# Skills-Graph Architecture

A unified reference for importing Bernd's experience records into a **Hypergraph-of-Thought** in Neo4j and exposing it through an **MCP** service that local or cloud-hosted LLM agents can query.

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## 1 Scope & Goals

- **Author** Bernd Prager
- **Revision** v1.0 · 2025-05-15
- **Purpose** Define components, data flows, schemas, and operational guidelines so that:
  - Markdown records (`jobs`, `extras`, `certifications`) → **hypergraph** (Neo4j)
  - Graph → **MCP server API**
  - LLM/agent stack (Ollama + LangChain) can answer skill-centric queries.

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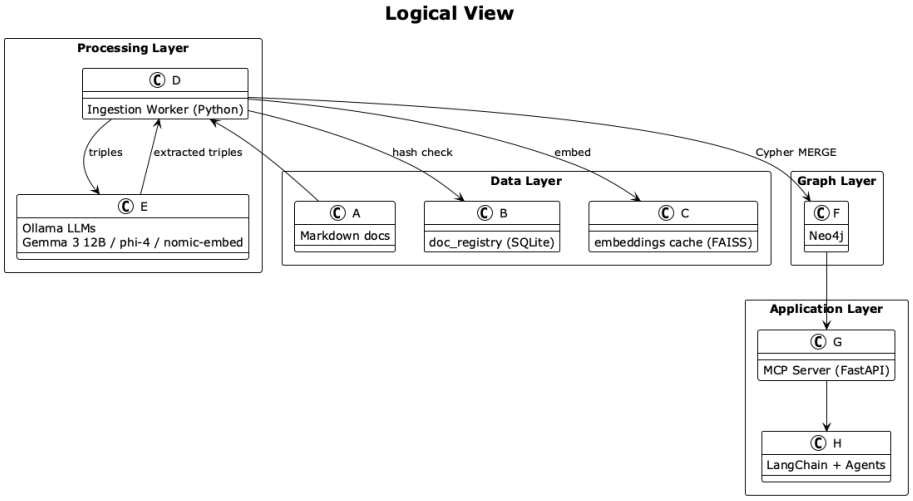
## 2 Logical View

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## 3 Data Sources

| Folder | Type | Example File | Primary Entities |
|---|---|---|---|
| `docs/jobs/` | Job experience | `EPAM.md` | Role, Project, Skill, Tool |
| `docs/extras/` | Extra-professional | `Ext_WJD.md` | Activity, Skill |
| `docs/certs/` | Certifications | `certifications.md` | Certification, Skill |

**Registry Table (`doc_registry`)**

| Column | Type | Description |
|---|---|---|
| `doc_id` | TEXT PK | stem of filename |
| `hash` | CHAR(64) | SHA-256 checksum |
| `last_ingested` | DATETIME | UTC timestamp |

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## 4 Ingestion Worker

- **Language** Python 3.11
- **Key libs** langchain-community, neo4j-driver, faiss-cpu, pyyaml, python-multipart.

### 4.1 Steps per document

1. **Hash check** Skip if unchanged.
2. **Chunk** ~1 500 tokens with overlap = 200.
3. **Embeddings** `nomic-embed-text` → FAISS index (shared).
4. **LLM IE** `gemma3:12b` prompt with known skills/tools.
5. **Dedup** similarity lookup (`>=0.83` FTS OR `>=0.88` embed).
6. **Cypher MERGE** nodes + rels.
7. **Hyperedge build** hash(sorted node-ids) → create/update.

### 4.2 Config File

Store schema & prompt hints in **`graph_schema.yaml`** (see separate file).

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## 5 Graph Schema (Neo4j)

Refer to `graph_schema.yaml` for machine-readable detail.

- **Core labels** `Person`, `Role`, `Organization`, `Project`, `Activity`, `Certification`, `Skill`, `Tool`, `Topic`, `Hyperedge`.

- **Key rels** `HAS_ROLE, WORKED_AT, CONTRIBUTED_TO, USED_IN, SHOWCASED_IN, COVERS_TOPIC, OWNS_CERT, SUPPORTS_SKILL, CONNECTS`.
- **Indexes**
  - `CREATE CONSTRAINT person_name IF NOT EXISTS ON (p:Person) ASSERT p.name IS UNIQUE;`
  - `CREATE FULLTEXT INDEX skill_name IF NOT EXISTS FOR (s:Skill) ON EACH [s.name];`

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## 6 Infrastructure Topology

| Host | Stack | Ports |
|---|---|---|
| **odin** (Ubuntu 22 LTS, Ryzen 9) | Neo4j 5.15 (Docker) | 7474/7687 |
| idem | Ollama 0.1.x (models in `/var/lib/ollama`) | 11434 |
| idem | Ingestion Worker (systemd unit) | – |
| idem | FastAPI MCP server | 8000 |

**Note** RTX 2060 (6 GB VRAM) runs `gemma3:12b` Q4_0; bigger models spill to RAM.

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## 7 MCP Server

- **Framework** FastAPI + LangChain Graph
- **Auth** Bearer JWT (future: OIDC)
- **Endpoints**
  - `POST /query` → JSON {prompt, agent="graph-rag"}
  - `POST /skill_matrix` → returns CSV of skills vs. evidence nodes
- **Agent Types**
  - **GraphRAGAgent** → augments prompt with Cypher results
  - **SkillLensAgent** → tailored skill queries (`MATCH (s:Skill)<-[:SHOWCASED_IN]-(n) …`)

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## 8 Observability

- **Neo4j** → Prometheus exporter (`/metrics`)
- **Worker** → structured logs (JSON) + Loki
- **FastAPI** → OpenTelemetry traces

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## 9 Maintenance

| Job | Schedule | Tool |
|---|---|---|
| `nightly_dedupe` | 03:00 | APOC `refactor.mergeNodes` |
| `refresh_embeddings` | After dedupe | Custom Python |
| `recompute_metrics` | Weekly | Neo4j Algo (betweenness) |

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## 10 Security & Backup

- **Backups** Neo4j `neo4j-admin backup` daily → `/backups/neo4j/` (btrfs snapshot).
- **Access** Neo4j roles: `reader` for MCP; `admin` for ingestion.
- **Secrets** Env files managed via `systemd EnvironmentFile=`.

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## 11 Future Enhancements

1. Swap FAISS for **Chroma** to avoid RAM overhead.
2. Experiment with **phi4-reasoning** as hyperedge-suggestion co-pilot.
3. Deploy MCP in **K8s (k3s)** for HA.

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Great — I'll add a new section titled **12 Deployment & Observability Setup** summarizing the changes we've made, including:

- Docker Compose managed via systemd
- Correct use of `env_file` separation to avoid config injection issues
- Proper environment variable formatting for Neo4j config keys
- Integration of the `petrov-e/neo4j_exporter` for Prometheus

I'll update the architecture file now.

## 12 Deployment & Observability Setup

- **Stack Orchestration** Neo4j and its Prometheus exporter run together via a single `docker-compose` configuration, with **systemd** managing the entire stack as one unit (starting/stopping both services together).

- **Environment Files** The Neo4j container is launched with a minimal env file (only the `NEO4J_AUTH` credential). The exporter uses a separate env file (`NEO4J_USER` and `NEO4J_PASSWORD` for the DB login), preventing any unsupported variables from being passed into the Neo4j container.
- **Config Variables** For Neo4j settings that contain underscores in their keys, use double-underscore in the environment variable name. For example, `dbms.security.allow_csv_import_from_file_urls` is set via `NEO4J_dbms_security_allow__csv__import__from__file__urls` in the container's env.
- **Prometheus Exporter** Uses the Neo4j exporter image from GHCR (`ghcr.io/petrov-e/neo4j_exporter`) since no official Docker Hub image exists. The metrics endpoint (`/metrics`) is exposed on container port 5000, mapped to host port **7475** for Prometheus scraping.
- **Neosemantics (n10s)** The **n10s** RDF plugin is installed at container startup via the `NEO4J_PLUGINS` environment variable (including `"n10s"` in its JSON list). All neosemantics procedures (`n10s.*`) are enabled by adding `n10s.*` to `dbms.security.procedures.unrestricted`, allowing those plugin procedures to run without restriction.