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Exploiting the Model-Context Protocol for Earth Observation Data Access and Workflow Orchestration

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The EO4EU project [1] democratises access to Earth Observation (EO) data by providing a comprehensive platform that caters to a wide spectrum of stakeholders, from researchers to policymakers. The EO4EU platform facilitates the seamless retrieval of EO data and the orchestration of complex computational and machine learning workflows. To this aim, the EO4EU platform integrates a semantic knowledge graph to enhance EO metadata discoverability, supports data fusion across heterogeneous sources, and enables advanced data visualisation techniques, including immersive VR/XR environments.

The Model-Context Protocol (MCP) [2] is a lightweight, standards-based protocol designed to support the dynamic coupling of Large Language Models (LLMs) and contextual data in distributed computing environments. MCP is built on top of JSON-RPC, a stateless, transport-agnostic remote procedure call protocol that enables structured communication between clients and services. MCP introduces a set of abstractions, namely tools, resources, and prompts, tailored to the operational logic of LLMs. These abstractions allow clients to discover the functionalities of local and remote platforms. Tools represent executable components; resources encapsulate data or metadata; and prompts define suggested context to instantiate or run a tool. This design promotes modularity, reusability, and interoperability across heterogeneous systems. It enables the integration of existing platforms with LLMs regardless of their accessibility model, whether proprietary, open weight or open source, deployed locally or accessed remotely.

As part of the EO4EU project, we have developed a prototype MCP server for the EO4EU platform. This server leverages the EO4EU REST APIs and encapsulates them into MCP-compliant tools. Each tool is designed to perform a goal-oriented operation, such as data discovery or workflow management, exposing to MCP clients a description which is interpretable and actionable by LLMs. This approach enables seamless interaction between language models and the EO4EU platform, facilitating the discovery of datasets tailored to specific use cases and the management of workflows from a single user interface.

Lessons learned include the importance of managing LLM context window length: verbose API responses can quickly exhaust the available context window, but the MCP server can mitigate this by filtering out irrelevant information. Additionally, a one-to-many mapping between MCP tools and API endpoints can help in reducing the length of the context. Moreover, in general, several challenges remain, such as LLM hallucinations which may result in infinite MCP tool invocation loops. Finally, we observed that swapping the underlying LLM can significantly alter the system's behaviour, stressing the importance of the specific implementation of MCP abstractions.

References:
[1] https://www.eo4eu.eu/
[2] https://modelcontextprotocol.io/

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