Python Implementation of Model Context Protocol (MCP) for Enhanced AI Integration

1. Introduction to Model Context Protocol (MCP)

The Model Context Protocol (MCP) has emerged as an open standard that aims to revolutionize the way AI assistants interact with the vast ecosystem of data and tools available today.[1] By providing a universal protocol, MCP addresses the challenges of fragmented integrations that have historically plagued the connection of Large Language Models (LLMs) with external resources.[1] The core objective of MCP is to enable LLMs to efficiently access and utilize both local and remote data sources, thereby enhancing their ability to provide more relevant and context-aware responses.[1] This standardized approach can be likened to a "USB-C port for AI applications," suggesting a versatile and widely applicable interface for connecting diverse AI models with a multitude of functionalities.[3]

At its heart, MCP operates on a client-server architecture, involving three primary components: Hosts, Clients, and Servers.[1] Hosts are typically the LLM applications themselves, such as chatbots or Integrated Development Environments (IDEs), which initiate connections to MCP Servers.[1] Clients, residing within these host applications, establish and maintain one-to-one connections with specific servers.[1] These clients act as intermediaries, facilitating the exchange of messages between the host and the server. The Servers, on the other hand, are responsible for providing the actual capabilities to the clients in the form of context, tools, and prompts.[1] This architecture allows for a modular and scalable approach to integrating AI with external resources.

The power of MCP lies in its ability to expose key capabilities through its servers, primarily categorized as Tools, Resources, and Prompts.[1] Tools are model-controlled functions that allow LLMs to perform specific actions, while Resources are application-controlled data that provide context to the LLMs. Prompts are user-controlled templates that guide LLM interactions. The MCP Python SDK provides a robust framework for developers to build both clients and servers that leverage these capabilities.[13]

2. Fundamentals of MCP Communication in Python

To begin working with MCP in Python, the first step involves setting up the development environment and installing the necessary mcp package. It is recommended to use uv, a fast and secure Python package installer and resolver, for managing the project and its dependencies.[7] The mcp package can be installed using

the command uv add "mcp[cli]".[90] Alternatively, pip install mcp can also be used.[89]

A basic MCP client in Python typically involves importing the necessary modules from the mcp library, such as ClientSession and StdioServerParameters.[9] The StdioServerParameters class is used to configure the connection to an MCP server that communicates via standard input/output. An example of setting up a client might involve specifying the command to run the server script and any required arguments. The ClientSession class then manages the connection lifecycle, including initialization and communication with the server.

On the server side, a basic MCP server in Python can be created using the FastMCP class from the mcp.server.fastmcp module.[7] This class simplifies the creation of MCP servers by using Python type hints and docstrings to automatically generate tool definitions. Decorators like @mcp.tool() and @mcp.resource() are used to define the capabilities of the server.

3. Demonstrating Core MCP Modules and Functions with Python Code Examples

The following sections provide Python code examples illustrating the usage of various MCP modules and functions.

(a) CallToolRequest and CallToolResult:

The CallToolRequest module is used by the MCP client to invoke a specific tool provided by the server.[99] To create a CallToolRequest, you need to specify the method as "tools/call", the name of the tool to be executed, and a dictionary of arguments required by the tool.

Python

```
from mcp.types import CallToolRequest, Request

# Example of creating a CallToolRequest
tool_name = "my_tool"
tool_arguments = {"param1": "value1", "param2": 123}
call_tool_request = CallToolRequest(
    request=Request(method="tools/call"),
```

```
    params=CallToolRequest.Params(name=tool_name, arguments=tool_arguments)
)
```

The CallToolResult module represents the server's response to a CallToolRequest.[99] The result contains a content array, which can include different types of content such as text, image, or a reference to a resource, and a boolean flag isError indicating whether the tool execution was successful.

```
Python

from mcp.types import CallToolResult, TextContent

# Example of handling a successful CallToolResult
tool_result_success = CallToolResult(content=, isError=False)

# Example of handling a CallToolResult indicating an error
tool_result_error = CallToolResult(content=, isError=True)

# Accessing the content of the result
if tool_result_success.isError:
    print(f"Tool execution failed: {tool_result_success.content.text}")
else:
    print(f"Tool executed successfully: {tool_result_success.content.text}")
```

(b) ClientCapabilities:

The ClientCapabilities module allows the MCP client to inform the server about the features it supports during the initialization handshake.[19] This includes the protocol version supported by the client and its ability to handle tools, resources, prompts, sampling requests, and roots.

```
Python

from mcp.types import ClientCapabilities, Implementation
```

```
# Example of defining ClientCapabilities
client_info = Implementation(name="MyPythonClient", version="1.0.0")
client_capabilities = ClientCapabilities(
    sampling={},
    experimental={},
    roots={"listChanged": True}
)

# This ClientCapabilities object would be part of the InitializeRequest
```

The ClientCapabilities object helps the server understand the client's capabilities and allows for negotiation of compatible features between the client and the server.

(c) InitializeRequest and InitializeResult:

The InitializeRequest module is the first message sent by the client to the server when a connection is established [1], [112]

Works cited

1. Model Context Protocol (MCP) Quickstart - Glama, accessed on April 15, 2025, https://glama.ai/blog/2024-11-25-model-context-protocol-quickstart
2. Microsoft partners with Anthropic to create official C# SDK for Model Context Protocol, accessed on April 15, 2025, https://devblogs.microsoft.com/blog/microsoft-partners-with-anthropic-to-create-official-c-sdk-for-model-context-protocol
3. What is Model Context Protocol (MCP): Explained - Composio, accessed on April 15, 2025, https://composio.dev/blog/what-is-model-context-protocol-mcp-explained/
4. Introducing the Model Context Protocol - Anthropic, accessed on April 15, 2025, https://www.anthropic.com/news/model-context-protocol
5. Understanding the Model Context Protocol (MCP) - Philippe Charrière's Blog, accessed on April 15, 2025, https://k33g.hashnode.dev/understanding-the-model-context-protocol-mcp
6. An Introduction to Model Context Protocol - MCP 101 - DigitalOcean, accessed on April 15, 2025, https://www.digitalocean.com/community/tutorials/model-context-protocol
7. Model Context Protocol - Cursor, accessed on April 15, 2025, https://docs.cursor.com/context/model-context-protocol
8. What Is the Model Context Protocol (MCP) and How It Works - Descope, accessed on April 15, 2025, https://www.descope.com/learn/post/mcp
9. Model Context Protocol (MCP) an overview - Philschmid, accessed on April 15, 2025, https://www.philschmid.de/mcp-introduction
10. Model Context Protocol (MCP) and Amazon Bedrock - Community.aws, accessed

on April 15, 2025, https://community.aws/content/2uFvyCPQt7KcMxD9ldsJyjZM1Wp/model-context-protocol-mcp-and-amazon-bedrock
11. model-context-protocol-resources/guides/mcp-client-development-guide.md at main, accessed on April 15, 2025, https://github.com/cyanheads/model-context-protocol-resources/blob/main/guides/mcp-client-development-guide.md
12. Model Context Protocol (MCP): Lets Implement an MCP server in Go, accessed on April 15, 2025, https://prasanthmj.github.io/ai/mcp-go/
13. The official Python SDK for Model Context Protocol servers and clients - GitHub, accessed on April 15, 2025, https://github.com/modelcontextprotocol/python-sdk
14. Everything a Developer Needs to Know About the Model Context Protocol (MCP) - Neo4j, accessed on April 15, 2025, https://neo4j.com/blog/developer/model-context-protocol/
15. MCP Resources vs Tools : r/ClaudeAI - Reddit, accessed on April 15, 2025, https://www.reddit.com/r/ClaudeAI/comments/1jso42a/mcp_resources_vs_tools/
16. Model Context Protocol (MCP): 8 MCP Servers Every Developer Should Try!, accessed on April 15, 2025, https://dev.to/pavanbelagatti/model-context-protocol-mcp-8-mcp-servers-every-developer-should-try-5hm2
17. MCP Server Boot Starter :: Spring AI Reference, accessed on April 15, 2025, https://docs.spring.io/spring-ai/reference/api/mcp/mcp-server-boot-starter-docs.html
18. mcp-agent - PyPI, accessed on April 15, 2025, https://pypi.org/project/mcp-agent/
19. Java MCP SDK :: Spring AI Reference, accessed on April 15, 2025, https://docs.spring.io/spring-ai-mcp/reference/mcp.html
20. Hanzo MCP | Glama, accessed on April 15, 2025, https://glama.ai/mcp/servers/@hanzoai/mcp
21. Resources - Model Context Protocol, accessed on April 15, 2025, https://modelcontextprotocol.io/docs/concepts/resources
22. MCP server: A step-by-step guide to building from scratch - Composio, accessed on April 15, 2025, https://composio.dev/blog/mcp-server-step-by-step-guide-to-building-from-scratch/
23. jlowin/fastmcp: The fast, Pythonic way to build MCP servers and clients - GitHub, accessed on April 15, 2025, https://github.com/jlowin/fastmcp
24. MCP Client - Model Context Protocol, accessed on April 15, 2025, https://modelcontextprotocol.io/sdk/java/mcp-client
25. Model Context Protocol (MCP) - Anthropic API, accessed on April 15, 2025, https://docs.anthropic.com/en/docs/agents-and-tools/mcp
26. f/mcptools: A command-line interface for interacting with MCP (Model Context Protocol) servers using both stdio and HTTP transport. - GitHub, accessed on April 15, 2025, https://github.com/f/mcptools
27. A Deep Dive Into MCP and the Future of AI Tooling | Andreessen Horowitz,

accessed on April 15, 2025, https://a16z.com/a-deep-dive-into-mcp-and-the-future-of-ai-tooling/
28. Unleashing the Power of Model Context Protocol (MCP): A Game-Changer in AI Integration, accessed on April 15, 2025, https://techcommunity.microsoft.com/blog/educatordeveloperblog/unleashing-the-power-of-model-context-protocol-mcp-a-game-changer-in-ai-integrat/4397564
29. Git Spice Help MCP Server | Glama, accessed on April 15, 2025, https://glama.ai/mcp/servers/@sach999/git-spice-help-mcp?
30. metatool-ai/mcp-server-metamcp - GitHub, accessed on April 15, 2025, https://github.com/metatool-ai/mcp-server-metamcp
31. For Server Developers - Model Context Protocol, accessed on April 15, 2025, https://modelcontextprotocol.io/quickstart/server
32. mcp_schema - Rust - Docs.rs, accessed on April 15, 2025, https://docs.rs/mcp-schema
33. A type-safe implementation of the official Model Context Protocol (MCP) schema in Rust. - GitHub, accessed on April 15, 2025, https://github.com/rust-mcp-stack/rust-mcp-schema
34. straw_mcp - Dart API docs - Pub.dev, accessed on April 15, 2025, https://pub.dev/documentation/straw_mcp/latest/
35. [Client] Implement proper roots and sampling client capabilities abstraction · Issue #13 · cloudwalk/hermes-mcp - GitHub, accessed on April 15, 2025, https://github.com/cloudwalk/hermes-mcp/issues/13
36. Prompts - Model Context Protocol, accessed on April 15, 2025, https://modelcontextprotocol.io/docs/concepts/prompts
37. MCP Overview - Cline Documentation, accessed on April 15, 2025, https://docs.cline.bot/mcp-servers/mcp
38. In-Depth review of the MCP authorization spec (2025-03-26 edition) - Logto blog, accessed on April 15, 2025, https://blog.logto.io/mcp-auth-spec-review-2025-03-26
39. Tools - Model Context Protocol, accessed on April 15, 2025, https://modelcontextprotocol.io/docs/concepts/tools
40. Example Clients - Model Context Protocol, accessed on April 15, 2025, https://modelcontextprotocol.io/clients
41. Model Context Protocol (MCP): A comprehensive introduction for developers - Stytch, accessed on April 15, 2025, https://stytch.com/blog/model-context-protocol-introduction/
42. Can someone explain MCP to me? How are you using it? And what has it allowed you to do that you couldn't do before? : r/ClaudeAI - Reddit, accessed on April 15, 2025, https://www.reddit.com/r/ClaudeAI/comments/1h55zxd/can_someone_explain_mcp_to_me_how_are_you_using/
43. Core architecture - Model Context Protocol, accessed on April 15, 2025, https://modelcontextprotocol.io/docs/concepts/architecture
44. JigsawStack MCP Servers: Bridging LLMs with Context and Tools, accessed on

April 15, 2025, https://jigsawstack.com/blog/jigsawstack-mcp-servers
45. Sentry MCP Server - Glama, accessed on April 15, 2025, https://glama.ai/mcp/servers/sfel2251tz
46. Model Context Protocol (MCP): Integrating Azure OpenAI for Enhanced Tool Integration and Prompting - Microsoft Tech Community, accessed on April 15, 2025, https://techcommunity.microsoft.com/blog/azure-ai-services-blog/model-context-protocol-mcp-integrating-azure-openai-for-enhanced-tool-integratio/4393788
47. MCP Web Tools Server - Glama, accessed on April 15, 2025, https://glama.ai/mcp/servers/cn5q63wd5r/blob/main/docs/05-communication-protocols.md
48. punkpeye/fastmcp: A TypeScript framework for building MCP servers. - GitHub, accessed on April 15, 2025, https://github.com/punkpeye/fastmcp
49. Cloudinary MCP Server | Glama, accessed on April 15, 2025, https://glama.ai/mcp/servers/zjiw1ry8ly/blob/master/documentation/mcp-llm-guide.md
50. model-context-protocol-resources/guides/mcp-server-development-guide.md at main - GitHub, accessed on April 15, 2025, https://github.com/cyanheads/model-context-protocol-resources/blob/main/guides/mcp-server-development-guide.md
51. Multifaceted Impacts of Plant-Beneficial Pseudomonas spp. in Managing Various Plant Diseases and Crop Yield Improvement | ACS Omega, accessed on April 15, 2025, https://pubs.acs.org/doi/10.1021/acsomega.3c00870
52. Understanding MCP From Scratch - YouTube, accessed on April 15, 2025, https://www.youtube.com/watch?v=CDjjaTALI68
53. Decision Support Tool for Risk Assessment & Maneuver Planning in Collision Avoidance Alexander Ryan Lead Aerospace Engineer, accessed on April 15, 2025, https://ntrs.nasa.gov/api/citations/20220012070/downloads/FINAL%20ISG%20AMOS%20Paper-Decision%20Support%20Tool%20for%20Risk%20Assessment%20%26%20Maneuver%20Planning%20for%20CA.pdf
54. langchaingo-mcp-adapter/adapter_test.go at main - GitHub, accessed on April 15, 2025, https://github.com/i2y/langchaingo-mcp-adapter/blob/main/adapter_test.go
55. MCP + Filesystem is magic : r/ClaudeAI - Reddit, accessed on April 15, 2025, https://www.reddit.com/r/ClaudeAI/comments/1h4yvep/mcp_filesystem_is_magic/
56. MCP OpenAI Server | Glama, accessed on April 15, 2025, https://glama.ai/mcp/servers/riynwmasx9/tree/main/docs
57. Prompts - Model Context Protocol Specification, accessed on April 15, 2025, https://spec.modelcontextprotocol.io/specification/2024-11-05/server/prompts/
58. MCP Server - Model Context Protocol, accessed on April 15, 2025, https://modelcontextprotocol.io/sdk/java/mcp-server
59. MCP Kotlin SDK, accessed on April 15, 2025, https://jetbrains.github.io/mcp-kotlin-sdk/
60. TimHolden_figma-mcp-server/README.md at main · MCP-Mirror, accessed on

April 15, 2025, https://github.com/MCP-Mirror/TimHolden_figma-mcp-server/blob/main/README.md
61. Tools - Model Context Protocol Specification, accessed on April 15, 2025, https://spec.modelcontextprotocol.io/specification/2024-11-05/server/tools/
62. SetLevelRequest in mcp_attr::schema - Rust - Docs.rs, accessed on April 15, 2025, https://docs.rs/mcp-attr/latest/mcp_attr/schema/struct.SetLevelRequest.html
63. UnsubscribeRequest in mcp_attr::schema - Rust - Docs.rs, accessed on April 15, 2025, https://docs.rs/mcp-attr/latest/mcp_attr/schema/struct.UnsubscribeRequest.html
64. Model Context Protocol (MCP) Explained: The New Standard for AI Tools? - YouTube, accessed on April 15, 2025, https://www.youtube.com/watch?v=rmphqjsc4Po
65. Transports - Model Context Protocol Specification, accessed on April 15, 2025, https://spec.modelcontextprotocol.io/specification/2025-03-26/basic/transports/
66. mohamedahmed01/laravel-mcp-sdk: Laravel Based Implementation for Model Context Protocol - GitHub, accessed on April 15, 2025, https://github.com/mohamedahmed01/laravel-mcp-sdk
67. mcp-go/examples/everything/main.go at main - GitHub, accessed on April 15, 2025, https://github.com/mark3labs/mcp-go/blob/main/examples/everything/main.go
68. MCP tools - Agent Development Kit - Google, accessed on April 15, 2025, https://google.github.io/adk-docs/tools/mcp-tools/
69. MCP + image support - Bug Reports - Cursor - Community Forum, accessed on April 15, 2025, https://forum.cursor.com/t/mcp-image-support/48801
70. Documentation Crawler & MCP Server - Glama, accessed on April 15, 2025, https://glama.ai/mcp/servers/@alizdavoodi/MCPDocSearch/tree/main/mcp_server
71. A2A Client MCP Server | Glama, accessed on April 15, 2025, https://glama.ai/mcp/servers/@tesla0225/mcp-a2a/blob/main/a2a-client.ts
72. mcp_dart library - Dart API - Pub.dev, accessed on April 15, 2025, https://pub.dev/documentation/mcp_dart/latest/mcp_dart
73. types package - github.com/dwrtz/mcp-go/pkg/types - Go Packages, accessed on April 15, 2025, https://pkg.go.dev/github.com/dwrtz/mcp-go/pkg/types
74. JSON Canvas MCP Server | Glama, accessed on April 15, 2025, https://glama.ai/mcp/servers/ajj64p9c3i/blob/main/simple_mcp_server.py
75. GitHub MCP Server | Glama, accessed on April 15, 2025, https://glama.ai/mcp/servers/bnif4b1rh6/blob/master/docs/mcp-documentation.md
76. DynamoDB MCP Server | Glama, accessed on April 15, 2025, https://glama.ai/mcp/servers/3voqtftc3c/blob/main/tests/test_server.py
77. cremich/promptz-mcp: MCP Server implementation for ... - GitHub, accessed on April 15, 2025, https://github.com/cremich/promptz-mcp
78. Payman AI MCP Server - Glama, accessed on April 15, 2025, https://glama.ai/mcp/servers/@hrishi0102/payman_mcp/blob/main/payman-serve

r.ts
79. stephentoub/mcp: The official C# SDK for Model Context Protocol servers and clients, maintained by Microsoft - GitHub, accessed on April 15, 2025, https://github.com/stephentoub/mcp
80. mcp-framework/src/transports/http/server.ts at main - GitHub, accessed on April 15, 2025, https://github.com/QuantGeekDev/mcp-framework/blob/main/src/transports/http/server.ts
81. rust_mcp_schema - Rust - Docs.rs, accessed on April 15, 2025, https://docs.rs/rust-mcp-schema
82. ListPromptsResult in mcp_schema - Rust - Docs.rs, accessed on April 15, 2025, https://docs.rs/mcp-schema/latest/mcp_schema/struct.ListPromptsResult.html
83. Merge pull request #2 from ThinkInAIXYZ/feat/core feat(core): 简单的定义& gateway 实现· 8888/github.com/ThinkInAIXYZ/go-mcp - CNB, accessed on April 15, 2025, https://cnb.cool/8888/github.com/ThinkInAIXYZ/go-mcp/-/commit/81d1a9544237c1ba45b0cced074e84c01f15eb1f
84. server package - github.com/dceluis/mcp-go/server - Go Packages, accessed on April 15, 2025, https://pkg.go.dev/github.com/dceluis/mcp-go/server
85. camel.toolkits.mcp_toolkit — CAMEL 0.2.44 documentation, accessed on April 15, 2025, https://docs.camel-ai.org/_modules/camel/toolkits/mcp_toolkit.html
86. protocol package - github.com/go-go-golems/go-go-mcp/pkg, accessed on April 15, 2025, https://pkg.go.dev/github.com/go-go-golems/go-go-mcp/pkg/protocol
87. Building A Simple MCP Server - KDnuggets, accessed on April 15, 2025, https://www.kdnuggets.com/building-a-simple-mcp-server
88. README.md - MCP Python SDK - GitHub, accessed on April 15, 2025, https://github.com/modelcontextprotocol/python-sdk/blob/main/README.md
89. mcp - PyPI, accessed on April 15, 2025, https://pypi.org/project/mcp/
90. Model Context Protocol (MCP): A Guide With Demo Project - DataCamp, accessed on April 15, 2025, https://www.datacamp.com/tutorial/mcp-model-context-protocol
91. Model Context Protocol (MCP) Hands-On Walkthrough for the Unstructured Workflow Endpoint, accessed on April 15, 2025, https://docs.unstructured.io/examplecode/tools/mcp
92. Building Custom Extensions with Goose - GitHub Pages, accessed on April 15, 2025, https://block.github.io/goose/docs/tutorials/custom-extensions/
93. For Client Developers - Model Context Protocol, accessed on April 15, 2025, https://modelcontextprotocol.io/quickstart/client
94. Client - PydanticAI, accessed on April 15, 2025, https://ai.pydantic.dev/mcp/client/
95. punkpeye/awesome-mcp-servers - GitHub, accessed on April 15, 2025, https://github.com/punkpeye/awesome-mcp-servers
96. How to build MCP Servers and Clients from Scratch - DEV Community, accessed on April 15, 2025, https://dev.to/composiodev/how-to-build-mcp-servers-and-clients-from-scratch

-4o2f
97. Mcp - LlamaIndex, accessed on April 15, 2025, https://docs.llamaindex.ai/en/stable/api_reference/tools/mcp/
98. mcp-http-client-example/main.py at main - GitHub, accessed on April 15, 2025, https://github.com/slavashvets/mcp-http-clilent-example/blob/main/main.py
99. client package - github.com/mark3labs/mcp-go/client - Go Packages, accessed on April 15, 2025, https://pkg.go.dev/github.com/mark3labs/mcp-go/client
100. Building a Generative AI MCP Client Application in Go using Ollama, accessed on April 15, 2025, https://k33g.hashnode.dev/building-a-generative-ai-mcp-client-application-in-go-using-ollama
101. mcp - Go Packages, accessed on April 15, 2025, https://pkg.go.dev/github.com/mark3labs/mcp-go/mcp
102. mcp-nutanix - Glama, accessed on April 15, 2025, https://glama.ai/mcp/servers/@thunderboltsid/mcp-nutanix/blob/main/main.go
103. mark3labs/mcp-go: A Go implementation of the Model Context Protocol (MCP), enabling seamless integration between LLM applications and external data sources and tools. - GitHub, accessed on April 15, 2025, https://github.com/mark3labs/mcp-go
104. What's MCP all about? Comparing MCP with LLM function calling - Neon, accessed on April 15, 2025, https://neon.tech/blog/mcp-vs-llm-function-calling
105. python-sdk/src/mcp/client/session.py at main - GitHub, accessed on April 15, 2025, https://github.com/modelcontextprotocol/python-sdk/blob/main/src/mcp/client/session.py
106. Base MCP Server | Glama, accessed on April 15, 2025, https://glama.ai/mcp/servers/@base/base-mcp
107. ClientCapabilities in mcp_attr::schema - Rust - Docs.rs, accessed on April 15, 2025, https://docs.rs/mcp-attr/latest/mcp_attr/schema/struct.ClientCapabilities.html
108. InitializeRequest in mcp_attr::schema - Rust - Docs.rs, accessed on April 15, 2025, https://docs.rs/mcp-attr/latest/mcp_attr/schema/struct.InitializeRequest.html
109. riza-io/mcp-go: Build Model Context Protocol (MCP) servers in Go - GitHub, accessed on April 15, 2025, https://github.com/riza-io/mcp-go
110. Gemini MCP Server | Glama, accessed on April 15, 2025, https://glama.ai/mcp/servers/bq7qhwa4y0/blob/main/src/protocol.ts
111. README.md - modelcontextprotocol/csharp-sdk - GitHub, accessed on April 15, 2025, https://github.com/modelcontextprotocol/csharp-sdk/blob/main/README.md
112. mcp-openapi-server/mcp-specs.d.ts at main - GitHub, accessed on April 15, 2025, https://github.com/ivo-toby/mcp-openapi-server/blob/main/mcp-specs.d.ts
113. MCP Part III - Application: Custom Server for a Specific Use Case - Olivier Wulveryck, accessed on April 15, 2025, https://blog.owulveryck.info/2025/01/27/mcp-part-iii-application-custom-server-f

or-a-specific-use-case.html