# Powershell Programming Language

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**Abstract**

PowerShell is a Microsoft scripting language and shell for automating system tasks using object-based pipelines and .NET integration.

## 1 Introduction

PowerShell is a powerful tool that automates system management by treating data as objects, simplifying complex tasks for IT admins.

# Contents

# 2 PowerShell Programming Language Concepts

PowerShell is a task automation and configuration management framework from Microsoft, consisting of a command-line shell and associated scripting language. Here are the key concepts:

## 2.1 Core Concepts

### Cmdlets (Command-lets)

- Lightweight commands that perform specific functions
- Follow a `Verb-Noun` naming convention (e.g., `Get-Process`, `Set-Location`)
- Process objects rather than text streams

### Pipeline

- Chains cmdlets together using the `|` operator
- Passes .NET objects between commands (not just text)
- Example:

```
Get-Process | Where-Object { $_.CPU -gt 10 } | Sort-Object -Property CPU
```

### Objects

- Everything in PowerShell is a .NET object
- Rich type system with properties and methods
- Can access .NET Framework classes directly

## 2.2 Scripting Concepts

### Variables

- Prefixed with `$` (e.g., `$name = "PowerShell"`)
- Loosely typed but can enforce types (e.g., `[int]$count = 10`)

### Control Structures

- Conditionals: `if`, `elseif`, `else`, `switch`
- Loops: `for`, `foreach`, `while`, `do-while`, `do-until`
- Example:

```
if ($value -gt 10) {
    Write-Output "Value is large"
} else {
    Write-Output "Value is small"
}
```

### Functions

- Can be simple or advanced (with parameters)
- Example:

```
function Get-Square {
    param([int]$number)
    return $number * $number
}
```

### Script Blocks

- Anonymous functions: `{ param($a,$b) $a + $b }`
- Used with cmdlets like `Where-Object` and `ForEach-Object`

## 2.3 Advanced Concepts

### Modules

- Packages of cmdlets, providers, functions, and variables
- Can be imported with `Import-Module`

### Error Handling

- Try/Catch/Finally blocks
- `$Error` automatic variable contains error history
- Example:

```
try {
    Get-Content "nonexistent.txt" -ErrorAction Stop
}
catch {
    Write-Output "Error occurred: $_"
}
```

### Remoting

- Execute commands on remote computers
- Uses WS-Management protocol (WinRM)
- Example:

```
Invoke-Command -ComputerName Server01 -ScriptBlock { Get-Process }
```

### Providers

- Expose data stores (filesystem, registry, certificates) as drives
- Navigate like a filesystem (e.g., `cd HKLM:\` for registry)

### Workflows

- Long-running, parallelizable tasks with checkpointing
- Built on Windows Workflow Foundation

## 2.4 PowerShell Features

- **Automatic Variables**: `$_`, `$PSHome`, `$Host`, etc.
- **Aliases**: Shortcuts for cmdlets (e.g., `ls` for `Get-ChildItem`)
- **Splatting**: Passing parameters as a hashtable
- **Regular Expressions**: Built-in support with `-match` operator
- **XML and JSON**: Native support for parsing and creating

PowerShell is both an interactive shell and a powerful scripting language that integrates deeply with Windows systems and can manage virtually any Windows component or application.

# 3 Cmdlets (Command-lets) in PowerShell

Cmdlets (pronounced "command-lets") are the fundamental building blocks of PowerShell, designed to perform specific tasks and follow a consistent naming convention.

## 3.1 Key Characteristics of Cmdlets

1. **Verb-Noun Naming Convention**
   - Format: `Verb-Noun` (e.g., `Get-Process`, `Set-Location`)
   - Verbs describe the action (Get, Set, New, Remove)
   - Nouns describe what the action operates on (Process, Location, Item)
2. **Lightweight Commands**
   - Single-purpose commands that do one thing well
   - Typically process input and produce output
   - Can be combined in pipelines
3. **Object-Oriented**
   - Work with .NET objects rather than text
   - Output objects with properties and methods

## 3.2 Common Cmdlet Verbs

| Verb | Purpose | Examples |
|---|---|---|
| Get | Retrieve information | `Get-Process`, `Get-ChildItem` |
| Set | Change or configure something | `Set-Location`, `Set-Content` |
| New | Create something new | `New-Item`, `New-Object` |
| Remove | Delete something | `Remove-Item`, `Remove-Variable` |
| Start | Begin an operation | `Start-Service`, `Start-Process` |
| Stop | End an operation | `Stop-Process`, `Stop-Service` |
| Invoke | Execute or call something | `Invoke-Command`, `Invoke-WebRequest` |
| Export | Send data out of PowerShell | `Export-Csv`, `Export-Clixml` |
| Import | Bring data into PowerShell | `Import-Csv`, `Import-Module` |

## 3.3 How Cmdlets Work

1. **Parameter Binding**
   - Accept input through parameters
   - Can be positional or named

   Example:

```
Get-ChildItem -Path "C:\Temp" -Recurse
```

2. **Pipeline Processing**
   - Cmdlets can accept input from and send output to other cmdlets

   Example:

```
Get-Process | Where-Object { $_.CPU -gt 50 } | Sort-Object -Property CPU -Descending
```

3. **Common Parameters**
   - All cmdlets support these standard parameters:

- `-Verbose`: Shows detailed information
- `-Debug`: Provides debugging information
- `-ErrorAction`: Controls error behavior
- `-OutVariable`: Stores output in a variable
- `-WhatIf`: Shows what would happen without executing

## 3.4 Creating Custom Cmdlets

You can create your own cmdlets by writing .NET classes that inherit from `Cmdlet` or `PSCmdlet` base classes:

```
[Cmdlet(VerbsCommon.Get, "Square")]
public class GetSquareCommand : Cmdlet
{
    [Parameter(Position=0, Mandatory=true)]
    public int Number { get; set; }

    protected override void ProcessRecord()
    {
        WriteObject(Number * Number);
    }
}
```

## 3.5 Finding and Discovering Cmdlets

1. **Get-Command**: Lists available cmdlets

   ```
   Get-Command -Verb Get
   ```

2. **Get-Help**: Shows help for a cmdlet

   ```
   Get-Help Get-Process -Full
   ```

3. **Get-Member**: Examines object properties and methods

   ```
   Get-Process | Get-Member
   ```

Cmdlets are designed to be composable—they work well together in pipelines and follow consistent patterns that make PowerShell both powerful and easy to learn.

# 4 PowerShell Pipeline: Concepts and Usage

The pipeline is one of PowerShell's most powerful features, allowing you to chain commands together by passing objects (not just text) from one cmdlet to another.

## 4.1 Core Pipeline Concepts

1. **Object-Based Flow**
   - Unlike traditional shells that pass text, PowerShell pipelines pass .NET objects
   - Each object retains its structure, properties, and methods as it moves through the pipeline
2. **Pipeline Operator**
   - The `|` symbol connects commands
   - Syntax: `Command1 | Command2 | Command3`
3. **Automatic Variable `$_`**
   - Represents the current object in the pipeline
   - Used in script blocks to reference the pipeline object

## 4.2 How the Pipeline Works

1. **ByValue Binding**
   - When a cmdlet receives pipeline input, it binds to the parameter that accepts that type of input "by value"

   Example:

```
Get-Process | Stop-Process  # Binds to -InputObject parameter
```

2. **ByPropertyName Binding**
   - When properties of input objects match parameter names

   Example:

```
[PSCustomObject]@{Name='notepad'} | Stop-Process
# Binds the 'Name' property to Stop-Process's -Name parameter
```

## 4.3 Common Pipeline Patterns

```
Get-Process | Where-Object { $_.CPU -gt 50 }
```

```
Get-Service | Select-Object Name, Status, StartType
```

```
Get-ChildItem | Sort-Object Length -Descending
```

```
Get-Process | Group-Object Company
```

```
Get-Content log.txt | Measure-Object -Word -Line -Character
```

## 4.4 Advanced Pipeline Techniques

1. **Pipeline Variable (`$PSItem`)**
   - Alternative to `$_` (more readable in some cases)

```
Get-ChildItem | Where-Object { $PSItem.Length -gt 1MB }
```

2. **Beginning and Ending Pipelines**
   - `Begin`/`Process`/`End` blocks in advanced functions

```
function Test-Pipeline {
    begin { $count = 0 }
    process { $count++; $_ }
    end { "Processed $count items" }
}
```

3. **Pipeline Stopping**
   - `Select-Object -First` stops the pipeline early

```
Get-ChildItem -Recurse | Select-Object -First 10
```

4. **Tee-Object for Branching**

```
Get-Process | Tee-Object -Variable procs | Export-Csv processes.csv
```

## 4.5 Performance Considerations

1. **Streaming Behavior**
   - Objects are processed one at a time (not all at once)
   - Enables processing large datasets without memory overload
2. **Pipeline vs. Variable Storage**
   - Pipelines are generally more memory efficient than storing all objects in variables
3. **Filter Left**
   - Apply filters as early as possible in the pipeline

```
# Better (filters first):
Get-ChildItem *.log | Where-Object Length -gt 1MB

# Less efficient:
Get-ChildItem | Where-Object { $_.Extension -eq '.log' -and $_.Length -gt 1MB }
```

The PowerShell pipeline is what enables its composable nature, allowing you to build complex operations from simple commands while maintaining excellent performance characteristics.

# 5 Objects in PowerShell

PowerShell is fundamentally object-oriented, unlike traditional shells that primarily work with text streams. This object-based approach is one of PowerShell's most powerful features.

## 5.1 Core Concepts of PowerShell Objects

1. **Everything is an Object**
   - All output from cmdlets, variables, and expressions are .NET objects
   - Objects retain their structure, properties, and methods throughout the pipeline
2. **Object Types**
   - Built-in .NET types (String, Int32, DateTime, etc.)
   - Custom objects created by cmdlets or with `[PSCustomObject]`
   - Collections (arrays, ArrayLists, etc.)

## 5.2 Working with Objects

### 5.2.1 Creating Objects

```
# Using [PSCustomObject]
$person = [PSCustomObject]@{
    Name = "John Doe"
    Age = 42
    IsActive = $true
}

# Using New-Object (legacy)
$date = New-Object System.DateTime(2023, 12, 31)
```

### 5.2.2 Accessing Properties and Methods

```
# Accessing properties
$person.Name
$person.Age

# Calling methods
$date.AddDays(5)
"hello".ToUpper()
```

### 5.2.3 Discovering Object Members

```
# Using Get-Member
Get-Process | Get-Member  # Shows all properties and methods
$person | Get-Member -MemberType Properties
```

## 5.3 Important Object Features

### 5.3.1 Properties

- Contain data about the object
- Can be value types (strings, numbers) or other objects
- Example: `(Get-Process -Name pwsh).Id`

### 5.3.2 Methods

- Actions the object can perform
- Example: `$file = Get-Item "C:\test.txt"; $file.Delete()`

#### 5.3.3 Events (less common)

- Notifications objects can raise
- Example: Registering for process exit events

## 5.4 Special Object Types

1. **PSObject Wrapper**
   - All objects in PowerShell are wrapped in a PSObject
   - Adds extra capabilities like:
     - Extended type system (ETS)
     - Note properties
     - Custom member definitions
2. **Automatic Variables**
   - Special objects always available:
     - `$_` or `$PSItem`: Current pipeline object
     - `$input`: Input enumerator in functions
     - `$args`: Function arguments
3. **Custom Objects**
   - Created with `[PSCustomObject]` or `New-Object`
   - Can add members dynamically:

```
$obj = [PSCustomObject]@{Name="Test"}
$obj | Add-Member -MemberType NoteProperty -Name "Value" -Value 100
```

## 5.5 Object Serialization

PowerShell can serialize objects for storage or transfer:

```
# Export to CLIXML (preserves object structure)
$processes = Get-Process
$processes | Export-Clixml -Path "processes.xml"

# Import from CLIXML
$imported = Import-Clixml -Path "processes.xml"
```

## 5.6 Object Comparison

PowerShell provides several ways to compare objects:

```
# Simple equality
$obj1 -eq $obj2

# Property comparison
Compare-Object $obj1 $obj2 -Property Name, Value

# Deep object comparison
[System.Collections.StructuralComparisons]::StructuralEqualityComparer.Equals($obj1, $obj2)
```

The object-oriented nature of PowerShell enables powerful data manipulation while maintaining rich type information throughout your scripts and pipelines. This is what allows PowerShell to go beyond simple text processing and provide deep system integration.

# 6 Variables in PowerShell

Variables in PowerShell are fundamental elements used to store data of all types. Unlike strictly typed languages, PowerShell variables are loosely typed by default but can be strictly typed when needed.

## 6.1 Variable Basics

### 6.1.1 Declaration and Assignment

```
$variableName = value       # Basic variable assignment
$number = 42               # Integer
$name = "John Doe"         # String
$isActive = $true          # Boolean
$items = 1, 2, 3, "four"   # Array
```

### 6.1.2 Variable Naming Rules

- Must begin with $
- Can contain letters, numbers, and underscores
- Not case-sensitive (but case-preserving)
- Should follow PascalCase or camelCase conventions
- Avoid special characters and spaces

## 6.2 Variable Types

### 6.2.1 Loose Typing (Default)

```
$value = "Hello"    # Initially a string
$value = 42         # Now an integer
$value = Get-Date   # Now a DateTime object
```

### 6.2.2 Strict Typing

```
[int]$count = 10            # Only accepts integers
[datetime]$today = Get-Date # Only accepts dates
[string]$name = "Alice"     # Only accepts strings
```

## 6.3 Special Variable Types

### 6.3.1 Arrays

```
$numbers = 1, 2, 3, 4, 5
$services = Get-Service
$emptyArray = @()
```

### 6.3.2 Hashtables (Dictionaries)

```
$person = @{
    Name = "John"
    Age = 30
    IsActive = $true
}
```

### 6.3.3 Custom Objects

```
$user = [PSCustomObject]@{
    Username = "jsmith"
    LastLogin = Get-Date
    Department = "IT"
}
```

## 6.4 Automatic Variables

PowerShell provides built-in variables:

```
$_ or $PSItem       # Current object in pipeline
$args               # Arguments passed to function
$error              # Array of recent errors
$home               # User's home directory
$host               # Information about current host
$null               # Represents null value
$true, $false       # Boolean values
$PID                # Current process ID
$PSVersionTable     # PowerShell version information
```

## 6.5 Variable Scope

PowerShell has several scopes:

```
$global:var = "Global"      # Available everywhere
$script:var = "Script"      # Available in current script
$local:var = "Local"        # Available in current scope (default)
$private:var = "Private"    # Only available in current scope
```

## 6.6 Variable Commands

### 6.6.1 Working with Variables

```
Get-Variable                  # List all variables
New-Variable -Name x -Value 10 # Create new variable
Remove-Variable x             # Delete variable
Clear-Variable y              # Clear variable value
Set-Variable z -Value 100     # Set variable value
```

## 6.7 Best Practices

1. Use descriptive variable names ($serverList instead of $x)
2. Consider strict typing for critical variables
3. Use scope modifiers appropriately
4. Clean up temporary variables when done
5. Avoid using automatic variable names for your variables

## 6.8 String Expansion

Variables expand in double-quoted strings:

```
$name = "Alice"
Write-Output "Hello, $name!"  # Outputs: Hello, Alice!
```

For complex expressions, use $():

```
Write-Output "Today is $(Get-Date -Format 'yyyy-MM-dd')"
```

Variables are fundamental to PowerShell scripting, providing flexible storage for everything from simple values to complex objects and collections.

# 7 Control Structures in PowerShell

PowerShell provides a comprehensive set of control structures for managing program flow, including conditionals, loops, and error handling. These structures allow you to create complex logic in your scripts.

## 7.1 Conditional Statements

### 7.1.1 If/ElseIf/Else

```
if (condition) {
    # code block
}
elseif (other_condition) {
    # code block
}
else {
    # code block
}

# Example:
if ($age -lt 18) {
    Write-Output "Minor"
}
elseif ($age -le 65) {
    Write-Output "Adult"
}
else {
    Write-Output "Senior"
}
```

### 7.1.2 Switch

```
switch ($value) {
    pattern1 { # code }
    pattern2 { # code }
    default { # code }
}

# Example:
switch ($day) {
    "Monday"    { Write-Output "Start of work week" }
    "Friday"    { Write-Output "TGIF!" }
    {$_ -in "Saturday","Sunday"} { Write-Output "Weekend" }
    default     { Write-Output "Midweek" }
}
```

## 7.2 Looping Structures

### 7.2.1 For Loop

```
for ($i = 0; $i -lt 10; $i++) {
    # code block
}

# Example:
for ($i = 1; $i -le 5; $i++) {
    Write-Output "Iteration $i"
}
```

### 7.2.2 Foreach Loop

```
foreach ($item in $collection) {
    # code block
}
```

```powershell
# Example:
$services = Get-Service
foreach ($service in $services) {
    if ($service.Status -eq "Running") {
        Write-Output $service.Name
    }
}
```

### 7.2.3 While Loop

```powershell
while (condition) {
    # code block
}

# Example:
$count = 0
while ($count -lt 5) {
    Write-Output "Count: $count"
    $count++
}
```

### 7.2.4 Do-While/Do-Until

```powershell
do {
    # code block
} while (condition)

do {
    # code block
} until (condition)

# Example:
$input = ""
do {
    $input = Read-Host "Enter 'quit' to exit"
} until ($input -eq "quit")
```

## 7.3 Flow Control Statements

### 7.3.1 Break and Continue

```powershell
# Break exits the loop completely
foreach ($file in Get-ChildItem) {
    if ($file.Length -gt 1MB) {
        Write-Output "Found large file: $($file.Name)"
        break
    }
}

# Continue skips to next iteration
for ($i = 0; $i -lt 10; $i++) {
    if ($i % 2 -eq 0) { continue }
    Write-Output "Odd number: $i"
}
```

### 7.3.2 Return

```powershell
function Test-Value {
    param($value)
    if ($value -lt 0) {
        return "Negative"
    }
    "Positive"
}
```

## 7.4 Error Handling

### 7.4.1 Try/Catch/Finally

```
try {
    # Code that might throw an error
    Get-Content "nonexistent.txt" -ErrorAction Stop
}
catch [System.IO.FileNotFoundException] {
    Write-Output "File not found: $($_.Exception.Message)"
}
catch {
    Write-Output "General error: $($_.Exception.Message)"
}
finally {
    # Cleanup code that always runs
    Write-Output "Operation attempted"
}
```

## 7.5 Best Practices

1. Use `-in` operator for multiple comparisons instead of nested ifs
2. Prefer `switch` over multiple `elseif` statements
3. Use `break` and `continue` judiciously to improve readability
4. Always handle potential errors with `try/catch` blocks
5. Consider using `-ErrorAction Stop` with commands that might fail
6. Use `$foreach` automatic variable in nested loops to reference outer loop

PowerShell's control structures provide flexible ways to implement complex logic while maintaining readability and robustness in your scripts.

# 8 Functions in PowerShell

Functions in PowerShell are reusable blocks of code that perform specific tasks. They help organize scripts, promote code reuse, and make complex operations more manageable.

## 8.1 Basic Function Structure

```
function Verb-Noun {
    [CmdletBinding()]
    param (
        # Parameters go here
    )

    begin {
        # Initialization code (runs once)
    }

    process {
        # Main processing code (runs for each pipeline input)
    }

    end {
        # Cleanup code (runs once)
    }
}
```

## 8.2 Simple Function Example

```
function Get-Greeting {
    param (
        [string]$Name = "User"
    )

    "Hello, $Name!"
}

# Usage:
Get-Greeting -Name "John"
Get-Greeting  # Uses default value
```

## 8.3 Advanced Function Features

### 8.3.1 Parameter Attributes

```
function Get-FileInfo {
    param (
        [Parameter(Mandatory=$true)]
        [ValidateScript({Test-Path $_})]
        [string]$Path,

        [ValidateSet("Size","Name","LastWriteTime")]
        [string]$Property = "Size"
    )

    Get-Item $Path | Select-Object $Property
}
```

### 8.3.2 Pipeline Input

```
function ConvertTo-UpperCase {
    param (
        [Parameter(ValueFromPipeline=$true)]
        [string]$InputString
    )

    process {
```

```
        $InputString.ToUpper()
    }
}

# Usage:
"hello", "world" | ConvertTo-UpperCase
```

### 8.3.3 Dynamic Parameters

```
function Get-DynamicExample {
    [CmdletBinding()]
    param (
        [string]$BaseParam
    )

    DynamicParam {
        # Create dynamic parameters here
    }

    process {
        # Function logic
    }
}
```

## 8.4 Function Types

### 8.4.1 Simple Functions

```
function Add-Numbers {
    param($a, $b)
    $a + $b
}
```

### 8.4.2 Advanced Functions (Cmdlet-like)

```
function Get-SystemInfo {
    [CmdletBinding()]
    param (
        [Parameter(Mandatory=$true)]
        [string]$ComputerName,

        [switch]$Detailed
    )

    # Function body
}
```

### 8.4.3 Filter Functions (Pipeline-optimized)

```
filter Get-LargeFiles {
    if ($_.Length -gt 1MB) {
        $_
    }
}

# Usage:
Get-ChildItem | Get-LargeFiles
```

## 8.5 Common Function Techniques

### 8.5.1 Default Parameter Values

```
function Set-Configuration {
    param (
```

```
        [string]$Server = "localhost",
        [int]$Port = 8080
    )
    # Function body
}
```

### 8.5.2 Parameter Validation

```
function Register-User {
    param (
        [ValidatePattern("[a-z0-9]+")]
        [string]$Username,

        [ValidateRange(18, 120)]
        [int]$Age
    )
    # Function body
}
```

### 8.5.3 Multiple Parameter Sets

```
function Get-Data {
    [CmdletBinding(DefaultParameterSetName="ByName")]
    param (
        [Parameter(ParameterSetName="ByName")]
        [string]$Name,

        [Parameter(ParameterSetName="ById")]
        [int]$Id
    )
    # Function body
}
```

## 8.6 Best Practices

1. Use **Verb-Noun naming convention** (e.g., `Get-Process`, `Set-Configuration`)
2. Add comment-based help:

   ```
   <#
   .SYNOPSIS
   Brief description

   .DESCRIPTION
   Detailed description

   .PARAMETER Name
   Parameter description

   .EXAMPLE
   Example command
   #>
   ```

3. Validate input parameters thoroughly
4. Support pipeline input when appropriate
5. Include error handling (try/catch blocks)
6. Use `Write-Verbose` for debugging information
7. Return meaningful output (avoid `Write-Host` for data output)
8. Consider performance for functions processing large datasets

## 8.7 Function Scope

Functions can control variable scope:

```
function Test-Scope {
    $localVar = "Local scope"
    $script:scriptVar = "Script scope"
    $global:globalVar = "Global scope"
}
```

PowerShell functions are powerful tools that can range from simple script helpers to full-fledged cmdlet-like components with comprehensive parameter handling, pipeline support, and error management.

# 9 Script Blocks in PowerShell

Script blocks are self-contained units of PowerShell code that can be stored in variables, passed as parameters, and executed on demand. They are enclosed in curly braces {} and are a fundamental building block for many advanced PowerShell techniques.

## 9.1 Basic Syntax

```
$scriptBlock = {
    # PowerShell code here
    Get-Process
    "Current time: $(Get-Date)"
}

# Execute the script block
& $scriptBlock
```

## 9.2 Key Features of Script Blocks

- **Anonymous Functions**: Act like unnamed functions
- **Deferred Execution**: Code runs only when invoked
- **Closures**: Can capture variables from their defining scope
- **Passable Code**: Can be passed as arguments to other commands

## 9.3 Execution Methods

### 9.3.1 Call Operator (&)

```
& { "Hello, World!" }  # Executes in current scope
```

### 9.3.2 Dot Sourcing Operator (.)

```
. { $variable = "Value" }  # Executes in current scope and retains variables
```

### 9.3.3 Invoke-Command

```
Invoke-Command -ScriptBlock { Get-Service }
```

## 9.4 Common Uses

### 9.4.1 Where-Object Filtering

```
Get-Process | Where-Object { $_.CPU -gt 100 }
```

### 9.4.2 ForEach-Object Processing

```
1..5 | ForEach-Object { $_ * 2 }
```

### 9.4.3 Scheduled Jobs

```
$job = Start-Job -ScriptBlock { Get-EventLog -LogName System -Newest 100 }
```

### 9.4.4 Parameter Arguments

```
Start-ThreadJob -ScriptBlock { Get-Process }
```

## 9.5 Advanced Techniques

### 9.5.1 Parameterized Script Blocks

```
$multiplier = {
    param($x, $y)
    $x * $y
}

& $multiplier -x 5 -y 6  # Returns 30
```

### 9.5.2 Variable Capture (Closures)

```
$prefix = "Result: "
$block = { "$prefix$(2 + 2)" }
& $block  # Returns "Result: 4"
```

### 9.5.3 Delayed Execution with Arguments

```
$action = {
    param($name)
    "Hello, $name!"
}

1..3 | ForEach-Object {
    & $action -name "User$_"
}
```

## 9.6 Script Block Properties

You can examine script blocks with these properties:

```
$block = { Get-Process }
$block.Ast        # Abstract Syntax Tree representation
$block.ToString() # Gets the code as a string
```

## 9.7 Best Practices

1. Use for reusable logic that doesn't need a full function
2. Keep them focused — single responsibility principle
3. Consider readability with proper formatting
4. Document complex blocks with comments
5. Be mindful of scope when capturing variables

Script blocks are particularly powerful when combined with PowerShell's other features like the pipeline, providing a flexible way to create dynamic, adaptable code structures.

# 10 Modules in PowerShell

Modules are the fundamental building blocks for organizing, packaging, and distributing PowerShell code. They enable code reuse, simplify sharing, and help manage complexity in PowerShell solutions.

## 10.1 Module Basics

### 10.1.1 What is a Module?

A module is a package containing:

- PowerShell functions
- Cmdlets
- Variables
- Aliases
- Providers
- Other resources

### 10.1.2 Module Types

1. **Script Modules** (`.psm1` files)
2. **Binary Modules** (compiled `.dll` files)
3. **Manifest Modules** (with `.psd1` manifest)
4. **Dynamic Modules** (in-memory modules)

## 10.2 Creating Modules

### 10.2.1 Script Module Example

```
# MyTools.psm1
function Get-SystemInfo {
    [CmdletBinding()]
    param([string]$ComputerName = $env:COMPUTERNAME)

    Get-CimInstance -ClassName Win32_ComputerSystem -ComputerName $ComputerName |
        Select-Object Name, Manufacturer, Model
}

function Get-DiskSpace {
    Get-CimInstance -ClassName Win32_LogicalDisk |
        Where-Object { $_.DriveType -eq 3 } |
        Select-Object DeviceID, @{Name="SizeGB";Expression={[math]::Round($_.Size/1GB,2)}},
                      @{Name="FreeGB";Expression={[math]::Round($_.FreeSpace/1GB,2)}}
}

Export-ModuleMember -Function Get-SystemInfo, Get-DiskSpace
```

### 10.2.2 Module Manifest

```
# MyTools.psd1
@{
    ModuleVersion = '1.0'
    Author = 'Your Name'
    Description = 'Collection of system information tools'
    RootModule = 'MyTools.psm1'
    FunctionsToExport = @('Get-SystemInfo','Get-DiskSpace')
    CompatiblePSEditions = @('Desktop','Core')
    PowerShellVersion = '5.1'
}
```

## 10.3 Module Management

### 10.3.1 Finding Modules

```
Get-Module -ListAvailable          # Lists all available modules
Find-Module -Name *Azure*          # Searches PSGallery
```

### 10.3.2 Importing Modules

```
Import-Module -Name MyTools        # Import specific module
Import-Module .\MyTools.psm1       # Import from file path
Get-Module                         # Lists loaded modules
```

### 10.3.3 Removing Modules

```
Remove-Module -Name MyTools
```

## 10.4 Module Paths

PowerShell looks for modules in these locations (in order):

```
$env:PSModulePath -split ';'  # View module paths

# Common locations:
# - £HOME\Documents\PowerShell\Modules
# - Program Files\PowerShell\Modules
# - Windows\System32\WindowsPowerShell\v1.0\Modules
```

## 10.5 Advanced Module Features

### 10.5.1 Nested Modules

```
# In manifest file:
NestedModules = @('SubModule1.psm1', 'SubModule2.psm1')
```

### 10.5.2 Module Dependencies

```
# In manifest file:
RequiredModules = @('Pester', @{ModuleName='Az';ModuleVersion='5.0'})
```

### 10.5.3 Class Modules

```
# MyClasses.psm1
class Device {
    [string]$Name
    [string]$Type

    [string]GetInfo() {
        return "$($this.Type): $($this.Name)"
    }
}
```

## 10.6 Best Practices

1. Use Verb-Noun naming for functions
2. Include help documentation in functions
3. Keep modules focused on specific tasks
4. Version your modules properly

5. Test modules thoroughly before distribution
6. Use module manifests for production modules
7. Consider compatibility with PowerShell editions
8. Document dependencies clearly

## 10.7 Publishing Modules

### 10.7.1 To PowerShell Gallery

```
Publish-Module -Name MyModule -NuGetApiKey YOUR-API-KEY
```

### 10.7.2 Private Repositories

```
Register-PSRepository -Name LocalRepo -SourceLocation \\server\modules
Publish-Module -Name MyModule -Repository LocalRepo
```

Modules are essential for creating maintainable, shareable PowerShell code that can be easily distributed through galleries, private repositories, or simple file sharing.

# 11 Error Handling in PowerShell

PowerShell provides robust error handling mechanisms to help you write resilient scripts that can anticipate, catch, and manage errors effectively.

## 11.1 Basic Error Handling

### 11.1.1 Terminating vs. Non-Terminating Errors

- **Terminating errors**: Stop execution completely
- **Non-terminating errors**: Report error but continue execution

### 11.1.2 ErrorAction Parameter

Control how commands handle errors:

```
Get-Content "nonexistent.txt" -ErrorAction SilentlyContinue
Get-Content "nonexistent.txt" -ErrorAction Stop  # Converts to terminating error
Get-Content "nonexistent.txt" -ErrorAction Inquire
Get-Content "nonexistent.txt" -ErrorAction Ignore
```

### 11.1.3 Preference Variables

Set default error behavior:

```
$ErrorActionPreference = "Stop"  # Options: Stop, Continue, SilentlyContinue, Ignore
$ErrorView = "NormalView"        # Or "CategoryView"
```

## 11.2 Try/Catch/Finally Blocks

### 11.2.1 Basic Structure

```
try {
    # Code that might cause errors
    Get-Content "missing.txt" -ErrorAction Stop
}
catch {
    # Handle the error
    Write-Warning "Error occurred: $_"
}
finally {
    # Cleanup code that always runs
    Write-Output "Operation attempted"
}
```

### 11.2.2 Catching Specific Exceptions

```
try {
    Get-Content "missing.txt" -ErrorAction Stop
}
catch [System.IO.FileNotFoundException] {
    Write-Warning "File not found: $($_.Exception.Message)"
}
catch [System.UnauthorizedAccessException] {
    Write-Warning "Access denied: $($_.Exception.Message)"
}
catch {
    Write-Warning "Unexpected error: $_"
}
```

## 11.3 Working with Error Records

### 11.3.1 Error Object Properties

```
catch {
    $_.Exception.Message      # Error message
    $_.Exception.StackTrace   # Call stack
    $_.InvocationInfo         # Script line info
    $_.CategoryInfo           # Error category
    $_.FullyQualifiedErrorId  # Error ID
}
```

### 11.3.2 Creating Custom Errors

```
throw "Simple error message"

throw [System.IO.FileNotFoundException] "File not found"

$errorRecord = [System.Management.Automation.ErrorRecord]::new(
    [Exception]::new("Custom error"),
    "ErrorID",
    [System.Management.Automation.ErrorCategory]::NotSpecified,
    $targetObject
)
throw $errorRecord
```

## 11.4 Error Logging and Reporting

### 11.4.1 $Error Automatic Variable

Contains recent errors:

```
$Error[0]  # Most recent error
$Error.Clear()  # Clear error history
```

### 11.4.2 ErrorVariable Parameter

Capture errors without affecting normal flow:

```
Get-Content "missing.txt" -ErrorVariable err -ErrorAction SilentlyContinue
if ($err) { Write-Warning "Errors occurred: $($err.Count)" }
```

### 11.4.3 Transcript Logging

```
Start-Transcript -Path "C:\logs\script_log.txt"
# Script commands
Stop-Transcript
```

## 11.5 Advanced Techniques

### 11.5.1 Retry Logic

```
$retryCount = 3
$retryDelay = 5

for ($i = 1; $i -le $retryCount; $i++) {
    try {
        # Operation that might fail
        Invoke-RestMethod "https://example.com/api"
        break
    }
    catch {
        if ($i -eq $retryCount) {
            throw "Operation failed after $retryCount attempts"
```

```
        }
        Start-Sleep -Seconds $retryDelay
    }
}
```

### 11.5.2 Error Handling in Pipelines

```
Get-ChildItem *.txt | ForEach-Object {
    try {
        Get-Content $_ -ErrorAction Stop
    }
    catch {
        Write-Warning "Failed to read $_: $($_.Exception.Message)"
    }
}
```

## 11.6 Best Practices

1. Use specific exception types in catch blocks when possible
2. Make errors actionable with clear messages
3. Implement logging for troubleshooting
4. Clean up resources in finally blocks
5. Consider error recovery strategies
6. Test error conditions during development
7. Document expected errors in function help
8. Use `-ErrorAction Stop` for critical operations

PowerShell's comprehensive error handling capabilities allow you to create scripts that can gracefully handle unexpected situations while providing meaningful feedback to users.

# 12 Error Handling in PowerShell

PowerShell provides robust error handling mechanisms to help you write resilient scripts that can anticipate, catch, and manage errors effectively.

## 12.1 Basic Error Handling

### 12.1.1 Terminating vs. Non-Terminating Errors

- **Terminating errors**: Stop execution completely
- **Non-terminating errors**: Report error but continue execution

### 12.1.2 ErrorAction Parameter

Control how commands handle errors:

```
Get-Content "nonexistent.txt" -ErrorAction SilentlyContinue
Get-Content "nonexistent.txt" -ErrorAction Stop  # Converts to terminating error
Get-Content "nonexistent.txt" -ErrorAction Inquire
Get-Content "nonexistent.txt" -ErrorAction Ignore
```

### 12.1.3 Preference Variables

Set default error behavior:

```
$ErrorActionPreference = "Stop"  # Options: Stop, Continue, SilentlyContinue, Ignore
$ErrorView = "NormalView"        # Or "CategoryView"
```

## 12.2 Try/Catch/Finally Blocks

### 12.2.1 Basic Structure

```
try {
    # Code that might cause errors
    Get-Content "missing.txt" -ErrorAction Stop
}
catch {
    # Handle the error
    Write-Warning "Error occurred: $_"
}
finally {
    # Cleanup code that always runs
    Write-Output "Operation attempted"
}
```

### 12.2.2 Catching Specific Exceptions

```
try {
    Get-Content "missing.txt" -ErrorAction Stop
}
catch [System.IO.FileNotFoundException] {
    Write-Warning "File not found: $($_.Exception.Message)"
}
catch [System.UnauthorizedAccessException] {
    Write-Warning "Access denied: $($_.Exception.Message)"
}
catch {
    Write-Warning "Unexpected error: $_"
}
```

## 12.3 Working with Error Records

### 12.3.1 Error Object Properties

```
catch {
    $_.Exception.Message      # Error message
    $_.Exception.StackTrace   # Call stack
    $_.InvocationInfo         # Script line info
    $_.CategoryInfo           # Error category
    $_.FullyQualifiedErrorId  # Error ID
}
```

### 12.3.2 Creating Custom Errors

```
throw "Simple error message"

throw [System.IO.FileNotFoundException] "File not found"

$errorRecord = [System.Management.Automation.ErrorRecord]::new(
    [Exception]::new("Custom error"),
    "ErrorID",
    [System.Management.Automation.ErrorCategory]::NotSpecified,
    $targetObject
)
throw $errorRecord
```

## 12.4 Error Logging and Reporting

### 12.4.1 $Error Automatic Variable

Contains recent errors:

```
$Error[0]  # Most recent error
$Error.Clear()  # Clear error history
```

### 12.4.2 ErrorVariable Parameter

Capture errors without affecting normal flow:

```
Get-Content "missing.txt" -ErrorVariable err -ErrorAction SilentlyContinue
if ($err) { Write-Warning "Errors occurred: $($err.Count)" }
```

### 12.4.3 Transcript Logging

```
Start-Transcript -Path "C:\logs\script_log.txt"
# Script commands
Stop-Transcript
```

## 12.5 Advanced Techniques

### 12.5.1 Retry Logic

```
$retryCount = 3
$retryDelay = 5

for ($i = 1; $i -le $retryCount; $i++) {
    try {
        # Operation that might fail
        Invoke-RestMethod "https://example.com/api"
        break
    }
    catch {
        if ($i -eq $retryCount) {
            throw "Operation failed after $retryCount attempts"
```

```
        }
        Start-Sleep -Seconds $retryDelay
    }
}
```

### 12.5.2 Error Handling in Pipelines

```
Get-ChildItem *.txt | ForEach-Object {
    try {
        Get-Content $_ -ErrorAction Stop
    }
    catch {
        Write-Warning "Failed to read $_: $($_.Exception.Message)"
    }
}
```

## 12.6 Best Practices

1. Use specific exception types in catch blocks when possible
2. Make errors actionable with clear messages
3. Implement logging for troubleshooting
4. Clean up resources in finally blocks
5. Consider error recovery strategies
6. Test error conditions during development
7. Document expected errors in function help
8. Use `-ErrorAction Stop` for critical operations

PowerShell's comprehensive error handling capabilities allow you to create scripts that can gracefully handle unexpected situations while providing meaningful feedback to users.

# 13 PowerShell Remoting

PowerShell Remoting is a powerful feature that enables you to run commands on remote computers using Windows Remote Management (WinRM). It's the recommended way to manage multiple machines in an enterprise environment.

## 13.1 Key Concepts

### 13.1.1 PSRemoting Architecture

- Uses WS-Management protocol (WinRM)
- Encrypted communication (HTTPS or HTTP with encryption)
- Works across domains with proper authentication
- Supports fan-out (1-to-many) and fan-in (many-to-1) scenarios

## 13.2 Setup and Configuration

### 13.2.1 Enabling PSRemoting

```
# On each target machine (run as Administrator):
Enable-PSRemoting -Force

# Verify WinRM service is running
Get-Service WinRM

# Configure trusted hosts (for workgroup environments)
Set-Item WSMan:\localhost\Client\TrustedHosts -Value "server1,server2" -Force
```

### 13.2.2 Basic Authentication Requirements

```
# For domain environments:
# - Computers must be domain-joined
# - User must have admin rights on remote machines

# For workgroup environments:
# - Configure SSL certificates or
# - Use CredSSP (with caution)
```

## 13.3 Core Remoting Commands

### 13.3.1 Interactive Session (Enter-PSSession)

```
Enter-PSSession -ComputerName Server01 -Credential Domain\Admin
# You'll get an interactive prompt on the remote machine
Exit-PSSession  # To disconnect
```

### 13.3.2 Run Commands Remotely (Invoke-Command)

```
# Single command
Invoke-Command -ComputerName Server01,Server02 -ScriptBlock { Get-Service }

# With parameters
Invoke-Command -ComputerName Server01 -ScriptBlock {
    param($serviceName)
    Get-Service -Name $serviceName
} -ArgumentList "WinRM"

# Run script file remotely
Invoke-Command -ComputerName Server01 -FilePath C:\scripts\check-disk.ps1
```

### 13.3.3 Persistent Sessions (New-PSSession)

```
# Create persistent session
$session = New-PSSession -ComputerName Server01 -Credential Domain\Admin

# Use the session
Invoke-Command -Session $session -ScriptBlock { Get-Process }

# Close when done
Remove-PSSession -Session $session
```

## 13.4 Advanced Remoting Techniques

### 13.4.1 Fan-Out (Multiple Computers)

```
$servers = "Server01","Server02","Server03"
Invoke-Command -ComputerName $servers -ScriptBlock { Get-CimInstance Win32_OperatingSystem } |
    Select-Object PSComputerName, Caption, LastBootUpTime
```

### 13.4.2 Implicit Remoting

```
$session = New-PSSession -ComputerName ExchangeServer
Import-PSSession -Session $session -Module Exchange -CommandName Get-Mailbox
# Now you can run Exchange cmdlets locally that execute remotely
```

### 13.4.3 Remote File Operations

```
# Copy files to remote session
Copy-Item -Path C:\scripts\deploy.ps1 -ToSession $session -Destination C:\temp

# Get files from remote session
Copy-Item -Path "C:\logs\app.log" -FromSession $session -Destination C:\local\logs
```

## 13.5 Security Considerations

### 13.5.1 Authentication Methods

```
# Basic (default)
Invoke-Command -ComputerName Server01 -Credential Domain\Admin -ScriptBlock { ... }

# SSL Certificate-based
$sessionOption = New-PSSessionOption -SkipCACheck -SkipCNCheck -SkipRevocationCheck
New-PSSession -ComputerName Server01 -UseSSL -SessionOption $sessionOption

# CredSSP (for multi-hop authentication - use with caution)
Enable-WSManCredSSP -Role Client -DelegateComputer *
Invoke-Command -ComputerName Server01 -Authentication CredSSP -Credential Domain\Admin -ScriptBlock { ... }
```

## 13.6 Troubleshooting

### 13.6.1 Common Commands

```
# Test connection
Test-WSMan -ComputerName Server01

# View WinRM configuration
Get-WSManInstance -ResourceURI winrm/config/listener

# Reset WinRM
winrm quickconfig
```

### 13.6.2 Logging and Diagnostics

```
# Enable logging
wevtutil.exe set-log Microsoft-Windows-WinRM/Operational /e:true

# View events
Get-WinEvent -LogName "Microsoft-Windows-WinRM/Operational" -MaxEvents 50
```

## 13.7 Best Practices

1. Use domain authentication when possible
2. Prefer SSL for encryption
3. Limit CredSSP usage due to security risks
4. Use constrained endpoints for least privilege
5. Implement session timeouts for security
6. Consider JEA (Just Enough Administration) for granular control
7. Batch remote operations to reduce overhead
8. Handle network interruptions gracefully

PowerShell Remoting provides enterprise-grade capabilities for managing systems at scale while maintaining security and efficiency.

# 14 PowerShell Providers

PowerShell Providers are components that expose specialized data stores as hierarchical namespaces (similar to a file system) that you can navigate and manage using standard PowerShell commands. They create a unified interface for working with diverse data sources.

## 14.1 Core Concepts

### 14.1.1 What Providers Do

- Present non-file system data in a file system-like structure
- Enable consistent navigation and manipulation
- Support core cmdlets like `Get-ChildItem`, `Set-Item`, `Remove-Item`

### 14.1.2 Built-in Providers

| Provider | Drive Prefix | Description |
|---|---|---|
| FileSystem | `C:`, `D:` | Physical disks and network shares |
| Registry | `HKLM:`, `HKCU:` | Windows Registry |
| Certificate | `Cert:` | Digital certificates store |
| Environment | `Env:` | System environment variables |
| Variable | `Variable:` | PowerShell variables |
| Alias | `Alias:` | Command aliases |
| Function | `Function:` | PowerShell functions |

## 14.2 Working with Providers

### 14.2.1 Discovering Available Providers

```
# List all available providers
Get-PSProvider

# List provider capabilities
Get-PSProvider | Select-Name, Capabilities
```

### 14.2.2 Navigating Provider Drives

```
# View available drives
Get-PSDrive

# Change to registry location
Set-Location HKLM:\Software

# List child items (same as dir/ls)
Get-ChildItem

# Create new registry key
New-Item -Path HKLM:\Software\MyApp -ItemType Directory
```

### 14.2.3 Provider-Specific Cmdlets

```
# Certificate provider
Get-ChildItem Cert:\CurrentUser\My
Get-PfxCertificate -FilePath C:\cert.pfx

# Environment provider
Get-ChildItem Env:
$env:PATH = "C:\Tools;" + $env:PATH
```

## 14.3 Common Provider Operations

### 14.3.1 Working with the Registry

```
# Navigate registry
Set-Location HKCU:\Software
Get-ChildItem

# Create registry key
New-Item -Path HKCU:\Software\MyApp

# Set registry value
Set-ItemProperty -Path HKCU:\Software\MyApp -Name "Setting1" -Value "123"

# Get registry value
Get-ItemProperty -Path HKCU:\Software\MyApp
```

### 14.3.2 Managing Certificates

```
# View certificates
Get-ChildItem Cert:\LocalMachine\My

# Import certificate
Import-PfxCertificate -FilePath C:\cert.pfx -CertStoreLocation Cert:\LocalMachine\My
```

### 14.3.3 Working with Variables

```
# View all variables
Get-ChildItem Variable:

# Create new variable via provider
New-Item -Path Variable:\NewVar -Value "TestValue"

# Remove variable
Remove-Item Variable:\NewVar
```

## 14.4 Creating Custom Providers

You can create your own providers by deriving from these base classes:

1. **CmdletProvider**: Basic provider
2. **ItemCmdletProvider**: Supports item operations
3. **ContainerCmdletProvider**: Supports containers
4. **NavigationCmdletProvider**: Supports navigation

### 14.4.1 Simple Provider Example

```
[CmdletProvider("MyProvider", ProviderCapabilities.None)]
public class MyProvider : CmdletProvider
{
    // Implementation would go here
}
```

## 14.5 Provider Capabilities

| Capability | Description |
|---|---|
| None | Basic provider |
| Include | Supports Include parameter |
| Exclude | Supports Exclude parameter |
| Filter | Supports Filter parameter |
| ShouldProcess | Supports -WhatIf and -Confirm |
| Credentials | Supports -Credential parameter |
| Transactions | Supports transactions |

## 14.6 Best Practices

1. Use standard cmdlets when possible (`Get-ChildItem`, `Set-Item`, etc.)
2. Be cautious with registry operations — always back up first
3. Understand provider limitations — not all support all operations
4. Check capabilities before attempting advanced operations
5. Consider security implications when working with sensitive stores
6. Use transactions where supported for atomic operations

PowerShell Providers create a powerful abstraction layer that allows you to manage diverse systems using familiar file system metaphors, significantly simplifying administrative tasks across different technologies.

# 15 PowerShell Workflows

PowerShell Workflows provide a way to create long-running, robust, and recoverable automation sequences that can survive reboots and network interruptions. Built on Windows Workflow Foundation (WF), workflows are particularly useful for complex, multi-machine orchestration tasks.

## 15.1 Key Features of Workflows

1. **Persistence**: Automatically saves state and can resume after interruptions
2. **Parallel Execution**: Run activities concurrently with minimal syntax
3. **Checkpointing**: Save progress at specific points for recovery
4. **Connection Resilience**: Handles temporary network outages
5. **Activity-Based**: Composed of discrete units of work

## 15.2 Basic Workflow Structure

```
workflow Verb-Noun {
    param([parameter(Mandatory=$true)][string]$ComputerName)

    # Workflow activities
    Sequence {
        # Runs commands in order
        Get-Process -PSComputerName $ComputerName
        Restart-Computer -ComputerName $ComputerName -Wait -For PowerShell
    }

    Parallel {
        # Runs commands concurrently
        Get-Service -PSComputerName $ComputerName
        Get-EventLog -LogName System -PSComputerName $ComputerName
    }
}
```

## 15.3 Workflow-Specific Constructs

### 15.3.1 Sequence Block

```
workflow ExampleWorkflow {
    sequence {
        "First activity"
        "Second activity"
    }
}
```

### 15.3.2 Parallel Block

```
workflow ExampleWorkflow {
    parallel {
        "Activity 1"
        "Activity 2"  # Runs concurrently with Activity 1
    }
}
```

### 15.3.3 ForEach -Parallel

```
workflow ExampleWorkflow {
    $computers = "Server01","Server02","Server03"

    foreach -parallel ($computer in $computers) {
        Get-Process -PSComputerName $computer
```

```
    }
}
```

### 15.3.4 Checkpoints

```
workflow ExampleWorkflow {
    "First activity"
    Checkpoint-Workflow  # Saves state here
    "Second activity"    # If interrupted, resumes here
}
```

## 15.4 Workflow Activities

Workflows use special "activities" rather than regular cmdlets:

| Regular Cmdlet | Workflow Activity |
|---|---|
| `Get-Process` | `Get-Process` (as activity) |
| `Restart-Computer` | `Restart-Computer` |
| `InlineScript` | Runs regular PowerShell |

### 15.4.1 InlineScript Block

```
workflow ExampleWorkflow {
    InlineScript {
        # Runs as traditional PowerShell
        Get-CimInstance Win32_OperatingSystem
    }
}
```

## 15.5 Workflow Parameters

Workflows support parameters with additional attributes:

```
workflow ExampleWorkflow {
    param(
        [parameter(Mandatory=$true)]
        [string[]]$ComputerNames,

        [ValidateSet("Start","Stop")]
        [string]$Action = "Start"
    )

    # Workflow body
}
```

## 15.6 Running and Managing Workflows

### 15.6.1 Starting a Workflow

```
ExampleWorkflow -ComputerName "Server01" -AsJob
```

### 15.6.2 Monitoring Workflows

```
Get-Job -State Running  # View running workflows
Receive-Job -Id 1       # Get output from workflow
```

### 15.6.3 Suspending and Resuming

```
Suspend-Job -Id 1       # Pause workflow
Resume-Job -Id 1        # Continue workflow
```

## 15.7 Best Practices

1. Use workflows for appropriate scenarios:
   - Long-running processes
   - Multi-machine orchestration
   - Operations requiring resilience
2. Minimize InlineScript blocks as they break workflow benefits
3. Use checkpoints strategically:
   - After critical operations
   - Not too frequently (performance impact)
4. Design for idempotency: workflows may restart from checkpoints
5. Consider performance overhead: workflows have more overhead than regular scripts
6. Handle credentials properly:

```
workflow SecureWorkflow {
    param([PSCredential]$Credential)
    # Use £Credential in activities
}
```

## 15.8 Limitations

- Not all PowerShell features are available
- More verbose than regular scripts
- Requires PowerShell 3.0 or later
- Some cmdlets aren't available as activities
- Debugging can be more challenging

PowerShell Workflows are particularly valuable in scenarios like:

- Data center automation
- Multi-machine configuration
- Deployment orchestration
- Long-running maintenance tasks

While less commonly used than regular PowerShell scripts today (with the rise of alternatives like PowerShell Jobs and Azure Automation), workflows remain a powerful tool for specific enterprise automation scenarios.