M-Unit Technical Article

Introduction

What it does

This tool permits a series of tests to be written addressing specific tags or entry points within a project and act to verify that the return results are as expected for that code. The significance of this is that, when run routinely any time that the project is modified, it will act to indicate whether the intended function has been modified inadvertently or whether the modification has had unexpected effects on other functionality within the project. The set of unit tests for a project should run rapidly (usually within a matter of seconds) and with minimal disruption for developers. Another function of unit tests is that they indicate what the intended software was written to do. The latter may be especially useful when new developers start working with the software or a programmer returns to a project after a prolonged period.

The concept of Unit Testing was already in place before Kent Beck created a tool that he used in the language Smalltalk, and then was turned into the tool Junit for Java by Kent Beck and Erich Gamma. This tool for running specific tests on facets of a software project was subsequently referred to as xUnit, since NUnit was developed for .NET developers, DUnit for Delphi developers, etc. MUnit is the equivalent tool for M developers to use and was originally created in 2003.

This version includes a number of improvements and changes.

- A problem identified by Steve Graham occurred with Cache when a computer name began with one or more digits. The code now checks for whether $SY contains a second '^' piece, and if not identifies it as a Cache system, instead of simply taking the numeric value as it did before, so it will identify a Cache system even if the system name begins with one or more digits.
- Due to comments from Christopher Edwards, the unit tests and coverage analysis will now run in an M system which knows nothing about the VA software. Simply load the routines into an account (making sure that it identifies the %ut namespace as being in the account).
- Sam Habiel suggested (and in his own version of the code added) the ability to pass by reference the namespace to run coverage on to COV^%ut1. This has been added to the %ut routine as well and also changed the first argument in COVERAGE^%ut to also be passed by reference. This will not affect any current code, but will permit a user to use more than one namespace at the same time (e.g., say passing in the variable NMSP by reference and with NMSP="XUS*",NMSP("XUT*")="" this will result in coverage analysis for both XUS* and XUT* routines, or in the case of the M-Unit routines, NMSP="%ut",NMSP("%ut1")="",NMSP("%utcover")="" will run the coverage on these routines without having coverage also being processed on %utt1, %utt2, etc as a result of NMSP="%ut*" as it has been performed.
- Sam Habiel also added code for GT.M to the verbose mode so that a value for verbosity (the second argument to EN^%ut) of 2 will result in timing of the individual tests in milliseconds while a value of 3 will result in timing in microseconds (shown as fractional milliseconds and only available in GT.M version 6.3 and above). This functionality has also been extended to Cache systems.
- When the BREAK parameter (the third argument to EN^%ut) is set it will actually tell the user what the error encountered was before telling them it broke on an error (but not identifying the error). The messages were also added to code related to BREAK on NOT EQUAL and on FAILURE to indicate why the break occurred.

- The code has been modified so that it will still run tests if the name on the first line of a routine does not match the name of the routine. Also, the code was modified so that it still does not run tests for a routine which does not have ;; on the second line of a routine - since it does not appear to be a human written routine, but it now prints a message indicating the routine is being skipped since it doesn't have the standard second line.

Using M-Unit

The M-Unit functionality is contained in the %ut, %ut1 and %utcover routines. The code was originally written by Joel Ivey when he was working as a developer for the Department of Veteran Affairs. The code had input as suggestions by several other developers both inside and outside of the VA, including Kevin Meldrum and especially Sam Habiel who made significant contributions to the current status including modifications to the preinstall routine for Cache to improve setting the %ut namespace for routines and globals to the current VistA partition. Current development is being continued for OSEHRA.

```
%ut	;VEN-SMH/JLI - PRIMARY PROGRAM FOR M-UNIT TESTING ;02/11/17  11:07
	;;1.5;MASH UTILITIES;;Feb 8, 2017;
	; Submitted to OSEHRA Feb 8, 2017 by Joel L. Ivey under the Apache 2 license
(http://www.apache.org/licenses/LICENSE-2.0.html)
	; Original routine authored by Joel L. Ivey as XTMUNIT while working for U.S. Department of Veterans
Affairs 2003-2012
	; Includes addition of %utVERB and %utBREAK arguments and code related to them as well as other
substantial additions authored by Sam Habiel 07/2013-04/2014
	; Additions and modifications made by Sam H. Habiel and Joel L. Ivey 2013-02/2017 ;
	;
	; This routine and its companion, %ut1, provide the basic functionality for
	; running unit tests on parts of M programs either at the command line level
	; or via the M-Unit GUI application for windows operating systems.
	;
	; Original by Dr. Joel Ivey (JLI)
	; Contributions by Dr. Sam Habiel (SMH)
```

From a user's perspective the basic start for unit tests from the command line is the entry point EN^%ut, the first argument is the name of the routine to be tested and is required, but the tag can take up to two additional arguments: a verbose indicator and a BREAK indicator, both of these require a non-zero value to activate them.

```
	D EN^%ut("ROUTINE_NAME")
or
	D EN^%ut("ROUTINE_NAME",VERBOSE,BREAK)
```

The command with a single argument will result in the unit tests being run and each successful test is shown by a period ('.') followed by specification of the number of tags entered, the number of tests run, the number of failures, and the number of errors encountered. Instead of the period for successes, failures or errors are indicated by the tag and routine name for the specific test, a description of the test if provided, and a message concerning the failure if provided or the line and routine at which the error occurred. The verbose option will result in a listing of each test that is executed, which may make it more difficult to identify problems if they have occurred. The BREAK option will result in termination of the unit test as soon as a failure or error is encountered, this is not usually recommended, since only a part of the unit tests (and potential problems) will have been examined. The unit tests will normally continue even if errors are encountered.

The code written in a unit test routine has specific entry points that should indicate a specific set of functionality being tested. The tag may have more than one test, but these should all focus on the same aspect being tested. Originally specification of the tags and a description of the functionality being tested by the tag testing were entered following an XTENT tag in the following manner.

```
XTENT   ;
        ;;TEST1;Testing functionality for one feature
        ;;ANEW1;Testing another piece of functionality
        ;;ATHIRD;Testing still something else
```

More recently, an alternative method was added similar to the annotation used in C#, thanks to the suggestion of Kevin Meldrum. The indicator @TEST is specified as the first string following the semi-colon on the same line as the tag, and a description can then be added following this indicator.

```
TEST4   ; @TEST another test for different functionality
```

Since there will frequently be multiple routines with tests created to test a specific project, these can be indicated in a manner similar to the original description of the entry tags, following a XTROU tag. The following could be used to link additional test routines to a ZZUXQA1 test routine.

```
XTROU   ;
        ;;ZZUXQA2
        ;;ZZUXQA3
        ;;ZZUXQA4
```

The other routines can also reference these as well, or additional related test routines. Each routine would be included only once, no matter how many of the other routines reference it in this manner.

A test routine can use one of three types of calls for its tests, determining truth, equivalence, or simply indicating failure for the test. In each of these a final argument can be used to specify information about the specific test result.

Truth is tested by the command

```
        DO CHKTF^%ut(TorF,message)
```

where 'TorF' is a value to be tested for true (passing the test) or false (failing the test).

Equivalence is tested by the command

```
        DO CHKEQ^%ut(expected,result,message)
```

where 'expected' is the value that is expected from the test, and 'result' is the value that was obtained and should be equal to 'expected' if the test is to pass. If a test fails, the expected value and the observed values are shown along with the 'message' indicating the test that failed.

Failure already determined is specified by the command

```
DO FAIL^%ut(message)
```

and is generally used when the processing has reached an area that it shouldn't be expected to reach given the circumstances, and 'message' then describes the situation.

The MUnit functionality is set up to capture information on errors, and to continue processing the remaining tests within the tag as well as additional tags.

There are four other tags that have meaning to the MUnit functionality - STARTUP, SETUP, TEARDOWN, and SHUTDOWN. Frequently, to provide specific data to use for testing, it may be necessary to add data which is totally temporary, either for all tests in one pass, or before each test is run.

The STARTUP tag specifies code that should be run once when the testing of a routine is starting up. If multiple routines should use the same STARTUP code, they can have a STARTUP tag that then runs the code in one of the routines. Its companion is SHUTDOWN, which if present, will be run only after all of the tests have been completed within a routine. Again, if multiple routines should use the same SHUTDOWN code they can each have a SHUTDOWN tag and then run the code in one of the routines. This is a change from the prior version, where STARTUP was run only at the start of a unit test sequence and SHUTDOWN only at the conclusion of all tests. However, this was found to cause problems if a suite of multiple unit tests from different applications were being run (e.g., by creating a primary unit test routine which referred to multiple test routines creating a suite of tests), and more than one of the applications required its own STARTUP and SHUTDOWN code.

The SETUP tag specifies code that should be run before each test tag in a given routine is run, there could be similar SETUP tags in other routines as well. Its companion is TEARDOWN which, if present, will be run immediately after each test tag is processed.

It should be noted that care should be taken in using these four tags, since they may end up hiding significant functionality from testing or result in problems later if changes are made to the tests (which would then be converted into changes in the project related to the tests).

The extrinsic function ($$ISUTEST^%ut) can be used to determine whether code is currently running within a unit test or not. The value returned will be true if it is currently in a unit test and false if it is not. This can be used within code that would likely be used under testing to determine whether user interaction might be requested or not, or to set a default value for testing purposes.

An additional tag (CHKLEAKS^%ut) is available for checking for variable leaks as a part of a unit test. This functionality can also be called outside of unit tests as well.

```
CHKLEAKS(%zuCODE,%zuLOC,%zuINPT) ; functionality to check for variable leaks on
executing a section of code
    ; %zuCODE - A string that specifies the code that is to be XECUTED and checked for leaks.
    ;         this should be a complete piece of code
    ;              (e.g., "S X=$$NEW^XLFDT()" or "D EN^%ut(""ROUNAME"")")
    ; %zuLOC  - A string that is used to indicate the code tested for variable leaks
    ; %zuINPT - An optional variable which may be passed by reference.  This may
    ;         be used to pass any variable values, etc. into the code to be
    ;         XECUTED.  In this case, set the subscript to the variable name and the
    ;         value of the subscripted variable to the desired value of the subscript.
    ;           e.g., (using NAME as my current namespace)
    ;              SET CODE="SET %zuINPT=$$ENTRY^ROUTINE(ZZVALUE1,ZZVALUE2)"
    ;              SET NAMELOC="ENTRY^ROUTINE leak test"   (or simply "ENTRY^ROUTINE")
    ;              SET NAMEINPT("ZZVALUE1")=ZZVALUE1
    ;              SET NAMEINPT("ZZVALUE2")=ZZVALUE2
    ;              DO CHKLEAKS^%ut(CODE,NAMELOC,.NAMEINPT)
    ;
    ;         If part of a unit test, any leaked variables in ENTRY^ROUTINE which result
    ;         from running the code with the variables indicated will be shown as FAILUREs.
    ;
    ;         If called outside of a unit test, any leaked variables will be printed to the
    ;         current device.
    ;
```

The COV^%ut API can be used to initiate coverage analysis of unit tests. Previously this functionality was limited to the GT.M version of M (MUMPS), but the current release now provides support for coverage analysis in Intersystems Cache as well. In the original release, this functionality was only available by calling COV^%ut1, but the tag has been moved to %ut to make it more convenient to use. A couple of newly added related APIs are described below as well. The COV^%ut API has three arguments

```
DO COV^%ut (.NAMESPACE,CODE,VERBOSITY)
```

where NAMESPACE specifies the routines to be included in the analysis. If the value does not include an asterick at the end, then only the routine matching the specified name would be included (e.g, "KBBPDEB1", would only include the routine KBBPDEB1 in the analysis). If the NAMESPACE value ends in an asterick, then all routines starting with the initial characters will be included in the analysis (e.g., KBBPD* would include all routines with names starting with KBBPD in the analysis). Namespace may also be passed as the arguments of an array (e.g., NAMESPACE="KBBPDEB1*","NAMESPACE("KBBPDEB2*")="" will run coverage analysis on both namespaces. This may also be used to specify all individual routines to be included in the coverage analysis.

CODE specifies the code command that should be run for the analysis. Thus, "DO EN^%ut(""KBBPUDE1"")" would run the routine KBBPUDE1 and any that it might call for the coverage analysis.

VERBOSITY determines the amount of detail to be displayed. A value of 0 or 1 will provide only an analysis of the lines covered out of the total number to be counted (non-code lines are not included in the coverage analysis) for each routine in the analysis, as well as covered and totals for all routines. A value of 2 will also include coverage data for each tag in the routines. A value of 3 will provide the data provided by 1 and 2, but also will list each line for a tag that was not covered during running of the routine(s), so that lines lacking coverage can be determined. A value of -1 will return all data in globals for the calling application to evaluate and present.

The COVERAGE^%ut API has been added to make it easier to analyze the coverage data while having it omit the data on routines that shouldn't be included in the analysis (e.g., those routines which are only unit test routines). It also permits different APIs to be called within the same analysis, so that coverage can be better approximated if different pieces of code need to be called (e.g., an entry point to run unit tests without the verbose flag, and another with the verbose flag, since both count as lines of code). This functionality is available in both Cache and GT.M systems.

```
DO COVERAGE^%ut(.NAMESPACE,.TESTROUS,.XCLUDE,VERBOSITY)
```

Where NAMESPACE functions in the same manner as described for COV^%ut (e.g., "%ut*") and is passed by reference as well.

TESTROUS is an array specifying the desired APIs that should be called and is passed by reference. If the subscript is non-numeric, it will be interpreted as a routine specification to be used. The values of the array may also be a comma separated list of APIs to be used during the analysis. If an API includes a '^' (as either TAG^ROU or ^ROU) then it will be run as DO TAG^ROU or DO ^ROU. If the API does not include a '^' then it will be run as DO EN^%ut("ROU"). An array could look like

```
SET TESTROUS(1)="^%ut,^%ut1"
SET TESTROUS("%utt1")="VERBOSE^%ut1"
```

which would cause the unit tests DO ^%ut, DO ^%ut1, DO EN^%ut("%utt1"), and DO VERBOSE^%ut1 to be run.

XCLUDE is an array specifying the names of routines that should be excluded from the coverage analysis, and can also be specified as either arguments or as a comma separated list in the value. Thus,

```
SET XCLUDE("%utt1")="%utt2,%utt3,%utt4,%utt5,%utt6,%uttcovr"
```

would result in only the functioning routines in %ut* being included in the coverage analysis.

The VERBOSITY argument can have the 0 through 3 values as described above.

The MULTAPIS^%ut API has been added to provide capabilities to run multiple sets of unit tests in the same manner as with the COVERAGE^%ut API, but it does not attempt to perform any coverage analyses. It has a single argument is passed by reference and has the same capabilities as TESTROUS above. Usage is as

```
DO MULTAPIS^%ut(.TESTROUS)
```

The new GETUTVAL^%ut and LSTUTVAL^%ut APIs can be used to generate cumulative totals If a routine with code to run multiple unit tests is created by calling the GETUTVAL^%ut API after each test passing a variable (which can be undefined initially) by reference to create an array containing a cumulative total for the tests. At the conclusion, the LSTUTVAL^%ut API can then be called to print the cumulative totals.

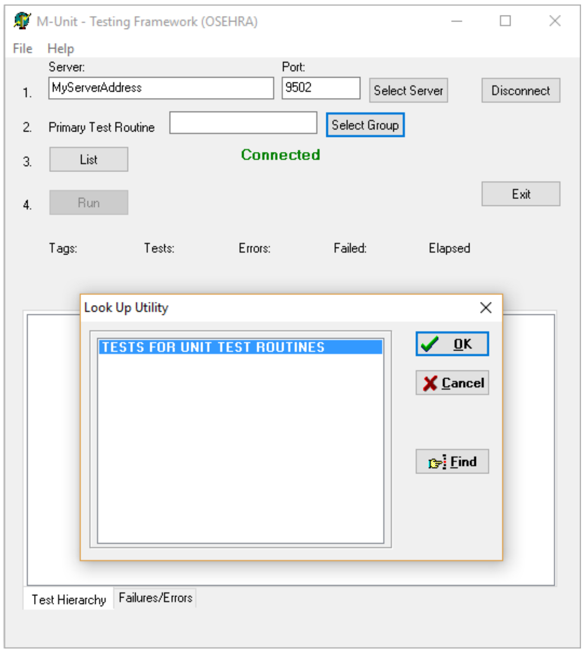
```
DO GETUTVAL^%ut(.TESTSUM)
```

Then

```
DO LSTUTVAL^%ut(.TESTSUM)
```

Will present the summary listing of values for the tests.

The GUI MUnit application provides a visually interactive rapid method for running unit tests on M code.



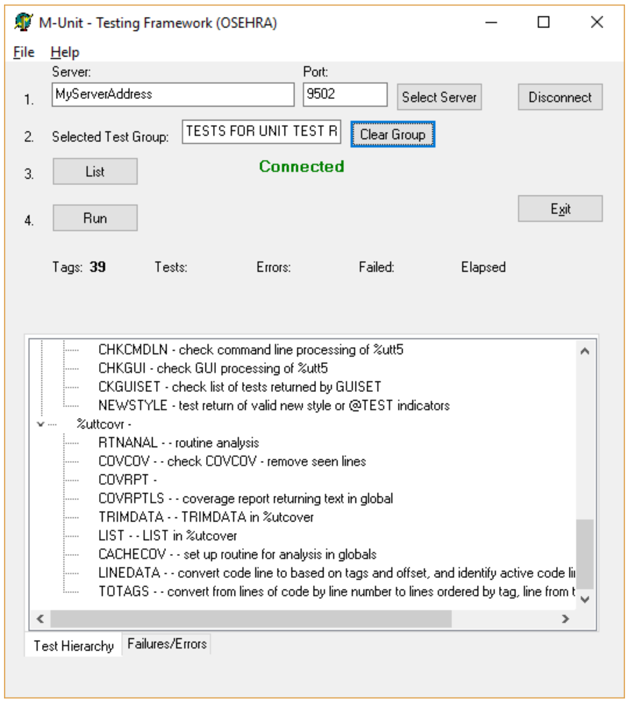
1. Server: MyServerAddress Port: 9502

Connected

TESTS FOR UNIT TEST ROUTINES

Figure 1. Selection of an M-Unit test

After specifying the server address and port, the user can sign on and then click the Select Group button to select a unit test from the M-UNIT TEST GROUP file (#17.9001) as shown here (Figure 1), or simply enter the name of a unit test routine in the Primary Test Routine field and click on List. This will bring up a list of the routines and tags in the unit test run (Figure 2).



1. Server: MyServerAddress Port: 9502

2. Selected Test Group: TESTS FOR UNIT TEST R

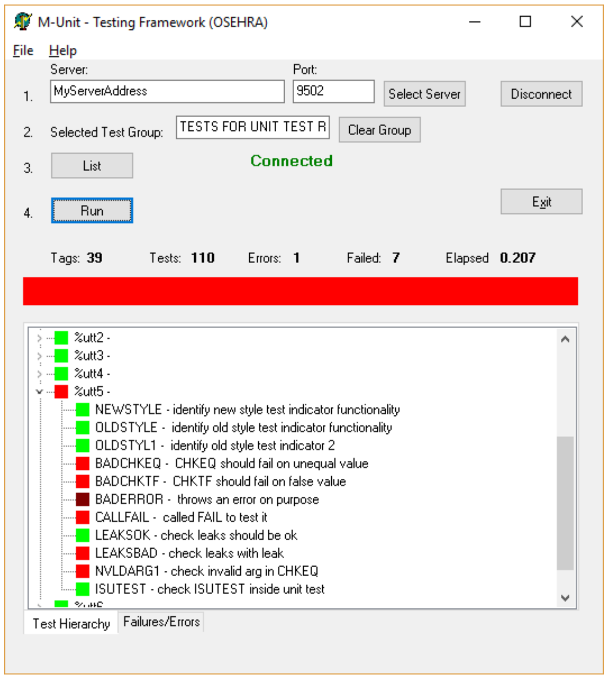
Connected

Tags: **39**

```
    CHKCMDLN - check command line processing of %ut5
    CHKGUI - check GUI processing of %ut5
    CKGUISET - check list of tests returned by GUISET
    NEWSTYLE - test return of valid new style or @TEST indicators
  %utcovr -
    RTNANAL - - routine analysis
    COVCOV - - check COVCOV - remove seen lines
    COVRPT -
    COVRPTLS - - coverage report returning text in global
    TRIMDATA - - TRIMDATA in %utcover
    LIST - - LIST in %utcover
    CACHECOV - - set up routine for analysis in globals
    LINEDATA - - convert code line to based on tags and offset, and identify active code li
    TOTAGS - - convert from lines of code by line number to lines ordered by tag, line from t
```

Figure 2. List of Unit tests selected for running

Clicking the Run button will run the unit tests, resulting in a bar which is green if all tests pass or red if any failures or errors are encountered (Figure 3).



1. Server: MyServerAddress Port: 9502

2. Selected Test Group: TESTS FOR UNIT TEST R

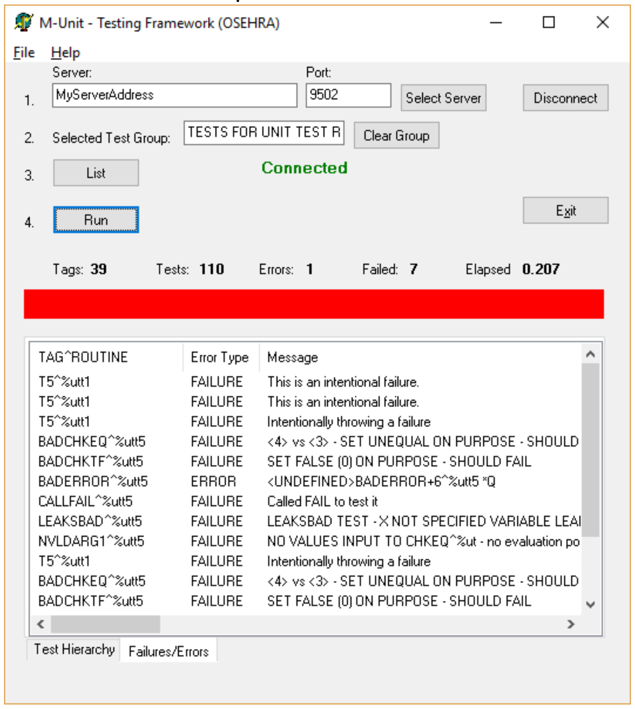
3. Connected

Tags: 39 Tests: 110 Errors: 1 Failed: 7 Elapsed 0.207

- 🟩 %utt2 -
- 🟩 %utt3 -
- 🟩 %utt4 -
- 🟥 %utt5 -
  - 🟩 NEWSTYLE - identify new style test indicator functionality
  - 🟩 OLDSTYLE - identify old style test indicator functionality
  - 🟩 OLDSTYL1 - identify old style test indicator 2
  - 🟥 BADCHKEQ - CHKEQ should fail on unequal value
  - 🟥 BADCHKTF - CHKTF should fail on false value
  - 🟥 BADERROR - throws an error on purpose
  - 🟥 CALLFAIL - called FAIL to test it
  - 🟩 LEAKSOK - check leaks should be ok
  - 🟥 LEAKSBAD - check leaks with leak
  - 🟥 NVLDARG1 - check invalid arg in CHKEQ
  - 🟩 ISUTEST - check ISUTEST inside unit test

Figure 3. The unit tests run with failures

If failures or errors are encountered, clicking on the Failures/Errors tab at the bottom of the listing opens a display of specific information on the problems.



1. Server: MyServerAddress Port: 9502

2. Selected Test Group: TESTS FOR UNIT TEST R

3. Connected

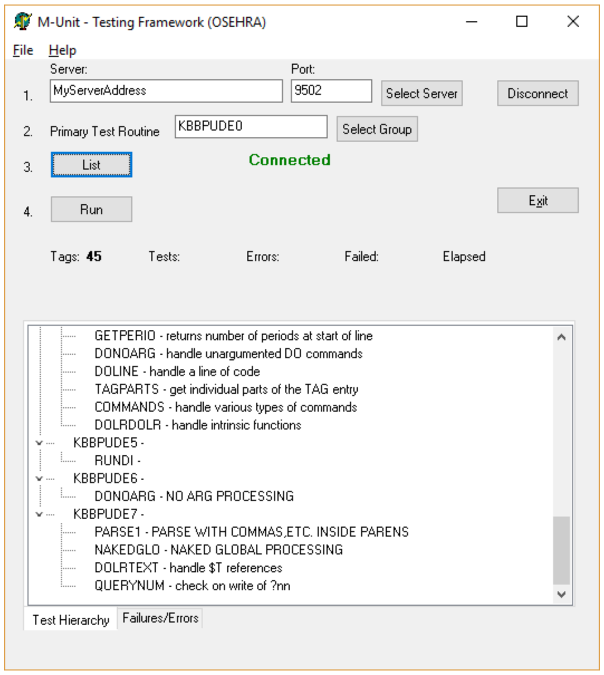
Tags: 39 Tests: 110 Errors: 1 Failed: 7 Elapsed 0.207

TAG^ROUTINE	Error Type	Message
T5^%utt1	FAILURE	This is an intentional failure.
T5^%utt1	FAILURE	This is an intentional failure.
T5^%utt1	FAILURE	Intentionally throwing a failure
BADCHKEQ^%utt5	FAILURE	<4> vs <3> - SET UNEQUAL ON PURPOSE - SHOULD
BADCHKTF^%utt5	FAILURE	SET FALSE (0) ON PURPOSE - SHOULD FAIL
BADERROR^%utt5	ERROR	<UNDEFINED>BADERROR+6^%utt5 *Q
CALLFAIL^%utt5	FAILURE	Called FAIL to test it
LEAKSBAD^%utt5	FAILURE	LEAKSBAD TEST - X NOT SPECIFIED VARIABLE LEAI
NVLDARG1^%utt5	FAILURE	NO VALUES INPUT TO CHKEQ^%ut - no evaluation po
T5^%utt1	FAILURE	Intentionally throwing a failure
BADCHKEQ^%utt5	FAILURE	<4> vs <3> - SET UNEQUAL ON PURPOSE - SHOULD
BADCHKTF^%utt5	FAILURE	SET FALSE (0) ON PURPOSE - SHOULD FAIL

Figure 4. Specifics on failed tests or errors

In the case shown (Figure 4), all of the failures are intentional. Usually, failures and/or errors are not intentional and the user can then edit the routine, and save the changes, then simply click on the Run button again to see the effect of the changes.

To select a new unit test, the user would click on the Clear Group button, then again either select another group or as shown in Figure 5, entering the name of a unit test routine (KBBPUDE0 and related routines are not included with the M-Unit Test code and is shown only as an example) and clicking on the List button.



1. Server: MyServerAddress Port: 9502

2. Primary Test Routine KBBPUDE0

3. Connected

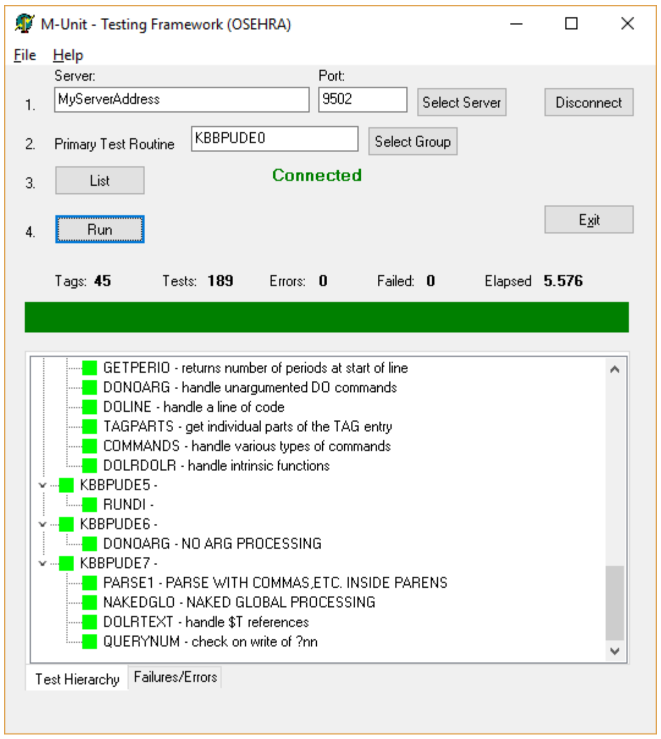
4.

Tags: **45** Tests: Errors: Failed: Elapsed

```
GETPERIO - returns number of periods at start of line
DONOARG - handle unargumented DO commands
DOLINE - handle a line of code
TAGPARTS - get individual parts of the TAG entry
COMMANDS - handle various types of commands
DOLRDOLR - handle intrinsic functions
KBBPUDE5 -
  RUNDI -
KBBPUDE6 -
  DONOARG - NO ARG PROCESSING
KBBPUDE7 -
  PARSE1 - PARSE WITH COMMAS,ETC. INSIDE PARENS
  NAKEDGLO - NAKED GLOBAL PROCESSING
  DOLRTEXT - handle $T references
  QUERYNUM - check on write of ?nn
```

Figure 5. Specification of unit tests by routine name

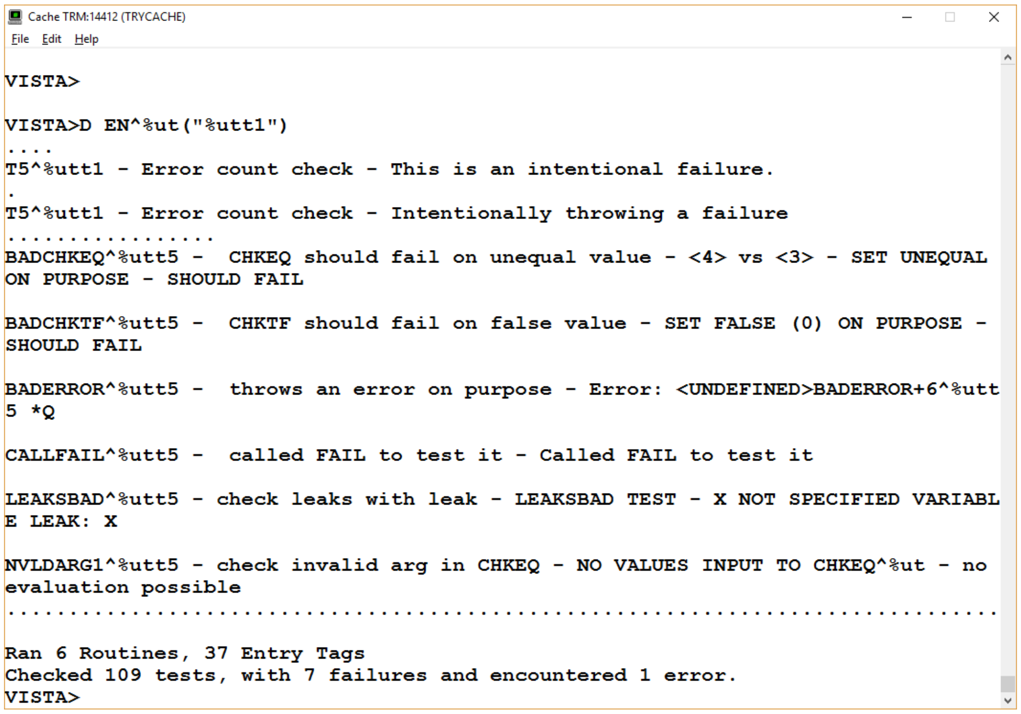
Again, clicking the Run button will run the unit tests (Figure 6). This figure shows the desired result, a green bar meaning that all tests passed.



```
1. Server: MyServerAddress    Port: 9502
2. Primary Test Routine  KBBPUDE0
3.                        Connected
4.
Tags: 45   Tests: 189   Errors: 0   Failed: 0   Elapsed 5.576

    GETPERIO - returns number of periods at start of line
    DONOARG - handle unargumented DO commands
    DOLINE - handle a line of code
    TAGPARTS - get individual parts of the TAG entry
    COMMANDS - handle various types of commands
    DOLRDOLR - handle intrinsic functions
  KBBPUDE5 -
    RUNDI -
  KBBPUDE6 -
    DONOARG - NO ARG PROCESSING
  KBBPUDE7 -
    PARSE1 - PARSE WITH COMMAS,ETC. INSIDE PARENS
    NAKEDGLO - NAKED GLOBAL PROCESSING
    DOLRTEXT - handle $T references
    QUERYNUM - check on write of ?nn
```

Figure 6. Result from the second group of unit tests

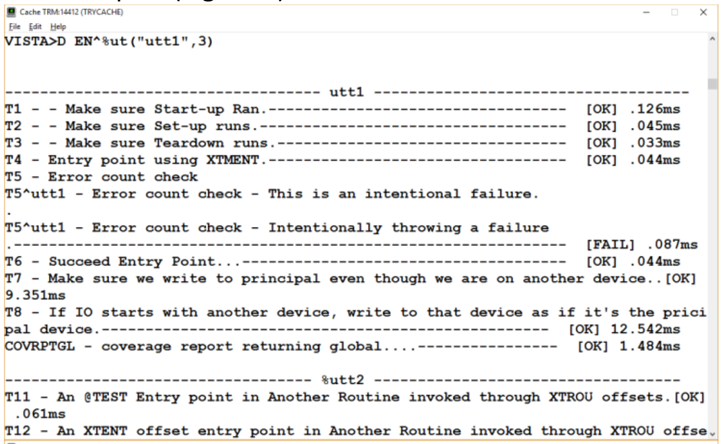
The results of %utt1 and related routines run at the command line without the verbose flag are shown in Figure 7.



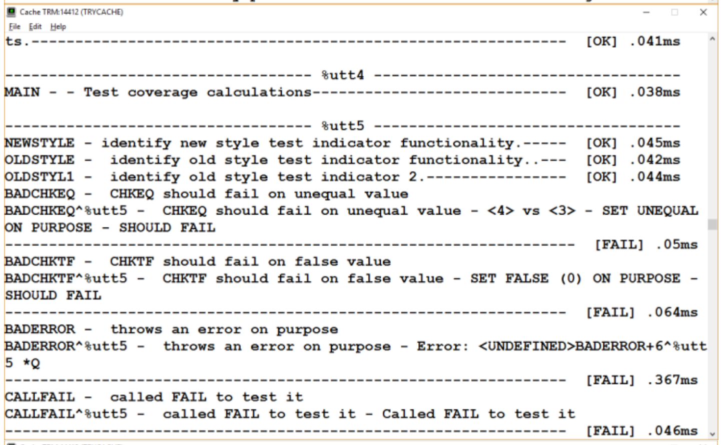
```
VISTA>

VISTA>D EN^%ut("%utt1")
....
T5^%utt1 - Error count check - This is an intentional failure.
.
T5^%utt1 - Error count check - Intentionally throwing a failure
.................
BADCHKEQ^%utt5 -  CHKEQ should fail on unequal value - <4> vs <3> - SET UNEQUAL
ON PURPOSE - SHOULD FAIL

BADCHKTF^%utt5 -  CHKTF should fail on false value - SET FALSE (0) ON PURPOSE -
SHOULD FAIL

BADERROR^%utt5 -  throws an error on purpose - Error: <UNDEFINED>BADERROR+6^%utt
5 *Q

CALLFAIL^%utt5 -  called FAIL to test it - Called FAIL to test it

LEAKSBAD^%utt5 - check leaks with leak - LEAKSBAD TEST - X NOT SPECIFIED VARIABL
E LEAK: X

NVLDARG1^%utt5 - check invalid arg in CHKEQ - NO VALUES INPUT TO CHKEQ^%ut - no
evaluation possible
................................................................................

Ran 6 Routines, 37 Entry Tags
Checked 109 tests, with 7 failures and encountered 1 error.
VISTA>
```

Figure 7. Command line unit tests for %utt1

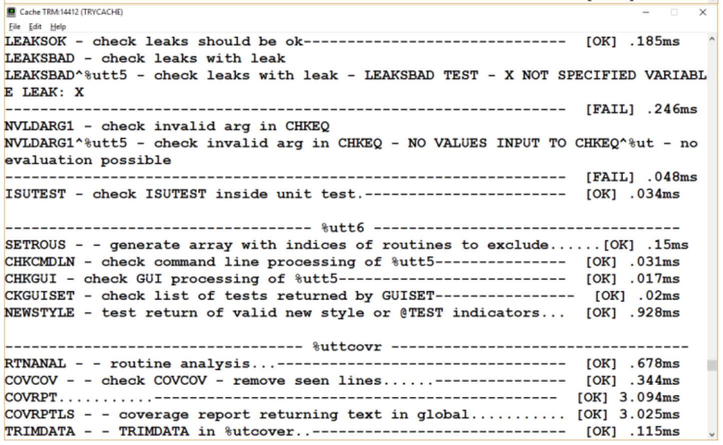
The results of the single %utt1 unit test routine (and its related routines) run with the VERBOSE option, that some people prefer, specified permits the individual tests and their results to be seen, but makes the results more difficult to interpret (Figure 8).



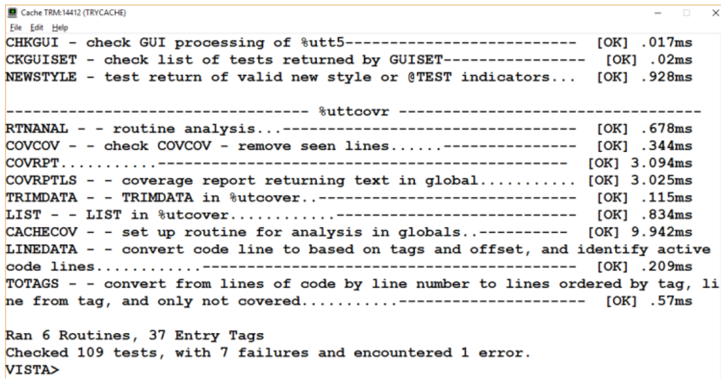
```
VISTA>D EN^%ut("utt1",3)


------------------------------------ utt1 -------------------------------------
T1 - - Make sure Start-up Ran.---------------------------------  [OK] .126ms
T2 - - Make sure Set-up runs.----------------------------------  [OK] .045ms
T3 - - Make sure Teardown runs.--------------------------------  [OK] .033ms
T4 - Entry point using XTMENT.---------------------------------  [OK] .044ms
T5 - Error count check
T5^utt1 - Error count check - This is an intentional failure.
.
T5^utt1 - Error count check - Intentionally throwing a failure
.--------------------------------------------------------------  [FAIL] .087ms
T6 - Succeed Entry Point...------------------------------------  [OK] .044ms
T7 - Make sure we write to principal even though we are on another device..[OK]
9.351ms
T8 - If IO starts with another device, write to that device as if it's the prici
pal device.--------------------------------------------------  [OK] 12.542ms
COVRPTGL - coverage report returning global....----------------  [OK] 1.484ms

----------------------------------- %utt2 -----------------------------------
T11 - An @TEST Entry point in Another Routine invoked through XTROU offsets.[OK]
 .061ms
T12 - An XTENT offset entry point in Another Routine invoked through XTROU offse
```



```
ts.------------------------------------------------------------  [OK] .041ms

----------------------------------- %utt4 -----------------------------------
MAIN - - Test coverage calculations----------------------------  [OK] .038ms

----------------------------------- %utt5 -----------------------------------
NEWSTYLE - identify new style test indicator functionality.-----  [OK] .045ms
OLDSTYLE -  identify old style test indicator functionality..---  [OK] .042ms
OLDSTYL1 -  identify old style test indicator 2.----------------  [OK] .044ms
BADCHKEQ -  CHKEQ should fail on unequal value
BADCHKEQ^%utt5 -  CHKEQ should fail on unequal value - <4> vs <3> - SET UNEQUAL
ON PURPOSE - SHOULD FAIL
-----------------------------------------------------------------  [FAIL] .05ms
BADCHKTF -  CHKTF should fail on false value
BADCHKTF^%utt5 -  CHKTF should fail on false value - SET FALSE (0) ON PURPOSE -
SHOULD FAIL
----------------------------------------------------------------  [FAIL] .064ms
BADERROR -  throws an error on purpose
BADERROR^%utt5 -  throws an error on purpose - Error: <UNDEFINED>BADERROR+6^%utt
5 *Q
----------------------------------------------------------------  [FAIL] .367ms
CALLFAIL -  called FAIL to test it
CALLFAIL^%utt5 -  called FAIL to test it - Called FAIL to test it
----------------------------------------------------------------  [FAIL] .046ms
```



```
LEAKSOK - check leaks should be ok------------------------------  [OK] .185ms
LEAKSBAD - check leaks with leak
LEAKSBAD^%utt5 - check leaks with leak - LEAKSBAD TEST - X NOT SPECIFIED VARIABL
E LEAK: X
----------------------------------------------------------------  [FAIL] .246ms
NVLDARG1 - check invalid arg in CHKEQ
NVLDARG1^%utt5 - check invalid arg in CHKEQ - NO VALUES INPUT TO CHKEQ^%ut - no
evaluation possible
----------------------------------------------------------------  [FAIL] .048ms
ISUTEST - check ISUTEST inside unit test.-----------------------  [OK] .034ms

----------------------------------- %utt6 -----------------------------------
SETROUS - - generate array with indices of routines to exclude......[OK] .15ms
CHKCMDLN - check command line processing of %utt5---------------  [OK] .031ms
CHKGUI - check GUI processing of %utt5--------------------------  [OK] .017ms
CKGUISET - check list of tests returned by GUISET----------------  [OK] .02ms
NEWSTYLE - test return of valid new style or @TEST indicators...  [OK] .928ms

---------------------------------- %uttcovr ----------------------------------
RTNANAL - - routine analysis...---------------------------------  [OK] .678ms
COVCOV - - check COVCOV - remove seen lines......---------------  [OK] .344ms
COVRPT..........-----------------------------------------------  [OK] 3.094ms
COVRPTLS - - coverage report returning text in global.......... [OK] 3.025ms
TRIMDATA - - TRIMDATA in %utcover..-----------------------------  [OK] .115ms
```



```
CHKGUI - check GUI processing of %utt5---------------------------  [OK] .017ms
CKGUISET - check list of tests returned by GUISET----------------  [OK] .02ms
NEWSTYLE - test return of valid new style or @TEST indicators...  [OK] .928ms

---------------------------------- %uttcovr ----------------------------------
RTNANAL - - routine analysis...---------------------------------  [OK] .678ms
COVCOV - - check COVCOV - remove seen lines......---------------  [OK] .344ms
COVRPT...........---------------------------------------------  [OK] 3.094ms
COVRPTLS - - coverage report returning text in global........... [OK] 3.025ms
TRIMDATA - - TRIMDATA in %utcover..-----------------------------  [OK] .115ms
LIST - - LIST in %utcover...........---------------------------  [OK] .834ms
CACHECOV - - set up routine for analysis in globals..----------  [OK] 9.942ms
LINEDATA - - convert code line to based on tags and offset, and identify active
code lines...........------------------------------------------  [OK] .209ms
TOTAGS - - convert from lines of code by line number to lines ordered by tag, li
ne from tag, and only not covered...........---------------------  [OK] .57ms

Ran 6 Routines, 37 Entry Tags
Checked 109 tests, with 7 failures and encountered 1 error.
VISTA>
```

Figure 8. Command line unit tests for %utt1 with VERBOSE option 3

Running Coverage Analysis of Unit Tests for the M-Unit code

Running the routine ^%uttcovr from the top (I.e., D ^%uttcovr) runs a series of unit tests including from the top of each of the routines ^%ut, ^%ut1, and ^%utcover, which each run unit tests when run from the top, as well as the regular unit tests. As noted earlier, the fourth argument of the COVERAGE^%ut API determines the verbosity of the results, and the ^%uttcovr analysis runs the verbosity 3, which the most detailed level. The results of the COVERAGE^%ut API are presented in the order of most detailed first so that the final output is the summary, and the user can scroll back for details.   As the analysis runs, the output lists each set of unit tests preceeded by a header indicating (e.g.,

"------------------- RUNNING %utt1 ------------------- " or

"------------------- RUNNING ^%utt1 -------------------"

where the routine name without the up arrow indicates it was started with the command D EN^%ut(, while those with an up arrow indicate it was started by running the routine from the top or from a specified tag.)

When the coverage is run with a verbosity value of zero or one, it presents only the least detailed item, the coverage by routine and total coverage for the analyzed routines (the coverage on a Cache system is shown)

```
Routine %ut      (96.15%)   275 out of 286 lines covered
Routine %ut1      (86.25%)   232 out of 269 lines covered
Routine %utcover     (100.00%)   107 out of 107 lines covered

Overall Analysis 614 out of 662 lines covered (92% coverage)
```

When the coverage is run with a verbosity value of two, it presents the coverage by tag within the routines as well. Before presenting the summary by routine and overall. The output for %ut and %ut1 is shown below for a Cache system (the output for %utcover showed 100.00% for all tags).

```
Routine %ut           (96.15%)   275 out of 286 lines covered
  - Summary
 Tag %ut^%ut            (100.00%)   2 out of 2 lines covered
 Tag CHKEQ^%ut           (100.00%)   18 out of 18 lines covered
 Tag CHKLEAKS^%ut        (100.00%)   2 out of 2 lines covered
 Tag CHKTF^%ut           (100.00%)   15 out of 15 lines covered
 Tag COV^%ut             (100.00%)   2 out of 2 lines covered
 Tag COVERAGE^%ut        (100.00%)   2 out of 2 lines covered
 Tag DOSET^%ut           (100.00%)   6 out of 6 lines covered
 Tag EN^%ut              (100.00%)   6 out of 6 lines covered
 Tag EN1^%ut             (100.00%)   65 out of 65 lines covered
 Tag ERROR^%ut           (100.00%)   9 out of 9 lines covered
 Tag ERROR1^%ut          (100.00%)   9 out of 9 lines covered
 Tag FAIL^%ut            (100.00%)   2 out of 2 lines covered
 Tag GETLIST^%ut         (100.00%)   11 out of 11 lines covered
 Tag GETSET^%ut          (100.00%)   4 out of 4 lines covered
 Tag GETSYS^%ut          (100.00%)   3 out of 3 lines covered
 Tag GETUTVAL^%ut        (100.00%)   5 out of 5 lines covered
 Tag GTMVER^%ut            (0.00%)   0 out of 1 lines covered
 Tag GUILOAD^%ut         (100.00%)   8 out of 8 lines covered
 Tag GUINEXT^%ut         (100.00%)   43 out of 43 lines covered
 Tag GUISET^%ut          (100.00%)   8 out of 8 lines covered
 Tag ISUTEST^%ut         (100.00%)   1 out of 1 lines covered
 Tag LOAD^%ut            (100.00%)   10 out of 10 lines covered
 Tag LSTUTVAL^%ut        (100.00%)   4 out of 4 lines covered
 Tag MULTAPIS^%ut        (100.00%)   2 out of 2 lines covered
 Tag PICKSET^%ut         (100.00%)   3 out of 3 lines covered
 Tag RUNSET^%ut          (100.00%)   9 out of 9 lines covered
 Tag SETUT^%ut           (100.00%)   6 out of 6 lines covered
 Tag SUCCEED^%ut         (100.00%)   6 out of 6 lines covered
 Tag VERBOSE^%ut         (100.00%)   10 out of 10 lines covered
 Tag VERBOSE1^%ut        (100.00%)   4 out of 4 lines covered
 Tag ZHDIF^%ut             (0.00%)   0 out of 10 lines covered

Routine %ut1           (86.25%)   232 out of 269 lines covered
  - Summary
 Tag %ut1^%ut1           (100.00%)   2 out of 2 lines covered
 Tag ACTLINES^%ut1       (100.00%)   8 out of 8 lines covered
 Tag CACHECOV^%ut1        (88.24%)   15 out of 17 lines covered
 Tag CHECKTAG^%ut1       (100.00%)   10 out of 10 lines covered
 Tag CHEKTEST^%ut1       (100.00%)   9 out of 9 lines covered
 Tag COV^%ut1             (51.39%)   37 out of 72 lines covered
 Tag COVCOV^%ut1         (100.00%)   9 out of 9 lines covered
 Tag COVRPT^%ut1         (100.00%)   5 out of 5 lines covered
 Tag COVRPTLS^%ut1       (100.00%)   31 out of 31 lines covered
 Tag FAIL^%ut1           (100.00%)   12 out of 12 lines covered
 Tag GETTAG^%ut1         (100.00%)   4 out of 4 lines covered
 Tag GETTREE^%ut1        (100.00%)   7 out of 7 lines covered
 Tag GETVALS^%ut1        (100.00%)   11 out of 11 lines covered
 Tag ISUTEST^%ut1        (100.00%)   1 out of 1 lines covered
 Tag LINEDATA^%ut1       (100.00%)   9 out of 9 lines covered
 Tag NEWSTYLE^%ut1       (100.00%)   4 out of 4 lines covered
Tag NVLDARG^%ut1        (100.00%)   11 out of 11 lines covered
Tag RESETIO^%ut1        (100.00%)   2 out of 2 lines covered
Tag RTNANAL^%ut1        (100.00%)   29 out of 29 lines covered
Tag SETIO^%ut1          (100.00%)   2 out of 2 lines covered
Tag TOTAGS^%ut1         (100.00%)   13 out of 13 lines covered
Tag UP^%ut1             (100.00%)   1 out of 1 lines covered
```

When the same analysis is run with a verbosity value of 3 (the value used when the ^%uttcovr routine is run from the top) the output for %ut1 (the tags following COVRPT^%ut1 all showed 100.00% coverage as before) also shows the lines that were NOT covered in the COV^%ut1 tag (and the 19 lines marked with an 'x' indicate those which were not covered in either system).

```
Routine %ut           (96.15%)   275 out of 286 lines covered
  - Detailed Breakdown
 Tag %ut^%ut            (100.00%)   2 out of 2 lines covered
 Tag CHKEQ^%ut          (100.00%)   18 out of 18 lines covered
 Tag CHKLEAKS^%ut       (100.00%)   2 out of 2 lines covered
 Tag CHKTF^%ut          (100.00%)   15 out of 15 lines covered
 Tag COV^%ut            (100.00%)   2 out of 2 lines covered
 Tag COVERAGE^%ut       (100.00%)   2 out of 2 lines covered
 Tag DOSET^%ut          (100.00%)   6 out of 6 lines covered
 Tag EN^%ut             (100.00%)   6 out of 6 lines covered
 Tag EN1^%ut            (100.00%)   65 out of 65 lines covered
 Tag ERROR^%ut          (100.00%)   9 out of 9 lines covered
 Tag ERROR1^%ut         (100.00%)   9 out of 9 lines covered
 Tag FAIL^%ut           (100.00%)   2 out of 2 lines covered
 Tag GETLIST^%ut        (100.00%)   11 out of 11 lines covered
 Tag GETSET^%ut         (100.00%)   4 out of 4 lines covered
 Tag GETSYS^%ut         (100.00%)   3 out of 3 lines covered
 Tag GETUTVAL^%ut       (100.00%)   5 out of 5 lines covered
 Tag GTMVER^%ut           (0.00%)   0 out of 1 lines covered
   the following is a list of the lines **NOT** covered
     GTMVER+1   Q $S($G(X):$P($ZV," ",3,99),1:$P($P($ZV," V",2)," "))
 Tag GUILOAD^%ut        (100.00%)   8 out of 8 lines covered
 Tag GUINEXT^%ut        (100.00%)   43 out of 43 lines covered
 Tag GUISET^%ut         (100.00%)   8 out of 8 lines covered
 Tag ISUTEST^%ut        (100.00%)   1 out of 1 lines covered
 Tag LOAD^%ut           (100.00%)   10 out of 10 lines covered
 Tag LSTUTVAL^%ut       (100.00%)   4 out of 4 lines covered
 Tag MULTAPIS^%ut       (100.00%)   2 out of 2 lines covered
 Tag PICKSET^%ut        (100.00%)   3 out of 3 lines covered
 Tag RUNSET^%ut         (100.00%)   9 out of 9 lines covered
 Tag SETUT^%ut          (100.00%)   6 out of 6 lines covered
 Tag SUCCEED^%ut        (100.00%)   6 out of 6 lines covered
 Tag VERBOSE^%ut        (100.00%)   10 out of 10 lines covered
 Tag VERBOSE1^%ut       (100.00%)   4 out of 4 lines covered
 Tag ZHDIF^%ut            (0.00%)   0 out of 10 lines covered
   the following is a list of the lines **NOT** covered
```

```
    ZHDIF+1   N SC0 S SC0=$P(%ZH0,",",2)
    ZHDIF+2   N SC1 S SC1=$P(%ZH1,",",2)
    ZHDIF+3   N DC0 S DC0=$P(%ZH0,",")*86400
    ZHDIF+4   N DC1 S DC1=$P(%ZH1,",")*86400
    ZHDIF+5   N MCS0 S MCS0=$P(%ZH0,",",3)/1000000
    ZHDIF+6   N MCS1 S MCS1=$P(%ZH1,",",3)/1000000
    ZHDIF+8   N T0 S T0=SC0+DC0+MCS0
    ZHDIF+9   N T1 S T1=SC1+DC1+MCS1
    ZHDIF+11   N %ZH2 S %ZH2=T1-T0*1000
    ZHDIF+12   QUIT %ZH2_"ms"


Routine %ut1          (86.25%)   232 out of 269 lines covered
  - Detailed Breakdown
 Tag %ut1^%ut1          (100.00%)   2 out of 2 lines covered
 Tag ACTLINES^%ut1       (100.00%)   8 out of 8 lines covered
 Tag CACHECOV^%ut1        (88.24%)   15 out of 17 lines covered
   the following is a list of the lines **NOT** covered
    CACHECOV+17   . . N % S %N=0 F XCNP=XCNP+1:1 S %N=%N+1,%=$T(+%N^@X) Q:$L(%)
=0  S @(DIF_XCNP_",0)")=%
    CACHECOV+18   . . Q
 Tag CHECKTAG^%ut1       (100.00%)   10 out of 10 lines covered
 Tag CHEKTEST^%ut1       (100.00%)   9 out of 9 lines covered
 Tag COV^%ut1            (51.39%)   37 out of 72 lines covered
   the following is a list of the lines **NOT** covered
    COV+18   . N NMSP S NMSP=$G(NMSPS)
    COV+19   . D:NMSP]""  S NMSP="" F  S NMSP=$O(NMSPS(NMSP)) Q:NMSP=""  D
    COV+20   .. N %ZR ; GT.M specific
    COV+21   .. D SILENT^%RSEL(NMSP,"SRC") ; GT.M specific. On Cache use $O(^$R
(RTN)).
    COV+22   .. N RN S RN=""
    COV+23   .. F  S RN=$O(%ZR(RN)) Q:RN=""  W RN," " D
    COV+24   ... N L2 S L2=$T(+2^@RN)
    COV+26   . . . S L2=$TR(L2,$C(9)," ") ; change tabs to spaces ; JLI 160316
inserted to replace above
    COV+29   . . . I $E($P(L2," ",2),1,2)'=";;" K %ZR(RN) W !,"Routine "_RN_" r
emoved from analysis, since it doesn't have the standard second line",! ; JLI 16
0316 inserted to replace above
    COV+30   .. M RTNS=%ZR
    COV+31   .. K %ZR
    COV+32   . Q
x    COV+36   . D:NMSP]""  S NMSP="" F  S NMSP=$O(NMSPS(NMSP)) Q:NMSP=""  D
x    COV+52   . K ^TMP("%utCOVCOHORTSAV",$J)
x    COV+53   . M ^TMP("%utCOVCOHORTSAV",$J)=^TMP("%utCOVCOHORT",$J)
x    COV+54   . K ^TMP("%utCOVRESULT",$J)
x    COV+55   . S ^TMP("%utcovrunning",$J)=1,%utcovxx=1
x    COV+57   . I ($$GETSYS^%ut()=47) VIEW "TRACE":1:$NA(^TMP("%utCOVRESULT",$J)
)  ; GT.M START PROFILING
```

```
    COV+59   . I ($$GETSYS^%ut()=0) D  ; CACHE CODE TO START PROFILING
 x    COV+60   . . N NMSP,NMSPV S NMSP="",NMSPV="" F  S NMSPV=$O(RTNS(NMSPV)) Q:N
MSPV=""  S NMSP=NMSP_NMSPV_","
x    COV+61   . . S NMSP=$E(NMSP,1,$L(NMSP)-1)
x    COV+62   . . S STATUS=##class(%Monitor.System.LineByLine).Start($lb(NMSP),$
lb("RtnLine"),$lb($j))
    COV+70   . . SET $ETRAP="Q:($ES&$Q) -9 Q:$ES  W ""CTRL-C ENTERED"""
    COV+71   . . USE $PRINCIPAL:(CTRAP=$C(3))
    COV+72   . . Q
x    COV+88   . . D TOTAGS(COVERSAV,0),TOTAGS(COVER,1)
x    COV+89   . . D ##class(%Monitor.System.LineByLine).Stop()
x    COV+90   . . Q
x    COV+91   . D COVCOV($NA(^TMP("%utCOVCOHORT",$J)),$NA(^TMP("%utCOVRESULT",$J
))) ; Venn diagram matching between globals
x    COV+93   . I VERBOSITY=-1 D
x    COV+94   . . K ^TMP("%utCOVREPORT",$J)
x    COV+95   . . D COVRPTGL^%utcover($NA(^TMP("%utCOVCOHORTSAV",$J)),$NA(^TMP("
%utCOVCOHORT",$J)),$NA(^TMP("%utCOVRESULT",$J)),$NA(^TMP("%utCOVREPORT",$J)))
x    COV+96   . . Q
x    COV+97   . E  D COVRPT($NA(^TMP("%utCOVCOHORTSAV",$J)),$NA(^TMP("%utCOVCOHO
RT",$J)),$NA(^TMP("%utCOVRESULT",$J)),VERBOSITY)
x    COV+98   . Q
 Tag COVCOV^%ut1         (100.00%)   9 out of 9 lines covered
 Tag COVRPT^%ut1         (100.00%)   5 out of 5 lines covered
 Tag COVRPTLS^%ut1       (100.00%)   31 out of 31 lines covered
 Tag FAIL^%ut1           (100.00%)   12 out of 12 lines covered
 Tag GETTAG^%ut1         (100.00%)   4 out of 4 lines covered
 Tag GETTREE^%ut1        (100.00%)   7 out of 7 lines covered
 Tag GETVALS^%ut1        (100.00%)   11 out of 11 lines covered
 Tag ISUTEST^%ut1        (100.00%)   1 out of 1 lines covered
 Tag LINEDATA^%ut1       (100.00%)   9 out of 9 lines covered
 Tag NEWSTYLE^%ut1       (100.00%)   4 out of 4 lines covered
 Tag NVLDARG^%ut1        (100.00%)   11 out of 11 lines covered
 Tag RESETIO^%ut1        (100.00%)   2 out of 2 lines covered
 Tag RTNANAL^%ut1        (100.00%)   29 out of 29 lines covered
 Tag SETIO^%ut1          (100.00%)   2 out of 2 lines covered
 Tag TOTAGS^%ut1         (100.00%)   13 out of 13 lines covered
 Tag UP^%ut1             (100.00%)   1 out of 1 lines covered
```

On a GT.M system the summary output shows

```
Routine %ut      (95.10%)   272 out of 286 lines covered
Routine %ut1      (82.16%)   221 out of 269 lines covered
Routine %utcover     (100.00%)   107 out of 107 lines covered

Overall Analysis 600 out of 662 lines covered (90% coverage)
```

The output from a GT.M system and shows the following output for %ut1 and lines that were also listed in the Cache system output as not being covered have been marked by adding a 'x' at the beginning of the line.

```
Routine %ut1          (82.16%)   221 out of 269 lines covered
  - Detailed Breakdown
 Tag %ut1^%ut1           (100.00%)   2 out of 2 lines covered
 Tag ACTLINES^%ut1       (100.00%)   8 out of 8 lines covered
 Tag CACHECOV^%ut1        (88.24%)   15 out of 17 lines covered
   the following is a list of the lines **NOT** covered
     CACHECOV+14   . . X "N %,%N S %N=0 X ""ZL @X F XCNP=XCNP+1:1 S %N=%N+1,%=$T
(+%N) Q:$L(%)=0  S @(DIF_XCNP_"""",0)"""")=%""" ; JLI see 160701 note in comment
s at top
     CACHECOV+15   . . Q
 Tag CHECKTAG^%ut1       (100.00%)   10 out of 10 lines covered
 Tag CHEKTEST^%ut1       (100.00%)   9 out of 9 lines covered
 Tag COV^%ut1            (51.39%)   37 out of 72 lines covered
   the following is a list of the lines **NOT** covered
     COV+35   . N NMSP S NMSP=$G(NMSPS)
 x    COV+36   . D:NMSP]""  S NMSP="" F  S NMSP=$O(NMSPS(NMSP)) Q:NMSP=""  D
     COV+37   . . S NMSP1=NMSP I NMSP["*" S NMSP1=$P(NMSP,"*")
     COV+38   . . I $D(^$R(NMSP1)) S RTNS(NMSP1)=""
     COV+39   . . I NMSP["*" S RTN=NMSP1 F  S RTN=$O(^$R(RTN)) Q:RTN'[NMSP1  S R
TNS(RTN)=""
     COV+40   . . Q
     COV+41   . Q
x    COV+52   . K ^TMP("%utCOVCOHORTSAV",$J)
x    COV+53   . M ^TMP("%utCOVCOHORTSAV",$J)=^TMP("%utCOVCOHORT",$J)
x    COV+54   . K ^TMP("%utCOVRESULT",$J)
x    COV+55   . S ^TMP("%utcovrunning",$J)=1,%utcovxx=1
x    COV+57   . I ($$GETSYS^%ut()=47) VIEW "TRACE":1:$NA(^TMP("%utCOVRESULT",$J)
)  ; GT.M START PROFILING
x    COV+60   . . N NMSP,NMSPV S NMSP="",NMSPV="" F  S NMSPV=$O(RTNS(NMSPV)) Q:N
MSPV=""  S NMSP=NMSP_NMSPV_","
x    COV+61   . . S NMSP=$E(NMSP,1,$L(NMSP)-1)
x    COV+62   . . S STATUS=##class(%Monitor.System.LineByLine).Start($lb(NMSP),$
lb("RtnLine"),$lb($j))
     COV+63   . . I +STATUS'=1 D DecomposeStatus^%apiOBJ(STATUS,.ERR,"-d") F I=1
:1:ERR W ERR(I),!
     COV+64   . . I +STATUS'=1 K ERR S EXIT=1
     COV+65   . . Q
     COV+79   . I ($$GETSYS^%ut()=0) ; CACHE SPECIFIC
     COV+80   . K %utcovxx,^TMP("%utcovrunning",$J)
     COV+81   . Q
     COV+84   . I ($$GETSYS^%ut()=0) D  ; CACHE SPECIFIC CODE
     COV+85   . . S COVERSAV=$NA(^TMP("%utCOVCOHORTSAV",$J)) K @COVERSAV
     COV+86   . . S COVER=$NA(^TMP("%utCOVCOHORT",$J)) K @COVER
```

```
    COV+87   . . D CACHECOV(COVERSAV,COVER)
x    COV+88   . . D TOTAGS(COVERSAV,0),TOTAGS(COVER,1)
x    COV+89   . . D ##class(%Monitor.System.LineByLine).Stop()
x    COV+90   . . Q
x    COV+91   . D COVCOV($NA(^TMP("%utCOVCOHORT",$J)),$NA(^TMP("%utCOVRESULT",$J
))) ; Venn diagram matching between globals
x    COV+93   . I VERBOSITY=-1 D
x    COV+94   . . K ^TMP("%utCOVREPORT",$J)
x    COV+95   . . D COVRPTGL^%utcover($NA(^TMP("%utCOVCOHORTSAV",$J)),$NA(^TMP("
%utCOVCOHORT",$J)),$NA(^TMP("%utCOVRESULT",$J)),$NA(^TMP("%utCOVREPORT",$J)))
x    COV+96   . . Q
x    COV+97   . E  D COVRPT($NA(^TMP("%utCOVCOHORTSAV",$J)),$NA(^TMP("%utCOVCOHO
RT",$J)),$NA(^TMP("%utCOVRESULT",$J)),VERBOSITY)
x    COV+98   . Q
 Tag COVCOV^%ut1         (100.00%)   9 out of 9 lines covered
 Tag COVRPT^%ut1         (100.00%)   5 out of 5 lines covered
 Tag COVRPTLS^%ut1       (100.00%)   31 out of 31 lines covered
 Tag FAIL^%ut1           (100.00%)   12 out of 12 lines covered
 Tag GETTAG^%ut1         (100.00%)   4 out of 4 lines covered
 Tag GETTREE^%ut1        (100.00%)   7 out of 7 lines covered
 Tag GETVALS^%ut1          (0.00%)   0 out of 11 lines covered
   the following is a list of the lines **NOT** covered
    GETVALS+2   N LINE,MORE,ROUNAME,RSET,VAL,X
    GETVALS+4   S RSET=##class(%ResultSet).%New("%Monitor.System.LineByLine:Res
ult")
    GETVALS+5   S ROUNAME=##class(%Monitor.System.LineByLine).GetRoutineName(RO
UNUM)
    GETVALS+6   S LINE=RSET.Execute(ROUNAME)
    GETVALS+7   F LINE=1:1 S MORE=RSET.Next() Q:'MORE  D
    GETVALS+8   . S X=RSET.GetData(1)
    GETVALS+9   . S VAL=$LI(X,MTRICNUM)
    GETVALS+10   . S @GLOB@(ROUNAME,LINE,"C")=+VAL ; values are 0 if not seen,
otherwises positive number
    GETVALS+11   . Q
    GETVALS+12   D RSET.Close()
    GETVALS+13   Q
 Tag ISUTEST^%ut1        (100.00%)   1 out of 1 lines covered
 Tag LINEDATA^%ut1       (100.00%)   9 out of 9 lines covered
 Tag NEWSTYLE^%ut1       (100.00%)   4 out of 4 lines covered
 Tag NVLDARG^%ut1        (100.00%)   11 out of 11 lines covered
 Tag RESETIO^%ut1        (100.00%)   2 out of 2 lines covered
 Tag RTNANAL^%ut1        (100.00%)   29 out of 29 lines covered
 Tag SETIO^%ut1          (100.00%)   2 out of 2 lines covered
 Tag TOTAGS^%ut1         (100.00%)   13 out of 13 lines covered
 Tag UP^%ut1             (100.00%)   1 out of 1 lines covered


Routine %ut1           (83.04%)   235 out of 283 lines covered
```

```
  - Detailed Breakdown
 Tag %ut1^%ut1           (100.00%)   2 out of 2 lines covered
 Tag ACTLINES^%ut1       (100.00%)   8 out of 8 lines covered
 Tag CACHECOV^%ut1        (88.24%)   15 out of 17 lines covered
   the following is a list of the lines **NOT** covered
     CACHECOV+14   . . X "N %,%N S %N=0 X ""ZL @X F XCNP=XCNP+1:1 S %N=%N+1,%=$T
(+%N) Q:$L(%)=0  S @(DIF_XCNP_"""",0)"""")=%""" ; JLI see 160701 note in comment
s at top
     CACHECOV+15   . . Q
 Tag CHECKTAG^%ut1       (100.00%)   10 out of 10 lines covered
 Tag CHEKTEST^%ut1       (100.00%)   9 out of 9 lines covered
 Tag COV^%ut1             (51.39%)   37 out of 72 lines covered
   the following is a list of the lines **NOT** covered
     COV+35   . N NMSP S NMSP=$G(NMSPS)
x     COV+36   . D:NMSP]""  S NMSP="" F  S NMSP=$O(NMSPS(NMSP)) Q:NMSP=""  D
     COV+37   . . S NMSP1=NMSP I NMSP["*" S NMSP1=$P(NMSP,"*")
     COV+38   . . I $D(^$R(NMSP1)) S RTNS(NMSP1)=""
     COV+39   . . I NMSP["*" S RTN=NMSP1 F  S RTN=$O(^$R(RTN)) Q:RTN'[NMSP1  S R
TNS(RTN)=""
     COV+40   . . Q
     COV+41   . Q
x     COV+52   . K ^TMP("%utCOVCOHORTSAV",$J)
x     COV+53   . M ^TMP("%utCOVCOHORTSAV",$J)=^TMP("%utCOVCOHORT",$J)
x     COV+54   . K ^TMP("%utCOVRESULT",$J)
x     COV+55   . S ^TMP("%utcovrunning",$J)=1,%utcovxx=1
x     COV+57   . I ($$GETSYS^%ut()=47) VIEW "TRACE":1:$NA(^TMP("%utCOVRESULT",$J)
)  ; GT.M START PROFILING
x     COV+60   . . N NMSP,NMSPV S NMSP="",NMSPV="" F  S NMSPV=$O(RTNS(NMSPV)) Q:N
MSPV=""  S NMSP=NMSP_NMSPV_","
x     COV+61   . . S NMSP=$E(NMSP,1,$L(NMSP)-1)
x     COV+62   . . S STATUS=##class(%Monitor.System.LineByLine).Start($lb(NMSP),$
lb("RtnLine"),$lb($j))
     COV+63   . . I +STATUS'=1 D DecomposeStatus^%apiOBJ(STATUS,.ERR,"-d") F I=1
:1:ERR W ERR(I),!
     COV+64   . . I +STATUS'=1 K ERR S EXIT=1
     COV+65   . . Q
     COV+79   . I ($$GETSYS^%ut()=0) ; CACHE SPECIFIC
     COV+80   . K %utcovxx,^TMP("%utcovrunning",$J)
     COV+81   . Q
     COV+84   . I ($$GETSYS^%ut()=0) D  ; CACHE SPECIFIC CODE
     COV+85   . . S COVERSAV=$NA(^TMP("%utCOVCOHORTSAV",$J)) K @COVERSAV
     COV+86   . . S COVER=$NA(^TMP("%utCOVCOHORT",$J)) K @COVER
     COV+87   . . D CACHECOV(COVERSAV,COVER)
x     COV+88   . . D TOTAGS(COVERSAV,0),TOTAGS(COVER,1)
x     COV+89   . . D ##class(%Monitor.System.LineByLine).Stop()
x     COV+90   . . Q
x     COV+91   . D COVCOV($NA(^TMP("%utCOVCOHORT",$J)),$NA(^TMP("%utCOVRESULT",$J
))) ; Venn diagram matching between globals
```

```
x     COV+93   . I VERBOSITY=-1 D
x     COV+94   . . K ^TMP("%utCOVREPORT",$J)
x     COV+95   . . D COVRPTGL($NA(^TMP("%utCOVCOHORTSAV",$J)),$NA(^TMP("%utCOVCOH
ORT",$J)),$NA(^TMP("%utCOVRESULT",$J)),$NA(^TMP("%utCOVREPORT",$J)))
x     COV+96   . . Q
x     COV+97   . E  D COVRPT($NA(^TMP("%utCOVCOHORTSAV",$J)),$NA(^TMP("%utCOVCOHO
RT",$J)),$NA(^TMP("%utCOVRESULT",$J)),VERBOSITY)
x     COV+98   . Q
 Tag COVCOV^%ut1         (100.00%)   9 out of 9 lines covered
 Tag COVRPT^%ut1         (100.00%)   5 out of 5 lines covered
 Tag COVRPTGL^%ut1       (100.00%)   14 out of 14 lines covered
 Tag COVRPTLS^%ut1       (100.00%)   31 out of 31 lines covered
 Tag FAIL^%ut1           (100.00%)   12 out of 12 lines covered
 Tag GETTAG^%ut1         (100.00%)   4 out of 4 lines covered
 Tag GETTREE^%ut1        (100.00%)   7 out of 7 lines covered
 Tag GETVALS^%ut1          (0.00%)   0 out of 11 lines covered
   the following is a list of the lines **NOT** covered
     GETVALS+2   N LINE,MORE,ROUNAME,RSET,VAL,X
     GETVALS+4   S RSET=##class(%ResultSet).%New("%Monitor.System.LineByLine:Res
ult")
     GETVALS+5   S ROUNAME=##class(%Monitor.System.LineByLine).GetRoutineName(RO
UNUM)
     GETVALS+6   S LINE=RSET.Execute(ROUNAME)
     GETVALS+7   F LINE=1:1 S MORE=RSET.Next() Q:'MORE  D
     GETVALS+8   . S X=RSET.GetData(1)
     GETVALS+9   . S VAL=$LI(X,MTRICNUM)
     GETVALS+10   . S @GLOB@(ROUNAME,LINE,"C")=+VAL ; values are 0 if not seen,
otherwises positive number
     GETVALS+11   . Q
     GETVALS+12   D RSET.Close()
     GETVALS+13   Q
 Tag ISUTEST^%ut1        (100.00%)   1 out of 1 lines covered
 Tag LINEDATA^%ut1       (100.00%)   9 out of 9 lines covered
 Tag NEWSTYLE^%ut1       (100.00%)   4 out of 4 lines covered
 Tag NVLDARG^%ut1        (100.00%)   11 out of 11 lines covered
 Tag RESETIO^%ut1        (100.00%)   2 out of 2 lines covered
 Tag RTNANAL^%ut1        (100.00%)   29 out of 29 lines covered
 Tag SETIO^%ut1          (100.00%)   2 out of 2 lines covered
 Tag TOTAGS^%ut1         (100.00%)   13 out of 13 lines covered
 Tag UP^%ut1             (100.00%)   1 out of 1 lines covered
```

Coverage on the GT.M and Cache systems varies due to sections that are system specific. When the output for the %ut1 routines are compared there were 19 lines that are not executed in both Cache and GT.M systems so a combined coverage across both systems for the %ut1 routine is 92.93% [Actually, 15 lines of the code not covered in both systems is related to the code that is starting the coverage analysis and code that turns off the coverage and performs the analyses, so really only 4 lines of code were not used in both systems]. In %ut there are 10 lines which were not covered in the above analyses in both systems (all in the tag ZHDIF which is GT.M specific and related to the determination of fractional milliseconds for execution times and is only available in GT.M systems version 6.3 and above), but these lines were covered in the analysis of coverage in the GT.M system on a GT.M version 6.3 system without VistA support, so across all three systems, coverage was 100% for %ut. In %utcover the coverage was 100% in all three systems.

On-going/Future plans for M-Unit functionality:

As a unique program in the realm of M[UMPS] code testing but following in the footsteps of other well established unit test frameworks, the M-Unit software will continue to move forward and improve (as the @TEST indicator was added based on changes in NUnit and Junit and coverage analysis for both GT.M and Intersystems). So far this is the sixth release of M-Unit to the open source community working to improve the functionality for the community. M-Unit will likely branch out and expand the types of checks that are available, matching the functions of other established test beds.

Summary

M-Unit provides a tool which can assist in writing and modifying routines in M projects with an aim to minimizing flaws in development and in the ongoing life of the software.