Functions AI Agent Callbacks

Google Summer of Code 2025 —

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About me

I am a 20-year-old undergraduate student at the Indian Institute of Technology, Roorkee, with a strong passion for open-source development and cloud-native technologies. My technical proficiency includes programming languages such as Python, JavaScript, and Golang, along with extensive experience in tools like Docker and Kubernetes. Over the past month, I have contributed to the Knative project, learning about Serving, Eventing, and Functions components, which has deepened my understanding of serverless architectures.

Additionally, I am currently an LFX mentee with the Inspektor-Gadget community for Term 1 of 2025, a mentorship that concludes in May, just before the GSoC coding period begins. This experience has enhanced my technical skills and emphasized the importance of collaboration within open-source communities.

Contributions to Knative

Repository	PR	Description
knative/serving	#15643 (merged)	Added support for configuring the Privileged field in securityContext
knative/func	#2733 (merged)	Refactored data member of the InvokeMessage to be []byte
knative/func	#2729 (merged)	Adds Inline JSON schema reference in func.yaml
knative/func	#2715 (merged)	Fixes Incorrect Implementation of --file Option
knative/func	#2713 (merged)	updated node template to ignore node_modules in .gitignore
knative/func	#2746 (merged)	Removes redundant default labels and annotations
knative/eventing	#8376 (open)	Add ability to override jwks_url

Projects

RELICS.ai [link]

- Made a blockchain-based security game that challenges users to prompt-inject AI agents to solve on-chain challenges

memer.ai [link]

- Developed an AI-powered meme generator that connects to your Twitter account via OAuth. It uses natural language processing to generate creative memes and allows for one-click posting, streamlining content creation for social media.

GopherLibrary [link]

- A library application built in Golang based on mvc architecture

ShellFox [link] (ongoing)

- A minimalist CLI browser that brings the web to your terminal.

Why me?

I am qualified to contribute to the Functions AI Agent Callbacks project because my background and interests directly align with its core objectives. I've a solid experience with Golang and Cloud Native applications as I've been an open-source contributor in this space for the past few months (See my contributions here). My work in agentic AI is demonstrated by projects like RELICS.ai and memer.ai.

In addition to my AI related work, I bring strong cybersecurity expertise to the table. Through active participation in CTF competitions with team InfoSecIITR, where I focus on both web and AI security, I have developed a solid foundation in identifying and mitigating security risks. This experience is crucial for ensuring that the interactions between AI agents and serverless functions are secure and reliable.

Overall, my experience with agentic AI, combined with my cybersecurity background, positions me well to tackle the real-world challenges of integrating AI decision-making with serverless architectures. I am excited to contribute my skills to this innovative project under the mentorship of the Knative and CNCF communities, driving forward advancements in secure, efficient AI-serverless integration.

Abstract

Enhancing Knative Functions with AI Agent Integration via MCP

The integration of AI agents with Knative Functions presents an opportunity to enhance the automation and efficiency of serverless computing. By developing a Model Context Protocol (MCP) server tailored for Knative Functions, we can enable AI agents to dynamically create and deploy functions using natural language prompts within MCP-compatible clients like Windsurf or Cursor. This project aims to

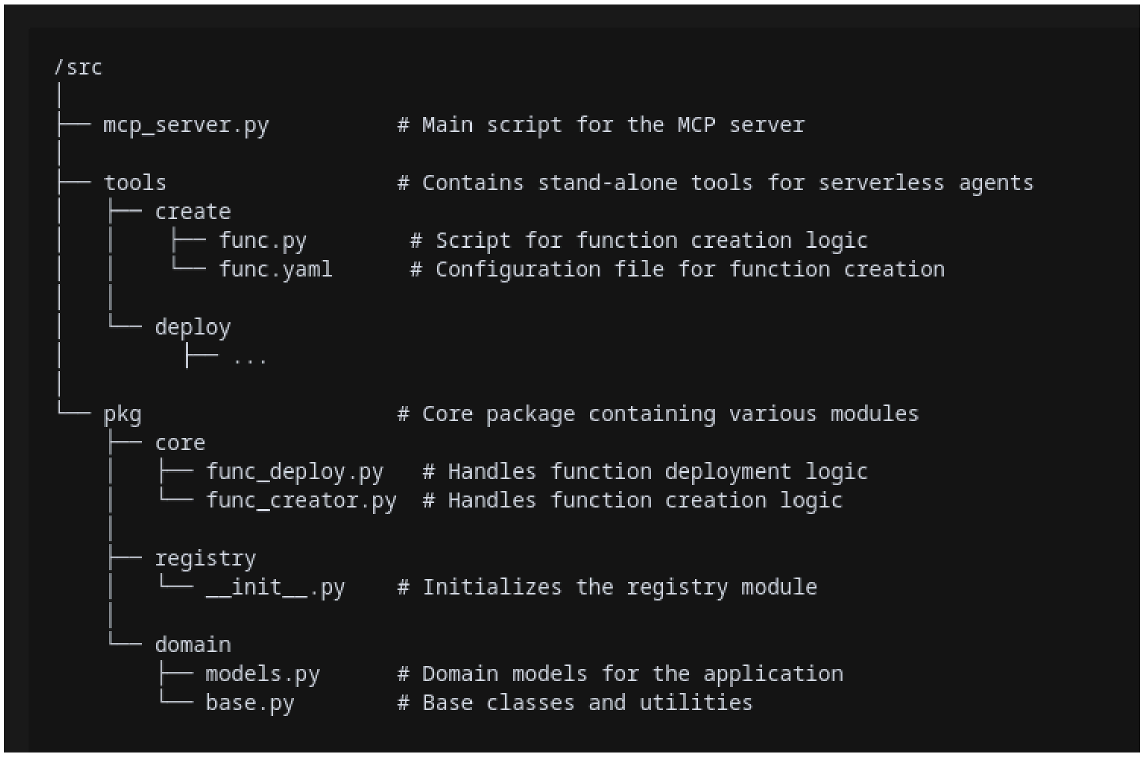
deliver a seamless, end-to-end serverless application experience—allowing users to create and deploy apps directly from their prompt window.

This initiative involves creating multiple tools—such as 'create' and 'deploy'—that mirror the functionality of existing CLI commands. These tools would facilitate seamless interaction between AI agents and Knative Functions, streamlining the development and deployment process.

Additionally, we can also offer these tools as standalone Knative Functions, providing an alternative for users who prefer not to utilize MCP clients, thereby enhancing convenience and cost-efficiency. This way users who do not wish to use MCP clients like windsurf/cursor may benefit from serverless functionality and can use the functions in their classic agent tool workflow. This dual functionality offers users the ability to choose between utility and cost efficiency.

Approach

Directory Structure



```
/src
│
├── mcp_server.py          # Main script for the MCP server
│
├── tools                  # Contains stand-alone tools for serverless agents
│   ├── create
│   │    ├── func.py        # Script for function creation logic
│   │    └── func.yaml      # Configuration file for function creation
│   │
│   └── deploy
│         ├── ...
│
└── pkg                    # Core package containing various modules
    ├── core
    │   ├── func_deploy.py   # Handles function deployment logic
    │   └── func_creator.py  # Handles function creation logic
    │
    ├── registry
    │   └── __init__.py    # Initializes the registry module
    │
    └── domain
        ├── models.py      # Domain models for the application
        └── base.py        # Base classes and utilities
```

(For demonstration purposes, I've chosen python as the SDK was available, but this can be easily replicated in golang if required).

I propose making the core logic of the function tools reusable by placing it in a dedicated `pkg` directory. This design ensures that both an MCP server and standalone tools can leverage the same underlying functionality. For example, the repository will have two main directories—`mcp` and `tools`—while `pkg` will include subdirectories such as `domain`, `registry`, and `core`.

- **`registry`** manages the logic for tool registration, making it possible to maintain a registry of available tools that make the code easier to scale.
- **`domain`** provides a base class and standardized interfaces for tools, facilitating consistent logic, easier testing, and smoother development.
- **`core`** contains the core functionality or shared logic used by both the MCP server and the standalone tools.

`tools` directory will contain standalone serverless tools as Knative functions. These tools will use the same core logic as defined in **`core`** directory maintaining consistency and easy maintainance.

`mcp_server.py` is the MCP server that will connect to clients (eg. Cursor). Mcp tools will be derived from the same **`core`** directory.

By consolidating shared code in `pkg`, we maintain a modular architecture that supports both an MCP-based approach and traditional standalone tooling. This design promotes code reuse, simplifies future development, and ensures consistent standards across different deployment scenarios.

Implementation

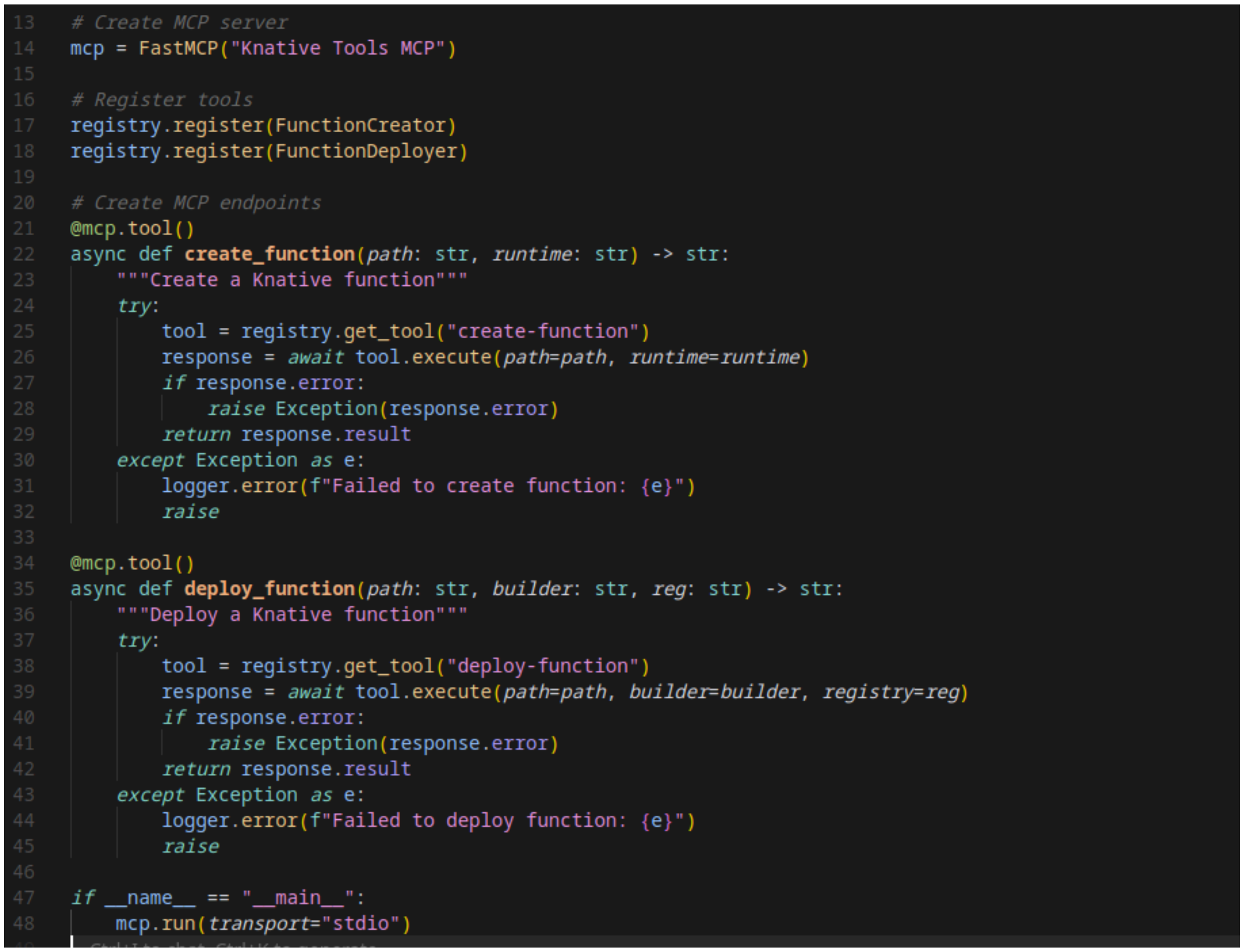
I have developed a Proof-of-Concept (PoC) for demonstration purposes [link], as described in the abstract. This section provides a detailed explanation of the implementation. The current PoC is written in Python due to the availability of the Python SDK and time constraints. However, I am prepared to replicate this functionality in Go, aligning with the GSOC timeline.

MCP server

demo.mp4

The accompanying video demonstrates the intended interaction between Cursor and the Knative MCP server. The current implementation supports function creation and direct deployment to the kubernetes cluster — all seamlessly managed through the prompt interface.

Now, let's dive into the code of the MCP server. The core MCP server logic is relatively straightforward, as most of the functionality is encapsulated within the `pkg` directory. Below is a snippet illustrating how the MCP server could be structured:



```python
# Create MCP server
mcp = FastMCP("Knative Tools MCP")

# Register tools
registry.register(FunctionCreator)
registry.register(FunctionDeployer)

# Create MCP endpoints
@mcp.tool()
async def create_function(path: str, runtime: str) -> str:
    """Create a Knative function"""
    try:
        tool = registry.get_tool("create-function")
        response = await tool.execute(path=path, runtime=runtime)
        if response.error:
            raise Exception(response.error)
        return response.result
    except Exception as e:
        logger.error(f"Failed to create function: {e}")
        raise

@mcp.tool()
async def deploy_function(path: str, builder: str, reg: str) -> str:
    """Deploy a Knative function"""
    try:
        tool = registry.get_tool("deploy-function")
        response = await tool.execute(path=path, builder=builder, registry=reg)
        if response.error:
            raise Exception(response.error)
        return response.result
    except Exception as e:
        logger.error(f"Failed to deploy function: {e}")
        raise

if __name__ == "__main__":
    mcp.run(transport="stdio")
```

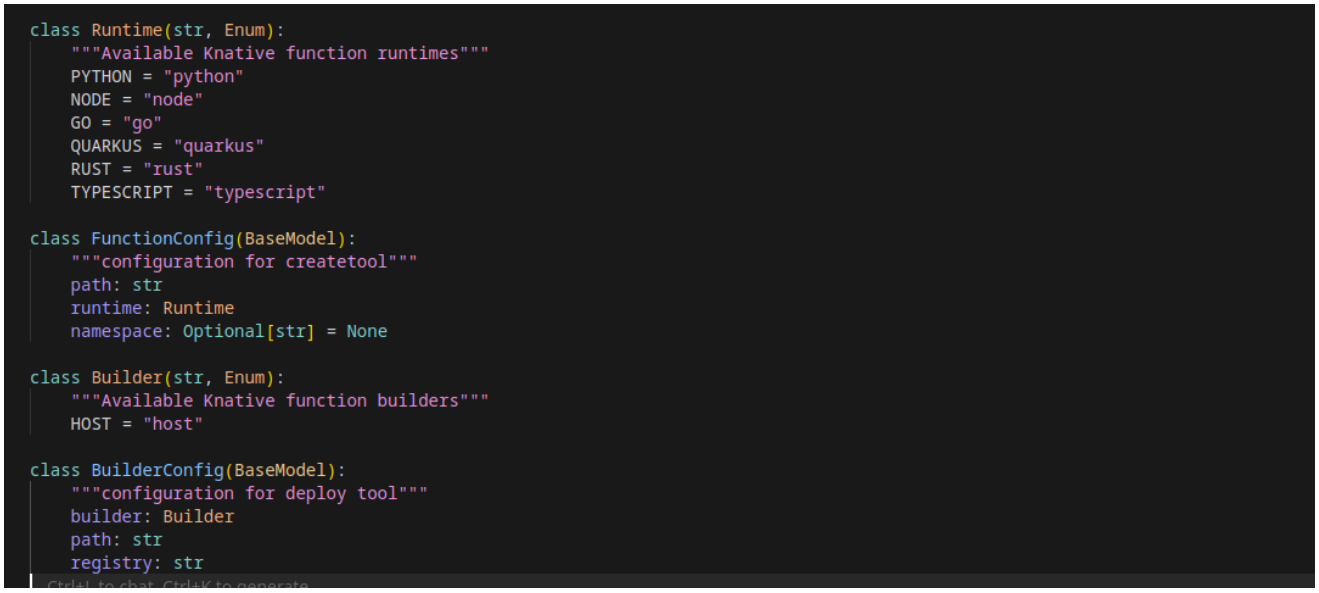
First, we import the necessary functions and register them in a central registry. I recommend maintaining this registry for cleaner and more modular management of the tools. It simplifies adding third-party tools in the future and keeps the codebase organized. However, the registry is optional—removing it won't affect the server's functionality.

Next, we create the MCP tools by retrieving them from the registry. Finally, we start the MCP server using the `stdio` transport. A comparison between sse and `stdio` is discussed in a later section.

pkg

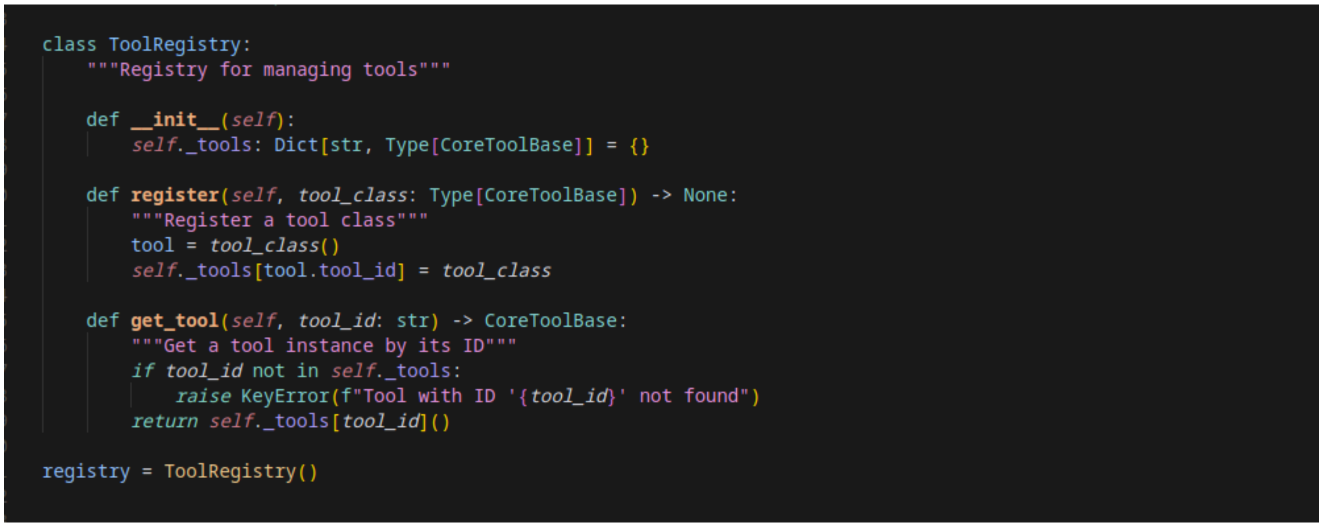
The `pkg` directory contains the core logic of the tools. It is divided into three main subdirectories, each serving a specific purpose.

The **`domain`** directory includes `base.py` and `models.py`. The `base.py` file defines the base class for the core tools, ensuring that all tools remain consistent and standardized. On the other hand, `models.py` contains classes that represent the available flag values and configuration options for various tools. This modular design makes it easier to manage and extend the toolset as needed. The following snippet is from the `models.py`:



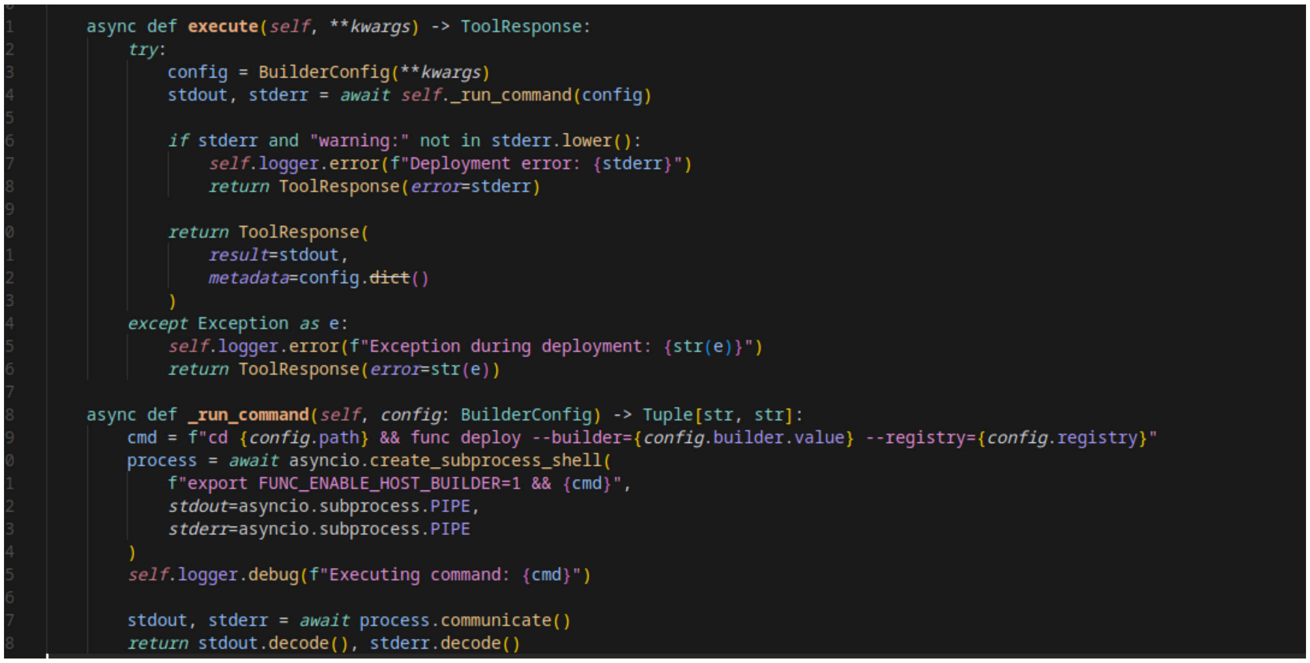
```
class Runtime(str, Enum):
    """Available Knative function runtimes"""
    PYTHON = "python"
    NODE = "node"
    GO = "go"
    QUARKUS = "quarkus"
    RUST = "rust"
    TYPESCRIPT = "typescript"

class FunctionConfig(BaseModel):
    """configuration for createtool"""
    path: str
    runtime: Runtime
    namespace: Optional[str] = None

class Builder(str, Enum):
    """Available Knative function builders"""
    HOST = "host"

class BuilderConfig(BaseModel):
    """configuration for deploy tool"""
    builder: Builder
    path: str
    registry: str
```

The **`registry`** directory maintains a central registry of tools. As mentioned earlier, this registry makes it easier to manage tools in a modular manner. Additionally, one key advantage of maintaining this registry is that it enables running multiple MCP servers using different subsets of the same toolset. This adds flexibility and scalability to the system.



```
class ToolRegistry:
    """Registry for managing tools"""

    def __init__(self):
        self._tools: Dict[str, Type[CoreToolBase]] = {}

    def register(self, tool_class: Type[CoreToolBase]) -> None:
        """Register a tool class"""
        tool = tool_class()
        self._tools[tool.tool_id] = tool_class

    def get_tool(self, tool_id: str) -> CoreToolBase:
        """Get a tool instance by its ID"""
        if tool_id not in self._tools:
            raise KeyError(f"Tool with ID '{tool_id}' not found")
        return self._tools[tool_id]()

registry = ToolRegistry()
```

The **`core`** directory houses the core logic for each tool. Each tool follows a fixed template derived from the `base` class in the `domain` directory. It defines a `schema` and an `execute` function, which handle the reception of information and the subsequent actions performed by the tool. This approach keeps the logic organized and predictable. Below is the snippet of execute function of the func_deploy tool for reference:



```
async def execute(self, **kwargs) -> ToolResponse:
    try:
        config = BuilderConfig(**kwargs)
        stdout, stderr = await self._run_command(config)

        if stderr and "warning:" not in stderr.lower():
            self.logger.error(f"Deployment error: {stderr}")
            return ToolResponse(error=stderr)

        return ToolResponse(
            result=stdout,
            metadata=config.~~dict~~()
        )
    except Exception as e:
        self.logger.error(f"Exception during deployment: {str(e)}")
        return ToolResponse(error=str(e))

async def _run_command(self, config: BuilderConfig) -> Tuple[str, str]:
    cmd = f"cd {config.path} && func deploy --builder={config.builder.value} --registry={config.registry}"
    process = await asyncio.create_subprocess_shell(
        f"export FUNC_ENABLE_HOST_BUILDER=1 && {cmd}",
        stdout=asyncio.subprocess.PIPE,
        stderr=asyncio.subprocess.PIPE
    )
    self.logger.debug(f"Executing command: {cmd}")

    stdout, stderr = await process.communicate()
    return stdout.decode(), stderr.decode()
```

Stand-alone tools (optional)

I also propose creating a `tools` directory that will contain individual tools wrapped as Knative functions. This will provide an option for users who prefer to use serverless agent tools in their applications instead of relying on MCP, offering greater flexibility and adaptability. Since this feature is optional, we can discuss whether including it would add meaningful value to the project.

SSE v/s STDIO

The current implementation uses the STDIO transport because the focus is on running a self-hosted MCP server on the same machine, making STDIO faster and more convenient. SSE is not preferred in this case because opening a socket exposed to the internet could introduce unacceptable security risks. Therefore, STDIO remains the safer choice for our setup. However, I'm open to discussing the possibility of using SSE or exploring other custom transport options if needed.

Deliverables

- Phase I

- Discuss and finalize the project architecture and scope.
- Develop the MCP server and standalone tools for Knative functions.

- Phase II

- Extend the tools to support most required configurations and flags, similar to CLI commands.

- Phase III

- Write extensive unit and integration tests for the tools.

- Phase IV (Optional)

- If time permits, research the suitability of the MCP server for other Knative components and extend the tools to support Serving and Eventing.

Timeline

Timespan	Activity
May 8 - June 1	Community Bonding Period: - Interact with the people in the community and get to know the community better. - Discuss the plan with the mentors and community to select the best possible strategy to implement the project. - Discuss the need for the optionals part of the proposal with the mentors.
June 2 - June 15	- Implement basic MCP server. - Implement basic core tools , create and deploy, and complete their integration within the MCP server.
June 16 - June 22	- Extend the core tools to use configurations and flags as used by the CLI func commands.
June 23 - July 6	- Write integration tests for the stand-alone tools - Write unit tests for other functionality such as the registering tools, executing tools, etc.
June 7 - July 18	- Buffer period for finishing pending work and addressing changes by reviewers. - Prepare a report for Phase 1 Evaluation
Midterm evaluation	
July 18 - August 5	- Extend the tool range and include tools from other Knative components like serving, eventing
August 6 - August 14	- Write unit and integration tests for the additional tools
August 14 - August 20	- Clean up the code and document the changes
August 21 - August 31	- Buffer period for finishing pending work and addressing changes by reviewers. - Prepare a report for FinalEvaluation
Final evaluation	

Commitments and Availability

I plan to dedicate 4-5 hours per day, totaling around 35 hours per week. On weekends, I can extend this to 6-7 hours if needed. I'll be on summer break from the start of the coding period until July 15th (tentative), with no university commitments except toward the end of the break.

Additionally, I'm doing an LFX mentorship, which will conclude on May 30, before the coding period begins, ensuring no conflicts. After July 15th, I will resume college classes, but I can confidently commit 3-4 hours daily (~20-25 hours per week) during that period. I am also open to adjusting my schedule to accommodate important project deadlines or sync-up meetings, ensuring smooth progress and timely deliverables.

I'm highly motivated and excited to contribute to this project, and I'm confident that my availability and dedication will allow me to meet expectations effectively.

Thank you for going through my proposal :)