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1 About This Document

This document introduces user commands and describes how to create/implement new user commands.

1.1 Audience

It is assumed that the reader has a reasonable understanding of Dyalog.

For information on the resources available to help develop your Dyalog knowledge, see https://www.dyalog.com/introduction.htm.

1.2 Conventions

Unless explicitly stated otherwise, all examples in Dyalog documentation assume that ⎕IO and ⎕ML are both 1.

Various icons are used in this document to emphasise specific material.

General note icons, and the type of material that they are used to emphasise, include:

💡 Hints, tips, best practice and recommendations from Dyalog Ltd.

ℹ️ Information note highlighting material of particular significance or relevance.

📜 Legacy information pertaining to behaviour in earlier releases of Dyalog or to functionality that still exists but has been superseded and is no longer recommended.

⚠️ Warnings about actions that can impact the behaviour of Dyalog or have unforeseen consequences.
Although the Dyalog programming language is identical on all platforms, differences do exist in the way some functionality is implemented and in the tools and interfaces that are available. A full list of the platforms on which Dyalog version 17.1 is supported is available at https://www.dyalog.com/dyalog/current-platforms.htm. Within this document, differences in behaviour between operating systems are identified with the following icons (representing macOS, Linux, UNIX and Microsoft Windows respectively):
2 Introduction

User commands are tools that are available at any time, in any workspace, as extensions to the Dyalog development environment. The text-based implementation of user commands allows development tools to be easily shared between users, and the ability to create custom user commands in addition to the predefined user commands that are supplied with Dyalog means that it is simple to write utility tools for your environment that can be easily issued to an entire development team.

User commands are entered in an APL Session by starting an input line with a ] character, for example:

```
]ToHex 250+15
FB FC FD FE FF
```

A section of the APL Wiki is devoted to sharing custom user commands (see https://aplwiki.com/CategoryDyalogUserCommands).

2.1 Cache File

The first time that you start a Dyalog Session after installing/updating Dyalog, a cache file is created comprising the name of each of the user commands and the file in which it is defined. This can take a few seconds. If any of the files that contain user commands are altered or a new file containing user commands is created, then the cache file is rebuilt:

- the next time a Dyalog Session is started.
- when the JUReset user command is run (forces an in-Session recache).
- if a user attempts to run (or get help about) a user command that is not in the cache.

The cache file is also rebuilt if a user command is called after updating the cmddir global parameter (using the ]Settings user command – for more information enter ]Settings cmddir -? in a Session).

By default, the cache file is located in:

Documents\Dyalog APL <version> Files\UserCommand20.cache
$>

By default, the cache file is located in:

$HOME/.dyalog/UserCommand20.cache

By default, the cache file is located in:

Users/<name>/dyalog/UserCommand20.cache

The name and location of the cache file can be changed from its default by setting the UCMDCACHEFILE environment variable.

2.1.1 Defining the UCMDCACHEFILE Environment Variable

The name and location of the cache file can be changed from its default by setting the UCMDCACHEFILE environment variable.

Defining an environment variable is operating system-specific.

To define the UCMDCACHEFILE environment variable on Microsoft Windows (permanent method)

1. Open the Control Panel and click on the System icon.
   The System window is displayed.
2. In the Control Panel Home pane, click Advanced system settings.
   The System Properties window is displayed.
3. Navigate to the Advanced tab of the System Properties window.
4. Click Environment Variables....
   The Environment Variables dialog box is displayed.
5. In the User variables for <user> pane, click New....
   The New User Variable dialog box is displayed.
6. In the Variable name field, enter UCMDCACHEFILE.
7. In the Variable value field, enter <full path><cache file name> of the user commands cache file.
8. Click OK to create the new environment variable and exit the New User Variable dialog box.
9. Click OK to exit the Environment Variables dialog box.
10. Click OK to exit the System Properties window.
To define the UCMDCACHEFILE environment variable on Microsoft Windows (temporary method – for session duration only)

1. Open the cmd.exe application.
2. At the command prompt, enter:
   
   ```
   dyalog.exe UCMDCACHEFILE=[UCMDCACHEFILE]
   ```

   where `[UCMDCACHEFILE]` is the new `<full path>/<cache file name>` of the user commands cache file.

To define the UCMDCACHEFILE environment variable on Linux and macOS (permanent method)

1. Open the `$HOME/.dyalog/dyalog.config` file in your preferred text editor.
2. Add the following:
   
   ```
   export UCMDCACHEFILE=[UCMDCACHEFILE]
   ```

   where `[UCMDCACHEFILE]` is the new `<full path>/<cache file name>` of the user commands cache file.

The default value is `$HOME/.dyalog/UserCommand20.cache`.

To define the UCMDCACHEFILE environment variable on Linux (temporary method – for session duration only)

1. Open a shell.
2. At the command prompt, enter:
   
   ```
   UCMDCACHEFILE=[UCMDCACHEFILE] dyalog
   ```

   where `[UCMDCACHEFILE]` is the new `<full path>/<cache file name>` of the user commands cache file.
3 Using User Commands

This chapter introduces some of the concepts that underpin user commands in Dyalog.

3.1 Installation

A set of predefined user commands is installed automatically with Dyalog.

Updates to the set of predefined user commands can be downloaded from https://www.dyalog.com/tools/user-commands.htm.

3.2 Directory Structure

The [DYALOG]\SALT\spice directory contains the predefined user commands that are installed with Dyalog.

The spice directory can only be moved to a different location by moving its parent SALT directory and setting the SALT environment variable accordingly. For information on moving the SALT directory and setting the environment variable, see the SALT User Guide.

Although the spice directory can be moved, it must always remain directly beneath the SALT directory and must not be renamed.

3.3 Implementation

When an input line in a Session starts with a ] character, Dyalog looks for the function ⎕SE.UCMD:

- if this function exists, then it is called with the rest of the input line as the right argument and a reference to calling space as the left argument.
- if this function does not exist, then user commands are disabled.
This implementation means that application code can invoke user commands by calling ⍺SE . UCMD directly.

⚠️ Dyalog Ltd reserves the right to change the implementation of the user command framework.

**EXAMPLE**

The following command is entered while in a namespace:

```
] <ucmd> <-myModifier>=<value>
```

Dyalog’s interpreter preserves this exactly and makes the following call:

```
⍝THIS ⍺SE.UCMD '<ucmd> <-myModifier>=<value>'
```

⍺SE . UCMD converts this into a call to the user command framework; the functions defined for `<ucmd>` are actioned with the `<-myModifier>` modifier applied with a value of `<value>` and the result is displayed in the Session.

**EXAMPLE**

The result of `<ucmd>` is assigned to a variable called `<variable>`:

```
] <variable>←<ucmd> <-myModifier>=<value>
```

Dyalog’s interpreter preserves this exactly and makes the following call:

```
⍝THIS ⍺SE.UCMD '<variable>←<ucmd> <-myModifier>=<value>'
```

⍺SE . UCMD converts this into a call to the user command framework; the functions defined for `<ucmd>` are actioned with the `<-myModifier>` modifier applied with a value of `<value>` and the result is assigned to `<variable>`.

If `<variable>` was not included then the result of `<ucmd>` would be discarded and not shown in the Session, although any non-result output generated would be displayed.

### 3.3.1 Customising the Implementation

Although it is possible to implement a custom user command system by redefining ⍺SE . UCMD, Dyalog Ltd does not recommend this approach – adhering to the user command framework supplied with Dyalog promotes a single, consistent, format that enables all custom user commands to be shared between Dyalog Sessions.
### 3.4 File Format

Each user command comprises a script containing a single namespace object (for more information on scripted files, including declaration statements and permitted constructs, see the Dyalog Programming Reference Guide) and must be stored as files with the `.dyalog` extension.

- If an extension is not specified when using the `]Snap` or `]Save` user commands to save a script file, then `.dyalog` is automatically appended.
- By default, double-clicking on a `.dyalog` file opens that file using the standalone editor.

Files with the `.dyalog` extension are Unicode text files. This means that they can store any text that uses Unicode characters. This format includes most of the world's languages and the Dyalog character set, and is supported by many software applications. By using text files as a storage mechanism, user commands and other tools written using Dyalog can be combined with industry-standard tools for source code management.

### 3.5 Groups

User commands with common features can be grouped together under a single name. These groups have no effect on the functionality of the individual user commands but enable related user commands to be gathered together for ease of reference and provide a means of sorting and classifying user commands that can be very useful as the number of user commands increases.

User command names must be unique within a group but do not have to be unique across all groups. This means that groups allow a systematic naming convention for user commands that perform similar functions on different types of APL object, for example, the predefined user command `]FILE.Compare` compares two files, `]ARRAY.Compare` compares two arrays and `]FN.Compare` compares two functions.

- Although a user command can have the same name as its group (or another group), Dyalog Ltd does not recommend this as it can introduce ambiguity to a user reading the code.

- When running (or asking for help on) a user command, the group name can be prefixed to the user command name, separated by a `.` character; this group name prefix is mandatory if the user command name is not unique across all groups.
Every user command must be in a group, and every group must comprise at least one user command.

3.6 Syntax in Dyalog Sessions

User commands are entered in a Dyalog Session with a preceding right bracket. The basic syntax is as follows:

- to run a user command: ]<ucmd>...
- to display general help information: ]
- to list all user commands in their groups (without descriptions): ]-?
- to list all user commands in their groups (with descriptions): ]-??
- to list all the available commands in a specific group: ]<groupname> -?
- to display information for a specific user command: ]<ucmd> -?
- to list all the available user commands defined in .dyalog files in a specific directory: ]<full path to directory>/<directory name> -?
- to list all user commands or groups that match pattern X*YZ*(* is a wildcard): ]X*YZ* -?
- to assign the result of a user command to a variable: ]<var>←<ucmd>...
- to discard the result of a user command: ]←<ucmd>...

Multiple levels of help can be defined for each user command; the information that is returned is dependent on the level of help requested. The level is defined to be 1 less than the number of ? characters entered after the – character. For example:

- level 0: ]<ucmd> -? or ]Help ]<ucmd>
- level 1: ]<ucmd> -??
- level 2: ]<ucmd> -???

The number of levels of help available depends on a user command’s definition (for information on defining multiple levels of help in custom user commands, see Section 4.3.1).

⚠️ The names of user commands and groups are not case-sensitive although their arguments, modifiers and modifier values might be. The convention used in this document is that group names are shown in UPPERCASE and user command names are shown in Upper CamelCase.
3.7 Running User Commands

User commands are run with the following syntax:

\[ \text{ucmd} \ <\text{-modifiers/arguments}> \]

For information on the precise syntax for each user command, the arguments that can be supplied to it and the modifiers that it can take, enter \[\text{ucmd} \ -?\] or \[\text{Help } \text{ucmd}\] in a Dyalog Session.

When running a user command, the name of that command must be entered in full.

Dyalog’s auto-complete functionality means that any user commands that match the entered text are presented as selectable options, making it easy to correctly specify the requisite user command. (Auto-completion is not available in the TTY version of Dyalog.)

The names of user commands are not case-sensitive although their arguments, modifiers and modifier values might be.

3.7.1 Arguments

Some user commands can accept (or require) one or more arguments. To see a list of the possible arguments for a user command, enter \[\text{ucmd} \ -?\] or \[\text{Help } \text{ucmd}\] in a Dyalog Session.

For example, the behaviour of the user command \text{JCD} depends on the argument supplied when calling it. If it is run with no argument, then it returns the current working directory – this is equivalent to entering \text{cd} on the command line of a Microsoft Windows operating system or \text{pwd} in UNIX. However, if a single argument specifying the full path to a directory is supplied, then the user command changes the current working directory to be the one specified by the argument.

3.7.2 Modifiers and Modifier Values

The default behaviour of a user command can be altered through the application of \textit{modifiers} (instructions that the command should change its default behaviour).

Modifiers must be prefixed with the - character and are separated from any associated modifier values with the = character, for example, \texttt{-version=3} or \texttt{-format=APL}. A modifier that does not accept a modifier value but can only be present or absent is sometimes referred to as a flag or a switch, for example, \texttt{-protect}. 
When running a user command with a specified modifier, the name of the modifier does not always need to be entered in full as long as enough of the modifier's name is entered for it to be interpreted unambiguously. For example, if a user command has a modifier called -version and does not have any other modifiers starting with the letter v then the function can be successfully called with modifiers -version, -vers, -v, and so on.

Multiple modifiers can be included in a user command call – in this situation they must be separated by a space character. The order in which they are specified is irrelevant.
4 Creating User Commands

When an instruction is called repeatedly it can improve efficiency to have that instruction in a script file. The user command framework provides a very efficient mechanism for doing this, allowing a user to create and update instructions without the necessity of maintaining a workspace. Unlike a workspace, user commands do not need to be loaded into each Session. In addition, their text-based implementation makes them easy to store in a repository and share between users.

This chapter describes the syntax, rules and conventions governing the creation of custom user commands.

4.1 Basic Definition

A new user command can be defined in several ways, for example:

- in a text file (for example, using Microsoft Notepad) and then saved as a .dyalog file
- in a Dyalog Session and saved as a .dyalog file using the ]Save user command.
- in a Dyalog Session using the ]UNew user command – for more information enter ]UNew -? in a Session.

Once in the appropriate directory (see Section 4.7), the new user command can be run from the Dyalog Session.

The script for Dyalog's predefined user commands can be a useful starting point when creating a new user command. The location of an existing user command’s script can be found in the following ways:

- ]UVersion <ucmd> returns the script location for the specified user command
- ]ULoad <ucmd> loads the script for the specified user command into the active workspace and returns the script location.
- ]<ucmd> -? returns the script location for the specified user command if ]UDebug is on.
User commands are defined by three specific APL functions (along with any additional functions needed for the particular purpose of the user command). The three functions must be called:

- List – for information on the List function, see Section 4.2.
- Run – for information on the Run function, see Section 4.3.
- Help – for information on the Help function, see Section 4.4.

These functions are wrapped together in a namespace (the order in which the functions are specified within the namespace is not important). A single namespace can host multiple user commands, but must only have one instance of each of the three functions irrespective of how many user commands it contains. (Although a class can be used instead of a namespace, a namespace is the recommended approach.)

See Appendix A for some sample user commands that demonstrate the use of multiple levels of help and parsing user command lines. See Appendix B for some examples of user commands wrapped in a namespace – these show how the List, Help and Run functions are defined.

### 4.2 The List Function

The List function informs the user command framework about the command being defined, enabling it to display a summary of the command when requested to list all available commands (\(-\) ), optionally with descriptions (\(-??\) ).

The List function is niladic and returns one namespace for each user command defined within it. Each namespace contains four variables:

- Desc – a summary of the user command’s functionality
- Name – the name of the user command (see Section 4.2.1)
- Group – the name of the group to which the command belongs (see Section 4.2.2)
- Parse – parsing information for the framework (see Section 4.2.3)

#### 4.2.1 Name

User commands must have unique names within a group (names can be replicated across different groups if required). They must be valid APL identifier names (for more information on legal names, see the Dyalog Programming Reference Guide).

Modifiers must have unique names within the user command but do not have to be unique within the superset of user commands. Modifier names are case-sensitive; Dyalog recommends using lowercase characters only.
The names of user commands and modifiers cannot contain space characters.

When naming a modifier, avoid the names arguments, delim, propagate, swd and switch as these names are used by the parser.

4.2.2 Group

Every user command must be a member of a group (but can only be a member of one group). In addition:

- the user commands for a single group do not all need to be defined within a single namespace/.dyalog file
- a single namespace/.dyalog file can include user commands for several different groups
- user command names must be unique within a group but do not have to be unique across all groups (however, custom user commands should not be given the same name as any of the predefined user commands within the SALT group).

Although it is possible to add a custom user command to one of the predefined user command groups, Dyalog Ltd recommends that this is avoided as there could be unforeseen consequences (especially with the LINK, SALT and UCMD groups).

4.2.3 Parse

If the Parse variable for a user command is empty, then the Run function's second argument will comprise everything following the command name. By setting the Parse variable to non-empty values, the user command framework is able to handle arguments and modifiers. For more information on modifiers and modifier values, see Section 4.5. For more information on arguments, see Section 4.6.

The following general rules apply when processing a call to a user command:

- user commands take 0 or more arguments and 0 or more modifiers
- individual arguments and modifiers are separated by space characters
- arguments and modifiers can be specified in any order
- arguments can be optional or mandatory
- modifiers are identified by a preceding – character
- modifier values are identified by a preceding = character
- modifier names are case-sensitive
- individual arguments and modifier values can be delimited by single or double quotes to allow leading/trailing/internal space characters or to allow arguments that have a leading - character.
The user command framework verifies that these rules have been adhered to before creating a new namespace. It then populates this namespace with a variable called Arguments (containing all the arguments) and a variable for each of the modifiers with names matching those of the modifiers. Other manipulation tools are also added to the namespace, for example, the Switch function – see Section 4.5.1. This namespace is passed to the Run function (see Section 4.3) as its second argument.

If the Parse variable defined in a user command’s List function is empty, then the user command will accept anything; the entire character vector is the argument.

If the Parse variable defined in a user command’s List function is not empty, then it must describe the number of arguments and the modifiers used. The number of arguments is a simple number and the list of modifiers must include, for each modifier, its name, whether it accepts a value and, optionally, any restrictions for that value.

4.3 The Run Function

The Run function executes the code for the command. It is always called monadically with a two-element vector argument; the user command’s name and the supplied arguments/modifiers. As a single namespace can host multiple user commands, the Run function uses the command name to determine the appropriate actions to perform.

4.3.1 Defining Multiple Levels of Help

See Appendix A for some sample user commands that demonstrate the use of multiple levels of help.

The specific defined help information that is presented to a user when requesting help in a Dyalog Session is dependent on the level of help requested. This level is defined to be 1 less than the number of ? characters entered after the – character; for example, ]<ucmd> -?? returns the information defined for level 1 of the <ucmd> user command.

As with the predefined user commands, increasingly detailed levels of information can be provided for custom user commands. If multiple levels of help are defined, then Dyalog Ltd recommends including information to that effect in each level, for example, the information that is displayed in response to a ]<ucmd> -?? request should state that more detailed information is available if ]<ucmd> -?? is entered.

Any valid Dyalog algorithmic syntax can be used in the Help function to define different levels of help, for example, control structures or branching. Optionally, the different levels of help can be cumulative so that, for example, ]<ucmd> -?? returns the help information for levels 0 and 1 as well as the help for level 2.
The following code fragment is an example showing how separate (non-cumulative) levels of help can be defined within the `Help` function:

```lisp
∇ r←level Help Cmd
   :Select level
   :Case 0
      r←⊂'This is basic help.'
   :Case 1
      r←⊂'This is level 1 help.'
   :Case 2
      r←⊂'This is level 2 help.'
   :Else
      r←⊂'This is level 3 help.'
   :EndSelect
∇
```

In this case:
- `l<ucmd>` -? gives This is basic help.
- `l<ucmd>` -?? gives This is level 1 help.
- `l<ucmd>` -??? gives This is level 2 help.
- `l<ucmd>` -???? gives This is level 3 help.
- `l<ucmd>` -????? gives This is level 3 help.

The `:Else` control structure in the code fragment ensures that requests for higher levels of help than are defined return the highest-defined level rather than generating an error message.

The following code fragment is an example showing how cumulative levels of help can be defined within the `Help` function:

```lisp
∇ r←level Help Cmd
   r←⊂'This is basic help.'
   r,←⊂'This is level 1 help.'
   r,←⊂'This is level 2 help.'
   r,←⊂'This is level 3 help.'
   r←((1+level)⌊≢r)↑r
∇
```

In these cases:
- `l<ucmd>` -? gives This is basic help.
- `l<ucmd>` -?? gives This is basic help. This is level 1 help.
• ]<ucmd> -??? gives
  This is basic help.
  This is level 1 help.
  This is level 2 help.

• ]<ucmd> -???? gives
  This is basic help.
  This is level 1 help.
  This is level 2 help.
  This is level 3 help.

• ]<ucmd> -????? gives
  This is basic help.
  This is level 1 help.
  This is level 2 help.
  This is level 3 help.

Entering ]Help ]<ucmd> in a Dyalog Session always presents the user with the same level of help as ]<ucmd> -? even if there are multiple levels of help defined.

4.4 The Help Function

The Help function reports detailed information on the user command when this is requested (by entering ]<ucmd> -? or ]Help ]<ucmd> in a Dyalog Session). It is called dyadically; the left argument is the level and the right argument is the name of the user command.

As a single namespace can host multiple user commands, the Help function uses the command name to determine the appropriate information to return.

When a user requests help for a particular user command, the Help function returns a specific set of information by default:

```
]<GROUPNAME>.<commandname>
<specific defined help information>
```

If JUDebug is on, then the Help function returns an enhanced set of information by default:

```
]<GROUPNAME>.<commandname>
Source: <location of the user command's script file>
Version: <version number of the user command>
Syntax: <number of arguments> only if arguments can be specified
Accepts modifiers <list of all modifiers> only if modifiers can be specified
  <modifier restrictions> only if modifiers exist that have restrictions
```
4.5 Modifiers

Modifiers enable a user command to apply filters and rules so that an entirely new (similar) user command does not need to be written. The user command framework allows you to define the modifiers that your user command will accept. The rules when defining each modifier in the Parse variable are:

- If a modifier accepts characters in a set, then the Parse variable includes the modifier and possible values with the ε character as a separator. For example:
  - `<modifier name>ε<set of characters>`
  so ~XYZεabc012 means that the modifier ~XYZ can accept any number and combination of characters in the set abc012, such as ab2a0b.

- If a modifier accepts specific character vectors, then the Parse variable includes the modifier and possible values with the = character as a separator and the character vectors separated by space characters. For example:
  - `<modifier name>=<charvec1> <charvec2> <charvec3>`
  so ~XYZ=abc 012 means that the modifier ~XYZ can accept either abc or 012 as a modifier value.

- If a modifier accepts any character vector, then the Parse variable includes the modifier and a = character with nothing after it. For example:
  - `<modifier name>=`
  so ~XYZ= means that the modifier ~XYZ can accept any value.

For each of these three rules, enclosing the separator character within square brackets means that specification of modifier values is optional. For example, ~XYZ[=] means that the modifier ~XYZ can be specified without a value but will accept any value.

4.5.1 Default Modifier Values

A modifier always has an internal value. This is one of the following:

- 0 if the modifier is not included when running the user command
- 1 if the modifier is included when running the user command but no modifier value is included
- a character vector matching the specified modifier value

A modifier can be configured to default to a specific value in one of three ways; these approaches are shown in this section with the modifier ~X defaulting to a modifier value of 123 (a three-element character vector).
Approach 1: Assign a default value to the modifier using the ":" character as the separator:

\[ \text{List[i].Parse}'-X:123' \]

With this approach, the default value is reported only if the modifier is not used; a value of 1 is reported if the modifier is used but no value is specified.

Approach 2: Test whether the modifier value is 0 and, if it is, then set it to the required default value.

For example:

\[ :\text{if } X\text{=}0 \diamond X\text{+'123'} \diamond :\text{endif} \]

Approach 3: Define the default value using the dyadic form of the \texttt{Switch} function (automatically defined in the namespace that is passed to the \texttt{Run} function (see \textit{Section 4.3}) as its second argument).

Given the name of a modifier as a right argument:

- \textbf{monadic Switch} returns:
  - 0 if an invalid modifier name is specified
  - 0 if the modifier is not specified and no default value has been set for that modifier
  - 1 if the modifier is specified without a modifier value
  - a character vector matching the specified modifier value
  - a character vector matching the default modifier value if a modifier is not specified but a default value has been set for that modifier

- \textbf{dyadic Switch} returns:
  - the value of the left argument (default value) if an invalid modifier value is specified
  - the value of the left argument (default value) if a modifier is not specified and no default value has been set for that modifier
  - the specified modifier value if defined – however, if the value of the default is numeric then it assumes that the specified modifier value should also be numeric and transforms it into a number. This means that, if the modifier and modifier value \(-X=123\) is entered, the expression 99 \texttt{Args.Switch 'X'} will return (,123) not '123'; the \texttt{Switch} function always returns a vector, making it very easy to differentiate between 0 (the modifier is not included when running the user command) and ,0 (a modifier value of 0 was specified when running the user command).
4.6 Arguments

Unlike modifiers, arguments do not have names. However, as arguments must be specified in a particular order and each have a specific purpose, they should be given an appropriate name in the Help function to make their purpose clear.

The number of arguments that a user command can take is specified in the Parse variable (see Section 4.2.3 – this explains the rules for determining the value to specify there).

4.6.1 Default Argument Values

A default value can be defined for an argument – this value is automatically used if the argument is not specified when running the user command. Default values are defined within the Run function.

Example

To set a default value of 'defaultfor4th' for the 4th argument:

```
args←a.Arguments,(pa.Arguments)↓0 0 0 'defaultfor4th'
```

where `a` is the second argument supplied to the Run function, that is the arguments/modifiers supplied to the user command (see Section 4.3). In this example, the first three arguments have their default values set to 0 if they are optional arguments; if they are mandatory then any value specified here is ignored.

4.6.2 Arguments Including Space Characters

Arguments that contain space characters must be delimited with ' or " characters. For example, if the user command ]NewID must have 2 arguments supplied, full name and address, then Parse should be set to '2' and the user command is run as follows:

```
]NewID 'Morten Kromberg' 'Dyalog Ltd'
```

If the user command ]NewID accepts 3 arguments, firstname, surname and address, then Parse should be set to '3' and the user command is run as follows:

```
]NewID Morten Kromberg 'Dyalog Ltd'
```

4.6.3 Minimum Number of Arguments

If a user command must have a minimum number of arguments, then Parse can be coded to that effect by assigning it a range of numbers of arguments, that is:

```
Parse←'<min number of args>~<max number of args>'
```
A minimum number of arguments cannot be specified without also specifying a maximum number of arguments. However, if there is no maximum number of arguments then an arbitrary high number can be used. For example, if at least three arguments must be supplied when calling a user command but there is no limit to the number of arguments that the user command can process, then Parse could be assigned as Parse+ '3–9999'.

### 4.6.4 Maximum Number of Arguments

If a user command can only process a limited number of arguments, then Parse can be coded to that effect by appending S to the maximum number of arguments. For example, if the user command can accept 0, 1 or 2 arguments but no more, then Parse should be set to '2S'.

### 4.6.5 Long Arguments

The last argument can be defined to comprise anything that remains after removing the other arguments. Parse can be coded to that effect by appending L to the maximum number of arguments – any additional arguments after the maximum number is reached are merged into the last argument. For example, if the user command can accept 1 argument consisting of everything that is included when running the command, then Parse should be set to '1L'.

The long argument L can be appended to the maximum number of arguments S (see Section 4.6.4) to specify that any additional arguments after the maximum number has been supplied should be merged into the last one supplied. For example, if '3SL' is specified, then 0, 1, 2 or 3 arguments can be supplied when calling the user command but any more than this will be merged with the third argument. This means that:

```
]cmd a1 a2 a3 a4 a5 a6
```

runs the user command cmd with three arguments: a1, a2 and 'a3 a4 a5 a6'.

### 4.6.6 Summary of Argument Specification in the Parser

Parse+ 'n' where n can be:

- \( n_1 \) : exactly \( n_1 \) arguments must be supplied
- \( n_2 \)–\( n_3 \) : a minimum of \( n_2 \) arguments and a maximum of \( n_3 \) arguments can be supplied
- \( n_4 S \) : a maximum of \( n_4 \) arguments can be supplied (equivalent to 0–\( n_4 \))
- \( n_5 L \) : \( n_5 \) arguments must be supplied; if more than this are supplied then the first \( n_5 - 1 \) arguments are taken and the rest are merged together into the final \( n_5 \) argument

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• \( n_6 - n_7 \) : a minimum of \( n_6 \) arguments and a maximum of \( n_7 \) arguments can be supplied; if more than this are supplied then the first \( n_7 - 1 \) arguments are taken and the rest are merged together into the final \( n_7 \) argument

• \( n_8 - n_8 \) : a maximum of \( n_8 \) arguments can be supplied; if more than this are supplied then the first \( n_8 - 1 \) arguments are taken and the rest are merged together into the final \( n_8 \) argument (equivalent to 0–\( n_8 \))

• \( n_9 - n_{10} \) : a minimum of \( n_9 \) arguments and a maximum of \( n_{10} \) arguments can be supplied; if more than this are supplied then the first \( n_{10} - 1 \) arguments are taken and the rest are merged together into the final \( n_{10} \) argument (equivalent to 0–\( n_{10} \))

### 4.7 Saving Custom User Commands

Custom user commands must be saved in a .dyalog file (if a custom user command has been created in a namespace in a Dyalog Session, then it can be saved as a .dyalog file using the ]Save user command).

The predefined user commands are located in the [DYALOG]\SALT\spice directory. Dyalog Ltd recommends that you save custom user commands in a different directory that is not located beneath the SALT directory; this is because there might be permissions issues with accessing custom commands beneath this directory and there is always the possibility that Dyalog Ltd might issue a user command with the same filename as your custom user command at a future date.

The custom user command directory must be added to the user command search path to enable the user commands within it to be detected. To do this, use the ]Settings user command to set the cmddir global parameter to the full path and name of the directory (for more information enter ]Settings -? in a Session). The new directory is added to the start of the list of directories, making it the first one searched.

![Information icon](https://via.placeholder.com/15/000000/FF00FF?text=Information)

When adding a new directory to the list of directories searched by the user command framework, you must precede its path with a , character.

![Information icon](https://via.placeholder.com/15/000000/FF00FF?text=Information)

If the cmddir global parameter includes multiple directories, then the user command framework searches the directories in the order listed (starting from the left) and retrieves the first user command it finds with the specified name. To see the list of directories (and the order in which they are searched), enter ]Settings cmddir.

If the ]UNew user command is used to create and save a new user command, then its location is automatically added to the list of directories searched.
4.8 Detecting New Custom User Commands

If the newcmd global parameter is set to auto and a user command is entered in a Dyalog Session that the user command framework does not recognise, then the user command directory(s) is scanned to locate new user commands that have been manually added. However, if the newcmd global parameter is set to manual or a change is made to the Help function or List function of an existing user command, then the user command JUReset must be run to force a complete reload of all user commands.

In addition, new user commands that are placed in the MyUCMDs directory are automatically active without needing to specify ]Settings cmddir -permanent.

- On the Linux operating system, the MyUCMDs directory is located directly under the $HOME directory.
- On the macOS operating system, the MyUCMDs directory is located directly under the $HOME directory.
- On the Microsoft Windows operating system, the MyUCMDs directory is located directly under the %USERPROFILE%\Documents directory.
A  SAMPLES Group

The SAMPLES group contains user commands that demonstrate the use of multiple levels of help and parsing user command lines.

The user commands in this group are not like those in other groups; they do not provide any useful functionality but their code can be examined to assist with understanding when creating custom user commands. This can be achieved by opening them in any text editor, for example, Microsoft Notepad.

This group is only available if ]Settings cmddir , [SALT]/study is issued.

A.1  ]UCMDHelp

An example of a custom user command that defines multiple levels of help information in the Help function, selectable by the number of question marks supplied by the user, for example, ]<ucmd> -????.

To open the code for this user command in the Editor:

]ULoad UCMDHelp
Namespace#.HelpExample now contains source for ]SAMPLES.UCMDHelp from <full path>\SALT\study\aSampleHelp.dyalog
)ED HelpExample

A.2  ]UCMDNoParsing

An example of a custom user command that does not use parsing; the argument is the entire character vector after the command name.
To open the code for this user command in the Editor:

]ULoad UCMDNoParsing
Namespace #.anyname now contains source for ]SAMPLES.UCMDNoParsing
from <full path>\SALT\study\aSample.dyalog

)ED anyname

A.3 ]UCMDParsing

An example of a custom user command that uses parsing; the character vector after the
command name is parsed and turned into a namespace containing the arguments
(tokenised) and each of the identified modifiers.

To open the code for this user command in the Editor:

]ULoad UCMDParsing
Namespace #.anyname now contains source for ]SAMPLES.UCMDParsing
from <full path>\SALT\study\aSample.dyalog

)ED anyname
B  Example User Commands

This appendix includes examples illustrating the construction of user commands.

The examples in this appendix have been created to illustrate different aspects of user commands. This means that they do not necessarily follow an efficient workflow process or best coding practice.

B.1  Example: Basic User Command Definition

This example illustrates the definition of a basic user command.

A new user command called Time is required to display the local time. The necessary functions are defined in a namespace called timefns:

```
:Namespace timefns
  ⎕ML ⎕IO←1  A set to avoid inheriting external values
  ▽ r←List
    r←⊂NS``1p``'  A r is a vector of length 1 with the
    A item set to be a ref to a namespace
    r.(Group Parse Name)←''TimeGrp'' '' 'Time'
    r[1].Desc←'Time example Script'
  ▼
  ▽ r←Run(Cmd Args)
    r←1↓,'⊂:⊃,ZI2'⎕FMT ⎕TS[4 5 6] A show time
  ▼
  ▽ r←Help Cmd
    r←'}Time (no arguments)'
  ▼
:EndNamespace
```
In this example:

- The List function sets the four variables Desc, Name, Group and Parse to 'Time example Script', 'Time', 'TimeGrp' and '' respectively.
- The Run function only needs to call ⎕TS so the command name and any supplied arguments are ignored. This function also formats the time into a user-friendly format.
- The Help function identifies that there is only one user command in the namespace (there is only one user command name, Time, defined) and returns the appropriate information for that user command.

Running this user command in a Dyalog Session returns three numbers; these three numbers are the current time, indicating the hour (according to the 24 hour clock), the number of minutes past the hour and the number of seconds elapsed respectively.

```dyalog
]Time -?
```

```
]TIMEGRP.Time
]Time (no arguments)
```

(The same result is returned if ]Time -?? or ]Help ]Time is entered)

```dyalog
]Time
13:05:09
```

(indicating that the current system time is 13:05 and 9 seconds)

### B.2 Example: Cross-Operating System Definition

This example illustrates the inclusion of two different user commands within a single namespace, different techniques for achieving the same result depending on the operating system being used and using breakout without user commands.

Although the current system time returned by the Time user command (see Section B.1) is useful, it might be more relevant to have a choice of displaying local time or UTC (Co-ordinated Universal Time). To do this, a new user command called UTC is required. As this is closely related to the Time user command, it should be created in the same namespace; this involves adding a new function called Zulu and modifying the Run, List and Help functions.
To illustrate the ability of a user command to obtain information through a breakout call to .NET, this example also includes options in the Run function that are dependent on the operating system that the Dyalog Session is being run on (.NET is only valid when running on the Microsoft Windows operating system). These options ensure that the same user command is cross-system compatible for Microsoft Windows and UNIX.

```apl
:Namespace timefns
  ⎕ML ⎕IO←1           ⍝ A set to avoid inheriting external values
  ⍎r←List
  r←⊂NS''2pc''         ⍝ r is a vector of length 2 with the
                       ⍝ items set to be refs to namespaces
  r.(Group Parse)←'TimeGrp''
  r.Name←'Time' 'UTC'
  r.Desc←'Show local time' 'Show UTC time'

∇ r←Run(Cmd Args);dt
  :If 'Windows' ≡ 7↑⊃'.'⎕WG 'APLVERSION' ⍝ If Windows
    ⎕USING←'System'
    dt←DateTime.Now
    :If 'UTC'≡Cmd
      dt←Zulu dt
    :EndIf
    r←(r⍳'')↓r←⍕dt
  :EndIf
  :Else                  ⍝ If not Windows
    dt←('UTC'=Cmd)/'TZ=UTC'
    r←⊃⎕SH dt,' date "%H:%M:%S"'  ⍝ A set timezone
  :EndIf

∇ r←Help Cmd;which
  which←'Time' 'UTC'⍳Cmd
  r←which⊃'
]Time (no arguments)' ']UTC (no arguments)'

∇ r←Zulu date
  ⍝ Use .NET to retrieve UTC info
  r←TimeZone.CurrentTimeZone.ToUniversalTime date

:EndNamespace
```
In this example:

- The List function is amended to allow for two function definitions in the four variable definitions:
  - Desc is set to 'Show local time' 'Show UTC time' (two values, therefore the first applies to the first user command and the second applies to the second user command)
  - Name is set to 'Time' 'UTC' (two values, therefore the first applies to the first user command and the second applies to the second user command)
  - Group is set to <TimeGrp (only one value so applied to both user commands)
  - Parse is set to '' (only one value so applied to both user commands)

- The Run function is amended to use the Cmd argument to determine which user command is being run (any further supplied arguments are still ignored). The operating system on which the Dyalog Session is being run is then identified; this determines whether to use the current system time or the APL system function ⎕TS. For example, if the UTC user command is being run on a Microsoft Windows operating system, then the Run function calls the Zulu function. The Run function also formats the resulting time into a more user-friendly format irrespective of the operating system and user command.

- The Help function is amended to enable it to identify that there are two user commands in the namespace (there are two user command names, Time and UTC, defined) and return the appropriate information according to which name is specified.

- The Zulu function is added to retrieve the UTC time through a .NET call – this function is only called if the Run function identifies that the Dyalog Session is running on a Microsoft Windows operating system and the ]UTC user command is specified.

After changing the code but before running these user commands, the ]UReset user command should be run to force a cache file update (otherwise the code changes will not be detected).

The Time and UTC user commands can now be run from a Dyalog Session:

```
]TimeGrp -?

TIMEGRP:
  Time  Show local time in a city
  UTC   Show UTC time

]Time -?

]TIMEGRP.Time

]Time (no arguments)
```
(the same result is returned if \texttt{]Time -??} or \texttt{]Help ]Time} is entered)

\texttt{]Time}
\texttt{13:17:34}

(indicating that the current system time is 13:17 and 34 seconds)

\texttt{]UTC -?}

\texttt{]TIMEGRP.UTC}
\texttt{]UTC (no arguments)}

(the same result is returned if \texttt{]UTC -??} or \texttt{]Help ]UTC} is entered)

\texttt{]UTC}
\texttt{12:18:15}

(indicating that the co-ordinated universal time is 12:18 and 15 seconds)

\subsection{Example: Optional Arguments}

\textit{This example illustrates the creation of a user command with an optional argument.}

Although the \texttt{Time} and \texttt{UTC} user commands return the local time and UTC respectively (see Section B.2), they only work for the location in which the system is located. To return the time in different locations, new functions could be defined for each location and the \texttt{Run}, \texttt{List} and \texttt{Help} functions modified accordingly. Alternatively, the \texttt{Run} function can be modified to use the location as an argument to compute the time (this does not take account of daylight saving time). Using this second approach the \texttt{timefs.dyalog} file can be modified as follows (example assumes the Microsoft Windows operating system only):

\begin{verbatim}
:Namespace timefs

GMT ⌈IO-1 ⌈set to avoid inheriting external values

∇ r←List
 r←(NS¨2p``;`` A \(r\) is a vector of length 2 with the
 A items set to be refs to namespaces
 r.(Group Parse)+c'TimeGrp'`'
 r.Name←'Time' 'UTC'
 r.Desc←'Show local time in a city' 'Show UTC time'

∇ r←Run(Cmd Args);dt;offset;cities;diff;city;lcity;ix

\end{verbatim}
USING 'System'
dt←DateTime.Now
:Select Cmd
  :Case 'UTC'
    dt←Zulu dt
  :Case 'Time'
    :If 0≠pcity←Args~'
      offset←CityTimeOffset city
      'Unknown city' ⍵SIGNAL 11p≈θ≡offset
      diff←NEW TimeSpan(3↑offset)
      dt←(Zulu dt)+diff
    :EndIf
  :EndSelect
r←(r⍳' ')+r←⎕dt
∇
∇ r←Help Cmd;which
  which←'Time' 'UTC' ⍵Ccmd
  r←which⊃' [city]' 'UTC (no arguments)'
∇
∇ r←Zulu date
  ⍝ Use .NET to retrieve UTC info
  r←TimeZone.CurrentTimeZone.ToUniversalTime date
∇
∇ r←CityTimeOffset city;lcity;cities;ix;offsets
  cities←'l.a.' 'montreal' 'copenhagen' 'sydney'
  offsets←¯8 ¯5 1 10
  r←θ
  lcity←(819↓)city
  ix←cities⍳lcity
  :If ix≤⍴cities
    r←ix[]offsets
  :EndIf
  A [else return θ]
∇
:EndNamespace

In this example:

- The List function has one small amendment to the description of the Desc variable for the first user command.

- The Run function still uses the Cmd argument to determine which user command is being run; different actions are taken according to which is specified. If the Cmd argument is UTC then the function proceeds as before. However, if the Cmd argument is Time then the function now takes the second argument into account.
and passes it to the CityTimeOffset function (the Args~' \' expression removes any extraneous spaces in the name of the city, so that a user can enter (for example) ' l.a.' or ' l. a.' and get a valid result) If the CityTimeOffset function returns an offset value then the Run function uses this to calculate the time in the specified city, otherwise it generates an "Unknown city" error message.

- The Help function has one small amendment to state that an optional argument specifying the location can be included when running the Time user command.
- The Zulu function remains unchanged.
- The CityTimeOffset function is added to determine whether the second argument matches the name of one of the cities that have had time offsets defined and return the appropriate offset if a match is found. The name of the city entered when running the user command is made case insensitive by converting them to lower case with the (819↓) expression.

After changing the code but before running these user commands, the ]UReset user command should be run to force a cache file update (otherwise the code changes will not be detected).

The Time and UTC user commands can now be run from a Dyalog Session:

```
]Time -?
```

```
]TIMEGRP.Time
]Time [city]
```

(the same result is returned if ]Time -?? or ]Help ]Time is entered)

```
]Time
13:17:34
```

(indicating that the current system time is 13:17 and 34 seconds)

```
]Time l.a.
04:17:51
```

(indicating that the current time in Los Angeles, ignoring daylight saving time, is 04:17 and 51 seconds)

```
]Time l.x.
* Command Execution Failed: Unknown city
```

(an invalid city was specified)

```
]UTC -?
```

```
]TIMEGRP.UTC
```
]UTC (no arguments)
(the same result is returned if ]UTC -?? or ]Help ]UTC is entered)

]UTC
06:08:30
(indicating that the local co-ordinated universal time is 6:08 and 30 seconds)

]TimeGrp -?
TIMEGRP:
Time  Show local time in a city
UTC   Show UTC time

B.4 Example: The Parse Variable

This example illustrates use of the Parse variable; by setting this to non-empty values, the user command framework is able to handle arguments and modifiers.

For more information on the Parse variable, see Section 4.2.3. For more information on modifiers and modifier values, see Section 4.5. For more information on arguments, see Section 4.6.

A new user command called Number is required to display either the age of the specified person or to convert a decimal number into its Hexadecimal equivalent. The necessary functions are defined in a namespace called number:

:Namespace number

 ⎕ML ⎕IO←1 ⎕ set to avoid inheriting external values
 ⍵ r←List
   r←⊂'1⍴''
   r.(Group Parse Name Desc)←'AgeHex' '' 'Number' 'Gives age or Hexadecimal format'
 ⍵

 ⍵ r←Run(Cmd Args);N;H;alph;Name;Names
 r←∅
 Names←Args.Arguments
 :For Name :In Names
   :Select Name
   :Case 'Fiona'
     r,+40
   :Case 'Andy'

A new user command called Number is required to display either the age of the specified person or to convert a decimal number into its Hexadecimal equivalent. The necessary functions are defined in a namespace called number:
In this example, the Parse variable is empty – this means that the Run function takes everything following the command name as a simple character vector. However, if a valid name is entered with the expectation of having that person's age returned, then an error message is generated:

\[\] Number Fiona
* Command Execution Failed: SYNTAX ERROR

The same error message is generated if a decimal number is entered with the expectation of its Hexadecimal equivalent being returned:

\[\] Number 42
* Command Execution Failed: SYNTAX ERROR

This error arises because the user command is expecting a namespace as its input and instead it is receiving a simple character vector.

These errors arise because the Args parameter in the Run function is a simple character vector rather than a namespace; this is due to the empty Parse variable. Populating the Parse variable means that the Args parameter becomes a namespace.

For this example, the only changes that will be made to the user command's code are to its Parse variable definition.
To enable the user command to perform the necessary namespace conversion, the Parse variable is changed from ' ' to '2S' – this means that the user command can accept 0, 1 or 2 arguments but no more (for more information on this, see Section 4.6.4).

Changing the Parse variable again, this time from '2S' to '2L', means that 2 arguments must be supplied; if more than this are supplied then the first argument is taken as specified and the rest are merged together to become the second argument (for more information on this, see Section 4.6.5).

B.5 Example: Debugging a User Command

This example illustrates using the ]UDebug user command to debug a namespace containing a user command group definition.

Three keyboard shortcuts for command codes are referred to in this example – <TC> (Trace), <ED> (Edit) and <EP> (Escape). The usual key combinations for these are operating-system-dependent.

Relevant key combinations on the Microsoft Windows operating system:
- <TC> is usually Ctrl + Enter
- <ED> is usually Shift + Enter
- <EP> is usually Escape
Relevant key combinations on the UNIX operating system:

- `<TC>` is usually APLKey + Shift + Enter
- `<ED>` is usually APLKey + Enter
- `<EP>` is usually Escape

Relevant key combinations on the macOS operating system:

- `<TC>` is usually Ctrl + Enter
- `<ED>` is usually Shift + Enter
- `<EP>` is usually Escape

A user command can be debugged by tracing through ⎕SE.UCMD (see Section 3.3). However, a more convenient method is to instruct the framework to suspend on the first line of the Run or Help function – tracing/debugging can then proceed from there. To do this, debugging mode must be switched on:

```
]DEBUG on
```

If an error is encountered in debugging mode, execution of the user command is suspended rather than returning to the calling function.

When debugging is enabled, specifying a space followed by the – character at the end of the command opens the Trace window with the code suspended on Run[1]. For example, using the number namespace defined in Section B.4 to hold the AgeHex group of user commands:

```
]Number 42 Andy
2A 51
]Number 42 Andy – Run[1]
```

To progress through the Run function, enter the Trace command (<TC>).

You can now trace and debug the code in the namespace.

The Trace window shows that, in the number namespace, the Parse variable is set to 2S. This means that the Args variable is a namespace. The namespace contains a number of variables, one of which is Arguments:

```
]Disp Args
]]SE.[Namespace]
   Args.[Namespace] 2
Arguments
```
This shows that the Arguments variable is a vector comprising two character vectors.

Enter the Edit command (<ED>) to open the namespace definition in the Edit window and change the Parse variable from '2S' to '2L'. Save the changes and repeatedly enter the Escape command (<EP>) until you are no longer tracing through code. Then enter:

```
]Number 42 Andy 8 9 10 -
```

With the Run function suspended, enter:

```
]Disp Args.Arguments
```

```
42 Andy
```

This shows that the Arguments variable is still a vector comprising two character vectors. However, the second of the two character vectors now includes everything after the first argument in the call to the user command.

Press the <ED> key combination to open the namespace definition in the Edit window and change the Parse variable from '2L' to '2S -true'. The '-true' means that the parser now accepts a modifier called -true that does not accept a modifier value but can only be present or absent (see Section 3.7.2). Save the changes and repeatedly hit <EP> until you are no longer tracing through code. Then enter:

```
]Number 42 Andy -
Args.true
```

This shows an additional variable, true, created with the same name as the modifier that was included in the Parse variable. However, when calling the ]Number user command, this on/off modifier was not specified. Therefore:

```
Args.true
```

0
To see the effect of calling the ]Number user command with this modifier specified:

)reset
]Number 42 Andy -true -
Args.true

1

Debugging mode is switched off using:

]UDebug off

Was ON
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