

Resilient Software (eco-systems) through Agent Spaces

Axel Polleres, WU (Vienna University of Economics and Business)

Abstract:

Connected Software Systems involving different stakeholders operating across organisational boundaries need to guarantee the stakeholders' sovereignty. That means that such software systems should be considered as "Agent Spaces" [1]: borrowing and building upon the metaphor of "Data Spaces" as **multi-stakeholder, decentralized**, spaces that allow **sovereign sharing** of data, we therefore also need to ensure that the involved/shared software tools, services, agentic language models themselves act in a sovereign manner, i.e., on behalf of the involved stakeholders. However - especially as these models are operating upon API-based services themselves, potentially make questions about sovereignty shift, as (i) they involve the model provider as a new stakeholder (ii) that operate in a centralized manner.

Agentic language models and Knowledge graphs (as an abstraction layer on top of data assets), on the one hand, have boosted to make data integration and service mediation appear more seamless in such settings, as opposed to earlier, historic attempts, such as (Semantic) Web Services [2]. On the other hand, AI agents that build upon tool-calling language models add a lot of uncertainty that requires safe guardrails, even within a closed scope "agent space".

In my talk I argued to consider these two aspects: (a) how to **scope** systems and their components shared by a set of stakeholders within "Agent spaces" that operate under a common governance; (b) what core concepts and distinctions we should recall from Semantic Web Services (e.g. service, capability, goal, description, discovery, composition).

- Axel Polleres, Diego Rincon-Yanez, Amin Anjomshoaa, Daniel Dobriy, and Emanuel Sallinger. From data spaces to agent spaces. In *The Fourth International Workshop on Semantics in Dataspaces (SDS 2026)*, co-located with ESWC, Dubrovnik, Croatia, May 2026. to appear. cf. <https://short.wu.ac.at/towards-agent-spaces>
- Axel Polleres, Frederik Bauer, Daniil Dobriy, Tobias Käfer, Lukas Kubelka, Andreas Harth, and Thomas Wehr. On the historic roots of Agentic AI in Semantic Web Services. In *WWW Companion '26: Companion Proceedings of the ACM Web Conference 2026*, pages 10--14, June 2026. extended abstract, History of the Web track). <https://doi.org/10.1145/3774905.3795076>

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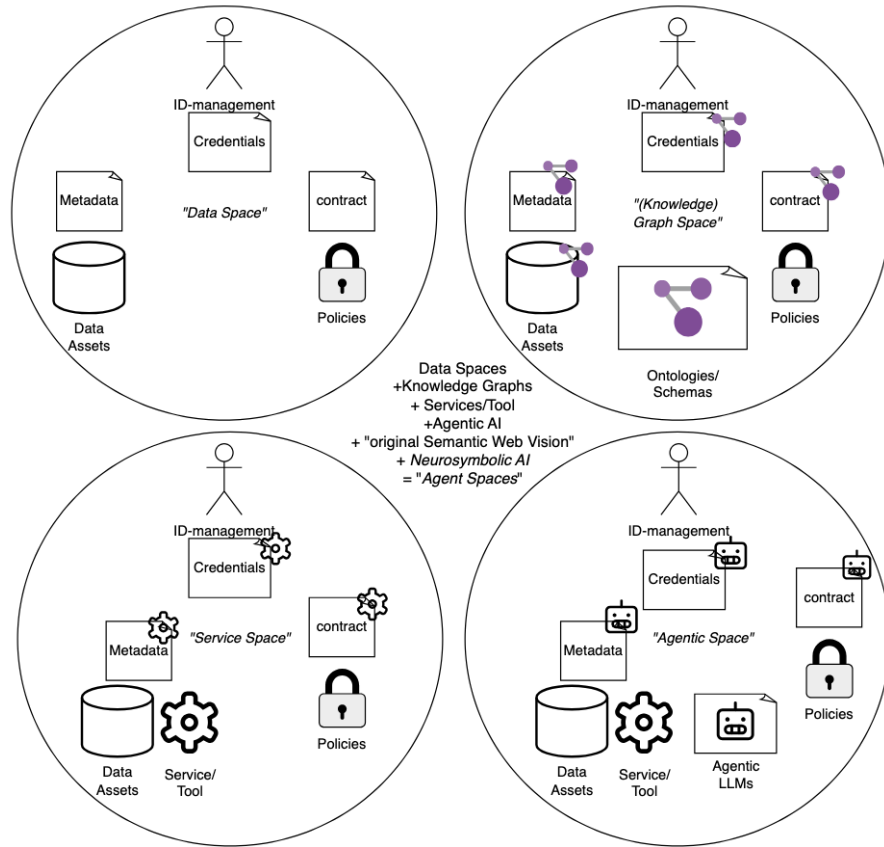
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What do I mean by
“Agent Spaces”
... and what does this have to
do with
(Semantic) **Web Services?**

2 recent papers related to resilient AI systems:



On the Historic Roots of Agentic AI in Semantic Web Services

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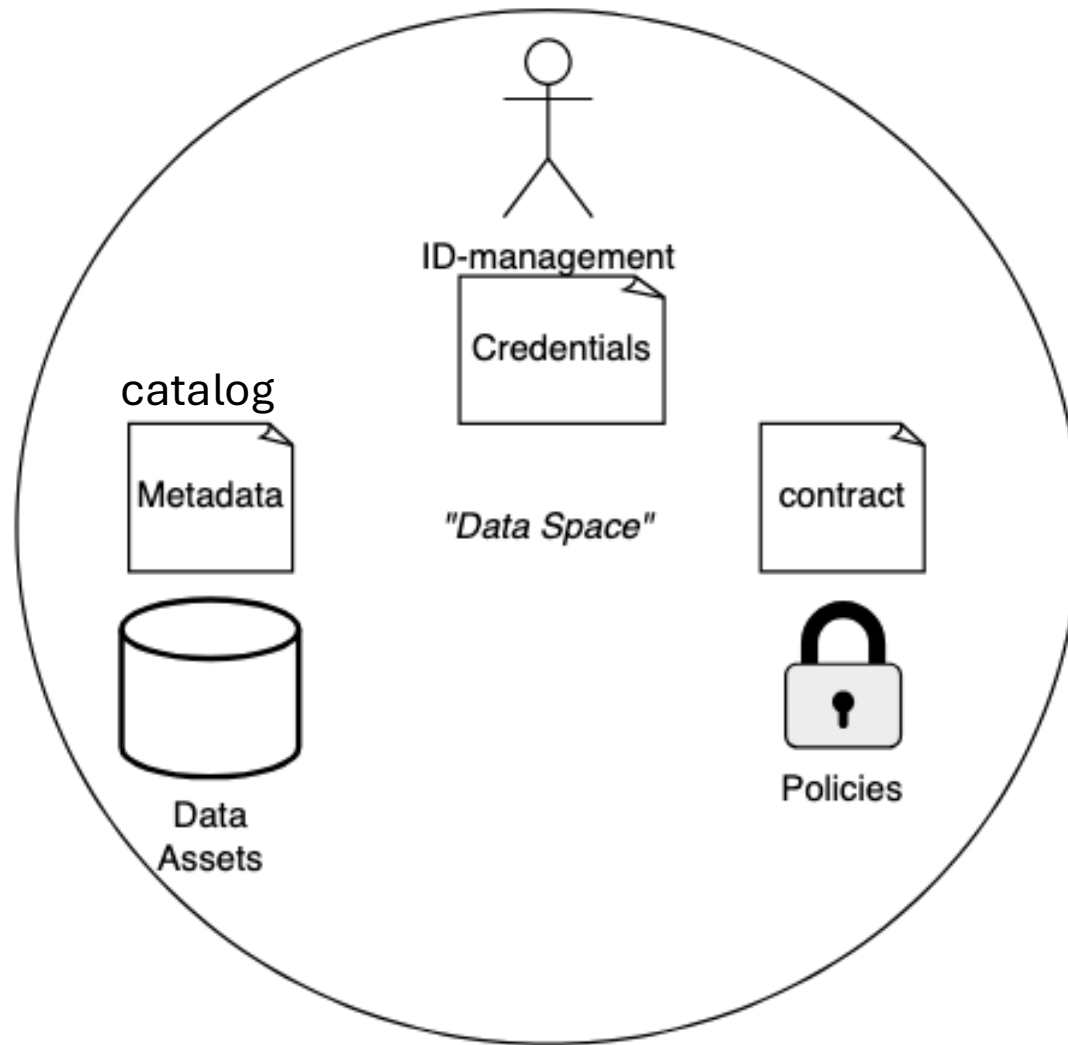
Abstract

In our short talk, we point out that (1) the Semantic Web vision already provided some of the underlying ideas of today's endeavours around agentic AI, and (2) that abstractions, approaches and methods developed in the Web Services and Semantic Web Services communities can be beneficially applied to agentic AI. At the same time, we argue that looking back to history reveals certain still unresolved challenges.

Yet, with the advent of Large Language Models (LLMs) and their ability to generate code, interpret data, even use external tools [29] and carry out complex tasks [32], we see old ideas resurface and register renewed interest towards building software agents that carry out tasks for us. Increasingly capable models are being developed; supporting frameworks, such as Anthropic's Model Context Protocol (MCP) [4] and Google's Agent2Agent protocol (A2A) [13] are gaining traction.

From Data Spaces to Agent Spaces^{*}

Axel Polleres^{1,2,*,†}, Diego Rincon-Yanez^{1,*,†}, Amin Anjomshoaa^{1,†}, Daniel Dobriy^{1,*,†} and Emanuel Sallinger^{3,†}



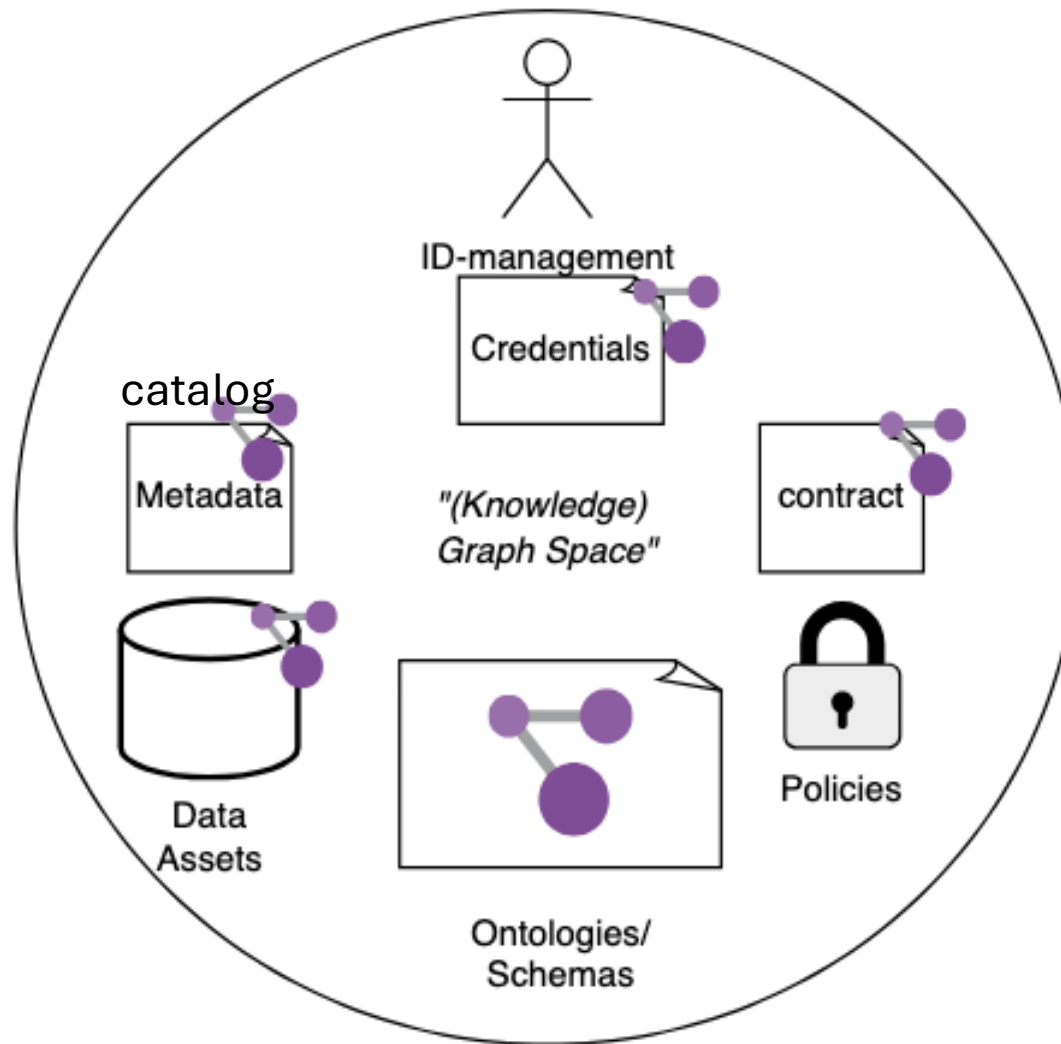
"Data Space":
Should guarantee:

- **sovereign**
- **decentralized**
- **multi-stakeholder (scoped)**

data sharing

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Semantic Web (uniform graph based data format, joint symbolic schemata)+

Data Spaces =

“Knowledge Graph Spaces”:

Should guarantee:

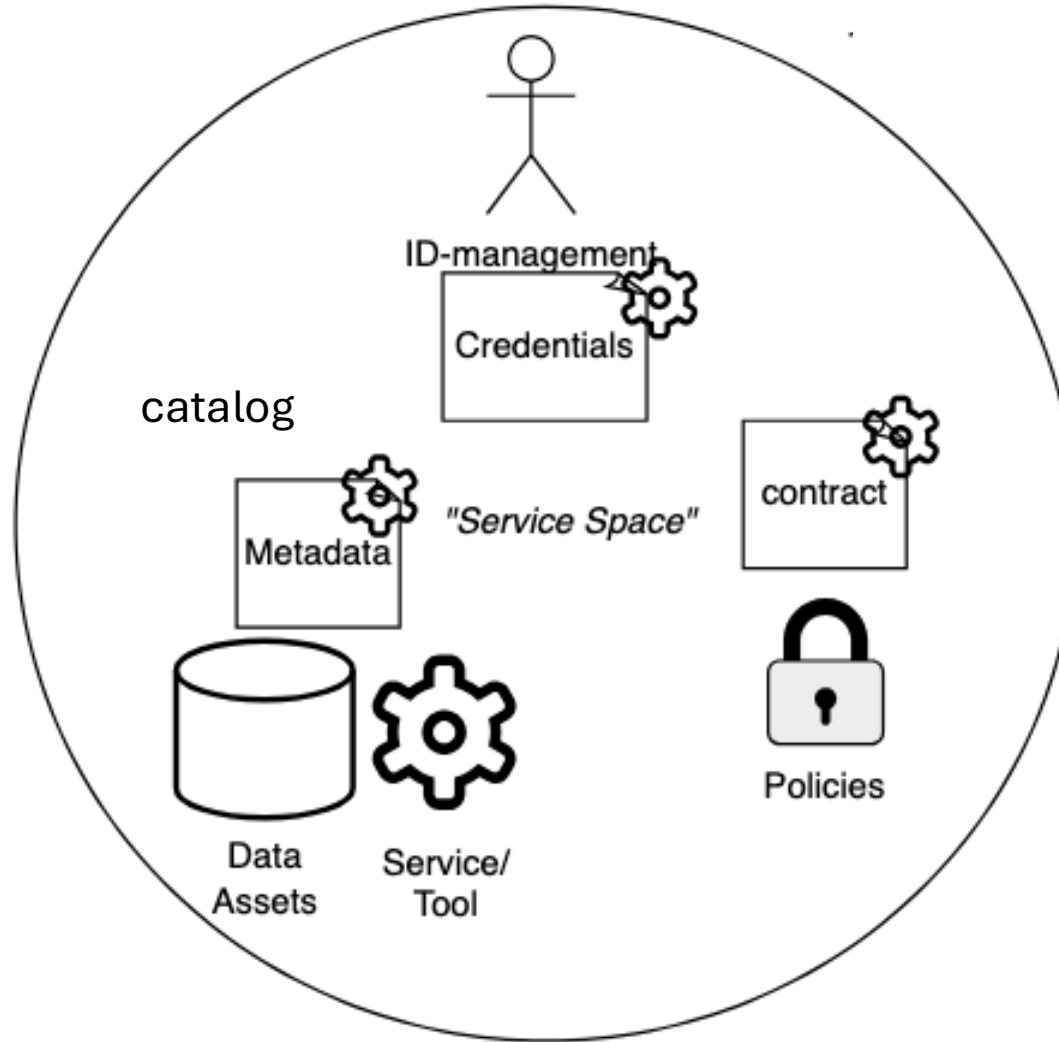
- *sovereign*
- *decentralized*
- *multi-stakeholder (scoped)*

Interoperable data sharing+
Ontological agreement

Symbolic AI

From Data Spaces to Agent Spaces[★]

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Tools/Services+
Data Spaces =
“ServiceSpaces”:

- *sovereign*
- *decentralized*
- *multi-stakeholder (scoped)*

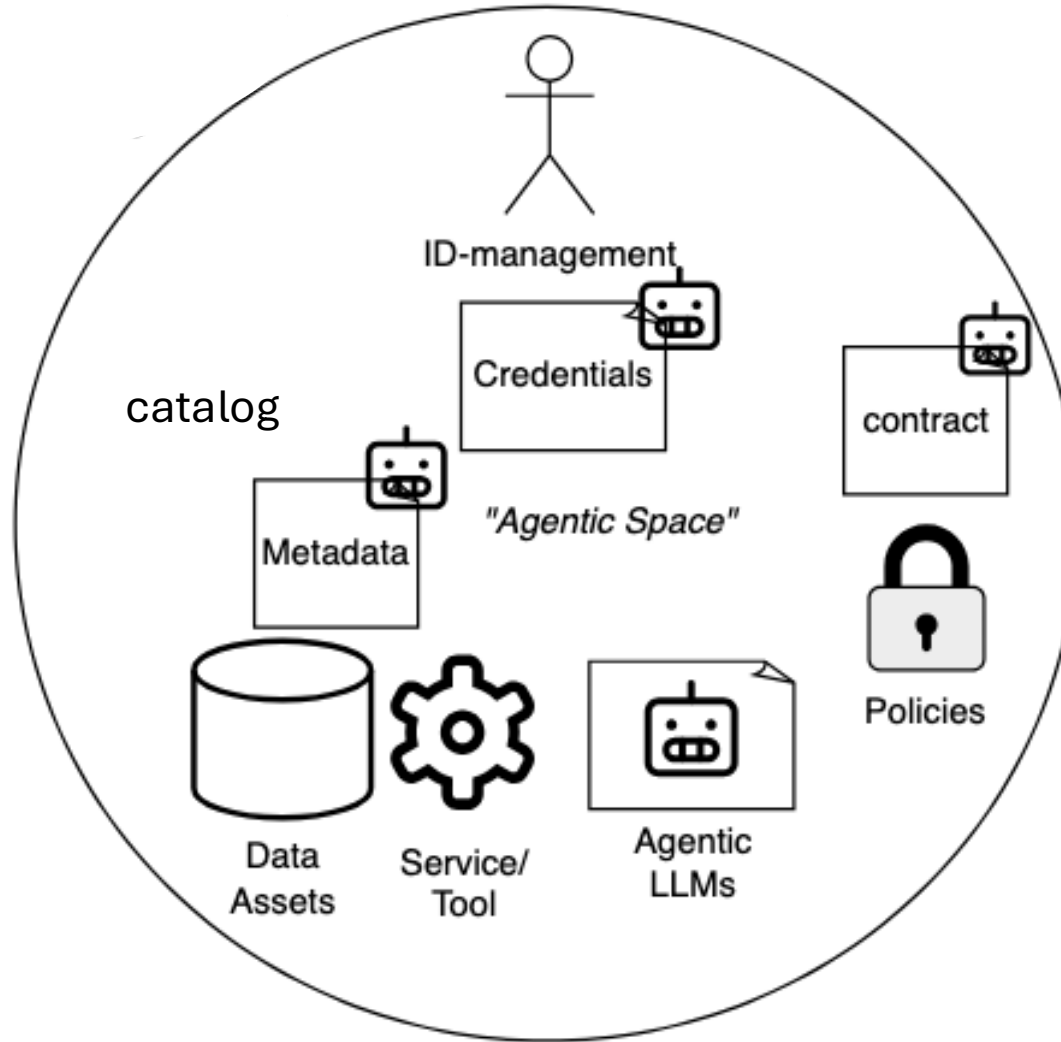
Interoperable data and service
sharing

Web Services ~2000s

Semantic Web Services ~2005

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Adding Agents....

“Agentic Spaces”

- *sovereign ?*
- *decentralized ?*
- *multi-stakeholder +1*

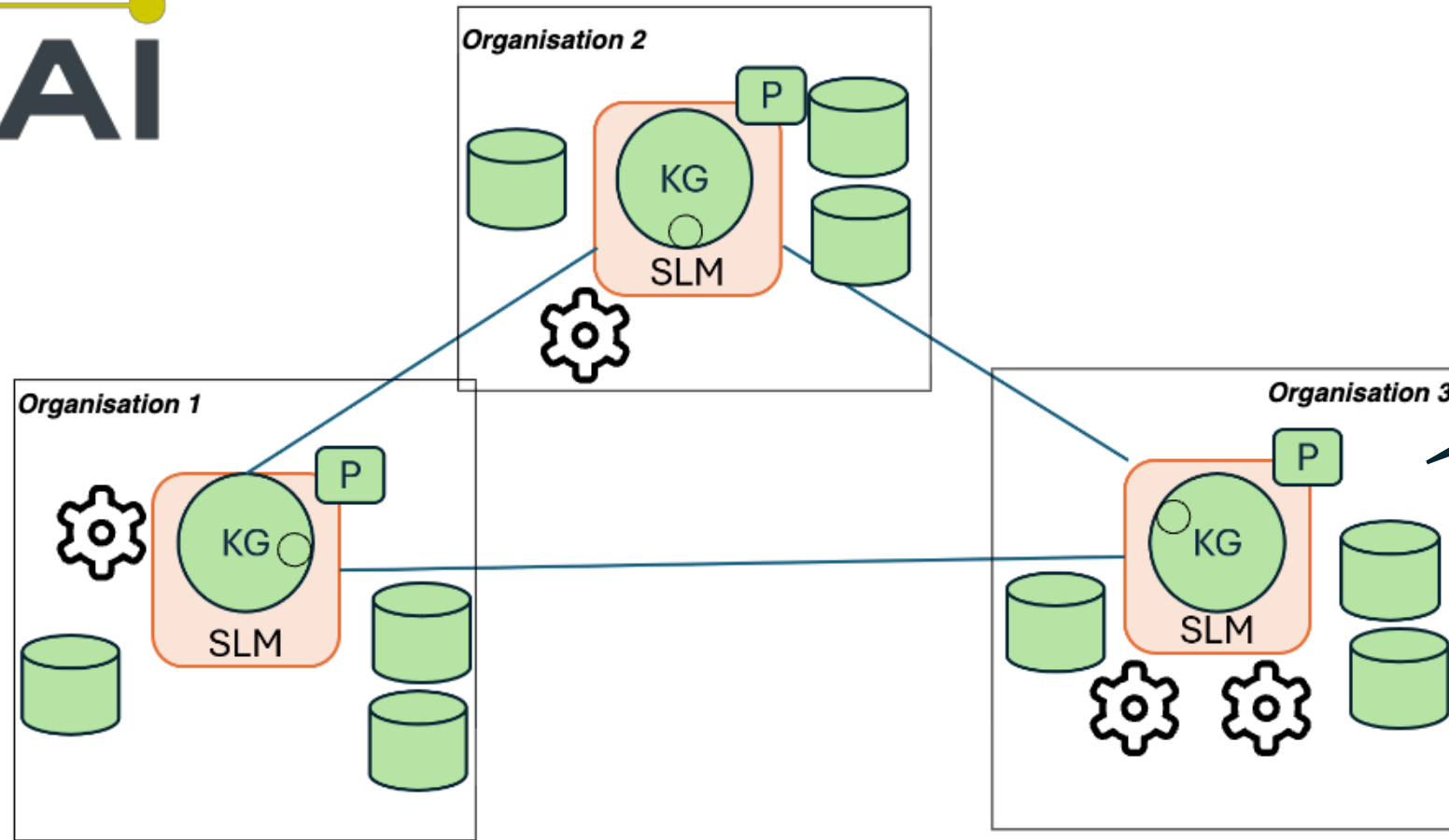
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Neuro-Symbolic approaches

Agent-space:

Resilient eco-system

- **Sovereign,**
- **Decentralized,**
- **Stakeholder-controlled Models/Agents (scoped!)**
- **Symbolic guardrails**
- **Agreed policies**

Figure 2: An **Agent Space** with Linked Knowledge Graphs (KGs), wrapped by a sovereign, agentic language model (SLM), that is governed by symbolic policy guardrails (P).

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Why it might be good to recall some concepts from “Semantic Web Services”:

- **service: “tools”** (“operations” or function ~MCP) vs. **“service”** (“provision of an (abstract) value or product”) “[Preist, 2004]” vs. **“agent”** (“service provided by LLM” ~A2A)
- **description:** formal symbolic/verifiable vs. informal NL description.
 - *skill*
 - *capability*
 - *interface*
- **discovery:** (trustable) matching/catalogs/negotiation
- **composition** (orchestration/choreography)

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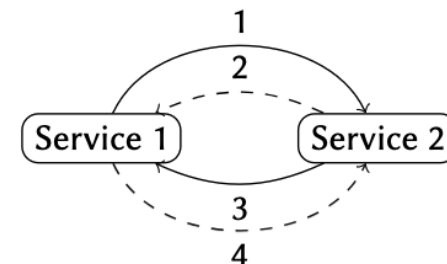
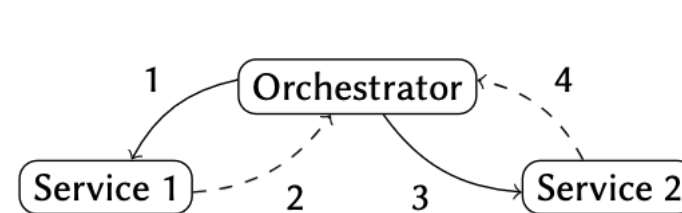
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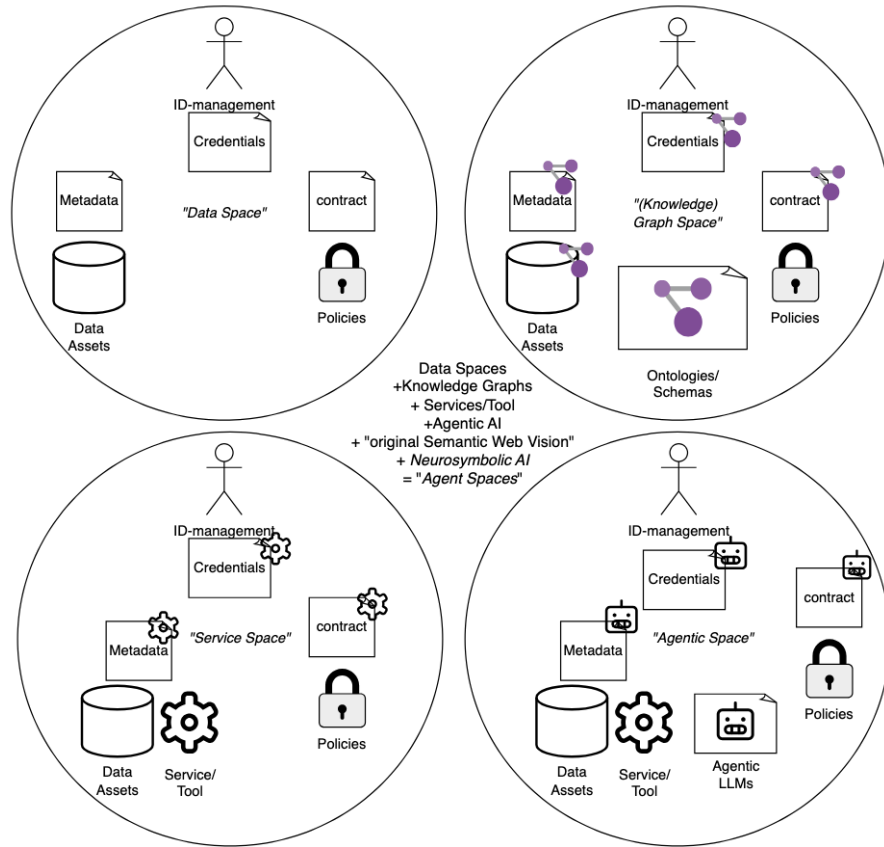
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p.s.: I have an extra slide, if needed ;-)



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