openMINDS SANDS:
A metadata model for ontology-based brain atlas definitions in graph databases.

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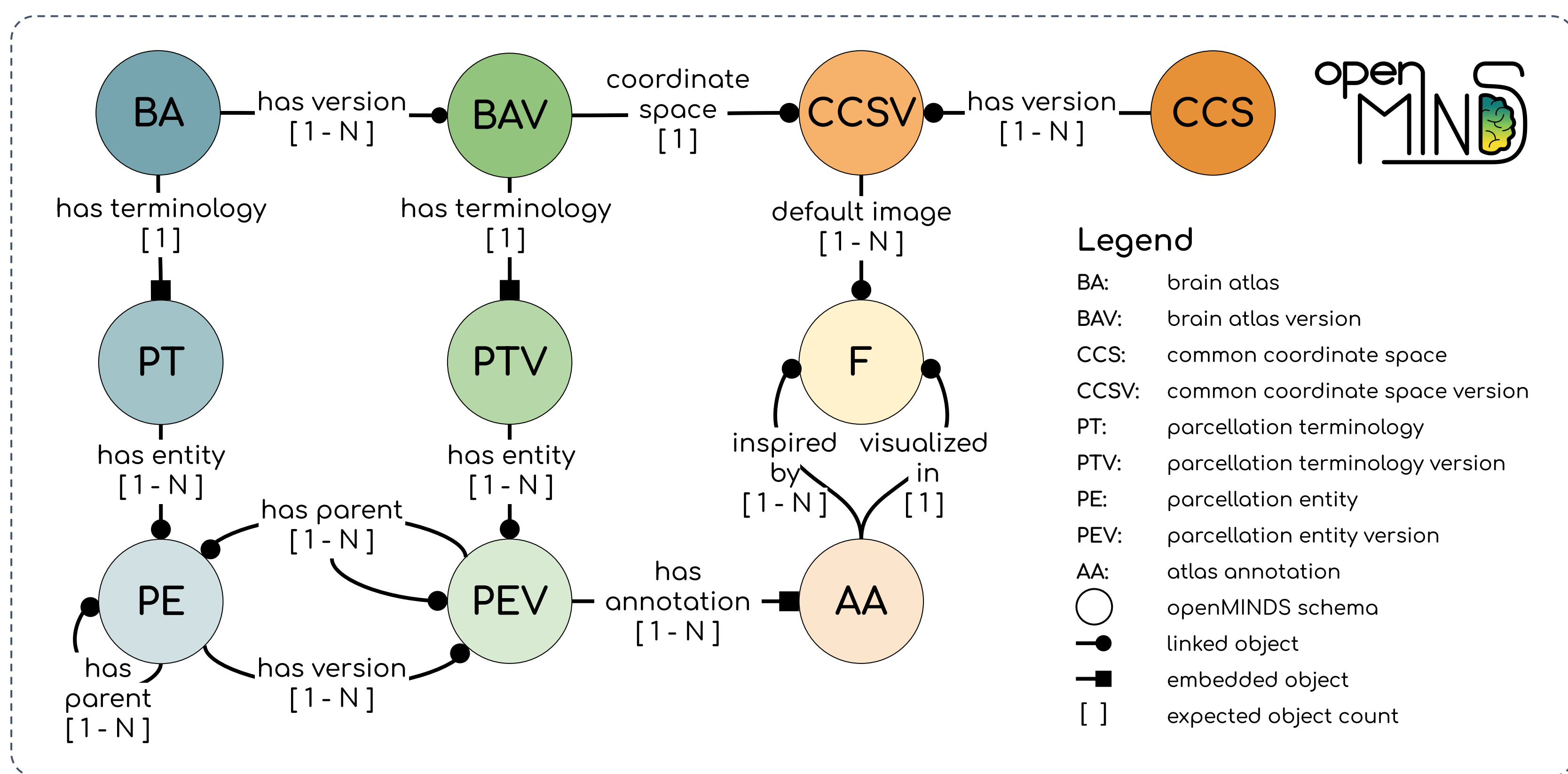**Figure 1:** Simplified SANDS metadata model for brain atlases.

Figure 2: Links to documentation of schema specifications for all schemas of Fig.1.
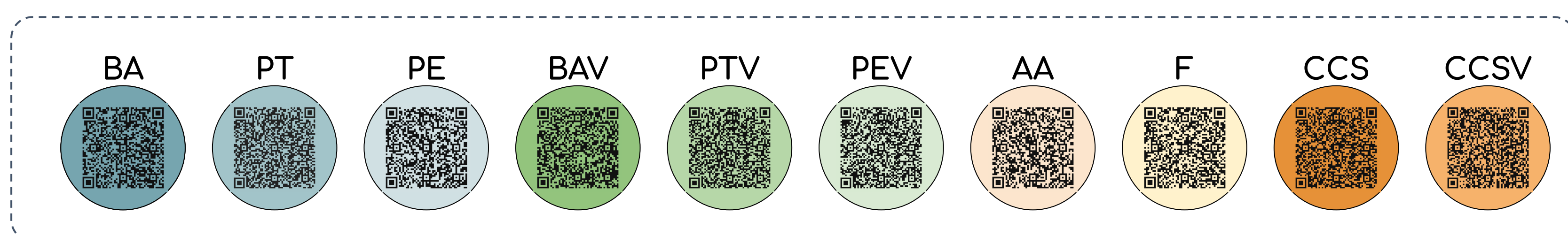

Figure 3: Simplified SANDS metadata (sub)model for anatomical integration (example 1).
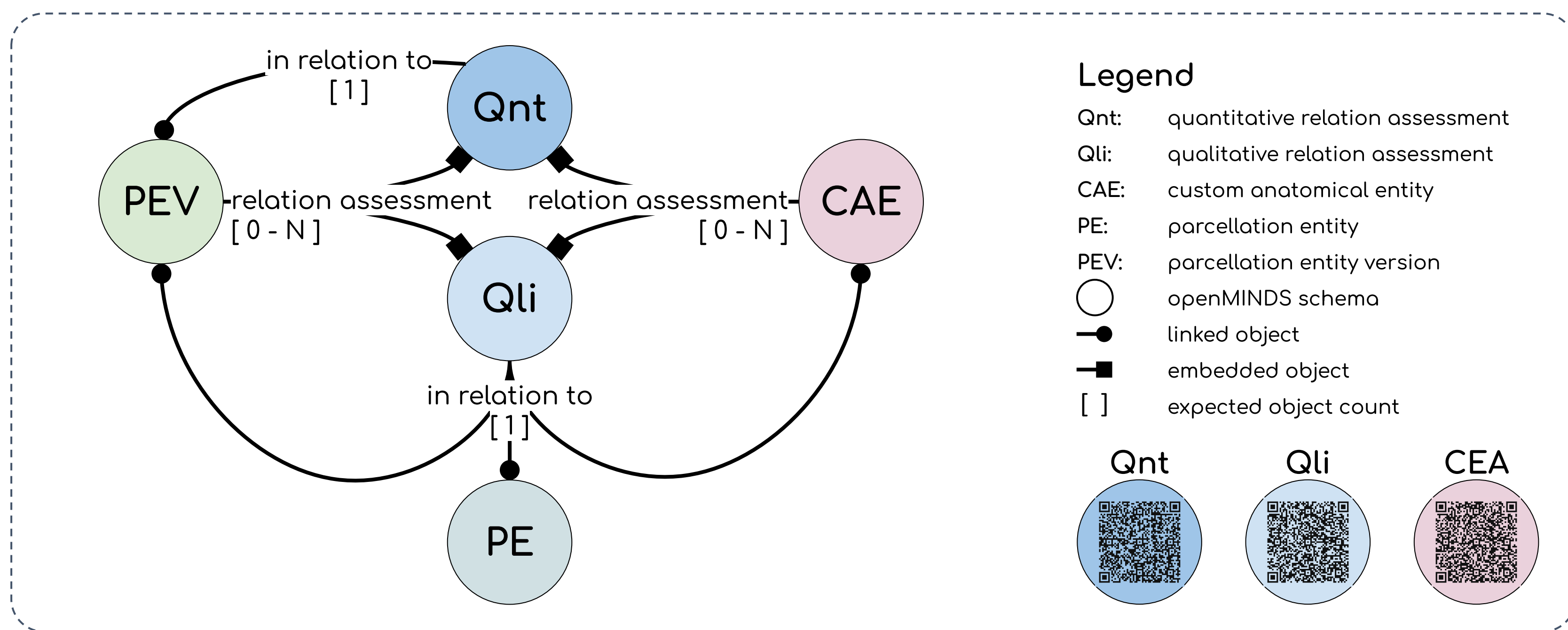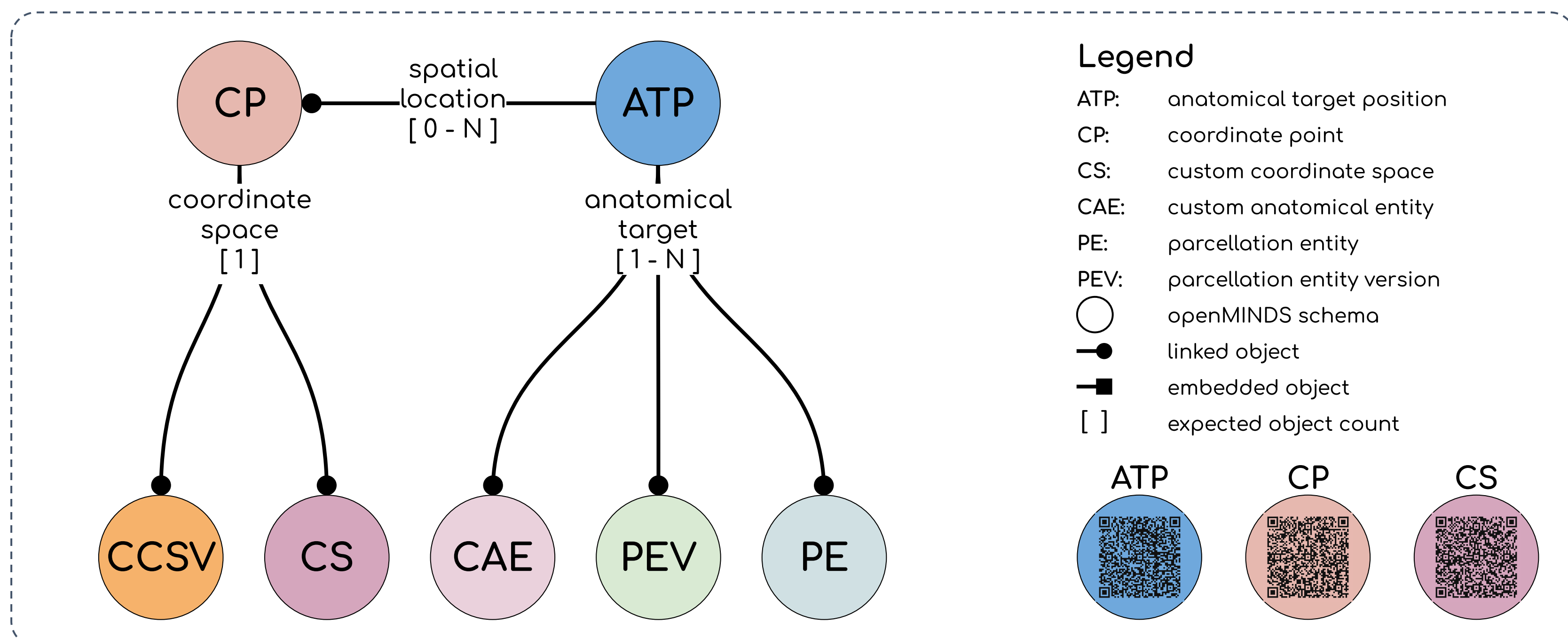

Figure 4: Simplified SANDS metadata (sub)model for anatomical integration (example 2).

WHAT? openMINDS is a community-driven, open-source metadata framework adoptable by any graph database management system. It is composed of linked metadata models, libraries of serviceable metadata instances, and supportive tooling. The **metadata model SANDS** focuses on specification of graph structures for brain atlases and integration of data through precise definitions of anatomical locations.

WHY? Brain atlases and their composing elements need to become more **FAIR**[1] between graph database systems of different brain initiatives worldwide in order to facilitate precise communication for accurate data integration. The **At**las **O**ntology **M**odel (**AtOM**)[2] suggests that each brain atlas is composed of **reference data** in a **common coordinate space**, presenting **anatomical annotations** with a given **terminology**. Any specific combination of these four elements constitutes a unique atlas configuration, or version.

HOW? In accordance with AtOM, the metadata model SANDS translates these ontological brain atlas elements into a modular set of metadata schemas (Fig.1) that also integrate well with the other openMINDS metadata models. Each schema specifies the expected information for a respective atlas element (Fig.2). In conjunction with the metadata model for brain atlases, SANDS offers submodels for anatomical integration of atlas or non-atlas data (e.g., Fig.3, Fig.4). As service and suitable for general use, openMINDS also offers libraries of graph descriptions (formatted as JSON-LD collections) for an increasing number of brain atlases and common coordinate spaces (Fig.5).

IMPACT: SANDS offers an ontology-based metadata model for brain atlases and anatomical locations of non-atlas data adoptable by any graph database management system. The libraries of graph descriptions for brain atlases and common coordinate spaces offer human and machine-readable metadata instances for accurate referencing across scientific studies and software services. Through SANDS, brain atlases become more FAIR between different brain initiatives worldwide.

YOU WANT TO CONTRIBUTE? Get in touch: **openminds@ebrains.eu**

Figure 5: Links to documentation of serviceable serializations.
Serializations of atlas or common coordinate spaces might not be complete yet. Contributions are highly appreciated..

Common Coordinate Spaces:
- Allen Mouse Brain CCF
- BigBrain Model
- MNI Colin27 Average Brain
- MNI ICBM152
- MEBRAINS brain template
- WHS of the SD Rat Brain

Brain Atlases:
- Allen Mouse Brain Atlas
- Julich-Brain Atlas
- Brodmann Areas (human)
- Desikan-Killiany Atlas
- Deep White Matter Atlas
- WHS Rat Brain Atlas