Concepts

Architecture Overview

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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.

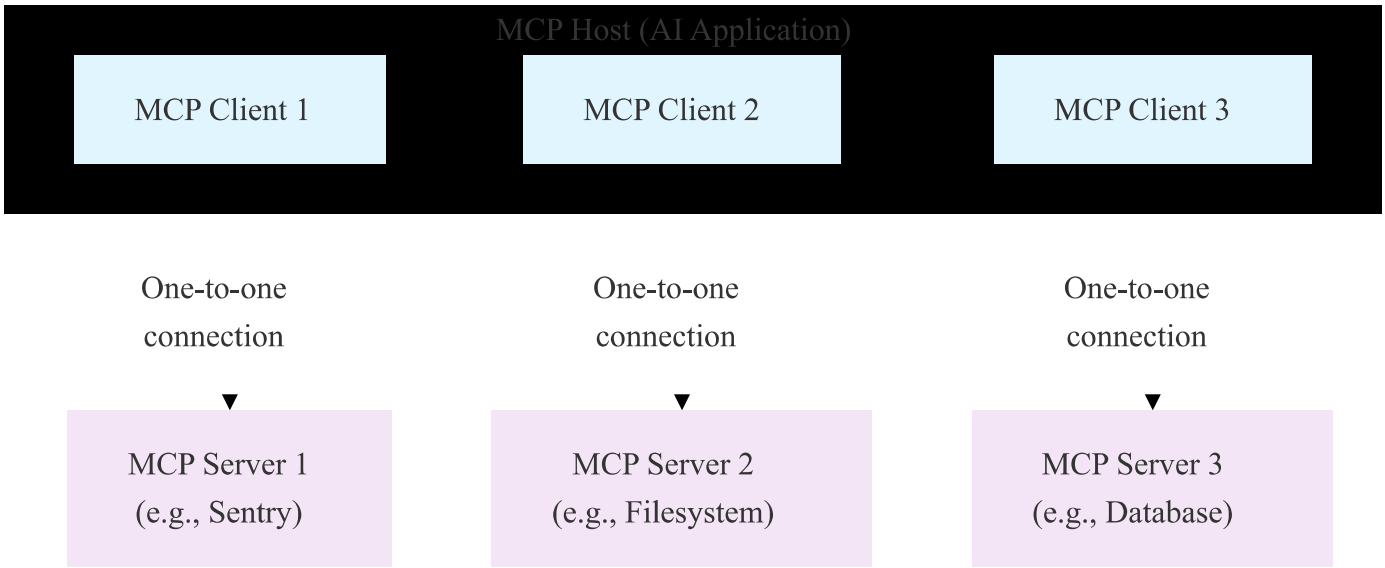
The key participants in the MCP architecture are:

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 offical **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, 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 provides core functionality including tools for AI actions, resources for context data, and prompts for interaction templates from 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 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 it's 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.

1 **Initialization (Lifecycle Management)**

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.

Request Response

```
{
  "jsonrpc": "2.0",
  "id": 1,
  "method": "initialize",
  "params": {
    "protocolVersion": "2025-06-18",
    "capabilities": {
      "tools": {}
    },
    "clientInfo": {
      "name": "example-client",
      "version": "1.0.0"
    }
  }
}
```

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** they can handle (tools, resources, prompts) and whether they support features like **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:

> `"tools": {}` - The client declares it can work with the tools primitive (can call `tools/list` and `tools/call` methods)

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:

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.

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)
```

2 **Tool Discovery (Primitives)**

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 tool are available on the server before attempting to use them.

Request Response

```
{
  "jsonrpc": "2.0",
  "id": 2,
  "method": "tools/list"
}
```

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 be URI-like for better namespacing (e.g., `com.example.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.

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)
```

3 **Tool Execution (Primitives)**

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 (`com.example.weather/current`) rather than a simplified name:

Request Response

```
{
  "jsonrpc": "2.0",
  "id": 3,
  "method": "tools/call",
  "params": {
    "name": "com.example.weather/current",
    "arguments": {
      "location": "San Francisco",
      "units": "imperial"
    }
  }
}
```

Key Elements of Tool Execution

The request structure includes several important components:

1. `name` : Must match exactly the tool name from the discovery response (`com.example.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.

```
# 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)
```

4 **Real-time Updates (Notifications)**

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:

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:

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.

```
# 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()
```