Model Context Protocol

MCP Concepts and tutorials

Protocol Revision: 2025-06-18
from https://modelcontextprotocol.io

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Connect your AI applications to the world

AI-enabled tools are powerful, but they’re often limited to the information you manually provide or require bespoke integrations.

Whether it’s reading files from your computer, searching through an internal or external knowledge base, or updating tasks in an project management tool, MCP provides a secure, standardized, *simple* way to give AI systems the context they need.

How it works

1. Choose MCP servers

Pick from pre-built servers for popular tools like GitHub, Google Drive, Slack and hundreds of others. Combine multiple servers for complete workflows, or easily build your own for custom integrations.

2. Connect your AI application

Configure your AI application (like Claude, VS Code, or ChatGPT) to connect to your MCP servers. The application can now see available tools, resources and prompts from all connected servers.

3. Work with context

Your AI-powered application can now access real data, execute actions, and provide more helpful responses based on your actual context.

Introduction

> Get started with the Model Context Protocol (MCP)

MCP is an open protocol that standardizes how applications provide context to large language models (LLMs). Think of MCP like a USB-C port for AI applications. Just as USB-C provides a standardized way to connect your devices to various peripherals and accessories, MCP provides a standardized way to connect AI models to different data sources and tools. MCP enables you to build agents and complex workflows on top of LLMs and connects your models with the world.

MCP provides:

- **A growing list of pre-built integrations** that your LLM can directly plug into
- **A standardized way** to build custom integrations for AI applications
- **An open protocol** that everyone is free to implement and use
- **The flexibility to change** between different apps and take your context with you

Choose Your Path

Learn the core concepts and architecture of MCP

{" "}

Connect to existing MCP servers and start using them

{" "}

Create MCP servers to expose your data and tools

Develop applications that connect to MCP servers

Ready to Build?

MCP provides official **SDKs** in multiple languages, see the [SDK documentation] to find the right SDK for your project. The SDKs handle the protocol details so you can focus on building your features.

SDKs

> Official SDKs for building with the Model Context Protocol

Build MCP servers and clients using our official SDKs. Choose the SDK that matches your technology stack - all SDKs provide the same core functionality and full protocol support.

Available SDKs

Getting Started

Each SDK provides the same functionality but follows the idioms and best practices of its language. All SDKs support:

- Creating MCP servers that expose tools, resources, and prompts
- Building MCP clients that can connect to any MCP server
- Local and Remote transport protocols
- Protocol compliance with type safety

Visit the SDK page for your chosen language to find installation instructions, documentation, and examples.

Next Steps

Ready to start building with MCP? Choose your path:

Learn how to create your first MCP server

Create applications that connect to MCP servers

Browse pre-built servers for inspiration

Dive deeper into how MCP works

Concepts

Architecture Overview

This overview of the Model Context Protocol (MCP) discusses its scope and core concepts, and provides an example demonstrating each core concept.

Because MCP SDKs abstract away many concerns, most developers will likely find the data layer protocol section to be the most useful. It discusses how MCP servers can provide context to an AI application.

For specific implementation details, please refer to the documentation for your language-specific SDK.

Scope

The Model Context Protocol includes the following projects:

- MCP Specification: A specification of MCP that outlines the implementation requirements for clients and servers.
- MCP SDKs: SDKs for different programming languages that implement MCP.
- **MCP Development Tools**: Tools for developing MCP servers and clients, including the MCP Inspector
- MCP Reference Server Implementations: Reference implementations of MCP servers.

MCP focuses solely on the protocol for context exchange—it does not dictate how AI applications use LLMs or manage the provided context.

Concepts of MCP

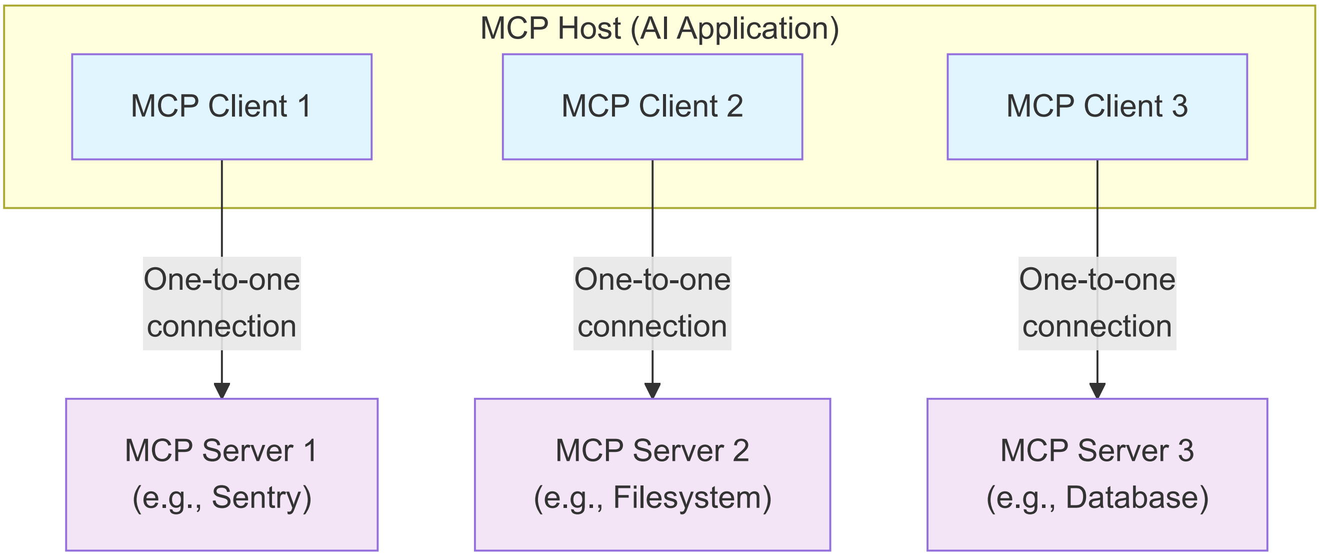
Participants

MCP follows a client-server architecture where an MCP host — an AI application like Claude Code or Claude Desktop — establishes connections to one or more MCP servers. The MCP host accomplishes this by creating one MCP client for each MCP server. Each MCP client maintains a dedicated one-to-one connection with its corresponding MCP server.

The key participants in the MCP architecture are:

- **MCP Host**: The AI application that coordinates and manages one or multiple MCP clients
- **MCP Client**: A component that maintains a connection to an MCP server and obtains context from an MCP server for the MCP host to use
- **MCP Server**: A program that provides context to MCP clients

For example: Visual Studio Code acts as an MCP host. When Visual Studio Code establishes a connection to an MCP server, such as the Sentry MCP server, the Visual Studio Code runtime instantiates an MCP client object that maintains the connection to the Sentry MCP server.
When Visual Studio Code subsequently connects to another MCP server, such as the local filesystem server, the Visual Studio Code runtime instantiates an additional MCP client object to maintain this connection, hence maintaining a one-to-one
relationship of MCP clients to MCP servers.



Note that **MCP server** refers to the program that serves context data, regardless of where it runs. MCP servers can execute locally or remotely. For example, when Claude Desktop launches the filesystem server, the server runs locally on the same machine because it uses the STDIO transport. This is commonly referred to as a "local" MCP server. The official Sentry MCP server runs on the Sentry platform, and uses the Streamable HTTP transport. This is commonly referred to as a "remote" MCP server.

Layers

MCP consists of two layers:

- **Data layer**: Defines the JSON-RPC based protocol for client-server communication, including lifecycle management, and core primitives, such as tools, resources, prompts and notifications.
- **Transport layer**: Defines the communication mechanisms and channels that enable data exchange between clients and servers, including transport-specific connection establishment, message framing, and authorization.

Conceptually the data layer is the inner layer, while the transport layer is the outer layer.

Data layer

The data layer implements a JSON-RPC 2.0 based exchange protocol that defines the message structure and semantics.
This layer includes:

- **Lifecycle management**: Handles connection initialization, capability negotiation, and connection termination between clients and servers
- **Server features**: Enables servers to provide core functionality including tools for AI actions, resources for context data, and prompts for interaction templates from and to the client
- **Client features**: Enables servers to ask the client to sample from the host LLM, elicit input from the user, and log messages to the client

- **Utility features**: Supports additional capabilities like notifications for real-time updates and progress tracking for long-running operations

Transport layer

The transport layer manages communication channels and authentication between clients and servers. It handles connection establishment, message framing, and secure communication between MCP participants.

MCP supports two transport mechanisms:

- **Stdio transport**: Uses standard input/output streams for direct process communication between local processes on the same machine, providing optimal performance with no network overhead.
- **Streamable HTTP transport**: Uses HTTP POST for client-to-server messages with optional Server-Sent Events for streaming capabilities. This transport enables remote server communication and supports standard HTTP authentication methods including bearer tokens, API keys, and custom headers. MCP recommends using OAuth to obtain authentication tokens.

The transport layer abstracts communication details from the protocol layer, enabling the same JSON-RPC 2.0 message format across all transport mechanisms.

Data Layer Protocol

A core part of MCP is defining the schema and semantics between MCP clients and MCP servers. Developers will likely find the data layer — in particular, the set of primitives — to be the most interesting part of MCP. It is the part of MCP that defines the ways developers can share context from MCP servers to MCP clients.

MCP uses JSON-RPC 2.0 as its underlying RPC protocol. Client and servers send requests to each other and respond accordingly. Notifications can be used when no response is required.

Lifecycle management

MCP is a stateful protocol that requires lifecycle management. The purpose of lifecycle management is to negotiate the capabilities that both client and server support. Detailed information can be found in the specification, and the example showcases the initialization sequence.

Primitives

MCP primitives are the most important concept within MCP. They define what clients and servers can offer each other. These primitives specify the types of contextual information that can be shared with AI applications and the range of actions that can be performed.

MCP defines three core primitives that *servers* can expose:

- **Tools**: Executable functions that AI applications can invoke to perform actions (e.g., file operations, API calls, database queries)
- **Resources**: Data sources that provide contextual information to AI applications (e.g., file contents, database records, API responses)
- **Prompts**: Reusable templates that help structure interactions with language models (e.g., system prompts, few-shot examples)

Each primitive type has associated methods for discovery (`*/list`), retrieval (`*/get`), and in some cases, execution (`tools/call`).
MCP clients will use the `*/list` methods to discover available primitives. For example, a client can first list all available tools (`tools/list`) and then execute them. This design allows listings to be dynamic.

As a concrete example, consider an MCP server that provides context about a database. It can expose tools for querying the database, a resource that contains the schema of the database, and a prompt that includes few-shot examples for interacting with the tools.

For more details about server primitives see [server concepts].

MCP also defines primitives that *clients* can expose. These primitives allow MCP server authors to build richer interactions.

- **Sampling**: Allows servers to request language model completions from the client's AI application. This is useful when servers' authors want access to a language model, but want to stay model independent and not include a language model SDK in their MCP server. They can use the `sampling/complete` method to request a language model completion from the client's AI application.
- **Elicitation**: Allows servers to request additional information from users. This is useful when servers' authors want to get more information from the user, or ask for confirmation of an action. They can use the `elicitation/request` method to request additional information from the user.
- **Logging**: Enables servers to send log messages to clients for debugging and monitoring purposes.

For more details about client primitives see [client concepts].

Notifications

The protocol supports real-time notifications to enable dynamic updates between servers and clients. For example, when a server's available tools change—such as when new functionality becomes available or existing tools are modified—the server can send tool update notifications to inform connected clients about these changes. Notifications are sent as JSON-RPC 2.0 notification messages (without expecting a response) and enable MCP servers to provide real-time updates to connected clients.

Example

Data Layer

This section provides a step-by-step walkthrough of an MCP client-server interaction, focusing on the data layer protocol. We'll demonstrate the lifecycle sequence, tool operations, and notifications using JSON-RPC 2.0 messages.

MCP begins with lifecycle management through a capability negotiation handshake. As described in the [lifecycle management] section, the client sends an `initialize` request to establish the connection and negotiate supported features.

````
<CodeGroup>
  ```json Request
  {
    "jsonrpc": "2.0",
    "id": 1,
````
````

````markdown
    "method": "initialize",
    "params": {
      "protocolVersion": "2025-06-18",
      "capabilities": {
        "elicitation": {}
      },
      "clientInfo": {
        "name": "example-client",
        "version": "1.0.0"
      }
    }
  }
  ```

  ```json Response
  {
    "jsonrpc": "2.0",
    "id": 1,
    "result": {
      "protocolVersion": "2025-06-18",
      "capabilities": {
        "tools": {
          "listChanged": true
        },
        "resources": {}
      },
      "serverInfo": {
        "name": "example-server",
        "version": "1.0.0"
      }
    }
  }
  ```
</CodeGroup>

##### Understanding the Initialization Exchange

The initialization process is a key part of MCP's lifecycle management and serves several
critical purposes:

1. **Protocol Version Negotiation**: The `protocolVersion` field (e.g., "2025-06-18")
ensures both client and server are using compatible protocol versions. This prevents
communication errors that could occur when different versions attempt to interact. If a
mutually compatible version is not negotiated, the connection should be terminated.

2. **Capability Discovery**: The `capabilities` object allows each party to declare what
features they support, including which [primitives](#primitives) they can handle (tools,
resources, prompts) and whether they support features like [notifications](#notifications).
This enables efficient communication by avoiding unsupported operations.

3. **Identity Exchange**: The `clientInfo` and `serverInfo` objects provide identification
and versioning information for debugging and compatibility purposes.
````
````

````
In this example, the capability negotiation demonstrates how MCP primitives are declared:

**Client Capabilities**:

* `"elicitation": {}` - The client declares it can work with user interaction requests (can
receive `elicitation/create` method calls)

**Server Capabilities**:

* `"tools": {"listChanged": true}` - The server supports the tools primitive AND can send
`tools/list_changed` notifications when its tool list changes
* `"resources": {}` - The server also supports the resources primitive (can handle
`resources/list` and `resources/read` methods)

After successful initialization, the client sends a notification to indicate it's ready:

```json Notification
{
  "jsonrpc": "2.0",
  "method": "notifications/initialized"
}
```

##### How This Works in AI Applications

During initialization, the AI application's MCP client manager establishes connections to
configured servers and stores their capabilities for later use. The application uses this
information to determine which servers can provide specific types of functionality (tools,
resources, prompts) and whether they support real-time updates.

```python Pseudo-code for AI application initialization
# Pseudo Code
async with stdio_client(server_config) as (read, write):
    async with ClientSession(read, write) as session:
        init_response = await session.initialize()
        if init_response.capabilities.tools:
            app.register_mcp_server(session, supports_tools=True)
        app.set_server_ready(session)
```
````

Now that the connection is established, the client can discover available tools by sending a `tools/list` request. This request is fundamental to MCP's tool discovery mechanism — it allows clients to understand what tools are available on the server before attempting to use them.

````
<CodeGroup>
  ```json Request
  {
    "jsonrpc": "2.0",
    "id": 2,
    "method": "tools/list"
````
````

````
  }
  ```

  ```json Response
  {
    "jsonrpc": "2.0",
    "id": 2,
    "result": {
      "tools": [
        {
          "name": "calculator_arithmetic",
          "title": "Calculator",
          "description": "Perform mathematical calculations including basic arithmetic, trigonometric functions, and algebraic operations",
          "inputSchema": {
            "type": "object",
            "properties": {
              "expression": {
                "type": "string",
                "description": "Mathematical expression to evaluate (e.g., '2 + 3 * 4', 'sin(30)', 'sqrt(16)')"
              }
            },
            "required": ["expression"]
          }
        },
        {
          "name": "weather_current",
          "title": "Weather Information",
          "description": "Get current weather information for any location worldwide",
          "inputSchema": {
            "type": "object",
            "properties": {
              "location": {
                "type": "string",
                "description": "City name, address, or coordinates (latitude,longitude)"
              },
              "units": {
                "type": "string",
                "enum": ["metric", "imperial", "kelvin"],
                "description": "Temperature units to use in response",
                "default": "metric"
              }
            },
            "required": ["location"]
          }
        }
      ]
    }
  }
  ```
</CodeGroup>
````
````

````
##### Understanding the Tool Discovery Request

The `tools/list` request is simple, containing no parameters.

##### Understanding the Tool Discovery Response

The response contains a `tools` array that provides comprehensive metadata about each
available tool. This array-based structure allows servers to expose multiple tools
simultaneously while maintaining clear boundaries between different functionalities.

Each tool object in the response includes several key fields:

* **`name`**: A unique identifier for the tool within the server's namespace. This serves as
the primary key for tool execution and should follow a clear naming pattern (e.g.,
`calculator_arithmetic` rather than just `calculate`)
* **`title`**: A human-readable display name for the tool that clients can show to users
* **`description`**: Detailed explanation of what the tool does and when to use it
* **`inputSchema`**: A JSON Schema that defines the expected input parameters, enabling type
validation and providing clear documentation about required and optional parameters

##### How This Works in AI Applications

The AI application fetches available tools from all connected MCP servers and combines them
into a unified tool registry that the language model can access. This allows the LLM to
understand what actions it can perform and automatically generates the appropriate tool
calls during conversations.

```python Pseudo-code for AI application tool discovery
# Pseudo-code using MCP Python SDK patterns
available_tools = []
for session in app.mcp_server_sessions():
    tools_response = await session.list_tools()
    available_tools.extend(tools_response.tools)
conversation.register_available_tools(available_tools)
```
````

The client can now execute a tool using the `tools/call` method. This demonstrates how MCP primitives are used in practice: after discovering available tools, the client can invoke them with appropriate arguments.

````
##### Understanding the Tool Execution Request

The `tools/call` request follows a structured format that ensures type safety and clear
communication between client and server. Note that we're using the proper tool name from the
discovery response (`weather_current`) rather than a simplified name:

<CodeGroup>
  ```json Request
  {
    "jsonrpc": "2.0",
    "id": 3,
````
````

````
    "method": "tools/call",
    "params": {
      "name": "weather_current",
      "arguments": {
        "location": "San Francisco",
        "units": "imperial"
      }
    }
  }
  ```

  ```json Response
  {
    "jsonrpc": "2.0",
    "id": 3,
    "result": {
      "content": [
        {
          "type": "text",
          "text": "Current weather in San Francisco: 68°F, partly cloudy with light winds
from the west at 8 mph. Humidity: 65%"
        }
      ]
    }
  }
  ```
</CodeGroup>

##### Key Elements of Tool Execution

The request structure includes several important components:

1. **`name`**: Must match exactly the tool name from the discovery response
(`weather_current`). This ensures the server can correctly identify which tool to execute.

2. **`arguments`**: Contains the input parameters as defined by the tool's `inputSchema`. In
this example:

   * `location`: "San Francisco" (required parameter)
   * `units`: "imperial" (optional parameter, defaults to "metric" if not specified)

3. **JSON-RPC Structure**: Uses standard JSON-RPC 2.0 format with unique `id` for request-
response correlation.

##### Understanding the Tool Execution Response

The response demonstrates MCP's flexible content system:

1. **`content` Array**: Tool responses return an array of content objects, allowing for
rich, multi-format responses (text, images, resources, etc.)
````
````

````
2. **Content Types**: Each content object has a `type` field. In this example, `"type":
"text"` indicates plain text content, but MCP supports various content types for different
use cases.

3. **Structured Output**: The response provides actionable information that the AI
application can use as context for language model interactions.

This execution pattern allows AI applications to dynamically invoke server functionality and
receive structured responses that can be integrated into conversations with language models.

##### How This Works in AI Applications

When the language model decides to use a tool during a conversation, the AI application
intercepts the tool call, routes it to the appropriate MCP server, executes it, and returns
the results back to the LLM as part of the conversation flow. This enables the LLM to access
real-time data and perform actions in the external world.

```python
# Pseudo-code for AI application tool execution
async def handle_tool_call(conversation, tool_name, arguments):
    session = app.find_mcp_session_for_tool(tool_name)
    result = await session.call_tool(tool_name, arguments)
    conversation.add_tool_result(result.content)
```
````

MCP supports real-time notifications that enable servers to inform clients about changes without being explicitly requested. This demonstrates the notification system, a key feature that keeps MCP connections synchronized and responsive.

````
##### Understanding Tool List Change Notifications

When the server's available tools change—such as when new functionality becomes available,
existing tools are modified, or tools become temporarily unavailable—the server can
proactively notify connected clients:

```json Request
{
  "jsonrpc": "2.0",
  "method": "notifications/tools/list_changed"
}
```

##### Key Features of MCP Notifications

1. **No Response Required**: Notice there's no `id` field in the notification. This follows
JSON-RPC 2.0 notification semantics where no response is expected or sent.

2. **Capability-Based**: This notification is only sent by servers that declared
`"listChanged": true` in their tools capability during initialization (as shown in Step 1).
````

3. **Event-Driven**: The server decides when to send notifications based on internal state changes, making MCP connections dynamic and responsive.

Client Response to Notifications

Upon receiving this notification, the client typically reacts by requesting the updated tool list. This creates a refresh cycle that keeps the client's understanding of available tools current:

```json Request
{
  "jsonrpc": "2.0",
  "id": 4,
  "method": "tools/list"
}
```

Why Notifications Matter

This notification system is crucial for several reasons:

1. **Dynamic Environments**: Tools may come and go based on server state, external dependencies, or user permissions
2. **Efficiency**: Clients don't need to poll for changes; they're notified when updates occur
3. **Consistency**: Ensures clients always have accurate information about available server capabilities
4. **Real-time Collaboration**: Enables responsive AI applications that can adapt to changing contexts

This notification pattern extends beyond tools to other MCP primitives, enabling comprehensive real-time synchronization between clients and servers.

How This Works in AI Applications

When the AI application receives a notification about changed tools, it immediately refreshes its tool registry and updates the LLM's available capabilities. This ensures that ongoing conversations always have access to the most current set of tools, and the LLM can dynamically adapt to new functionality as it becomes available.

```python
# Pseudo-code for AI application notification handling
async def handle_tools_changed_notification(session):
    tools_response = await session.list_tools()
    app.update_available_tools(session, tools_response.tools)
    if app.conversation.is_active():
        app.conversation.notify_llm_of_new_capabilities()
```

Server Concepts

> Understanding MCP server concepts

MCP servers are programs that expose specific capabilities to AI applications through standardized protocol interfaces. Each server provides focused functionality for a particular domain.

Common examples include file system servers for document management, email servers for message handling, travel servers for trip planning, and database servers for data queries. Each server brings domain-specific capabilities to the AI application.

Core Building Blocks

Servers provide functionality through three building blocks:

Building Block	Purpose	Who Controls It	Real-World Example
Tools	For AI actions	Model-controlled	Search flights, send messages, create calendar events
Resources	For context data	Application-controlled	Documents, calendars, emails, weather data
Prompts	For interaction templates	User-controlled	"Plan a vacation", "Summarize my meetings", "Draft an email"

Tools - AI Actions

Tools enable AI models to perform actions through server-implemented functions. Each tool defines a specific operation with typed inputs and outputs. The model requests tool execution based on context.

Overview

Tools are schema-defined interfaces that LLMs can invoke. MCP uses JSON Schema for validation. Each tool performs a single operation with clearly defined inputs and outputs. Most importantly, tool execution requires explicit user approval, ensuring users maintain control over actions taken by a model.

Protocol operations:

Method	Purpose	Returns
`tools/list`	Discover available tools	Array of tool definitions with schemas
`tools/call`	Execute a specific tool	Tool execution result

Example tool definition:

```
{
  name: "searchFlights",
  description: "Search for available flights",
  inputSchema: {
    type: "object",
    properties: {
      origin: { type: "string", description: "Departure city" },
      destination: { type: "string", description: "Arrival city" },
      date: { type: "string", format: "date", description: "Travel date" }
    },
    required: ["origin", "destination", "date"]
  }
}
```

Example: Taking Action

Tools enable AI applications to perform actions on behalf of users. In a travel planning scenario, the AI application might use several tools to help book a vacation.

First, it searches for flights using

```
searchFlights(origin: "NYC", destination: "Barcelona", date: "2024-06-15")
```

`searchFlights` queries multiple airlines and returns structured flight options. Once flights are selected, it creates a calendar event with

```
createCalendarEvent(title: "Barcelona Trip", startDate: "2024-06-15", endDate: "2024-06-22")
```

to mark the travel dates. Finally, it sends an out-of-office notification using

```
sendEmail(to: "team@work.com", subject: "Out of Office", body: "...")
```

to inform colleagues about the absence.

Each tool execution requires explicit user approval, ensuring full control over actions taken.

User Interaction Model

Tools are model-controlled, meaning AI models can discover and invoke them automatically. However, MCP emphasizes human oversight through several mechanisms. Applications should clearly display available tools in the UI and provide visual indicators when tools are being considered or used. Before any tool execution, users must be presented with clear approval dialogs that explain exactly what the tool will do.

For trust and safety, applications often enforce manual approval to give humans the ability to deny tool invocations. Applications typically implement this through approval dialogs, permission settings for pre-approving certain safe operations, and activity logs that show all tool executions with their results.

Resources - Context Data

Resources provide structured access to information that the host application can retrieve and provide to AI models as context.

Overview

Resources expose data from files, APIs, databases, or any other source that an AI needs to understand context. Applications can access this information directly and decide how to use it - whether that's selecting relevant portions, searching with embeddings, or passing it all to the model.

Resources use URI-based identification, with each resource having a unique URI such as `file:///path/to/document.md`. They declare MIME types for appropriate content handling and support two discovery patterns: **direct resources** with fixed URIs, and **resource templates** with parameterized URIs.

Resource Templates enable dynamic resource access through URI templates. A template like `travel://activities/{city}/{category}` would access filtered activity data by substituting both `{city}` and `{category}` parameters. For example, `travel://activities/barcelona/museums` would return all museums in Barcelona. Resource Templates include metadata such as title, description, and expected MIME type, making them discoverable and self-documenting.

Protocol operations:

Method	Purpose	Returns
`resources/list`	List available direct resources	Array of resource descriptors
`resources/templates/list`	Discover resource templates	Array of resource template definitions
`resources/read`	Retrieve resource contents	Resource data with metadata
`resources/subscribe`	Monitor resource changes	Subscription confirmation

Example: Accessing Context Data

Continuing with the travel planning example, resources provide the AI application with access to relevant information:

- **Calendar data** (`calendar://events/2024`) - To check availability
- **Travel documents** (`file:///Documents/Travel/passport.pdf`) - For important information
- **Previous itineraries** (`trips://history/barcelona-2023`) - User selects which past trip style to follow

Instead of manually copying this information, resources provide raw information to AI applications. The application can choose how to best handle the data. Applications might choose to select a subset of data, using embeddings or keyword search, or pass the raw data from a resource directly to a model. In our example, during the planning phase, the AI application can pass the calendar data, weather data and travel preferences, so that the model can check availability, look up weather patterns, and reference travel preferences.

Resource Template Examples:

```
{
  "uriTemplate": "weather://forecast/{city}/{date}",
```

```
  "name": "weather-forecast",
  "title": "Weather Forecast",
  "description": "Get weather forecast for any city and date",
  "mimeType": "application/json"
}

{
  "uriTemplate": "travel://flights/{origin}/{destination}",
  "name": "flight-search",
  "title": "Flight Search",
  "description": "Search available flights between cities",
  "mimeType": "application/json"
}
```

These templates enable flexible queries. For weather data, users can access forecasts for any city/date combination. For flights, they can search routes between any two airports. When a user has input "NYC" as the `origin` airport and begins to input "Bar" as the `destination` airport, the system can suggest "Barcelona (BCN)" or "Barbados (BGI)".

Parameter Completion

Dynamic resources support parameter completion. For example:

- Typing "Par" as input for `weather://forecast/{city}` might suggest "Paris" or "Park City"
- The system helps discover valid values without requiring exact format knowledge

User Interaction Model

Resources are application-driven, giving hosts flexibility in how they retrieve, process, and present available context. Common interaction patterns include tree or list views for browsing resources in familiar folder-like structures, search and filter interfaces for finding specific resources, automatic context inclusion based on heuristics or AI selection, and manual selection interfaces.

Applications are free to implement resource discovery through any interface pattern that suits their needs. The protocol doesn't mandate specific UI patterns, allowing for resource pickers with preview capabilities, smart suggestions based on current conversation context, bulk selection for including multiple resources, or integration with existing file browsers and data explorers.

Prompts - Interaction Templates

Prompts provide reusable templates. They allow MCP server authors to provide parameterized prompts for a domain, or showcase how to best use the MCP server.

Overview

Prompts are structured templates that define expected inputs and interaction patterns. They are user-controlled, requiring explicit invocation rather than automatic triggering. Prompts can be context-aware, referencing available resources and tools to create comprehensive workflows. Like resources, prompts support parameter completion to help users discover valid argument values.

Protocol operations:

Method	Purpose	Returns
`prompts/list`	Discover available prompts	Array of prompt descriptors
`prompts/get`	Retrieve prompt details	Full prompt definition with arguments

Example: Streamlined Workflows

Prompts provide structured templates for common tasks. In the travel planning context:

"Plan a vacation" prompt:

```
{
  "name": "plan-vacation",
  "title": "Plan a vacation",
  "description": "Guide through vacation planning process",
  "arguments": [
    { "name": "destination", "type": "string", "required": true },
    { "name": "duration", "type": "number", "description": "days" },
    { "name": "budget", "type": "number", "required": false },
    { "name": "interests", "type": "array", "items": { "type": "string" } }
  ]
}
```

Rather than unstructured natural language input, the prompt system enables:

1. Selection of the "Plan a vacation" template
2. Structured input: Barcelona, 7 days, $3000, ["beaches", "architecture", "food"]
3. Consistent workflow execution based on the template

User Interaction Model

Prompts are user-controlled, requiring explicit invocation. Applications typically expose prompts through various UI patterns such as slash commands (typing "/" to see available prompts like /plan-vacation), command palettes for searchable access, dedicated UI buttons for frequently used prompts, or context menus that suggest relevant prompts.

The protocol gives implementers freedom to design interfaces that feel natural within their application. Key principles include easy discovery of available prompts, clear descriptions of what each prompt does, natural argument input with validation, and transparent display of the prompt's underlying template.

How It All Works Together

The real power of MCP emerges when multiple servers work together, combining their specialized capabilities through a unified interface.

Example: Multi-Server Travel Planning

Consider an AI application with three connected servers:

1. **Travel Server** - Handles flights, hotels, and itineraries
2. **Weather Server** - Provides climate data and forecasts

3. **Calendar/Email Server** - Manages schedules and communications

The Complete Flow

1. **User invokes a prompt with parameters:**

```
{
  "prompt": "plan-vacation",
  "arguments": {
    "destination": "Barcelona",
    "departure_date": "2024-06-15",
    "return_date": "2024-06-22",
    "budget": 3000,
    "travelers": 2
  }
}
```

2. **User selects resources to include:**
   - `calendar://my-calendar/June-2024` (from Calendar Server)
   - `travel://preferences/europe` (from Travel Server)
   - `travel://past-trips/Spain-2023` (from Travel Server)
3. **AI processes the request:**

   The AI first reads all selected resources to gather context. From the calendar, it identifies available dates. From travel preferences, it learns preferred airlines and hotel types. From past trips, it discovers previously enjoyed locations. From weather data, it checks climate conditions for the travel period.

   Using this context, the AI then requests user approval to execute a series of coordinated actions: searching for flights from NYC to Barcelona, finding hotels within the specified budget, creating a calendar event for the trip duration, and sending confirmation emails with the trip details.

Client Concepts

> Understanding MCP client concepts

MCP clients are instantiated by host applications to communicate with particular MCP servers. The host application, like Claude.ai or an IDE, manages the overall user experience and coordinates multiple clients. Each client handles one direct communication with one server.

Understanding the distinction is important: the *host* is the application users interact with, while *clients* are the protocol-level components that enable server connections.

Core Client Features

In addition to making use of context provided by servers, clients may provide several features to servers. These client features allow server authors to build richer interactions. For example, clients can allow MCP servers to request additional information from the user via elicitations. Clients can offer the following capabilities:

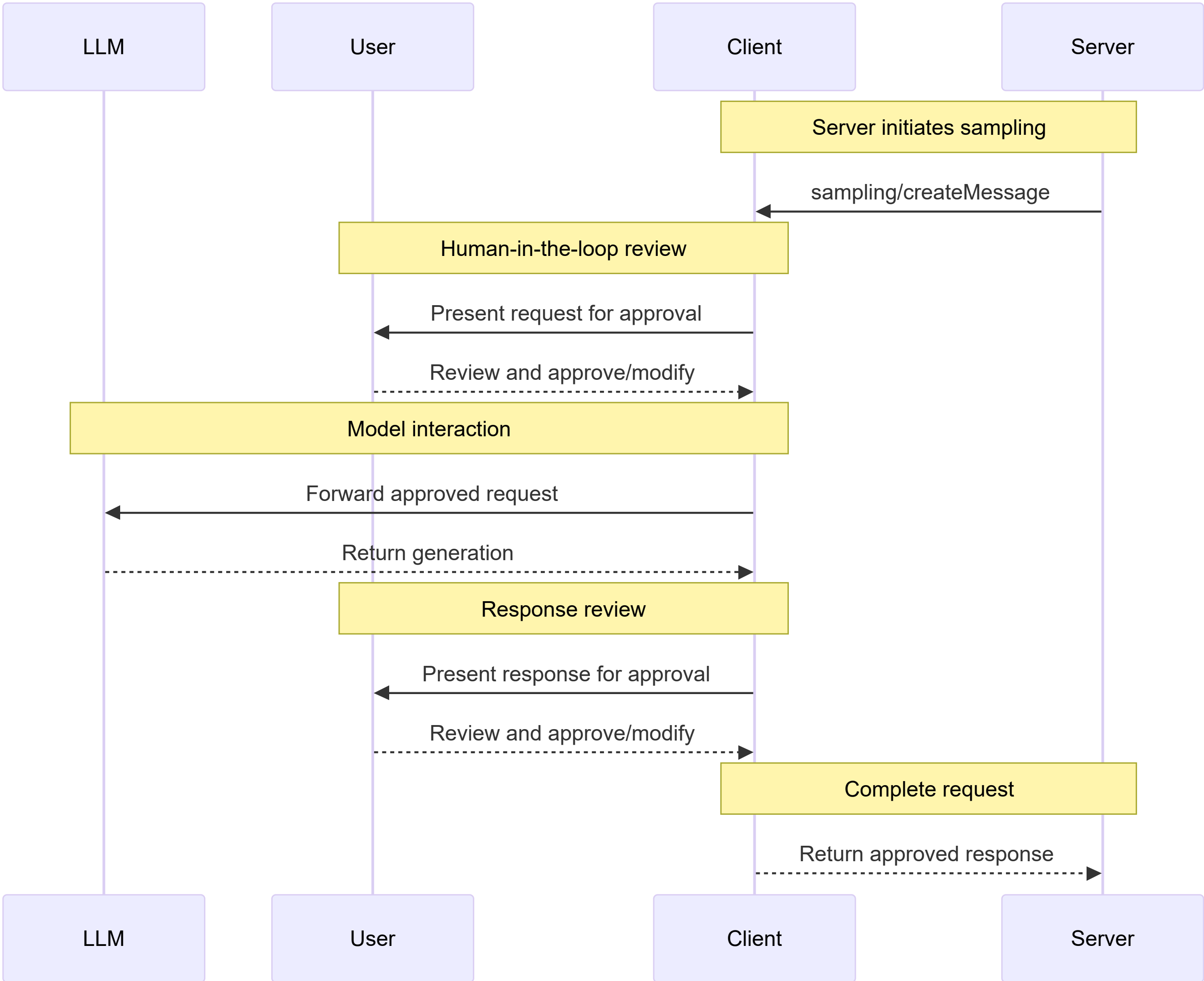
Sampling

Sampling allows servers to request language model completions through the client, enabling agentic behaviors while maintaining security and user control.

Overview

Sampling enables servers to perform AI-dependent tasks without directly integrating with or paying for AI models. Instead, servers can request that the client—which already has AI model access—handle these tasks on their behalf. This approach puts the client in complete control of user permissions and security measures. Because sampling requests occur within the context of other operations—like a tool analyzing data—and are processed as separate model calls, they maintain clear boundaries between different contexts, allowing for more efficient use of the context window.

Sampling flow:



The flow ensures security through multiple human-in-the-loop checkpoints. Users review and can modify both the initial request and the generated response before it returns to the server.

Request parameters example:

```
{
  messages: [
```

```
    {
      role: "user",
      content: "Analyze these flight options and recommend the best choice:\n" +
               "[47 flights with prices, times, airlines, and layovers]\n" +
               "User preferences: morning departure, max 1 layover"
    }
  ],
  modelPreferences: {
    hints: [{
      name: "claude-3-5-sonnet"  // Suggested model
    }],
    costPriority: 0.3,      // Less concerned about API cost
    speedPriority: 0.2,     // Can wait for thorough analysis
    intelligencePriority: 0.9  // Need complex trade-off evaluation
  },
  systemPrompt: "You are a travel expert helping users find the best flights based on their preferences",
  maxTokens: 1500
}
```

Example: Flight Analysis Tool

Consider a travel booking server with a tool called `findBestFlight` that uses sampling to analyze available flights and recommend the optimal choice. When a user asks "Book me the best flight to Barcelona next month," the tool needs AI assistance to evaluate complex trade-offs.

The tool queries airline APIs and gathers 47 flight options. It then requests AI assistance to analyze these options: "Analyze these flight options and recommend the best choice: [47 flights with prices, times, airlines, and layovers] User preferences: morning departure, max 1 layover."

The client asks the user: "Allow sampling request?" Upon approval, the AI evaluates trade-offs—like cheaper red-eye flights versus convenient morning departures. The tool uses this analysis to present the top three recommendations.

User Interaction Model

Sampling is designed with human-in-the-loop control as a fundamental principle. Users maintain oversight through several mechanisms:

Approval controls: Every sampling request needs explicit user consent. Clients show what the server wants to analyze and why. Users can approve, deny, or modify requests.

Transparency features: Clients display the exact prompt, model selection, and token limits. Users review AI responses before they return to the server.

Configuration options: Users can set model preferences, configure auto-approval for trusted operations, or require approval for everything. Clients may provide options to redact sensitive information. Users decide how much conversation context may be included in sampling requests through the `includeContext` parameter.

Isolation: Sampling requests are isolated from the main conversation context by default. Servers cannot access user conversations.

Security considerations: Both clients and servers must handle sensitive data appropriately during sampling. Clients should implement rate limiting and validate all message content. The human-in-the-loop design ensures that server-initiated AI interactions cannot compromise security or access sensitive data without explicit user consent.

Roots

Roots define filesystem boundaries for server operations, allowing clients to specify which directories servers should focus on.

Overview

Roots are a mechanism for clients to communicate filesystem access boundaries to servers. They consist of file URIs that indicate directories where servers can operate, helping servers understand the scope of available files and folders. Rather than giving servers unrestricted filesystem access, roots guide them to relevant working directories while maintaining security boundaries.

Root structure:

```
{
  "uri": "file:///Users/agent/travel-planning",
  "name": "Travel Planning Workspace"
}
```

Roots are exclusively filesystem paths and always use the `file://` URI scheme. They help servers understand project boundaries, workspace organization, and accessible directories. The roots list can be updated dynamically as users work with different projects or folders, with servers receiving notifications through `roots/list_changed` when boundaries change.

It's important to note that while roots provide guidance to servers about where to operate, the client is always in full control of file access. Roots simply communicate intended boundaries—actual file access is always mediated by the client's security policies.

Example: Travel Planning Workspace

A travel agent working with multiple client trips benefits from roots to organize filesystem access. Consider a workspace with different directories for various aspects of travel planning.

The client provides filesystem roots to the travel planning server:

- `file:///Users/agent/travel-planning` - Main workspace containing all travel files
- `file:///Users/agent/travel-templates` - Reusable itinerary templates and resources
- `file:///Users/agent/client-documents` - Client passports and travel documents

When the agent creates a Barcelona itinerary, the server works within these boundaries—accessing templates, saving the new itinerary, and referencing client documents. It cannot access files outside these roots. Servers typically access files within roots by using relative paths from the root directories or by utilizing file search tools that respect the root boundaries.

If the agent opens an archive folder like `file:///Users/agent/archive/2023-trips`, the client updates the roots list via `roots/list_changed`.

User Interaction Model

Roots are typically managed automatically by host applications based on user actions, though some applications may expose manual root management:

Automatic root detection: When users open folders, clients automatically expose them as roots. Opening a travel workspace gives servers access to itineraries and documents within that directory.

Manual root configuration: Advanced users can specify roots through configuration. For example, adding `/travel-templates` for reusable resources while excluding directories with financial records.

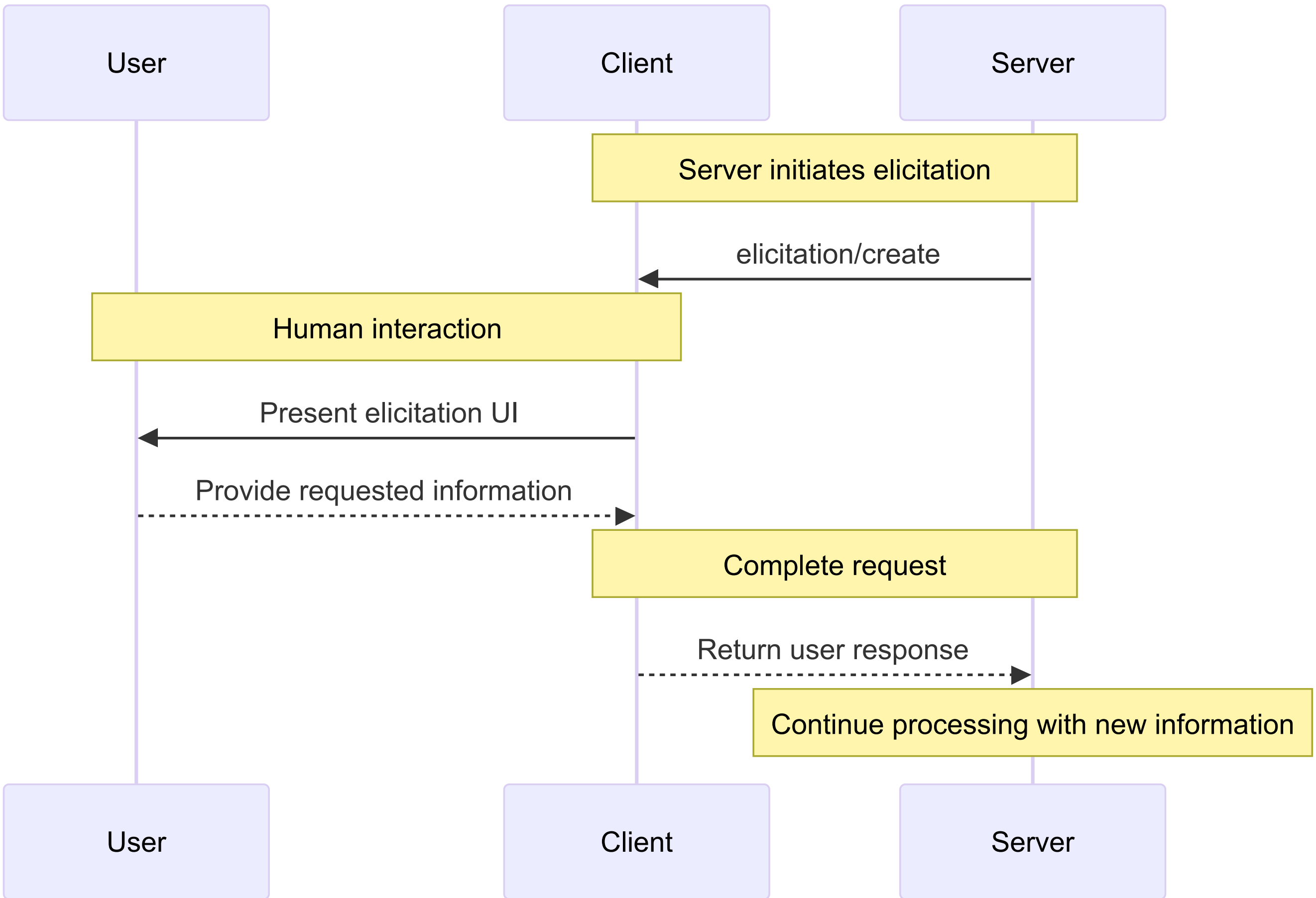
Elicitation

Elicitation enables servers to request specific information from users during interactions, creating more dynamic and responsive workflows.

Overview

Elicitation provides a structured way for servers to gather necessary information on demand. Instead of requiring all information up front or failing when data is missing, servers can pause their operations to request specific inputs from users. This creates more flexible interactions where servers adapt to user needs rather than following rigid patterns.

Elicitation flow:



The flow enables dynamic information gathering. Servers can request specific data when needed, users provide information through appropriate UI, and servers continue processing with the newly acquired context.

Elicitation components example:

```
{
  method: "elicitation/requestInput",
  params: {
    message: "Please confirm your Barcelona vacation booking details:",
    schema: {
      type: "object",
      properties: {
        confirmBooking: {
          type: "boolean",
          description: "Confirm the booking (Flights + Hotel = $3,000)"
        },
        seatPreference: {
          type: "string",
          enum: ["window", "aisle", "no preference"],
          description: "Preferred seat type for flights"
        },
        roomType: {
          type: "string",
          enum: ["sea view", "city view", "garden view"],
          description: "Preferred room type at hotel"
        },
        travelInsurance: {
          type: "boolean",
          default: false,
          description: "Add travel insurance ($150)"
        }
      },
      required: ["confirmBooking"]
    }
  }
}
```

Example: Holiday Booking Approval

A travel booking server demonstrates elicitation's power through the final booking confirmation process. When a user has selected their ideal vacation package to Barcelona, the server needs to gather final approval and any missing details before proceeding.

The server elicits booking confirmation with a structured request that includes the trip summary (Barcelona flights June 15-22, beachfront hotel, total $3,000) and fields for any additional preferences—such as seat selection, room type, or travel insurance options.

As the booking progresses, the server elicits contact information needed to complete the reservation. It might ask for traveler details for flight bookings, special requests for the hotel, or emergency contact information.

User Interaction Model

Elicitation interactions are designed to be clear, contextual, and respectful of user autonomy:

Request presentation: Clients display elicitation requests with clear context about which server is asking, why the information is needed, and how it will be used. The request message explains the purpose while the schema provides structure and validation.

Response options: Users can provide the requested information through appropriate UI controls (text fields, dropdowns, checkboxes), decline to provide information with optional explanation, or cancel the entire operation. Clients validate responses against the provided schema before returning them to servers.

Privacy considerations: Elicitation never requests passwords or API keys. Clients warn about suspicious requests and let users review data before sending.

Versioning

The Model Context Protocol uses string-based version identifiers following the format `YYYY-MM-DD`, to indicate the last date backwards incompatible changes were made.

> The protocol version will *not* be incremented when the protocol is updated, as long as the changes maintain backwards compatibility. This allows for incremental improvements while preserving interoperability.

Revisions

Revisions may be marked as:

- **Draft**: in-progress specifications, not yet ready for consumption.
- **Current**: the current protocol version, which is ready for use and may continue to receive backwards compatible changes.
- **Final**: past, complete specifications that will not be changed.

The **current** protocol version is [**2025-06-18**](2025-06-18).

Negotiation

Version negotiation happens during initialization. Clients and servers **MAY** support multiple protocol versions simultaneously, but they **MUST** agree on a single version to use for the session.

The protocol provides appropriate error handling if version negotiation fails, allowing clients to gracefully terminate connections when they cannot find a version compatible with the server.

Tutorials

Using MCP

Connect to Remote MCP Servers

> Learn how to connect Claude to remote MCP servers and extend its capabilities with internet-hosted tools and data sources

Remote MCP servers extend AI applications' capabilities beyond your local environment, providing access to internet-hosted tools, services, and data sources. By connecting to remote MCP servers, you transform AI assistants from helpful tools into informed teammates capable of handling complex, multi-step projects with real-time access to external resources.

Many clients now support remote MCP servers, enabling a wide range of integration possibilities. This guide demonstrates how to connect to remote MCP servers using Claude as an example, one of the many clients that support MCP. While we focus on Claude's implementation through Custom Connectors, the concepts apply broadly to other MCP-compatible clients.

Understanding Remote MCP Servers

Remote MCP servers function similarly to local MCP servers but are hosted on the internet rather than your local machine. They expose tools, prompts, and resources that Claude can use to perform tasks on your behalf. These servers can integrate with various services such as project management tools, documentation systems, code repositories, and any other API-enabled service.

The key advantage of remote MCP servers is their accessibility. Unlike local servers that require installation and configuration on each device, remote servers are available from any MCP client with an internet connection. This makes them ideal for web-based AI applications, integrations that emphasize ease-of-use and services that require server-side processing or authentication.

What are Custom Connectors?

Custom Connectors serve as the bridge between Claude and remote MCP servers. They allow you to connect Claude directly to the tools and data sources that matter most to your workflows, enabling Claude to operate within your favorite software and draw insights from the complete context of your external tools.

With Custom Connectors, you can:

- Connect Claude to existing remote MCP servers provided by third-party developers
- Build your own remote MCP servers to connect with any tool

Connecting to a Remote MCP Server

The process of connecting Claude to a remote MCP server involves adding a Custom Connector through the Claude interface. This establishes a secure connection between Claude and your chosen remote server.

Open Claude in your browser and navigate to the settings page. You can access this by clicking on your profile icon and selecting "Settings" from the dropdown menu. Once in settings, locate and click on the

"Connectors" section in the sidebar.

```
This will display your currently configured connectors and provide options to add new ones.
```

In the Connectors section, scroll to the bottom where you'll find the "Add custom connector" button. Click this button to begin the connection process.

```
<Frame>
  <img src="https://mintlify.s3.us-west-1.amazonaws.com/mcp/images/quickstart-remote/1-add-connector.png" alt="Add custom connector button in Claude settings" />
</Frame>

A dialog will appear prompting you to enter the remote MCP server URL. This URL should be provided by the server developer or administrator. Enter the complete URL, ensuring it includes the proper protocol (https\://) and any necessary path components.

<Frame>
  <img src="https://mintlify.s3.us-west-1.amazonaws.com/mcp/images/quickstart-remote/2-connect.png" alt="Dialog for entering remote MCP server URL" />
</Frame>

After entering the URL, click "Add" to proceed with the connection.
```

Most remote MCP servers require authentication to ensure secure access to their resources. The authentication process varies depending on the server implementation but commonly involves OAuth, API keys, or username/password combinations.

```
<Frame>
  <img src="https://mintlify.s3.us-west-1.amazonaws.com/mcp/images/quickstart-remote/3-auth.png" alt="Authentication screen for remote MCP server" />
</Frame>

Follow the authentication prompts provided by the server. This may redirect you to a third-party authentication provider or display a form within Claude. Once authentication is complete, Claude will establish a secure connection to the remote server.
```

After successful connection, the remote server's resources and prompts become available in your Claude conversations. You can access these by clicking the paperclip icon in the message input area, which opens the attachment menu.

```
<Frame>
  <img src="https://mintlify.s3.us-west-1.amazonaws.com/mcp/images/quickstart-remote/4-select-resources-menu.png" alt="Attachment menu showing available resources" />
</Frame>

The menu displays all available resources and prompts from your connected servers. Select the items you want to include in your conversation. These resources provide Claude with context and information from your external tools.

<Frame>
  <img src="https://mintlify.s3.us-west-1.amazonaws.com/mcp/images/quickstart-remote/5-select-prompts-resources.png" alt="Selecting specific resources and prompts from the menu" />
</Frame>
```

Remote MCP servers often expose multiple tools with varying capabilities. You can control which tools Claude is allowed to use by configuring permissions in the connector settings. This ensures Claude only performs actions you've explicitly authorized.

```
<Frame>
  <img src="https://mintlify.s3.us-west-1.amazonaws.com/mcp/images/quickstart-remote/6-configure-tools.png" alt="Tool permission configuration interface" />
</Frame>

Navigate back to the Connectors settings and click on your connected server. Here you can enable or disable specific tools, set usage limits, and configure other security parameters according to your needs.
```

Best Practices for Using Remote MCP Servers

When working with remote MCP servers, consider these recommendations to ensure a secure and efficient experience:

Security considerations: Always verify the authenticity of remote MCP servers before connecting. Only connect to servers from trusted sources, and review the permissions requested during authentication. Be cautious about granting access to sensitive data or systems.

Managing multiple connectors: You can connect to multiple remote MCP servers simultaneously. Organize your connectors by purpose or project to maintain clarity. Regularly review and remove connectors you no longer use to keep your workspace organized and secure.

Next Steps

Now that you've connected Claude to a remote MCP server, you can explore its capabilities in your conversations. Try using the connected tools to automate tasks, access external data, or integrate with your existing workflows.

Create custom remote MCP servers to integrate with proprietary tools and services

Browse our collection of official and community-created MCP servers

Learn how to connect Claude Desktop to local MCP servers for direct system access

Dive deeper into how MCP works and its architecture

Remote MCP servers unlock powerful possibilities for extending Claude's capabilities. As you become familiar with these integrations, you'll discover new ways to streamline your workflows and accomplish complex tasks more efficiently.

Connect to Local MCP Servers

> Learn how to extend Claude Desktop with local MCP servers to enable file system access and other powerful integrations

Model Context Protocol (MCP) servers extend AI applications' capabilities by providing secure, controlled access to local resources and tools. Many clients support MCP, enabling diverse integration possibilities across different platforms and applications.

This guide demonstrates how to connect to local MCP servers using Claude Desktop as an example, one of the many clients that support MCP. While we focus on Claude Desktop's implementation, the concepts apply broadly to other MCP-compatible clients. By the end of this tutorial, Claude will be able to interact with files on your computer, create new documents, organize folders, and search through your file system—all with your explicit permission for each action.

Prerequisites

Before starting this tutorial, ensure you have the following installed on your system:

Claude Desktop

Download and install Claude Desktop for your operating system. Claude Desktop is currently available for macOS and Windows. Linux support is coming soon.

If you already have Claude Desktop installed, verify you're running the latest version by clicking the Claude menu and selecting "Check for Updates..."

Node.js

The Filesystem Server and many other MCP servers require Node.js to run. Verify your Node.js installation by opening a terminal or command prompt and running:

```
node --version
```

If Node.js is not installed, download it from nodejs.org. We recommend the LTS (Long Term Support) version for stability.

Understanding MCP Servers

MCP servers are programs that run on your computer and provide specific capabilities to Claude Desktop through a standardized protocol. Each server exposes tools that Claude can use to perform actions, with your approval. The Filesystem Server we'll install provides tools for:

- Reading file contents and directory structures
- Creating new files and directories
- Moving and renaming files
- Searching for files by name or content

All actions require your explicit approval before execution, ensuring you maintain full control over what Claude can access and modify.

Installing the Filesystem Server

The process involves configuring Claude Desktop to automatically start the Filesystem Server whenever you launch the application. This configuration is done through a JSON file that tells Claude Desktop which servers to run and how to connect to them.

Start by accessing the Claude Desktop settings. Click on the Claude menu in your system's menu bar (not the settings within the Claude window itself) and select "Settings..."

```
On macOS, this appears in the top menu bar:

<Frame style={{ textAlign: "center" }}>
  <img src="https://mintlify.s3.us-west-1.amazonaws.com/mcp/images/quickstart-menu.png"
width="400" alt="Claude Desktop menu showing Settings option" />
</Frame>

This opens the Claude Desktop configuration window, which is separate from your Claude
account settings.
```

In the Settings window, navigate to the "Developer" tab in the left sidebar. This section contains options for configuring MCP servers and other developer features.

```
Click the "Edit Config" button to open the configuration file:

<Frame>
  <img src="https://mintlify.s3.us-west-1.amazonaws.com/mcp/images/quickstart-developer.png"
alt="Developer settings showing Edit Config button" />
</Frame>

This action creates a new configuration file if one doesn't exist, or opens your existing
configuration. The file is located at:

* **macOS**: `~/Library/Application Support/Claude/claude_desktop_config.json`
* **Windows**: `%APPDATA%\Claude\claude_desktop_config.json`
```

Replace the contents of the configuration file with the following JSON structure. This configuration tells Claude Desktop to start the Filesystem Server with access to specific directories:

````
<CodeGroup>
  ```json macOS
  {
    "mcpServers": {
      "filesystem": {
        "command": "npx",
        "args": [
          "-y",
          "@modelcontextprotocol/server-filesystem",
          "/Users/username/Desktop",
          "/Users/username/Downloads"
        ]
      }
    }
  }
  ```

  ```json Windows
  {
    "mcpServers": {
      "filesystem": {
        "command": "npx",
        "args": [
          "-y",
          "@modelcontextprotocol/server-filesystem",
          "C:\\Users\\username\\Desktop",
          "C:\\Users\\username\\Downloads"
````
````

````
        ]
      }
    }
  }
  ```
</CodeGroup>

Replace `username` with your actual computer username. The paths listed in the `args` array
specify which directories the Filesystem Server can access. You can modify these paths or
add additional directories as needed.

<Tip>
  **Understanding the Configuration**

  * `"filesystem"`: A friendly name for the server that appears in Claude Desktop
  * `"command": "npx"`: Uses Node.js's npx tool to run the server
  * `"-y"`: Automatically confirms the installation of the server package
  * `"@modelcontextprotocol/server-filesystem"`: The package name of the Filesystem Server
  * The remaining arguments: Directories the server is allowed to access
</Tip>

<Warning>
  **Security Consideration**

  Only grant access to directories you're comfortable with Claude reading and modifying. The
server runs with your user account permissions, so it can perform any file operations you
can perform manually.
</Warning>
````

After saving the configuration file, completely quit Claude Desktop and restart it. The application needs to restart to load the new configuration and start the MCP server.
````

```
Upon successful restart, you'll see an MCP server indicator <img
src="https://mintlify.s3.us-west-1.amazonaws.com/mcp/images/claude-desktop-mcp-slider.svg"
style={{display: 'inline', margin: 0, height: '1.3em'}} /> in the bottom-right corner of the
conversation input box:

<Frame>
  <img src="https://mintlify.s3.us-west-1.amazonaws.com/mcp/images/quickstart-slider.png"
alt="Claude Desktop interface showing MCP server indicator" />
</Frame>

Click on this indicator to view the available tools provided by the Filesystem Server:

<Frame style={{ textAlign: "center" }}>
  <img src="https://mintlify.s3.us-west-1.amazonaws.com/mcp/images/quickstart-tools.png"
width="400" alt="Available filesystem tools in Claude Desktop" />
</Frame>

If the server indicator doesn't appear, refer to the [Troubleshooting](#troubleshooting)
section for debugging steps.
```

Using the Filesystem Server

With the Filesystem Server connected, Claude can now interact with your file system. Try these example requests to explore the capabilities:

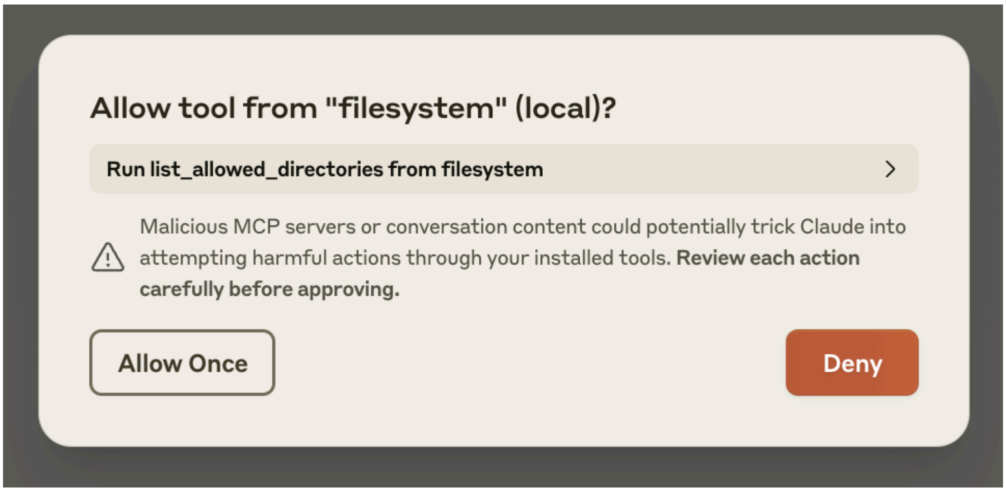
File Management Examples

- **"Can you write a poem and save it to my desktop?"** - Claude will compose a poem and create a new text file on your desktop
- **"What work-related files are in my downloads folder?"** - Claude will scan your downloads and identify work-related documents
- **"Please organize all images on my desktop into a new folder called 'Images'"** - Claude will create a folder and move image files into it

How Approval Works

Before executing any file system operation, Claude will request your approval. This ensures you maintain control over all actions:

<Frame style={{ textAlign: "center" }}>



Review each request carefully before approving. You can always deny a request if you're not comfortable with the proposed action.

Troubleshooting

If you encounter issues setting up or using the Filesystem Server, these solutions address common problems:

1. Restart Claude Desktop completely
2. Check your `claude_desktop_config.json` file syntax
3. Make sure the file paths included in `claude_desktop_config.json` are valid and that they are absolute and not relative
4. Look at logs to see why the server is not connecting
5. In your command line, try manually running the server (replacing `username` as you did in `claude_desktop_config.json`) to see if you get any errors:

````
<CodeGroup>
  ```bash macOS/Linux
  npx -y @modelcontextprotocol/server-filesystem /Users/username/Desktop
/Users/username/Downloads
  ```


  ```powershell Windows
  npx -y @modelcontextprotocol/server-filesystem C:\Users\username\Desktop
C:\Users\username\Downloads
  ```
</CodeGroup>
````

Claude.app logging related to MCP is written to log files in:

```
* macOS: `~/Library/Logs/Claude`

* Windows: `%APPDATA%\Claude\logs`
```

````
* `mcp.log` will contain general logging about MCP connections and connection failures.

* Files named `mcp-server-SERVERNAME.log` will contain error (stderr) logging from the named server.

You can run the following command to list recent logs and follow along with any new ones (on Windows, it will only show recent logs):

<CodeGroup>
  ```bash macOS/Linux
  tail -n 20 -f ~/Library/Logs/Claude/mcp*.log
  ```

  ```powershell Windows
  type "%APPDATA%\Claude\logs\mcp*.log"
  ```
</CodeGroup>
````

If Claude attempts to use the tools but they fail:

```
1. Check Claude's logs for errors
2. Verify your server builds and runs without errors
3. Try restarting Claude Desktop
```

Please refer to our debugging guide for better debugging tools and more detailed guidance.

If your configured server fails to load, and you see within its logs an error referring to `${APPDATA}` within a path, you may need to add the expanded value of `%APPDATA%` to your `env` key in `claude_desktop_config.json`:

````
```json
{
  "brave-search": {
    "command": "npx",
    "args": ["-y", "@modelcontextprotocol/server-brave-search"],
    "env": {
      "APPDATA": "C:\\Users\\user\\AppData\\Roaming\\",
      "BRAVE_API_KEY": "..."
    }
  }
}
```
````

````
With this change in place, launch Claude Desktop once again.

<Warning>
  **NPM should be installed globally**

  The `npx` command may continue to fail if you have not installed NPM globally. If NPM is already installed globally, you will find `%APPDATA%\npm` exists on your system. If not, you can install NPM globally by running the following command:

  ```bash
  npm install -g npm
  ```
</Warning>
````

Next Steps

Now that you've successfully connected Claude Desktop to a local MCP server, explore these options to expand your setup:

Browse our collection of official and community-created MCP servers for additional capabilities

Create custom MCP servers tailored to your specific workflows and integrations

Learn how to connect Claude to remote MCP servers for cloud-based tools and services

Dive deeper into how MCP works and its architecture

Server Development

Build an MCP Server

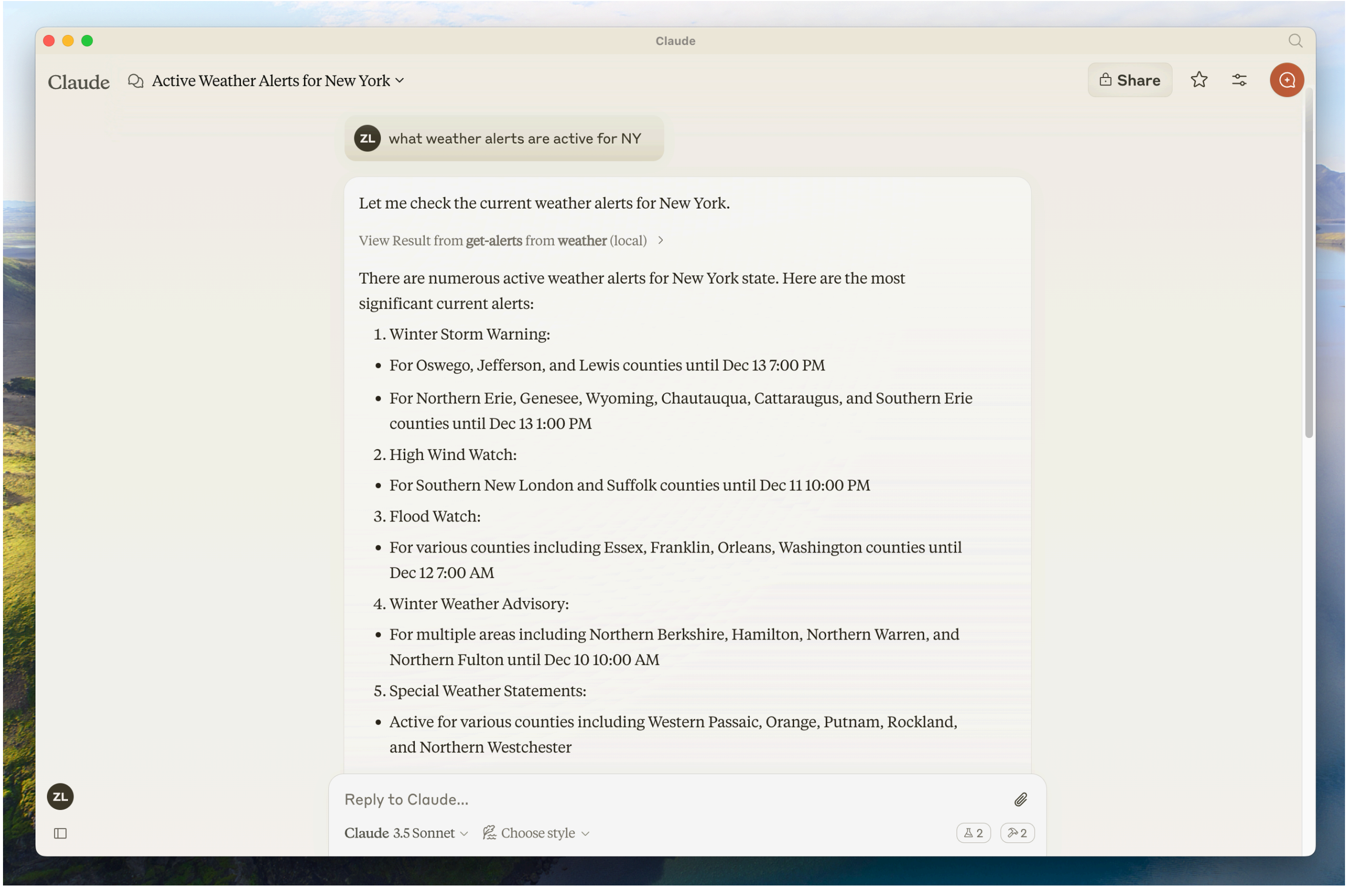
> Get started building your own server to use in Claude for Desktop and other clients.

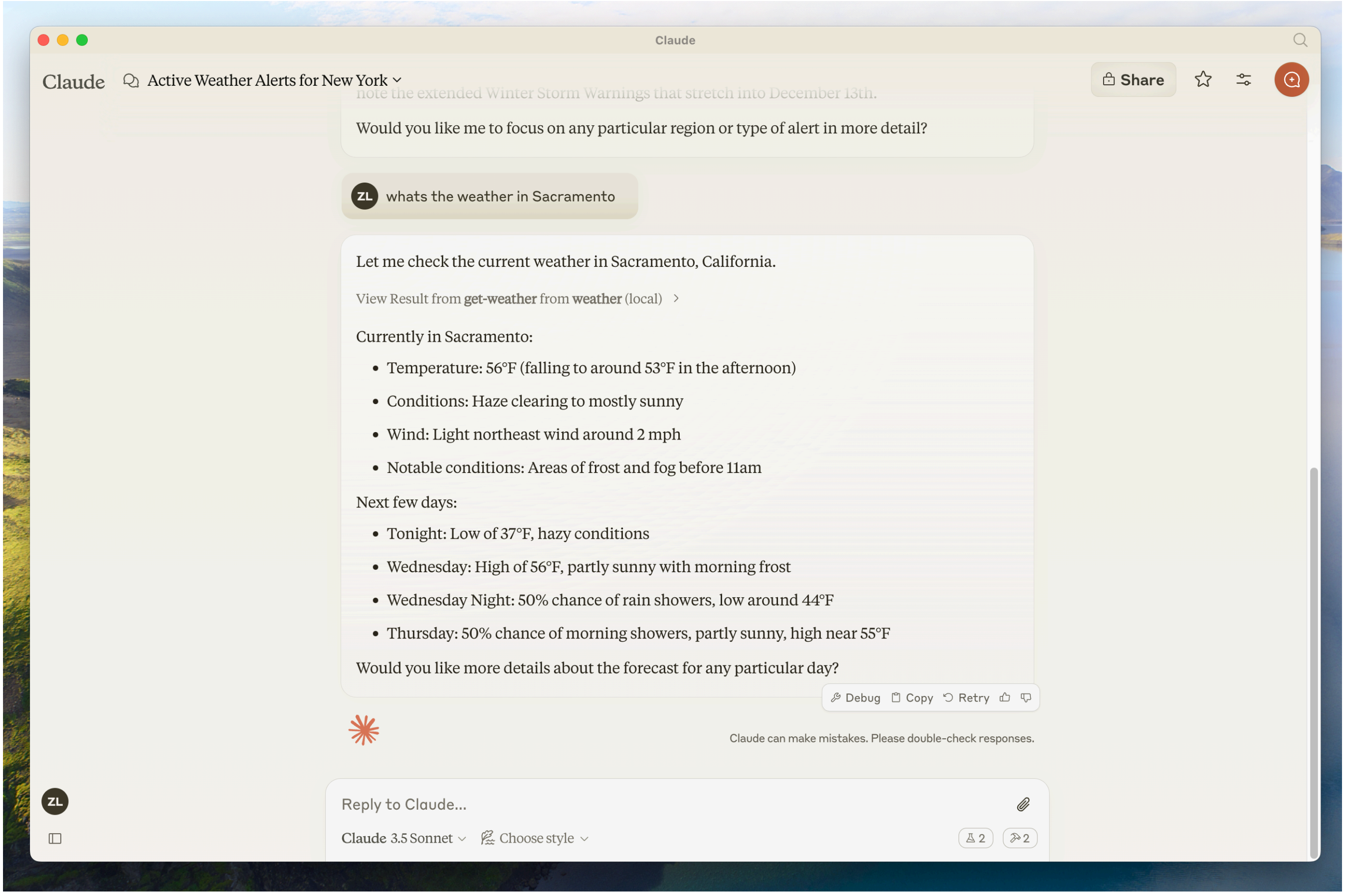
In this tutorial, we'll build a simple MCP weather server and connect it to a host, Claude for Desktop. We'll start with a basic setup, and then progress to more complex use cases.

What we'll be building

Many LLMs do not currently have the ability to fetch the forecast and severe weather alerts. Let's use MCP to solve that!

We'll build a server that exposes two tools: `get_alerts` and `get_forecast`. Then we'll connect the server to an MCP host (in this case, Claude for Desktop):





Servers can connect to any client. We've chosen Claude for Desktop here for simplicity, but we also have guides on building your own client as well as a list of other clients here.

Core MCP Concepts

MCP servers can provide three main types of capabilities:

1. **Resources**: File-like data that can be read by clients (like API responses or file contents)
2. **Tools**: Functions that can be called by the LLM (with user approval)
3. **Prompts**: Pre-written templates that help users accomplish specific tasks

This tutorial will primarily focus on tools.

Let's get started with building our weather server! You can find the complete code for what we'll be building here.

```
##### Prerequisite knowledge

This quickstart assumes you have familiarity with:

* Python
* LLMs like Claude
```

Logging in MCP Servers

When implementing MCP servers, be careful about how you handle logging:

For STDIO-based servers: Never write to standard output (stdout). This includes:

* `print()` statements in Python
* `console.log()` in JavaScript
* `fmt.Println()` in Go
* Similar stdout functions in other languages

Writing to stdout will corrupt the JSON-RPC messages and break your server.

For HTTP-based servers: Standard output logging is fine since it doesn't interfere with HTTP responses.

Best Practices

1. Use a logging library that writes to stderr or files.

Quick Examples

```python
# ❌ Bad (STDIO)
print("Processing request")

# ✅ Good (STDIO)
import logging
logging.info("Processing request")
```

System requirements

* Python 3.10 or higher installed.
* You must use the Python MCP SDK 1.2.0 or higher.

Set up your environment

First, let's install `uv` and set up our Python project and environment:

<CodeGroup>
  ```bash macOS/Linux
  curl -LsSf https://astral.sh/uv/install.sh | sh
  ```

  ```powershell Windows
  powershell -ExecutionPolicy ByPass -c "irm https://astral.sh/uv/install.ps1 | iex"
  ```
</CodeGroup>

Make sure to restart your terminal afterwards to ensure that the `uv` command gets picked up.

````
Now, let's create and set up our project:

<CodeGroup>
  ```bash macOS/Linux
  # Create a new directory for our project
  uv init weather
  cd weather

  # Create virtual environment and activate it
  uv venv
  source .venv/bin/activate

  # Install dependencies
  uv add "mcp[cli]" httpx

  # Create our server file
  touch weather.py
  ```

  ```powershell Windows
  # Create a new directory for our project
  uv init weather
  cd weather

  # Create virtual environment and activate it
  uv venv
  .venv\Scripts\activate

  # Install dependencies
  uv add mcp[cli] httpx

  # Create our server file
  new-item weather.py
  ```
</CodeGroup>

Now let's dive into building your server.

#### Building your server

##### Importing packages and setting up the instance

Add these to the top of your `weather.py`:

```python
from typing import Any
import httpx
from mcp.server.fastmcp import FastMCP

# Initialize FastMCP server
mcp = FastMCP("weather")

# Constants
````
````

NWS_API_BASE = "https://api.weather.gov"
USER_AGENT = "weather-app/1.0"
```

The FastMCP class uses Python type hints and docstrings to automatically generate tool definitions, making it easy to create and maintain MCP tools.

##### Helper functions

Next, let's add our helper functions for querying and formatting the data from the National Weather Service API:

```python
async def make_nws_request(url: str) -> dict[str, Any] | None:
    """Make a request to the NWS API with proper error handling."""
    headers = {
        "User-Agent": USER_AGENT,
        "Accept": "application/geo+json"
    }
    async with httpx.AsyncClient() as client:
        try:
            response = await client.get(url, headers=headers, timeout=30.0)
            response.raise_for_status()
            return response.json()
        except Exception:
            return None

def format_alert(feature: dict) -> str:
    """Format an alert feature into a readable string."""
    props = feature["properties"]
    return f"""
Event: {props.get('event', 'Unknown')}
Area: {props.get('areaDesc', 'Unknown')}
Severity: {props.get('severity', 'Unknown')}
Description: {props.get('description', 'No description available')}
Instructions: {props.get('instruction', 'No specific instructions provided')}
"""
```

Implementing tool execution

The tool execution handler is responsible for actually executing the logic of each tool. Let's add it:

```python
@mcp.tool()
async def get_alerts(state: str) -> str:
    """Get weather alerts for a US state.

    Args:
        state: Two-letter US state code (e.g. CA, NY)
    """
    url = f"{NWS_API_BASE}/alerts/active/area/{state}"

````
    data = await make_nws_request(url)

    if not data or "features" not in data:
        return "Unable to fetch alerts or no alerts found."

    if not data["features"]:
        return "No active alerts for this state."

    alerts = [format_alert(feature) for feature in data["features"]]
    return "\n---\n".join(alerts)

@mcp.tool()
async def get_forecast(latitude: float, longitude: float) -> str:
    """Get weather forecast for a location.

    Args:
        latitude: Latitude of the location
        longitude: Longitude of the location
    """
    # First get the forecast grid endpoint
    points_url = f"{NWS_API_BASE}/points/{latitude},{longitude}"
    points_data = await make_nws_request(points_url)

    if not points_data:
        return "Unable to fetch forecast data for this location."

    # Get the forecast URL from the points response
    forecast_url = points_data["properties"]["forecast"]
    forecast_data = await make_nws_request(forecast_url)

    if not forecast_data:
        return "Unable to fetch detailed forecast."

    # Format the periods into a readable forecast
    periods = forecast_data["properties"]["periods"]
    forecasts = []
    for period in periods[:5]: # Only show next 5 periods
        forecast = f"""
{period['name']}:
Temperature: {period['temperature']}°{period['temperatureUnit']}
Wind: {period['windSpeed']} {period['windDirection']}
Forecast: {period['detailedForecast']}
"""
        forecasts.append(forecast)

    return "\n---\n".join(forecasts)
```

Running the server

Finally, let's initialize and run the server:

```python
````

````
if __name__ == "__main__":
    # Initialize and run the server
    mcp.run(transport='stdio')
```

Your server is complete! Run `uv run weather.py` to start the MCP server, which will listen
for messages from MCP hosts.

Let's now test your server from an existing MCP host, Claude for Desktop.

#### Testing your server with Claude for Desktop

<Note>
  Claude for Desktop is not yet available on Linux. Linux users can proceed to the [Building
a client](/quickstart/client) tutorial to build an MCP client that connects to the server we
just built.
</Note>

First, make sure you have Claude for Desktop installed. [You can install the latest version
here.](https://claude.ai/download) If you already have Claude for Desktop, **make sure it's
updated to the latest version.**

We'll need to configure Claude for Desktop for whichever MCP servers you want to use. To do
this, open your Claude for Desktop App configuration at `~/Library/Application
Support/Claude/claude_desktop_config.json` in a text editor. Make sure to create the file if
it doesn't exist.

For example, if you have [VS Code](https://code.visualstudio.com/) installed:

<CodeGroup>
  ```bash macOS/Linux
  code ~/Library/Application\ Support/Claude/claude_desktop_config.json
  ```

  ```powershell Windows
  code $env:AppData\Claude\claude_desktop_config.json
  ```
</CodeGroup>

You'll then add your servers in the `mcpServers` key. The MCP UI elements will only show up
in Claude for Desktop if at least one server is properly configured.

In this case, we'll add our single weather server like so:

<CodeGroup>
  ```json macOS/Linux
  {
    "mcpServers": {
      "weather": {
        "command": "uv",
        "args": [
          "--directory",
          "/ABSOLUTE/PATH/TO/PARENT/FOLDER/weather",
````

````
          "run",
          "weather.py"
        ]
      }
    }
  }
  ```

  ```json Windows
  {
    "mcpServers": {
      "weather": {
        "command": "uv",
        "args": [
          "--directory",
          "C:\\ABSOLUTE\\PATH\\TO\\PARENT\\FOLDER\\weather",
          "run",
          "weather.py"
        ]
      }
    }
  }
  ```
</CodeGroup>

<Warning>
  You may need to put the full path to the `uv` executable in the `command` field. You can
get this by running `which uv` on macOS/Linux or `where uv` on Windows.
</Warning>

<Note>
  Make sure you pass in the absolute path to your server. You can get this by running `pwd`
on macOS/Linux or `cd` on Windows Command Prompt. On Windows, remember to use double
backslashes (`\\`) or forward slashes (`/`) in the JSON path.
</Note>

This tells Claude for Desktop:

1. There's an MCP server named "weather"
2. To launch it by running `uv --directory /ABSOLUTE/PATH/TO/PARENT/FOLDER/weather run
weather.py`

Save the file, and restart **Claude for Desktop**.
````

Let's get started with building our weather server! [You can find the complete code for what we'll be building here.]()

```
##### Prerequisite knowledge

This quickstart assumes you have familiarity with:
```
```

````
* TypeScript
* LLMs like Claude

##### Logging in MCP Servers

When implementing MCP servers, be careful about how you handle logging:

**For STDIO-based servers:** Never write to standard output (stdout). This includes:

* `print()` statements in Python
* `console.log()` in JavaScript
* `fmt.Println()` in Go
* Similar stdout functions in other languages

Writing to stdout will corrupt the JSON-RPC messages and break your server.

**For HTTP-based servers:** Standard output logging is fine since it doesn't interfere with HTTP responses.

##### Best Practices

1. Use a logging library that writes to stderr or files, such as `logging` in Python.
2. For JavaScript, be especially careful - `console.log()` writes to stdout by default

##### Quick Examples

```javascript
// ❌ Bad (STDIO)
console.log("Server started");

// ✅ Good (STDIO)
console.error("Server started"); // stderr is safe
```

##### System requirements

For TypeScript, make sure you have the latest version of Node installed.

##### Set up your environment

First, let's install Node.js and npm if you haven't already. You can download them from [nodejs.org](https://nodejs.org/).
Verify your Node.js installation:

```bash
node --version
npm --version
```

For this tutorial, you'll need Node.js version 16 or higher.

Now, let's create and set up our project:
````

````
<CodeGroup>
  ```bash macOS/Linux
  # Create a new directory for our project
  mkdir weather
  cd weather

  # Initialize a new npm project
  npm init -y

  # Install dependencies
  npm install @modelcontextprotocol/sdk zod
  npm install -D @types/node typescript

  # Create our files
  mkdir src
  touch src/index.ts
  ```

  ```powershell Windows
  # Create a new directory for our project
  md weather
  cd weather

  # Initialize a new npm project
  npm init -y

  # Install dependencies
  npm install @modelcontextprotocol/sdk zod
  npm install -D @types/node typescript

  # Create our files
  md src
  new-item src\index.ts
  ```
</CodeGroup>

Update your package.json to add type: "module" and a build script:

```json package.json
{
  "type": "module",
  "bin": {
    "weather": "./build/index.js"
  },
  "scripts": {
    "build": "tsc && chmod 755 build/index.js"
  },
  "files": ["build"]
}
```

Create a `tsconfig.json` in the root of your project:
````

```json tsconfig.json
{
  "compilerOptions": {
    "target": "ES2022",
    "module": "Node16",
    "moduleResolution": "Node16",
    "outDir": "./build",
    "rootDir": "./src",
    "strict": true,
    "esModuleInterop": true,
    "skipLibCheck": true,
    "forceConsistentCasingInFileNames": true
  },
  "include": ["src/**/*"],
  "exclude": ["node_modules"]
}
```

Now let's dive into building your server.

Building your server

Importing packages and setting up the instance

Add these to the top of your `src/index.ts`:

```typescript
import { McpServer } from "@modelcontextprotocol/sdk/server/mcp.js";
import { StdioServerTransport } from "@modelcontextprotocol/sdk/server/stdio.js";
import { z } from "zod";

const NWS_API_BASE = "https://api.weather.gov";
const USER_AGENT = "weather-app/1.0";

// Create server instance
const server = new McpServer({
  name: "weather",
  version: "1.0.0",
  capabilities: {
    resources: {},
    tools: {},
  },
});
```

Helper functions

Next, let's add our helper functions for querying and formatting the data from the National Weather Service API:

```typescript
// Helper function for making NWS API requests
```

```
async function makeNWSRequest<T>(url: string): Promise<T | null> {
  const headers = {
    "User-Agent": USER_AGENT,
    Accept: "application/geo+json",
  };

  try {
    const response = await fetch(url, { headers });
    if (!response.ok) {
      throw new Error(`HTTP error! status: ${response.status}`);
    }
    return (await response.json()) as T;
  } catch (error) {
    console.error("Error making NWS request:", error);
    return null;
  }
}

interface AlertFeature {
  properties: {
    event?: string;
    areaDesc?: string;
    severity?: string;
    status?: string;
    headline?: string;
  };
}

// Format alert data
function formatAlert(feature: AlertFeature): string {
  const props = feature.properties;
  return [
    `Event: ${props.event || "Unknown"}`,
    `Area: ${props.areaDesc || "Unknown"}`,
    `Severity: ${props.severity || "Unknown"}`,
    `Status: ${props.status || "Unknown"}`,
    `Headline: ${props.headline || "No headline"}`,
    "---",
  ].join("\n");
}

interface ForecastPeriod {
  name?: string;
  temperature?: number;
  temperatureUnit?: string;
  windSpeed?: string;
  windDirection?: string;
  shortForecast?: string;
}

interface AlertsResponse {
  features: AlertFeature[];
}
```

````
interface PointsResponse {
  properties: {
    forecast?: string;
  };
}

interface ForecastResponse {
  properties: {
    periods: ForecastPeriod[];
  };
}
```

##### Implementing tool execution

The tool execution handler is responsible for actually executing the logic of each tool.
Let's add it:

```typescript
// Register weather tools
server.tool(
  "get_alerts",
  "Get weather alerts for a state",
  {
    state: z.string().length(2).describe("Two-letter state code (e.g. CA, NY)"),
  },
  async ({ state }) => {
    const stateCode = state.toUpperCase();
    const alertsUrl = `${NWS_API_BASE}/alerts?area=${stateCode}`;
    const alertsData = await makeNWSRequest<AlertsResponse>(alertsUrl);

    if (!alertsData) {
      return {
        content: [
          {
            type: "text",
            text: "Failed to retrieve alerts data",
          },
        ],
      };
    }

    const features = alertsData.features || [];
    if (features.length === 0) {
      return {
        content: [
          {
            type: "text",
            text: `No active alerts for ${stateCode}`,
          },
        ],
      };
````

```
    }

    const formattedAlerts = features.map(formatAlert);
    const alertsText = `Active alerts for ${stateCode}:\n\n${formattedAlerts.join("\n")}`;

    return {
      content: [
        {
          type: "text",
          text: alertsText,
        },
      ],
    };
  },
);

server.tool(
  "get_forecast",
  "Get weather forecast for a location",
  {
    latitude: z.number().min(-90).max(90).describe("Latitude of the location"),
    longitude: z
      .number()
      .min(-180)
      .max(180)
      .describe("Longitude of the location"),
  },
  async ({ latitude, longitude }) => {
    // Get grid point data
    const pointsUrl =
`${NWS_API_BASE}/points/${latitude.toFixed(4)},${longitude.toFixed(4)}`;
    const pointsData = await makeNWSRequest<PointsResponse>(pointsUrl);

    if (!pointsData) {
      return {
        content: [
          {
            type: "text",
            text: `Failed to retrieve grid point data for coordinates: ${latitude},
${longitude}. This location may not be supported by the NWS API (only US locations are
supported).`,
          },
        ],
      };
    }

    const forecastUrl = pointsData.properties?.forecast;
    if (!forecastUrl) {
      return {
        content: [
          {
            type: "text",
            text: "Failed to get forecast URL from grid point data",
```

```
        },
      ],
    };
  }

  // Get forecast data
  const forecastData = await makeNWSRequest<ForecastResponse>(forecastUrl);
  if (!forecastData) {
    return {
      content: [
        {
          type: "text",
          text: "Failed to retrieve forecast data",
        },
      ],
    };
  }

  const periods = forecastData.properties?.periods || [];
  if (periods.length === 0) {
    return {
      content: [
        {
          type: "text",
          text: "No forecast periods available",
        },
      ],
    };
  }

  // Format forecast periods
  const formattedForecast = periods.map((period: ForecastPeriod) =>
    [
      `${period.name || "Unknown"}:`,
      `Temperature: ${period.temperature || "Unknown"}°${period.temperatureUnit || "F"}`,
      `Wind: ${period.windSpeed || "Unknown"} ${period.windDirection || ""}`,
      `${period.shortForecast || "No forecast available"}`,
      "---",
    ].join("\n"),
  );

  const forecastText = `Forecast for ${latitude},
${longitude}:\n\n${formattedForecast.join("\n")}`;

  return {
    content: [
      {
        type: "text",
        text: forecastText,
      },
    ],
  };
},
```

````
);
```

##### Running the server

Finally, implement the main function to run the server:

```typescript
async function main() {
  const transport = new StdioServerTransport();
  await server.connect(transport);
  console.error("Weather MCP Server running on stdio");
}

main().catch((error) => {
  console.error("Fatal error in main():", error);
  process.exit(1);
});
```

Make sure to run `npm run build` to build your server! This is a very important step in
getting your server to connect.

Let's now test your server from an existing MCP host, Claude for Desktop.

#### Testing your server with Claude for Desktop

<Note>
  Claude for Desktop is not yet available on Linux. Linux users can proceed to the [Building
a client](/quickstart/client) tutorial to build an MCP client that connects to the server we
just built.
</Note>

First, make sure you have Claude for Desktop installed. [You can install the latest version
here.](https://claude.ai/download) If you already have Claude for Desktop, **make sure it's
updated to the latest version.**

We'll need to configure Claude for Desktop for whichever MCP servers you want to use. To do
this, open your Claude for Desktop App configuration at `~/Library/Application
Support/Claude/claude_desktop_config.json` in a text editor. Make sure to create the file if
it doesn't exist.

For example, if you have [VS Code](https://code.visualstudio.com/) installed:

<CodeGroup>
  ```bash macOS/Linux
  code ~/Library/Application\ Support/Claude/claude_desktop_config.json
  ```


  ```powershell Windows
  code $env:AppData\Claude\claude_desktop_config.json
  ```
</CodeGroup>
````
````

````
You'll then add your servers in the `mcpServers` key. The MCP UI elements will only show up
in Claude for Desktop if at least one server is properly configured.

In this case, we'll add our single weather server like so:

<CodeGroup>
  ```json macOS/Linux
  {
    "mcpServers": {
      "weather": {
        "command": "node",
        "args": ["/ABSOLUTE/PATH/TO/PARENT/FOLDER/weather/build/index.js"]
      }
    }
  }
  ```

  ```json Windows
  {
    "mcpServers": {
      "weather": {
        "command": "node",
        "args": ["C:\\PATH\\TO\\PARENT\\FOLDER\\weather\\build\\index.js"]
      }
    }
  }
  ```
</CodeGroup>

This tells Claude for Desktop:

1. There's an MCP server named "weather"
2. Launch it by running `node /ABSOLUTE/PATH/TO/PARENT/FOLDER/weather/build/index.js`

Save the file, and restart **Claude for Desktop**.
````

This is a quickstart demo based on Spring AI MCP auto-configuration and boot starters.
To learn how to create sync and async MCP Servers, manually, consult the [Java SDK Server] documentation.

```
Let's get started with building our weather server!
[You can find the complete code for what we'll be building here.](https://github.com/spring-
projects/spring-ai-examples/tree/main/model-context-protocol/weather/starter-stdio-server)

For more information, see the [MCP Server Boot Starter](https://docs.spring.io/spring-
ai/reference/api/mcp/mcp-server-boot-starter-docs.html) reference documentation.
```

````
For manual MCP Server implementation, refer to the [MCP Server Java SDK documentation]
(/sdk/java/mcp-server).

##### Logging in MCP Servers

When implementing MCP servers, be careful about how you handle logging:

**For STDIO-based servers:** Never write to standard output (stdout). This includes:

* `print()` statements in Python
* `console.log()` in JavaScript
* `fmt.Println()` in Go
* Similar stdout functions in other languages

Writing to stdout will corrupt the JSON-RPC messages and break your server.

**For HTTP-based servers:** Standard output logging is fine since it doesn't interfere with
HTTP responses.

##### Best Practices

1. Use a logging library that writes to stderr or files.
2. Ensure any configured logging library will not write to STDOUT

##### System requirements

* Java 17 or higher installed.
* [Spring Boot 3.3.x](https://docs.spring.io/spring-boot/installing.html) or higher

##### Set up your environment

Use the [Spring Initializer](https://start.spring.io/) to bootstrap the project.

You will need to add the following dependencies:

<CodeGroup>
  ```xml Maven
  <dependencies>
        <dependency>
            <groupId>org.springframework.ai</groupId>
            <artifactId>spring-ai-starter-mcp-server</artifactId>
        </dependency>

        <dependency>
            <groupId>org.springframework</groupId>
            <artifactId>spring-web</artifactId>
        </dependency>
  </dependencies>
  ```

  ```groovy Gradle
  dependencies {
    implementation platform("org.springframework.ai:spring-ai-starter-mcp-server")
````
````

````
    implementation platform("org.springframework:spring-web")
  }
  ```
</CodeGroup>

Then configure your application by setting the application properties:

<CodeGroup>
  ```bash application.properties
  spring.main.bannerMode=off
  logging.pattern.console=
  ```

  ```yaml application.yml
  logging:
    pattern:
      console:
  spring:
    main:
      banner-mode: off
  ```
</CodeGroup>

The [Server Configuration Properties](https://docs.spring.io/spring-ai/reference/api/mcp/mcp-server-boot-starter-docs.html#_configuration_properties) documents all available properties.

Now let's dive into building your server.

#### Building your server

##### Weather Service

Let's implement a [WeatherService.java](https://github.com/spring-projects/spring-ai-examples/blob/main/model-context-protocol/weather/starter-stdio-server/src/main/java/org/springframework/ai/mcp/sample/server/WeatherService.java) that uses a REST client to query the data from the National Weather Service API:

```java
@Service
public class WeatherService {

    private final RestClient restClient;

    public WeatherService() {
        this.restClient = RestClient.builder()
            .baseUrl("https://api.weather.gov")
            .defaultHeader("Accept", "application/geo+json")
            .defaultHeader("User-Agent", "WeatherApiClient/1.0 (your@email.com)")
            .build();
    }

  @Tool(description = "Get weather forecast for a specific latitude/longitude")
````

````
  public String getWeatherForecastByLocation(
      double latitude,   // Latitude coordinate
      double longitude   // Longitude coordinate
  ) {
      // Returns detailed forecast including:
      // - Temperature and unit
      // - Wind speed and direction
      // - Detailed forecast description
  }

  @Tool(description = "Get weather alerts for a US state")
  public String getAlerts(
      @ToolParam(description = "Two-letter US state code (e.g. CA, NY)") String state
  ) {
      // Returns active alerts including:
      // - Event type
      // - Affected area
      // - Severity
      // - Description
      // - Safety instructions
  }

  // ......
}
```

The `@Service` annotation with auto-register the service in your application context.
The Spring AI `@Tool` annotation, making it easy to create and maintain MCP tools.

The auto-configuration will automatically register these tools with the MCP server.

##### Create your Boot Application

```java
@SpringBootApplication
public class McpServerApplication {

    public static void main(String[] args) {
        SpringApplication.run(McpServerApplication.class, args);
    }

    @Bean
    public ToolCallbackProvider weatherTools(WeatherService weatherService) {
        return  MethodToolCallbackProvider.builder().toolObjects(weatherService).build();
    }
}
```

Uses the the `MethodToolCallbackProvider` utils to convert the `@Tools` into actionable
callbacks used by the MCP server.

##### Running the server
````
````

````
Finally, let's build the server:

```bash
./mvnw clean install
```

This will generate a `mcp-weather-stdio-server-0.0.1-SNAPSHOT.jar` file within the `target`
folder.

Let's now test your server from an existing MCP host, Claude for Desktop.

#### Testing your server with Claude for Desktop

<Note>
  Claude for Desktop is not yet available on Linux.
</Note>

First, make sure you have Claude for Desktop installed.
[You can install the latest version here.](https://claude.ai/download) If you already have
Claude for Desktop, **make sure it's updated to the latest version.**

We'll need to configure Claude for Desktop for whichever MCP servers you want to use.
To do this, open your Claude for Desktop App configuration at `~/Library/Application
Support/Claude/claude_desktop_config.json` in a text editor.
Make sure to create the file if it doesn't exist.

For example, if you have [VS Code](https://code.visualstudio.com/) installed:

<CodeGroup>
  ```bash macOS/Linux
  code ~/Library/Application\ Support/Claude/claude_desktop_config.json
  ```

  ```powershell Windows
  code $env:AppData\Claude\claude_desktop_config.json
  ```
</CodeGroup>

You'll then add your servers in the `mcpServers` key.
The MCP UI elements will only show up in Claude for Desktop if at least one server is
properly configured.

In this case, we'll add our single weather server like so:

<CodeGroup>
  ```json macOS/Linux
  {
    "mcpServers": {
      "spring-ai-mcp-weather": {
        "command": "java",
        "args": [
          "-Dspring.ai.mcp.server.stdio=true",
          "-jar",
````
````

````
          "/ABSOLUTE/PATH/TO/PARENT/FOLDER/mcp-weather-stdio-server-0.0.1-SNAPSHOT.jar"
        ]
      }
    }
  }
  ```

  ```json Windows
  {
    "mcpServers": {
      "spring-ai-mcp-weather": {
        "command": "java",
        "args": [
          "-Dspring.ai.mcp.server.transport=STDIO",
          "-jar",
          "C:\\ABSOLUTE\\PATH\\TO\\PARENT\\FOLDER\\weather\\mcp-weather-stdio-server-0.0.1-
SNAPSHOT.jar"
        ]
      }
    }
  }
  ```
</CodeGroup>

<Note>
  Make sure you pass in the absolute path to your server.
</Note>

This tells Claude for Desktop:

1. There's an MCP server named "my-weather-server"
2. To launch it by running `java -jar /ABSOLUTE/PATH/TO/PARENT/FOLDER/mcp-weather-stdio-
server-0.0.1-SNAPSHOT.jar`

Save the file, and restart **Claude for Desktop**.

#### Testing your server with Java client

##### Create a MCP Client manually

Use the `McpClient` to connect to the server:

```java
var stdioParams = ServerParameters.builder("java")
  .args("-jar", "/ABSOLUTE/PATH/TO/PARENT/FOLDER/mcp-weather-stdio-server-0.0.1-
SNAPSHOT.jar")
  .build();

var stdioTransport = new StdioClientTransport(stdioParams);

var mcpClient = McpClient.sync(stdioTransport).build();

mcpClient.initialize();
````

````
ListToolsResult toolsList = mcpClient.listTools();

CallToolResult weather = mcpClient.callTool(
  new CallToolRequest("getWeatherForecastByLocation",
      Map.of("latitude", "47.6062", "longitude", "-122.3321")));

CallToolResult alert = mcpClient.callTool(
  new CallToolRequest("getAlerts", Map.of("state", "NY")));

mcpClient.closeGracefully();
```

##### Use MCP Client Boot Starter

Create a new boot starter application using the `spring-ai-starter-mcp-client` dependency:

```xml
<dependency>
    <groupId>org.springframework.ai</groupId>
    <artifactId>spring-ai-starter-mcp-client</artifactId>
</dependency>
```

and set the `spring.ai.mcp.client.stdio.servers-configuration` property to point to your
`claude_desktop_config.json`.
You can reuse the existing Anthropic Desktop configuration:

```properties
spring.ai.mcp.client.stdio.servers-configuration=file:PATH/TO/claude_desktop_config.json
```

When you start your client application, the auto-configuration will create, automatically
MCP clients from the claude_desktop_config.json.

For more information, see the [MCP Client Boot Starters](https://docs.spring.io/spring-
ai/reference/api/mcp/mcp-server-boot-client-docs.html) reference documentation.

#### More Java MCP Server examples

The [starter-webflux-server](https://github.com/spring-projects/spring-ai-
examples/tree/main/model-context-protocol/weather/starter-webflux-server) demonstrates how
to create a MCP server using SSE transport.
It showcases how to define and register MCP Tools, Resources, and Prompts, using the Spring
Boot's auto-configuration capabilities.
````

Let's get started with building our weather server! [You can find the complete code for what we'll be building here.]

```
##### Prerequisite knowledge
```
```

````
This quickstart assumes you have familiarity with:

* Kotlin
* LLMs like Claude

##### System requirements

* Java 17 or higher installed.

##### Set up your environment

First, let's install `java` and `gradle` if you haven't already.
You can download `java` from [official Oracle JDK website]
(https://www.oracle.com/java/technologies/downloads/).
Verify your `java` installation:

```bash
java --version
```

Now, let's create and set up your project:

<CodeGroup>
  ```bash macOS/Linux
  # Create a new directory for our project
  mkdir weather
  cd weather

  # Initialize a new kotlin project
  gradle init
  ```

  ```powershell Windows
  # Create a new directory for our project
  md weather
  cd weather

  # Initialize a new kotlin project
  gradle init
  ```
</CodeGroup>

After running `gradle init`, you will be presented with options for creating your project.
Select **Application** as the project type, **Kotlin** as the programming language, and
**Java 17** as the Java version.

Alternatively, you can create a Kotlin application using the [IntelliJ IDEA project wizard]
(https://kotlinlang.org/docs/jvm-get-started.html).

After creating the project, add the following dependencies:

<CodeGroup>
````

````
  ```kotlin build.gradle.kts
  val mcpVersion = "0.4.0"
  val slf4jVersion = "2.0.9"
  val ktorVersion = "3.1.1"

  dependencies {
      implementation("io.modelcontextprotocol:kotlin-sdk:$mcpVersion")
      implementation("org.slf4j:slf4j-nop:$slf4jVersion")
      implementation("io.ktor:ktor-client-content-negotiation:$ktorVersion")
      implementation("io.ktor:ktor-serialization-kotlinx-json:$ktorVersion")
  }
  ```

  ```groovy build.gradle
  def mcpVersion = '0.3.0'
  def slf4jVersion = '2.0.9'
  def ktorVersion = '3.1.1'

  dependencies {
      implementation "io.modelcontextprotocol:kotlin-sdk:$mcpVersion"
      implementation "org.slf4j:slf4j-nop:$slf4jVersion"
      implementation "io.ktor:ktor-client-content-negotiation:$ktorVersion"
      implementation "io.ktor:ktor-serialization-kotlinx-json:$ktorVersion"
  }
  ```
</CodeGroup>

Also, add the following plugins to your build script:

<CodeGroup>
  ```kotlin build.gradle.kts
  plugins {
      kotlin("plugin.serialization") version "your_version_of_kotlin"
      id("com.github.johnrengelman.shadow") version "8.1.1"
  }
  ```

  ```groovy build.gradle
  plugins {
      id 'org.jetbrains.kotlin.plugin.serialization' version 'your_version_of_kotlin'
      id 'com.github.johnrengelman.shadow' version '8.1.1'
  }
  ```
</CodeGroup>

Now let’s dive into building your server.

#### Building your server

##### Setting up the instance

Add a server initialization function:
````

````
```kotlin
// Main function to run the MCP server
fun `run mcp server`() {
    // Create the MCP Server instance with a basic implementation
    val server = Server(
        Implementation(
            name = "weather", // Tool name is "weather"
            version = "1.0.0" // Version of the implementation
        ),
        ServerOptions(
            capabilities = ServerCapabilities(tools = ServerCapabilities.Tools(listChanged = true))
        )
    )

    // Create a transport using standard IO for server communication
    val transport = StdioServerTransport(
        System.`in`.asInput(),
        System.out.asSink().buffered()
    )

    runBlocking {
        server.connect(transport)
        val done = Job()
        server.onClose {
            done.complete()
        }
        done.join()
    }
}
```

##### Weather API helper functions

Next, let's add functions and data classes for querying and converting responses from the
National Weather Service API:

```kotlin
// Extension function to fetch forecast information for given latitude and longitude
suspend fun HttpClient.getForecast(latitude: Double, longitude: Double): List<String> {
    val points = this.get("/points/$latitude,$longitude").body<Points>()
    val forecast = this.get(points.properties.forecast).body<Forecast>()
    return forecast.properties.periods.map { period ->
        """
            ${period.name}:
            Temperature: ${period.temperature} ${period.temperatureUnit}
            Wind: ${period.windSpeed} ${period.windDirection}
            Forecast: ${period.detailedForecast}
        """.trimIndent()
    }
}

// Extension function to fetch weather alerts for a given state
````
````

```kotlin
suspend fun HttpClient.getAlerts(state: String): List<String> {
    val alerts = this.get("/alerts/active/area/$state").body<Alert>()
    return alerts.features.map { feature ->
        """
            Event: ${feature.properties.event}
            Area: ${feature.properties.areaDesc}
            Severity: ${feature.properties.severity}
            Description: ${feature.properties.description}
            Instruction: ${feature.properties.instruction}
        """.trimIndent()
    }
}

@Serializable
data class Points(
    val properties: Properties
) {
    @Serializable
    data class Properties(val forecast: String)
}

@Serializable
data class Forecast(
    val properties: Properties
) {
    @Serializable
    data class Properties(val periods: List<Period>)

    @Serializable
    data class Period(
        val number: Int, val name: String, val startTime: String, val endTime: String,
        val isDaytime: Boolean, val temperature: Int, val temperatureUnit: String,
        val temperatureTrend: String, val probabilityOfPrecipitation: JsonObject,
        val windSpeed: String, val windDirection: String,
        val shortForecast: String, val detailedForecast: String,
    )
}

@Serializable
data class Alert(
    val features: List<Feature>
) {
    @Serializable
    data class Feature(
        val properties: Properties
    )

    @Serializable
    data class Properties(
        val event: String, val areaDesc: String, val severity: String,
        val description: String, val instruction: String?,
    )
}
```

````
```

##### Implementing tool execution

The tool execution handler is responsible for actually executing the logic of each tool.
Let's add it:

```kotlin
// Create an HTTP client with a default request configuration and JSON content negotiation
val httpClient = HttpClient {
    defaultRequest {
        url("https://api.weather.gov")
        headers {
            append("Accept", "application/geo+json")
            append("User-Agent", "WeatherApiClient/1.0")
        }
        contentType(ContentType.Application.Json)
    }
    // Install content negotiation plugin for JSON serialization/deserialization
    install(ContentNegotiation) { json(Json { ignoreUnknownKeys = true }) }
}

// Register a tool to fetch weather alerts by state
server.addTool(
    name = "get_alerts",
    description = """
        Get weather alerts for a US state. Input is Two-letter US state code (e.g. CA, NY)
    """.trimIndent(),
    inputSchema = Tool.Input(
        properties = buildJsonObject {
            putJsonObject("state") {
                put("type", "string")
                put("description", "Two-letter US state code (e.g. CA, NY)")
            }
        },
        required = listOf("state")
    )
) { request ->
    val state = request.arguments["state"]?.jsonPrimitive?.content
    if (state == null) {
        return@addTool CallToolResult(
            content = listOf(TextContent("The 'state' parameter is required."))
        )
    }

    val alerts = httpClient.getAlerts(state)

    CallToolResult(content = alerts.map { TextContent(it) })
}

// Register a tool to fetch weather forecast by latitude and longitude
server.addTool(
    name = "get_forecast",
````

~~~~
    description = """
        Get weather forecast for a specific latitude/longitude
    """.trimIndent(),
    inputSchema = Tool.Input(
        properties = buildJsonObject {
            putJsonObject("latitude") { put("type", "number") }
            putJsonObject("longitude") { put("type", "number") }
        },
        required = listOf("latitude", "longitude")
    )
) { request ->
    val latitude = request.arguments["latitude"]?.jsonPrimitive?.doubleOrNull
    val longitude = request.arguments["longitude"]?.jsonPrimitive?.doubleOrNull
    if (latitude == null || longitude == null) {
        return@addTool CallToolResult(
            content = listOf(TextContent("The 'latitude' and 'longitude' parameters are
required."))
        )
    }

    val forecast = httpClient.getForecast(latitude, longitude)

    CallToolResult(content = forecast.map { TextContent(it) })
}
```

##### Running the server

Finally, implement the main function to run the server:

```kotlin
fun main() = `run mcp server`()
```

Make sure to run `./gradlew build` to build your server. This is a very important step in
getting your server to connect.

Let's now test your server from an existing MCP host, Claude for Desktop.

#### Testing your server with Claude for Desktop

<Note>
  Claude for Desktop is not yet available on Linux. Linux users can proceed to the [Building
a client](/quickstart/client) tutorial to build an MCP client that connects to the server we
just built.
</Note>

First, make sure you have Claude for Desktop installed. [You can install the latest version
here.](https://claude.ai/download) If you already have Claude for Desktop, **make sure it's
updated to the latest version.**

We'll need to configure Claude for Desktop for whichever MCP servers you want to use.
~~~~

````
To do this, open your Claude for Desktop App configuration at `~/Library/Application
Support/Claude/claude_desktop_config.json` in a text editor.
Make sure to create the file if it doesn't exist.

For example, if you have [VS Code](https://code.visualstudio.com/) installed:

<CodeGroup>
  ```bash macOS/Linux
  code ~/Library/Application\ Support/Claude/claude_desktop_config.json
  ```

  ```powershell Windows
  code $env:AppData\Claude\claude_desktop_config.json
  ```
</CodeGroup>

You'll then add your servers in the `mcpServers` key.
The MCP UI elements will only show up in Claude for Desktop if at least one server is
properly configured.

In this case, we'll add our single weather server like so:

<CodeGroup>
  ```json macOS/Linux
  {
    "mcpServers": {
      "weather": {
        "command": "java",
        "args": [
          "-jar",
          "/ABSOLUTE/PATH/TO/PARENT/FOLDER/weather/build/libs/weather-0.1.0-all.jar"
        ]
      }
    }
  }
  ```

  ```json Windows
  {
    "mcpServers": {
      "weather": {
        "command": "java",
        "args": [
          "-jar",
          "C:\\PATH\\TO\\PARENT\\FOLDER\\weather\\build\\libs\\weather-0.1.0-all.jar"
        ]
      }
    }
  }
  ```
</CodeGroup>

This tells Claude for Desktop:
````

```
1. There's an MCP server named "weather"
2. Launch it by running `java -jar
/ABSOLUTE/PATH/TO/PARENT/FOLDER/weather/build/libs/weather-0.1.0-all.jar`

Save the file, and restart **Claude for Desktop**.
```

Let's get started with building our weather server! [You can find the complete code for what we'll be building here.]

```
##### Prerequisite knowledge

This quickstart assumes you have familiarity with:

* C#
* LLMs like Claude
* .NET 8 or higher

##### Logging in MCP Servers

When implementing MCP servers, be careful about how you handle logging:

**For STDIO-based servers:** Never write to standard output (stdout). This includes:

* `print()` statements in Python
* `console.log()` in JavaScript
* `fmt.Println()` in Go
* Similar stdout functions in other languages

Writing to stdout will corrupt the JSON-RPC messages and break your server.

**For HTTP-based servers:** Standard output logging is fine since it doesn't interfere with
HTTP responses.

##### Best Practices

1. Use a logging library that writes to stderr or files

##### System requirements

* [.NET 8 SDK](https://dotnet.microsoft.com/download/dotnet/8.0) or higher installed.

##### Set up your environment

First, let's install `dotnet` if you haven't already. You can download `dotnet` from
[official Microsoft .NET website](https://dotnet.microsoft.com/download/). Verify your
`dotnet` installation:

```bash
dotnet --version
```
```

````
```

Now, let's create and set up your project:

<CodeGroup>
  ```bash macOS/Linux
  # Create a new directory for our project
  mkdir weather
  cd weather
  # Initialize a new C# project
  dotnet new console
  ```

  ```powershell Windows
  # Create a new directory for our project
  mkdir weather
  cd weather
  # Initialize a new C# project
  dotnet new console
  ```
</CodeGroup>

After running `dotnet new console`, you will be presented with a new C# project.
You can open the project in your favorite IDE, such as [Visual Studio]
(https://visualstudio.microsoft.com/) or [Rider](https://www.jetbrains.com/rider/).
Alternatively, you can create a C# application using the [Visual Studio project wizard]
(https://learn.microsoft.com/en-us/visualstudio/get-started/csharp/tutorial-console?view=vs-
2022).
After creating the project, add NuGet package for the Model Context Protocol SDK and
hosting:

```bash
# Add the Model Context Protocol SDK NuGet package
dotnet add package ModelContextProtocol --prerelease
# Add the .NET Hosting NuGet package
dotnet add package Microsoft.Extensions.Hosting
```

Now let’s dive into building your server.

Building your server

Open the `Program.cs` file in your project and replace its contents with the following code:

```csharp
using Microsoft.Extensions.DependencyInjection;
using Microsoft.Extensions.Hosting;
using ModelContextProtocol;
using System.Net.Http.Headers;

var builder = Host.CreateEmptyApplicationBuilder(settings: null);

builder.Services.AddMcpServer()
````

````
    .WithStdioServerTransport()
    .WithToolsFromAssembly();

builder.Services.AddSingleton(_ =>
{
    var client = new HttpClient() { BaseAddress = new Uri("https://api.weather.gov") };
    client.DefaultRequestHeaders.UserAgent.Add(new ProductInfoHeaderValue("weather-tool",
"1.0"));
    return client;
});

var app = builder.Build();

await app.RunAsync();
```


<Note>
  When creating the `ApplicationHostBuilder`, ensure you use `CreateEmptyApplicationBuilder`
instead of `CreateDefaultBuilder`. This ensures that the server does not write any
additional messages to the console. This is only necessary for servers using STDIO
transport.
</Note>

This code sets up a basic console application that uses the Model Context Protocol SDK to
create an MCP server with standard I/O transport.

##### Weather API helper functions

Create an extension class for `HttpClient` which helps simplify JSON request handling:

```csharp
using System.Text.Json;

internal static class HttpClientExt
{
    public static async Task<JsonDocument> ReadJsonDocumentAsync(this HttpClient client,
string requestUri)
    {
        using var response = await client.GetAsync(requestUri);
        response.EnsureSuccessStatusCode();
        return await JsonDocument.ParseAsync(await response.Content.ReadAsStreamAsync());
    }
}
```

Next, define a class with the tool execution handlers for querying and converting responses
from the National Weather Service API:

```csharp
using ModelContextProtocol.Server;
using System.ComponentModel;
using System.Globalization;
using System.Text.Json;
````

```
namespace QuickstartWeatherServer.Tools;

[McpServerToolType]
public static class WeatherTools
{
    [McpServerTool, Description("Get weather alerts for a US state.")]
    public static async Task<string> GetAlerts(
        HttpClient client,
        [Description("The US state to get alerts for.")] string state)
    {
        using var jsonDocument = await
client.ReadJsonDocumentAsync($"/alerts/active/area/{state}");
        var jsonElement = jsonDocument.RootElement;
        var alerts = jsonElement.GetProperty("features").EnumerateArray();

        if (!alerts.Any())
        {
            return "No active alerts for this state.";
        }

        return string.Join("\n--\n", alerts.Select(alert =>
        {
            JsonElement properties = alert.GetProperty("properties");
            return $"""
                    Event: {properties.GetProperty("event").GetString()}
                    Area: {properties.GetProperty("areaDesc").GetString()}
                    Severity: {properties.GetProperty("severity").GetString()}
                    Description: {properties.GetProperty("description").GetString()}
                    Instruction: {properties.GetProperty("instruction").GetString()}
                    """;
        }));
    }

    [McpServerTool, Description("Get weather forecast for a location.")]
    public static async Task<string> GetForecast(
        HttpClient client,
        [Description("Latitude of the location.")] double latitude,
        [Description("Longitude of the location.")] double longitude)
    {
        var pointUrl = string.Create(CultureInfo.InvariantCulture, $"/points/{latitude},
{longitude}");
        using var jsonDocument = await client.ReadJsonDocumentAsync(pointUrl);
        var forecastUrl =
jsonDocument.RootElement.GetProperty("properties").GetProperty("forecast").GetString()
            ?? throw new Exception($"No forecast URL provided by
{client.BaseAddress}points/{latitude},{longitude}");

        using var forecastDocument = await client.ReadJsonDocumentAsync(forecastUrl);
        var periods =
forecastDocument.RootElement.GetProperty("properties").GetProperty("periods").EnumerateArray
();
```

````
        return string.Join("\n---\n", periods.Select(period => $"""
                {period.GetProperty("name").GetString()}
                Temperature: {period.GetProperty("temperature").GetInt32()}°F
                Wind: {period.GetProperty("windSpeed").GetString()}
{period.GetProperty("windDirection").GetString()}
                Forecast: {period.GetProperty("detailedForecast").GetString()}
                """));
    }
}
```

##### Running the server

Finally, run the server using the following command:

```bash
dotnet run
```

This will start the server and listen for incoming requests on standard input/output.

#### Testing your server with Claude for Desktop

<Note>
  Claude for Desktop is not yet available on Linux. Linux users can proceed to the [Building
a client](/quickstart/client) tutorial to build an MCP client that connects to the server we
just built.
</Note>

First, make sure you have Claude for Desktop installed. [You can install the latest version
here.](https://claude.ai/download) If you already have Claude for Desktop, **make sure it's
updated to the latest version.**
We'll need to configure Claude for Desktop for whichever MCP servers you want to use. To do
this, open your Claude for Desktop App configuration at `~/Library/Application
Support/Claude/claude_desktop_config.json` in a text editor. Make sure to create the file if
it doesn't exist.
For example, if you have [VS Code](https://code.visualstudio.com/) installed:

<CodeGroup>
  ```bash macOS/Linux
  code ~/Library/Application\ Support/Claude/claude_desktop_config.json
  ```

  ```powershell Windows
  code $env:AppData\Claude\claude_desktop_config.json
  ```
</CodeGroup>

You'll then add your servers in the `mcpServers` key. The MCP UI elements will only show up
in Claude for Desktop if at least one server is properly configured.
In this case, we'll add our single weather server like so:

<CodeGroup>
````
````

````
  ```json macOS/Linux
  {
    "mcpServers": {
      "weather": {
        "command": "dotnet",
        "args": ["run", "--project", "/ABSOLUTE/PATH/TO/PROJECT", "--no-build"]
      }
    }
  }
  ```

  ```json Windows
  {
    "mcpServers": {
      "weather": {
        "command": "dotnet",
        "args": [
          "run",
          "--project",
          "C:\\ABSOLUTE\\PATH\\TO\\PROJECT",
          "--no-build"
        ]
      }
    }
  }
  ```
</CodeGroup>

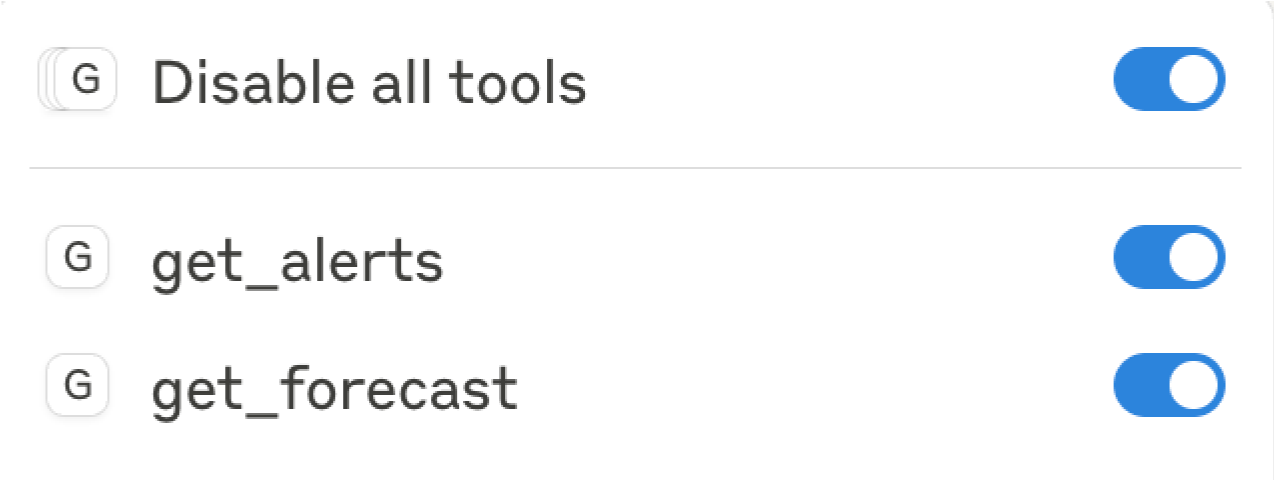
This tells Claude for Desktop:

1. There's an MCP server named "weather"
2. Launch it by running `dotnet run /ABSOLUTE/PATH/TO/PROJECT`
   Save the file, and restart **Claude for Desktop**.
````

### Test with commands

Let's make sure Claude for Desktop is picking up the two tools we've exposed in our `weather` server. You can do this by looking for the "Search and tools" <img src="https://mintlify.s3.us-west-1.amazonaws.com/mcp/images/claude-desktop-mcp-slider.svg" style={{display: 'inline', margin: 0, height: '1.3em'}} /> icon:

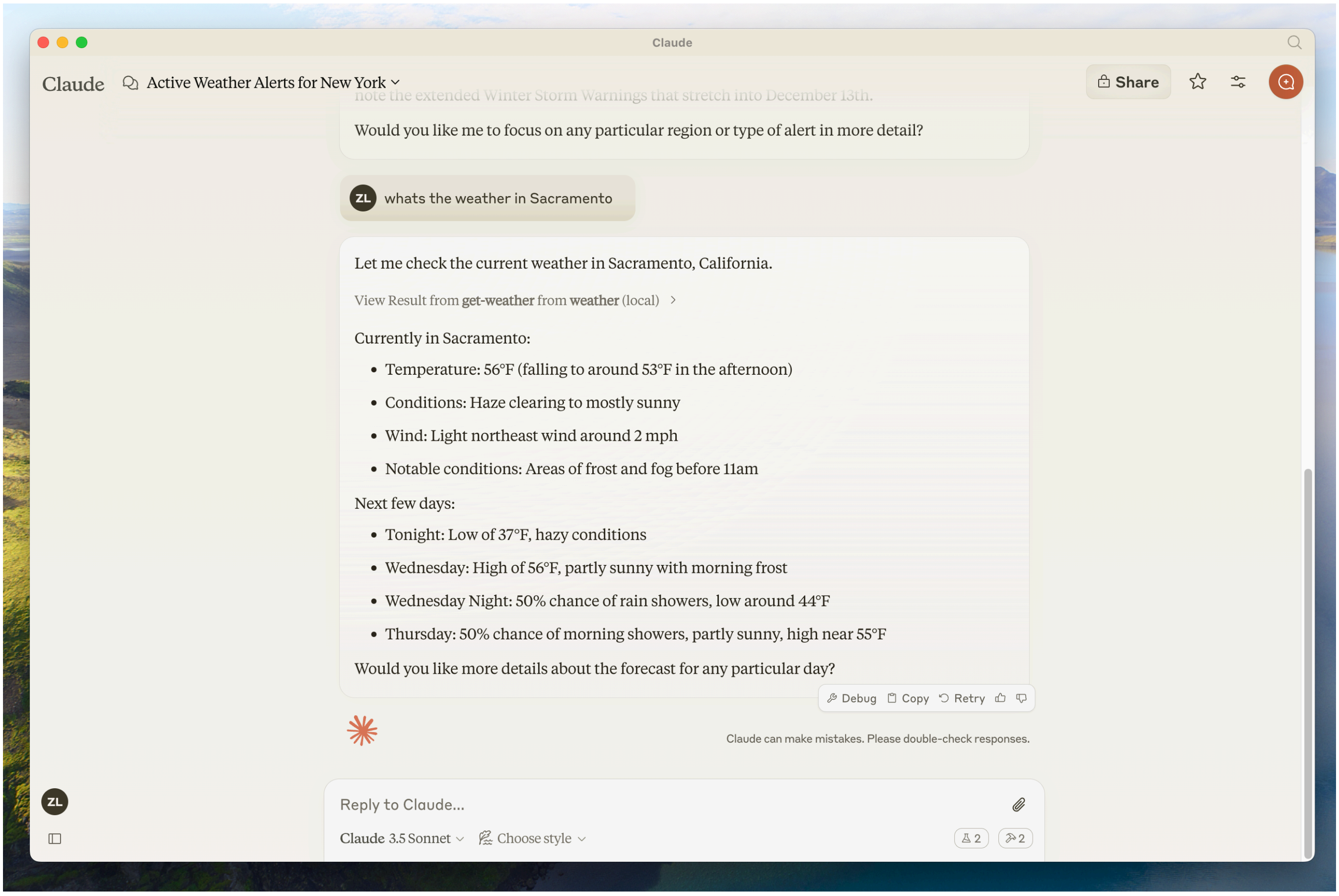

After clicking on the slider icon, you should see two tools listed:

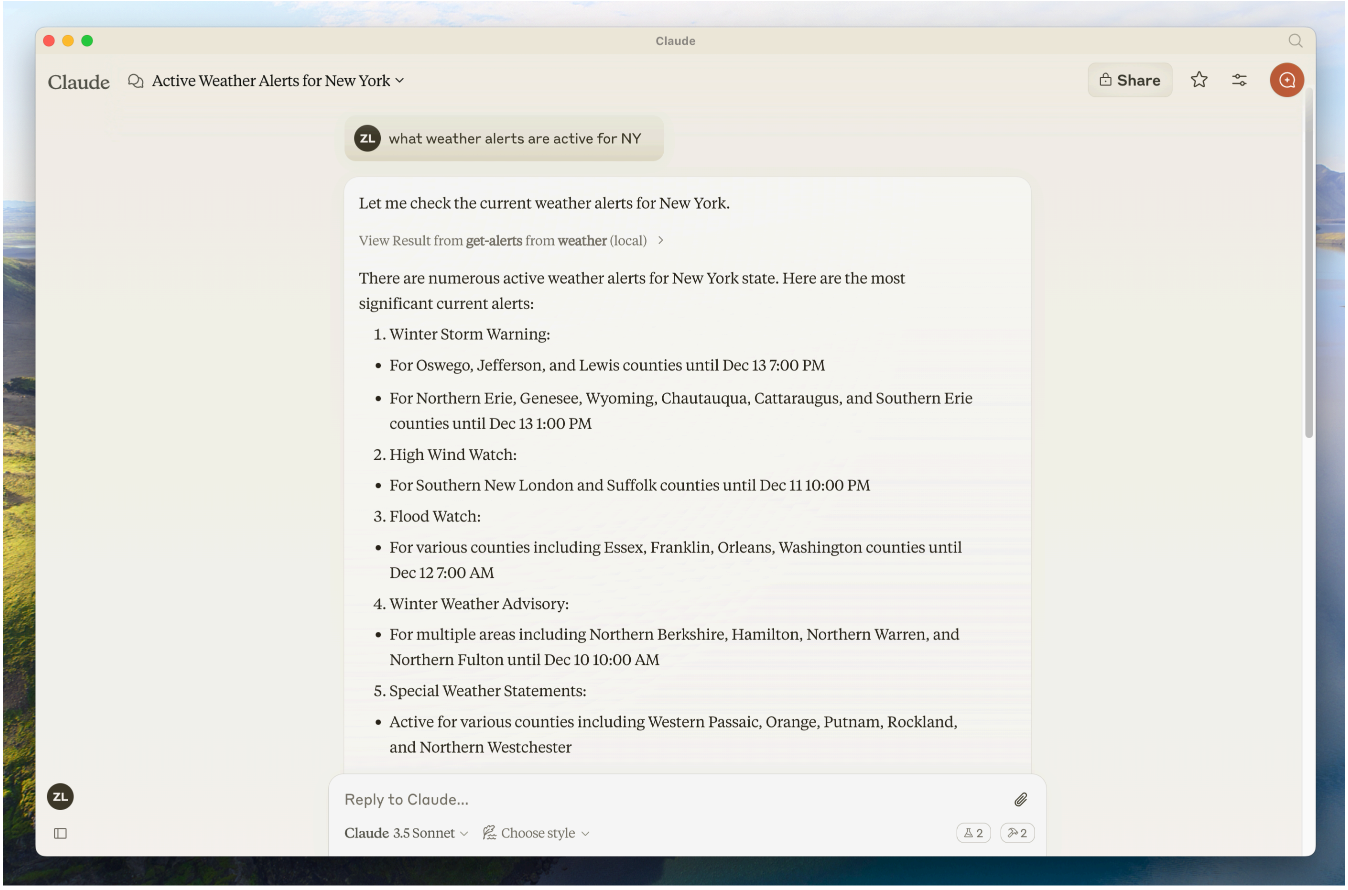



If your server isn't being picked up by Claude for Desktop, proceed to the Troubleshooting section for debugging tips.

If the tool settings icon has shown up, you can now test your server by running the following commands in Claude for Desktop:

- What's the weather in Sacramento?
- What are the active weather alerts in Texas?






Since this is the US National Weather service, the queries will only work for US locations.

## What's happening under the hood

When you ask a question:

1. The client sends your question to Claude
2. Claude analyzes the available tools and decides which one(s) to use
3. The client executes the chosen tool(s) through the MCP server
4. The results are sent back to Claude
5. Claude formulates a natural language response
6. The response is displayed to you!

## Troubleshooting

### Getting logs from Claude for Desktop

```
Claude.app logging related to MCP is written to log files in `~/Library/Logs/Claude`:

* `mcp.log` will contain general logging about MCP connections and connection failures.
* Files named `mcp-server-SERVERNAME.log` will contain error (stderr) logging from the named
server.
```

````
You can run the following command to list recent logs and follow along with any new ones:

```bash
# Check Claude's logs for errors
tail -n 20 -f ~/Library/Logs/Claude/mcp*.log
```

Server not showing up in Claude

1. Check your `claude_desktop_config.json` file syntax
2. Make sure the path to your project is absolute and not relative
3. Restart Claude for Desktop completely

Tool calls failing silently

If Claude attempts to use the tools but they fail:

1. Check Claude's logs for errors
2. Verify your server builds and runs without errors
3. Try restarting Claude for Desktop

None of this is working. What do I do?

Please refer to our [debugging guide](/legacy/tools/debugging) for better debugging tools
and more detailed guidance.
````

**Error: Failed to retrieve grid point data**

```
This usually means either:

1. The coordinates are outside the US
2. The NWS API is having issues
3. You're being rate limited

Fix:

* Verify you're using US coordinates
* Add a small delay between requests
* Check the NWS API status page

**Error: No active alerts for \[STATE]**

This isn't an error - it just means there are no current weather alerts for that state. Try
a different state or check during severe weather.
```

For more advanced troubleshooting, check out our guide on [Debugging MCP]

### Next steps

Learn how to build your own MCP client that can connect to your server

Check out our gallery of official MCP servers and implementations

Learn how to effectively debug MCP servers and integrations

Learn how to use LLMs like Claude to speed up your MCP development

# Inspector

> In-depth guide to using the MCP Inspector for testing and debugging Model Context Protocol servers

The [MCP Inspector](https://github.com/modelcontextprotocol/inspector) is an interactive developer tool for testing and debugging MCP servers. While the [Debugging Guide](/docs/tools/debugging) covers the Inspector as part of the overall debugging toolkit, this document provides a detailed exploration of the Inspector's features and capabilities.

## Getting started

### Installation and basic usage

The Inspector runs directly through `npx` without requiring installation:

```
npx @modelcontextprotocol/inspector <command>
```

```
npx @modelcontextprotocol/inspector <command> <arg1> <arg2>
```

#### Inspecting servers from NPM or PyPi

A common way to start server packages from [NPM](https://npmjs.com) or [PyPi](https://pypi.com).

```
bash
    npx -y @modelcontextprotocol/inspector npx <package-name> <args>
    ### For example
    npx -y @modelcontextprotocol/inspector npx @modelcontextprotocol/server-filesystem
/Users/username/Desktop
```

```bash
npx @modelcontextprotocol/inspector uvx <package-name> <args>
# For example
npx @modelcontextprotocol/inspector uvx mcp-server-git --repository ~/code/mcp/servers.git
```

#### Inspecting locally developed servers

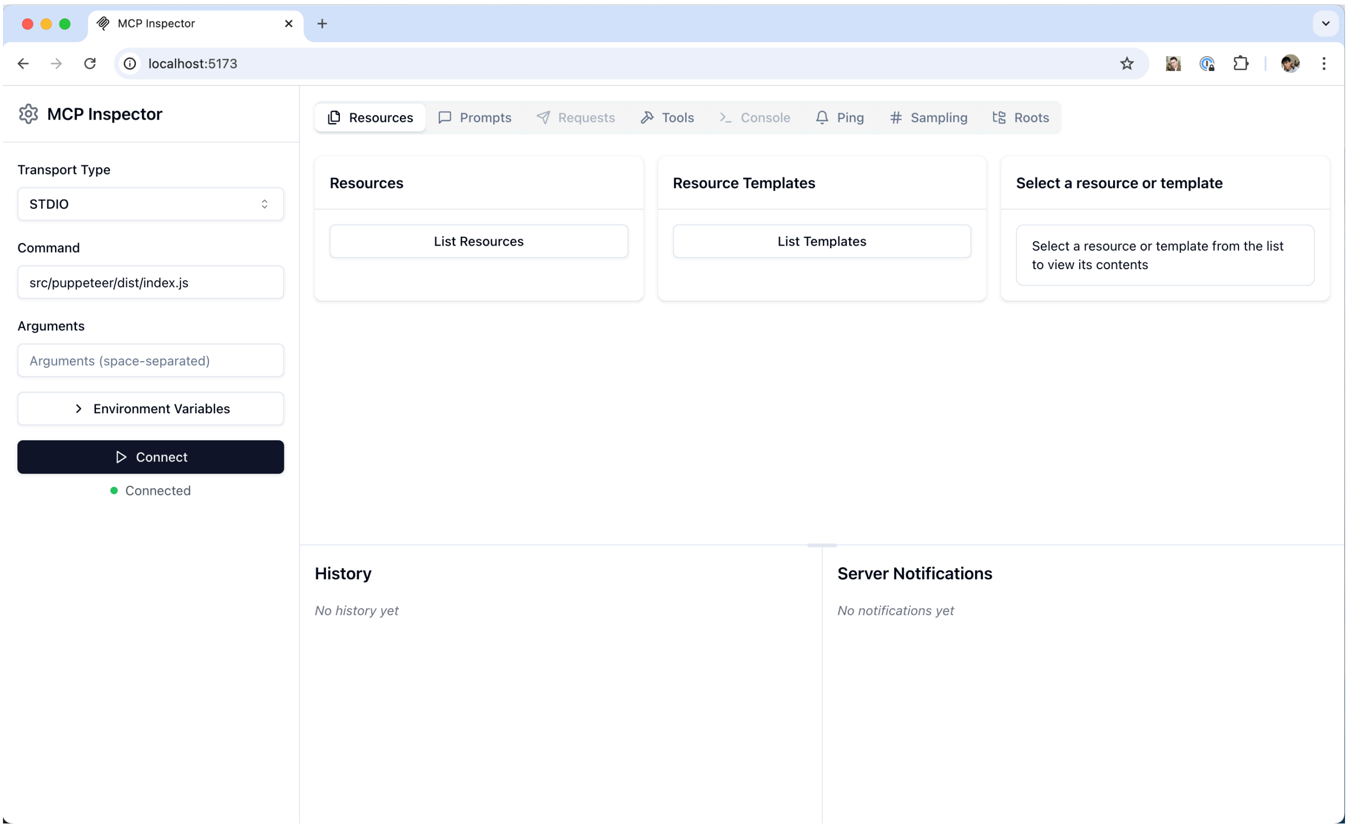
To inspect servers locally developed or downloaded as a repository, the most common way is:

```bash
npx @modelcontextprotocol/inspector node path/to/server/index.js args...
```

```bash
npx @modelcontextprotocol/inspector \
  uv \
  --directory path/to/server \
  run \
  package-name \
  args...
```

Please carefully read any attached README for the most accurate instructions.

## Feature overview




The Inspector provides several features for interacting with your MCP server:

### Server connection pane

- Allows selecting the [transport](transport) for connecting to the server
- For local servers, supports customizing the command-line arguments and environment

### Resources tab

- Lists all available resources
- Shows resource metadata (MIME types, descriptions)
- Allows resource content inspection
- Supports subscription testing

### Prompts tab

- Displays available prompt templates
- Shows prompt arguments and descriptions
- Enables prompt testing with custom arguments
- Previews generated messages

**Tools tab**

- Lists available tools
- Shows tool schemas and descriptions
- Enables tool testing with custom inputs
- Displays tool execution results

**Notifications pane**

- Presents all logs recorded from the server
- Shows notifications received from the server

## Best practices

**Development workflow**

1. Start Development
   - Launch Inspector with your server
   - Verify basic connectivity
   - Check capability negotiation
2. Iterative testing
   - Make server changes
   - Rebuild the server
   - Reconnect the Inspector
   - Test affected features
   - Monitor messages
3. Test edge cases
   - Invalid inputs
   - Missing prompt arguments
   - Concurrent operations
   - Verify error handling and error responses

## Next steps

Check out the MCP Inspector source code

Learn about broader debugging strategies

# Client Development

## Build an MCP Client

> Get started building your own client that can integrate with all MCP servers.

In this tutorial, you'll learn how to build an LLM-powered chatbot client that connects to MCP servers. It helps to have gone through the Server quickstart that guides you through the basics of building your first server.

You can find the complete code for this tutorial here.

````
System Requirements

Before starting, ensure your system meets these requirements:

* Mac or Windows computer
* Latest Python version installed
* Latest version of `uv` installed

Setting Up Your Environment

First, create a new Python project with `uv`:

```bash
# Create project directory
uv init mcp-client
cd mcp-client

# Create virtual environment
uv venv

# Activate virtual environment
# On Windows:
.venv\Scripts\activate
# On Unix or macOS:
source .venv/bin/activate

# Install required packages
uv add mcp anthropic python-dotenv

# Remove boilerplate files
# On Windows:
del main.py
# On Unix or macOS:
rm main.py

# Create our main file
touch client.py
```

Setting Up Your API Key
````

````markdown
You'll need an Anthropic API key from the [Anthropic Console]
(https://console.anthropic.com/settings/keys).

Create a `.env` file to store it:

```bash
# Create .env file
touch .env
```

Add your key to the `.env` file:

```bash
ANTHROPIC_API_KEY=<your key here>
```

Add `.env` to your `.gitignore`:

```bash
echo ".env" >> .gitignore
```

<Warning>
  Make sure you keep your `ANTHROPIC_API_KEY` secure!
</Warning>

#### Creating the Client

##### Basic Client Structure

First, let's set up our imports and create the basic client class:

```python
import asyncio
from typing import Optional
from contextlib import AsyncExitStack

from mcp import ClientSession, StdioServerParameters
from mcp.client.stdio import stdio_client

from anthropic import Anthropic
from dotenv import load_dotenv

load_dotenv()  # load environment variables from .env

class MCPClient:
    def __init__(self):
        # Initialize session and client objects
        self.session: Optional[ClientSession] = None
        self.exit_stack = AsyncExitStack()
        self.anthropic = Anthropic()
    # methods will go here
````
````

````
```

##### Server Connection Management

Next, we'll implement the method to connect to an MCP server:

```python
async def connect_to_server(self, server_script_path: str):
    """Connect to an MCP server

    Args:
        server_script_path: Path to the server script (.py or .js)
    """
    is_python = server_script_path.endswith('.py')
    is_js = server_script_path.endswith('.js')
    if not (is_python or is_js):
        raise ValueError("Server script must be a .py or .js file")

    command = "python" if is_python else "node"
    server_params = StdioServerParameters(
        command=command,
        args=[server_script_path],
        env=None
    )

    stdio_transport = await self.exit_stack.enter_async_context(stdio_client(server_params))
    self.stdio, self.write = stdio_transport
    self.session = await self.exit_stack.enter_async_context(ClientSession(self.stdio,
self.write))

    await self.session.initialize()

    # List available tools
    response = await self.session.list_tools()
    tools = response.tools
    print("\nConnected to server with tools:", [tool.name for tool in tools])
```

Query Processing Logic

Now let's add the core functionality for processing queries and handling tool calls:

```python
async def process_query(self, query: str) -> str:
    """Process a query using Claude and available tools"""
    messages = [
        {
            "role": "user",
            "content": query
        }
    ]

    response = await self.session.list_tools()
````

```
    available_tools = [{
        "name": tool.name,
        "description": tool.description,
        "input_schema": tool.inputSchema
    } for tool in response.tools]

    # Initial Claude API call
    response = self.anthropic.messages.create(
        model="claude-3-5-sonnet-20241022",
        max_tokens=1000,
        messages=messages,
        tools=available_tools
    )

    # Process response and handle tool calls
    final_text = []

    assistant_message_content = []
    for content in response.content:
        if content.type == 'text':
            final_text.append(content.text)
            assistant_message_content.append(content)
        elif content.type == 'tool_use':
            tool_name = content.name
            tool_args = content.input

            # Execute tool call
            result = await self.session.call_tool(tool_name, tool_args)
            final_text.append(f"[Calling tool {tool_name} with args {tool_args}]")

            assistant_message_content.append(content)
            messages.append({
                "role": "assistant",
                "content": assistant_message_content
            })
            messages.append({
                "role": "user",
                "content": [
                    {
                        "type": "tool_result",
                        "tool_use_id": content.id,
                        "content": result.content
                    }
                ]
            })

            # Get next response from Claude
            response = self.anthropic.messages.create(
                model="claude-3-5-sonnet-20241022",
                max_tokens=1000,
                messages=messages,
                tools=available_tools
            )
```

````
            final_text.append(response.content[0].text)

    return "\n".join(final_text)
```

##### Interactive Chat Interface

Now we'll add the chat loop and cleanup functionality:

```python
async def chat_loop(self):
    """Run an interactive chat loop"""
    print("\nMCP Client Started!")
    print("Type your queries or 'quit' to exit.")

    while True:
        try:
            query = input("\nQuery: ").strip()

            if query.lower() == 'quit':
                break

            response = await self.process_query(query)
            print("\n" + response)

        except Exception as e:
            print(f"\nError: {str(e)}")

async def cleanup(self):
    """Clean up resources"""
    await self.exit_stack.aclose()
```

##### Main Entry Point

Finally, we'll add the main execution logic:

```python
async def main():
    if len(sys.argv) < 2:
        print("Usage: python client.py <path_to_server_script>")
        sys.exit(1)

    client = MCPClient()
    try:
        await client.connect_to_server(sys.argv[1])
        await client.chat_loop()
    finally:
        await client.cleanup()

if __name__ == "__main__":
    import sys
````

````
    asyncio.run(main())
```

You can find the complete `client.py` file [here.]
(https://gist.github.com/zckly/f3f28ea731e096e53b39b47bf0a2d4b1)

#### Key Components Explained

##### 1. Client Initialization

* The `MCPClient` class initializes with session management and API clients
* Uses `AsyncExitStack` for proper resource management
* Configures the Anthropic client for Claude interactions

##### 2. Server Connection

* Supports both Python and Node.js servers
* Validates server script type
* Sets up proper communication channels
* Initializes the session and lists available tools

##### 3. Query Processing

* Maintains conversation context
* Handles Claude's responses and tool calls
* Manages the message flow between Claude and tools
* Combines results into a coherent response

##### 4. Interactive Interface

* Provides a simple command-line interface
* Handles user input and displays responses
* Includes basic error handling
* Allows graceful exit

##### 5. Resource Management

* Proper cleanup of resources
* Error handling for connection issues
* Graceful shutdown procedures

#### Common Customization Points

1. **Tool Handling**

   * Modify `process_query()` to handle specific tool types
   * Add custom error handling for tool calls
   * Implement tool-specific response formatting

2. **Response Processing**

   * Customize how tool results are formatted
   * Add response filtering or transformation
````
````

````
   * Implement custom logging

3. **User Interface**
   * Add a GUI or web interface
   * Implement rich console output
   * Add command history or auto-completion

Running the Client

To run your client with any MCP server:

```bash
uv run client.py path/to/server.py # python server
uv run client.py path/to/build/index.js # node server
```

<Note>
  If you're continuing the weather tutorial from the server quickstart, your command might
look something like this: `python client.py .../quickstart-resources/weather-server-
python/weather.py`
</Note>

The client will:

1. Connect to the specified server
2. List available tools
3. Start an interactive chat session where you can:
   * Enter queries
   * See tool executions
   * Get responses from Claude

Here's an example of what it should look like if connected to the weather server from the
server quickstart:

<Frame>
  <img src="https://mintlify.s3.us-west-1.amazonaws.com/mcp/images/client-claude-cli-
python.png" />
</Frame>

How It Works

When you submit a query:

1. The client gets the list of available tools from the server
2. Your query is sent to Claude along with tool descriptions
3. Claude decides which tools (if any) to use
4. The client executes any requested tool calls through the server
5. Results are sent back to Claude
6. Claude provides a natural language response
7. The response is displayed to you

Best practices
````

````
1. **Error Handling**

   * Always wrap tool calls in try-catch blocks
   * Provide meaningful error messages
   * Gracefully handle connection issues

2. **Resource Management**

   * Use `AsyncExitStack` for proper cleanup
   * Close connections when done
   * Handle server disconnections

3. **Security**
   * Store API keys securely in `.env`
   * Validate server responses
   * Be cautious with tool permissions

Troubleshooting

Server Path Issues

* Double-check the path to your server script is correct
* Use the absolute path if the relative path isn't working
* For Windows users, make sure to use forward slashes (/) or escaped backslashes (\\) in the path
* Verify the server file has the correct extension (.py for Python or .js for Node.js)

Example of correct path usage:

```bash
# Relative path
uv run client.py ./server/weather.py

# Absolute path
uv run client.py /Users/username/projects/mcp-server/weather.py

# Windows path (either format works)
uv run client.py C:/projects/mcp-server/weather.py
uv run client.py C:\\projects\\mcp-server\\weather.py
```

Response Timing

* The first response might take up to 30 seconds to return
* This is normal and happens while:
  * The server initializes
  * Claude processes the query
  * Tools are being executed
* Subsequent responses are typically faster
* Don't interrupt the process during this initial waiting period

Common Error Messages
````

````
If you see:

* `FileNotFoundError`: Check your server path
* `Connection refused`: Ensure the server is running and the path is correct
* `Tool execution failed`: Verify the tool's required environment variables are set
* `Timeout error`: Consider increasing the timeout in your client configuration
````

[You can find the complete code for this tutorial here.]()

````
#### System Requirements

Before starting, ensure your system meets these requirements:

* Mac or Windows computer
* Node.js 17 or higher installed
* Latest version of `npm` installed
* Anthropic API key (Claude)

#### Setting Up Your Environment

First, let's create and set up our project:

<CodeGroup>
  ```bash macOS/Linux
  # Create project directory
  mkdir mcp-client-typescript
  cd mcp-client-typescript

  # Initialize npm project
  npm init -y

  # Install dependencies
  npm install @anthropic-ai/sdk @modelcontextprotocol/sdk dotenv

  # Install dev dependencies
  npm install -D @types/node typescript

  # Create source file
  touch index.ts
  ```

  ```powershell Windows
  # Create project directory
  md mcp-client-typescript
  cd mcp-client-typescript

  # Initialize npm project
  npm init -y

  # Install dependencies
````
````

````
  npm install @anthropic-ai/sdk @modelcontextprotocol/sdk dotenv

  # Install dev dependencies
  npm install -D @types/node typescript

  # Create source file
  new-item index.ts
  ```
</CodeGroup>

Update your `package.json` to set `type: "module"` and a build script:

```json package.json
{
  "type": "module",
  "scripts": {
    "build": "tsc && chmod 755 build/index.js"
  }
}
```

Create a `tsconfig.json` in the root of your project:

```json tsconfig.json
{
  "compilerOptions": {
    "target": "ES2022",
    "module": "Node16",
    "moduleResolution": "Node16",
    "outDir": "./build",
    "rootDir": "./",
    "strict": true,
    "esModuleInterop": true,
    "skipLibCheck": true,
    "forceConsistentCasingInFileNames": true
  },
  "include": ["index.ts"],
  "exclude": ["node_modules"]
}
```

Setting Up Your API Key

You'll need an Anthropic API key from the [Anthropic Console]
(https://console.anthropic.com/settings/keys).

Create a `.env` file to store it:

```bash
echo "ANTHROPIC_API_KEY=<your key here>" > .env
```

Add `.env` to your `.gitignore`:
````
````

````
```bash
echo ".env" >> .gitignore
```

<Warning>
  Make sure you keep your `ANTHROPIC_API_KEY` secure!
</Warning>

#### Creating the Client

##### Basic Client Structure

First, let's set up our imports and create the basic client class in `index.ts`:

```typescript
import { Anthropic } from "@anthropic-ai/sdk";
import {
  MessageParam,
  Tool,
} from "@anthropic-ai/sdk/resources/messages/messages.mjs";
import { Client } from "@modelcontextprotocol/sdk/client/index.js";
import { StdioClientTransport } from "@modelcontextprotocol/sdk/client/stdio.js";
import readline from "readline/promises";
import dotenv from "dotenv";

dotenv.config();

const ANTHROPIC_API_KEY = process.env.ANTHROPIC_API_KEY;
if (!ANTHROPIC_API_KEY) {
  throw new Error("ANTHROPIC_API_KEY is not set");
}

class MCPClient {
  private mcp: Client;
  private anthropic: Anthropic;
  private transport: StdioClientTransport | null = null;
  private tools: Tool[] = [];

  constructor() {
    this.anthropic = new Anthropic({
      apiKey: ANTHROPIC_API_KEY,
    });
    this.mcp = new Client({ name: "mcp-client-cli", version: "1.0.0" });
  }
  // methods will go here
}
```

##### Server Connection Management

Next, we'll implement the method to connect to an MCP server:
````

````
```typescript
async connectToServer(serverScriptPath: string) {
  try {
    const isJs = serverScriptPath.endsWith(".js");
    const isPy = serverScriptPath.endsWith(".py");
    if (!isJs && !isPy) {
      throw new Error("Server script must be a .js or .py file");
    }
    const command = isPy
      ? process.platform === "win32"
        ? "python"
        : "python3"
      : process.execPath;

    this.transport = new StdioClientTransport({
      command,
      args: [serverScriptPath],
    });
    await this.mcp.connect(this.transport);

    const toolsResult = await this.mcp.listTools();
    this.tools = toolsResult.tools.map((tool) => {
      return {
        name: tool.name,
        description: tool.description,
        input_schema: tool.inputSchema,
      };
    });
    console.log(
      "Connected to server with tools:",
      this.tools.map(({ name }) => name)
    );
  } catch (e) {
    console.log("Failed to connect to MCP server: ", e);
    throw e;
  }
}
```

##### Query Processing Logic

Now let's add the core functionality for processing queries and handling tool calls:

```typescript
async processQuery(query: string) {
  const messages: MessageParam[] = [
    {
      role: "user",
      content: query,
    },
  ];

  const response = await this.anthropic.messages.create({
````
````

````
    model: "claude-3-5-sonnet-20241022",
    max_tokens: 1000,
    messages,
    tools: this.tools,
  });

  const finalText = [];

  for (const content of response.content) {
    if (content.type === "text") {
      finalText.push(content.text);
    } else if (content.type === "tool_use") {
      const toolName = content.name;
      const toolArgs = content.input as { [x: string]: unknown } | undefined;

      const result = await this.mcp.callTool({
        name: toolName,
        arguments: toolArgs,
      });
      finalText.push(
        `[Calling tool ${toolName} with args ${JSON.stringify(toolArgs)}]`
      );

      messages.push({
        role: "user",
        content: result.content as string,
      });

      const response = await this.anthropic.messages.create({
        model: "claude-3-5-sonnet-20241022",
        max_tokens: 1000,
        messages,
      });

      finalText.push(
        response.content[0].type === "text" ? response.content[0].text : ""
      );
    }
  }

  return finalText.join("\n");
}
```

##### Interactive Chat Interface

Now we'll add the chat loop and cleanup functionality:

```typescript
async chatLoop() {
  const rl = readline.createInterface({
    input: process.stdin,
    output: process.stdout,
````

````
  });

  try {
    console.log("\nMCP Client Started!");
    console.log("Type your queries or 'quit' to exit.");

    while (true) {
      const message = await rl.question("\nQuery: ");
      if (message.toLowerCase() === "quit") {
        break;
      }
      const response = await this.processQuery(message);
      console.log("\n" + response);
    }
  } finally {
    rl.close();
  }
}

async cleanup() {
  await this.mcp.close();
}
```

##### Main Entry Point

Finally, we'll add the main execution logic:

```typescript
async function main() {
  if (process.argv.length < 3) {
    console.log("Usage: node index.ts <path_to_server_script>");
    return;
  }
  const mcpClient = new MCPClient();
  try {
    await mcpClient.connectToServer(process.argv[2]);
    await mcpClient.chatLoop();
  } finally {
    await mcpClient.cleanup();
    process.exit(0);
  }
}

main();
```

#### Running the Client

To run your client with any MCP server:

```bash
# Build TypeScript
````

````
npm run build

# Run the client
node build/index.js path/to/server.py # python server
node build/index.js path/to/build/index.js # node server
```

<Note>
  If you're continuing the weather tutorial from the server quickstart, your command might look something like this: `node build/index.js .../quickstart-resources/weather-server-typescript/build/index.js`
</Note>

**The client will:**

1. Connect to the specified server
2. List available tools
3. Start an interactive chat session where you can:
   * Enter queries
   * See tool executions
   * Get responses from Claude

#### How It Works

When you submit a query:

1. The client gets the list of available tools from the server
2. Your query is sent to Claude along with tool descriptions
3. Claude decides which tools (if any) to use
4. The client executes any requested tool calls through the server
5. Results are sent back to Claude
6. Claude provides a natural language response
7. The response is displayed to you

#### Best practices

1. **Error Handling**

   * Use TypeScript's type system for better error detection
   * Wrap tool calls in try-catch blocks
   * Provide meaningful error messages
   * Gracefully handle connection issues

2. **Security**
   * Store API keys securely in `.env`
   * Validate server responses
   * Be cautious with tool permissions

#### Troubleshooting

##### Server Path Issues

* Double-check the path to your server script is correct
````
````

````
* Use the absolute path if the relative path isn't working
* For Windows users, make sure to use forward slashes (/) or escaped backslashes (\\) in the path
* Verify the server file has the correct extension (.js for Node.js or .py for Python)

Example of correct path usage:

```bash
# Relative path
node build/index.js ./server/build/index.js

# Absolute path
node build/index.js /Users/username/projects/mcp-server/build/index.js

# Windows path (either format works)
node build/index.js C:/projects/mcp-server/build/index.js
node build/index.js C:\\projects\\mcp-server\\build\\index.js
```

Response Timing

* The first response might take up to 30 seconds to return
* This is normal and happens while:
  * The server initializes
  * Claude processes the query
  * Tools are being executed
* Subsequent responses are typically faster
* Don't interrupt the process during this initial waiting period

Common Error Messages

If you see:

* `Error: Cannot find module`: Check your build folder and ensure TypeScript compilation succeeded
* `Connection refused`: Ensure the server is running and the path is correct
* `Tool execution failed`: Verify the tool's required environment variables are set
* `ANTHROPIC_API_KEY is not set`: Check your .env file and environment variables
* `TypeError`: Ensure you're using the correct types for tool arguments
````

This is a quickstart demo based on Spring AI MCP auto-configuration and boot starters.
To learn how to create sync and async MCP Clients manually, consult the [Java SDK Client](#) documentation

````
This example demonstrates how to build an interactive chatbot that combines Spring AI's
Model Context Protocol (MCP) with the [Brave Search MCP Server]
(https://github.com/modelcontextprotocol/servers-archived/tree/main/src/brave-search). The
application creates a conversational interface powered by Anthropic's Claude AI model that
can perform internet searches through Brave Search, enabling natural language interactions
with real-time web data.
[You can find the complete code for this tutorial here.](https://github.com/spring-
projects/spring-ai-examples/tree/main/model-context-protocol/web-search/brave-chatbot)

System Requirements

Before starting, ensure your system meets these requirements:

* Java 17 or higher
* Maven 3.6+
* npx package manager
* Anthropic API key (Claude)
* Brave Search API key

Setting Up Your Environment

1. Install npx (Node Package eXecute):
   First, make sure to install [npm](https://docs.npmjs.com/downloading-and-installing-node-
js-and-npm)
   and then run:

   ```bash
   npm install -g npx
   ```

2. Clone the repository:

   ```bash
   git clone https://github.com/spring-projects/spring-ai-examples.git
   cd model-context-protocol/brave-chatbot
   ```

3. Set up your API keys:

   ```bash
   export ANTHROPIC_API_KEY='your-anthropic-api-key-here'
   export BRAVE_API_KEY='your-brave-api-key-here'
   ```

4. Build the application:

   ```bash
   ./mvnw clean install
   ```

5. Run the application using Maven:
   ```bash
   ./mvnw spring-boot:run
````
````

~~~~
  ```

<Warning>
  Make sure you keep your `ANTHROPIC_API_KEY` and `BRAVE_API_KEY` keys secure!
</Warning>

#### How it Works

The application integrates Spring AI with the Brave Search MCP server through several
components:

##### MCP Client Configuration

1. Required dependencies in pom.xml:

```xml
<dependency>
    <groupId>org.springframework.ai</groupId>
    <artifactId>spring-ai-starter-mcp-client</artifactId>
</dependency>
<dependency>
    <groupId>org.springframework.ai</groupId>
    <artifactId>spring-ai-starter-model-anthropic</artifactId>
</dependency>
```

2. Application properties (application.yml):

```yml
spring:
  ai:
    mcp:
      client:
        enabled: true
        name: brave-search-client
        version: 1.0.0
        type: SYNC
        request-timeout: 20s
        stdio:
          root-change-notification: true
          servers-configuration: classpath:/mcp-servers-config.json
        toolcallback:
          enabled: true
    anthropic:
      api-key: ${ANTHROPIC_API_KEY}
```

This activates the `spring-ai-starter-mcp-client` to create one or more `McpClient`s based
on the provided server configuration.
The `spring.ai.mcp.client.toolcallback.enabled=true` property enables the tool callback
mechanism, that automatically registers all MCP tool as spring ai tools.
It is disabled by default.
~~~~

````
3. MCP Server Configuration (`mcp-servers-config.json`):

```json
{
  "mcpServers": {
    "brave-search": {
      "command": "npx",
      "args": ["-y", "@modelcontextprotocol/server-brave-search"],
      "env": {
        "BRAVE_API_KEY": "<PUT YOUR BRAVE API KEY>"
      }
    }
  }
}
```

Chat Implementation

The chatbot is implemented using Spring AI's ChatClient with MCP tool integration:

```java
var chatClient = chatClientBuilder
    .defaultSystem("You are useful assistant, expert in AI and Java.")
    .defaultToolCallbacks((Object[]) mcpToolAdapter.toolCallbacks())
    .defaultAdvisors(new MessageChatMemoryAdvisor(new InMemoryChatMemory()))
    .build();
```

<Warning>
  Breaking change: From SpringAI 1.0.0-M8 onwards, use `.defaultToolCallbacks(...)` instead
of `.defaultTool(...)` to register MCP tools.
</Warning>

Key features:

* Uses Claude AI model for natural language understanding
* Integrates Brave Search through MCP for real-time web search capabilities
* Maintains conversation memory using InMemoryChatMemory
* Runs as an interactive command-line application

Build and run

```bash
./mvnw clean install
java -jar ./target/ai-mcp-brave-chatbot-0.0.1-SNAPSHOT.jar
```

or

```bash
./mvnw spring-boot:run
```
````

````
The application will start an interactive chat session where you can ask questions. The
chatbot will use Brave Search when it needs to find information from the internet to answer
your queries.

The chatbot can:

* Answer questions using its built-in knowledge
* Perform web searches when needed using Brave Search
* Remember context from previous messages in the conversation
* Combine information from multiple sources to provide comprehensive answers

##### Advanced Configuration

The MCP client supports additional configuration options:

* Client customization through `McpSyncClientCustomizer` or `McpAsyncClientCustomizer`
* Multiple clients with multiple transport types: `STDIO` and `SSE` (Server-Sent Events)
* Integration with Spring AI's tool execution framework
* Automatic client initialization and lifecycle management

For WebFlux-based applications, you can use the WebFlux starter instead:

```xml
<dependency>
    <groupId>org.springframework.ai</groupId>
    <artifactId>spring-ai-mcp-client-webflux-spring-boot-starter</artifactId>
</dependency>
```

This provides similar functionality but uses a WebFlux-based SSE transport implementation,
recommended for production deployments.
````

[You can find the complete code for this tutorial here.]

````
#### System Requirements

Before starting, ensure your system meets these requirements:

* Java 17 or higher
* Anthropic API key (Claude)

#### Setting up your environment

First, let's install `java` and `gradle` if you haven't already.
You can download `java` from [official Oracle JDK website]
(https://www.oracle.com/java/technologies/downloads/).
Verify your `java` installation:

```bash
java --version
````
````

````
```

Now, let's create and set up your project:

<CodeGroup>
  ```bash macOS/Linux
  # Create a new directory for our project
  mkdir kotlin-mcp-client
  cd kotlin-mcp-client

  # Initialize a new kotlin project
  gradle init
  ```

  ```powershell Windows
  # Create a new directory for our project
  md kotlin-mcp-client
  cd kotlin-mcp-client
  # Initialize a new kotlin project
  gradle init
  ```
</CodeGroup>

After running `gradle init`, you will be presented with options for creating your project.
Select **Application** as the project type, **Kotlin** as the programming language, and
**Java 17** as the Java version.

Alternatively, you can create a Kotlin application using the [IntelliJ IDEA project wizard]
(https://kotlinlang.org/docs/jvm-get-started.html).

After creating the project, add the following dependencies:

<CodeGroup>
  ```kotlin build.gradle.kts
  val mcpVersion = "0.4.0"
  val slf4jVersion = "2.0.9"
  val anthropicVersion = "0.8.0"

  dependencies {
      implementation("io.modelcontextprotocol:kotlin-sdk:$mcpVersion")
      implementation("org.slf4j:slf4j-nop:$slf4jVersion")
      implementation("com.anthropic:anthropic-java:$anthropicVersion")
  }
  ```

  ```groovy build.gradle
  def mcpVersion = '0.3.0'
  def slf4jVersion = '2.0.9'
  def anthropicVersion = '0.8.0'
  dependencies {
      implementation "io.modelcontextprotocol:kotlin-sdk:$mcpVersion"
      implementation "org.slf4j:slf4j-nop:$slf4jVersion"
      implementation "com.anthropic:anthropic-java:$anthropicVersion"
````

````
  }
  ```
</CodeGroup>

Also, add the following plugins to your build script:

<CodeGroup>
  ```kotlin build.gradle.kts
  plugins {
      id("com.github.johnrengelman.shadow") version "8.1.1"
  }
  ```

  ```groovy build.gradle
  plugins {
      id 'com.github.johnrengelman.shadow' version '8.1.1'
  }
  ```
</CodeGroup>

#### Setting up your API key

You'll need an Anthropic API key from the [Anthropic Console]
(https://console.anthropic.com/settings/keys).

Set up your API key:

```bash
export ANTHROPIC_API_KEY='your-anthropic-api-key-here'
```

<Warning>
  Make sure your keep your `ANTHROPIC_API_KEY` secure!
</Warning>

#### Creating the Client

##### Basic Client Structure

First, let's create the basic client class:

```kotlin
class MCPClient : AutoCloseable {
    private val anthropic = AnthropicOkHttpClient.fromEnv()
    private val mcp: Client = Client(clientInfo = Implementation(name = "mcp-client-cli",
version = "1.0.0"))
    private lateinit var tools: List<ToolUnion>

    // methods will go here

    override fun close() {
        runBlocking {
            mcp.close()
````

````
            anthropic.close()
        }
    }
```

##### Server connection management

Next, we'll implement the method to connect to an MCP server:

```kotlin
suspend fun connectToServer(serverScriptPath: String) {
    try {
        val command = buildList {
            when (serverScriptPath.substringAfterLast(".")) {
                "js" -> add("node")
                "py" -> add(if (System.getProperty("os.name").lowercase().contains("win"))
"python" else "python3")
                "jar" -> addAll(listOf("java", "-jar"))
                else -> throw IllegalArgumentException("Server script must be a .js, .py or
.jar file")
            }
            add(serverScriptPath)
        }

        val process = ProcessBuilder(command).start()
        val transport = StdioClientTransport(
            input = process.inputStream.asSource().buffered(),
            output = process.outputStream.asSink().buffered()
        )

        mcp.connect(transport)

        val toolsResult = mcp.listTools()
        tools = toolsResult?.tools?.map { tool ->
            ToolUnion.ofTool(
                Tool.builder()
                    .name(tool.name)
                    .description(tool.description ?: "")
                    .inputSchema(
                        Tool.InputSchema.builder()
                            .type(JsonValue.from(tool.inputSchema.type))
                            .properties(tool.inputSchema.properties.toJsonValue())
                            .putAdditionalProperty("required",
JsonValue.from(tool.inputSchema.required))
                            .build()
                    )
                    .build()
            )
        } ?: emptyList()
        println("Connected to server with tools: ${tools.joinToString(", ") {
it.tool().get().name() }}")
    } catch (e: Exception) {
        println("Failed to connect to MCP server: $e")
````

````markdown
        throw e
    }
}
```

Also create a helper function to convert from `JsonObject` to `JsonValue` for Anthropic:

```kotlin
private fun JsonObject.toJsonValue(): JsonValue {
    val mapper = ObjectMapper()
    val node = mapper.readTree(this.toString())
    return JsonValue.fromJsonNode(node)
}
```

##### Query processing logic

Now let's add the core functionality for processing queries and handling tool calls:

```kotlin
private val messageParamsBuilder: MessageCreateParams.Builder =
MessageCreateParams.builder()
    .model(Model.CLAUDE_3_5_SONNET_20241022)
    .maxTokens(1024)

suspend fun processQuery(query: String): String {
    val messages = mutableListOf(
        MessageParam.builder()
            .role(MessageParam.Role.USER)
            .content(query)
            .build()
    )

    val response = anthropic.messages().create(
        messageParamsBuilder
            .messages(messages)
            .tools(tools)
            .build()
    )

    val finalText = mutableListOf<String>()
    response.content().forEach { content ->
        when {
            content.isText() -> finalText.add(content.text().getOrNull()?.text() ?: "")

            content.isToolUse() -> {
                val toolName = content.toolUse().get().name()
                val toolArgs =
                    content.toolUse().get()._input().convert(object :
TypeReference<Map<String, JsonValue>>() {})

                val result = mcp.callTool(
                    name = toolName,
````

````
                    arguments = toolArgs ?: emptyMap()
                )
                finalText.add("[Calling tool $toolName with args $toolArgs]")

                messages.add(
                    MessageParam.builder()
                        .role(MessageParam.Role.USER)
                        .content(
                            """
                                "type": "tool_result",
                                "tool_name": $toolName,
                                "result": ${result?.content?.joinToString("\n") { (it as
TextContent).text ?: "" }}
                            """.trimIndent()
                        )
                        .build()
                )

                val aiResponse = anthropic.messages().create(
                    messageParamsBuilder
                        .messages(messages)
                        .build()
                )

                finalText.add(aiResponse.content().first().text().getOrNull()?.text() ?: "")
            }
        }
    }

    return finalText.joinToString("\n", prefix = "", postfix = "")
}
```

##### Interactive chat

We'll add the chat loop:

```kotlin
suspend fun chatLoop() {
    println("\nMCP Client Started!")
    println("Type your queries or 'quit' to exit.")

    while (true) {
        print("\nQuery: ")
        val message = readLine() ?: break
        if (message.lowercase() == "quit") break
        val response = processQuery(message)
        println("\n$response")
    }
}
```

##### Main entry point
````
````

````
Finally, we'll add the main execution function:

```kotlin
fun main(args: Array<String>) = runBlocking {
    if (args.isEmpty()) throw IllegalArgumentException("Usage: java -jar
<your_path>/build/libs/kotlin-mcp-client-0.1.0-all.jar <path_to_server_script>")
    val serverPath = args.first()
    val client = MCPClient()
    client.use {
        client.connectToServer(serverPath)
        client.chatLoop()
    }
}
```

#### Running the client

To run your client with any MCP server:

```bash
./gradlew build

# Run the client
java -jar build/libs/<your-jar-name>.jar path/to/server.jar # jvm server
java -jar build/libs/<your-jar-name>.jar path/to/server.py # python server
java -jar build/libs/<your-jar-name>.jar path/to/build/index.js # node server
```

<Note>
  If you're continuing the weather tutorial from the server quickstart, your command might
look something like this: `java -jar build/libs/kotlin-mcp-client-0.1.0-all.jar
.../samples/weather-stdio-server/build/libs/weather-stdio-server-0.1.0-all.jar`
</Note>

**The client will:**

1. Connect to the specified server
2. List available tools
3. Start an interactive chat session where you can:
   * Enter queries
   * See tool executions
   * Get responses from Claude

#### How it works

Here's a high-level workflow schema:

```mermaid
---
config:
    theme: neutral
---
````
````

````
sequenceDiagram
    actor User
    participant Client
    participant Claude
    participant MCP_Server as MCP Server
    participant Tools

    User->>Client: Send query
    Client<<->>MCP_Server: Get available tools
    Client->>Claude: Send query with tool descriptions
    Claude-->>Client: Decide tool execution
    Client->>MCP_Server: Request tool execution
    MCP_Server->>Tools: Execute chosen tools
    Tools-->>MCP_Server: Return results
    MCP_Server-->>Client: Send results
    Client->>Claude: Send tool results
    Claude-->>Client: Provide final response
    Client-->>User: Display response
```

When you submit a query:

1. The client gets the list of available tools from the server
2. Your query is sent to Claude along with tool descriptions
3. Claude decides which tools (if any) to use
4. The client executes any requested tool calls through the server
5. Results are sent back to Claude
6. Claude provides a natural language response
7. The response is displayed to you

#### Best practices

1. **Error Handling**

   * Leverage Kotlin's type system to model errors explicitly
   * Wrap external tool and API calls in `try-catch` blocks when exceptions are possible
   * Provide clear and meaningful error messages
   * Handle network timeouts and connection issues gracefully

2. **Security**
   * Store API keys and secrets securely in `local.properties`, environment variables, or
secret managers
   * Validate all external responses to avoid unexpected or unsafe data usage
   * Be cautious with permissions and trust boundaries when using tools

#### Troubleshooting

##### Server Path Issues

* Double-check the path to your server script is correct
* Use the absolute path if the relative path isn't working
* For Windows users, make sure to use forward slashes (/) or escaped backslashes (\\) in the
path
````
````

````
* Make sure that the required runtime is installed (java for Java, npm for Node.js, or uv
for Python)
* Verify the server file has the correct extension (.jar for Java, .js for Node.js or .py
for Python)

Example of correct path usage:

```bash
# Relative path
java -jar build/libs/client.jar ./server/build/libs/server.jar

# Absolute path
java -jar build/libs/client.jar /Users/username/projects/mcp-server/build/libs/server.jar

# Windows path (either format works)
java -jar build/libs/client.jar C:/projects/mcp-server/build/libs/server.jar
java -jar build/libs/client.jar C:\\projects\\mcp-server\\build\\libs\\server.jar
```

##### Response Timing

* The first response might take up to 30 seconds to return
* This is normal and happens while:
  * The server initializes
  * Claude processes the query
  * Tools are being executed
* Subsequent responses are typically faster
* Don't interrupt the process during this initial waiting period

##### Common Error Messages

If you see:

* `Connection refused`: Ensure the server is running and the path is correct
* `Tool execution failed`: Verify the tool's required environment variables are set
* `ANTHROPIC_API_KEY is not set`: Check your environment variables
````

[You can find the complete code for this tutorial here.]()

````
#### System Requirements

Before starting, ensure your system meets these requirements:

* .NET 8.0 or higher
* Anthropic API key (Claude)
* Windows, Linux, or macOS

#### Setting up your environment

First, create a new .NET project:
````

````
```bash
dotnet new console -n QuickstartClient
cd QuickstartClient
```

Then, add the required dependencies to your project:

```bash
dotnet add package ModelContextProtocol --prerelease
dotnet add package Anthropic.SDK
dotnet add package Microsoft.Extensions.Hosting
dotnet add package Microsoft.Extensions.AI
```

#### Setting up your API key

You'll need an Anthropic API key from the [Anthropic Console]
(https://console.anthropic.com/settings/keys).

```bash
dotnet user-secrets init
dotnet user-secrets set "ANTHROPIC_API_KEY" "<your key here>"
```

#### Creating the Client

##### Basic Client Structure

First, let's setup the basic client class in the file `Program.cs`:

```csharp
using Anthropic.SDK;
using Microsoft.Extensions.AI;
using Microsoft.Extensions.Configuration;
using Microsoft.Extensions.Hosting;
using ModelContextProtocol.Client;
using ModelContextProtocol.Protocol.Transport;

var builder = Host.CreateApplicationBuilder(args);

builder.Configuration
    .AddEnvironmentVariables()
    .AddUserSecrets<Program>();
```

This creates the beginnings of a .NET console application that can read the API key from
user secrets.

Next, we'll setup the MCP Client:

```csharp
var (command, arguments) = GetCommandAndArguments(args);
````
````

````
var clientTransport = new StdioClientTransport(new()
{
    Name = "Demo Server",
    Command = command,
    Arguments = arguments,
});

await using var mcpClient = await McpClientFactory.CreateAsync(clientTransport);

var tools = await mcpClient.ListToolsAsync();
foreach (var tool in tools)
{
    Console.WriteLine($"Connected to server with tools: {tool.Name}");
}
```

Add this function at the end of the `Program.cs` file:

```csharp
static (string command, string[] arguments) GetCommandAndArguments(string[] args)
{
    return args switch
    {
        [var script] when script.EndsWith(".py") => ("python", args),
        [var script] when script.EndsWith(".js") => ("node", args),
        [var script] when Directory.Exists(script) || (File.Exists(script) && script.EndsWith(".csproj")) => ("dotnet", ["run", "--project", script, "--no-build"]),
        _ => throw new NotSupportedException("An unsupported server script was provided. Supported scripts are .py, .js, or .csproj")
    };
}
```

This creates a MCP client that will connect to a server that is provided as a command line
argument. It then lists the available tools from the connected server.

##### Query processing logic

Now let's add the core functionality for processing queries and handling tool calls:

```csharp
using var anthropicClient = new AnthropicClient(new APIAuthentication(builder.Configuration["ANTHROPIC_API_KEY"]))
    .Messages
    .AsBuilder()
    .UseFunctionInvocation()
    .Build();

var options = new ChatOptions
{
    MaxOutputTokens = 1000,
    ModelId = "claude-3-5-sonnet-20241022",
````

````
    Tools = [.. tools]
};

Console.ForegroundColor = ConsoleColor.Green;
Console.WriteLine("MCP Client Started!");
Console.ResetColor();

PromptForInput();
while(Console.ReadLine() is string query && !"exit".Equals(query,
StringComparison.OrdinalIgnoreCase))
{
    if (string.IsNullOrWhiteSpace(query))
    {
        PromptForInput();
        continue;
    }

    await foreach (var message in anthropicClient.GetStreamingResponseAsync(query, options))
    {
        Console.Write(message);
    }
    Console.WriteLine();

    PromptForInput();
}

static void PromptForInput()
{
    Console.WriteLine("Enter a command (or 'exit' to quit):");
    Console.ForegroundColor = ConsoleColor.Cyan;
    Console.Write("> ");
    Console.ResetColor();
}
```

#### Key Components Explained

##### 1. Client Initialization

* The client is initialized using `McpClientFactory.CreateAsync()`, which sets up the
transport type and command to run the server.

##### 2. Server Connection

* Supports Python, Node.js, and .NET servers.
* The server is started using the command specified in the arguments.
* Configures to use stdio for communication with the server.
* Initializes the session and available tools.

##### 3. Query Processing

* Leverages [Microsoft.Extensions.AI](https://learn.microsoft.com/dotnet/ai/ai-extensions)
for the chat client.
````
````

````
* Configures the `IChatClient` to use automatic tool (function) invocation.
* The client reads user input and sends it to the server.
* The server processes the query and returns a response.
* The response is displayed to the user.

#### Running the Client

To run your client with any MCP server:

```bash
dotnet run -- path/to/server.csproj # dotnet server
dotnet run -- path/to/server.py # python server
dotnet run -- path/to/server.js # node server
```

<Note>
  If you're continuing the weather tutorial from the server quickstart, your command might look something like this: `dotnet run -- path/to/QuickstartWeatherServer`.
</Note>

The client will:

1. Connect to the specified server
2. List available tools
3. Start an interactive chat session where you can:
   * Enter queries
   * See tool executions
   * Get responses from Claude
4. Exit the session when done

Here's an example of what it should look like it connected to a weather server quickstart:

<Frame>
  <img src="https://mintlify.s3.us-west-1.amazonaws.com/mcp/images/quickstart-dotnet-client.png" />
</Frame>
````

Next steps

Check out our gallery of official MCP servers and implementations

View the list of clients that support MCP integrations

Learn how to use LLMs like Claude to speed up your MCP development

Understand how MCP connects clients, servers, and LLMs

FAQs

> Explaining MCP and why it matters in simple terms

What is MCP?

MCP (Model Context Protocol) is a standard way for AI applications and agents to connect to and work with your data sources (e.g. local files, databases, or content repositories) and tools (e.g. GitHub, Google Maps, or Puppeteer).

Think of MCP as a universal adapter for AI applications, similar to what USB-C is for physical devices. USB-C acts as a universal adapter to connect devices to various peripherals and accessories. Similarly, MCP provides a standardized way to connect AI applications to different data and tools.

Before USB-C, you needed different cables for different connections. Similarly, before MCP, developers had to build custom connections to each data source or tool they wanted their AI application to work with—a time-consuming process that often resulted in limited functionality. Now, with MCP, developers can easily add connections to their AI applications, making their applications much more powerful from day one.

Why does MCP matter?

For AI application users

MCP means your AI applications can access the information and tools you work with every day, making them much more helpful. Rather than AI being limited to what it already knows about, it can now understand your specific documents, data, and work context.

For example, by using MCP servers, applications can access your personal documents from Google Drive or data about your codebase from GitHub, providing more personalized and contextually relevant assistance.

Imagine asking an AI assistant: "Summarize last week's team meeting notes and schedule follow-ups with everyone."

By using connections to data sources powered by MCP, the AI assistant can:

- Connect to your Google Drive through an MCP server to read meeting notes
- Understand who needs follow-ups based on the notes
- Connect to your calendar through another MCP server to schedule the meetings automatically

For developers

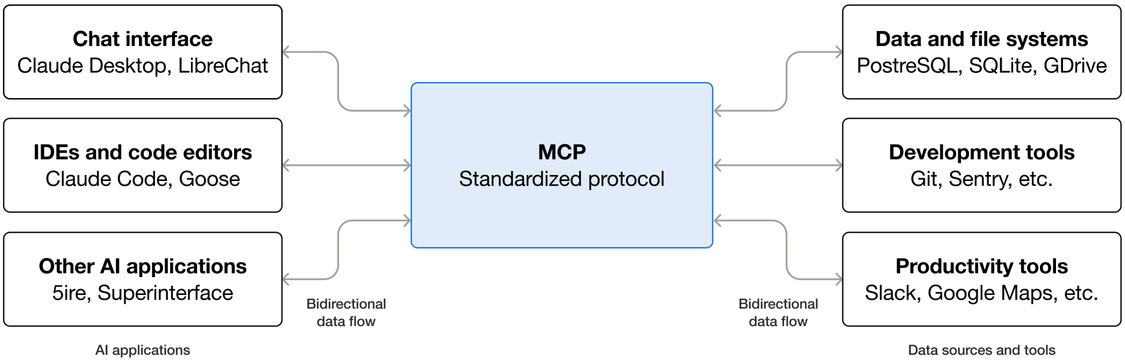
MCP reduces development time and complexity when building AI applications that need to access various data sources. With MCP, developers can focus on building great AI experiences rather than repeatedly creating custom connectors.

Traditionally, connecting applications with data sources required building custom, one-off connections for each data source and each application. This created significant duplicative work—every developer wanting to connect their AI application to Google Drive or Slack needed to build their own connection.

MCP simplifies this by enabling developers to build MCP servers for data sources that are then reusable by various applications. For example, using the open source Google Drive MCP server, many different applications can access data from Google Drive without each developer needing to build a custom connection.

This open source ecosystem of MCP servers means developers can leverage existing work rather than starting from scratch, making it easier to build powerful AI applications that seamlessly integrate with the tools and data sources their users already rely on.

How does MCP work?



MCP creates a bridge between your AI applications and your data through a straightforward system:

- **MCP servers** connect to your data sources and tools (like Google Drive or Slack)
- **MCP clients** are run by AI applications (like Claude Desktop) to connect them to these servers
- When you give permission, your AI application discovers available MCP servers
- The AI model can then use these connections to read information and take actions

This modular system means new capabilities can be added without changing AI applications themselves—just like adding new accessories to your computer without upgrading your entire system.

Who creates and maintains MCP servers?

MCP servers are developed and maintained by:

- Developers at Anthropic who build servers for common tools and data sources
- Open source contributors who create servers for tools they use
- Enterprise development teams building servers for their internal systems
- Software providers making their applications AI-ready

Once an open source MCP server is created for a data source, it can be used by any MCP-compatible AI application, creating a growing ecosystem of connections. See our [list of example servers](), or [get started building your own server]().