILS SCHEMA (MEASUREMENTS)
S VSTG="~1~5~~~~~~"_SIEN2_",.001,AA~1/1/1988~12/31/1988~~~~~|WT|R
D SS^BMXADO(.OUT,SIEN1,"",VSTG) ; GENERATE THE JOINED RECORD
Q
```

Figure 5-34: Sample of an M Code Standard Join

BMX ADO SS (called internally here from the M command line using SS^BMXADO) is instructed to join two files: PATIENT and MEASUREMENTS. The iterator for the master (PATIENT) file restricts the data to the first five IENs. The iterator for the details (MEASUREMENTS) file restricts data to weights entered during the year 1988. The details data rows are to be sorted in reverse chronological order.

The result set produced by this code is shown in the following example.



```
@@@meta@@@BMXIEN|2^
2|.001|I|10|BMXIEN|TRUE|TRUE|FALSE^
2|.01|T|30|NAME|FALSE|FALSE|FALSE^
2|.02|T|4|SEX|FALSE|FALSE|TRUE^
2|.03|D|21|DOB|FALSE|FALSE|TRUE^
2|.09|T|30|SSN|FALSE|FALSE|TRUE}
1^WATERMAN,RAE^FEMALE^NOV 10, 1960^000-12-0001}
2^WHEELWRIGHT,MANDY^FEMALE^FEB 08, 1919^000-28-0002}
3^MILLER,SALLY^FEMALE^JAN 25, 1944^000-35-0003}
4^JONES,JODY^FEMALE^MAR 21, 1924^000-46-0004}
5^ROBERTS,DIANE^FEMALE^OCT 30, 1954^000-53-0005}
@@@meta@@@BMXIEN|9000010.01||.001|.02IEN^
9000010.01|.001|I|10|BMXIEN|TRUE|TRUE|FALSE^
9000010.01|.01|T|30|TYPE|FALSE|FALSE|FALSE^
9000010.01|.01IEN|T|00009|TYPE_IEN|FALSE|FALSE|FALSE^
9000010.01|.02|T|30|PATIENT_NAME|FALSE|FALSE|FALSE^
9000010.01|.02IEN|T|00009|PATIENT_IEN|FALSE|FALSE|FALSE^
9000010.01|.03|T|30|VISIT|FALSE|FALSE|FALSE^
9000010.01|.03IEN|T|00009|VISIT_IEN|FALSE|FALSE|FALSE^
9000010.01|.04|T|100|VALUE|FALSE|FALSE|TRUE}
9^WT^2^WATERMAN,RAE^1^DEC 21, 1988@08:16^11^157}
10^WT^2^WATERMAN,RAE^1^SEP 07, 1988@07:35^12^158}
78^WT^2^WHEELWRIGHT,MANDY^2^DEC 30, 1988@09:17^65^135.375}
192^WT^2^MILLER,SALLY^3^DEC 05, 1988@10:00^186^328.25}
193^WT^2^MILLER,SALLY^3^NOV 30, 1988@08:51^187^328}
194^WT^2^MILLER,SALLY^3^OCT 28, 1988@08:59^190^322.25}
195^WT^2^MILLER,SALLY^3^OCT 21, 1988@12:00^191^321}
379^WT^2^JONES,JODY^4^DEC 08, 1988@10:52^604^181}
380^WT^2^JONES,JODY^4^AUG 19, 1988@12:03^665^176}
381^WT^2^JONES,JODY^4^AUG 04, 1988@08:28^677^176}
382^WT^2^JONES,JODY^4^JAN 21, 1988@15:53^800^167.25}
473^WT^2^ROBERTS,DIANE^5^DEC 16, 1988@07:44^1268^243}
474^WT^2^ROBERTS,DIANE^5^DEC 13, 1988@07:50^1269^239.5}
475^WT^2^ROBERTS,DIANE^5^DEC 09, 1988@07:00^1270^239.25}
476^WT^2^ROBERTS,DIANE^5^DEC 06, 1988@08:00^1271^241}
477^WT^2^ROBERTS,DIANE^5^DEC 02, 1988@08:26^1272^242.25}
```

Figure 5-35: Result set from standard join

In Figure 5-35, the schema record of the primary table (PATIENT) is in dark blue and the data records are in blue. The schema record of the secondary table (MEASUREMENTS) is in dark red and the data records are in red. The End of Record (EOR) character is represented by "}." Five PATIENT records are joined to sixteen MEASUREMENTS records. The join is based on the value of the .001 field in the PATIENT file that is linked to the .02IEN (PATIENT_IEN) field of the MEASUREMENTS file. The values (IENs) used to complete the join are in bold. One of the joins is noted by a dashed arrow. Note that the second record set contains only those records that are required to complete the join. There is a one-to-many relationship between master and details records.

The details record set contains special information to indicate that it is joined to the master record set. We know that the .001 field of the master file and the .02IEN field of the details file are responsible for the join. Consequently, in the Introductory Segment of the schema record of the details record set, ".001" is the value of the 4th piece and ".02IEN" is of the 5th piece (both pieces are shown in dark green).

5.5.10.2 Sub-file Join

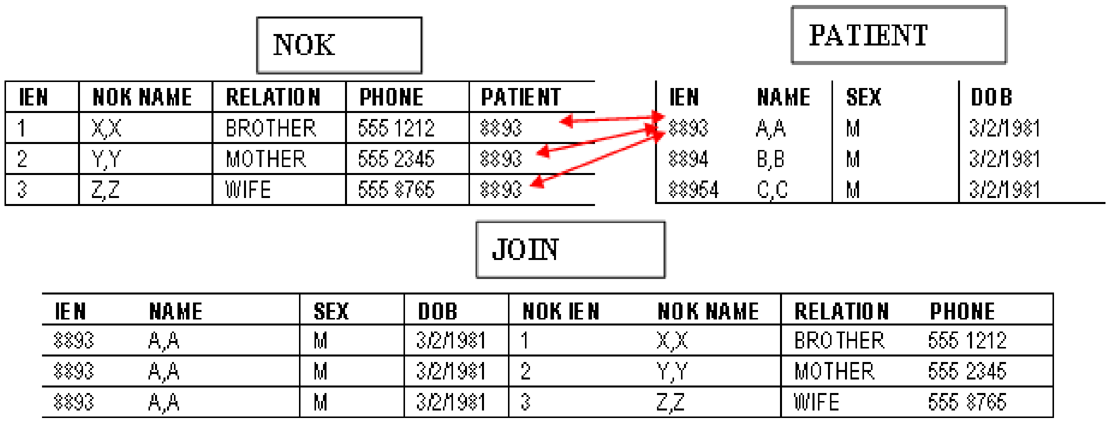
FileMan supports a hierarchical file structure through the use of sub-files (also known as "multiples"). By convention, relational tables are *never* structurally hierarchical; i.e., they never contain sub-tables or nested tables. In the relational world, hierarchical relationships are supported via joins. BMX ADO SS is capable of creating a record set that makes a sub–file and its parent *appear* to be two *joined* tables that can be shared with the rest of the (relational) world. In this way, FileMan files and sub-files become compatible with all other ADO.NET-compliant applications.

All of this is accomplished through the use of "virtual fields" in the schema. The precedent for a virtual field has already been established. In FileMan, the IEN is contained in the virtual field: *.001*. This convention is extended to sub-files such that the IEN of a sub-file will be stored in its .001 field and *the IEN of its parent file will be stored in the .0001 field.* BMX ADO SS automatically generates a .001 field for all files and a .0001 field if a sub-file is defined. The .0001 field is used to "join" the sub-file to the parent file. In the following example, consider a PATIENT file that contains a NEXT OF KIN multiple:

```
.001  IEN
.01   NAME
.02   DOB
.03   SEX
1  NEXT OF KIN (multiple)
.01   NOK NAME
.02   RELATIONSHIP TO PATIENT
.02   PHONE
```

Figure 5-36: Sample of a patient file containing next of kin multiple

BMX ADO SS translates this hierarchy into two joined files. See the following example.


NOK
PATIENT
JOIN

IEN	NOK NAME	RELATION	PHONE	PATIENT
1	X,X	BROTHER	555 1212	8893
2	Y,Y	MOTHER	555 2345	8893
3	Z,Z	WIFE	555 8765	8893

IEN	NAME	SEX	DOB
8893	A,A	M	3/2/1981
8894	B,B	M	3/2/1981
88954	C,C	M	3/2/1981

IEN	NAME	SEX	DOB	NOK IEN	NOK NAME	RELATION	PHONE
8893	A,A	M	3/2/1981	1	X,X	BROTHER	555 1212
8893	A,A	M	3/2/1981	2	Y,Y	MOTHER	555 2345
8893	A,A	M	3/2/1981	3	Z,Z	WIFE	555 8765

Figure 5-37: Graphic example translated files

The current version of BMXNet **does not** support traversal of more than one sub-file level. In other words, sub-sub-files cannot be used in a join. An analogous restriction applies to standard join, where no more than two tables can be traversed to complete the join.

The JOIN syntax for a sub-file is the usual pair except instead of a field number, the word “SUB” is in the second piece:

```
SCHEMA2,SUB; E.G., “9,SUB”.
```

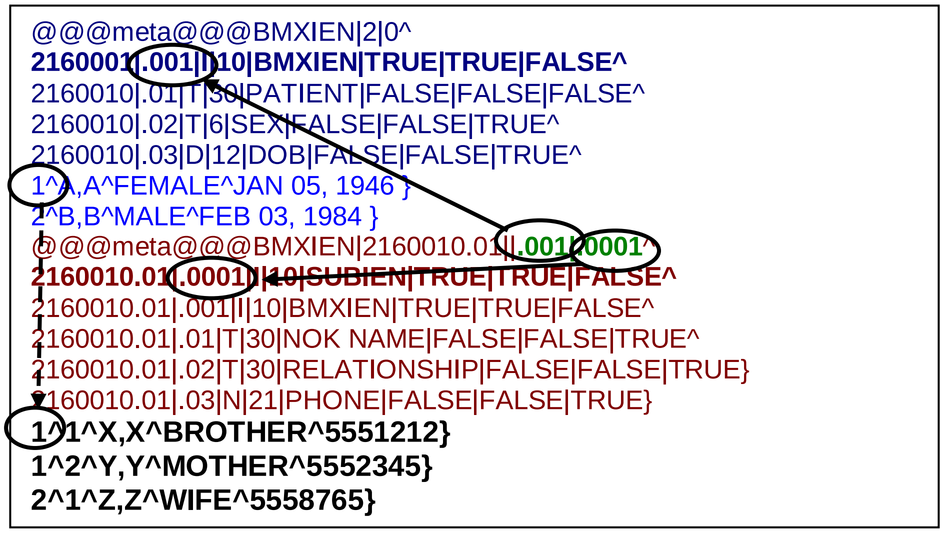
Figure 5-38: Join syntax for a sub-file

In the following example, schema #3 is attached to the master file, and schema #4 is attached to a sub-file.

```
S SIEN1=3 ; SIEN1 = THE IEN OF THE PARENT FILE’S SCHEMA (PATIENT)
S SIEN2=4 ; SIEN2 = THE IEN OF THE SUB-FILE’S SCHEMA (NOK)
S VSTG="~1~2~~~~~~"_SIEN2_”,SUB" ;VSTG RETURNS DATA FOR PTS 1 & 2
D SS^BMXADO(.OUT,SIEN1,"",VSTG) ; GENERATE THE SUB-FILE JOIN
Q
```

Figure 5-39: Sample M Code to generate a sub-file join

BMX ADO SS produces the array shown in Figure 5-40 for this kind of join. Note that it contains multiple record sets. Note that the second record set contains a .0001 field, and that the 4th piece of the Introductory Segment of the secondary schema record has a value of “.001”. The 5th piece has a value of “.0001” (both shown in dark green). This specifies that the two record sets are related by a “sub-file” join.



```
@@@meta@@@BMXIEN|2|0^
2160001|.001|I|10|BMXIEN|TRUE|TRUE|FALSE^
2160010|.01|T|30|PATIENT|FALSE|FALSE|FALSE^
2160010|.02|T|6|SEX|FALSE|FALSE|TRUE^
2160010|.03|D|12|DOB|FALSE|FALSE|TRUE^
1^A,A^FEMALE^JAN 05, 1946 }
2^B,B^MALE^FEB 03, 1984 }
@@@meta@@@BMXIEN|2160010.01|.001|.0001^
2160010.01|.0001|I|10|SUBIEN|TRUE|TRUE|FALSE^
2160010.01|.001|I|10|BMXIEN|TRUE|TRUE|FALSE^
2160010.01|.01|T|30|NOK NAME|FALSE|FALSE|TRUE^
2160010.01|.02|T|30|RELATIONSHIP|FALSE|FALSE|TRUE}
2160010.01|.03|N|21|PHONE|FALSE|FALSE|TRUE}
1^1^X,X^BROTHER^5551212}
1^2^Y,Y^MOTHER^5552345}
2^1^Z,Z^WIFE^5558765}
```

Figure 5-40: Graphic example of array produced for join

5.5.10.3 Compound Joins

The next example shows record sets resulting from a compound join. Here the master file, PATIENT, is joined to two details files, V MEASUREMENT and V MED. The result, displayed in Figure 5-42 is a set of three record sets generated in one transaction. Note that all the data rows of the two details record sets are linked to the five IENs in the data rows in the master record set. Also note the join information located in the 4th and 5th pieces of the Introductory Segments of each details schema record (dark green).

```
S SIEN1=1 ; SIEN1 = THE IEN OF THE MASTER SCHEMA (PATIENT)
S SIEN2=2 ; SIEN2 = THE IEN OF THE DETAILS 1ST DETAILS SCHEMA (MEDS)
S SIEN2=3 ; SIEN3 = THE IEN OF THE 2ND DETAILS SCHEMA (MEASUREMENTS)
S VSTG="~1~5~~~~~~" ; MASTER RECORD SET
S VSTG=VSTG_SIEN2_",.001,.02IEN,AA~1/1/1988~12/31/1988~~~~~|WT|R" ; 1ST DETAILS
RECORD SET
S VSTG=VSTG_SIEN3_",.001,.02IEN,AA~1/1/1960~12/31/2003~~~~~|R" ; 2ND DETAILS RECORD
SET
D SS^BMXADO(.OUT,SIEN1,"",VSTG) ; GENERATE THE RECORDS FOR THE JOIN
Q
```

Figure 5-41: Sample M Code to generate a compound join

```
@@@meta@@@BMXIEN|2|^
2|.001|I|10|BMXIEN|TRUE|TRUE|FALSE^
2|.01|T|30|NAME|FALSE|FALSE|FALSE^
2|.02|T|4|SEX|FALSE|FALSE|TRUE^
2|.03|D|21|DOB|FALSE|FALSE|TRUE^
2|.09|T|30|SSN|FALSE|FALSE|TRUE}
1^WATERMAN,RAE^FEMALE^NOV 10, 1960^000-12-0001}
2^WHEELWRIGHT,MANDY^FEMALE^FEB 08, 1919^000-28-0002}
3^MILLER,SALLY^FEMALE^JAN 25, 1944^000-35-0003}
4^JONES,JODY^FEMALE^MAR 21, 1924^000-46-0004}
5^ROBERTS,DIANE^FEMALE^OCT 30, 1954^000-53-0005}
@@@meta@@@BMXIEN|9000010.14||.001|.02IEN^
9000010.14|.001|I|10|BMXIEN|TRUE|TRUE|FALSE^
9000010.14|.01|T|30|MEDICATION|FALSE|FALSE|FALSE^
9000010.14|.01IEN|T|00009|MEDICATION_IEN|FALSE|FALSE|FALSE^
9000010.14|.02|T|30|PATIENT NAME|FALSE|FALSE|FALSE^
9000010.14|.02IEN|T|00009|PATIENT_IEN|FALSE|FALSE|FALSE^
9000010.14|.03|T|30|VISIT|FALSE|FALSE|FALSE^
9000010.14|.03IEN|T|00009|VISIT_IEN|FALSE|FALSE|FALSE^
9000010.14|.05|T|32|SIG|FALSE|FALSE|TRUE^
9000010.14|.06|I|7|QUANTITY|FALSE|FALSE|TRUE}
61^IBUPROFEN 400MG TAB^305^WATERMAN,RAE^1^FEB 14, 2002@11:54^71015^T1T QID^40}
67^IBUPROFEN 400MG TAB 40S^84120^WATERMAN,RAE^1^OCT 30, 2002@17:00^71043^TIT TID^90}
21^IBUPROFEN 400MG TAB^305^WHEELWRIGHT,MANDY^2^JAN 11, 1990@12:00^70165^T1T QID^40}
22^CHLORPROPAMIDE 250MG TAB^954^MILLER,SALLY^3^JAN 01, 1990@12:00^70195^T1T BID^60}
23^DIGOXIN 0.25MG TAB ^172^MILLER,SALLY^3^JAN 01, 1990@12:00^70195^T1T DY FH^30}
24^FUROSEMIDE 40MG TAB^654^MILLER,SALLY^3^JAN 01, 1990@12:00^70195^T1T QD^30}
58^DIGOXIN 0.25MG TAB ^172^JONES,JODY^4^AUG 09, 1990@12:00^70247^T1T DY FH^30}
59^IBUPROFEN 400MG TAB^305^JONES,JODY^4^AUG 09, 1990@12:00^70247^T1T QID^40}
60^IBUPROFEN 400MG TAB^305^JONES,JODY^4^AUG 25, 1990@12:00^70249^T1T QID^40}
52^CHLORPROPAMIDE 250MG TAB^954^ROBERTS,DIANE^5^NOV 01, 1989@08:42^1249^T1T BID^60}
25^IBUPROFEN 400MG TAB^305^ROBERTS,DIANE^5^JAN 05, 1990@12:00^70196^T1T QID^120}
26^CHLORPROPAMIDE 250MG TAB^954^ROBERTS,DIANE^5^JAN 05, 1990@12:00^70196^T2T
BID^120}
@@@meta@@@BMXIEN|9000010.01||.001|.02IEN^
9000010.01|.001|I|10|BMXIEN|TRUE|TRUE|FALSE^
9000010.01|.01|T|30|TYPE|FALSE|FALSE|FALSE^
9000010.01|.01IEN|T|00009|TYPE_IEN|FALSE|FALSE|FALSE^
9000010.01|.02|T|30|PATIENT NAME|FALSE|FALSE|FALSE^
9000010.01|.02IEN|T|00009|PATIENT_IEN|FALSE|FALSE|FALSE^
9000010.01|.03|T|30|VISIT|FALSE|FALSE|FALSE^
9000010.01|.03IEN|T|00009|VISIT_IEN|FALSE|FALSE|FALSE^
9000010.01|.04|T|100|VALUE|FALSE|FALSE|TRUE}
9^WT^2^WATERMAN,RAE^1^DEC 21, 1988@08:16^11^157}
10^WT^2^WATERMAN,RAE^1^SEP 07, 1988@07:35^12^158}
85^WT^2^WHEELWRIGHT,MANDY^2^MAR 18, 1988@09:15^78^137.5}
86^WT^2^WHEELWRIGHT,MANDY^2^MAR 08, 1988@14:06^80^135.125}
87^WT^2^WHEELWRIGHT,MANDY^2^FEB 12, 1988@10:36^83^142}
88^WT^2^WHEELWRIGHT,MANDY^2^JAN 22, 1988@09:08^85^139}
192^WT^2^MILLER,SALLY^3^DEC 05, 1988@10:00^186^328.25}
193^WT^2^MILLER,SALLY^3^NOV 30, 1988@08:51^187^328
379^WT^2^JONES,JODY^4^DEC 08, 1988@10:52^604^181}
380^WT^2^JONES,JODY^4^AUG 19, 1988@12:03^665^176}
381^WT^2^JONES,JODY^4^AUG 04, 1988@08:28^677^176}
382^WT^2^JONES,JODY^4^JAN 21, 1988@15:53^800^167.25}
473^WT^2^ROBERTS,DIANE^5^DEC 16, 1988@07:44^1268^243}
474^WT^2^ROBERTS,DIANE^5^DEC 13, 1988@07:50^1269^239.5}
475^WT^2^ROBERTS,DIANE^5^DEC 09, 1988@07:00^1270^239.25}
476^WT^2^ROBERTS,DIANE^5^DEC 06, 1988@08:00^1271^241}
```

Figure 5-42: Graphic example of result sets from a compound join

5.5.10.4 Nested View Strings

A nested view string is almost identical to an ordinary (top level) view string. However, the following differences apply to the nested VSTG.

1. The MAX parameter is ignored. The resulting set will contain as many data rows as necessary to complete the joins. However, the MAX parameter of the master VSTG *is* utilized by BMX ADO SS.
2. If the START and STOP parameters of the nested VSTG contain lookup IENs, the values will be ignored. The lookup IENs of details files are determined by the IENs of the master file. In fact BMX ADO SS will automatically manipulate the START and STOP values as record generation progresses. If the user supplies START and STOP IENS, they will be ignored and overwritten by BMX ADO SS. Note that in most cases when the AA index is used, START and STOP do not contain IEN values, so they *can* be used to control iteration under these circumstances. For example, if the details file is V MEASUREMENTS, START and STOP will contain dates that limit the values returned by the iterator. The START and STOP values of the master VSTG are *not* ignored by BMX ADO SS.
3. If (1) the master file is A PATIENT file and (2) if the AA index is used by the details file iterator, then the first piece of the PARAM parameter of the nested VSTG should be null. This piece normally contains the patient IEN. However, in a join, the value is automatically supplied by BMX ADO SS based on the contents of the master data rows. If the user supplies a value, it will be overwritten.

5.5.10.5 Sample VSTG Strings

Assume schema 10 is connected to the PATIENT file. Using IENs, iterate through IEN 10000. Start with the first entry in the list:

```
BMX ADO SS^10^0^~0~~100000
```

Figure 5-43: Sample of string

Assume schema 3 is connected to the VISIT file. Using the “AC” index, return all visits for patient IEN = 1. Return 5 records at a time:

```
BMX ADO SS^3^0^AC~1~1~5
```

Figure 5-44: Sample of string

Assume schema 3 is connected to the VISIT file. Using the “AC” index, return all visits for patient IEN = 1. Return five records at a time. Seed the iteration with DA = 2944:

```
BMX ADO SS^3^2994^AC~1~1~5
```

Figure 5-45: Sample of string

Assume schema 4 is connected to the VA PATIENT file. Using the “B” index, return all patients whose last name begins with “N”. Return 10 records at a time:

```
BMX ADO SS^4^0^B~N~NZZZ~10
```

Figure 5-46: Sample of string

Assume schema 8 is connected to the V MEASUREMENT file. Return all WEIGHTS for patient 1 in the date range 5/1/82 to 5/7/2000. Iterate in reverse chronological order:

```
BMX ADO SS^8^0^AA~5/1/1982~5/7/2000~10~~~~1|WT|R
```

Figure 5-47: Sample of string

Assume schema 3 is connected to the VISIT FILE. Assume schema 4 is connected to the VA PATIENT file. Join these files using the .05 field (PATIENT) of the visit file and the .001 field of the VA PATIENT file. Return all visits in the date range 1/3/85 to 1/4/85. Return no more than five master records (i.e., visits). Start with the first record in the date range:

```
BMX ADO SS^3^0^B~1/3/1985~1/4/1985~5~~~~~4,.05,.001
```

Figure 5-48: Sample of string

Assume schema 1 is connected to the TEST file. Assume schema 9 is connected to a sub-file in TEST. The IENs of the TEST file will drive the iteration. Start with the first records. Return an ANR for the file entries and related sub-file entries as shown in the following example.

```
BMX ADO SS^1^0^~~~~~~~~9,SUB
```

Figure 5-49: Sample of string

5.5.10.6 Sample Custom Iterator Code

If a custom iterator is used, the START, STOP and MAX parameters may be ignored. All iteration can be controlled by the value of PARAM. All custom iterators are extrinsic functions that return the null value (“”) or the last DA accessed (the “seed” of the next iteration group – if continuation is enabled). Consider the following example:

```
BMX ADO SS^3^0^~~~~~DAIT~BMXADOV~1|2|3~
```

Figure 5-50: Sample of iterator code screen

The PARAM “1|2|3” is passed to the extrinsic function $$DAIT^BMXADOV. This custom iterator loops through the IENs in the PARAM string (delimited by the “|”) to generate the record set.

```
DAIT(PARAM,IENS,MAX,OUT,TOT) ; EP - SET OF IENS ITERATION.
   ; THE PARAM CONTAINS A "|" SET OF DAS STRINGS
   ; ALL VALUES ARE RETURNED. MAX IS NOT CHECKED.
; START AND STOP ARE IRRELEVANT
; NOT TO BE USED WITH SUBFILES
   N PCE,DA,XIT,IENS,L,DAS
   S L=$L(PARAM,”|”)
   F PCE=1:1:L S DA=$P(PARAM,B,PCE) Q:’DA D DATA^BMXADOV1(IENS,DA)
   Q ""
   ;
```

Figure 5-51: Sample of iterator code screen

This extrinsic function demonstrates the characteristics that should be included in all custom iterators (shown in **bold** text). There must be five parameters in the entry point: PARAM, IENS, MAX, OUT, and TOT. PARAM comes from VSTG. Even though they do not seem to be used by the extrinsic function, do **not** change the value for NEW or the variables IENS, MAX, OUT or TOT. The entry point **DATA^BMXADOV1** must be called with the IENS and DA parameters. DATA^BMXADOV1 *generates the record set data rows* and *places them in the OUT array*. Assume that the schema IEN and other required variables are defined and available to DATA^BMXADOV1.

Here is another example:

```
BMX ADO SS^3^0~~~~~DUPV~BMXADOV~1|4/19/04@1PM|I|4585|A~
```

Figure 5-52: Sample of iterator code screen

Given a date and other visit attributes, this extrinsic function returns possible duplicate visits in the record set. The required components of the function are shown in bold. For example, **PARAM,IENS,MAX,OUT,TOT** and **DATA^BMXADOV1(IENS,DA)**
The iterator (sort) code is shown in blue. For example, F S IDT=$O(^AUPNVSIT("AA",DFN,IDT)) Q:$E(IDT,1,7)'=DAY S VIEN=999999999999 F S VIEN=$O(^AUPNVSIT("AA",DFN,IDT,VIEN),-1) Q:'VIEN D
The filter (search) code is shown in light blue. For example**.** I $P(X,U,11) Q ; MUST BE AN 'ACTIVE' VISIT - NOT 'DELETED'
. I $L(TYPE),TYPE'=$P(X,U,3) Q
. I $L(LOC),LOC'=$P(X,U,6) Q
. I $L(CAT),CAT'=$P(X,U,7) Q.

```
DUPV(PARAM,IENS,MAX,OUT,TOT) ; EP - DUPLICATE VISIT ITERATION
   ; PARAM: 'DFN|VISIT TIMESTAMP|TYPE|LOCATION|CATEGORY
   ; PATIENT DFN AND VISIT TIMESTAMP (EXTERNAL DATE FORMAT) MUST EXIST.
   ; THE OTHER 3 DUP PARAMETERS WILL BE CHECKED ONLY IF THEY ARE DEFINED.
   ; ALL DUPS ARE RETURNED. MAX,START,STOP ARE IGNORED
   N DFN,TIME,TYPE,LOC,CAT,IDT,VIEN,DAY,X,PATIENT,Y,%DT,FMTIME,DA,IENS
   S DFN=+PARAM,TIME=$P(PARAM,"|",2),TYPE=$P(PARAM,"|",3),

S LOC=$P(PARAM,"|",4),CAT=$P(PARAM,"|",5)
   I $D(^DPT(+$G(DFN),0)),$L($G(TIME))
   E Q ""
   S X=TIME,%DT="T" D ^%DT I Y=-1 Q
   S FMTIME=Y
   S (IDT,DAY)=9999999-(FMTIME\1),IDT=IDT-.0000001
   F S IDT=$O(^AUPNVSIT("AA",DFN,IDT)) Q:$E(IDT,1,7)'=DAY S VIEN=999999999999 F S
VIEN=$O(^AUPNVSIT("AA",DFN,IDT,VIEN),-1) Q:'VIEN D
   . S X=$G(^AUPNVSIT(VIEN,0)) I '$L(X) Q ; VISIT DATA MUST EXIT
   . I $P(X,U,11) Q ; MUST BE AN 'ACTIVE' VISIT - NOT 'DELETED'
   . I $L(TYPE),TYPE'=$P(X,U,3) Q
   . I $L(LOC),LOC'=$P(X,U,6) Q
   . I $L(CAT),CAT'=$P(X,U,7) Q
   . S DA=VIEN,IENS=DA_","
   . D DATA^BMXADOV1(IENS,DA)
   . Q
   Q ""
```

Figure 5-53: Sample of possible duplicate visits

Note that the purpose of custom iterator code is simply to generate DAs. It is the *schema* that actually determines how the data is to be formatted in the record set.

5.5.10.7 Managing Chunks

The VSTG parameter MAX determines the maximum number of records that will be passed back in a given BMX ADO SS transaction. If more than MAX records exist, BMX ADO SS will return records in MAX sized "*chunks*." The secret of managing chunks is to understand the "*SEED*" parameter. The SEED is the IEN of the last record in the DataTable. The SEED will only have a non-zero value if there are **more** records to display. Retrieve the seed from DataTable.ExtendedProperties["fmSeed"]. If there is a positive integer in that piece, that value can be used to start the next round of iteration. The following C# sample code demonstrates the how the SEED is used to return data in chunks.

```
CHUNK ; ITERATE IN CHUNKS
   ; RE-ITERATE USING THE "B" INDEX
   ; START WITH PT IEN 5 AS THE "SEED", STOP AFTER PATIENT NAME = "D", MAX # RECORDS
RETURNED = 5 PER CHUNK
   N %,SIEN,SEED,INTRO
   S SEED=0
   S SIEN=$$SCHEMA("PATIENT")
   F D I '$G(SEED) Q
   . D SS^BMXADO(.OUT,SIEN,SEED,"B~C~D~5")
   . D DISP(OUT) R %:$G(DTIME,60) E S SEED="" Q
   . I %?1"^" S SEED="" Q
   . S INTRO=$P(@OUT@(1),U,1)
   . S SEED=$P(INTRO,"|",3)
   . K ^TMP("BMX ADO",$J)
. Q
Q
```

Figure 5-54: Sample of screen used in managing chunks

5.5.11 Updating FileMan DataTables from .NET Applications

RemoteSession.SaveChanges(DataTable aDataTable) performs the update logic and returns true if any changes were saved, otherwise answers false.

5.5.11.1 Testing the BMXNet Updating Process in M

When designing an application, developers may wish to test the BMXNet filing process from within the Cache environment. This is accomplished via the entry point BAFM^BMXADOF1.

```
D BAFM^BMXADOF1(.OUT,CREF)
```

Figure 5-55: Sample of entry point

There is only one input variable: CREF. This is the closed reference that specifies the global array containing the record set. The record set array is stored under ^TMP("BMX ADO",$J,… , so CREF = "^TMP(""BMX ADO"",$J)". Once the call is made, BAFM gathers all the required information from the ANR, reformats it, and passes the update string to FILE^BMXADOF. BAFM can update multiple records in one "pass." All the data rows in the record set will be filed, assuming that the data rows can pass the internal verification processes of the both the Filer and FileMan. Acknowledgement and error messages from the update will be returned in the OUT array. Once BAFM is called, no user intervention is required.

The following code demonstrates the use of BAFM. To run this code on your system, change the values of the patient DFN ("1") and visit IEN ("71164"), both are displayed in bold text, to values that are valid in your test system. This code is distributed with BMXNet and can be found in ADD^BMXADOX1.

```
ADD   ; ADD A NEW ENTRY
   ; THIS IS A 2 STEP PROCESS:
   ; FIRST GET THE SCHEMA FOR THE FILE YOU WISH TO UPDATE
   ;  THIS SCHEMA TYPICALLY BEGINS WITH THE WORD "UPDATE"
   ;  IT CONTAINS NO ID IR IEN FIELDS
   ; SECOND ADD THE DATA NODE TO THE ARRAY
   ;  THE DATA NODE HAS EXACTLY THE SAME FORMAT AS A DATA STRING IN THE ANR
   ;  THE FIRST PIECE OF THE DATA STRING CONTAINS THE IEN OF THE RECORD.
;  SINCE THE RECORD HAS NOT BEEN ADDED YET, THE FIRST PIECE IS NULL.
   ;  IN THE DATA STRING, ALL POINTER VALUES ARE PRECEDED BY THE "`" CHARACTER
   ;  EACH DATA STRING IS ALWAYS TERMINATED WITH $C(30)
   ;  MULTIPLE DATA STRINGS CAN BE APPENDED AS NEW NODES AT THE BOTTOM OF THE ARRAY
   ;  IN THIS CASE WE ARE ADDING A RECORD TO THE V MEASUREMENT FILE
   ;  DATA STRING="^MEASUREMENT TYPE IEN^PATIENT DFN^VISIT IEN^RESULT"_$C(30)
   ; THERE ARE 2 INPUT PARAMS:
   ;  THE CLOSED REF WHERE THE INPUT ARRAY IS STORED
   ;  SINCE IT IS PASSED BY REFERENCE, The "OUT" PARAMETER CAN BE NULL OR UNDEFIEND.
   ;  OUT WILL BE DEFINED AT THE CONCLUSION OF THE TRANSACTION.
   ; ACKNOWLEDGEMENT AND ERROR MESSAGES ARE RETURNED IN THE OUT ARRAY
   ; OUT(1)="OK|ien" WHERE ien IS THE IEN OF THE RECORD THAT HAS BEE ADDED.
   ; IF THE TRANSACTION FAILED, AN ERROR MSG WILL BE IN THE OUT ARRAY
   ;
   N OUT,%,SIEN,NODE
   S SIEN=$$SCHEMA("UPDATE MEASUREMENTS") ; GET THE SCHEMA IEN FROM "BMX ADO SCHEMA"
FILE
   D SS^BMXADO(.OUT,SIEN,"","") ; PUT ANR IN AN ARRAY
   S NODE=$O(^TMP("BMX ADO",$J,999999),-1)+1 ; GET NEXT AVAILABLE NODE IN THE ANR
ARRAY
   S ^TMP("BMX ADO",$J,NODE)="^`2^`1^`71164^175.75"_$C(30) ; APPEND A DATA STRING TO
ANR ARRAY
   D DISP(OUT) R % ; DISPLAY THE INPUT ARRAY BEFORE UPDATING THE RECORD
   D BAFM^BMXADOF1(.OUT,$NA(^TMP("BMX ADO",$J))) ; EP FOR UPDAING THE RECORD
   K ^TMP("BMX ADO",$J) ; CLEAN UP
   W !!,OUT S %=0 F S %=$O(OUT(%)) Q:'% W !,OUT(%) ; RETURN ACKNOWLEDGEMENT/ERROR MSG
   Q
   ;
DISP(OUT); DISPLAY THE ANR ARRAY
   N I,X
   S I=0 W !
   F S I=$O(@OUT@(I)) Q:'I S X=@OUT@(I) S X=$TR(X,$C(30),"}") S X=$TR(X,$C(31),"{") W
!,X
   Q
   ;
```

```
SCHEMA(NAME) ; GIVEN SCHEMA NAME, RETURN THE SCHEMA IEN FROM THE BMX ADO SCHEMA FILE
   N IEN
   S IEN=$O(^BMXADO("B",NAME,0))
   Q IEN
   ;
```

Figure 5-56: Sample of BAFM

6.0 Raising and Responding to RPMS Events Using BMXNet

6.1 .NET RemoteEventService Overview

The event mechanism of BMXNet allows WinForm and EHR/VueCentric components to raise and respond to events, which occur in RPMS whicn use the BMXNet event notification mechanism. For example, a developer may want his application to be notified when a patient checks in for an appointment or when a lab result is available. Using the RemoteEventService, subscribers can receive real-time notification of these occurrences.

Refer to the BMXNET.chm on-line documentation for API documentation and examples.

6.1.1 RPMS Event Service Mechanism

From with RPMS, a BMXNet event may be raised by calling the following published entry point in the BMXNet package:

```
D EVENT^BMXMEVN(BMXEVENT,BMXPARAM,BMXORIG,BMXKEY)
```

Figure 6-1: Sample of calling the entry point

BMXORIG represents the event originator's session ($J). The event will not be raised back to the originator if BMXORIG is the session of the originator. BMXKEY is a ~-delimited list of security keys. Only holders of one of these keys will receive event notification. If BMXKEY is "" then all subscribed sessions will be notified.

6.2 Asynchronous Retrieval of RPMS Data

DataTable retrieval operations that are long running should use asynchronous calls. Each call on the .NET-side immediately returns, a job is started on RPMS to service the request, the .NET-side continuously polls RPMS for the result, and eventually the RPMS job posts the request result on the Async Response Queue and the .NET-side brings the DataTable over and triggers an event that the DataTable is available.

6.2.1 .NET RemoteSession Support for Asynchronous Data Retrieval

The BMXNet RemoteSession interface contains Async-prefixed methods that mirror the synchronous DataTable methods but instead of returning a DataTable the Async methods return DataTableFuture objects. The lifecycle of each asynchronous call is managed through the DataTableFuture objects.

```
DataTableFuture AsyncTableFromCommand(…)
DataTableFuture AsyncTableFromSQL(…)
DataTableFuture AsyncTableFromRPC(…)
```

When the Async methods are called, they immediately return an instance of DataTableFuture. Developers use the DataTableFuture objects, events, and methods to track and respond to the lifecycle of the asynchrounous request when the data is eventually retrieved from RPMS.

See the BMXNET.chm on-line documentation for API documentation and examples

6.2.2 BMX Logging

Logging has been rewritten in BMXNET40 to support basic EHR/VueCentric trace functionality. Because patient sensitive information may be written, developers should be careful to remove both the access to the logging events and to remove the text file.

See the BMXNET.chm on-line documentation for API documentation and examples.

7.0 LocalSession: Context Model and Local Events

New to BMNET is the Patient and Visit Context Model. The context model has been included to support EHR/VueCentric components and BMXNET-based applications that require patient and visit context. Local application events are also implemented to support components within the EHR/VueCentric framework and those executing within the scope of a single WinFramework.

See the BMXNET.chm on-line documentation for API documentation and examples.

7.1 User and Division

7.1.1 Common User and Division Interfaces

All BMXNET broker connections have an authenticated User and every User must access RPMS within the scope of a Division

7.1.2 User and Division in BMXWIN Framework

When using BMXWIN, a User is created when the LoginProcess successfully authenticates a user. If a default Division has been set for the user or there is only one Division available to the user, that Division will be set for the user. Otherwise, the BMXWIN framework provides both a programmatic and GUI dialog to set the user's division.

7.1.3 User and Division in BMXEHR Framework

The User and User's Division is always set when using the BMXEHR and the Division cannot be charged via the BMXEHR framework. Essentially, the EHR/VueCentric framework controls the User and Division.

7.2 Patient, Visit, and Context

7.2.1 Common Patient, Visit, and Context Interfaces

The Context object provides the ability to check the current Patient and Visit context, plus has events that notify subscribers when the patient and/or visit has changed. In most applications, the patient and/or visit is changed in a GUI.

If a solution is based on the common Patient/Visit/Context model then it is possible to deploy them both in the EHR/VueCentric and in a stand-alone WinForm application.

7.2.2 Patient, Visit, and Context in BMXWIN Framework

The key aspect of the BMXWIN framework is not the behavior of the Patient/Visit/Context model because that behavior is common across both BMXWIN and BMXEHR. The unique aspect of the BMXWIN framework is the WinFramework object, which enables the WinForm application to drive and change the context by updating the current patient and visit.

An artifact of how the EHR/VueCentric works is that before using a Visit object, check if the visit is a stub and send Create() if it is. In BMXWIN, the Visit will never be a stub, but if the solution intends to be deployed using both BMXWIN and BMXEHR it is good to have the same code path even if the BMXWIN is a no-op.

7.2.3 Patient, Visit, and Context in BMXEHR Framework

The EHR/VueCentric framework drives the Patient/Visit/Context model however; a visit can be temporarily created only on the client, which the BMXNET Visit model refers to this as a stub. Even though the context may have a visit, the developer must make sure that if it is a stub, before updating RPMS that the visit is created by sending Create(..) to the visit.

7.2.4 Context Events

Most applications are triggered by the current state of the Context and by when the context changes. There is a pre-context change ContextChanging event and a post-context change ContextChanged event. The ContextChanging event is a .NET CancelableEvent and allows any subscribers to veto the change and prevent ContextChanging from being called.

Note: Even though subscribers can veto a context change, the driver of the context change can force the change. This in turn, requires all subscribers to expect a context change even if the change was vetoed.

7.2.5 Context Events in BMXWIN Framework

The BMXWIN WinFramework object has the ability to change the patient and/or visit. WinFramework also provides methods to enable a GUI dialog to search for a patient and to pick a visit.

7.2.6 Context Events in BMXEHR Framework

The EHR/VueCentric Framework drives the ContextChanging and ContextChanged events, and no facility provides for the BMXEHR application to change the context. The BMXEHR application can only respond to the context.

7.3 Intra-Application Communications with LocalEventService

The LocalSession.EventServices implements an event model between components within a single EHR/VueCentric template or implemented in a WinForm solution that is using a single WinFramework object. The service provides a generic publish/subscribe model, like RemoteEventService, and for convenience a RefreshRequestEvent, which encapsulates the “REFRESH” event.

LocalSessionService events are instant and synchronous, do not provide for event Vetoing, and should be processed quickly.

See the BMXNET.chm on-line documentation for API documentation and examples.

8.0 EHR/VueCentric Integration

Developers use the BMXNET.dll framework to develop controls and easily host them within the EHR/VueCentric framework. The basic steps are:

1. Create an application/component as a UserControl that is both a RemoteSessionConsumer and a LocalSessionConsumer.
2. Create a wrapper UserControl, MyControlWrapper, COM-enable it in the Visual Studio Project Settings, set a Guid attribute on the Class, fill the UserControl with your application/component UserControl, and name it hostedControl. Add the following AttachToEhr(…), and call your wrapper UserControl.

```
[ComVisible(true)]
 [Guid("845A916C-3E3A-4BD1-9133-EEE99BEB9238")]
 public partial class MyControlWrapper : UserControl
 {
  public MyControlWrapper ()
  {
   InitializeComponent();
   this.AttachToEhr(this.hostedControl);
  }
```

Figure 8-1: Sample .NET COM Class Definition

3. Copy the partial class UserInfoComponent.EHR.cs file from the CrossComponent.EHR example, rename to the same as your user control wrapper, e.g. MyControlWrapper. The partial class implements the AttachToEhr(…) method.
4. Deploy the MyControlWrapper into EHR/VueCentric by following the EHR/VueCentric instructions for installing new components. Make sure that all supporting DLL’s (BMXNET.DLL, BMXEHR.DLL, MyControl.DLL) are referenced in the EHR/VueCentric registration and that they are deployed to the EHR/VueCentric server lib directory

Note: In some deployments, the BMXNET.DLL and BMXEHR.DLL may be pre-deployed into the bin directory so applications need not register them.

See the BMXNET.chm on-line documentation for API documentation and examples and pay close attention to how components can be written independent of deployment. Also, when reviewing the documentation note that some of the interfaces have restricted behavior based on whether it is running in the EHR/VueCentric framework or in a WinForm application. For example, RemoteSessionPool is not currently supported in the EHR/VueCentric framework. You may use the RemoteSessionPool interface, but it will continuously state there are zero sessions available.

Appendix A: References and Sources

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C# and the .NET Platform, Andrew Troelsen, Berkeley, CA: Appress, 2001.

Essential ADO.NET, Bob Beauchemin, Boston: Addison-Wesley, 2002.

Professional C#, 2nd ed., Simon Robinson, et. Al, Birmingham, UK: Wrox Press Ltd., 2002.

Windows Forms Programming in C#, Chris Sells, Boston: Addison-Wesley, 2004.

Appendix B: RPMS Rules of Behavior

The Resource and Patient Management (RPMS) system is a United States Department of Health and Human Services (HHS), Indian Health Service (IHS) information system that is ***FOR OFFICIAL USE ONLY***. The RPMS system is subject to monitoring; therefore, no expectation of privacy shall be assumed. Individuals found performing unauthorized activities are subject to disciplinary action including criminal prosecution.

All users (Contractors and IHS Employees) of RPMS will be provided a copy of the Rules of Behavior (RoB) and must acknowledge that they have received and read them prior to being granted access to a RPMS system, in accordance IHS policy.

- For a listing of general Rules of Behavior for all users, see the most recent edition of *IHS General User Security Handbook* (SOP 06-11a).
- For a listing of system administrators/managers rules, see the most recent edition of the *IHS Technical and Managerial Handbook* (SOP 06-11b).

Both documents are available at this IHS web site,

http://security.ihs.gov/

The Rules of Behavior listed in the following sections are specific to RPMS.

8.1 All RPMS Users

In addition to these rules, each application may include additional RoBs that may be defined within the documentation of that application (e.g., PCC, Dental, Pharmacy).

8.1.1 Access

RPMS users shall

- Only use data for which you have been granted authorization.
- Only give information to personnel who have access authority and have a need to know.
- Always verify a caller’s identification and job purpose with your supervisor or the entity provided as employer before providing any type of information system access, sensitive information, or non-public agency information.

- Be aware that personal use of information resources is authorized on a limited basis within the provisions *Indian Health Manual* Part 8, “Information Resources Management,” Chapter 6, “Limited Personal Use of Information Technology Resources.”

RPMS users shall not

- Retrieve information for someone who does not have authority to access the information.
- Access, research, or change any user account, file, directory, table, or record not required to perform your OFFICIAL duties.
- Store sensitive files on a PC hard drive, or portable devices or media, if access to the PC or files cannot be physically or technically limited.
- Exceed their authorized access limits in RPMS by changing information or searching databases beyond the responsibilities of their job or by divulging information to anyone not authorized to know that information.

8.1.2 Information Accessibility

RPMS shall restrict access to information based on the type and identity of the user. However, regardless of the type of user, access shall be restricted to the minimum level necessary to perform the job.

RPMS users shall

- Access only those documents they created and those other documents to which they have a valid need-to-know and to which they have specifically granted access through an RPMS application based on their menus (job roles), keys, and FileMan access codes. Some users may be afforded additional privileges based on the function they perform such as system administrator or application administrator.
- Acquire a written preauthorization in accordance with IHS polices and procedures prior to interconnection to or transferring data from RPMS.

8.1.3 Accountability

RPMS users shall

- Behave in an ethical, technically proficient, informed, and trustworthy manner.
- Logout of the system whenever they leave the vicinity of their PC.
- Be alert to threats and vulnerabilities in the security of the system.
- Report all security incidents to their local Information System Security Officer (ISSO)

- Differentiate tasks and functions to ensure that no one person has sole access to or control over important resources.
- Protect all sensitive data entrusted to them as part of their government employment.
- Shall abide by all Department and Agency policies and procedures and guidelines related to ethics, conduct, behavior, and IT information processes.

8.1.4 Confidentiality

RPMS users shall

- Be aware of the sensitivity of electronic and hardcopy information, and protect it accordingly.
- Store hardcopy reports/storage media containing confidential information in a locked room or cabinet.
- Erase sensitive data on storage media, prior to reusing or disposing of the media.
- Protect all RPMS terminals from public viewing at all times.
- Abide by all HIPAA regulations to ensure patient confidentiality.

RPMS users shall not

- Allow confidential information to remain on the PC screen when someone who is not authorized to that data is in the vicinity.
- Store sensitive files on a portable device or media without encrypting.

8.1.5 Integrity

RPMS users shall

- Protect your system against viruses and similar malicious programs.
- Observe all software license agreements.
- Follow industry standard procedures for maintaining and managing RPMS hardware, operating system software, application software, and/or database software and database tables.
- Comply with all copyright regulations and license agreements associated with RPMS software.

RPMS users shall not

- Violate Federal copyright laws.
- Install or use unauthorized software within the system libraries or folders

- Use freeware, shareware, or public domain software on/with the system without your manager's written permission and without scanning it for viruses first.

8.1.6 System Logon

RPMS users shall

- Have a unique User Identification/Account name and password.
- Be granted access based on authenticating the account name and password entered.
- Be locked out of an account after 5 successive failed login attempts within a specified time period (e.g., one hour).

8.1.7 Passwords

RPMS users shall

- Change passwords a minimum of every 90 days.
- Create passwords with a minimum of eight characters.
- If the system allows, use a combination of alpha, numeric characters for passwords, with at least one uppercase letter, one lower case letter, and one number. It is recommended, if possible, that a special character also be used in the password.
- Change vendor-supplied passwords immediately.
- Protect passwords by committing them to memory or store them in a safe place (do not store passwords in login scripts, or batch files.
- Change password immediately if password has been seen, guessed, or otherwise compromised; and report the compromise or suspected compromise to your ISSO.
- Keep user identifications (ID) and passwords confidential.

RPMS users shall not

- Use common words found in any dictionary as a password.
- Use obvious readable passwords or passwords that incorporate personal data elements (e.g., user's name, date of birth, address, telephone number, or social security number; names of children or spouses; favorite band, sports team, or automobile; or other personal attributes).
- Share passwords/IDs with anyone or accept the use of another's password/ID, even if offered.
- Reuse passwords. A new password must contain no more than five characters per 8 characters from the previous password.

- Post passwords.
- Keep a password list in an obvious place, such as under keyboards, in desk drawers, or in any other location where it might be disclosed.
- Give a password out over the phone.

8.1.8 Backups

RPMS users shall

- Plan for contingencies such as physical disasters, loss of processing, and disclosure of information by preparing alternate work strategies and system recovery mechanisms.
- Make backups of systems and files on a regular, defined basis.
- If possible, store backups away from the system in a secure environment.

8.1.9 Reporting

RPMS users shall

- Contact and inform your ISSO that you have identified an IT security incident and you will begin the reporting process by providing an IT Incident Reporting Form regarding this incident.
- Report security incidents as detailed in the *IHS Incident Handling Guide* (SOP 05-03).

RPMS users shall not

- Assume that someone else has already reported an incident. The risk of an incident going unreported far outweighs the possibility that an incident gets reported more than once

8.1.10 Session Timeouts

RPMS system implements system-based timeouts that back users out of a prompt after no more than 5 minutes of inactivity.

RPMS users shall

- Utilize a screen saver with password protection set to suspend operations at no greater than 10-minutes of inactivity. This will prevent inappropriate access and viewing of any material displayed on your screen after some period of inactivity.

8.1.11 Hardware

RPMS users shall

- Avoid placing system equipment near obvious environmental hazards (e.g., water pipes).
- Keep an inventory of all system equipment.
- Keep records of maintenance/repairs performed on system equipment.

RPMS users shall not

- Eat or drink near system equipment

8.1.12 Awareness

RPMS users shall

- Participate in organization-wide security training as required.
- Read and adhere to security information pertaining to system hardware and software.
- Take the annual information security awareness.
- Read all applicable RPMS Manuals for the applications used in their jobs.

8.1.13 Remote Access

Each subscriber organization establishes its own policies for determining which employees may work at home or in other remote workplace locations. Any remote work arrangement should include policies that

- Are in writing.
- Provide authentication of the remote user through the use of ID and password or other acceptable technical means.
- Outline the work requirements and the security safeguards and procedures the employee is expected to follow.
- Ensure adequate storage of files, removal, and non-recovery of temporary files created in processing sensitive data, virus protection, intrusion detection, and provides physical security for government equipment and sensitive data.
- Establish mechanisms to back up data created and/or stored at alternate work locations.

Remote RPMS users shall

- Remotely access RPMS through a virtual private network (VPN) when ever possible. Use of direct dial in access must be justified and approved in writing and its use secured in accordance with industry best practices or government procedures.

Remote RPMS users shall not

- Disable any encryption established for network, internet, and web browser communications.

8.2 RPMS Developers

RPMS developers shall

- Always be mindful of protecting the confidentiality, availability, and integrity of RPMS when writing or revising code.
- Always follow the IHS RPMS Programming Standards and Conventions (SAC) when developing for RPMS.
- Only access information or code within the namespaces for which they have been assigned as part of their duties.
- Remember that all RPMS code is the property of the U.S. Government, not the developer.
- Shall not access live production systems without obtaining appropriate written access, shall only retain that access for the shortest period possible to accomplish the task that requires the access.
- Shall observe separation of duties policies and procedures to the fullest extent possible.
- Shall document or comment all changes to any RPMS software at the time the change or update is made. Documentation shall include the programmer’s initials, date of change and reason for the change.
- Shall use checksums or other integrity mechanism when releasing their certified applications to assure the integrity of the routines within their RPMS applications.
- Shall follow industry best standards for systems they are assigned to develop or maintain; abide by all Department and Agency policies and procedures.
- Shall document and implement security processes whenever available.

RPMS developers shall not

- Write any code that adversely impacts RPMS, such as backdoor access, “Easter eggs,” time bombs, or any other malicious code or make inappropriate comments within the code, manuals, or help frames.

- Grant any user or system administrator access to RPMS unless proper documentation is provided.
- Not release any sensitive agency or patient information.

8.3 Privileged Users

Personnel who have significant access to processes and data in RPMS, such as, system security administrators, systems administrators, and database administrators have added responsibilities to ensure the secure operation of RPMS.

Privileged RPMS users shall

- Verify that any user requesting access to any RPMS system has completed the appropriate access request forms.
- Ensure that government personnel and contractor personnel understand and comply with license requirements. End users, supervisors, and functional managers are ultimately responsible for this compliance.
- Advise the system owner on matters concerning information technology security.
- Assist the system owner in developing security plans, risk assessments, and supporting documentation for the certification and accreditation process.
- Ensure that any changes to RPMS that affect contingency and disaster recovery plans are conveyed to the person responsible for maintaining continuity of operations plans.
- Ensure that adequate physical and administrative safeguards are operational within their areas of responsibility and that access to information and data is restricted to authorized personnel on a need to know basis.
- Verify that users have received appropriate security training before allowing access to RPMS.
- Implement applicable security access procedures and mechanisms, incorporate appropriate levels of system auditing, and review audit logs.
- Document and investigate known or suspected security incidents or violations and report them to the ISSO, CISO, and systems owner.
- Protect the supervisor, superuser, or system administrator passwords.
- Avoid instances where the same individual has responsibility for several functions (i.e., transaction entry and transaction approval).
- Watch for unscheduled, unusual, and unauthorized programs.
- Help train system users on the appropriate use and security of the system.

- Establish protective controls to ensure the accountability, integrity, confidentiality, and availability of the system.
- Replace passwords when a compromise is suspected. Delete user accounts as quickly as possible from the time that the user is no longer authorized system. Passwords forgotten by their owner should be replaced, not reissued.
- Terminate user accounts when a user transfers or has been terminated. If the user has authority to grant authorizations to others, review these other authorizations. Retrieve any devices used to gain access to the system or equipment. Cancel logon IDs and passwords, and delete or reassign related active and back up files.
- Use a suspend program to prevent an unauthorized user from logging on with the current user's ID if the system is left on and unattended.
- Verify the identity of the user when resetting passwords. This can be done either in person or having the user answer a question that can be compared to one in the administrator’s database.
- Shall follow industry best standards for systems they are assigned to; abide by all Department and Agency policies and procedures.

Privileged RPMS users shall not

- Access any files, records, systems, etc., that are not explicitly needed to perform their duties
- Grant any user or system administrator access to RPMS unless proper documentation is provided.
- Not release any sensitive agency or patient information.

Glossary

ADO.NET

Set of classes that expose data access services to the .NET programmer.

API

Application Program Interface. Callable entry points that enable software to communicate with other software.

Application Context

The Application Context is a read/write part of application programs that contains rules dictating how the application interacts with other applications and users.

BMXNet

A set of software utilities designed to connect to RPMS data by .NET applications

column_alias

Specifies an alternative name to replace the column name in the query result set. For example, an alias such as “Quantity,” “Quantity to Date,” or “Qty” can be specified for a column named **quantity**

field_name

Specifies from which field (column) the FROM clause should return. The field_name is associated with the preceding table_name by using a dot (.) between the two

FROM Keyword

Specifies that the system should return the values from the following table_list statement

INDEX Keyword

Identifies a specific FileMan cross-reference to use when retrieving data. Always use the SHOWPLAN keyword in conjunction with the INDEX keyword to ensure that you achieve the intended result.

Index Row

Part of the SHOWPLAN results that includes the M code created by BMXNet that will execute on the RPMS server and iterate through the FileMan file.

Iterate

To say or perform again; to repeat

join_type

Specifies a join using nonstandard syntax and the WHERE clause. The =* operator is used to specify a one-to-many (OTM) join. Use the OTM join to express relationship between Tables A and B such that a record in Table A can be referenced by a FileMan pointer field in one or more records in Table B.

Log on

Connect to a network

M

A programming language that originated from the medical sector but is currently used in a variety of database applications due to its retrieval capabilities.

M Routines

A collection of command lines, all associated with a single name that can be stored and retrieved as a unit.

MAXRECORDS Keyword

Specifies the maximum number of records to return

Operator

A symbol that specifies which operation the systems should perform relative to the indicated operator arguments.

Operator Arguments

A value or expression dictating the information upon which the related operator acts.

Overloads

The creation of more than one procedure, instance constructor, or property in a class with the same name but different argument types. Overloading is especially useful when your object model dictates that you employ identical names for procedures that operate on different data types

Parameter

A value given to a variable until the related operation is completed. Parameters are treated by the system as constants. Parameters are often used to customize a program for a particular purpose

Port

Software that links one computer with another using TCP/IP address and port numbers assigned by network administrators.

primary_table_name

The file from which the system should first retrieve data.

related_table_name

The file from which the system should receive data that matches the primary table.

Remote Procedure Call (RPC)

A technique used to constructing distributed, client-server based applications. RPC extends the capabilities of local procedure calling, so that the called procedure need not exist in the same address space as the calling procedure.

Screen Rows

Part of the SHOWPLAN results that includes the M code that BMXNet will execute to filter the results. The “^” character in the query plan is replaced by the “~” character.

search_condition

Restricts the rows returned in the result set by using predicates. There is no limit to the number of predicates that can be included in a search condition.

SELECT Keyword

Specifies that the system should return the values by the select_list statement.

select_list

Specifies which fields (columns) the system should select for the returned set. The select_list is a series of expressions separated by commas.

Server

A computer that hosts RPMS applications.

SHOWPLAN Keyword

Returns the query plan, including the M code that will be executed to retrieve the records.

table_name

Specifies from which files (tables) the FROM clause should return fields.

table_source

Specifies from which files (tables) the FROM clause should return fields.

WHERE Keyword

Specifies a search condition to restrict the rows returned.

Contact Information

If you have any questions or comments regarding this distribution, please contact the OIT Help Desk (IHS).

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