APL64: Using □HTLC and □HTLS

Contents

Overview

Communication between APL64 instance

The □HTLC and □HTLS system functions support communication between APL64 instances. Communication uses □HTLC actions, such as Exec, Call, SysCall, CallAsync, etc.

Typical Uses

A Client APL instance creates one or more local APL instances and uses them as APL64 workspace engines with separate workspaces, functions, variables as necessary.

One or more client APL instances access a shared APL server instance, with each client updating the state of the APL server instance.

One or more client APL instances access one server APL instance which is the front-facing server which sends specific requests to additional server APL instances.

Client and Server Configuration

Instances of the APL64 Developer version can be configured as client and server using the □HTLC and □HTLS system functions. In this configuration the client and server instances of APL64 communicate using the http protocol. The client uses a .Net HTTPClient object. The server uses a .Net Kestrel server object listening on a programmer-specified url.

Local and Remote Servers

An APL instance as a client using the □HTLC 'ListenLocal' action can create one or more local servers (on the same machine) for exclusive use by that client.

An APL instance can become a server using ⎕HTLS ‘Listen’. This server can be local or remote with respect to potential clients.

Each server includes an independent APL64 interpreter (workspace engine). A server can exist on any compatible machine connected to the Internet or local area network supporting the http/https protocol. All required server components are included in APL64.

Example: Local Exclusive Server for a Client

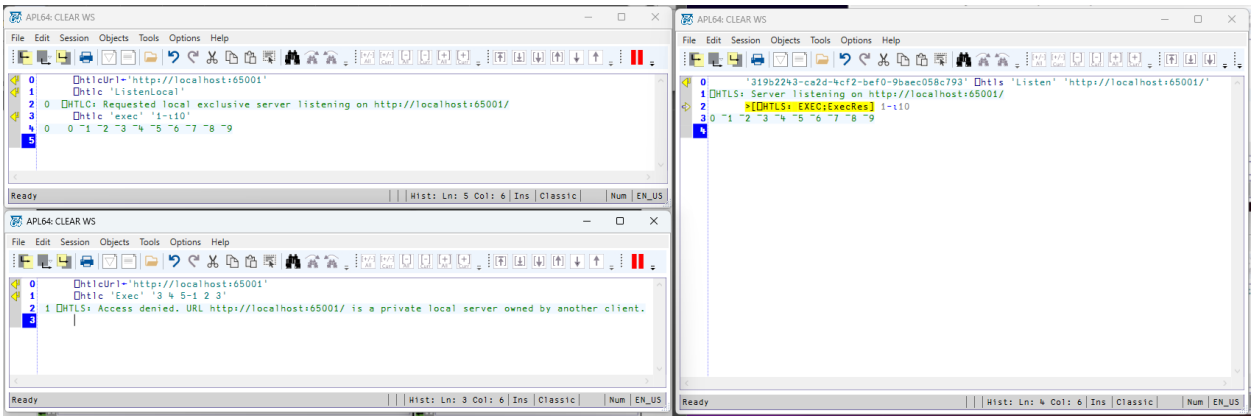
Client #1 Creates a local exclusive server and uses it:

```
⎕htlcUrl←'http://localhost:65001'
⎕htlc 'ListenLocal'
⎕htlc 'exec' '1-⍳10'
```

Client #2 attempts to access client #1 local exclusive server:

```
⎕htlcUrl←'http://localhost:65001'
⎕htlc 'Exec' '3 4 5-1 2 3'
```

Client #2 is denied access to client #1 server:



Multiple Clients and Servers

Multiple clients and servers can interact using ⎕HTLC. A server can listen on one or more urls. A client can access more than one server.

Development and Runtime Support

⎕HTLC and ⎕HTLS system functions can be used in APL64 developer version instances and in the APL64 runtime environment, including a Windows Runtime Executable (WRE) and a cross-platform component (CPC).

Client Actions using ⎕HTLC

⎕HTLC actions create client requests for the server to perform server-side processing. Results from the server are returned to the client. ⎕HTLC actions, such as Exec and Call, can initiate processing on an ⎕HTLS server.

All ⎕HTLC client actions initiated by one client are synchronous, except for the CallAsync action, so that the client waits for a response from the server until the server satisfies the request. The wait time is limited to the programmer-selected ⎕HTLC 'Timeout'. An exception is thrown if the timeout is exceeded.

Results provided to the client by the server include two or three elements:

- hasError (bool): 0/No error 1/error occurred
- errMsg (character vector) Empty unless an error occurred
- result value, if any, depends on the operation the client request from the server

The CallAsync action does not block the client processing, so that multiple CallAsync requests can be made to the server without waiting for the results. The CallAsync action responds immediately with an acknowledgement that the server has received the request. The CallAsync result from the server-side is received by the client asynchronously as a callback. The client specifies the APL64 programmer-defined function which will handle the callback. Each CallAsync action has a programmer-provided request identifier.

Server-side Debugging Supported

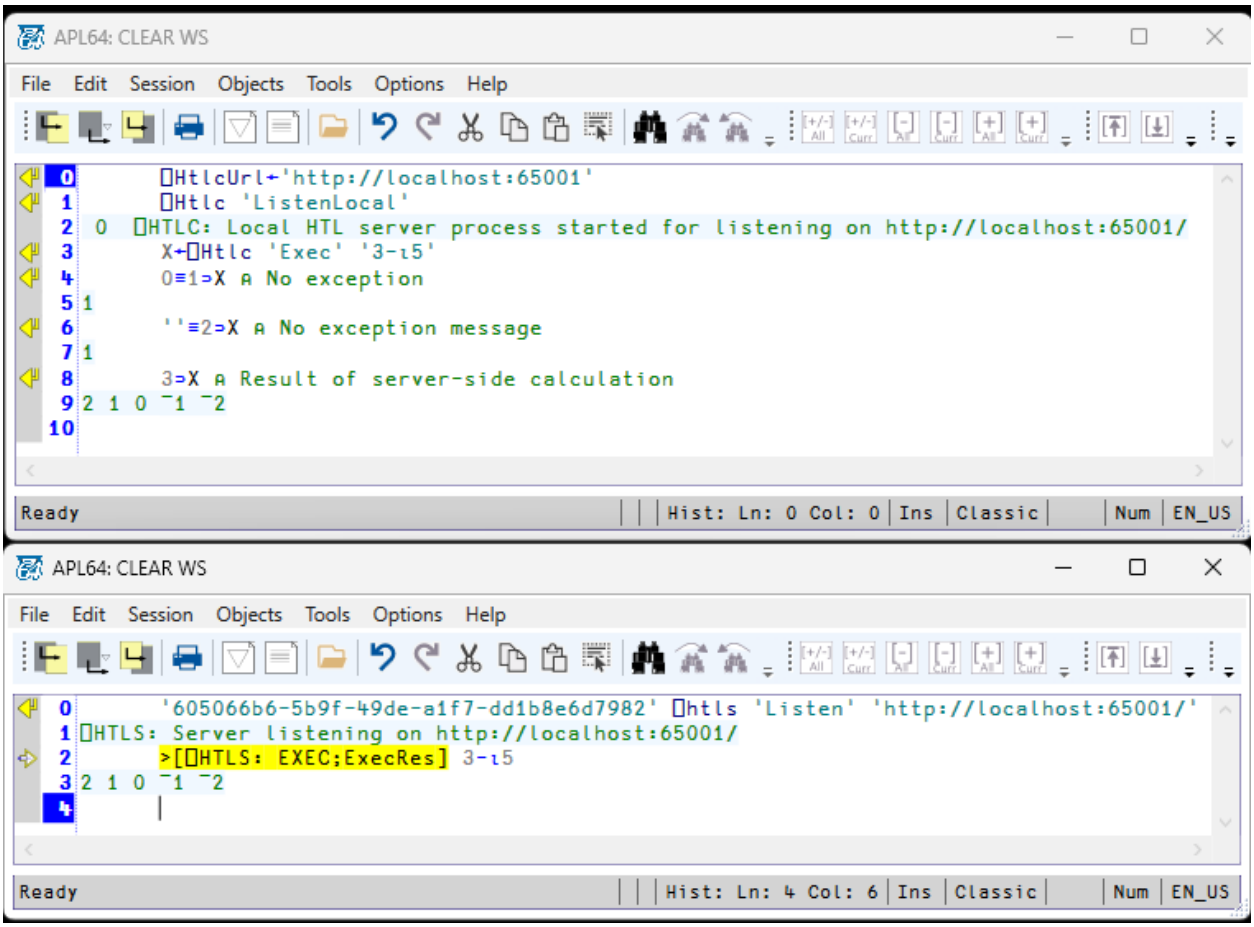
Both the client and server can be independently debugged when they are based on APL64 Developer version instances.

Simple Example

In this example an APL64 Developer version instance is the client. The client specifies the url for listening. The client uses the ⎕Htlc 'ListenLocal' action to create another APL64 Developer version instance listening on the url. The local server is for the exclusive use of the client. The client uses the ⎕Htlc 'Exec' action to perform a calculation on the server and obtains the result value. The client and server display the operations in their respective history panes, which exist because both the client and server are APL64 Developer version instances. The client-specified action on the server may produce a result, depending on the action.

Results from the server are received by the client as a two- or three-element APL64 vector: (hasErr(bool) errMsg(text) resultValue)

```
⎕HtlcUrl←'http://localhost:65001'
⎕Htlc 'ListenLocal'
X←⎕Htlc 'Exec' '3-⍳5'
0≡1⊃X ⍝ No exception
''≡2⊃X ⍝ No exception message
3⊃X ⍝ Result of server-side calculation
```



Local Exclusive or Public Server

If the server being accessed by the client was created by the client using the ⎕HTLC ListenLocal action, that server is for the exclusive use of that client. Requests from other clients made to that server are refused.

If the server being accessed by the client was created from an independent APL instance using the ⎕HTLS Listen action, that server is a public server which can be accessed by any client via this server's listened url)s.

Synchronous ⎕HTLC actions from the same Client

All ⎕HTLC actions from the same client, except for CallAsync, are synchronous for that client instance of APL64. The client requests server-side processing and waits for result from server. Only the server is listening on a url.

Asynchronous ⎕HTLC CallAsync action

For the CallAsync action the client requests server-side processing, the server acknowledges the request, and client can continue with additional actions.

When server completes the processing request, the server calls back to the client with the result.

The client and server are listening on separate urls, one url for the client to send the request to the server, and one for the server to send the result to the client.

Requests and Results associated with one Client

When the server, listening to one or more urls, receives a request from a client, the response to the client from the server will be returned over the url used by the client to access the server. No other clients will receive this response.

Multiple Clients accessing the same Server

When multiple clients make requests to the same server, it is the responsibility of the APL64 programmer to assure that client requests should represent independent processing requests, with no dependencies between other requests.

Requests by multiple clients to the same server are not queued by that server.

As client requests are satisfied by a server, the state of the current workspace on that client is updated. Subsequent client requests to that server will access that workspace state.

If multiple clients are accessing the same server, the responses from the server to these clients are not necessarily returned in the same order that the requests were received by the server.

Processing time for a request determines when a response can be returned by the server to the requesting client.

A ⎕HTLS server uses separate asynchronous tasks (with OS-assigned independent threads) to process client requests, which do not provide for a guaranteed processing order.

⎕HTLC Actions

The ⎕HTLC system function is used on a client instance of APL64. ⎕HTLC actions are executed on the server instance of APL64.

Syntax: [listenUrl] ⎕HTLC Action [arg1] ...

The listenUrl is an optional ⎕HTLC argument. ⎕HtlcUrl system variable can be set to contain the required URL value, instead of specifying that URL as a left argument to ⎕HTLC actions which require a URL value.

Call

The Call action executes a user-defined function on the HTLS server.

Syntax: (hasErr errMsg result) ← [serverUrl] ⎕HTLC 'Call' aplFnName [rarg] [larg]

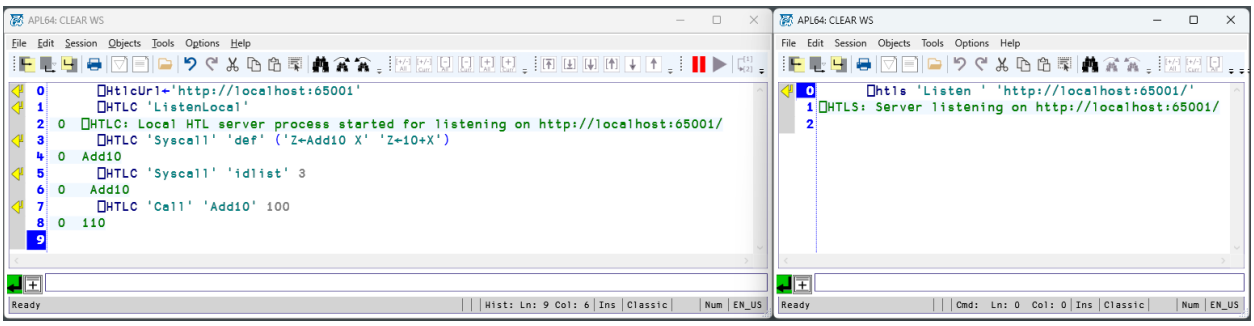
The aplFnName parameter is required. It specifies the name of the APL function to be called. The rar and larg parameters are optional. Omit both parameters to make a niladic function call. Specify Argument but omit larg to make a monadic function call. Specify both parameters to make a dyadic function call. You cannot specify larg if you omit rarg.

The Call action returns a three-element APL64 vector:

(hasErr(bool) errMsg(text) resultValue)

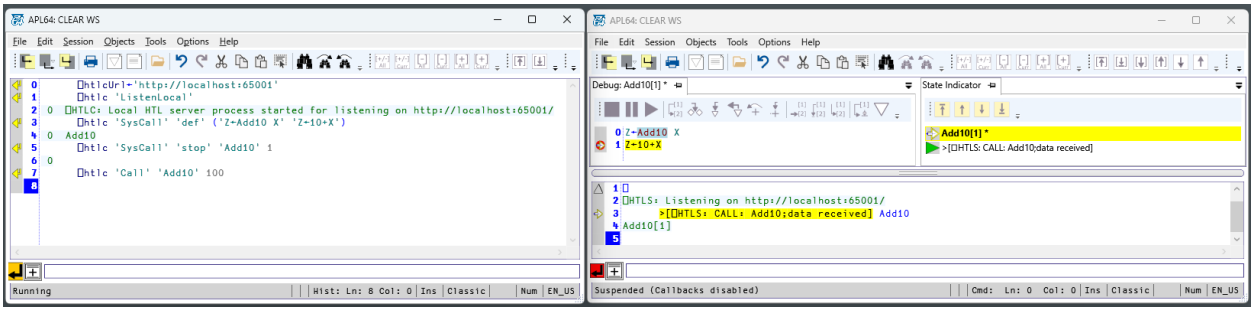
Example #1: Without Stop in the server-side function

```
'http://localhost:65001' ⎕HTLC 'ListenLocal'
'http://localhost:65001' ⎕HTLC 'Syscall' 'idlist' 3
'http://localhost:65001' ⎕HTLC 'Syscall' 'def' ('Z←Add10 X' 'Z←10+X')
'http://localhost:65001' ⎕HTLC 'Syscall' 'idlist' 3
'http://localhost:65001' ⎕HTLC 'Call' 'Add10' 100
```



Example #2: With stop in the server-side function:

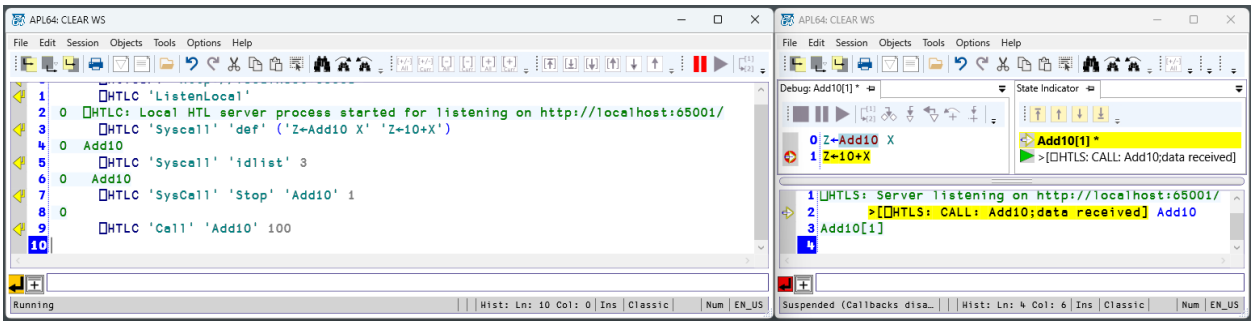
```
htlcUrl←'http://localhost:65001'
HTLC 'ListenLocal'
HTLC 'SysCall' 'DEF' ('Z←Add10 X' 'Z←10+X')
HTLC 'SysCall' 'Stop' 'Add10' 1
HTLC 'Call' 'Add10' 100
```



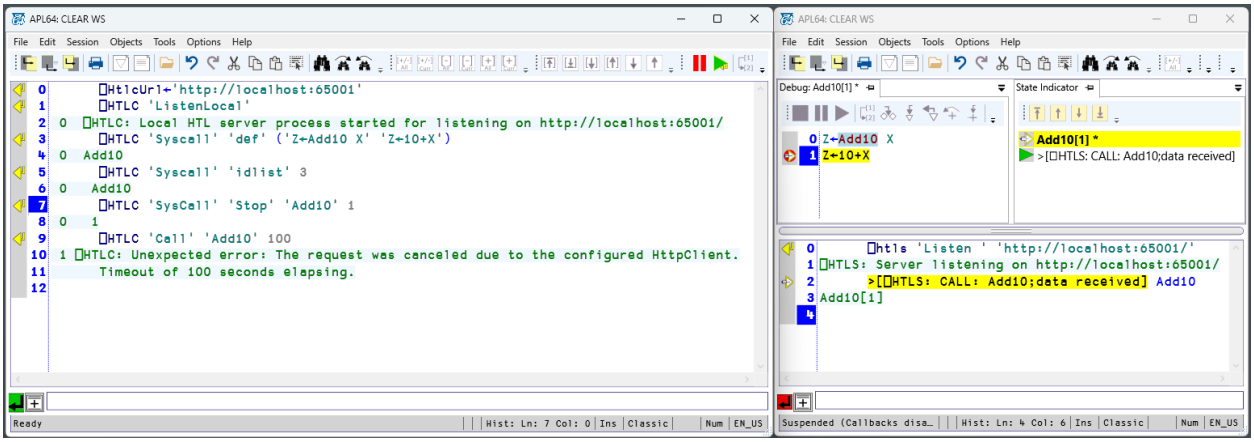
Example #3: With stop in the server-side function, and executing a server-side function directly on the server-side:

```
htlcUrl←'http://localhost:65001'
htlc 'ListenLocal'
htlc 'SysCall' 'def' ('Z←Add10 X' 'Z←10+X')
htlc 'SysCall' 'stop' 'Add10' 1
htlc 'Call' 'Add10' 100
```

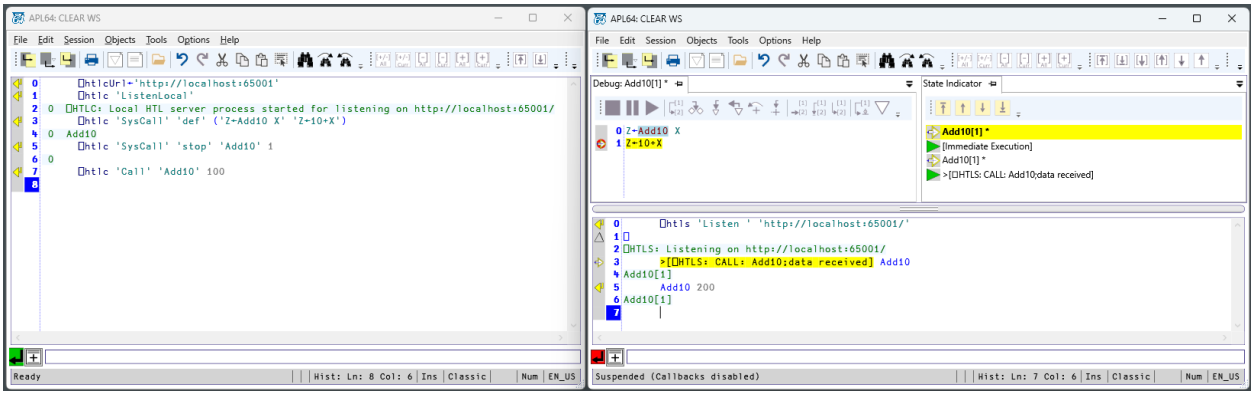
A suspension occurs on the server-side, and the client-side is waiting for a response from the server-side:



In this example if the server-side suspension persists, the client-side timeout will be exceeded. The expiration of the client-side timeout does not modify the server-side state:



In this example after executing the client-side statements, directly execute Add10 200 on the server-side. The server-side state now includes the two pending Add10 execution requests.



CallAsync

The CallAsync action improves application performance in asynchronous execution of a server-side function when many such operations are necessary. Such processing requests can be spread among multiple ⎕HTLS servers.

Syntax: (hasErr errMsg result) ← [serverUrl] ⎕HTLC 'CallAsync' reqId rUrl cFn sFn [rArg] [lArg]

reqId is a text value which uniquely identifies a CallAsync action. The reqId is returned to the client in the server responses to the client's CallAsync action.

rUrl is the response url on which the client is listening. It is the responsibility of the client to have an APL64 instance listening on the rUrl. Generally, the APL64 instance listening on the rUrl is the client instance, in which case use the ⎕HTLS 'Listen' rUrl action to start the client listing on the rUrl.

cFn is the name of the APL64 programmer-defined function which will be run on the APL64 instance listening on the rUrl. Generally, this APL64 instance is the client APL64 instance. The cFn should have no result, no left argument, and a required right argument.

cFn rArg Elt#	Data Type	Description of cFn rArg Elements
1	bool	hasErr
2	Char[]	errMsg
3	(reqId sFnResult)	hasErr is false
3	reqId	hasErr is true

sFn is the name of the server-side APL64 programmer-defined function which will be run on the server side. The sFn may have an optional result.

rArg and lArg are the optional arguments of the sFn on the server side.

The CallAsync action is a symmetric action, because both the client and server machines assume client and server roles.

Before the ⎕HTLC CallAsync action is used:

- The server must be listening on a url
- The client must be listening on a different url

When the CallAsync action is used, the server immediately sends an acknowledgement back to the client indicating that the CallAsync processing request has been received. This design allows the client to continue sending additional CallAsync processing requests to a server, while the previously sent CallAsync requests are being processed by that server.

All CallAsync actions must represent independent calculation requests on the server as there is no guarantee of the order in which CallAsync processing requests will be fully satisfied by the server.

The server's fullfillment of a CallAsync request occurs when the actual result of running the sFn is sent as an ⎕HTLC Call request to the rUrl to run the cFn.

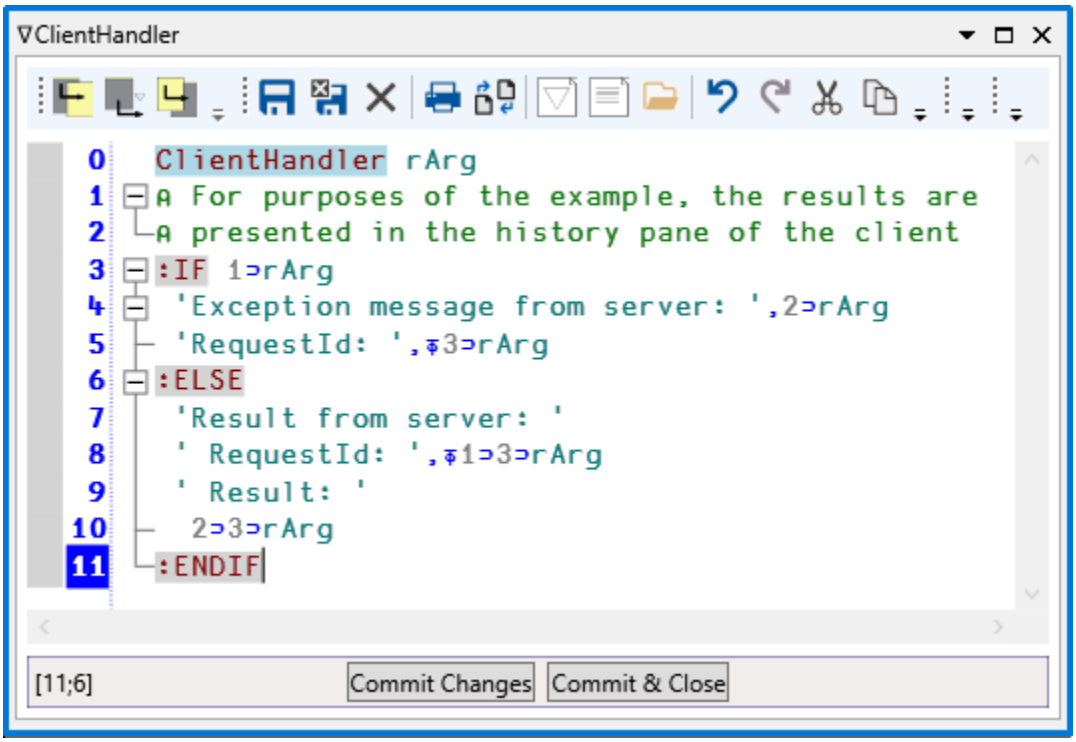
If the client and server are running within instances of the APL64 development version and the server is visible, it is possible to debug a CallAsync action.

Example:

In this example the client will use the CallAsync action to run a function on the server. The client defines the handler function which will handle the asynchronous output from the server and starta the client listening on the response url.

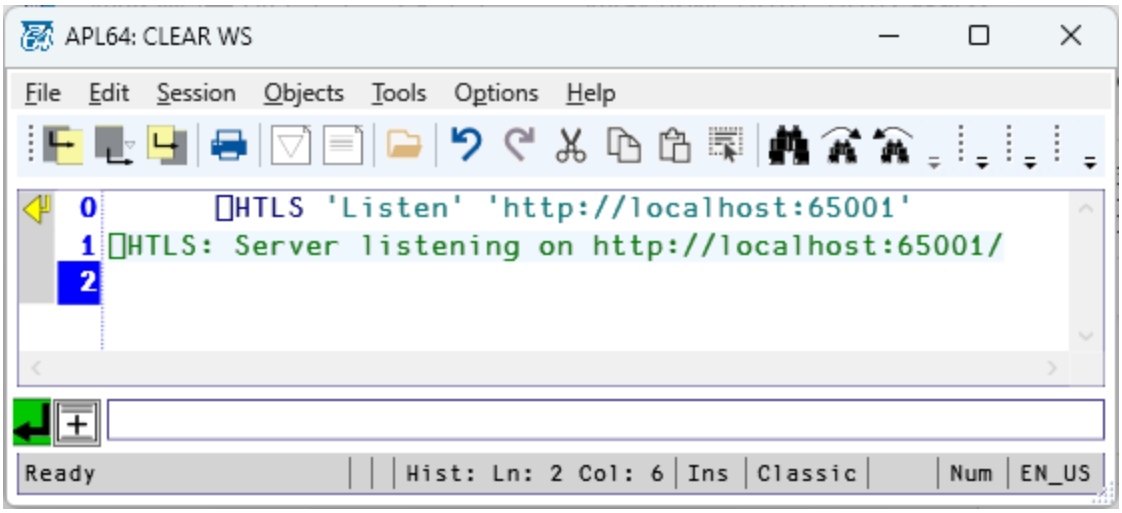
```
ClientHandler rArg
⍝ For purposes of the example, the results are
⍝ presented in the history pane of the client
:IF 1⊃rArg
```

```
 'Exception message from server: ',2⊃rArg
 'RequestId: ', ⍕ 3⊃rArg
:ELSE
 'Result from server: '
 ' RequestId: ', ⍕ 1⊃3⊃rArg
 ' Result: '
  2⊃3⊃rArg
:ENDIF
```



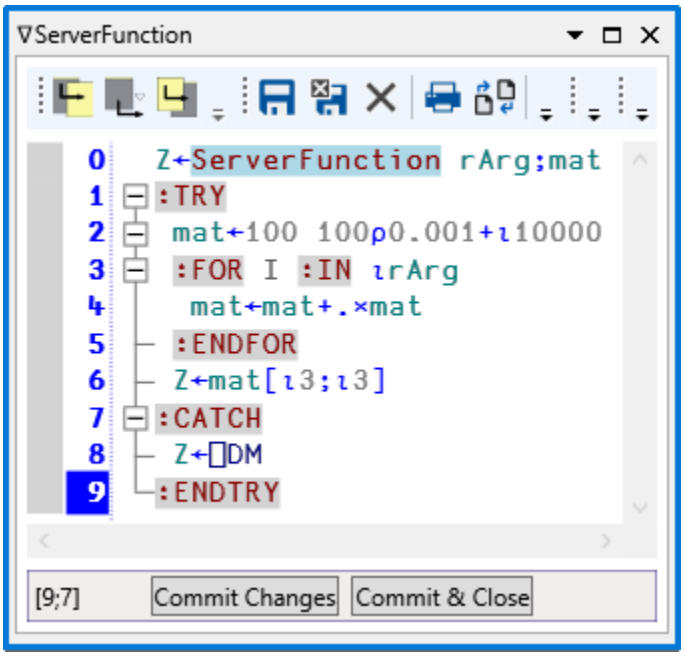
Start the client listening on a specified url, so the client can receive the asynchronous result from the server.

```
 HTLS 'Listen' 'http://localhost:65001'
```



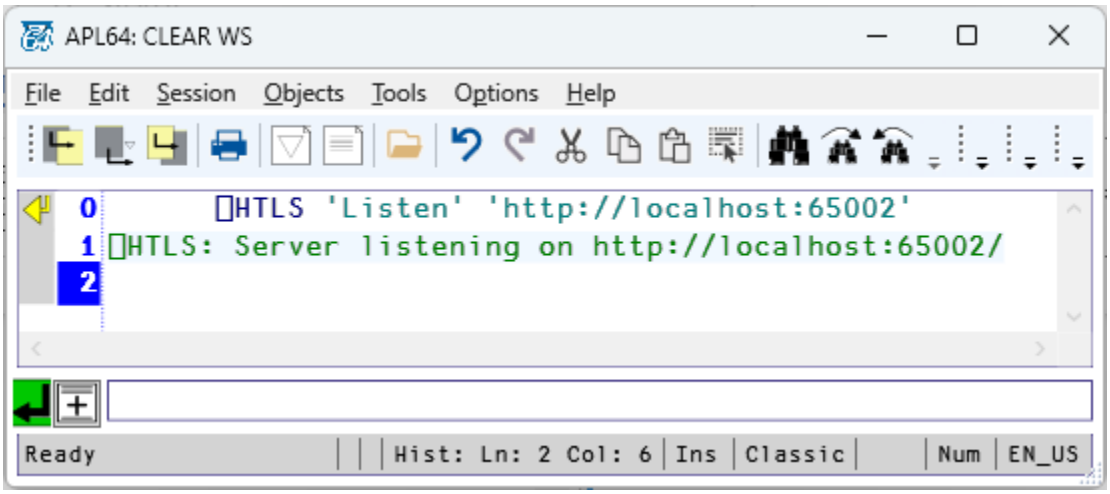
On the server create the function which will be run by the clients CallAsync action:

```
Z←ServerFunction rArg;mat
:TRY
 mat←100 100⍴0.001+⍳10000
 :FOR I :IN ⍳rArg
  mat←mat+.×mat
 :ENDFOR
 Z←mat[⍳3;⍳3]
:CATCH
 Z←⎕DM
:ENDTRY
```



Start the server listening on a different url, so the server can receive the client's CallAsync request.

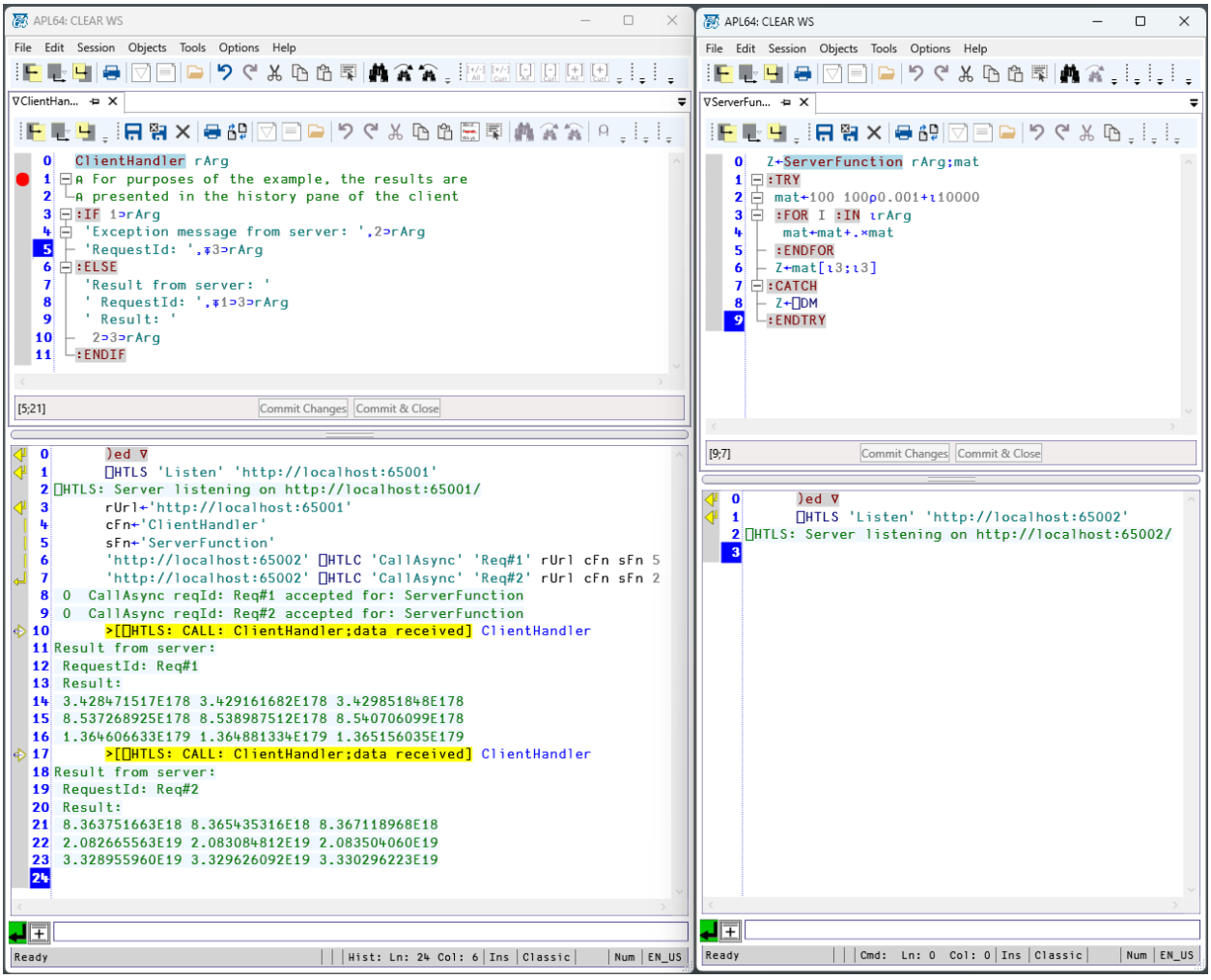
```
]HTLS 'Listen' 'http://localhost:65002'
```



On the client, run multiple CallAsync actions as a multi-line statement from the APL64 command line:

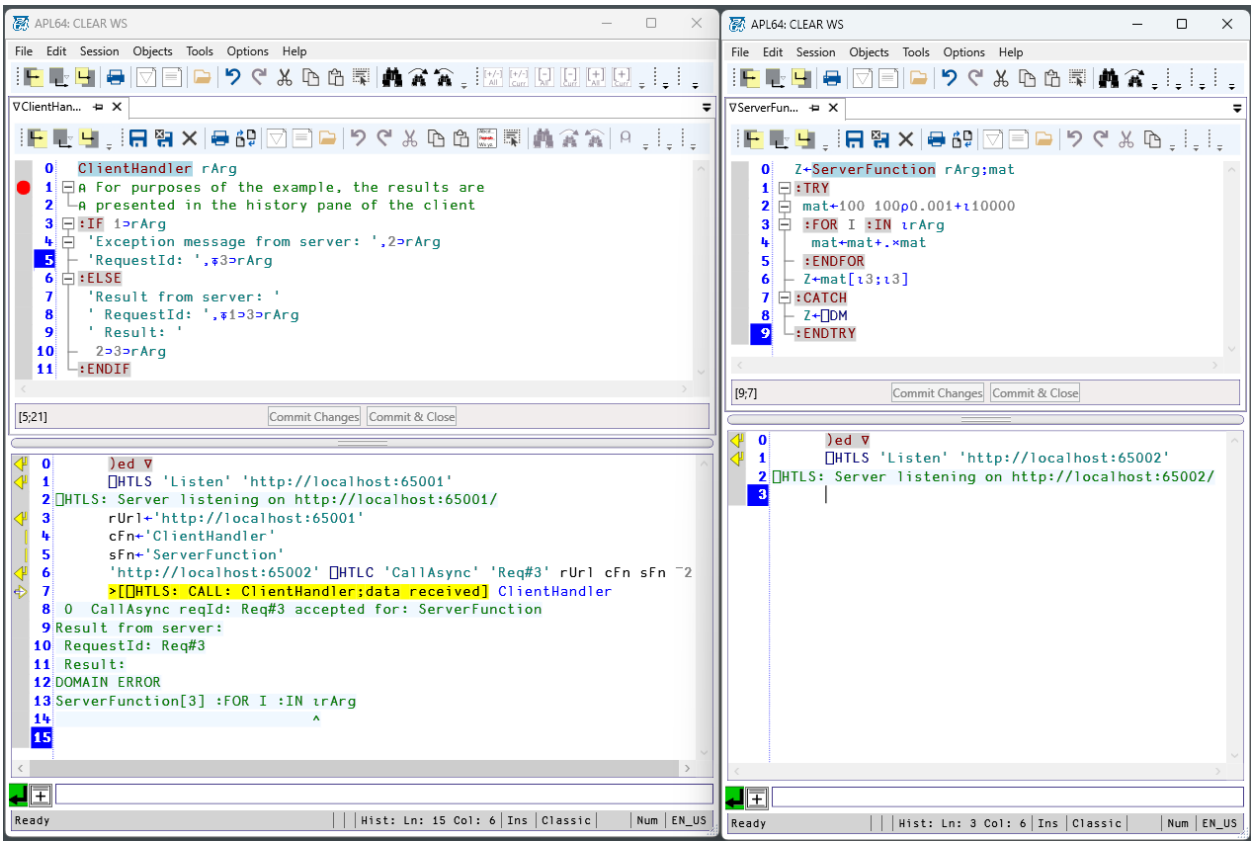
```
rUrl←'http://localhost:65001'
cFn←'ClientHandler'
sFn←'ServerFunction'
'http://localhost:65002' ]HTLC 'CallAsync' 'Req#1' rUrl cFn sFn 5
'http://localhost:65002' ]HTLC 'CallAsync' 'Req#2' rUrl cFn sFn 2
```

Both client]HTLC CallAsync requests are immediately accepted for processing by the]HTLS server. The results of running the ServerFunction on the server are reported back to the client as asynchronous callbacks. These results are sent from the server as]HTLC Call requests to the client which is running as an]HTLS server:



On the client, make an ⎕HTLC CallAsync request which will trigger an exception in the ServerFunction to see the exception reported from the server to the client via an ⎕HTLC Call action:

```
'http://localhost:65002' ⎕HTLC 'CallAsync' 'Req#3' rUrl cFn sFn ¯2
```



Exec

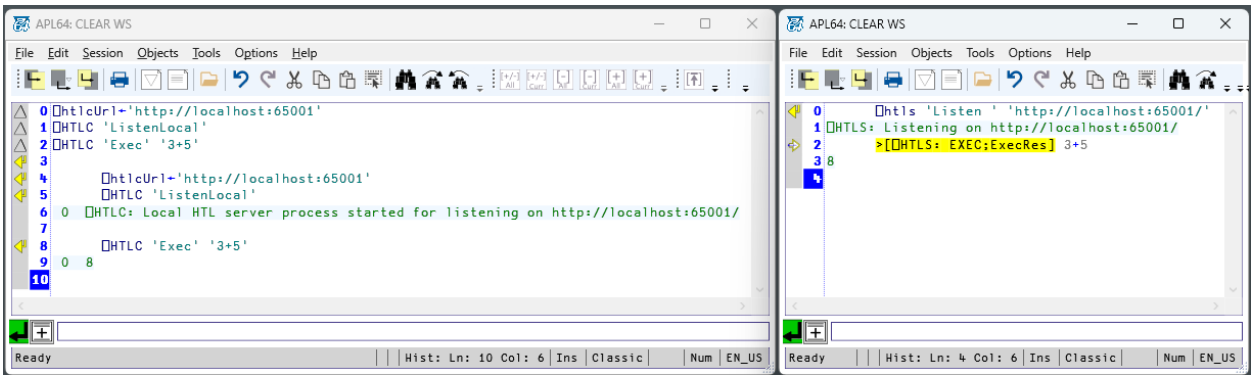
The Exec action executes an APL statement and returns its result value on the HTLS server.

Syntax: (hasErr errMsg result) ← [serverUrl] ⎕HTLC 'Exec' execStmt

execStmt may be a character scalar, character vector or string scalar.

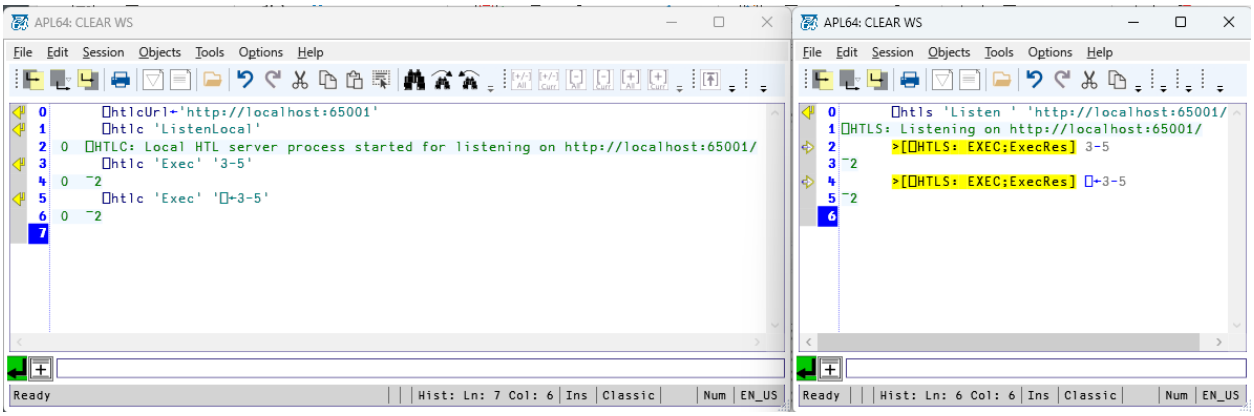
Example #1:

```
⎕htlcUrl←'http://localhost:65001'
⎕HTLC 'ListenLocal'
⎕HTLC 'Exec' '3+5'
```



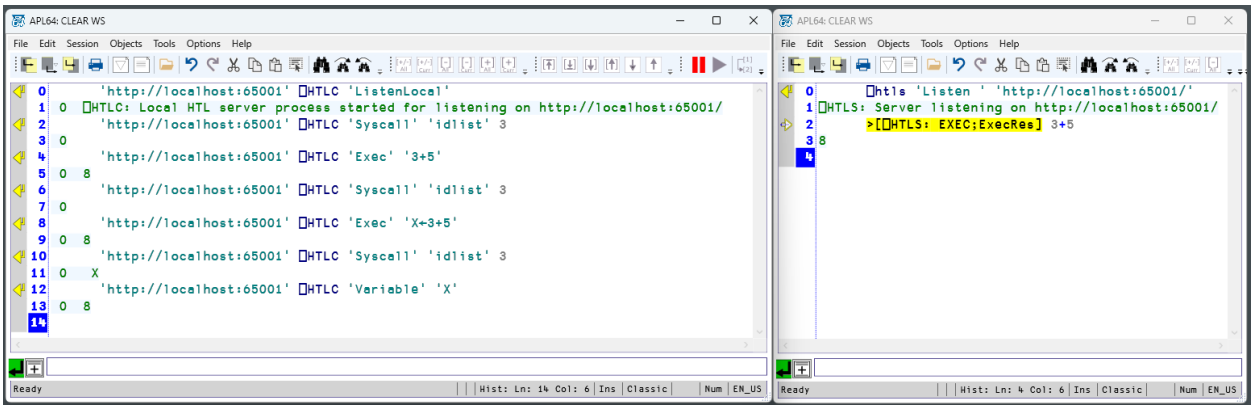
Example #2:

```
htlcUrl←'http://localhost:65001'
htlc 'ListenLocal'
htlc 'Exec' '3-5'
htlc 'Exec' '←3-5'
```



Example #3:

```
'http://localhost:65001' HTLC 'ListenLocal'
'http://localhost:65001' HTLC 'Syscall' 'idlist' 3
'http://localhost:65001' HTLC 'Exec' '3+5'
'http://localhost:65001' HTLC 'Syscall' 'idlist' 3
'http://localhost:65001' HTLC 'Exec' 'X←3+5'
'http://localhost:65001' HTLC 'Syscall' 'idlist' 3
'http://localhost:65001' HTLC 'Variable' 'X'
```



GetClientId

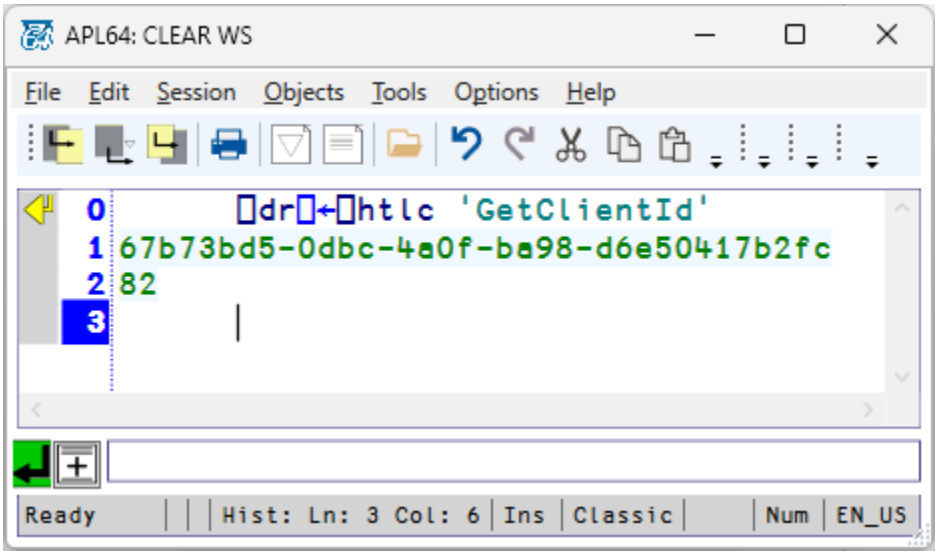
The GetClientId action returns a value used to identify the HTLC client and maintain exclusivity of local HTLS servers.

Syntax: clientId ← ⎕HTLC 'GetClientId'

The clientId is a character vector. This value is set the first time an HTLC client action is performed and is constant thereafter for the duration of the client's APL64 instance. Sharing a clientId could compromise the security of a local, exclusive HTLS server.

Example:

```
⎕dr⎕←⎕htlc 'GetClientId'
```



GetServerLog

The GetServerLog action returns the portion of an HTLS server log which is associated with the client.

Syntax: (hasErr, errMsg, [res]) ← [serverUrl] ⎕HTLC 'GetServerLog'

[res] is the HTLC-specific portion of the csv-format content of the HTLS server log for the HTLS server listening on the serverUrl.

For an example, see the HTLS GetLog action example in this document.

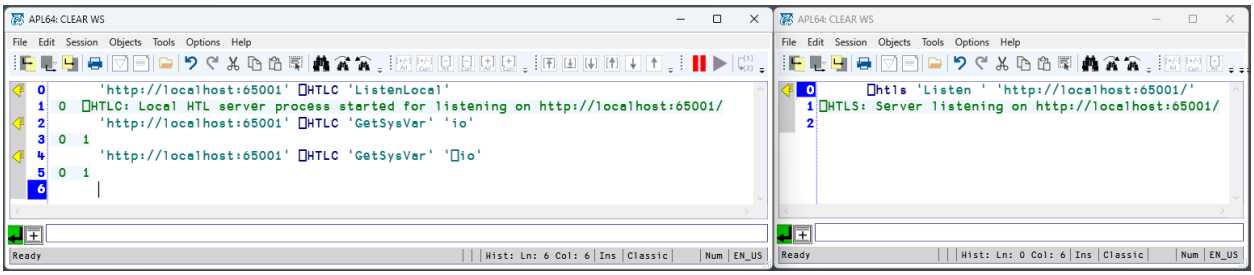
GetSysVar

The GetSysVar action returns the value of the specified system variable on the HTLS server.

Syntax: (hasErr errMsg result) ← [serverUrl] ⎕HTLC 'GetSysVar' sysVarName

sysVarName may be a character scalar, character vector or string scalar. When specifying the system variable name, the quad (⎕) prefix is optional.

```
'http://localhost:65001' ⎕HTLC 'ListenLocal'
'http://localhost:65001' ⎕HTLC 'GetSysVar' 'io'
'http://localhost:65001' ⎕HTLC 'GetSysVar' '⎕io'
```



GetVar

The GetVar action returns the programmer-defined variable in the server on the HTLS server.

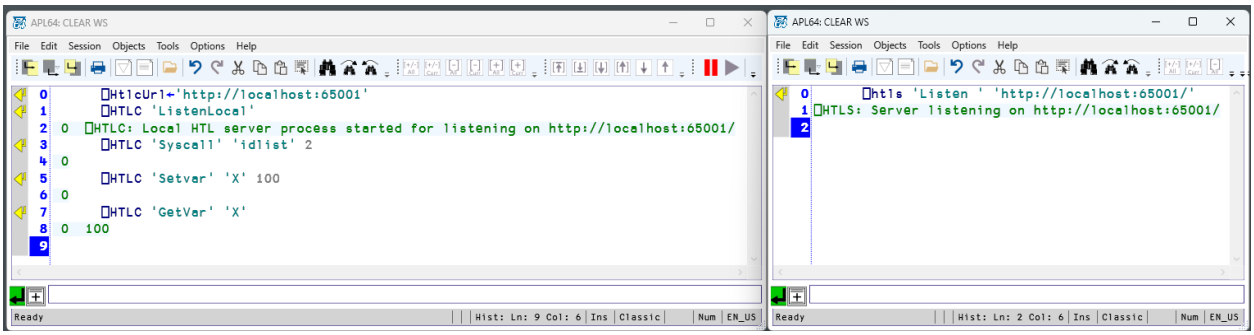
Syntax: (hasErr errMsg result) ← [serverUrl] ⎕HTLC 'GetVar' varName

varName may be a character scalar, character vector or string scalar.

Example:

```
⎕HtlcUrl←'http://localhost:65001'
⎕HTLC 'ListenLocal'
⎕HTLC 'Syscall' 'idlist' 2
⎕HTLC 'Setvar' 'X' 100
```

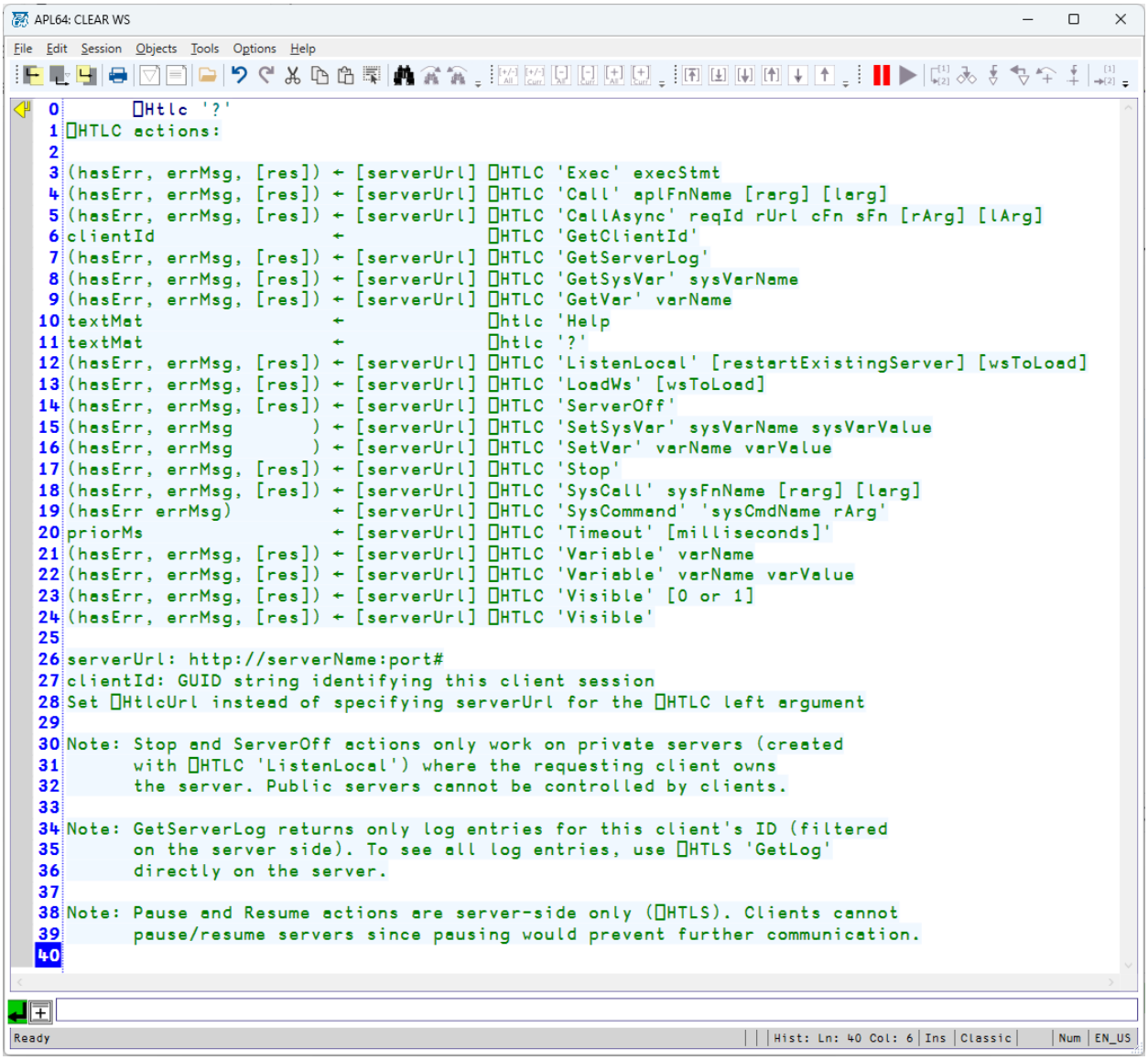
```
⎕HTLC 'GetVar' 'X'
```



Help (?)

The Help action returns the summary documentation of the ⎕HTLC system function.

Syntax: textMat ← ⎕htlc 'Help'
textMat ← ⎕htlc '?'



ListenLocal

The ListenLocal action creates a local ⎕HTLS server for exclusive use by the client.

Syntax:

(hasErr errMsg result) ← [serverUrl] ⎕HTLC 'ListenLocal' [wsToLoad]

(hasErr errMsg result) ← [serverUrl] ⎕HTLC 'ListenLocal' [restartExistingServer]

(hasErr, errMsg, [res]) ← [serverUrl] ⎕HTLC 'ListenLocal' [restartExistingServer] [wsToLoad]

(hasErr, errMsg, [res]) ← [serverUrl] ⎕HTLC 'ListenLocal' [wsToLoad] [restartExistingServer]

serverUrl is the URL to be listened by the server for incoming client requests.

wsToLoad is an optional path of the APL64 workspace to load.

restartExistingServer: Optional bool scalar indicating if a request will be made to the specified url to run the server-side 'ServerOff' action prior to sending the request to start the local, exclusive server listening on the url. The restartExistingServer option is effective only if the server to be restarted is exclusively controlled by the APL64 instance which used the ListenLocal action with this option.

The 'wsToLoad' and 'restartExistingServer' options can be included in any order in the ListenLocal statement.

The ListenLocal action:

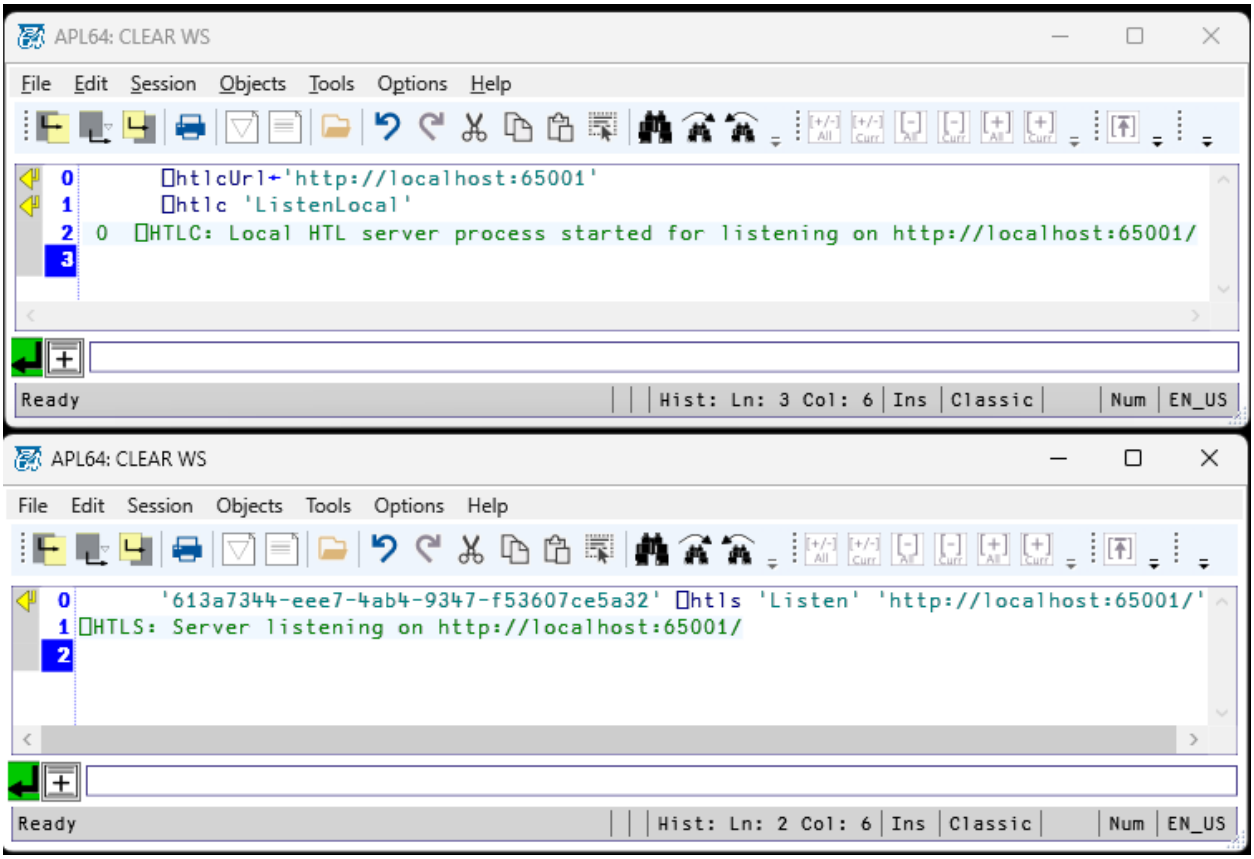
- Uses the .Net ProcessStart method to create a separate server instance of APL64 and start the server listening for incoming requests
- Starts the server instance of APL64 with the 'HTLListenUrl = serverUrl' command line parameter
- Cannot be used to start a remote server
- Does not support an https url
- Does not support multiple urls for listening
- The ListenLocal action creates a local □HTLS server for exclusive use by the client

When the server side, created by the 'ListenLocal' action, attempts to start listening, the url will be validated and any exceptions presented on the server-side.

Example 1: The client uses the □HTLC 'ListenLocal' action to create a local □HTLS server

```
□htlcUrl←'http://localhost:65001'
□htlc 'ListenLocal'
```

The .Net ProcessStart method is used to start an APL64 instance of the same type as the client. The .Net ProcessStart arguments for the new APL instance include the url and the unique id of the client. The unique id is retained by the server to ensure that the server is for the exclusive use of this client.

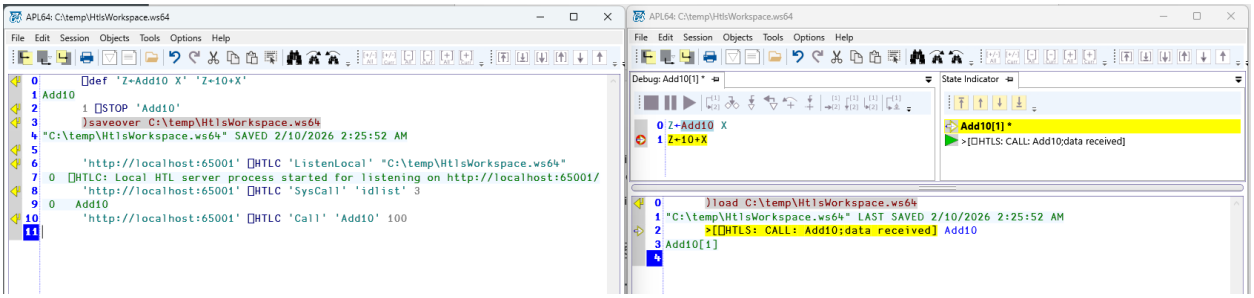


Example 2: Server-side debugging

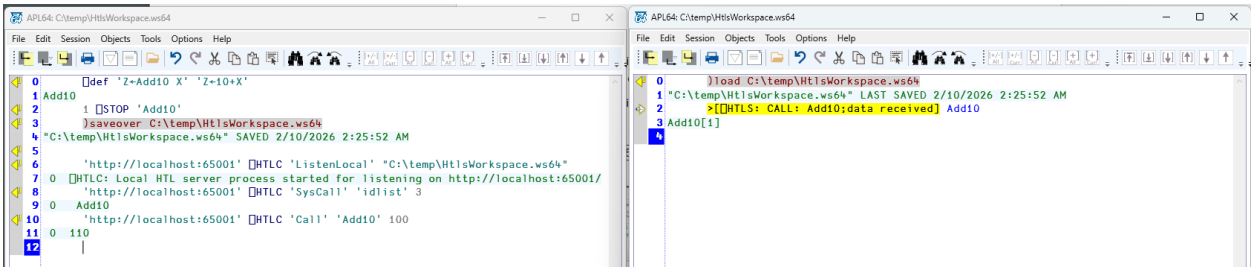
Prepare a workspace containing the function ⎕def 'Z←Add10 X' 'Z←10+X', put a stop on line [1] of the function using 1 ⎕STOP 'Add10', and save the c:\temp\HtlsWorkspace.ws64.

```
⎕def 'Z←Add10 X' 'Z←10+X'
1 ⎕STOP 'Add10'
)saveover C:\temp\HtlsWorkspace.ws64
'http://localhost:65001' ⎕HTLC 'ListenLocal' "C:\temp\HtlsWorkspace.ws64"
'http://localhost:65001' ⎕HTLC 'SysCall' 'idlist' 3
'http://localhost:65001' ⎕HTLC 'Call' 'Add10' 100
```

When the client calls the Add10 function, that function runs to the stop on the server, and the APL64 debugger pane is presented on the server:



Continue the execution of the Add10 function on the server, and the result will be returned to the client, unless the programmer timeout on the client-side is exceeded.:



Example #3: Server name is not LocalHost

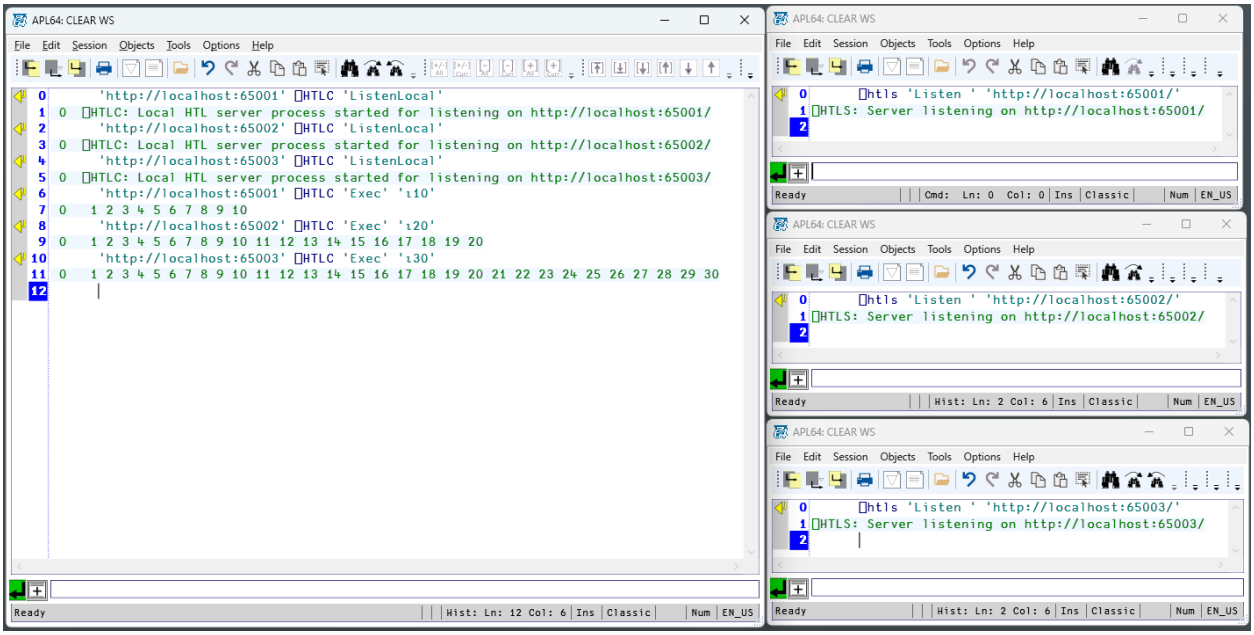
Using an IPv4 address or a server name other than local host:

- Cannot be used with the ⎕HTLC ListenLocal action
- When used with the ⎕HTLS Listen action, administrator access to the server machine to authorize communication with the server and port forwarding may be required

Example #4: Multiple Servers

In this example the ⎕Htlc 'ListenLocal' action is used to create multiple independent servers. Each server can have a different workspace loaded and perform different actions.

```
'http://localhost:65001' ⎕HTLC 'ListenLocal'
'http://localhost:65002' ⎕HTLC 'ListenLocal'
'http://localhost:65003' ⎕HTLC 'ListenLocal'
'http://localhost:65001' ⎕HTLC 'Exec' 'ι10'
'http://localhost:65002' ⎕HTLC 'Exec' 'ι20'
'http://localhost:65003' ⎕HTLC 'Exec' 'ι30'
```



Example #5: Exclusive listening server already exists: Restart it

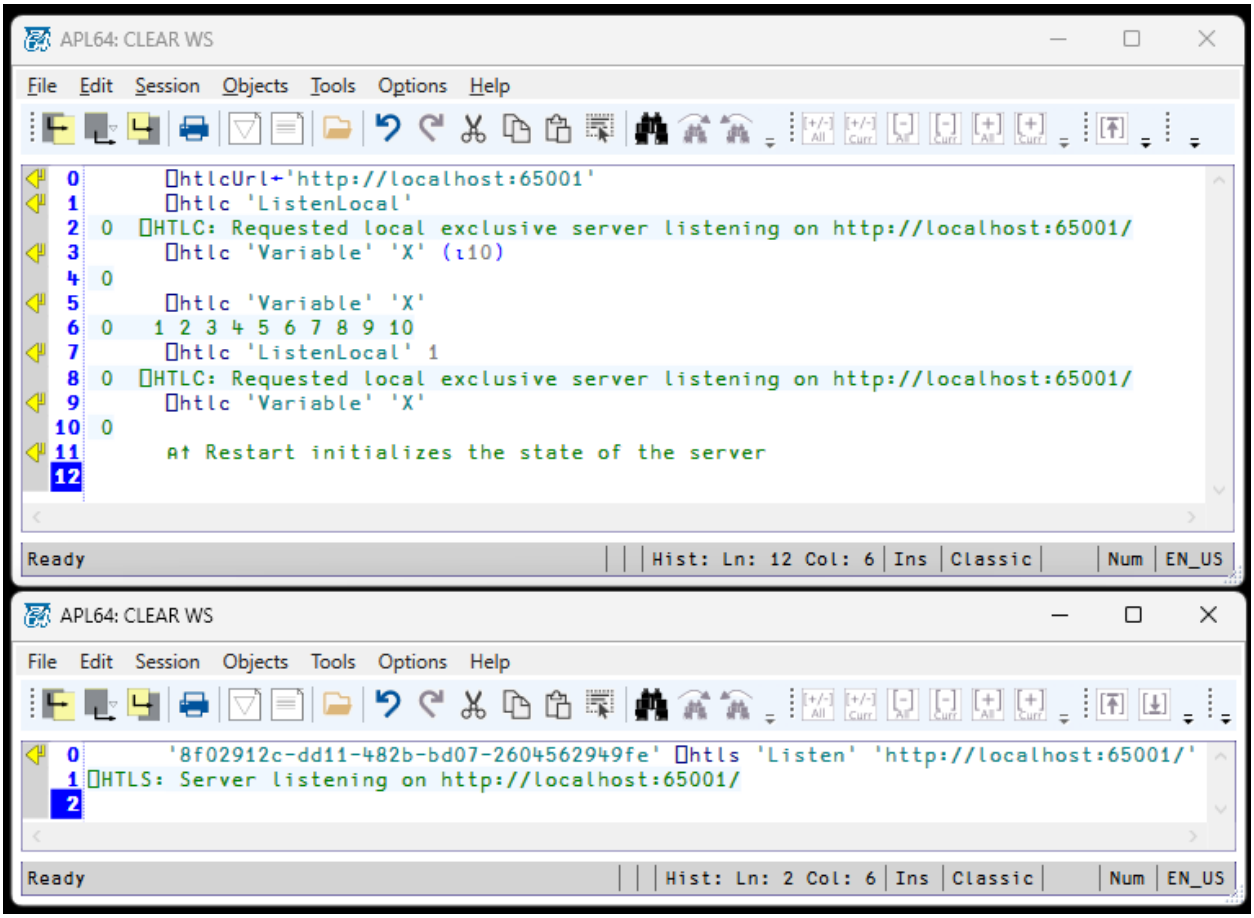
Create an exclusive listening server.

Modify the state of that server.

Use the ListenLocal action with the ‘RestartExistingServer’ option active.

Observe the server’s state is initialized.

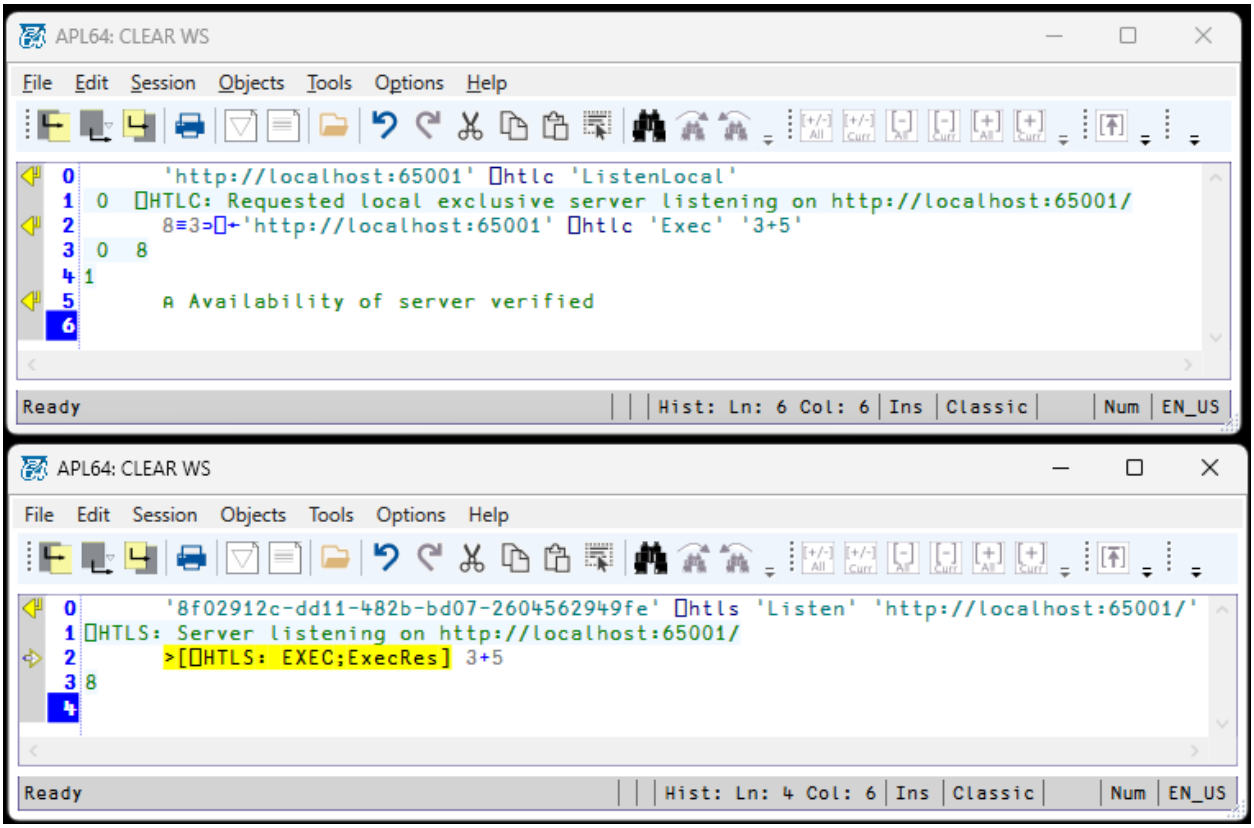
```
⎕htlcUrl←'http://localhost:65001'
⎕htlc 'ListenLocal'
⎕htlc 'Variable' 'X' (ı10)
⎕htlc 'Variable' 'X'
⎕htlc 'ListenLocal' 1
⎕htlc 'Variable' 'X'
◎↑ Restart initializes the state of the server
```



Example #6: Check for a pre-existing server

Create a listening server. Use an Exec action to check if the server is listening. If a valid response is returned, the server is listening. If the timeout expires, the server does not exist or is paused or stopped.

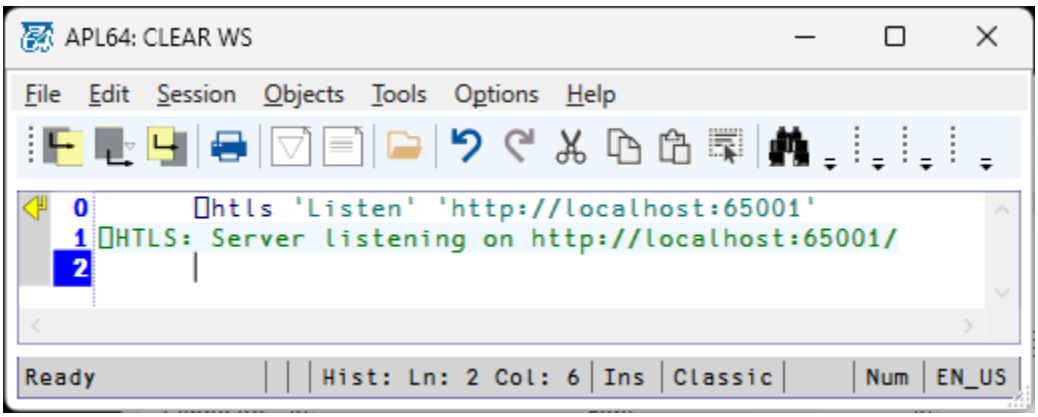
```
'http://localhost' ⎕htlc 'ListenLocal'
8≡3⊃⎕←'http://localhost:65001' ⎕htlc 'Exec' '3+5'
```



Example #7: Listening server already exists: Exception occurs

Create a non-exclusive ⎕HTLS server in an APL64 instance:

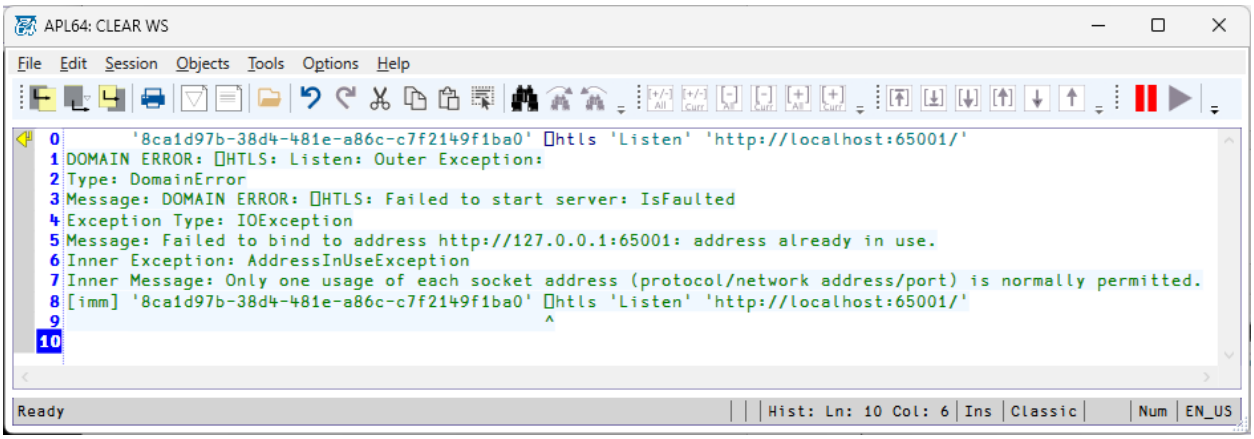
```
⎕htls 'Listen' 'http://localhost:65001'
```



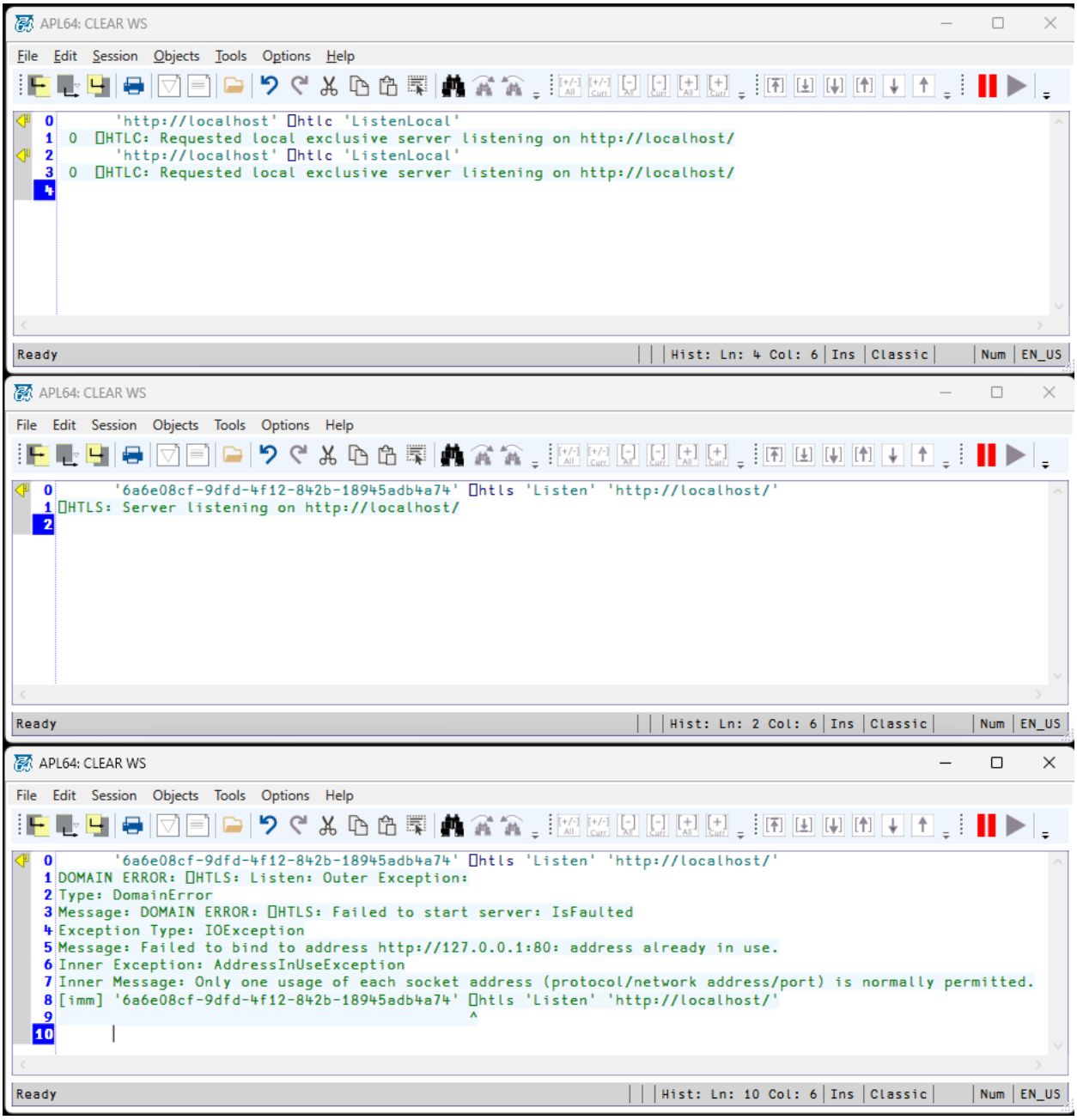
In a different APL64 instance on the same workstation attempt to create a server listening on the same url:

```
'http://localhost:65001' ⎕htlc 'ListenLocal' 1
```

The ListenLocal action will create an APL64 instance, but that instance cannot be listening on the specified url, because a server on the workstation is already listening on that url. An exception is thrown on the new APL64 instance which would not start listening:



The same exception will occur if the pre-existing server was an exclusive server:



LoadWs

The Load action loads an APL64 workspace in the HTLS server.

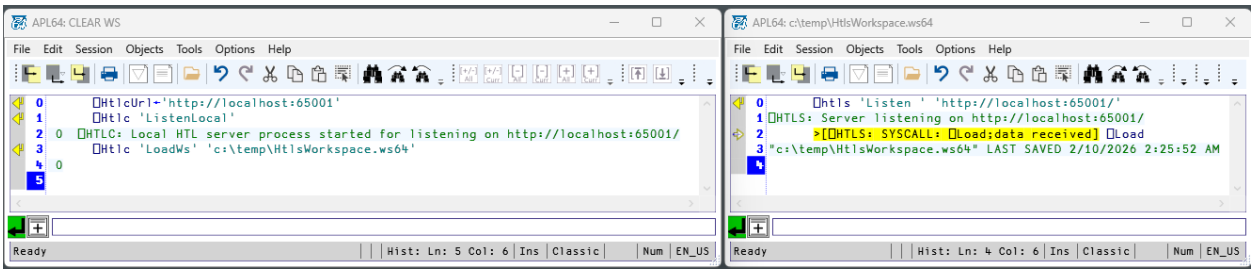
Syntax: (hasErr errMsg result) ← [serverUrl] ⎕HTLC 'LoadWs' ws

ws is the name of the APL64 workspace to load.

Example:

```
⎕HtlcUrl←'http://localhost:65001'
```

```
⎕Htlc 'ListenLocal'
⎕Htlc 'LoadWs' 'c:\temp\HtlsWorkspace.ws64'
```



ServerOff

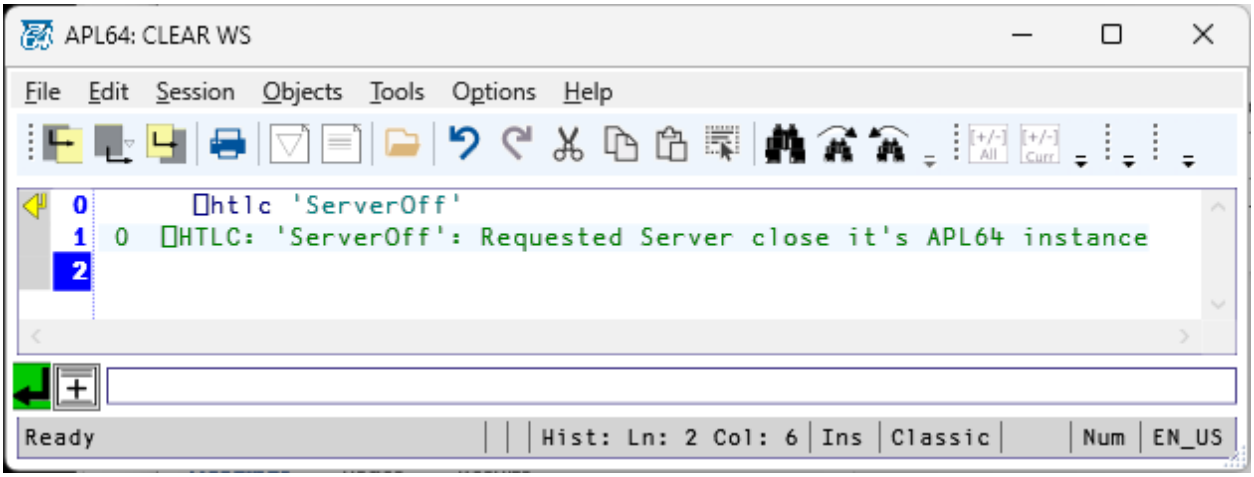
The ServerOff action requests the server-side APL64 instance to stop listening.

Syntax: (hasErr errMsg result) ← [serverUrl] ⎕HTLC 'ServerOff'

Since a server created by the client using the ListenLocal action, it is an exclusive server which no other clients can access, so the ServerOff action cannot affect other ⎕HTLC clients.

Example:

```
HtlcUrl←'http://localhost:65001'
⎕HTLC 'ListenLocal'
⎕HTLC 'ServerOff'
```



SetSysVar

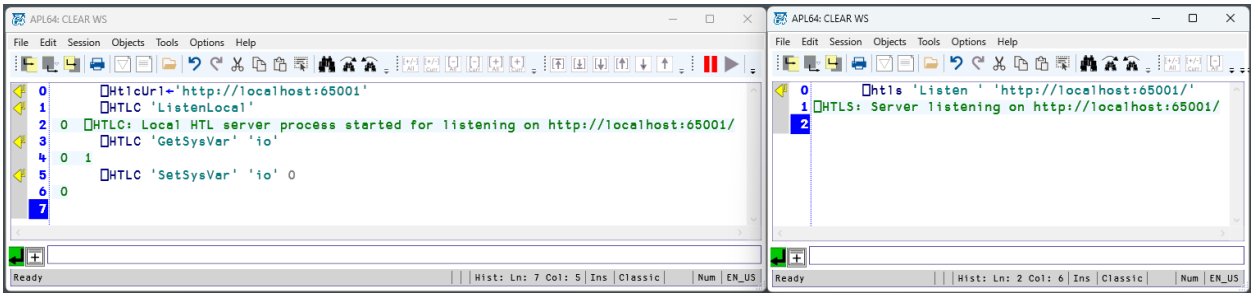
The SetSysVar action sets the value of the specified system variable on the HTLS server.

Syntax: (hasErr errMsg) ← [serverUrl] ⎕HTLC 'SetSysVar' sysVarName sysVarValue

sysVarValue may be a character scalar, character vector or string scalar. When specifying the system variable name, the quad (⎕) prefix is optional.

Example:

```
⎕HtlcUrl←'http://localhost:65001'
⎕HTLC 'ListenLocal'
⎕HTLC 'GetSysVar' 'io'
⎕HTLC 'SetSysVar' 'io' 0
```



SetVar

The SetVar action sets the programmer-defined variable on the HTLS server.

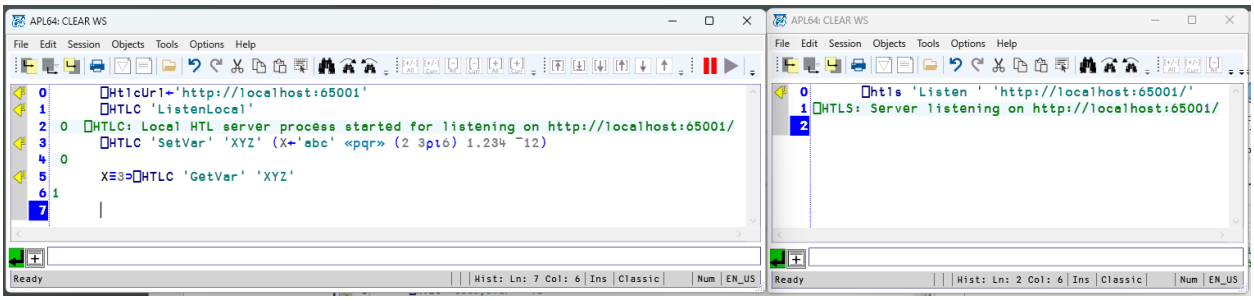
Syntax: (hasErr errMsg) ← [serverUrl] ⎕HTLC 'SetVar' varName varValue

varName is the name of the programmer-defined variable and may be a character scalar, character vector or string scalar. If the specified variable does not exist it will be created.

varValue is the value to assign to the variable.

Example:

```
⎕HtlcUrl←'http://localhost:65001'
⎕HTLC 'ListenLocal'
⎕HTLC 'SetVar' 'XYZ' (X←'abc' «pqr» (2 3⍴⍳6) 1.234 ¯12)
X≡3⊃⎕HTLC 'GetVar' 'XYZ'
```



Stop

The Stop action requests the server to stop listening.

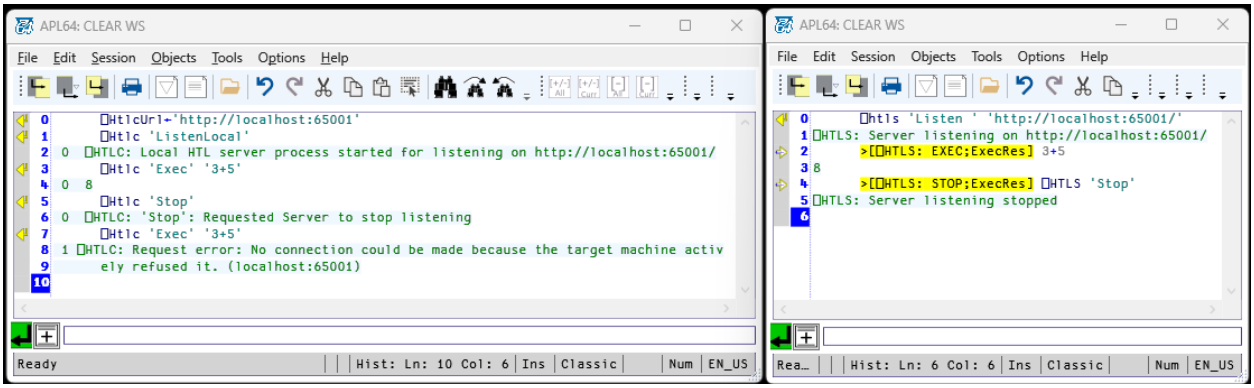
Syntax: (hasErr errMsg result) ← [serverUrl] ⎕HTLC 'Stop'

The Stop action stops the server listening on all urls which were configured for that server. Note: This action may take a few seconds to complete.

The client-side cannot coordinate the Stop action with other instances of APL64 which may be communicating with the server.

Example:

```
⎕HtlcUrl←'http://localhost:65001'
⎕Htlc 'ListenLocal'
⎕Htlc 'Exec' '3+5'
⎕Htlc 'Stop'
⎕Htlc 'Exec' '3+5'
```



SysCall

The SysCall action calls a system-function on the HTLS server.

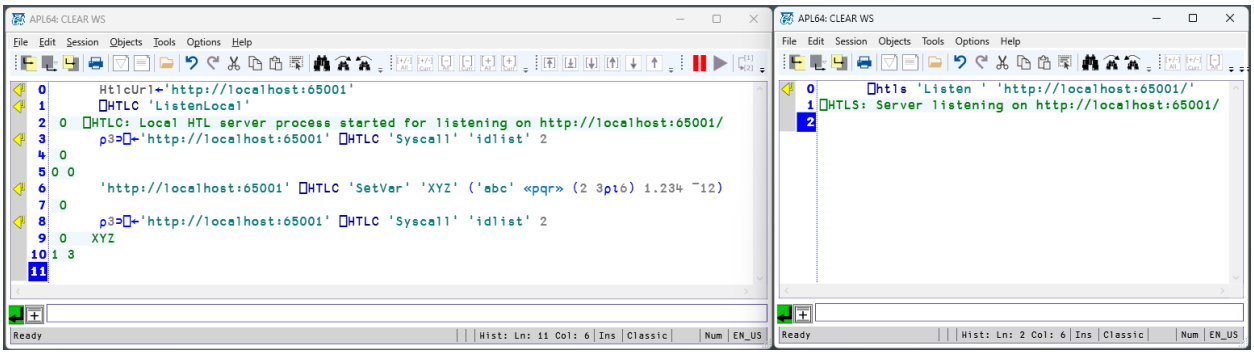
Syntax: (hasErr errMsg result) ← [serverUrl] ⎕HTLC 'SysCall' sysFnName [rarg] [larg]

The SysCall action is similar to the Call action. However, it calls a system-function rather than user-defined functions. When the system-function is not prefixed by '⎕', it will be added by the SysCall action.

Example:

```
HtlcUrl←'http://localhost:65001'
⎕HTLC 'ListenLocal'
⍴3⊃⎕←'http://localhost:65001' ⎕HTLC 'Syscall' 'idlist' 2
```

```
'http://localhost:65001' ⎕HTLC 'SetVar' 'XYZ' ('abc' «pqr» (2 3⍴⍳6) 1.234 ¯12)
⍴3⊃⎕←'http://localhost:65001' ⎕HTLC 'Syscall' 'idlist' 2
```



SysCommand

The SysCommand action executes an APL system command on the HTLS server.

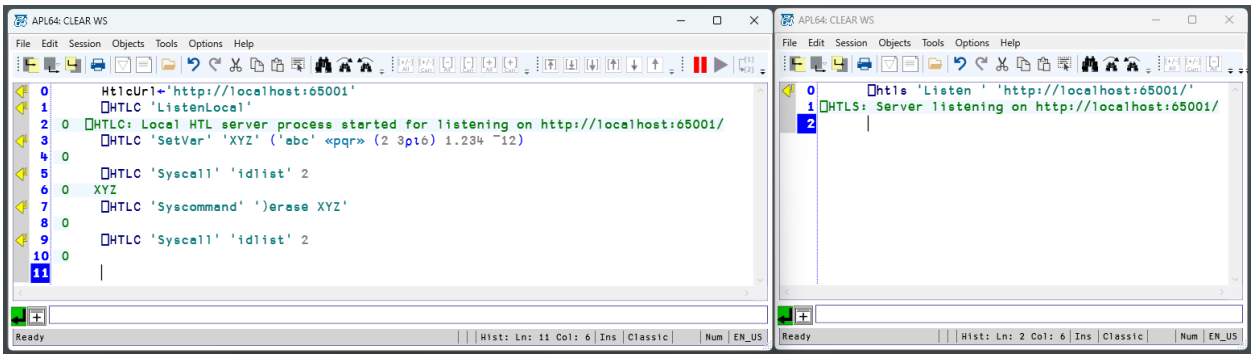
Syntax: (hasErr errMsg) ← [serverUrl] ⎕HTLC 'SysCommand' 'sysCmdName rArg'

If the programmer-provided 'sysCmdName is not prefixed by ')', it will be added by the SysCommand'action.

The SysCommand action output includes only the hasErr and errMsg elements, as no result value of a system command is returned to the client-side.

Example:

```
HtlcUrl←'http://localhost:65001'
⎕HTLC 'ListenLocal'
⎕HTLC 'SetVar' 'XYZ' ('abc' «pqr» (2 3⍴⍳6) 1.234 ¯12)
⎕HTLC 'Syscall' 'idlist' 2
⎕HTLC 'Syscommand' ')erase XYZ'
⎕HTLC 'Syscall' 'idlist' 2
```



Timeout

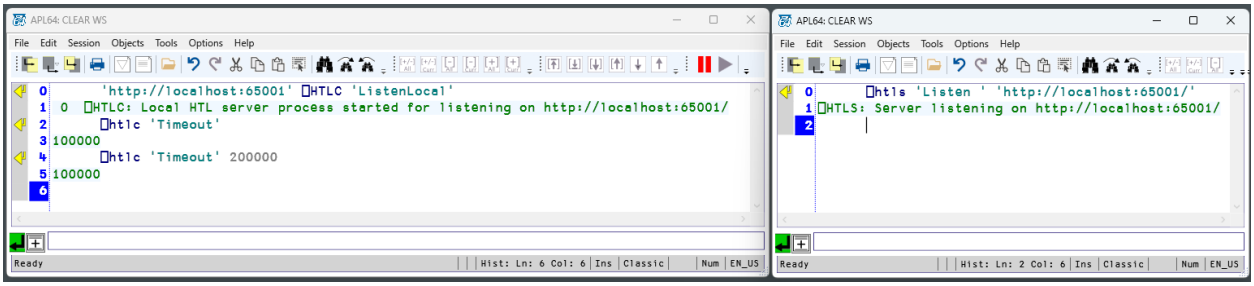
The timeout action sets or returns the length of time the client will wait for a response from the HTLS server.

Syntax: priorMs ← [serverUrl] ⎕HTLC 'Timeout' [milliseconds]

The default value is 100000 milliseconds.

Example:

```
'http://localhost:65001' ⎕HTLC 'ListenLocal'
⎕htlc 'Timeout'
⎕htlc 'Timeout' 200000
```



Variable

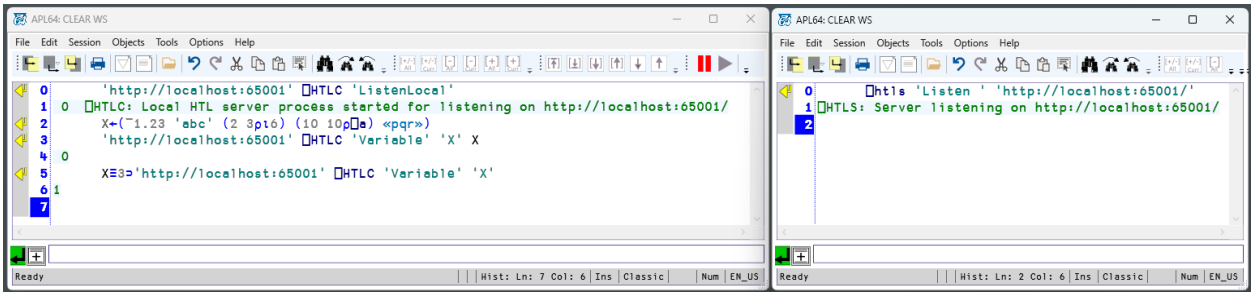
The Variable action sets or returns the value of a user-defined variable on the HTLS server.

Syntax: (hasErr errMsg result) ← [serverUrl] ⎕HTLC 'Variable' varName [varValue]

If the specified variable does not exist it will be created. This is implemented as a property that takes the variable name and optional value as its arguments.

Example:

```
'http://localhost:65001' ⎕HTLC 'ListenLocal'
X←(¯1.23 'abc' (2 3⍴⍳6) (10 10⍴⎕a) «pqr»)
'http://localhost:65001' ⎕HTLC 'Variable' 'X' X
X≡3⊃'http://localhost:65001' ⎕HTLC 'Variable' 'X'
```



Visible

The Visible action controls the visibility of the ⎕HTLS server.

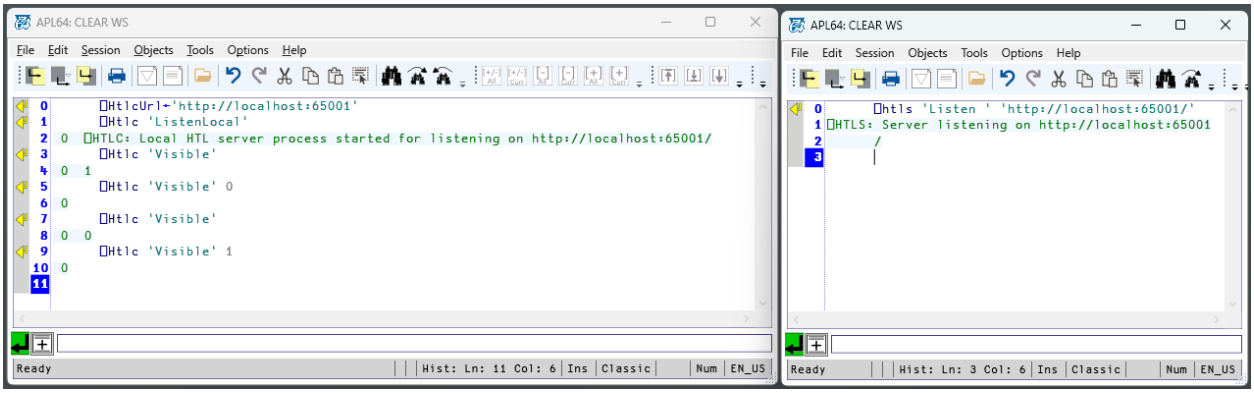
Syntax: (hasErr errMsg result) ← [serverUrl] ⎕HTLC 'Visible' flag

flag is the optional argument to control the visibility of the ⎕HTLS server. The default is 1 which means the ⎕HTLS server is visible.

The server can be made visible only when the server is based on an APL64 Developer version instance. When server-side exceptions occur which cannot be transmitted to the client-side, the exception message will be rendered to the history pane of the visible server-side.

Example:

```
⎕HtlcUrl←'http://localhost:65001'
⎕Htlc 'ListenLocal'
⎕Htlc 'Visible'
⎕Htlc 'Visible' 0
⎕Htlc 'Visible'
⎕Htlc 'Visible' 1
```



□HTLS Actions

The □HTLS system function is used on the server instance of APL64. □HTLS actions are performed on the server instance of APL64.

Syntax: [result] ← □HTLS Action [arg1] ...

The server processing to satisfy client requests is asynchronous using multiple .Net tasks with OS-assigned independent threads.

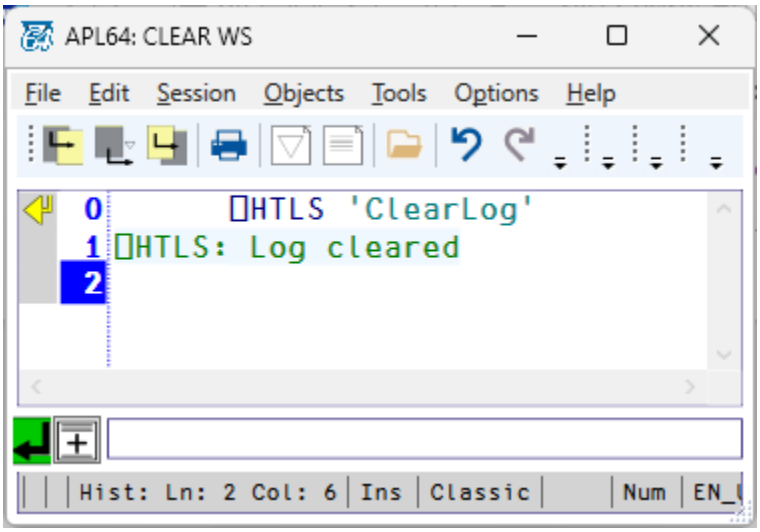
ClearLog

The ClearLog action clears the content of the current log file, if any.

Syntax: □HTLS 'ClearLog'

Example:

```
□HTLS 'ClearLog'
```



GetLog

The GetLog action returns the content of the current HTLS log file, if any, in csv format.

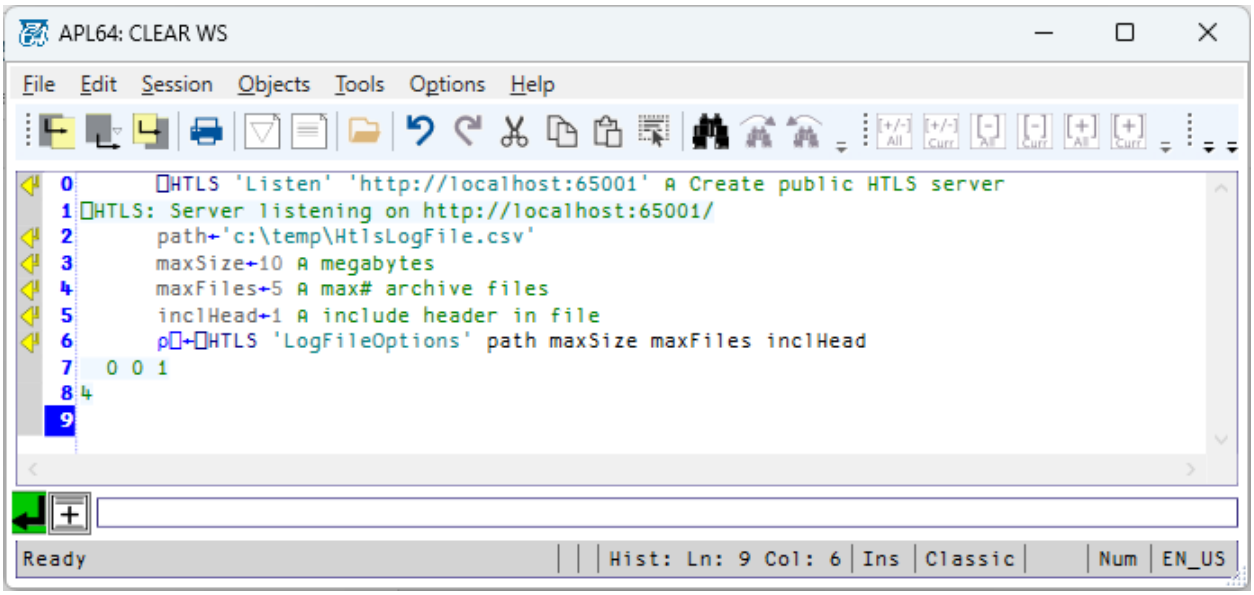
Syntax: logLines(csv) ← □HTLS 'GetLog'

Example:

In this example a client tries to stop a public server, which is not permitted.

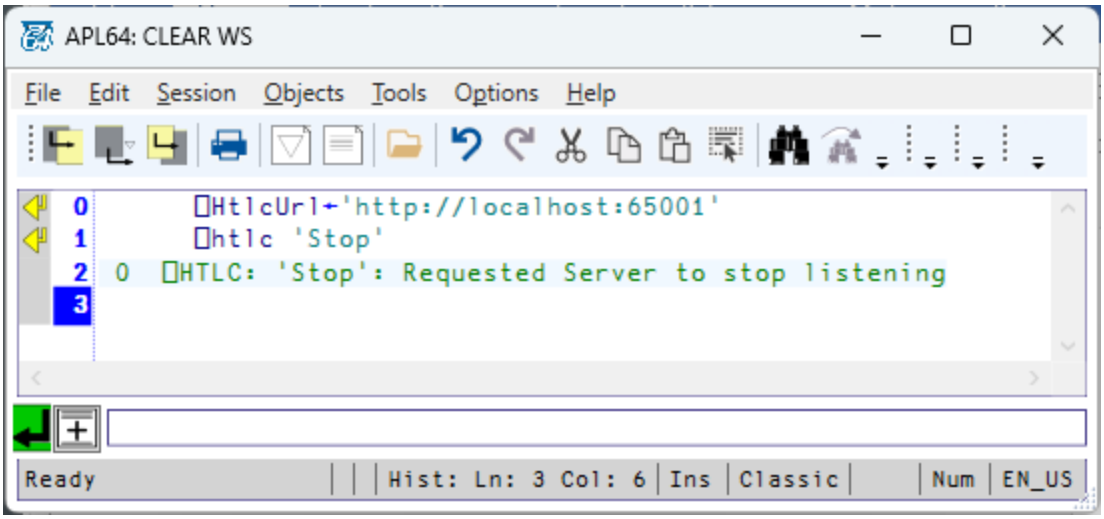
On an instance of the APL64 Developer version, create a public HTLS server:

```
⎕HTLS 'Listen' 'http://localhost:65001' ⍝ Create public HTLS server
path←'c:\temp\HtlsLogFile.csv'
maxSize←10 ⍝ megabytes
maxFiles←5 ⍝ max# archive files
inclHead←1 ⍝ include header in file
ρ⎕←⎕HTLS 'LogFileOptions' path maxSize maxFiles inclHead
```



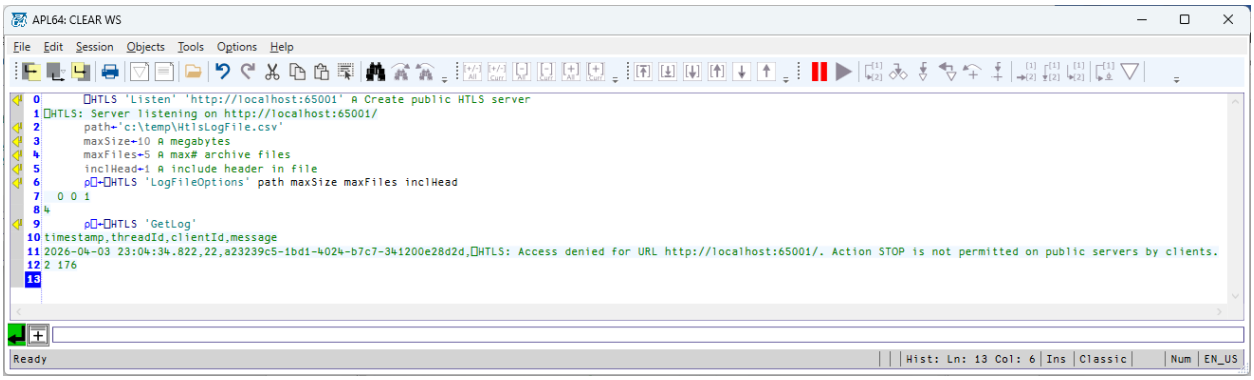
On another instance of the APL64 Developer version, create an HTLC client and try to stop the public server. The client displays the message that the request to stop the server has been made. The client does not wait for a message from the server, because if the server actually stopped, it could not send such a message to the client, and the client would need to wait until the expiration of the timeout to realize it failed.

```
⎕HtlcUrl←'http://localhost:65001'
⎕htlc 'Stop'
```



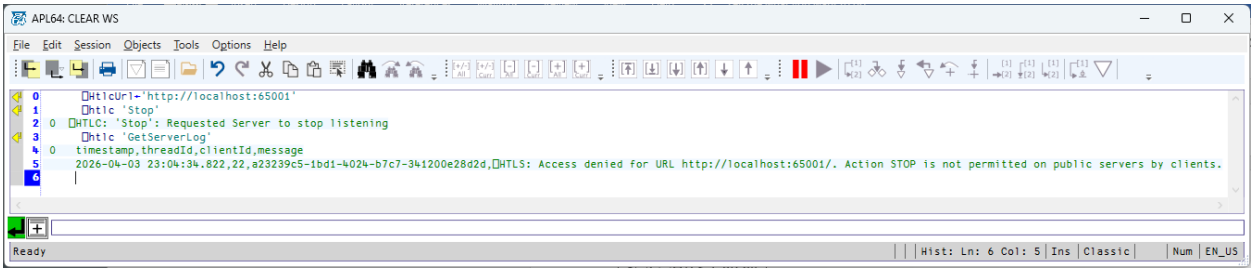
Because a client of a public server cannot stop that server, the action will fail. The server logs the message that the stop action failed on the server side. The server can obtain the current log file content at any time. On the HTLS server, obtain the current log file content:

```
ρ⎕←⎕HTLS 'GetLog'
```



Meanwhile the client wants to check if the server actually stopped, so the client gets the portion of the HTLS server log which is associated with the HTLC client indicating the server did not stop.

```
ρ⎕←⎕HTLC 'GetServerLog'
```



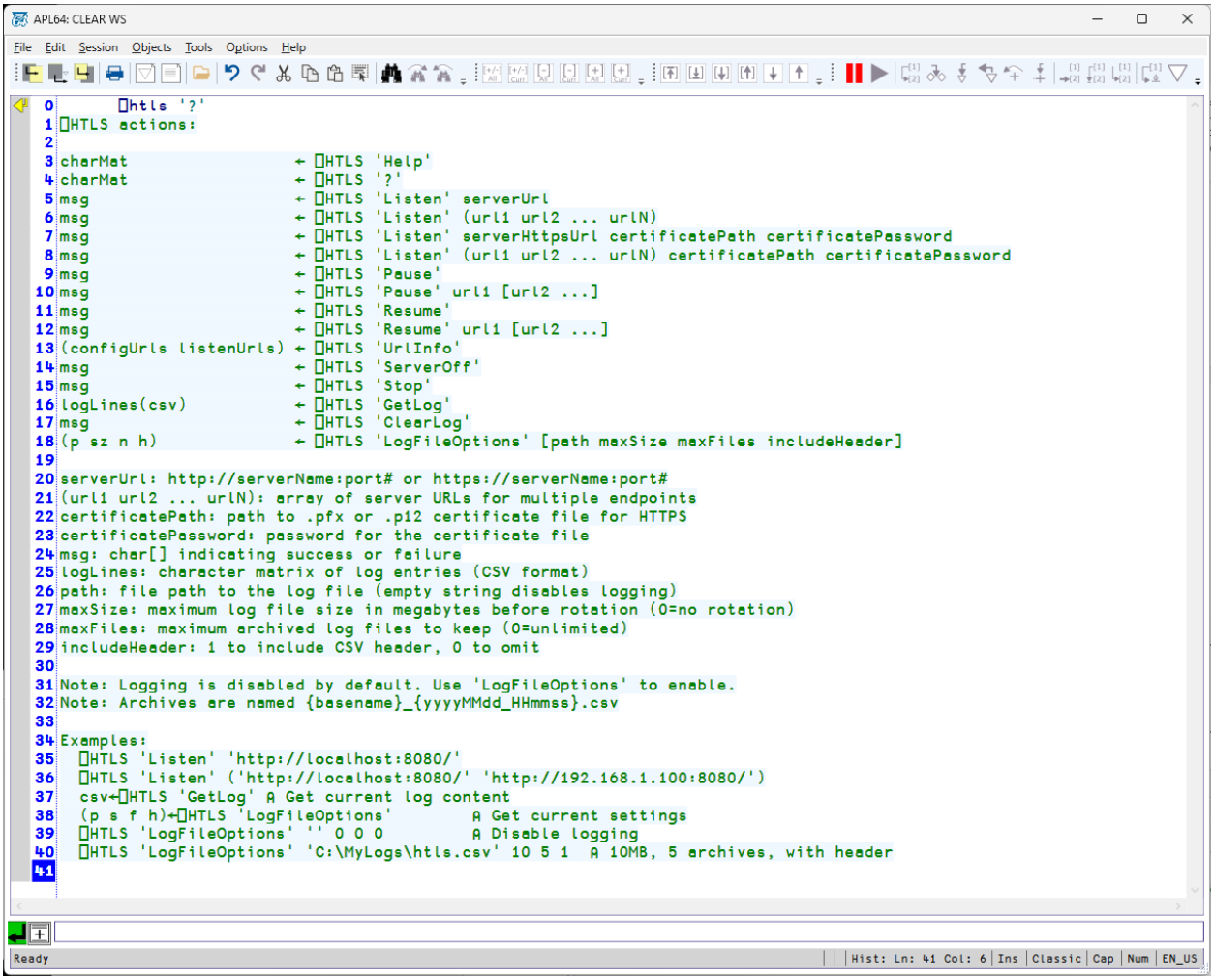
Help (?)

The Help action returns the summary documentation of the ⎕HTLS system function.

Syntax: charMat ← ⎕HTLS 'Help'

charMat ← ⎕HTLS '?'

```
⎕HTLS '?'
```



Listen

The Listen action requests the □HTLS server to listen to incoming client requests on the specified URL(s).

Single url:

msg ← □HTLS 'Listen' serverUrl [certificatePath certificatePassword]

Multiple urls:

msg ← □HTLS 'Listen' (url1 url2 ... urlN) [certificatePath certificatePassword]

The server instance of APL64 will be listening to incoming client requests on the specified serverUrl(s).

Urls are of the form: http://serverName:port#. The serverName can be a name or an IP address of the server machine, e.g. http://myserver:65001 or http://192.168.1.107:65001.

The port number, if any, should be selected so that it does not interfere with other http traffic reaching the server machine.

certificatePath and certificatePassword are optional arguments used when the https protocol is needed. The certificatePath can point to a .pfx- or .p12-format certificate file. A self-signed certificate can be used for development purposes. The certificate specified by the certificate path must be suitable for all the https urls on which the server is listening.

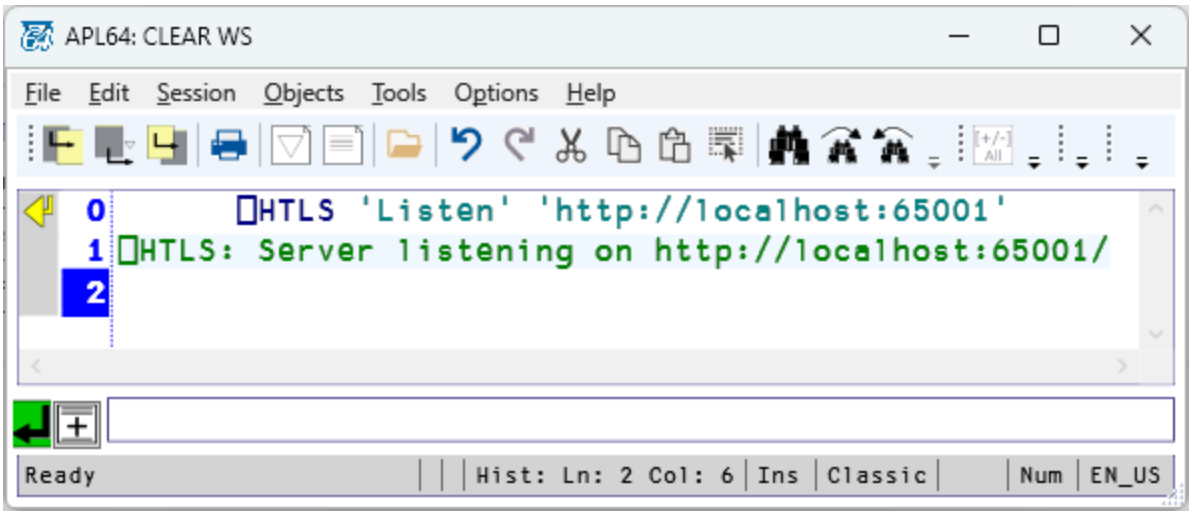
A server created using the Listen action is a public server which can be accessed by any □HTLC client.

Subsequent use of the □HTLS 'Listen' action for the same APL64 instance, will stop the server from listening to the previous url(s) and start listening on the new url(s).

If the server is not on the same workstation or local network as the client, it is a remote server. For a remote server permissions, security and port forwarding need to be considered so that client requests can reach the server and server responses can reach the client.

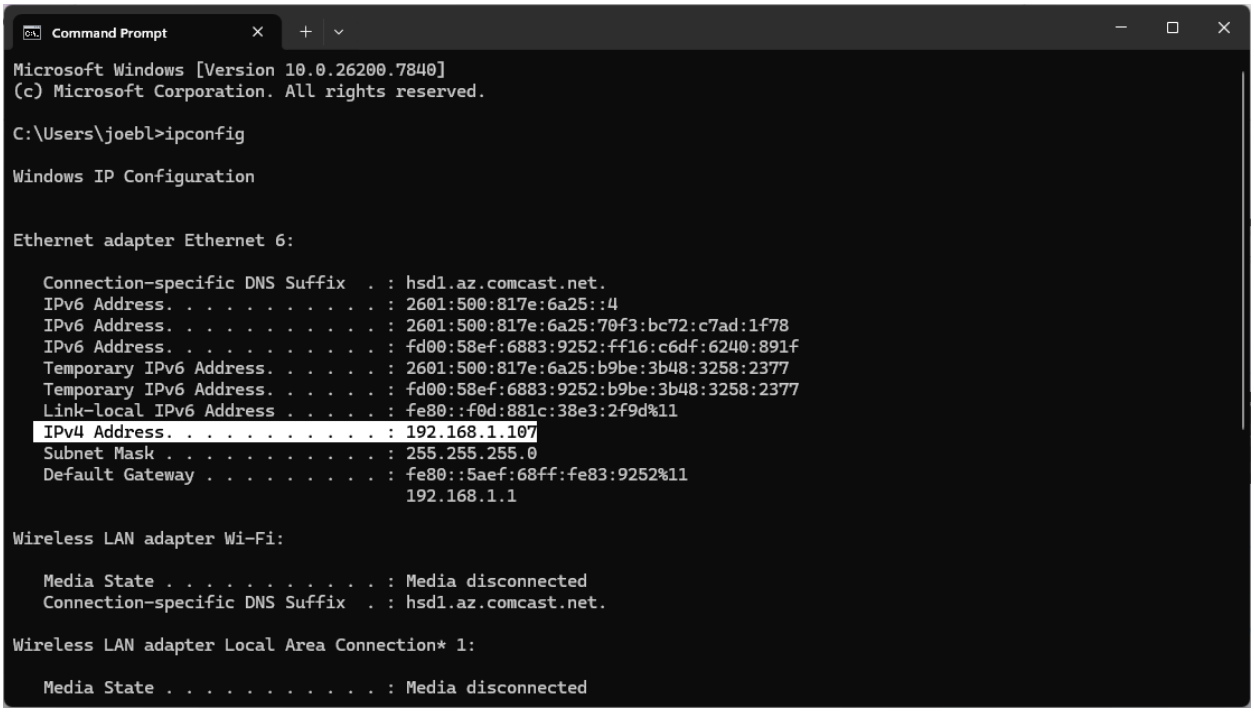
Example #1: Listen on localhost server

```
□HTLS 'Listen' 'http://localhost:65001'
```



Example #2: Listen on a named server, not localhost server

Find the IPv4 address of the server machine:

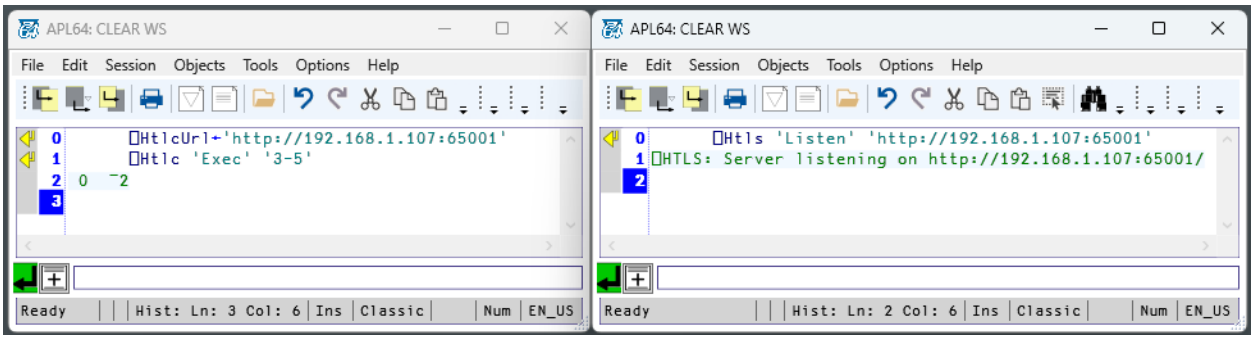


Create the server and start listening on the url:

```
⎕Htls 'Listen' 'http://192.168.1.107:65001'
```

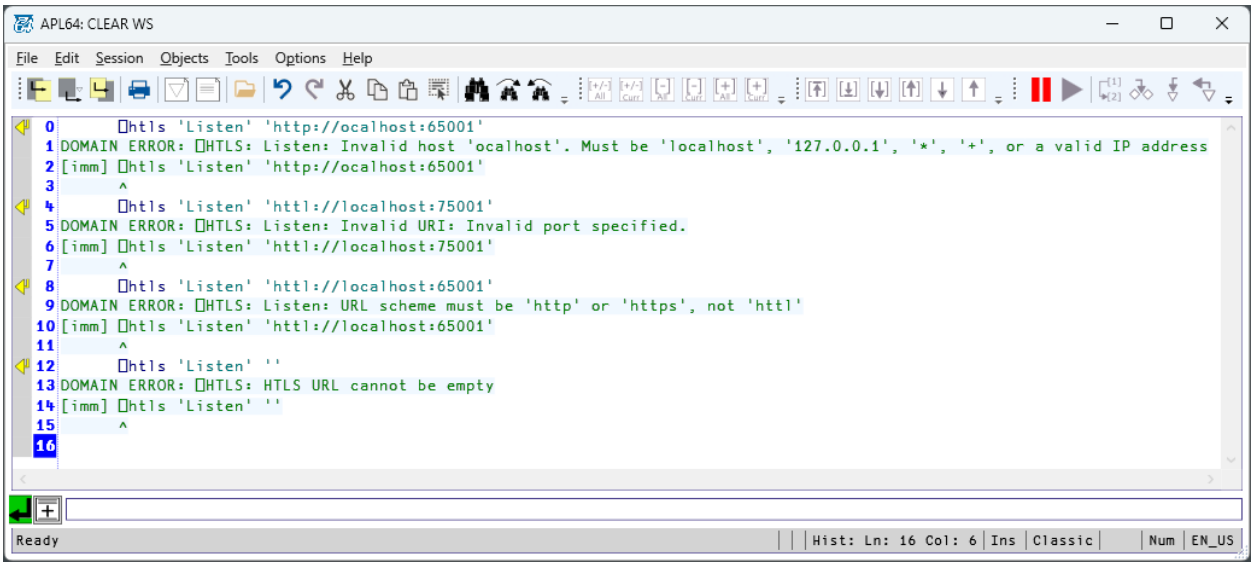
On the client-side access the server to do work:

```
⎕HtlcUrl←'http://192.168.1.107:65001'
⎕Htlc 'Exec' '3-5'
```



Example #3: Exception handling by the server-side ‘Listen’ action

```
⎕htls 'Listen' 'http://ocalhost:65001'
⎕htls 'Listen' 'httl://localhost:75001'
⎕htls 'Listen' 'http://localhost:65001'
⎕htls 'Listen' ''
```



Example #4: Multiple Servers

In this example the ⎕Htlc 'ListenLocal' action is used to create multiple independent servers. Another APL64 instance is created and the ⎕Htls 'Listen' is used to make it an additional server. Each server can have a different workspace loaded and perform different actions.

On the client side:

The client creates two local servers, each listening on separate urls.

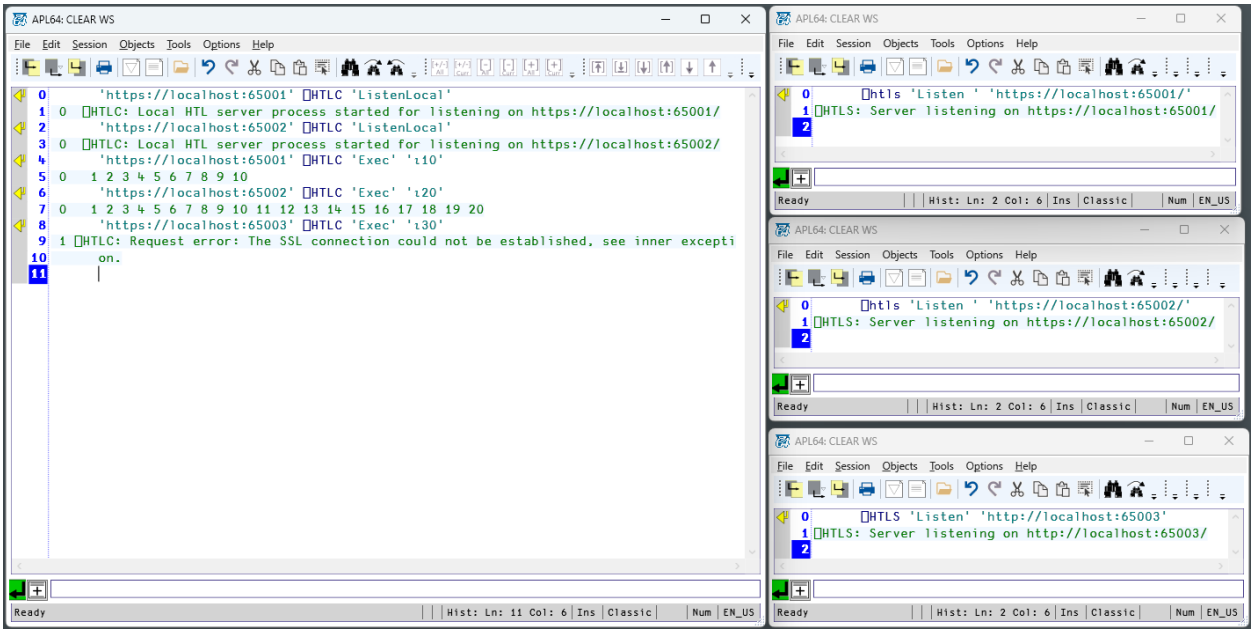
```
'http://localhost:65001' ⎕HTLC 'ListenLocal'
'http://localhost:65002' ⎕HTLC 'ListenLocal'
'http://localhost:65001' ⎕HTLC 'Exec' 'ι10'
'http://localhost:65002' ⎕HTLC 'Exec' 'ι20'
```

On the server side:

A separate APL64 instance starts listening on a third url.

```
⎕HTLS 'Listen'  'http://localhost:65003'
```

There a total of four APL64 instances running in this example. The servers created by ⎕HTLC ListenLocal are exclusive servers for the client. The server created by the ⎕HTLS Listen action is a public server.



Example #5: Server listening on multiple urls

Establish server:

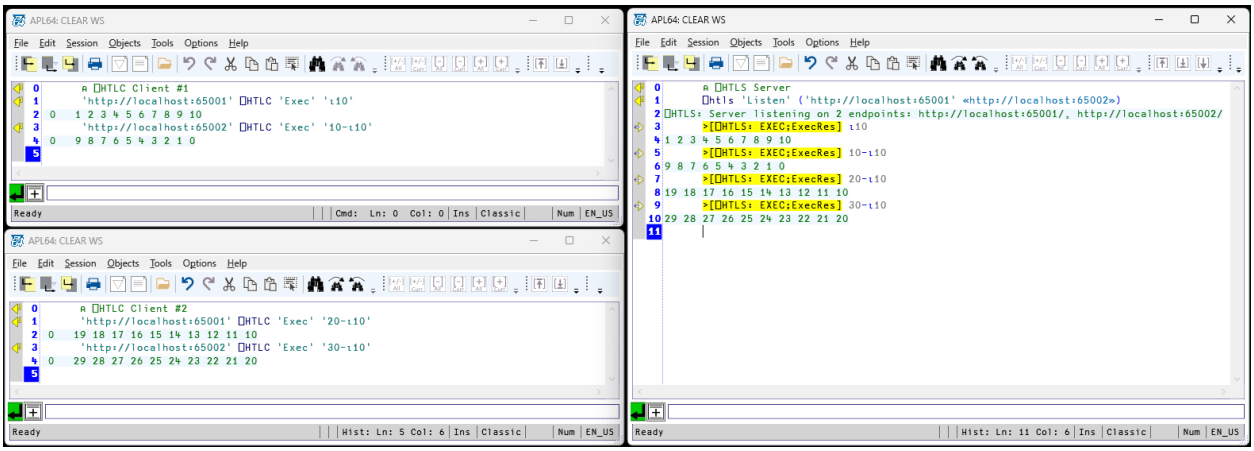
```
⍝ ⎕HTLS Server
⎕htls 'Listen' ('http://localhost:65001' «http://localhost:65002»)
```

Establish two clients and make requests to the server:

```
⍝ ⎕HTLC Client #1
'http://localhost:65001' ⎕HTLC 'Exec' 'ι10'
```

```
'http://localhost:65002' ⎕HTLC 'Exec' '10-⍳10'
```

```
⍝ ⎕HTLC Client #2
'http://localhost:65001' ⎕HTLC 'Exec' '20-⍳10'
'http://localhost:65002' ⎕HTLC 'Exec' '30-⍳10'
```



LogFileOptions

The LogFileOptions action sets the log file options for the ⎕HTLS server.

Syntax:

(p s f h) ← ⎕HTLS 'LogFileOptions'

Returns the log file options in effect

(p s f h)←⎕HTLS 'LogFileOptions' path maxSize maxFiles includeHeader

path: Path for current log file, or empty character vector for no logging.

maxSize: Maximum number of megabytes in the current log file

maxFiles: Maximum number of log file archives

includeHeader: 0/No 1/Yes

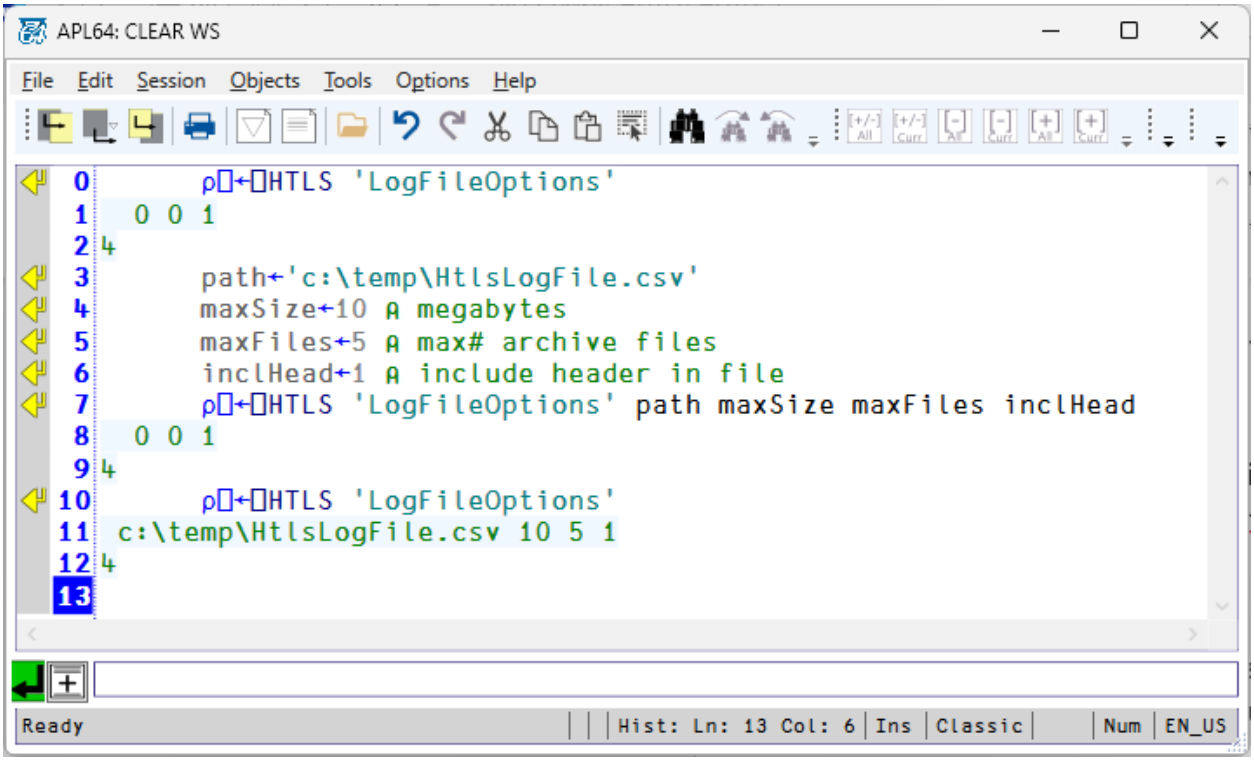
Servers are generally not continuously monitored by a person, so instead HTLS server-side exceptions can be logged for subsequent review.

If logging is enabled, by providing a log file path, the log file contains exceptions which occur on the HTLS server. If the maxSize is reached, the current log file is archived in the same location as the current log file, and a new current log file is created. If the maxFiles is reached, the oldest log file archives are deleted as necessary.

APL64 interpreter exceptions for HTLC client actions such as Exec or Call, are not logged on the server-side. They are returned to the HTLC client in the action result.

Example:

```
ρ⎕←⎕HTLS 'LogFileOptions'
path←'c:\temp\HtlsLogFile.csv'
maxSize←10 ⍝ megabytes
maxFiles←5 ⍝ max# archive files
inclHead←1 ⍝ include header in file
ρ⎕←⎕HTLS 'LogFileOptions' path maxSize maxFiles inclHead
ρ⎕←⎕HTLS 'LogFileOptions'
```



Messages logged by an ⎕HTLS server include:

- ⎕HTLS: Listen: Unexpected exception stopping old host: ...
- ⎕HTLS: Pause: Unexpected exception stopping host: ...
- ⎕HTLS: Resume: Unexpected exception stopping host:
- ⎕HTLS: Stop: Unexpected exception: ...
- ⎕HTLS: Error processing request: ...
- ⎕HTLS: Access denied for URL .... Requesting client ID ... does not match assigned client ID ...

- □HTLS: Access denied. URL ... is a private local server owned by another client.
- □HTLS: Access denied for URL ... Action ... is not permitted on public servers by clients.
- □HTLS: Server listening stopped by client id: ...
- □HTLS: Server initiating ServerOff action requested by client id: ...
- □HTLS: Unexpected exception attempting client-requested action

Pause

The Pause action pauses the listening of the □HTLS server on all or programmer-specified url(s).

msg ← □HTLS 'Pause'

msg ← □HTLS 'Pause' url1 [url2 ...]

Note: □HTLC clients of the server will receive exceptions while the server is paused.

Example: See the Resume action example

Resume

The Resume action resumes the listening of the □HTLS server on all or programmer-specified url(s) which were previously listening.

msg ← □HTLS 'Resume'

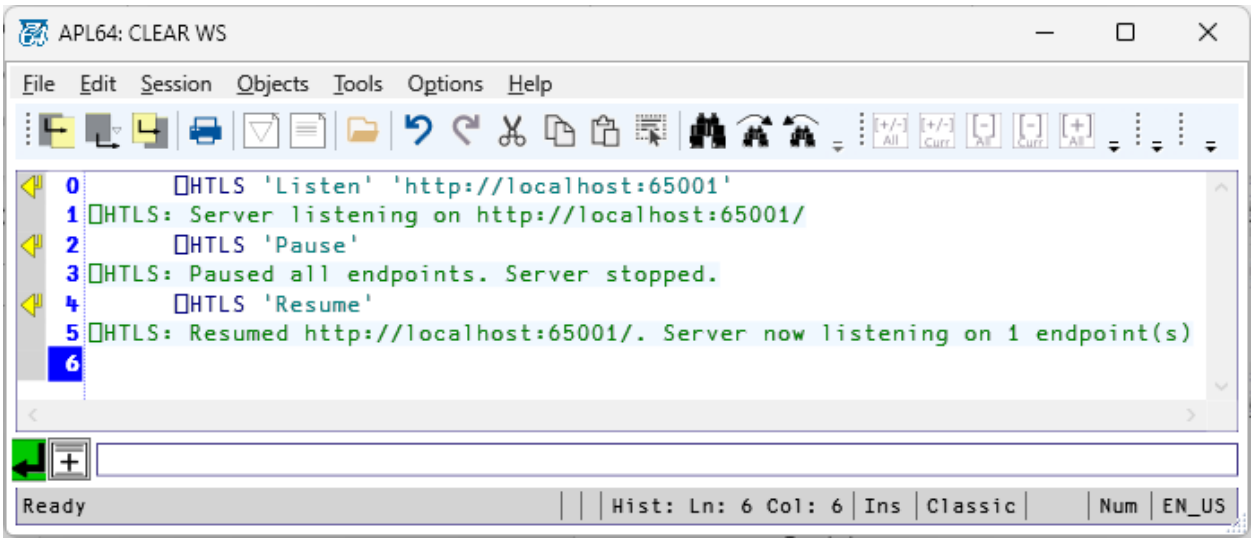
msg ← □HTLS 'Resume' url1 [url2 ...]

Note: Once the server is resumed, □HTLC clients of the server can utilize the server.

Example: Pause / Resume all urls

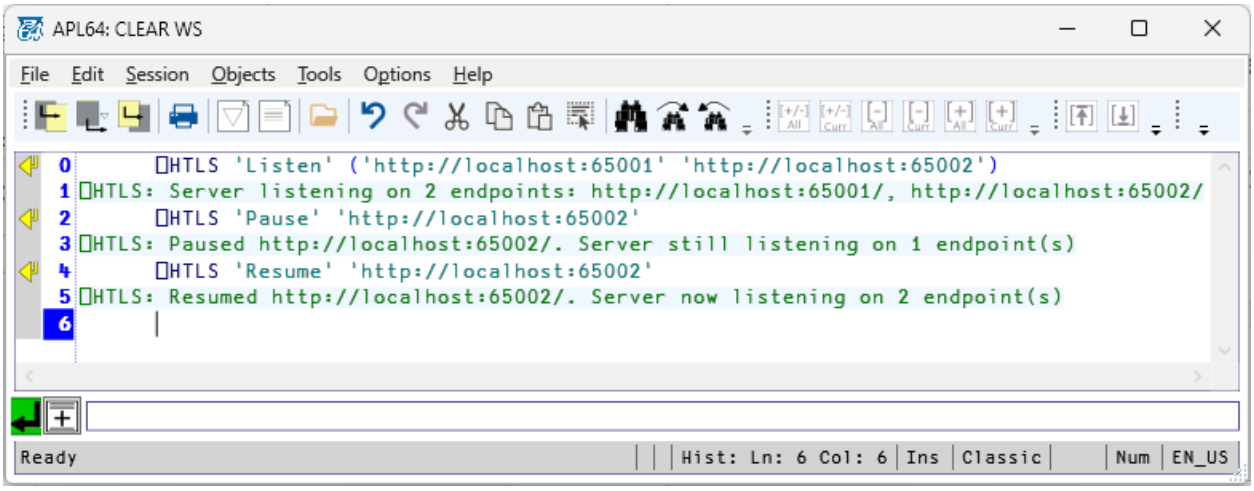
Server: Execute these statements one-at-a-time:

```
□HTLS 'Listen' 'http://localhost:65001'
□HTLS 'Pause'
□HTLS 'Resume'
```



Example: Pause / Resume selected url(s)

```
⎕HTLS 'Listen' ('http://localhost:65001' 'http://localhost:65002')
⎕HTLS 'Pause' 'http://localhost:65002'
⎕HTLS 'Resume' 'http://localhost:65002'
```



ServerOff

The ServerOff action requests the ⎕HTLS server to stop all listening to incoming client requests on the specified URL(s) and exit.

Syntax: (hasErr errMsg result) ← ⎕HTLS 'ServerOff'

Note: This action may take a few seconds to complete on the ⎕HTLS server.

```
⎕HTLS 'Listen' 'http://localhost:65001'
⎕HTLS 'ServerOff' ⍝ Click Enter to end server's APL instance
```

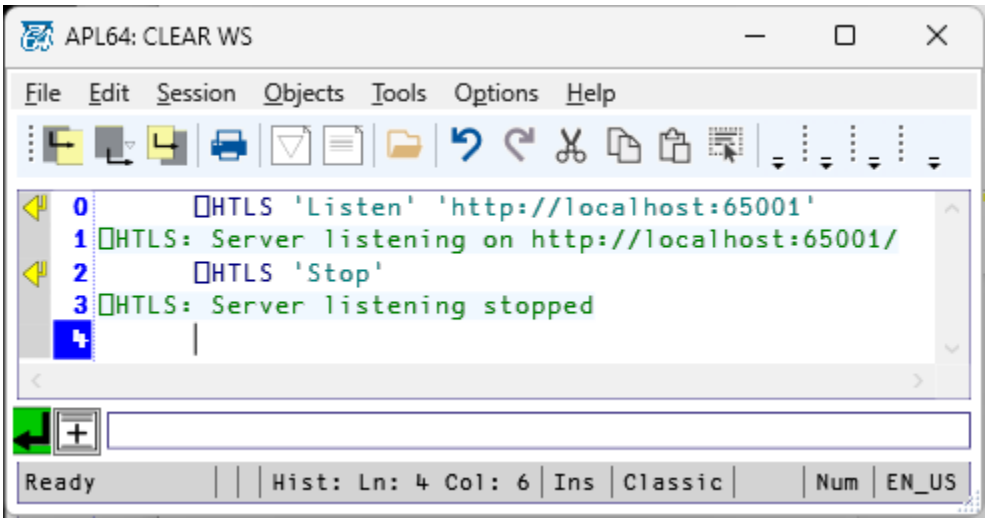
Stop

The Stop action requests the ⎕HTLS server to stop listening to incoming client requests on the specified URL(s).

Syntax: msg ← ⎕HTLS 'Stop'

Note: The server instance of APL64 is not ended.

```
⎕HTLS 'Listen' 'http://localhost:65001'
⎕HTLS 'Stop'
```



UrlInfo

The UrlInfo action returns the currently configured and listened to urls.

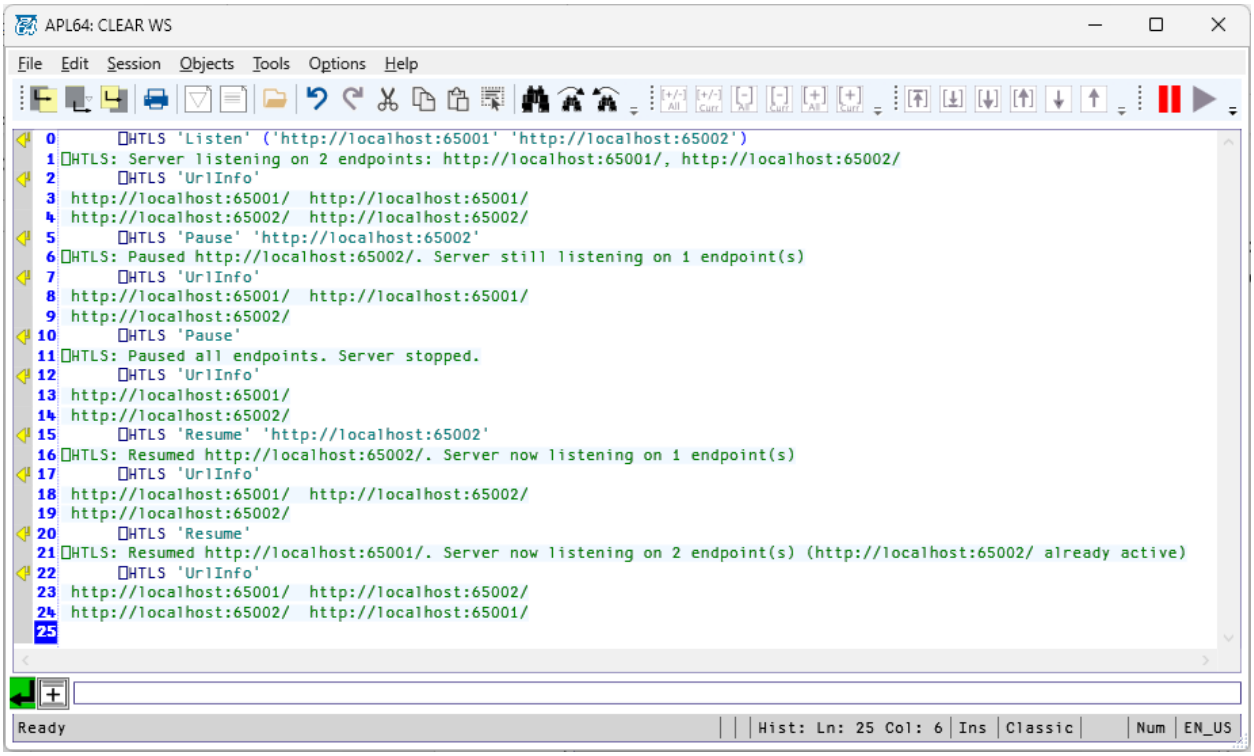
Syntax: (configUrls listenUrls) ← ⎕HTLS 'UrlInfo'

The UrlInfo action returns a two-element vector. The first vector element is a character array of the currently configured url(s), including the listening and paused url(s). The second vector element is a character array of the currently listened to urls. Because an ⎕HTLS server is an asynchronous, multi-threaded server, the UrlInfo action is 'snap-shot' information which can change at any time depending on the actions performed upon the server.

Example:

```
⎕HTLS 'Listen' ('http://localhost:65001' 'http://localhost:65002')
⎕HTLS 'UrlInfo'
```

```
      ]HTLS 'Pause' 'http://localhost:65002'
      ]HTLS 'UrlInfo'
      ]HTLS 'Pause'
      ]HTLS 'UrlInfo'
      ]HTLS 'Resume' 'http://localhost:65002'
      ]HTLS 'UrlInfo'
      ]HTLS 'Resume'
      ]HTLS 'UrlInfo'
```



]HTLCURL

Many of the]HTLC actions require a URL left argument. Instead of specifying this URL for each]HTLC action,]HTLCURL can be set to contain the required URL value. When]HTLCURL has a value, no left argument URL value is needed for those]HTLC actions which require a URL value.

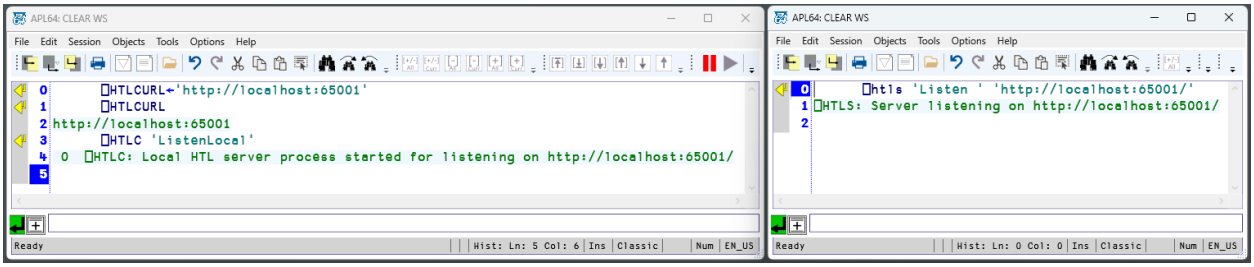
Syntax:

]HTLCURL←URLText

varName←]HTLCURL

Example:

```
⎕HTLCURL←'http://localhost:65001'
⎕HTLCURL
⎕HTLC 'ListenLocal'
```



Development and Runtime Use of ⎕HTLC and ⎕HTLS

Development Environment

The APL64 Developer version provides the APL64 development environment. All ⎕HTLC and ⎕HTLS system function actions can be used in the APL64 development environment. When used in the APL64 development environment, the ⎕HTLS server can be made visible and debugged.

Runtime Environment

APL64 has two runtime environments designed for applications in production use. The APL64 production environments are available as a Windows Runtime Executable (WRE) or a Cross-platform Component (CPC).

- All ⎕HTLC system function actions, except for ListenLocal, can be used in an APL64 WRE or CPC.
- All ⎕HTLS system function actions, including Listen, can be used in an APL64 WRE or CPC.

Example #1: Using ⎕HTLS in a WRE

In this example an APL64 WRE (Windows Runtime Executable) is used to start an APL64 ⎕HTLS server.

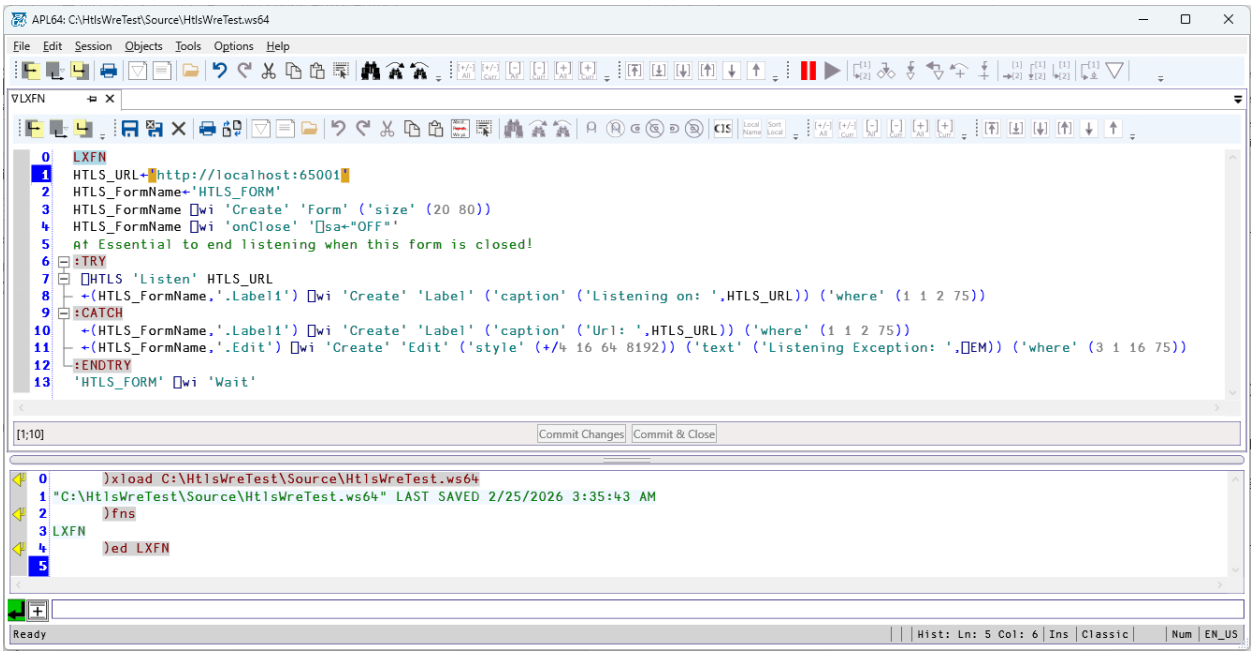
Create the WRE (C:\HtlsWreTest\Source\HtlsWreTest.ws64) workspace

Create the WRE workspace containing the required ⎕LX function:

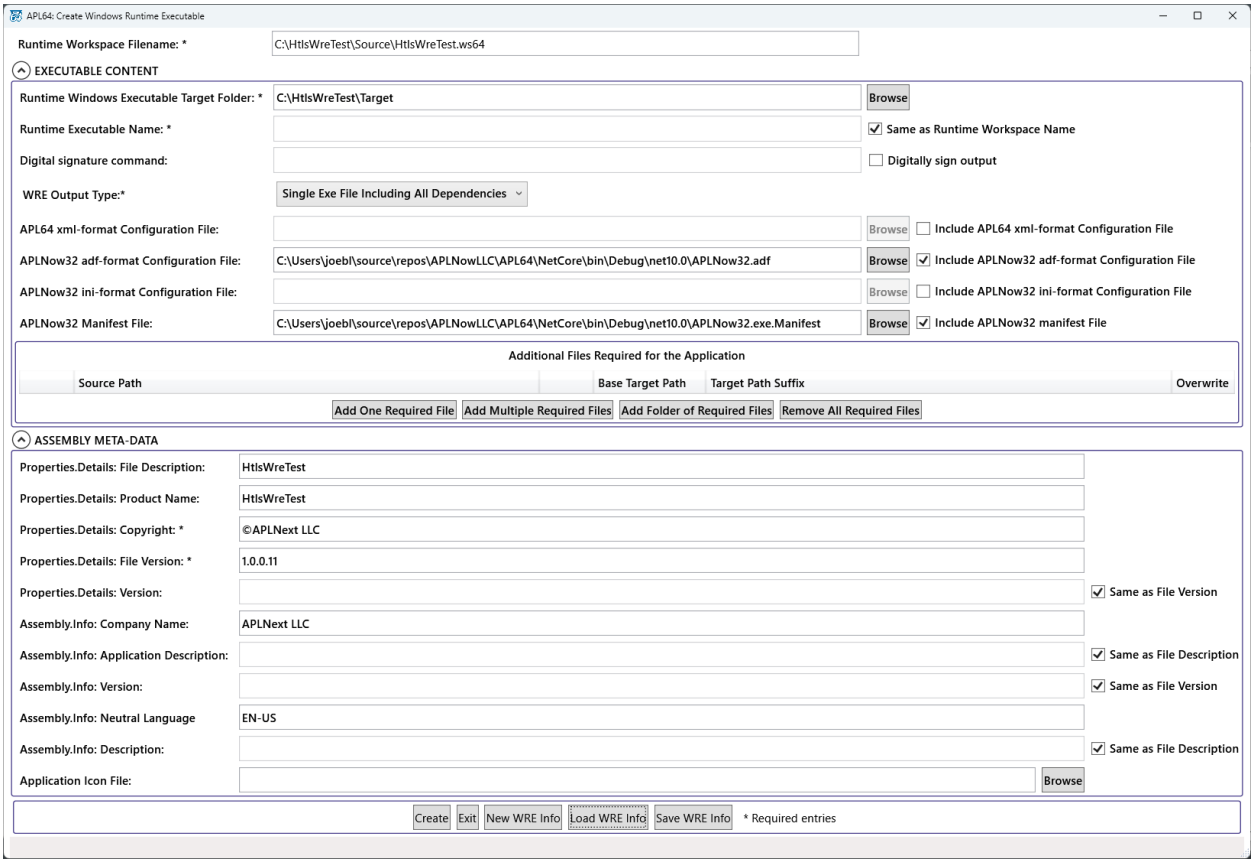
```
LXFN
HTLS_URL←'http://localhost:65001'
HTLS_FormName←'HTLS_FORM'
```

```
HTLS_FormName ⎕wi 'Create' 'Form' ('size' (20 80))
HTLS_FormName ⎕wi 'onClose' '⎕sa←"OFF"'
⍝↑ Essential to end listening when this form is closed!
:TRY
 ⎕HTLS 'Listen' HTLS_URL
 ←(HTLS_FormName,'.Label1') ⎕wi 'Create' 'Label' ('caption' ('Listening on: ',HTLS_URL))
('where' (1 1 2 75))
:CATCH
 ←(HTLS_FormName,'.Label1') ⎕wi 'Create' 'Label' ('caption' ('Url: ',HTLS_URL)) ('where' (1
1 2 75))
 ←(HTLS_FormName,'.Edit') ⎕wi 'Create' 'Edit' ('style' (+/4 16 64 8192)) ('text' ('Listening
Exception: ',⎕EM)) ('where' (3 1 16 75))
:ENDTRY
'HTLS_FORM' ⎕wi 'Wait'
```

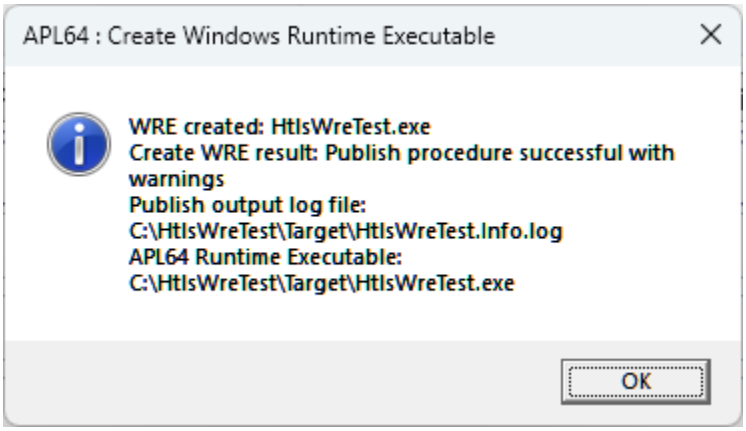
A waiting ⎕wi Form or a continuous-loop in the ⎕LX function is needed to prevent the WRE from closing.



Complete the APL64 WRE creation utility dialog



Click the WRE creation utility dialog ‘Create’ button

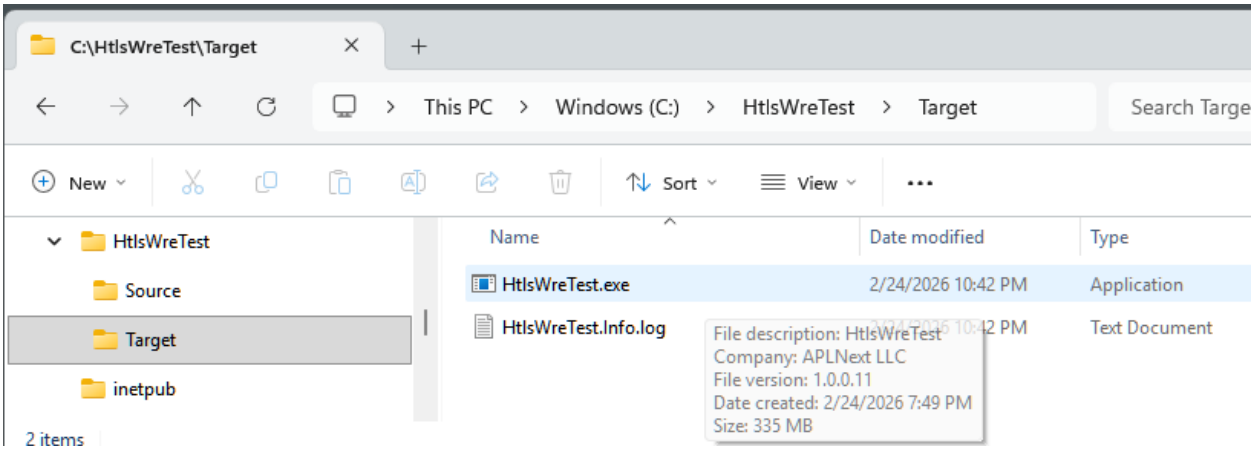


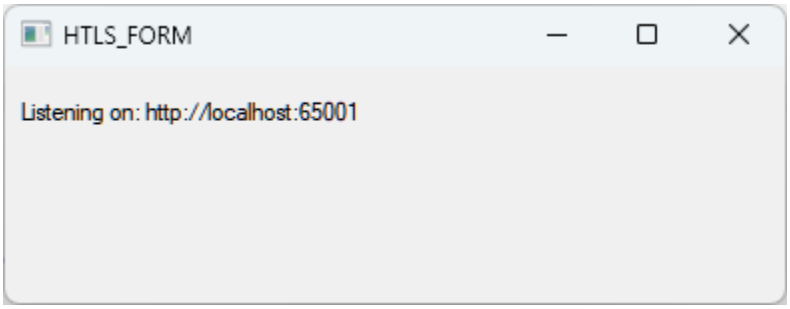
Save the WRE Creation Utility Input

Click the WRE creation utility ‘Save WRE Info’ button to save the WRE configuration information for future use.

Run the APL64 WRE to create the HTLS Server

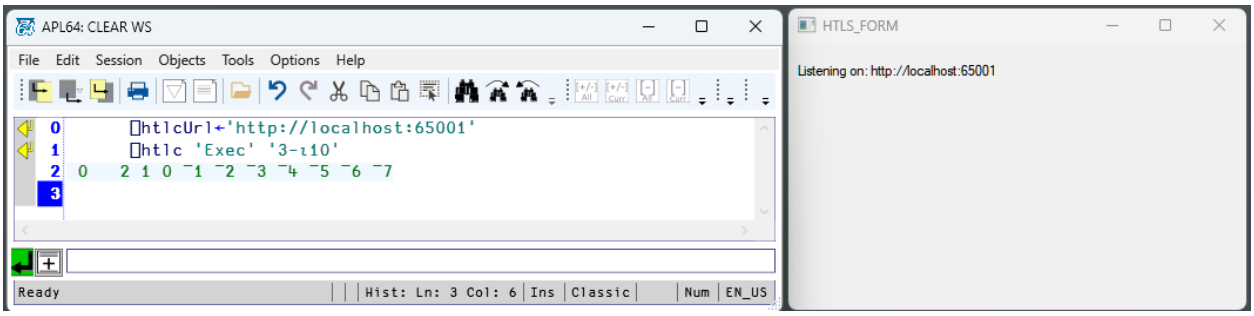
Double-click the Windows Runtime Executable file:

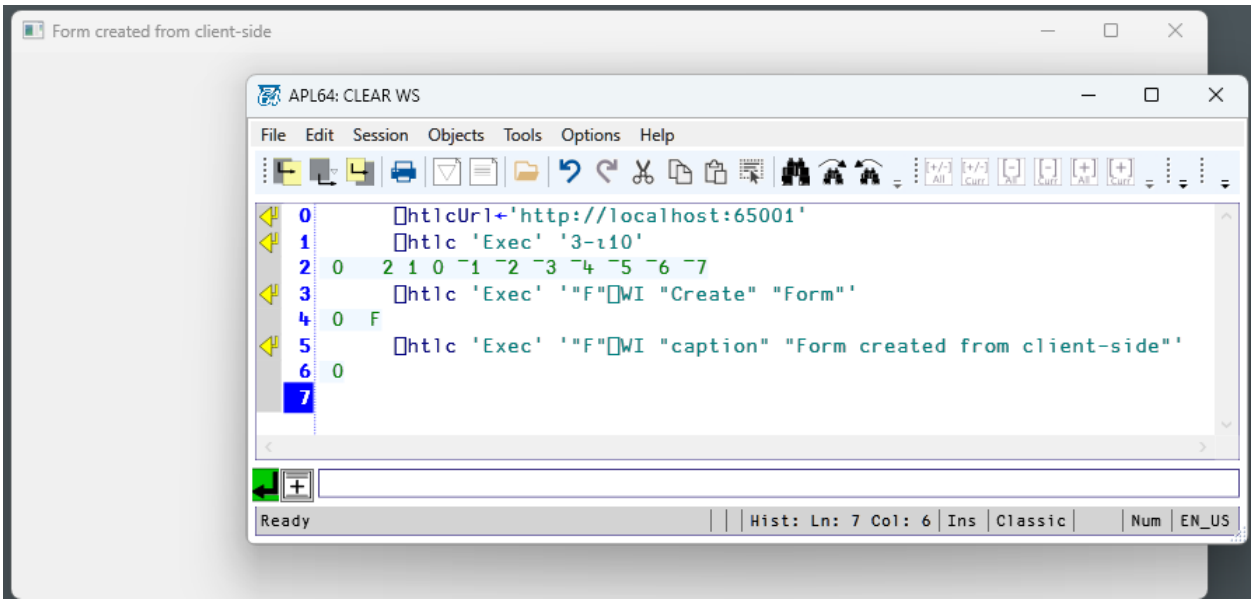




Use an APL64 Instance to access the WRE-based ⎕HTLS Server

Create a separate APL64 instance and use ⎕HTLC to access the public WRE-based ⎕HTLS server:





The ⎕HTLS server may be stopped by closing the ⎕HTLS window.

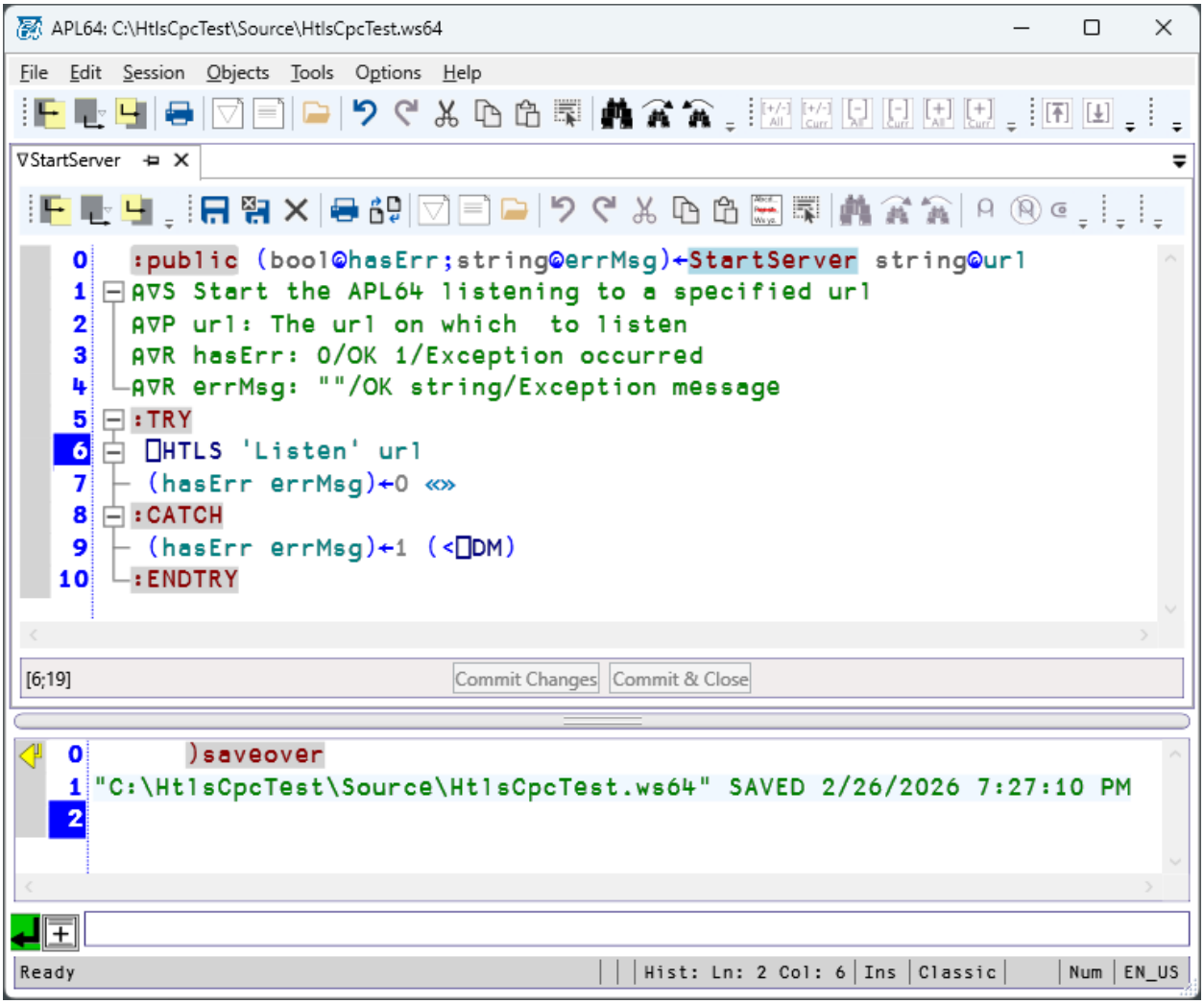
Example #2: ⎕HTLS in a CPC

In this example an APL64 CPC is created to start an ⎕HTLS server. This APL64 CPC can be used by a .Net project to start an ⎕HTLS server.

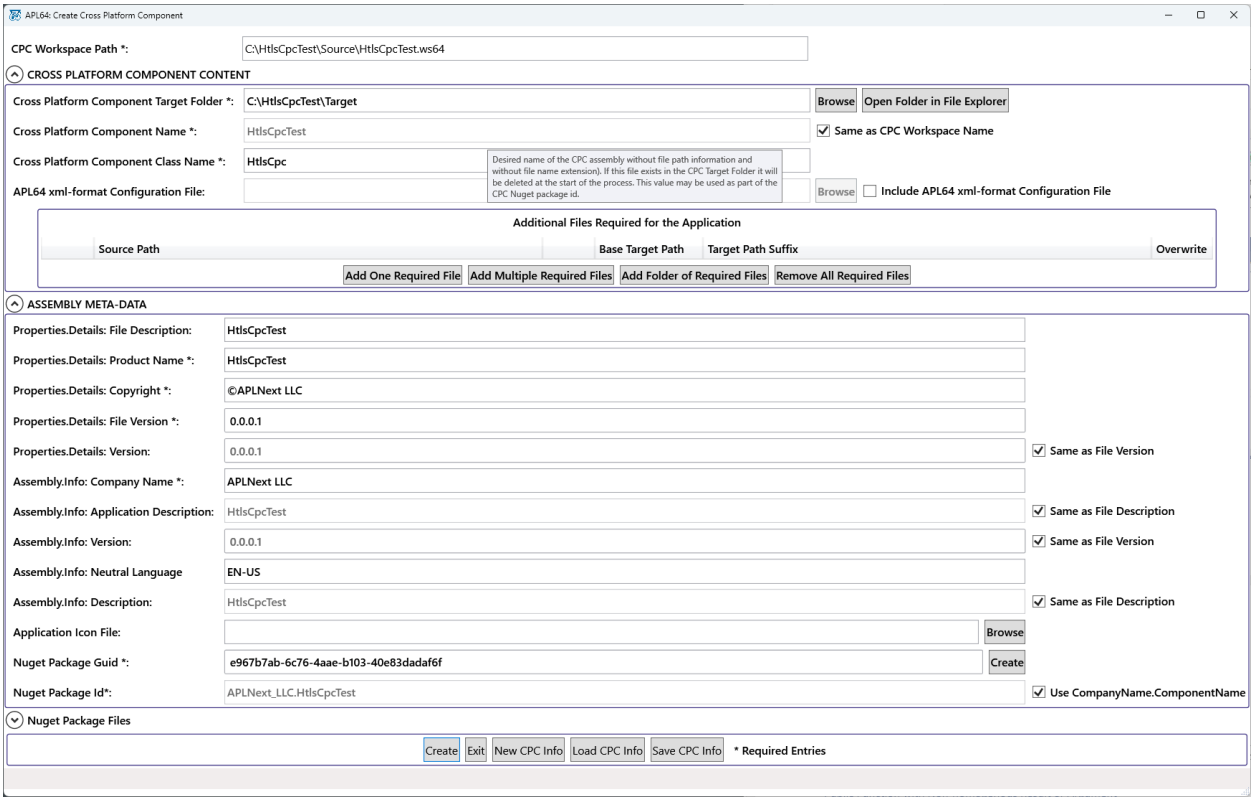
Create the C:\HtlsCpcTest\Source\HtlsCpcTest.ws64 workspace

Create the required workspace with at least one public function, and include.Net Intellisense scaffold remarks:

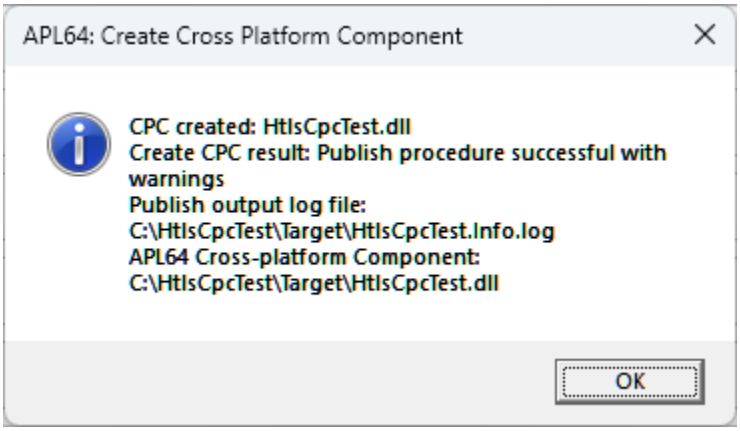
```
:public (bool@hasErr;string@errMsg)←StartServer string@url
⍝∇S Start the APL64 listening to a specified url
⍝∇P url: The url on which  to listen
⍝∇R hasErr: 0/OK 1/Exception occurred
⍝∇R errMsg: ""/OK string/Exception message
:TRY
 ⎕HTLS 'Listen' url
 (hasErr errMsg)←0 «»
:CATCH
 (hasErr errMsg)←1 (<⎕DM)
:ENDTRY
```



Complete the APL64 CPC creation dialog



Click the CPC creation dialog 'Create' button

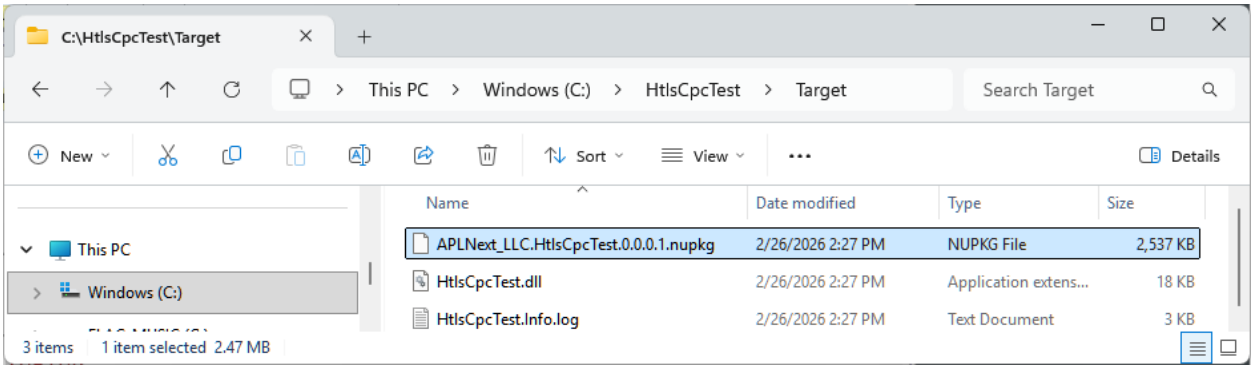


Save the CPC Creation Dialog Input

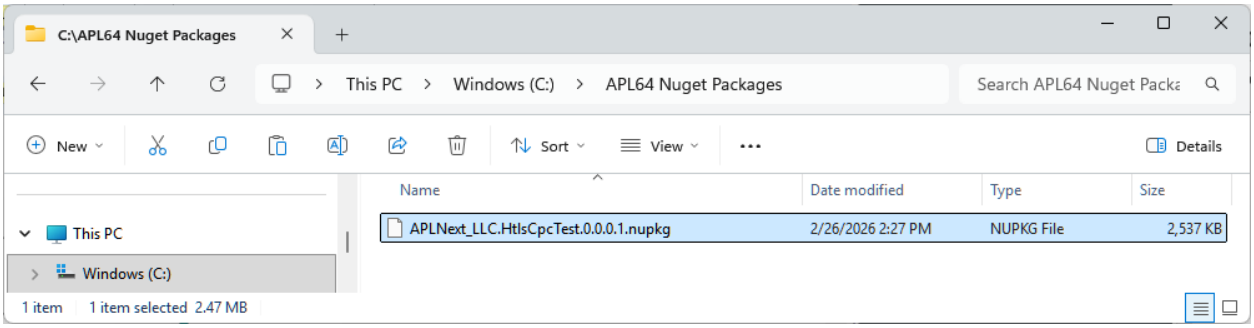
Click the CPC creation dialog 'Save CPC Info' button to preserve the CPC configuration for future use.

Copy the resulting Nuget package from the Target folder to the Nuget package publish folder:

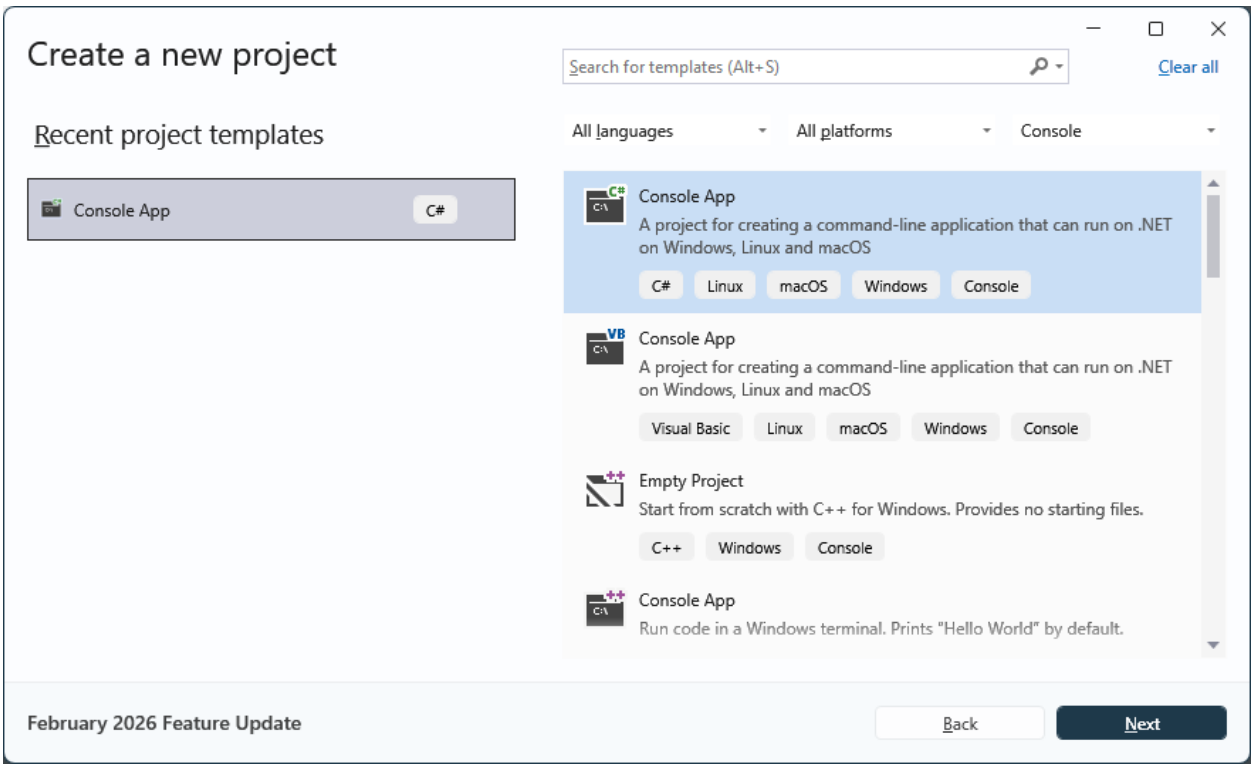
From:

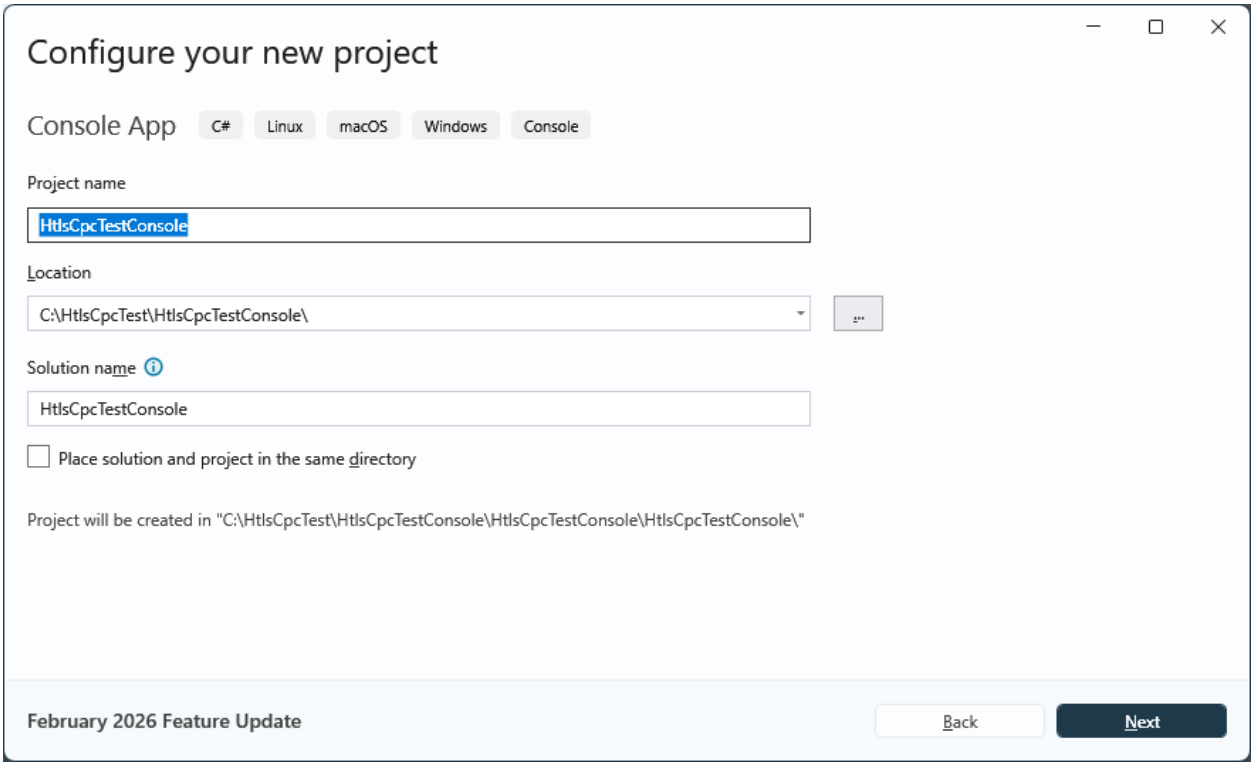


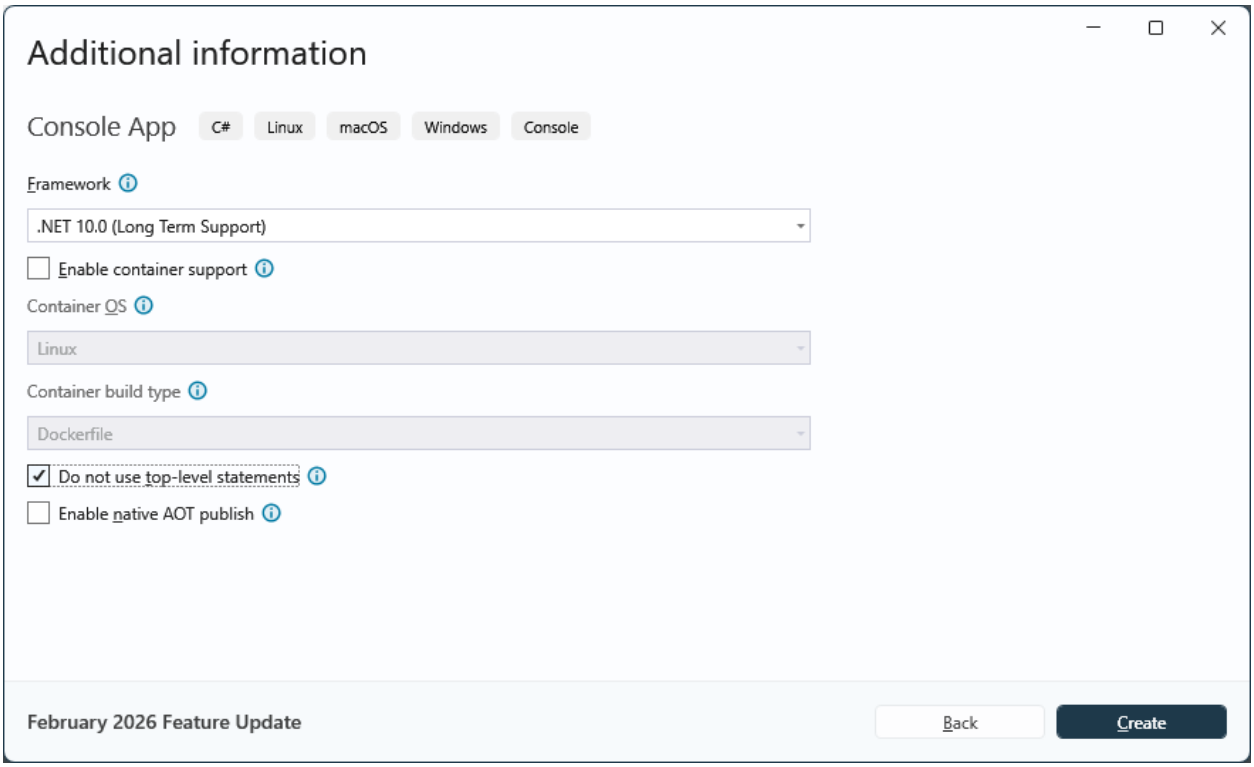
To:



Use the APL64 CPC Nuget package in a .Net console project



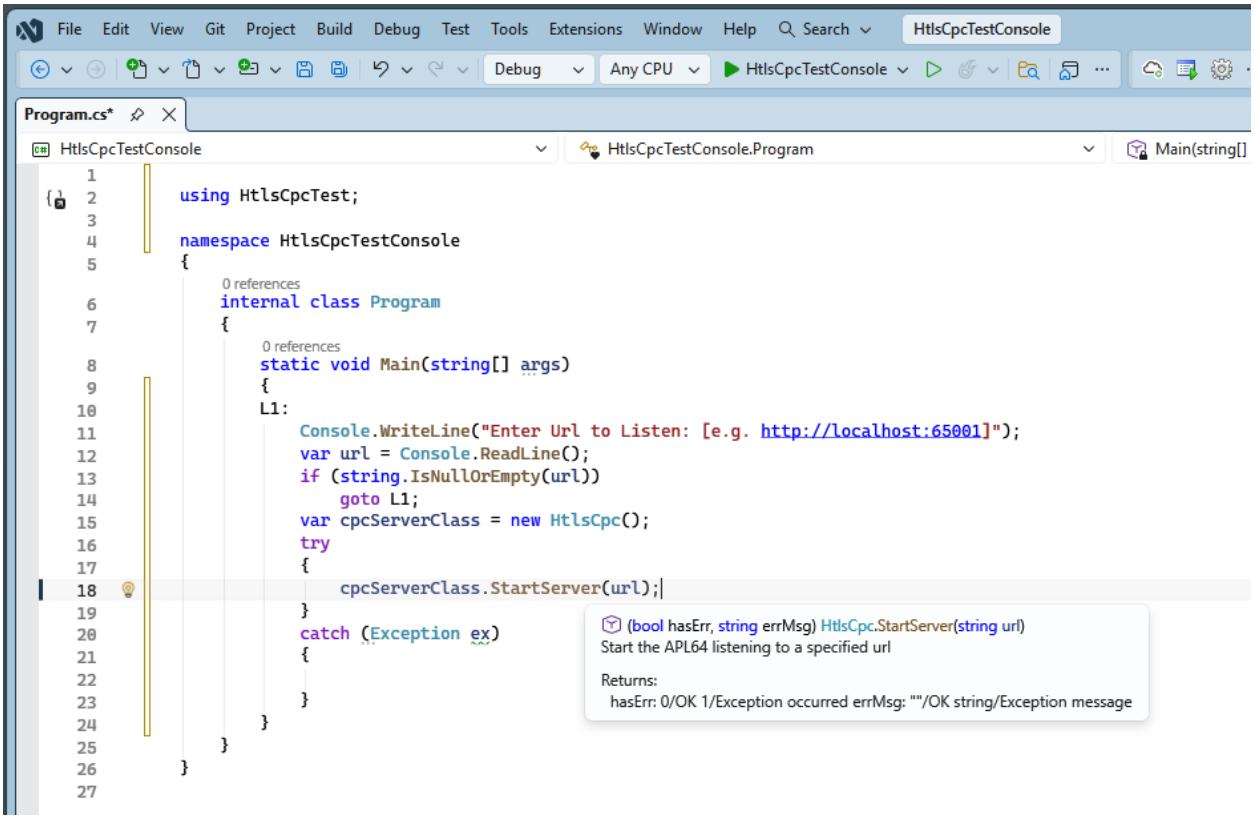




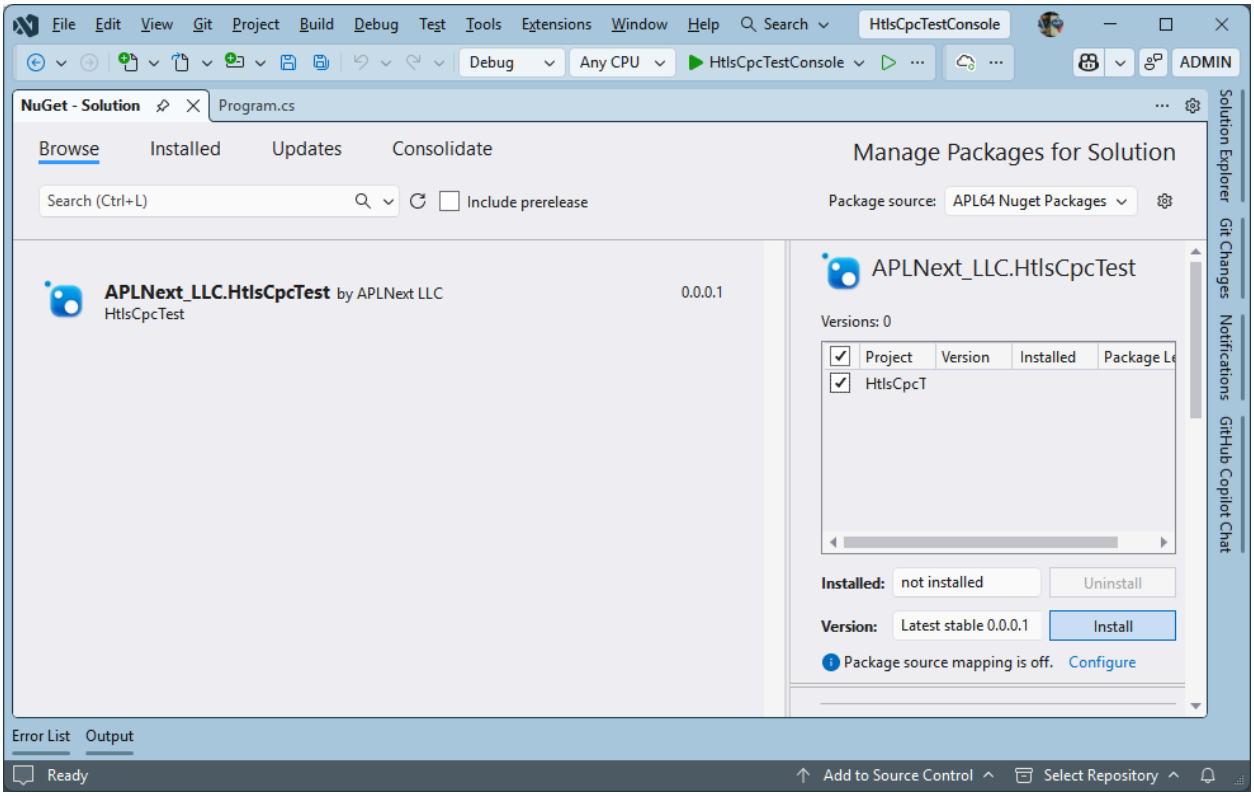
Replace the default C# source code with this code:

```
using HtlsCpcTest;
namespace HtlsCpcTestConsole
```

```
{
   internal class Program
   {
      static void Main(string[] args)
      {
      L1:
         Console.WriteLine("Enter Url to Listen: [e.g. http://localhost:65001]");
         var url = Console.ReadLine();
         if (string.IsNullOrEmpty(url))
            goto L1;
         var cpcServerClass = new HtlsCpc();
         try
         {
            cpcServerClass.StartServer(url);
         }
         catch (Exception ex)
         {

         }
      }
   }
}
```

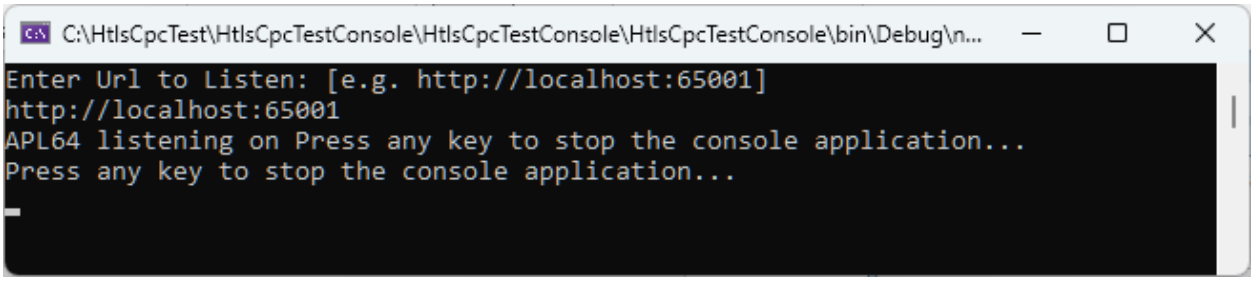


Use Tools > Nuget Package Manager > Manage Nuget Packages for Solution dialog to install the APL64 CPC Nuget package to the solution:



Run the console application using the APL64 CPC to Start the ⎕HTLS Server

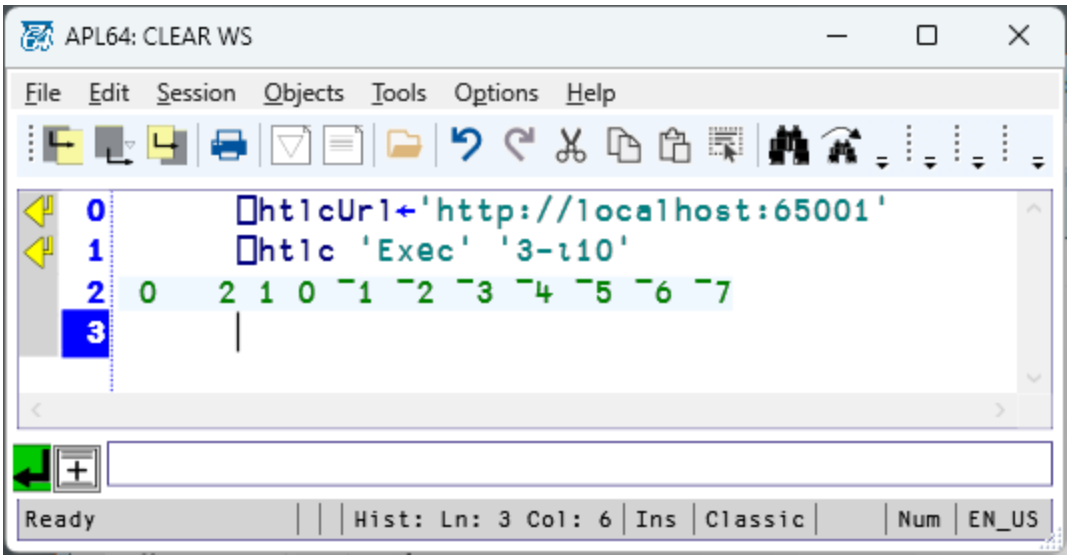
Run the console application and enter an appropriate url for listening:



Use an APL64 Developer Instance to Access the ⎕HTLS Server

Start an APL64 instance and use ⎕HTLC to access the CPC-based server:

```
⎕htlcUrl←'http://localhost:65001'
⎕htlc 'Exec' '3-⍳10'
```



Example #3: ⎕HTLC in a CPC

In this example APL64 public functions in an APL64 CPC are created for each applicable ⎕HTLC action. The resulting APL64 CPC can be used to access an APL64 ⎕HTLS server from .Net using C#.

You can follow these instructions to build a copy of the CPC as a Nuget package which is a .Net client for an ⎕HTLS server. The completed CPC Nuget package is also available here:

https://aplnow.com/APL64/UserDocumentation/APLNext.HtlsNetClient.2026.6.0.4.zip

Create the disk folders for the example

- C:\HTLS NET CLIENT
- C:\HTLS NET CLIENT\Source
- C:\HTLS NET CLIENT\Target

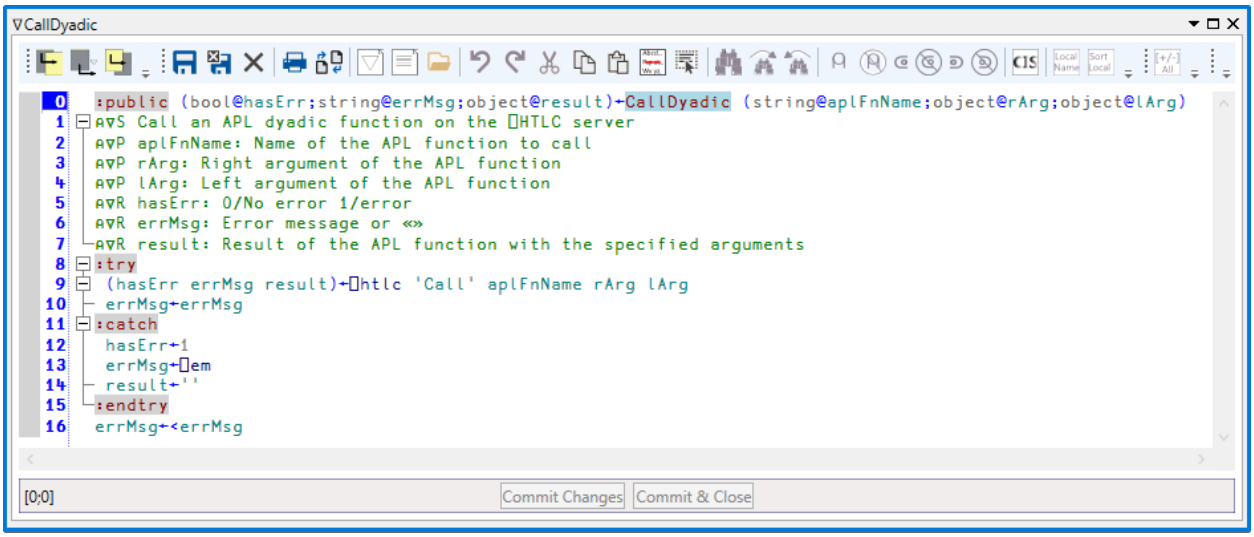
Create source workspace and public functions

Create the required workspace (C:\HTLS NET CLIENT\Source\HtlsNetClient.ws64) with these APL64 public functions, including .Net Intellisense scaffold remarks. Depending on your requirements, not all of these functions need to be created.

CallDyadic

```
:public (bool@hasErr;string@errMsg;object@result)←CallDyadic
(string@aplFnName;object@rArg;object@lArg)
⍝∇S Call an APL dyadic function on the ⎕HTLC server
⍝∇P aplFnName: Name of the APL function to call
⍝∇P rArg: Right argument of the APL function
⍝∇P lArg: Left argument of the APL function
```

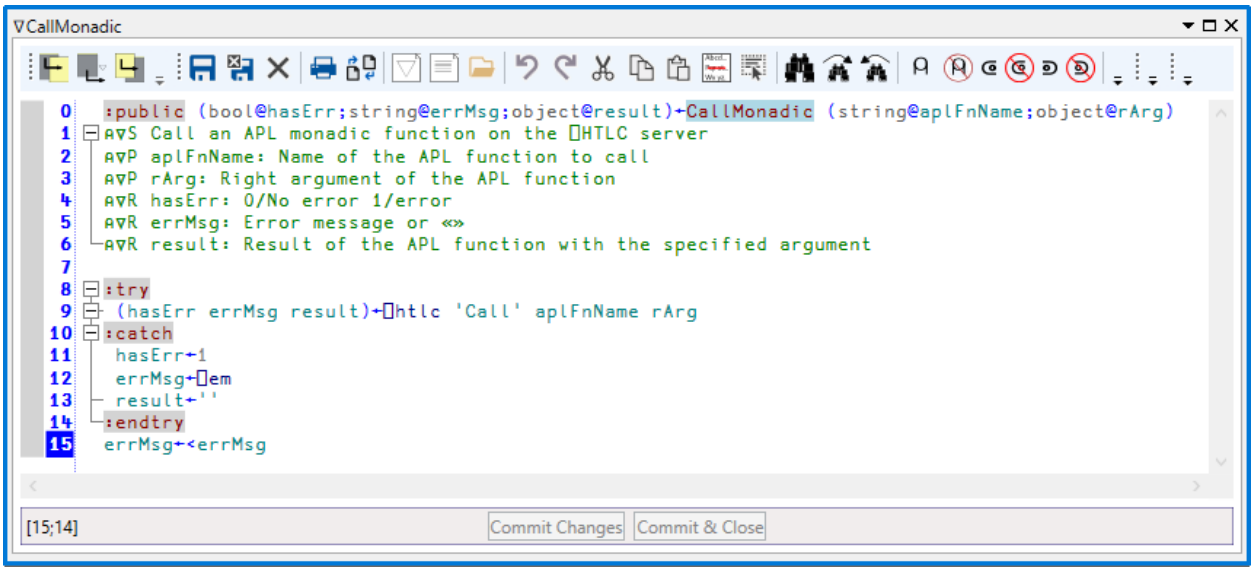
```
⍝⍝∇R hasErr: 0/No error 1/error
⍝⍝∇R errMsg: Error message or ««
⍝⍝∇R result: Result of the APL function with the specified arguments
:try
 (hasErr errMsg result)←⎕htlc 'Call' aplFnName rArg lArg
 errMsg←errMsg
:catch
 hasErr←1
 errMsg←⎕em
 result←''
:endtry
errMsg←<errMsg
```



CallMonadic

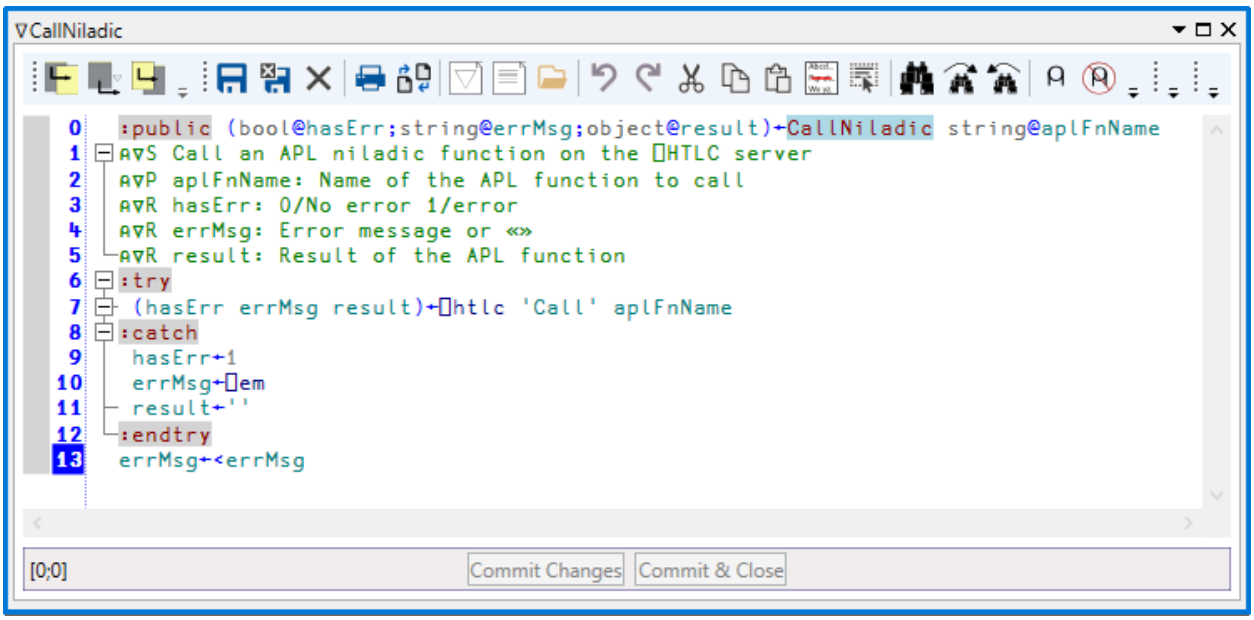
```
:public(bool@hasErr;string@errMsg;object@result)←CallMonadic
(string@aplFnName;object@rArg)
⍝⍝∇S Call an APL monadic function on the ⎕HTLC server
⍝⍝∇P aplFnName: Name of the APL function to call
⍝⍝∇P rArg: Right argument of the APL function
⍝⍝∇R hasErr: 0/No error 1/error
⍝⍝∇R errMsg: Error message or ««
⍝⍝∇R result: Result of the APL function with the specified argument

:try
 (hasErr errMsg result)←⎕htlc 'Call' aplFnName rArg
:catch
 hasErr←1
 errMsg←⎕em
```

```
 result←''
:endtry
errMsg←<errMsg
```



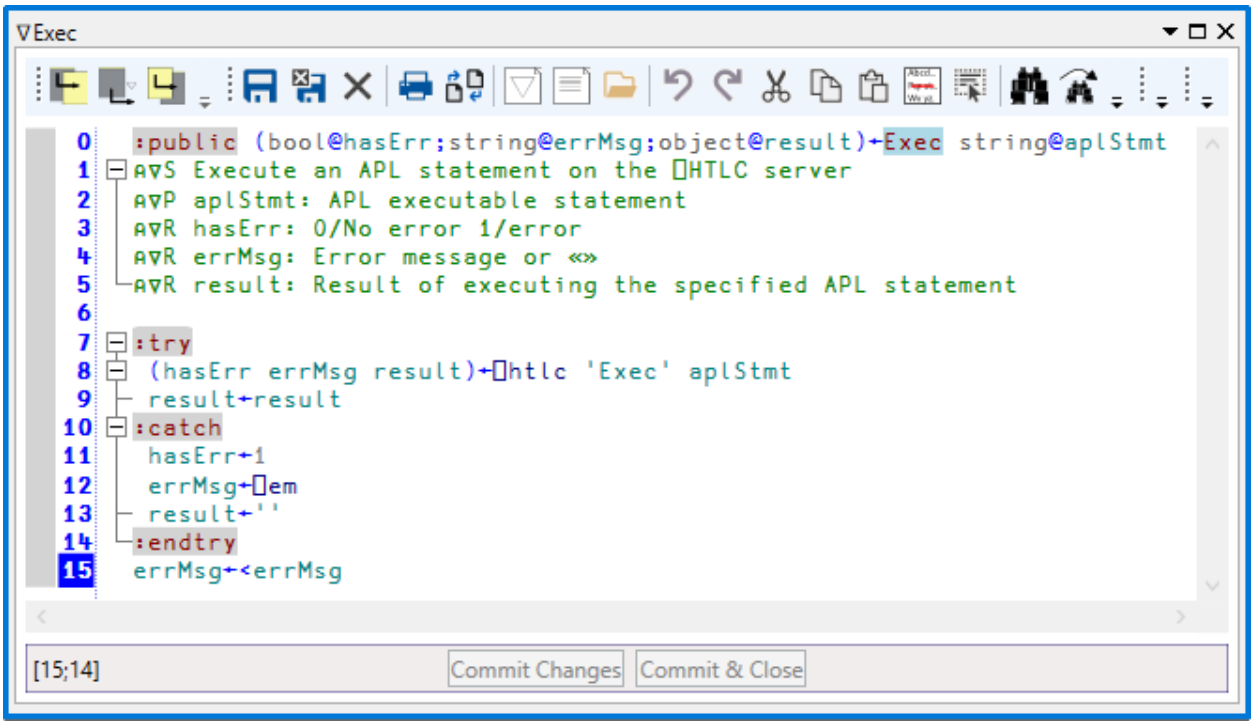
CallNiladic

```
:public (bool@hasErr;string@errMsg;object@result)←CallNiladic string@aplFnName
⍝∇S Call an APL niladic function on the ⎕HTLC server
⍝∇P aplFnName: Name of the APL function to call
⍝∇R hasErr: 0/No error 1/error
⍝∇R errMsg: Error message or ««
⍝∇R result: Result of the APL function
:try
 (hasErr errMsg result)←⎕htlc 'Call' aplFnName
:catch
 hasErr←1
 errMsg←⎕em
 result←''
:endtry
errMsg←<errMsg
```



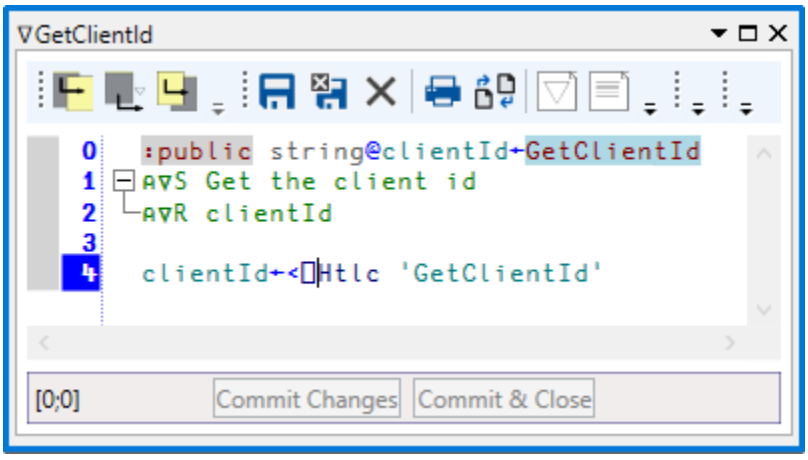
Exec

```
:public (bool@hasErr;string@errMsg;object@result)←Exec string@aplStmt
⍝∇S Execute an APL statement on the ⎕HTLC server
⍝∇P aplStmt: APL executable statement
⍝∇R hasErr: 0/No error 1/error
⍝∇R errMsg: Error message or ««
⍝∇R result: Result of executing the specified APL statement

:try
 (hasErr errMsg result)←⎕htlc 'Exec' aplStmt
 result←result
:catch
 hasErr←1
 errMsg←⎕em
 result←''
:endtry
errMsg←<errMsg
```



GetClientId

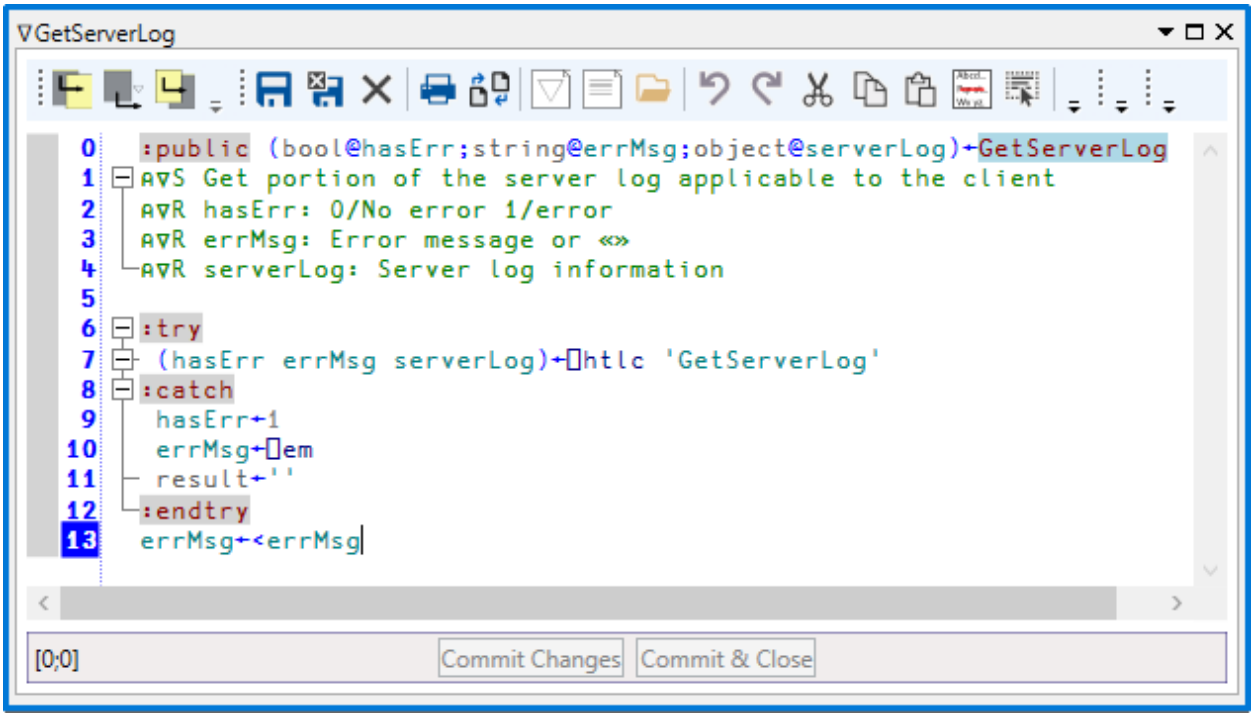
```
:public string@clientId←GetClientId
⍝∇S Get the client id
⍝∇R clientId

clientId←<⎕Htlc 'GetClientId'
```



GetServerLog

```
:public (bool@hasErr;string@errMsg;object@serverLog)←GetServerLog
⍝∇S Get portion of the server log applicable to the client
⍝∇R hasErr: 0/No error 1/error
```

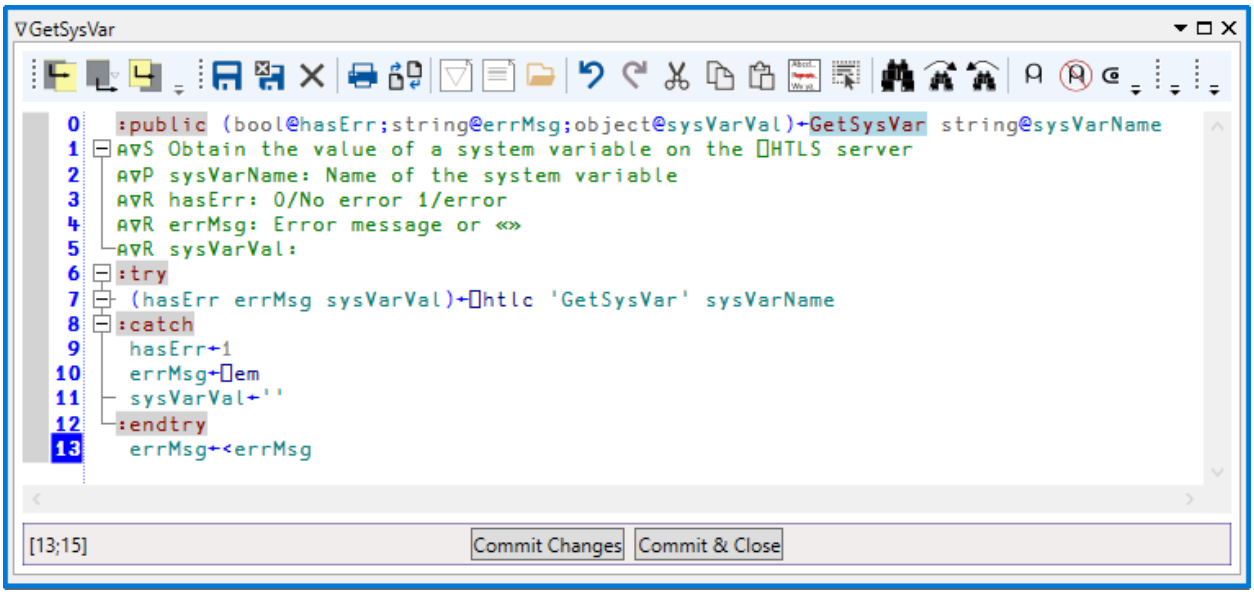
```
⍝∇R errMsg: Error message or ««
⍝∇R serverLog: Server log information

:try
 (hasErr errMsg serverLog)←⎕htlc 'GetServerLog'
:catch
 hasErr←1
 errMsg←⎕em
 result←''
:endtry
errMsg←<errMsg
```



GetSysVar

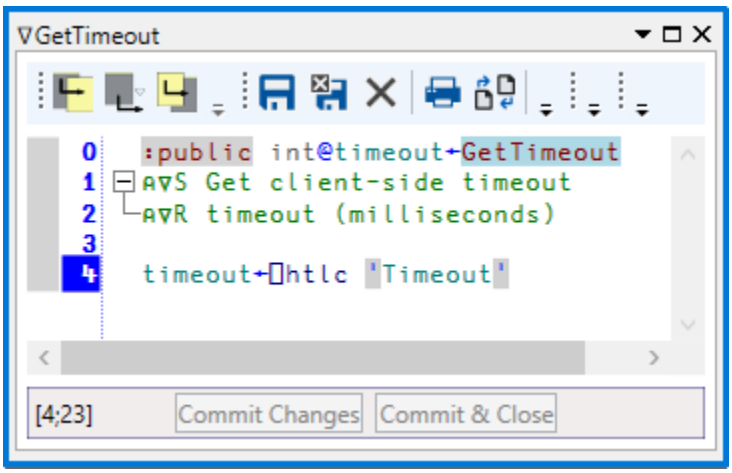
```
:public (bool@hasErr;string@errMsg;object@sysVarVal)←GetSysVar string@sysVarName
⍝∇S Obtain the value of a system variable on the ⎕HTLS server
⍝∇P sysVarName: Name of the system variable
⍝∇R hasErr: 0/No error 1/error
⍝∇R errMsg: Error message or ««
⍝∇R sysVarVal:
:try
 (hasErr errMsg sysVarVal)←⎕htlc 'GetSysVar' sysVarName
:catch
 hasErr←1
 errMsg←⎕em
```

```
 sysVarVal←''
:endtry
 errMsg←<errMsg
```



GetTimeout

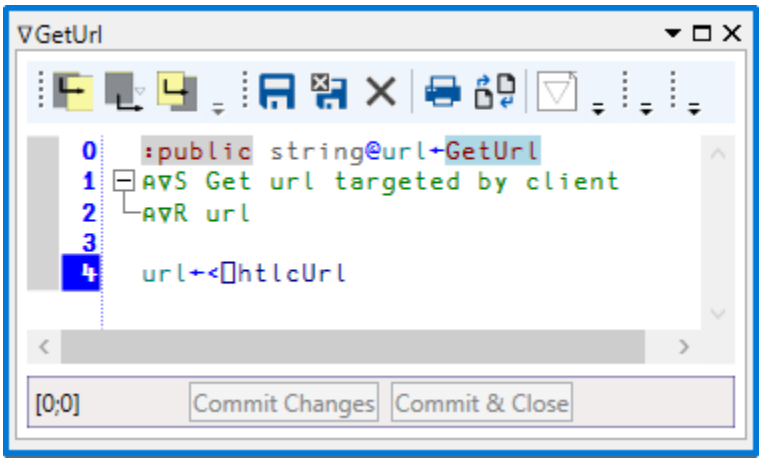
```
:public int@timeout←GetTimeout
⍝∇S Get client-side timeout
⍝∇R timeout (milliseconds)

timeout←⎕htlc 'Timeout'
```



GetUrl

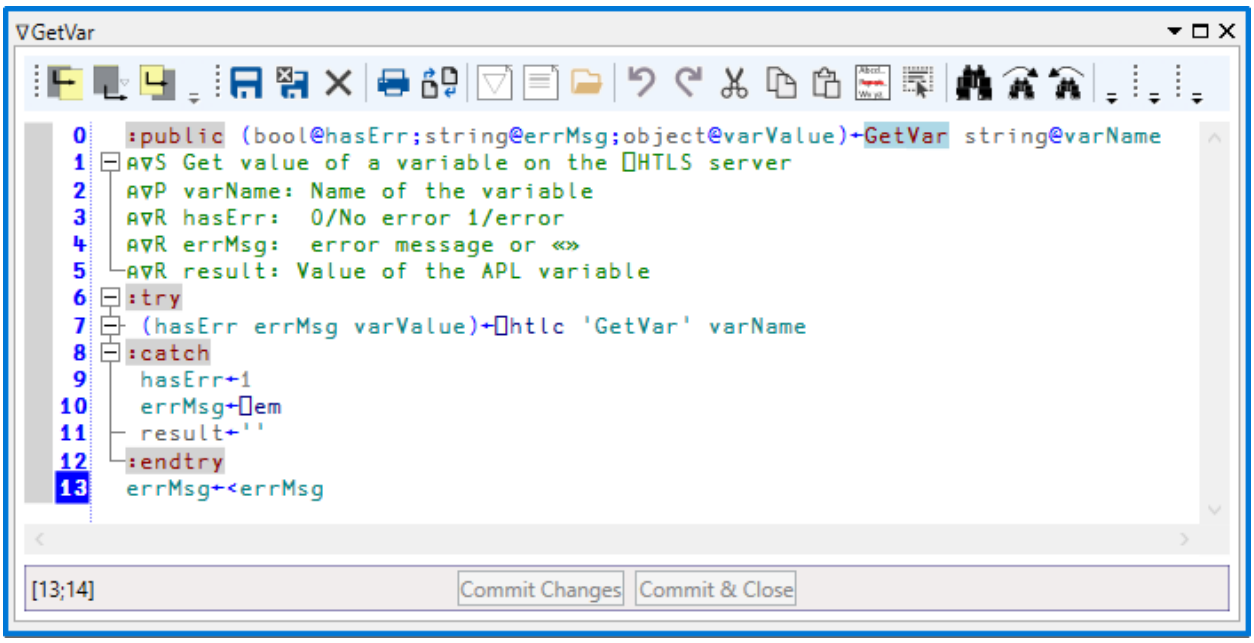
```
:public string@url←GetUrl
```

```
⍝∇S Get url targeted by client
⍝∇R url

url←<⎕htlcUrl
```



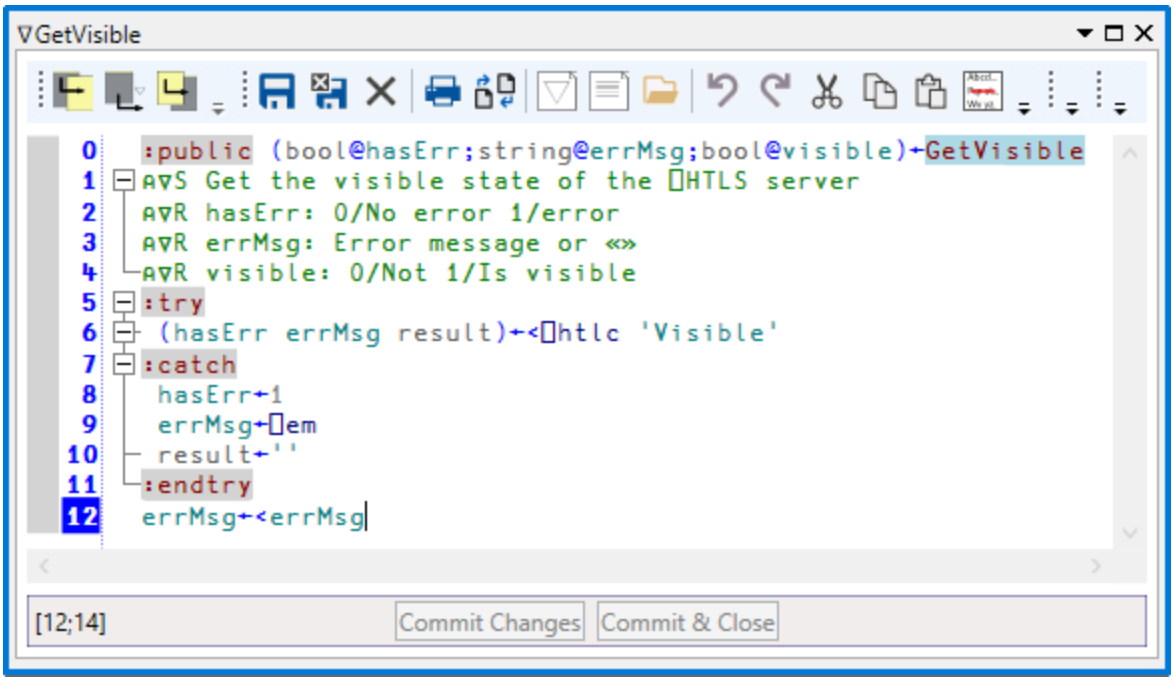
GetVar

```
:public (bool@hasErr;string@errMsg;object@varValue)←GetVar string@varName
⍝∇S Get value of a variable on the ⎕HTLS server
⍝∇P varName: Name of the variable
⍝∇R hasErr:  0/No error 1/error
⍝∇R errMsg:  error message or «»
⍝∇R result: Value of the APL variable
:try
 (hasErr errMsg varValue)←⎕htlc 'GetVar' varName
:catch
 hasErr←1
 errMsg←⎕em
 result←''
:endtry
errMsg←<errMsg
```



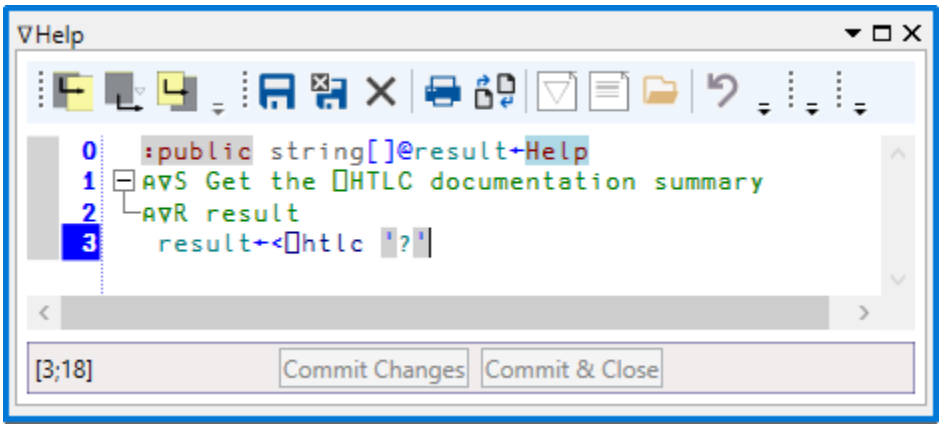
GetVisible

```
:public (bool@hasErr;string@errMsg;bool@visible)←GetVisible
⍝∇S Get the visible state of the ⎕HTLS server
⍝∇R hasErr: 0/No error 1/error
⍝∇R errMsg: Error message or «»
⍝∇R visible: 0/Not 1/Is visible
:try
 (hasErr errMsg result)←<⎕htlc 'Visible'
:catch
 hasErr←1
 errMsg←⎕em
 result←''
:endtry
errMsg←<errMsg
```



Help

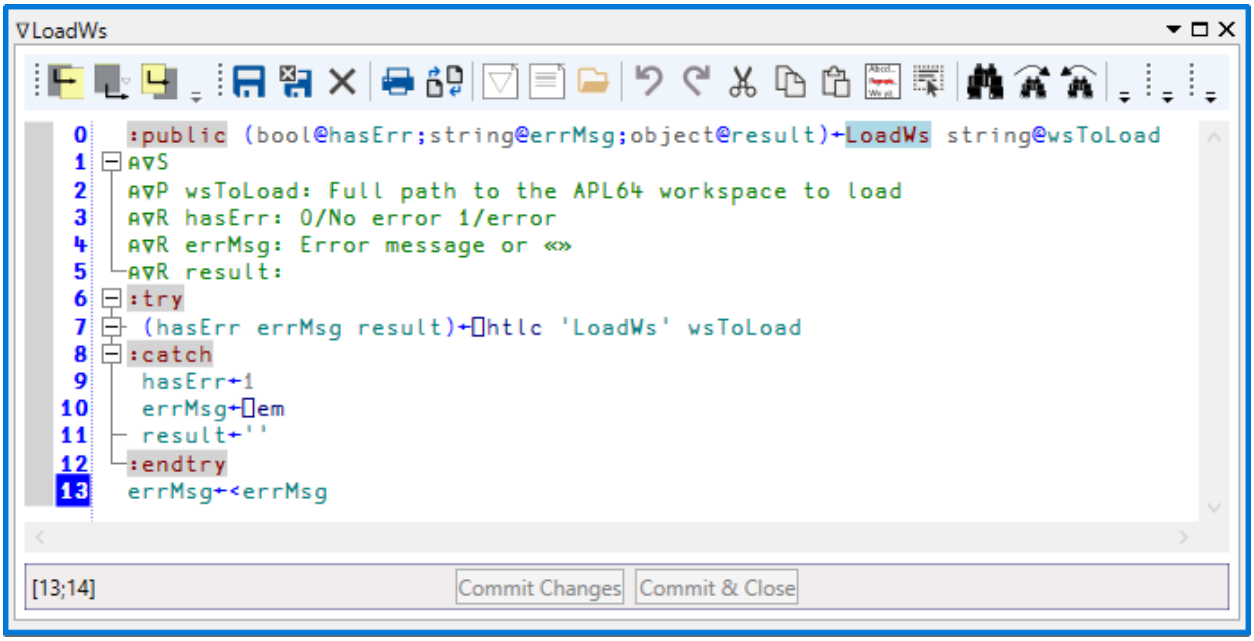
```
:public string[]@result←Help
⍝∇S Get the ⎕HTLC documentation summary
⍝∇R result
 result←<⎕htlc '?'
```



LoadWs

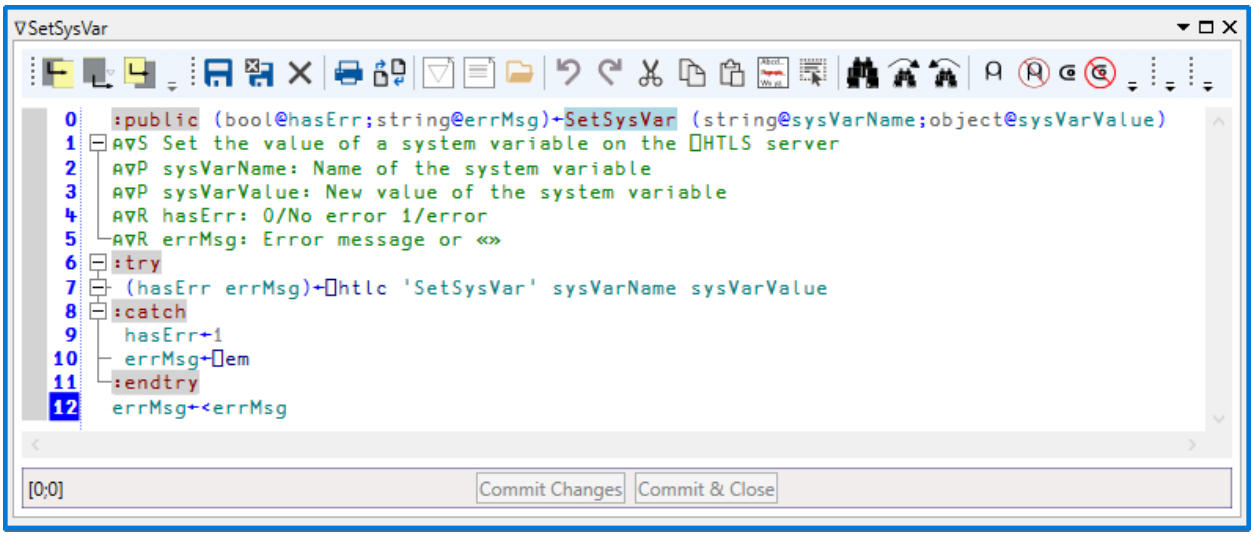
```
:public (bool@hasErr;string@errMsg;object@result)←LoadWs string@wsToLoad
⍝∇S
⍝∇P wsToLoad: Full path to the APL64 workspace to load
⍝∇R hasErr: 0/No error 1/error
⍝∇R errMsg: Error message or «»
⍝∇R result:
```

```
:try
 (hasErr errMsg result)←⎕htlc 'LoadWs' wsToLoad
:catch
 hasErr←1
 errMsg←⎕em
 result←''
:endtry
errMsg←⊂errMsg
```



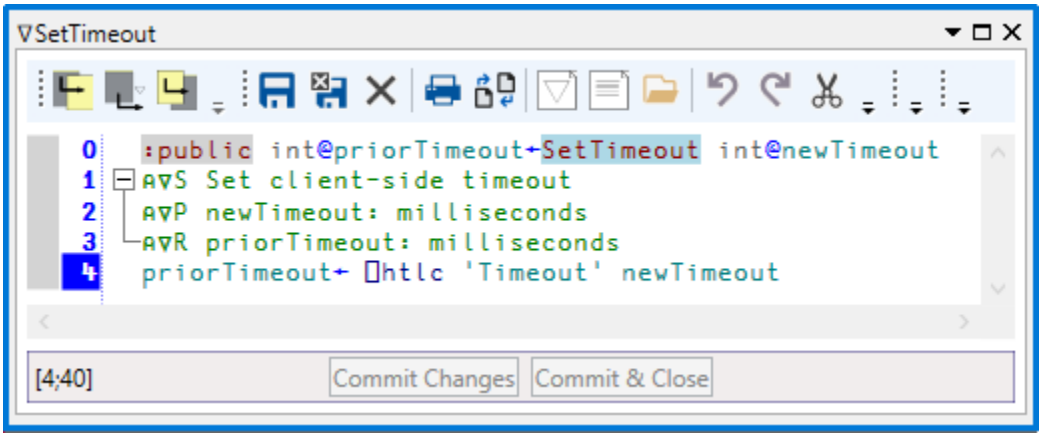
SetSysVar

```
:public (bool@hasErr;string@errMsg)←SetSysVar
(string@sysVarName;object@sysVarValue)
⍝∇S Set the value of a system variable on the ⎕HTLS server
⍝∇P sysVarName: Name of the system variable
⍝∇P sysVarValue: New value of the system variable
⍝∇R hasErr: 0/No error 1/error
⍝∇R errMsg: Error message or «»
:try
 (hasErr errMsg)←⎕htlc 'SetSysVar' sysVarName sysVarValue
:catch
 hasErr←1
 errMsg←⎕em
:endtry
errMsg←⊂errMsg
```



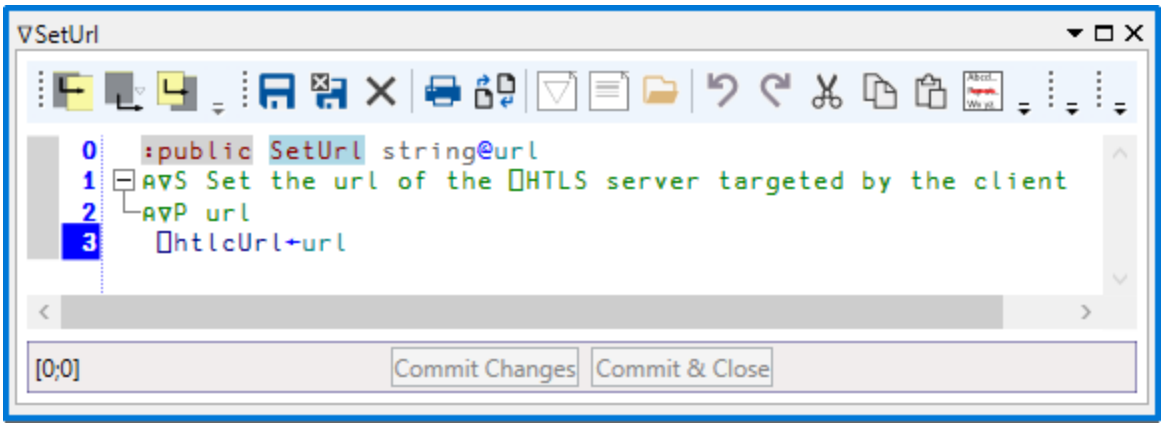
SetTimeOut

```
:public int@priorTimeout←SetTimeout int@newTimeout
⍝∇S Set client-side timeout
⍝∇P newTimeout: milliseconds
⍝∇R priorTimeout: milliseconds
priorTimeout← ⎕htlc 'Timeout' newTimeout
```



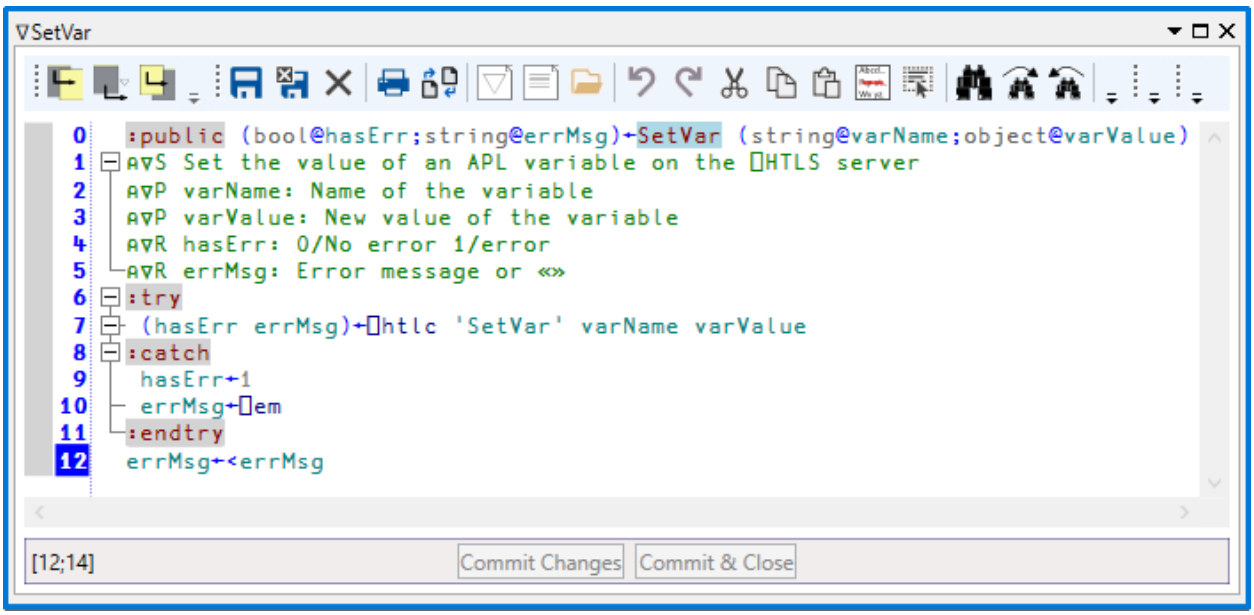
SetUrl

```
:public SetUrl string@url
⍝∇S Set the url of the ⎕HTLS server targeted by the client
⍝∇P url
⎕htlcUrl←url
```



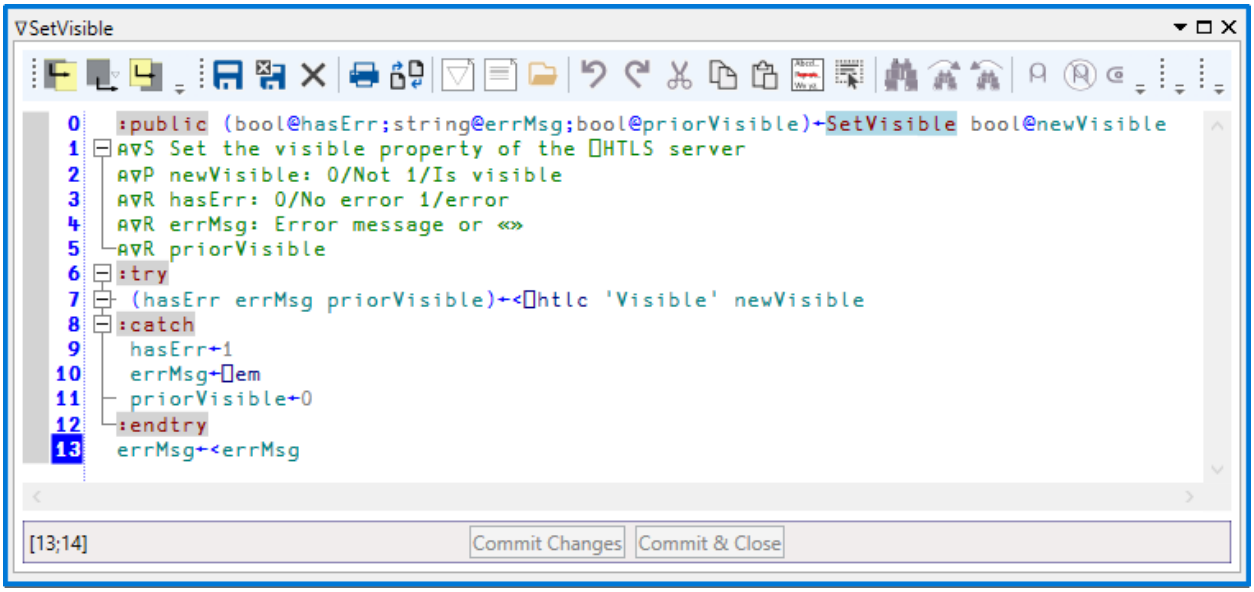
SetVar

```
⍝∇S Set the value of an APL variable on the ⎕HTLS server
⍝∇P varName: Name of the variable
⍝∇P varValue: New value of the variable
⍝∇R hasErr: 0/No error 1/error
⍝∇R errMsg: Error message or ««
:try
 (hasErr errMsg)←⎕htlc 'SetVar' varName varValue
:catch
 hasErr←1
 errMsg←⎕em
:endtry
errMsg←<errMsg
```



SetVisible

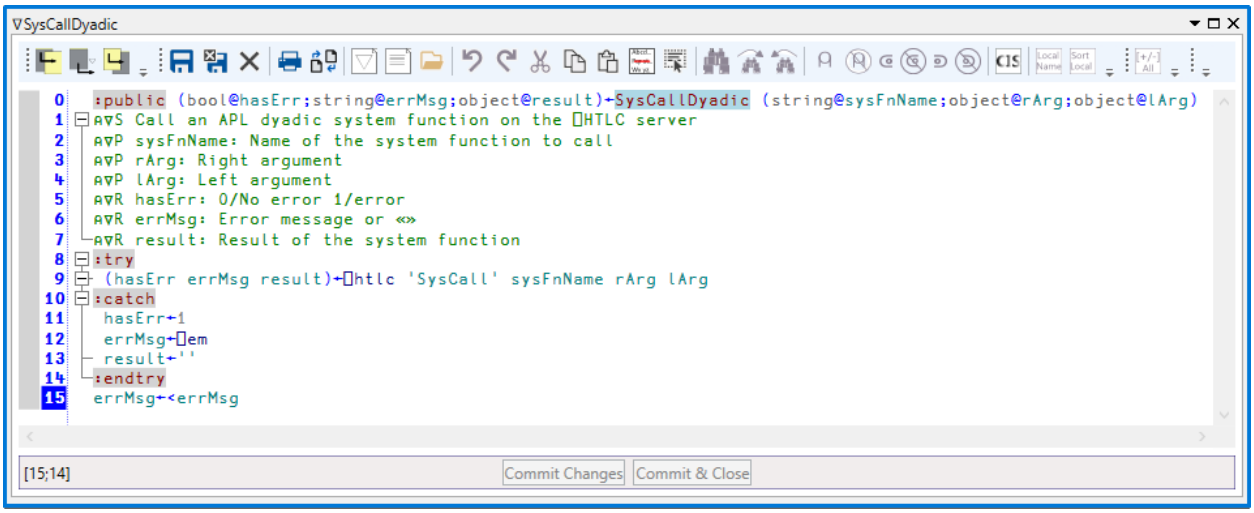
```
:public (bool@hasErr;string@errMsg;bool@priorVisible)←SetVisible bool@newVisible
⍝∇S Set the visible property of the ⎕HTLS server
⍝∇P newVisible: 0/Not 1/Is visible
⍝∇R hasErr: 0/No error 1/error
⍝∇R errMsg: Error message or «»
⍝∇R priorVisible
:try
 (hasErr errMsg priorVisible)←<⎕htlc 'Visible' newVisible
:catch
 hasErr←1
 errMsg←⎕em
 priorVisible←0
:endtry
errMsg←<errMsg
```



SysCallDyadic

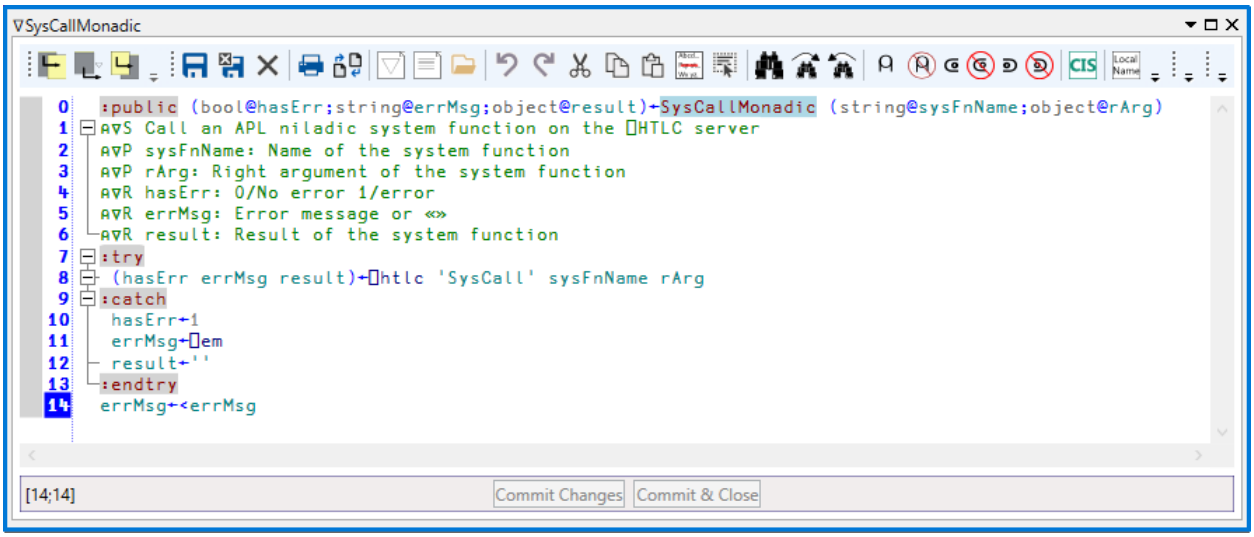
```
:public (bool@hasErr;string@errMsg;object@result)←SysCallDyadic
(string@sysFnName;object@rArg;object@lArg)
⍝∇S Call an APL dyadic system function on the ⎕HTLC server
⍝∇P sysFnName: Name of the system function to call
⍝∇P rArg: Right argument
⍝∇P lArg: Left argument
⍝∇R hasErr: 0/No error 1/error
⍝∇R errMsg: Error message or «»
⍝∇R result: Result of the system function
:try
```

```
 (hasErr errMsg result)←⎕htlc 'SysCall' sysFnName rArg lArg
:catch
 hasErr←1
 errMsg←⎕em
 result←''
:endtry
errMsg←<errMsg
```



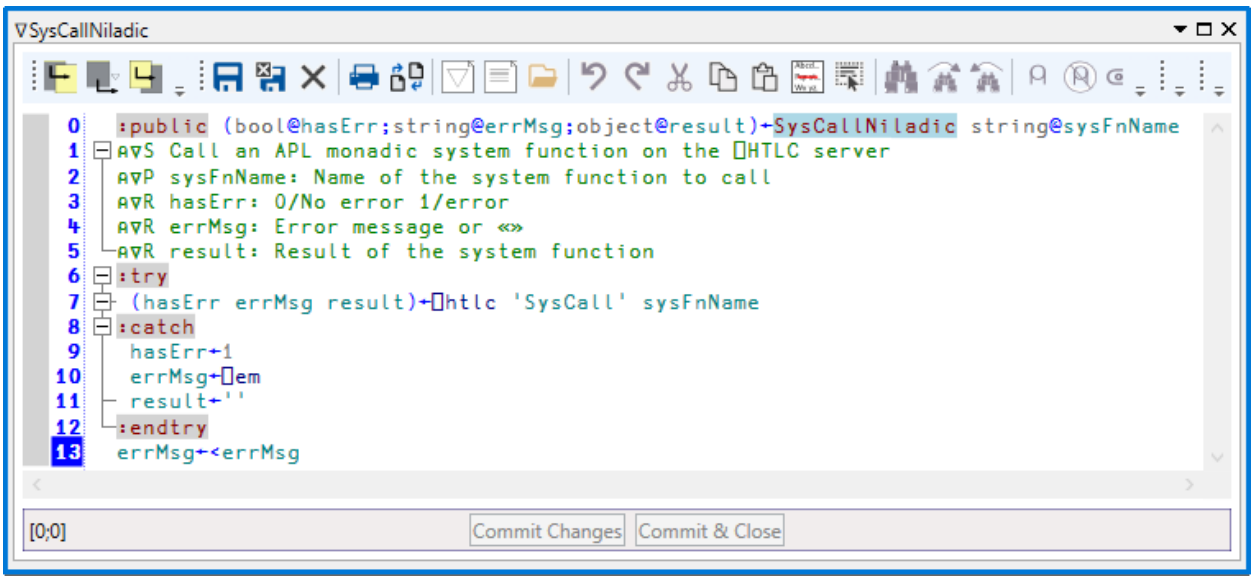
SysCallMonadic

```
:public(bool@hasErr;string@errMsg;object@result)←SysCallMonadic
(string@sysFnName;object@rArg)
⍝∇S Call an APL niladic system function on the ⎕HTLC server
⍝∇P sysFnName: Name of the system function
⍝∇P rArg: Right argument of the system function
⍝∇R hasErr: 0/No error 1/error
⍝∇R errMsg: Error message or «»
⍝∇R result: Result of the system function
:try
 (hasErr errMsg result)←⎕htlc 'SysCall' sysFnName rArg
:catch
 hasErr←1
 errMsg←⎕em
 result←''
:endtry
errMsg←<errMsg
```



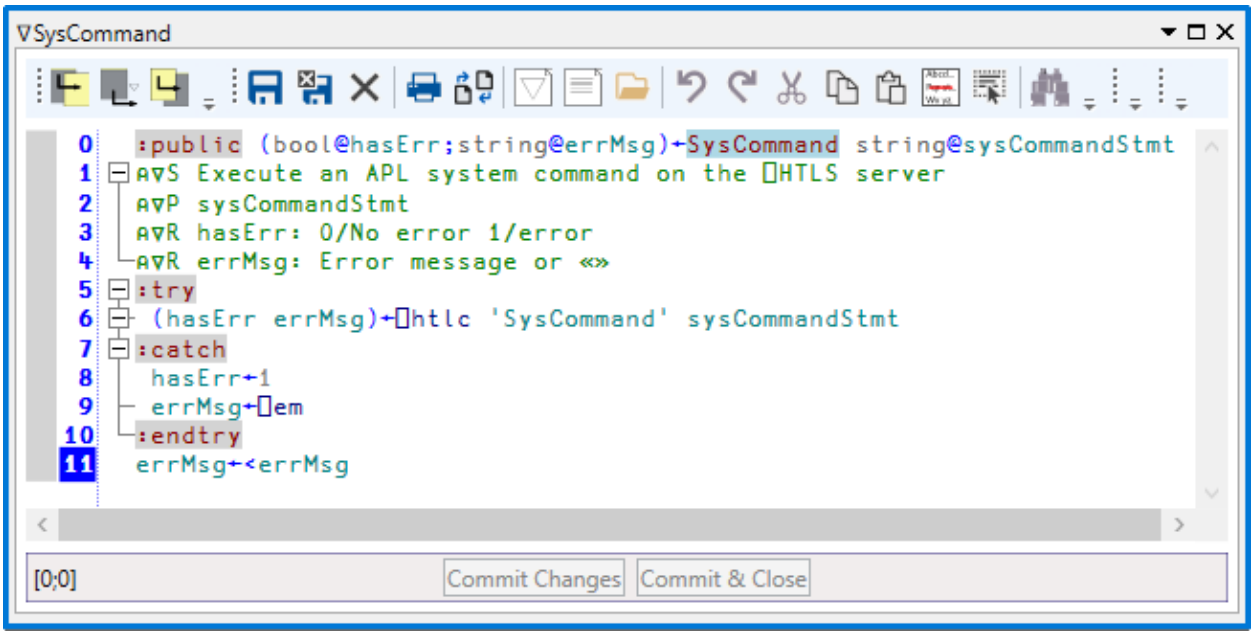
SysCallNiladic

```
:public (bool@hasErr;string@errMsg;object@result)←SysCallNiladic string@sysFnName
⍝∇S Call an APL monadic system function on the ⎕HTLC server
⍝∇P sysFnName: Name of the system function to call
⍝∇R hasErr: 0/No error 1/error
⍝∇R errMsg: Error message or «»
⍝∇R result: Result of the system function
:try
 (hasErr errMsg result)←⎕htlc 'SysCall' sysFnName
:catch
 hasErr←1
 errMsg←⎕em
 result←''
:endtry
errMsg←<errMsg
```

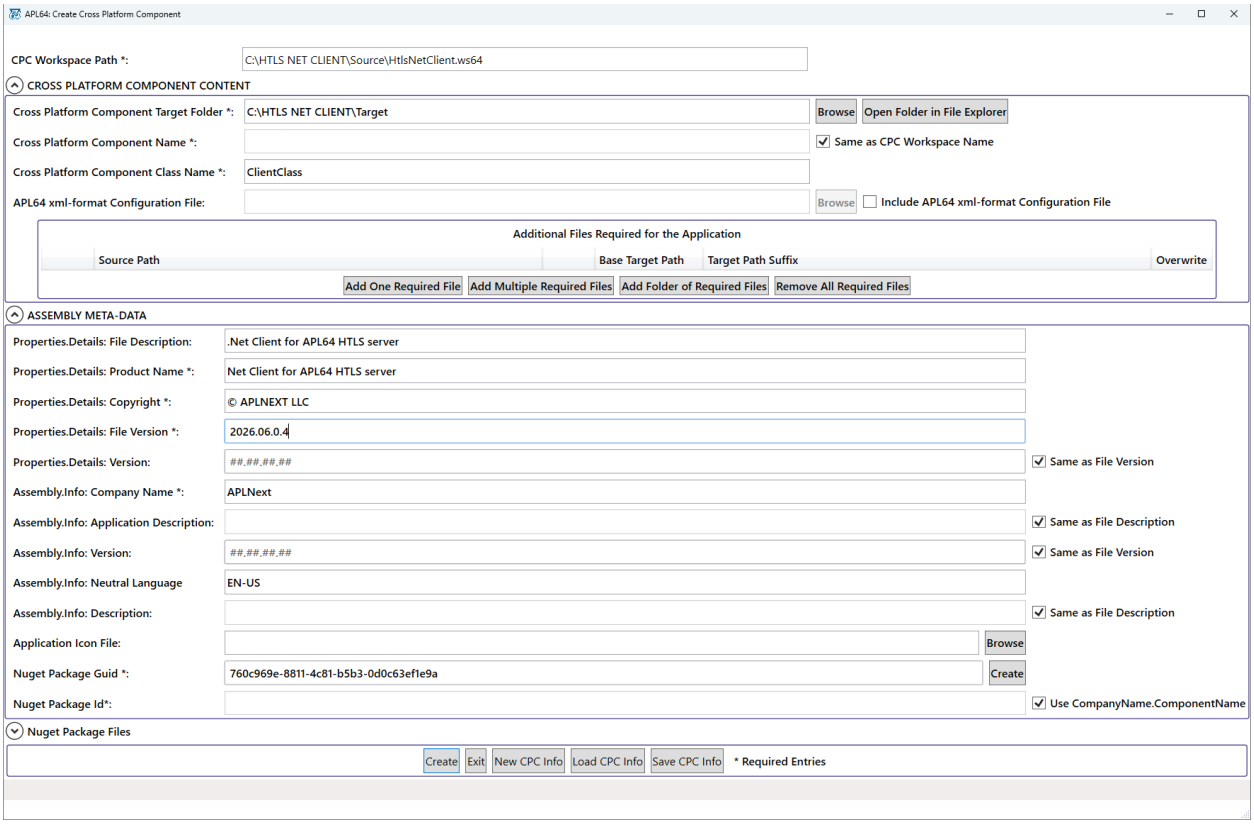


SysCommand

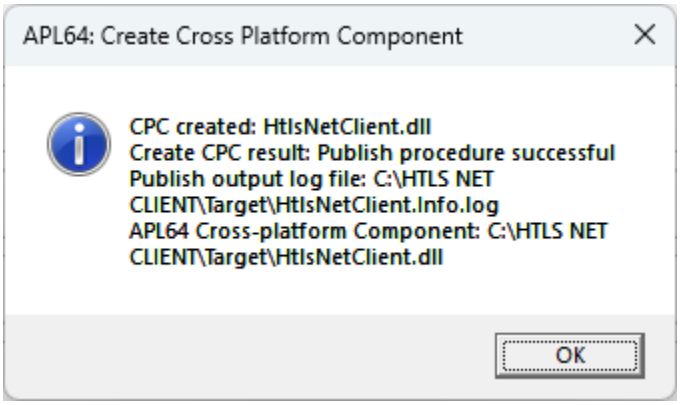
```
:public (bool@hasErr;string@errMsg)←SysCommand string@sysCommandStmt
⍝∇S Execute an APL system command on the ⎕HTLS server
⍝∇P sysCommandStmt
⍝∇R hasErr: 0/No error 1/error
⍝∇R errMsg: Error message or ««
:try
 (hasErr errMsg)←⎕htlc 'SysCommand' sysCommandStmt
:catch
 hasErr←1
 errMsg←⎕em
:endtry
errMsg←<errMsg
```



Complete the APL64 CPC creation dialog

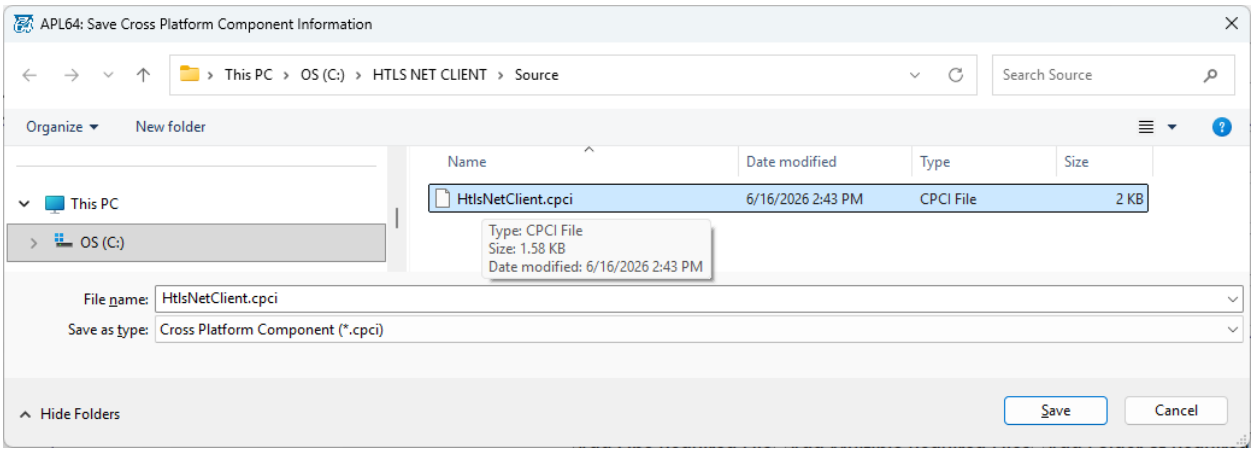


Click the CPC creation dialog 'Create' button



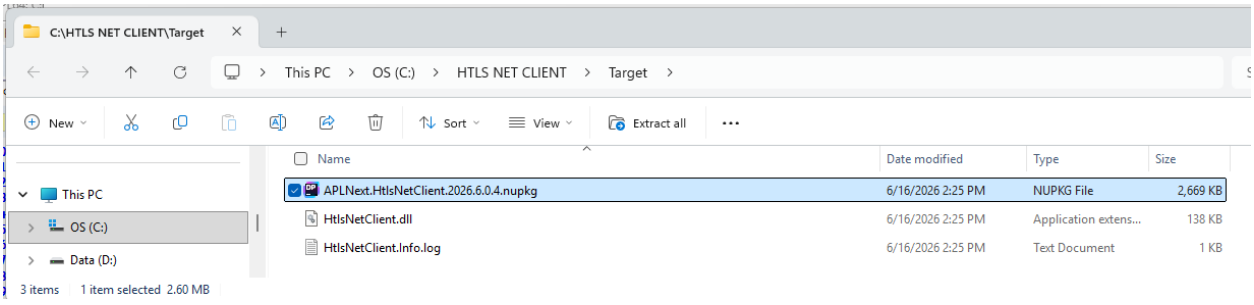
Save the CPC Creation Dialog Info

Click the CPC creation dialog 'Save CPC Info' button to preserve the CPC configuration for future use.

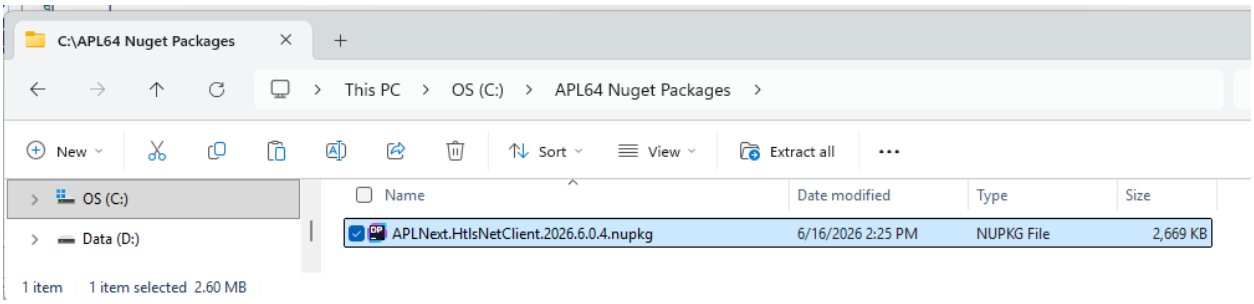


Copy the resulting Nuget package from the Target folder to the Nuget package publish folder:

From:

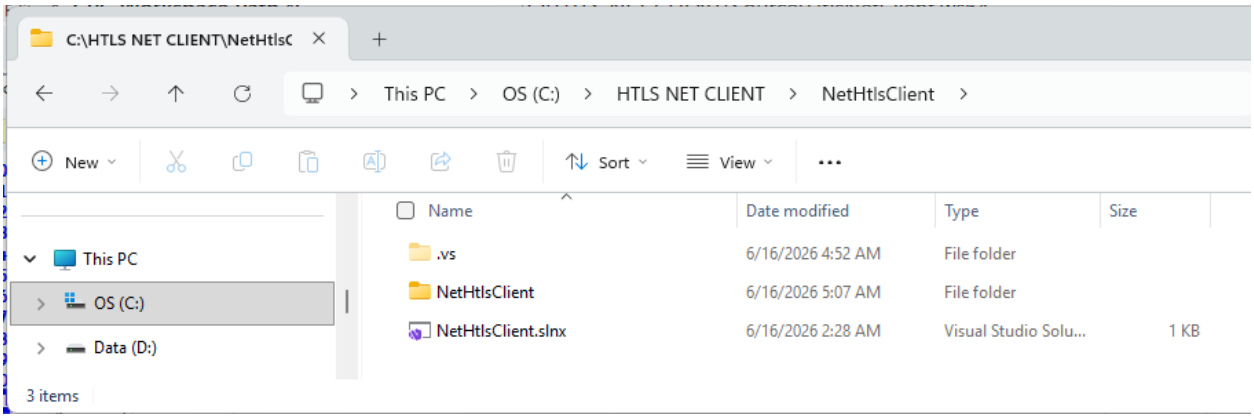


To:

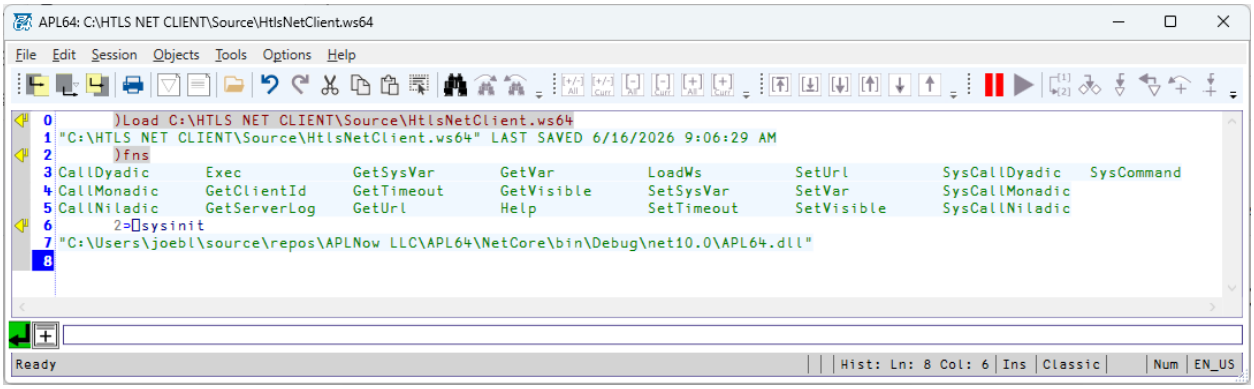


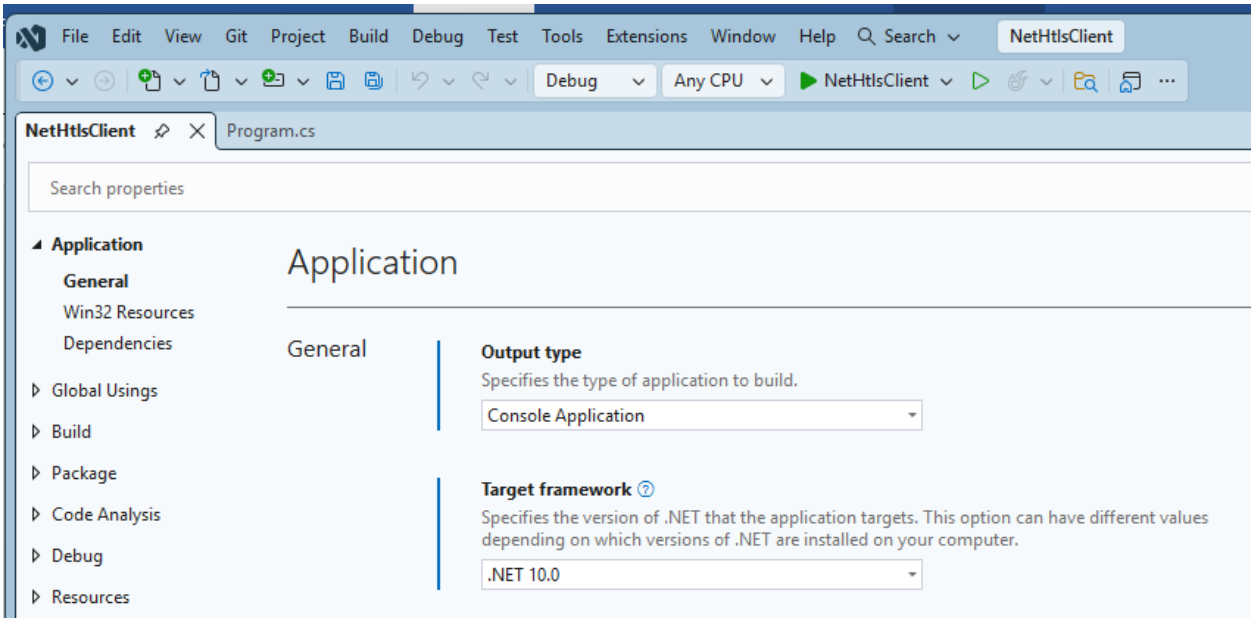
Create a .Net Project to use the CPC Nuget Package

Using Visual Studio create the NetHtlsClient C# console project in the C:\HTLS NET CLIENT\NetHtlsClient folder:



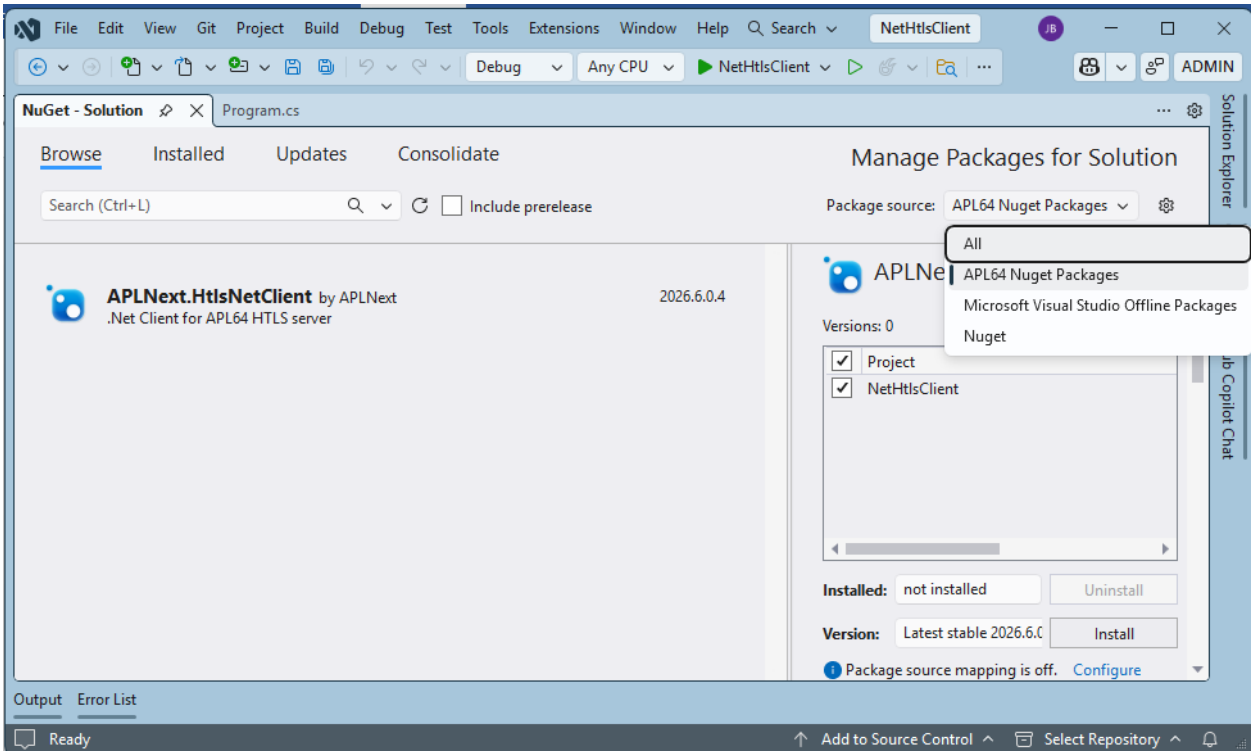
This project is targeted to the current APL64 .Net version which can be checked using:





Install the CPC Nuget Package into the .Net Project

Use Tools > Nuget Package Manager > Manage Nuget Packages for Solution dialog to install the APL64 CPC Nuget package into the solution.



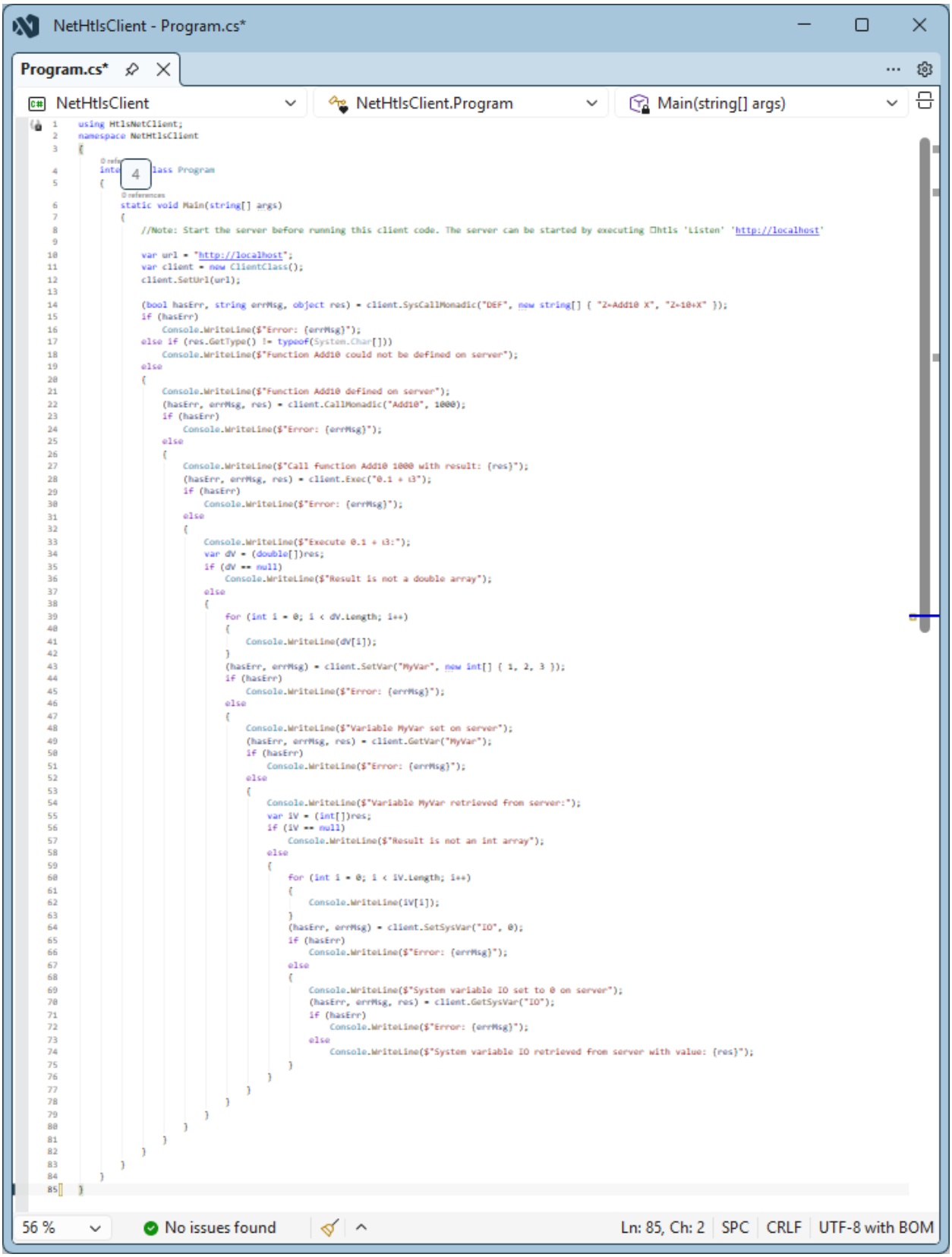
Enter the C# source code

This source code illustrates the use of some ⎕HTLC actions in the APL64 CPC Nuget package, including SetUrl, SysCallMonadic, CallMonadic, Exec, SetVar, GetVar, SetSysVar and GetSysVar:

```
using HtlsNetClient;
namespace NetHtlsClient
{
  internal class Program
  {
    static void Main(string[] args)
    {
      //Note: Start the server before running this client code. The server can be started by executing ⎕htls 'Listen' 'http://localhost'

      var url = "http://localhost";
      var client = new ClientClass();
      client.SetUrl(url);

      (bool hasErr, string errMsg, object res) = client.SysCallMonadic("DEF", new string[] { "Z←Add10 X", "Z←10+X" });
      if (hasErr)
        Console.WriteLine($"Error: {errMsg}");
      else if (res.GetType() != typeof(System.Char[]))
        Console.WriteLine($"Function Add10 could not be defined on server");
      else
      {
        Console.WriteLine($"Function Add10 defined on server");
        (hasErr, errMsg, res) = client.CallMonadic("Add10", 1000);
        if (hasErr)
          Console.WriteLine($"Error: {errMsg}");
        else
        {
          Console.WriteLine($"Call function Add10 1000 with result: {res}");
          (hasErr, errMsg, res) = client.Exec("0.1 + ⍳3");
          if (hasErr)
            Console.WriteLine($"Error: {errMsg}");
          else
          {
            Console.WriteLine($"Execute 0.1 + ⍳3:");
            var dV = (double[])res;
            if (dV == null)
              Console.WriteLine($"Result is not a double array");
```

```
            else
            {
              for (int i = 0; i < dV.Length; i++)
              {
                Console.WriteLine(dV[i]);
              }
              (hasErr, errMsg) = client.SetVar("MyVar", new int[] { 1, 2, 3 });
              if (hasErr)
                Console.WriteLine($"Error: {errMsg}");
              else
              {
                Console.WriteLine($"Variable MyVar set on server");
                (hasErr, errMsg, res) = client.GetVar("MyVar");
                if (hasErr)
                  Console.WriteLine($"Error: {errMsg}");
                else
                {
                  Console.WriteLine($"Variable MyVar retrieved from server:");
                  var iV = (int[])res;
                  if (iV == null)
                    Console.WriteLine($"Result is not an int array");
                  else
                  {
                    for (int i = 0; i < iV.Length; i++)
                    {
                      Console.WriteLine(iV[i]);
                    }
                    (hasErr, errMsg) = client.SetSysVar("IO", 0);
                    if (hasErr)
                      Console.WriteLine($"Error: {errMsg}");
                    else
                    {
                      Console.WriteLine($"System variable IO set to 0 on server");
                      (hasErr, errMsg, res) = client.GetSysVar("IO");
                      if (hasErr)
                        Console.WriteLine($"Error: {errMsg}");
                      else
                        Console.WriteLine($"System variable IO retrieved from server with
value: {res}");
                    }
                  }
                }
              }
            }
```

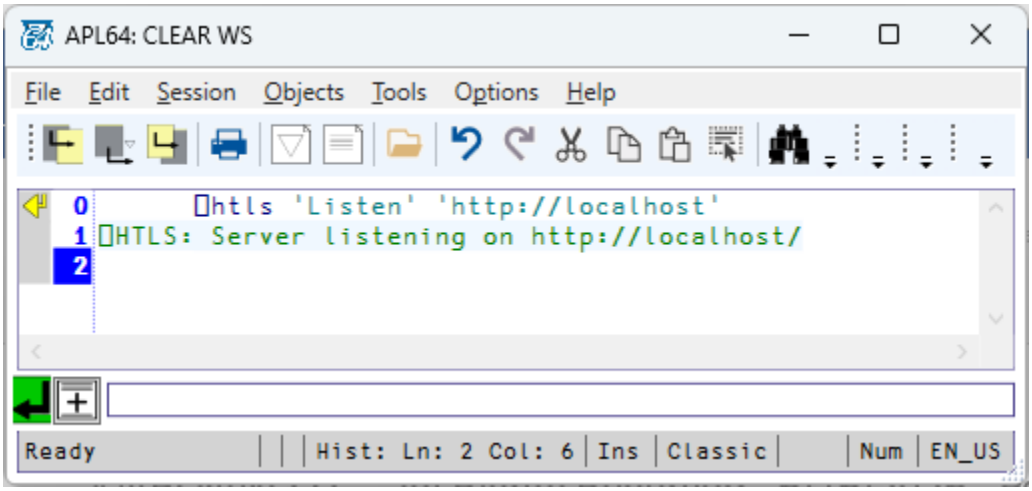
```
          }
        }
      }
    }
  }
}
```



Start an APL64 instance and use ⎕HTLS to create an HTLS server

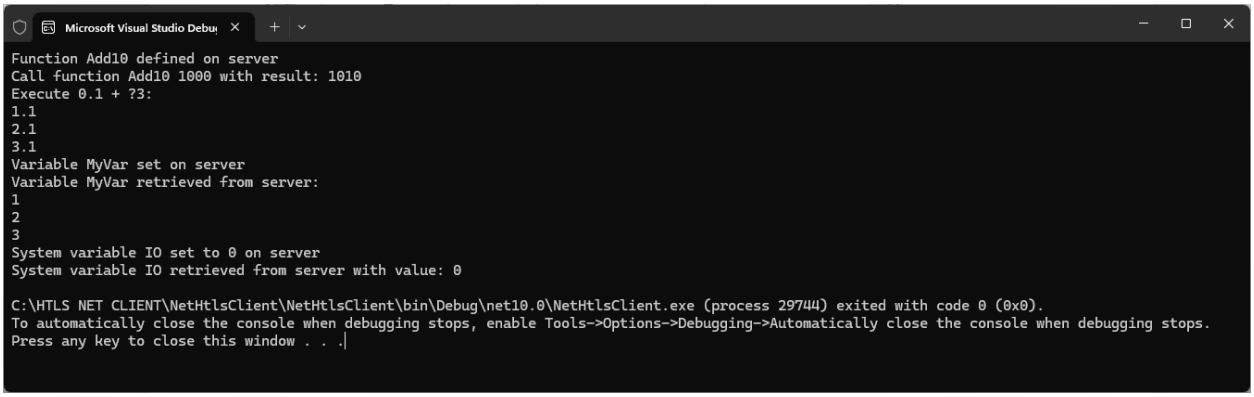
An ⎕HTLS server can be started manually from an instance of APL64 Developer version, APL64 WRE (Windows Runtime Executable) or APL64 CPC (Cross-platform Component).

```
⎕htls 'Listen' 'http://localhost'
```



Run the console application

Use F5 in Visual Studio to run the .Net C# console project using the APL64 HtlsNetClient CPC Nuget package:



Comparing ⎕HTLC/HTLS and ⎕WSE

Analogous Client and Server Environments

Both ⎕HTLC/HTLS and ⎕WSE create client and server environments.

⎕HTLC/HTLS uses two independent instances of APL64 for the separate client and server environments. The ⎕HTLS server is an 'out-of-process' server, since it is not running within the memory space of the ⎕HTLC client instance.

When ⎕HTLS is used in the APL64 development environment, the ⎕HTLS server can be made visible and can be debugged. The ⎕HTLS server cannot be made visible or debugged in an APL64 WRE or CPC. Appropriate end-user security should be considered when the ⎕HTLS server is used in an APL64 WRE or CPC.

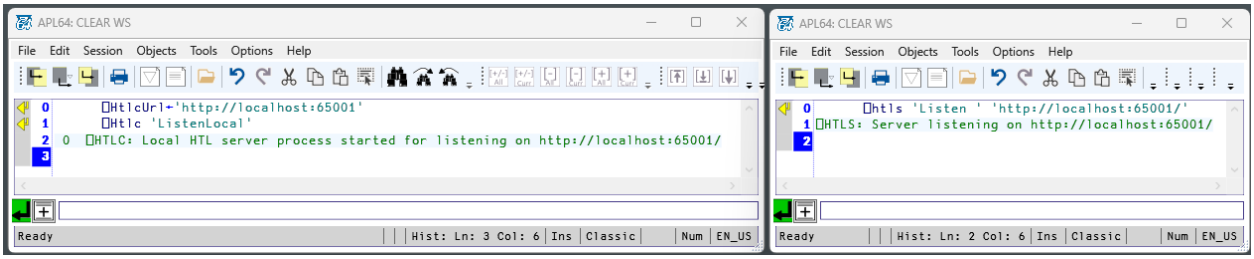
⎕WSE (Workspace Engine) uses a single instance of APL64 for the separate client and server environments. The ⎕WSE is an 'in-process' server, since it is running within the memory space of the APL64 instance which executed the ⎕WSE 'Create' action.

The ⎕WSE server cannot be made visible and cannot be debugged. The APL64 ⎕WSE system function has parallel processing actions in addition to CallAsync, which are not applicable to ⎕HTLC/HTLS.

Creating the Server

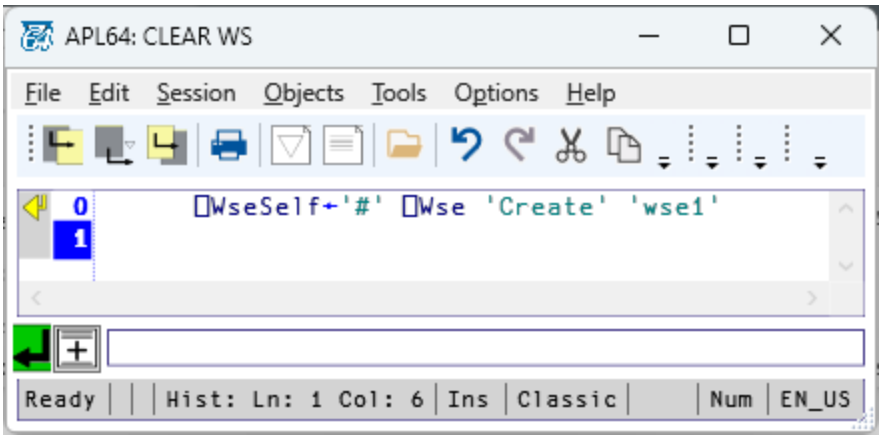
⎕HTLS servers are identified by distinct urls. An ⎕HTLS server is visible by default but can be hidden using the ⎕HTLC Visible action. An ⎕HTLS server cannot hide itself.

```
⎕HtlcUrl←'http://localhost:65001'
⎕Htlc 'ListenLocal'
```



⎕WSE servers are identified by name. An ⎕WSE server is not visible.

```
⎕WseSelf←'#'⎕wse 'Create' 'wse1'
```



⎕HTLC and ⎕WSE have Analogous Actions

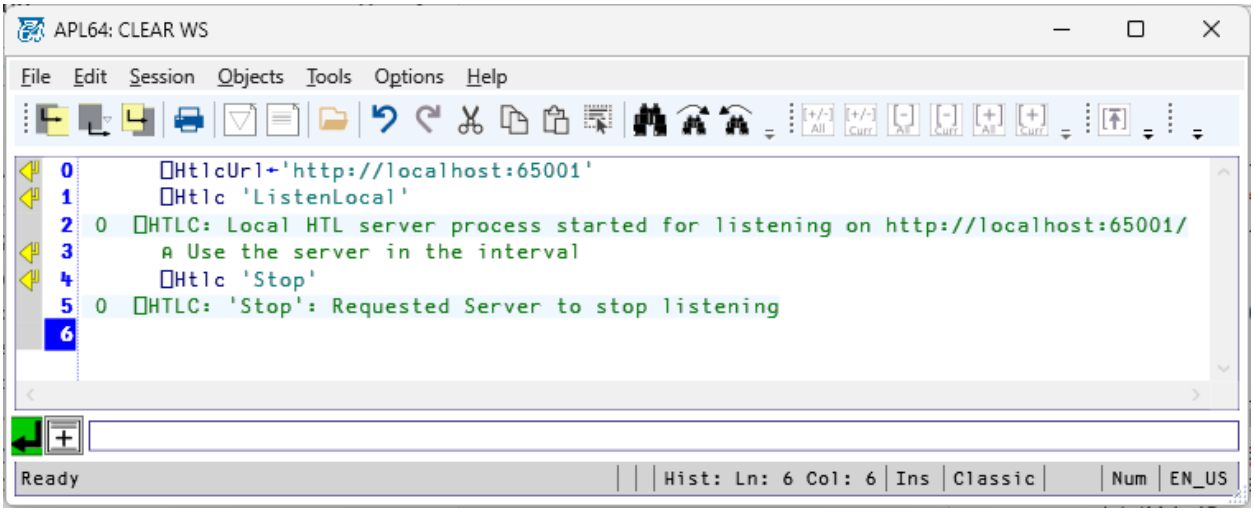
Because ⎕HTLC and ⎕WSE have analogous actions an APL64 programmer can use an ⎕HTLS server for visible debugging in a development environment and use a ⎕WSE server in the runtime environment.

Action	⎕HTLC and ⎕WSE Argument(s)
Call	fnName [rArg] [lArg]
CallAsync	fnName [rArg] [lArg]
Exec	aplExpression
GetSysVar	sysVarName
GetVar	varName
LoadWs	wsPath
SetSysVar	sysVarName value
SetVar	varName value
SysCall	sysFnName [rArg] [lArg]
SysCommand	sysCmdName text
Variable	varName [value]

Closing the Server

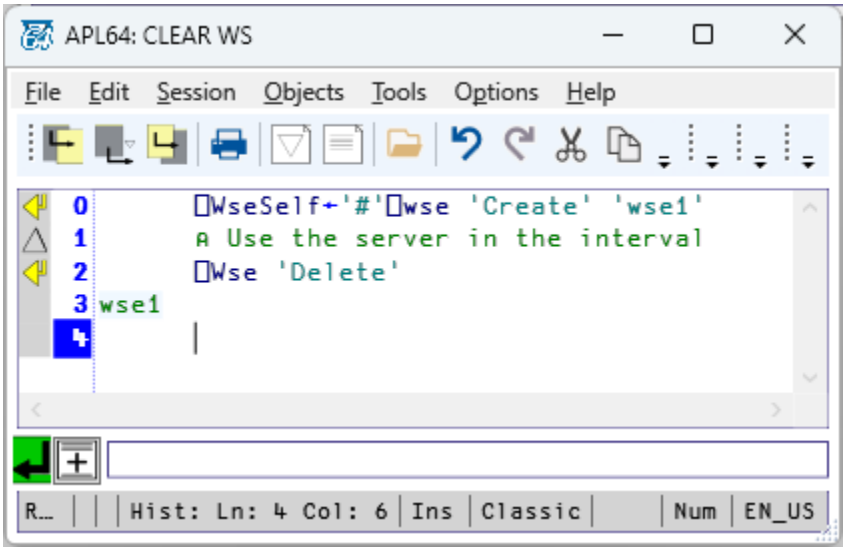
⎕HTLC

```
⎕HtlcUrl←'http://localhost:65001'
⎕Htlc 'ListenLocal'
⍝ Use the server in the interval
⎕Htlc 'Stop'
```



⎕WSE

```
⎕WseSelf←'#'⎕wse 'Create' 'wse1'
⍝ Use the server in the interval
⎕Wse 'Delete'
```



Multiple Instances

Multiple instances of ⎕HTLS servers are supported. The same or different instances of APL64 can listen to different urls.

Multiple instances of ⎕WSE servers are supported. Each ⎕WSE server must have a distinct name.

Performance

An □HTLS and a □WSE server use the same APL64 interpreter technology. Their performance differs because of how APL64 data is transferred between client and server.

Because an □HTLS server is an out of process server, communication with an □HTLS server uses the http data transfer protocol. Since the http protocol is designed for byte-format data, serialization of APL64 data occurs when □HTLC actions access an □HTLS server and when an □HTLS server responds to an □HTLC request. The out of process design of an □HTLS server is what permits debugging and visibility of the server.

A □WSE server is an in-process server, so there is no data transfer protocol or serialization of APL data for communication between a □WSE client and □WSE server. The in-process design of a □WSE server means that it cannot be debugged or made visible.

Debugging

An □HTLC client and a □WSE client can be debugged if they are used in the APL64 Developer version.

□HTLC clients and □HTLS servers can be independently debugged when they are created with an APL64 Developer version instance. Only the client side of a □WSE client and server arrangement can be debugged.

Configuring an □HTLS server to listen on an HTTPS port

An https port is generally required for a server to be accepted by responsible clients. A server exposed to clients which does not use an https port will generate client-side warnings which may limit server use by a client.

Syntax: msg ← □HTLS 'Listen' serverHttpsUrl certificatePath certificatePassword

Besides providing the https url, certificate path and certificate password, additional setup of the server machine environment is necessary. This section of the document describes the required setup elements.

Port Forwarding (For access by external clients)

If the server is behind a router/firewall, and needs to accept external input, the Internet service router needs configuration. The Internet router configuration must be modified to permit port forwarding (synonyms: virtual server or NAT) to the HTLS server.

- Configure port forwarding rules on the router

- Forward external port input to the internal server port

Default HTTPS port is 443 which requires administrator rights, but custom ports like 8443 or 9443 may not require administrator rights.

Firewall Configuration

Windows Firewall must allow inbound traffic on the HTTPS port. The choice of access type must also be made: Private, Public access types.

Administrator Privileges

They are required when:

- Listening on privileged ports (< 1024, including port 443)

- Binding to wildcard addresses (*) or (+)

- Accessing HTTP.SYS namespace reservations

Certificate Trust and Validation

Use certificates from trusted certificate authorities such as:

- Let's Encrypt (Free)
- DigiCert
- GoDaddy

For the development and testing environment a self-signed certificate can be used.

Url Binding Permissions (http.sys on Windows)

When binding to wildcard (*) or (+) addresses without administrator privileges,

URL ACL (Access Control List) reservations may be necessary.

Wildcards can be supported:

- *(asterisk) - Strong wildcard, binds to all IP addresses
- + (plus) - Weak wildcard, allows sharing with other applications

Dns and Hostname Resolution

For external access configure DNS A record pointing to server's public IP address, e.g. api.yourdomain.com points to 203.0.113.50

For internal network access configure an internal DNS server, or add an entry to the client hosts file in the c:\Windows\System32\drivers\etc\hosts location, e.g.

192.168.1.100 points to the local DNS: api.localserver.com

Router Settings (For external Https access)

- Reserve specific internal IP for the server in the router DHCP settings

- Ensure port forwarding always points to correct device

- Assure the ISP does not block the selected port (e.g. 443)

Network Topology

Server Location	**Configuration Requirements**
Same workstation (localhost)	Firewall
Local network (192.168.x.y)	Firewall, optional local DNS
External access (registered dsn)	Firewall, port forwarding, registered DNS

Testing and Verification

- Certificate file exists and is readable
- Firewall allows inbound traffic on HTTPS port
- Running as administrator (if port < 1024)
- Port forwarding configured (if external access needed
- DNS/hosts pointing to server IP address
- Certificate trusted by clients

HTLS validation and exception handling

Exception	**Indicates**
UnauthorizedAccessException	Administrator rights likely required
FileNotFoundException	Certificate file missing or path incorrect
CryptographicException	Certificate password or invalid format
IOException	Port already in use or access denied

Validation
URL format validation
Port number range (1-65535)
Scheme validation (http or https)
Certificate file existence
Host format (localhost, IP address, wildcards)

Security Best Practices

Certificates

- Use strong passwords for .pfx files
- Restrict file permissions to minimum required
- Rotate certificates before expiration
- Use 2048-bit or higher RSA keys
- Consider ECC certificates for better performance

Network

- Use firewall rules to restrict access by IP when possible
- Disable UPnP in production environments
- Use non-standard ports to reduce automated attacks
- Implement rate limiting and DDoS protection
- Monitor logs for suspicious activity

Authentication

- Implement client certificate validation if needed
- Use strong authentication mechanisms
- Enable logging using HTLS LogFileOptions action