Tackling IoT Interoperability Problems with Ontology-Driven Smart Approach

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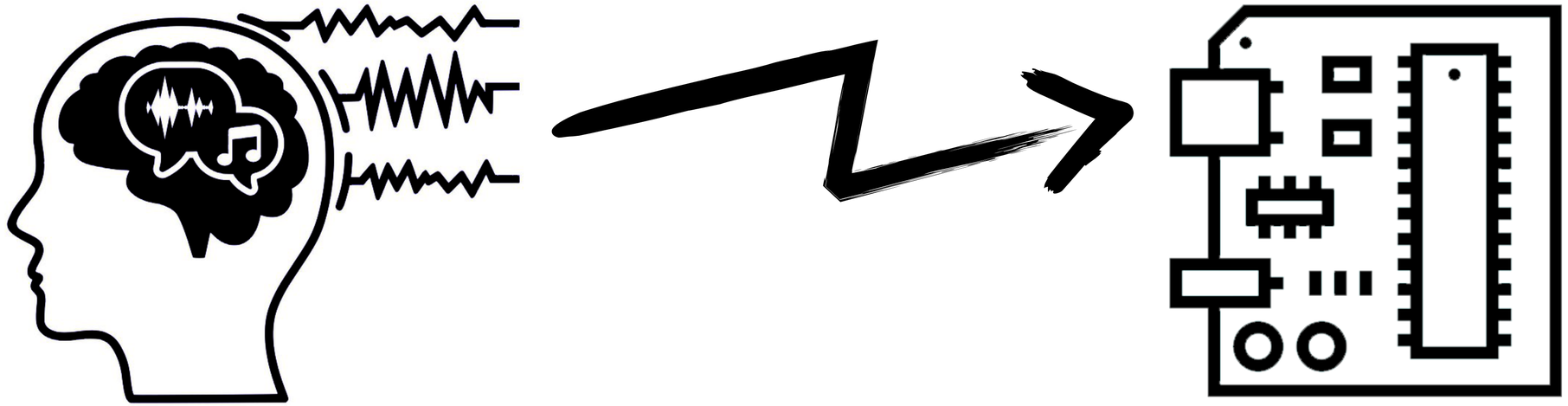
Modern IoT: Interoperability Problem

Cimmino, A., Oravec, V., Serena, F., Kostelnik, P., Poveda-Villalón, M., Tryferidis, A., García-Castro, R., Vanya, S., Tzovaras, D., Grimm, C.: VICINITY: IoT Semantic Interoperability Based on the Web of Things. In: 2019 15th International Conference on Distributed Computing in Sensor Systems (DCOSS). pp. 241–247 (2019). https://doi.org/10.1109/DCOSS.2019.00061

Modern IoT: Human-Computer Interaction Problem

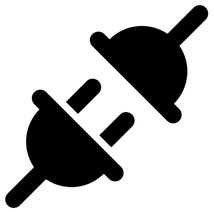
Calderon, M., Delgadillo, S., Garcia-Macias, A.: A More Human-Centric Internet of Things with Temporal and Spatial Context. Procedia Computer Science 83, 553–559 (2016). https://doi.org/10.1016/j.procs.2016.04.263

Brain-Computer Interface

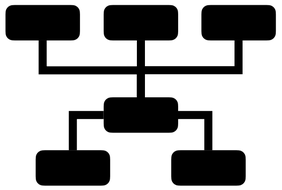


Allison, B.: The I of BCIs: Next Generation Interfaces for Brain–Computer Interface Systems That Adapt to Individual Users.
In: Human-Computer Interaction. Novel Interaction Methods and Techniques. pp. 558–568 (2009)

Key Contributions



Ontology-driven solution for integrating heterogeneous computing resources into a configurable IoT network



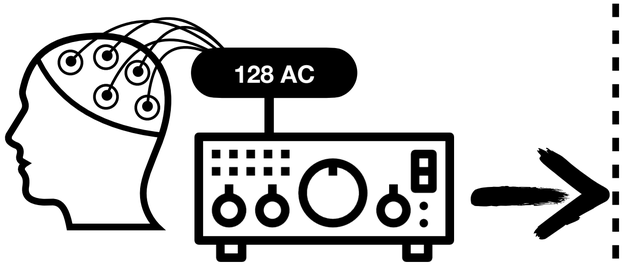
BCI-O extension to describe and integrate specific EEG devices

Methods and tools for the seamless embedding of non-invasive EEG-based BCI in the IoT networks

Practically useful BCI-controlled IoT device that can help to locate lost or forgotten things (under development)

SciVi Platform as a Middleware

Ryabinin, K., Chuprina, S., Belousov, K.: Ontology-Driven Automation of IoT-Based Human-Machine Interfaces Development. Lecture Notes in Computer Science 11540, 110–124 (2019). https://doi.org/10.1007/978-3-030-22750-0_9



EEG Device

SciVi

Data Filtering Module

Visualization Module

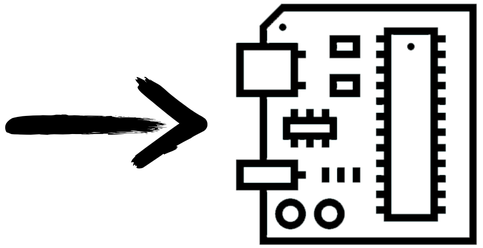
Integration Module

Ontologies

DFD Editor

Firmware Generator

Middleware Generator



IoT Device

OpenSource:
https://scivi.tools

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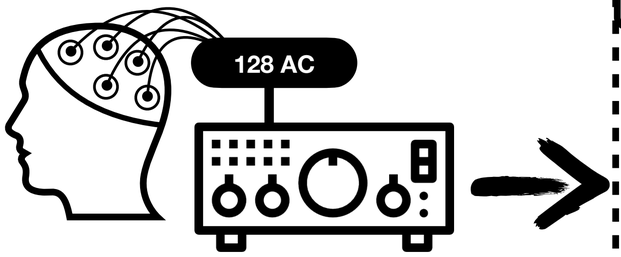
Ontology – formal model of application domain (T.R. Gruber, 1993)

$O = \langle T, R, A \rangle$

T – thesaurus of application domain concepts

R – set of relations between concepts

A – set of axioms



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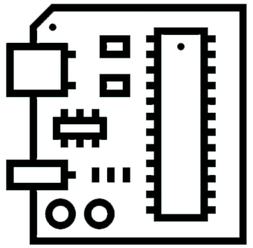

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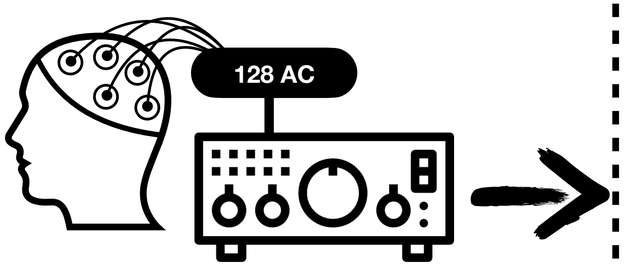

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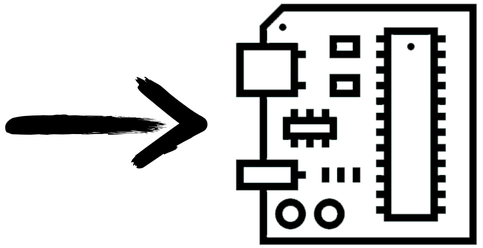

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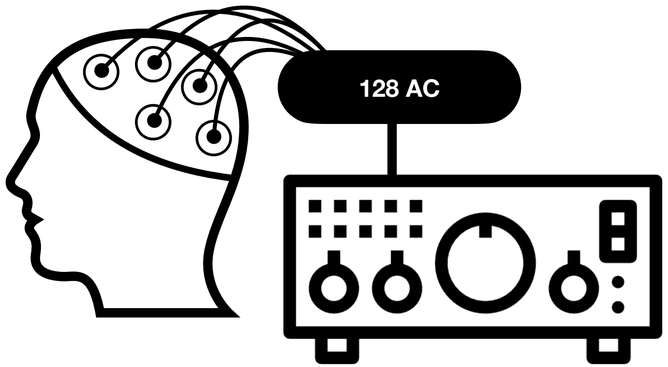
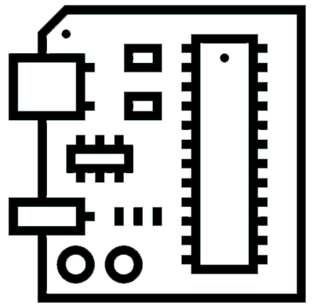
Use Case: Pager of Things Controlled by the Brain





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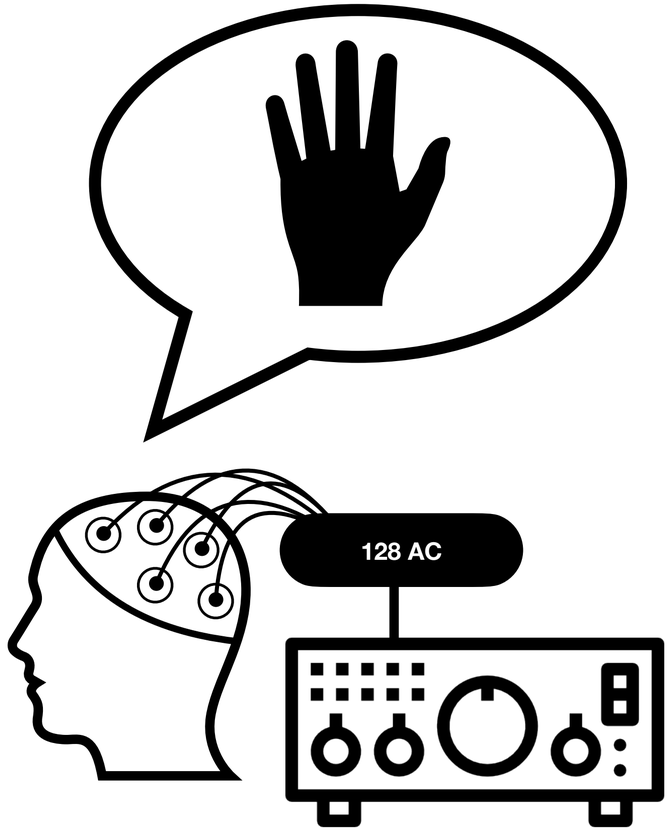

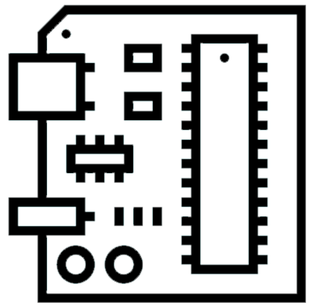

Imagine Hand Rising

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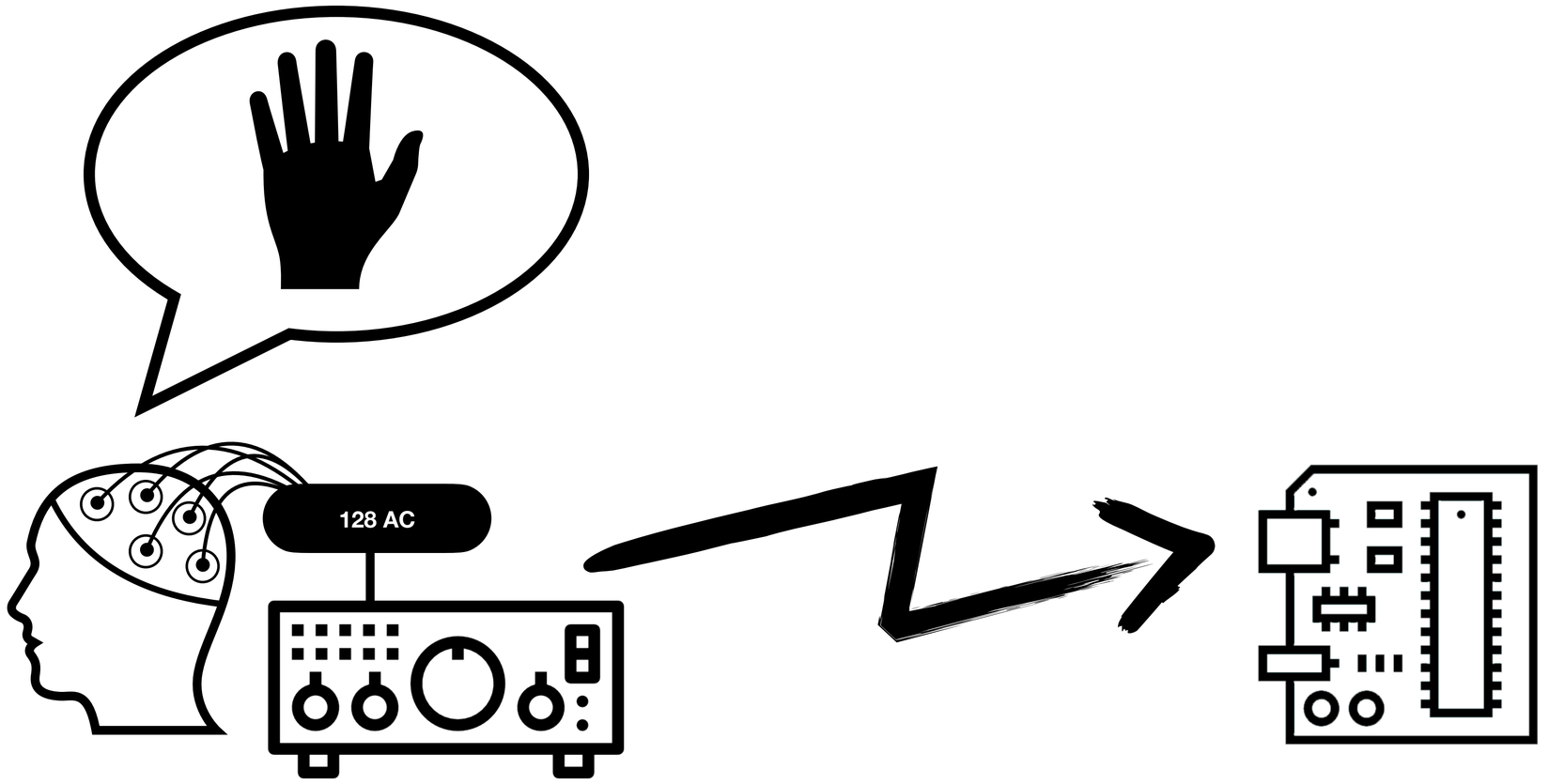

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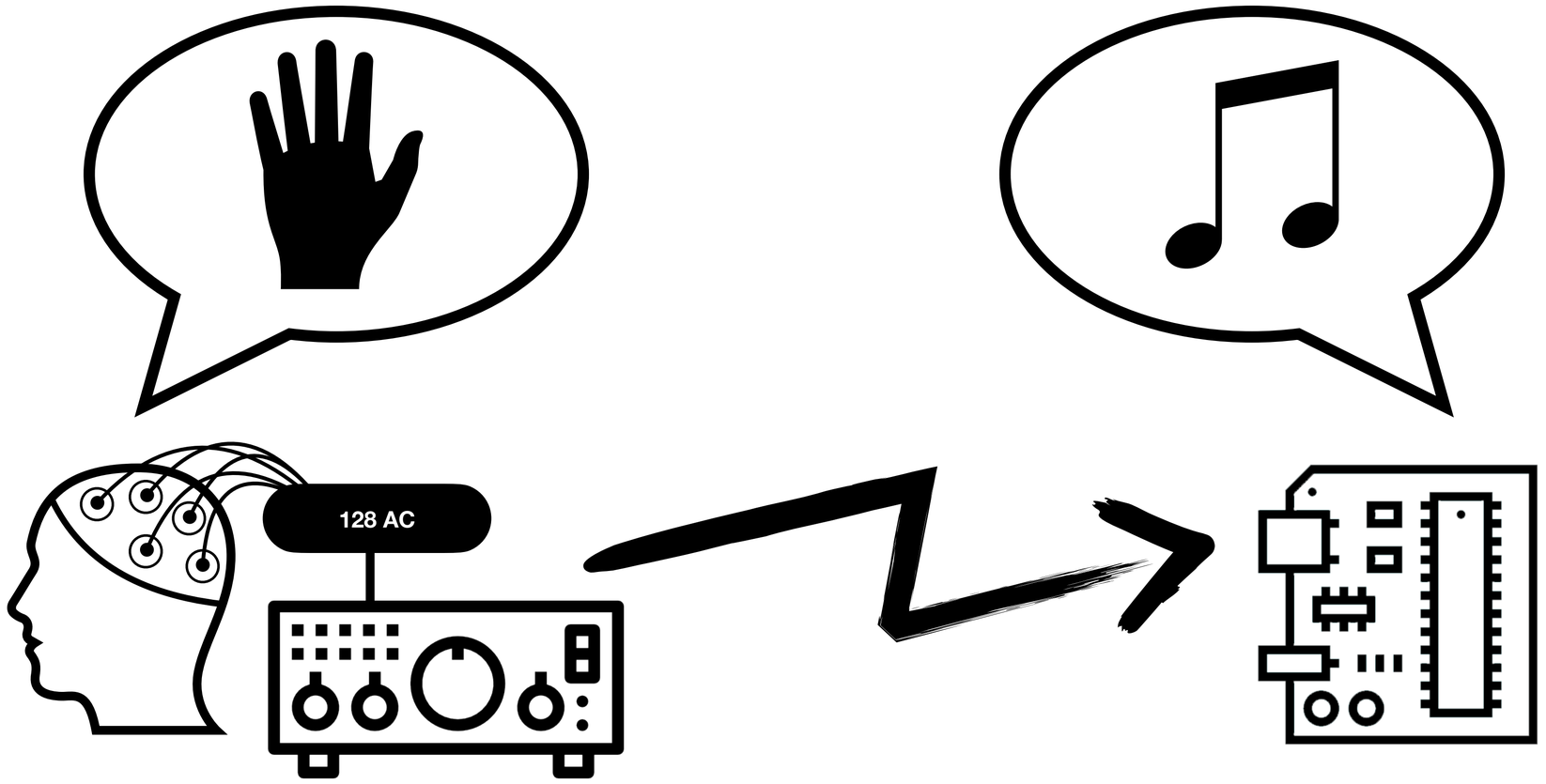
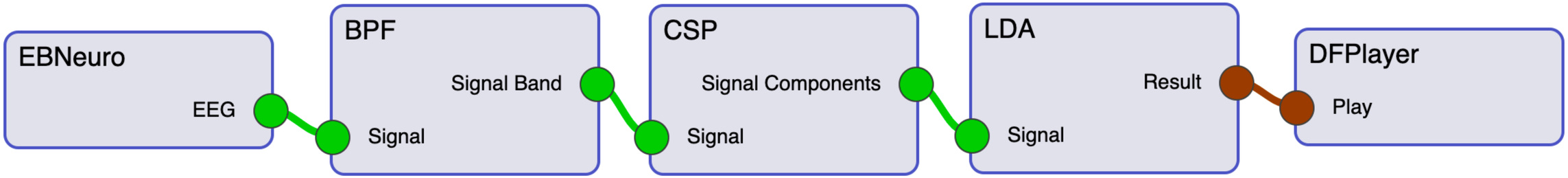


Imagine Hand Rising

Play Sound Signal

Data Flow Diagram Declaring Interoperation



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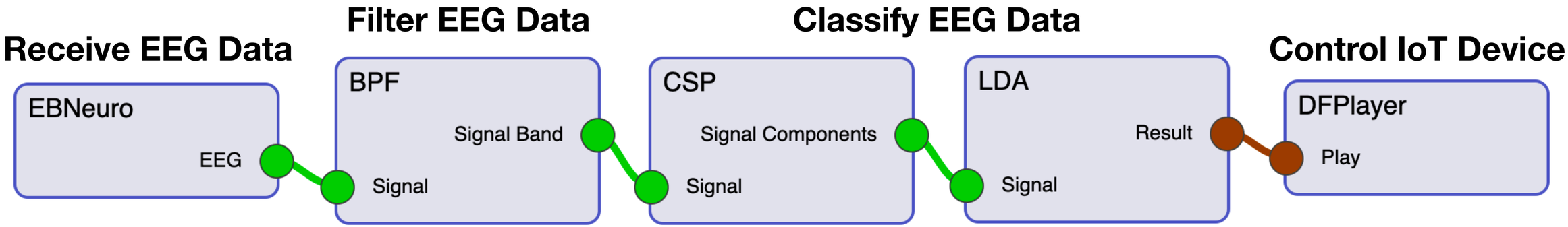

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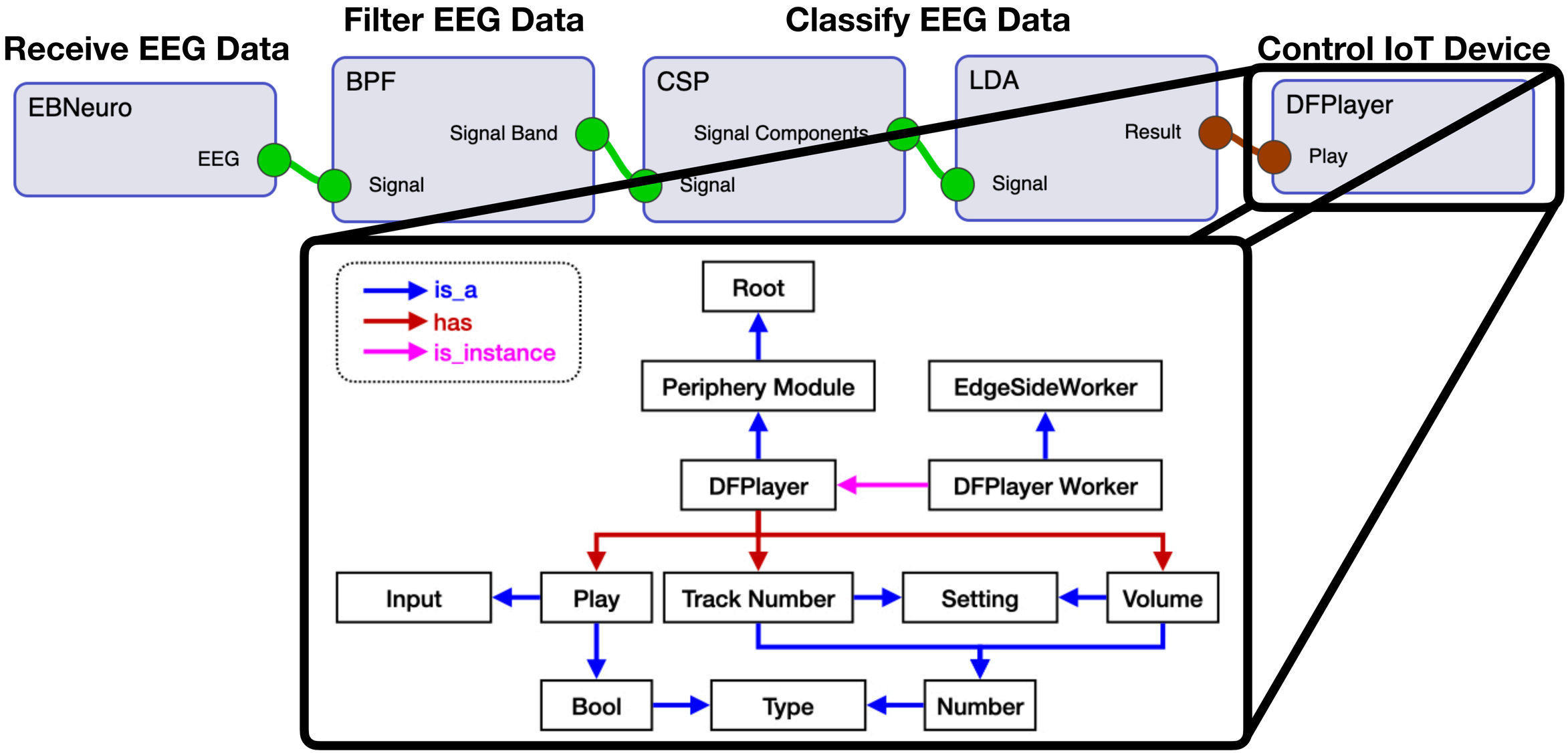

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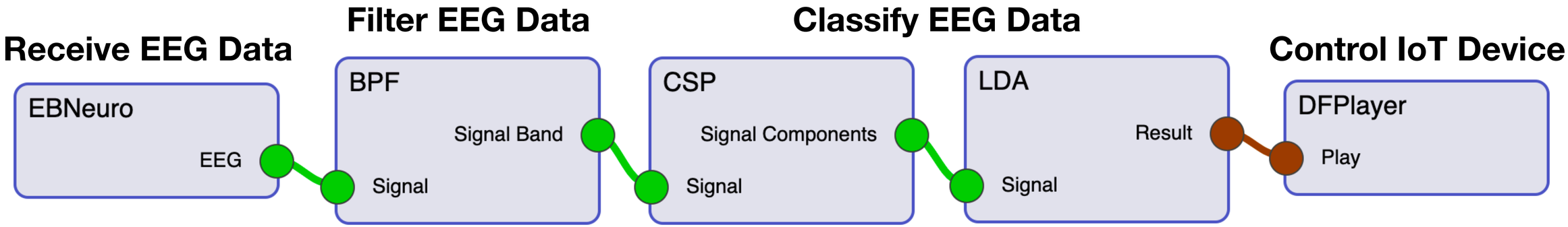

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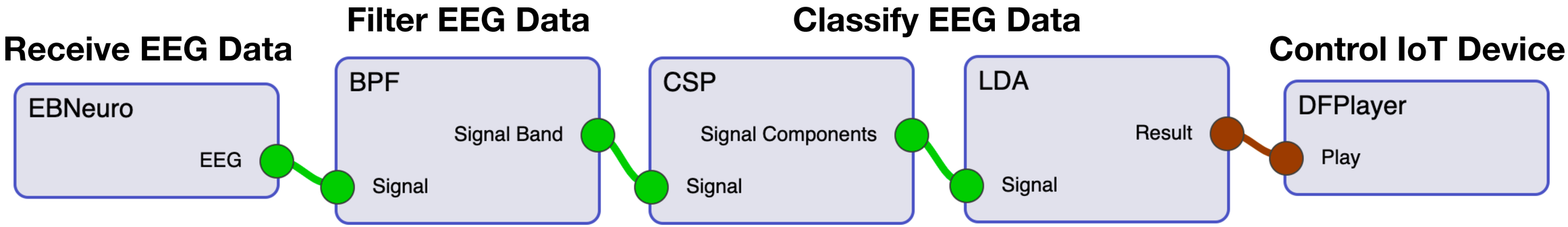

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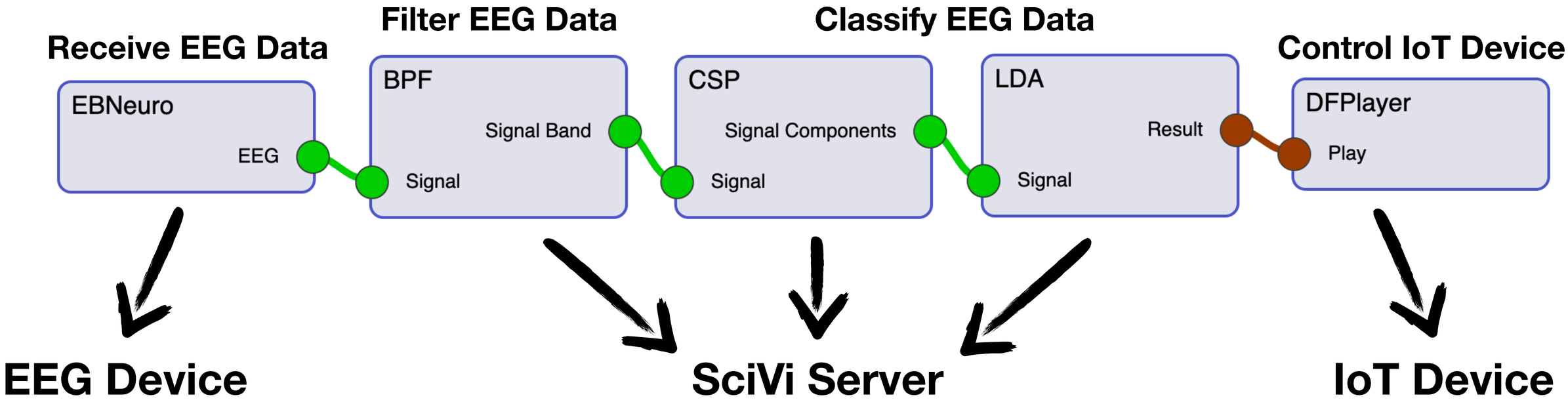

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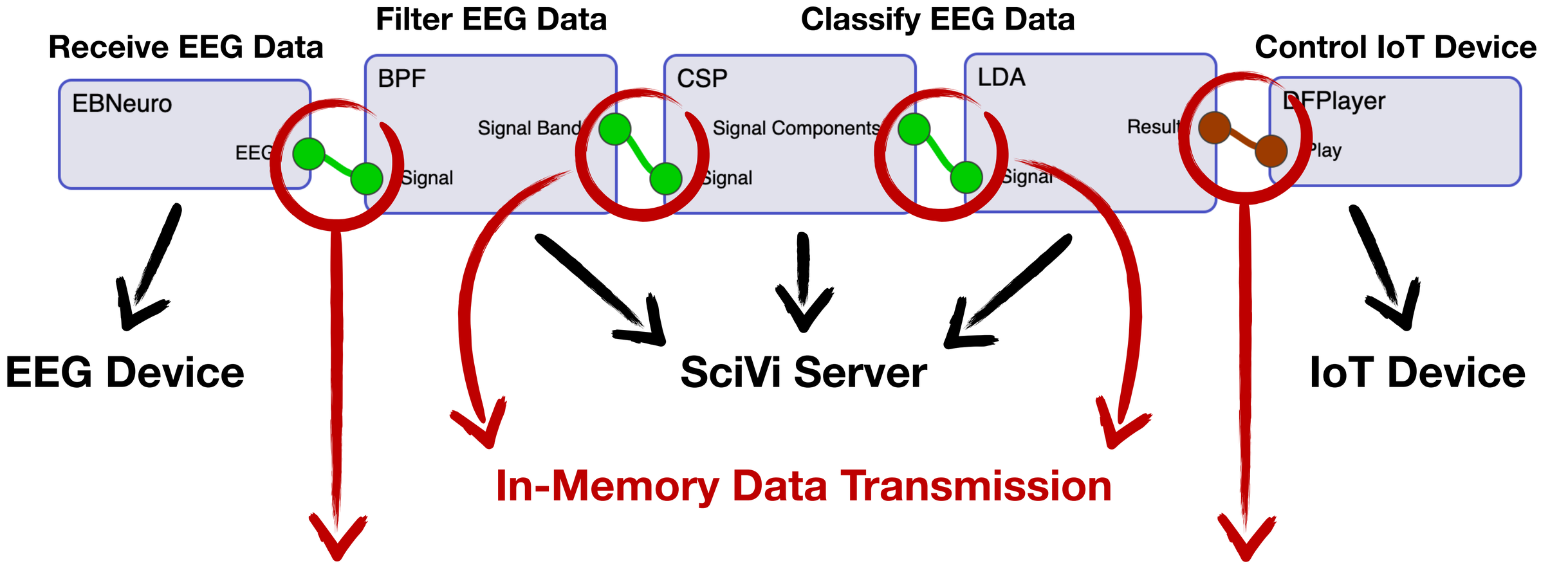
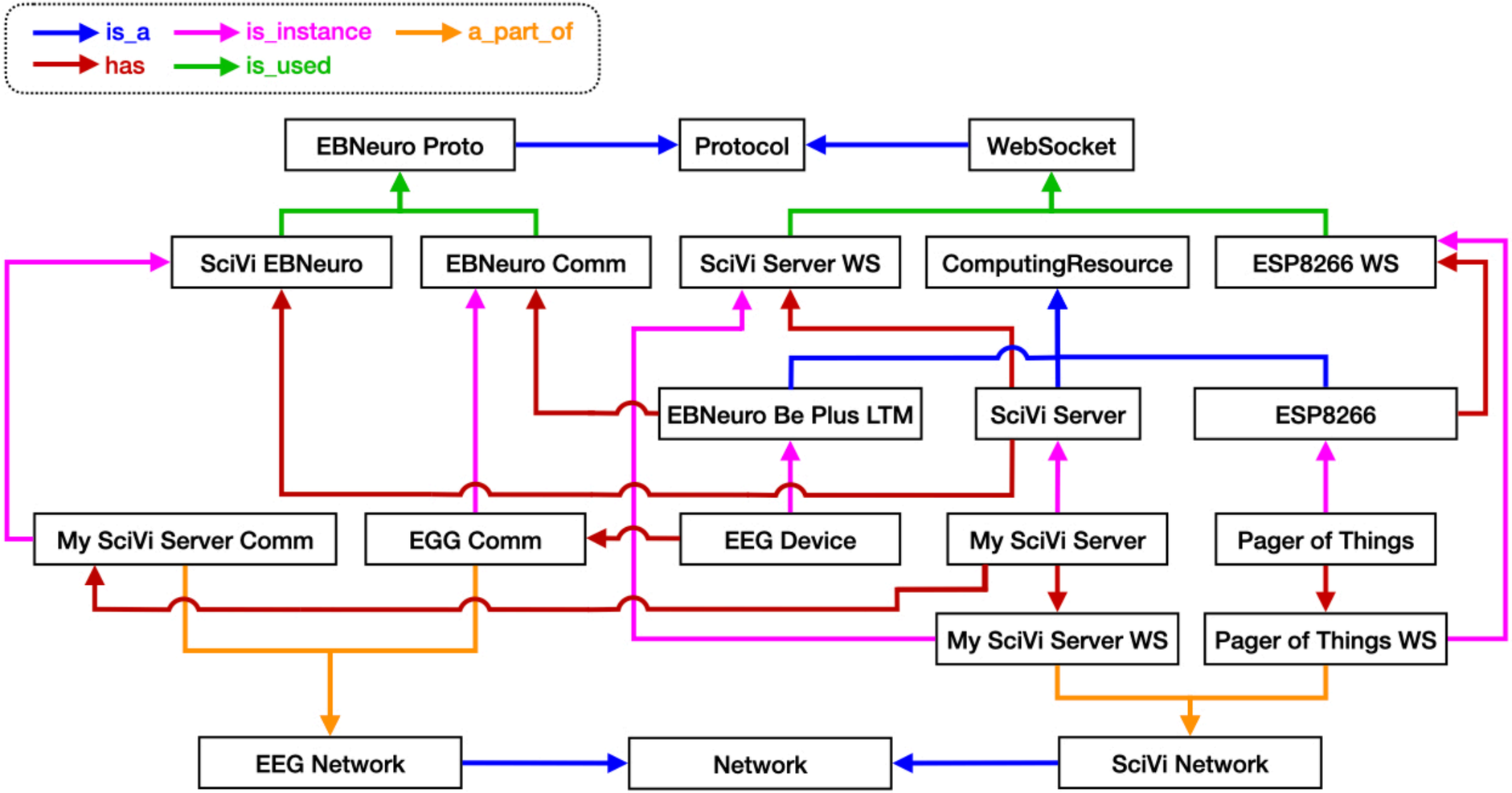


Step 1 Building the IoT network ontology



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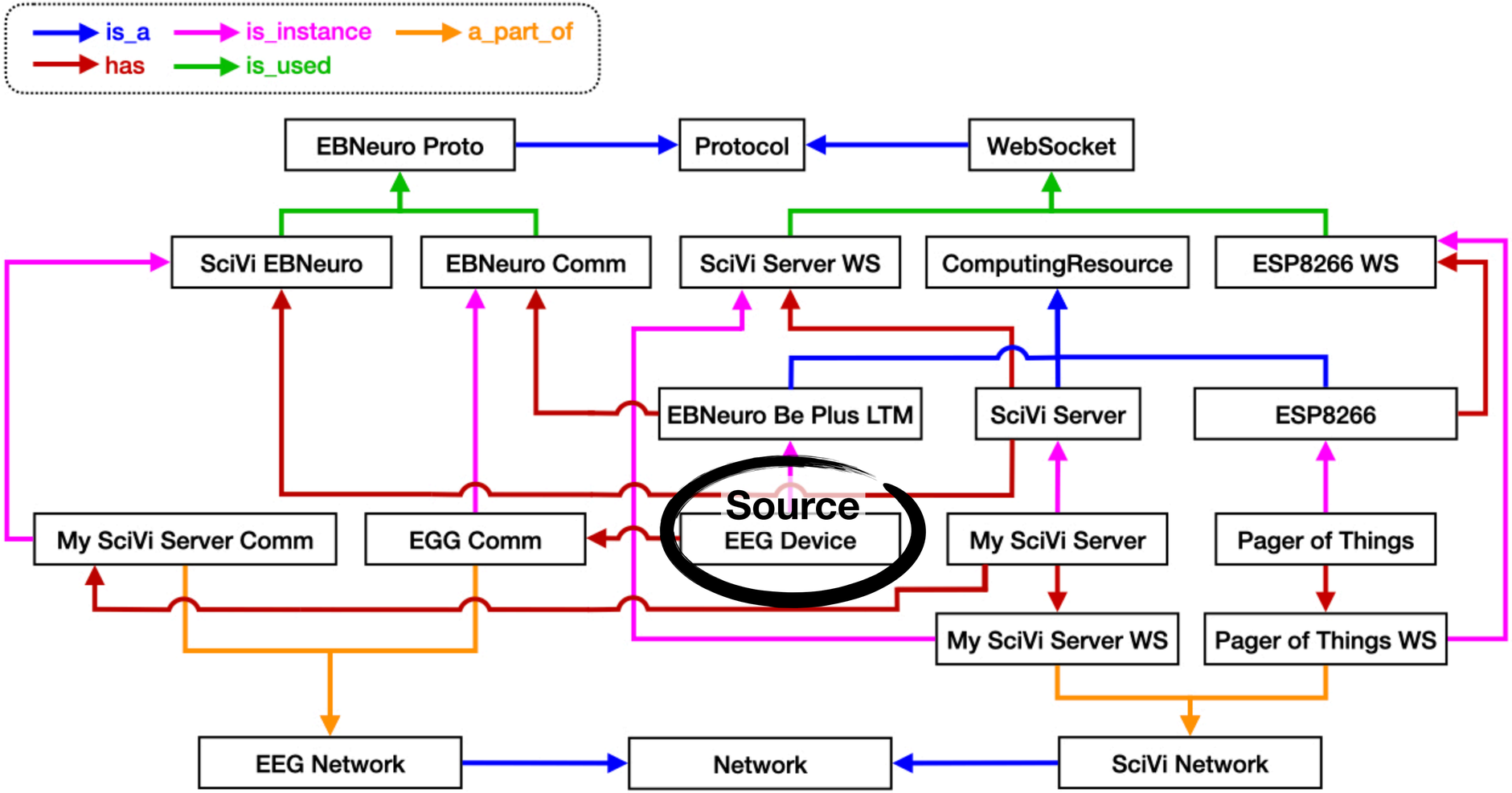

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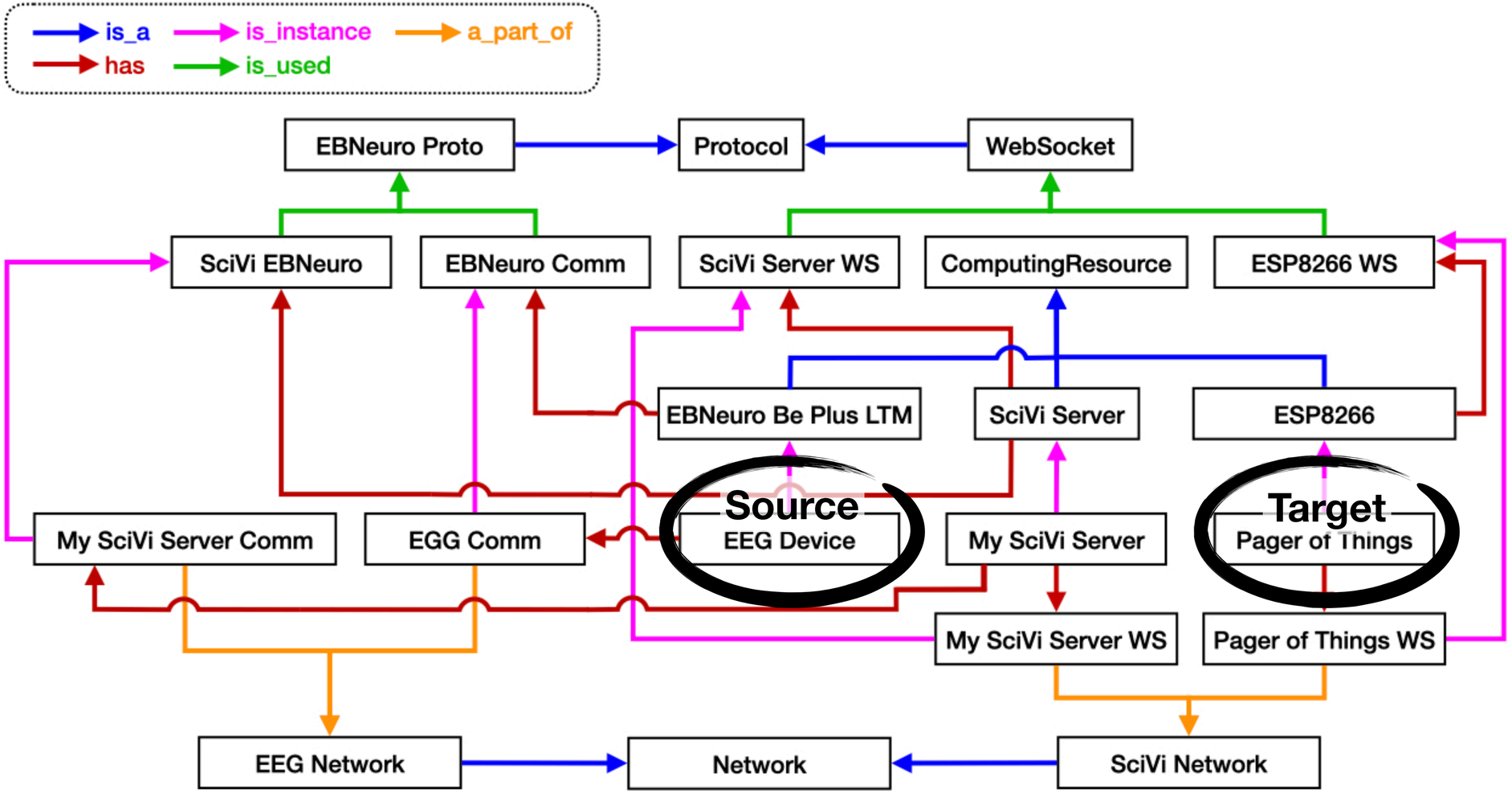

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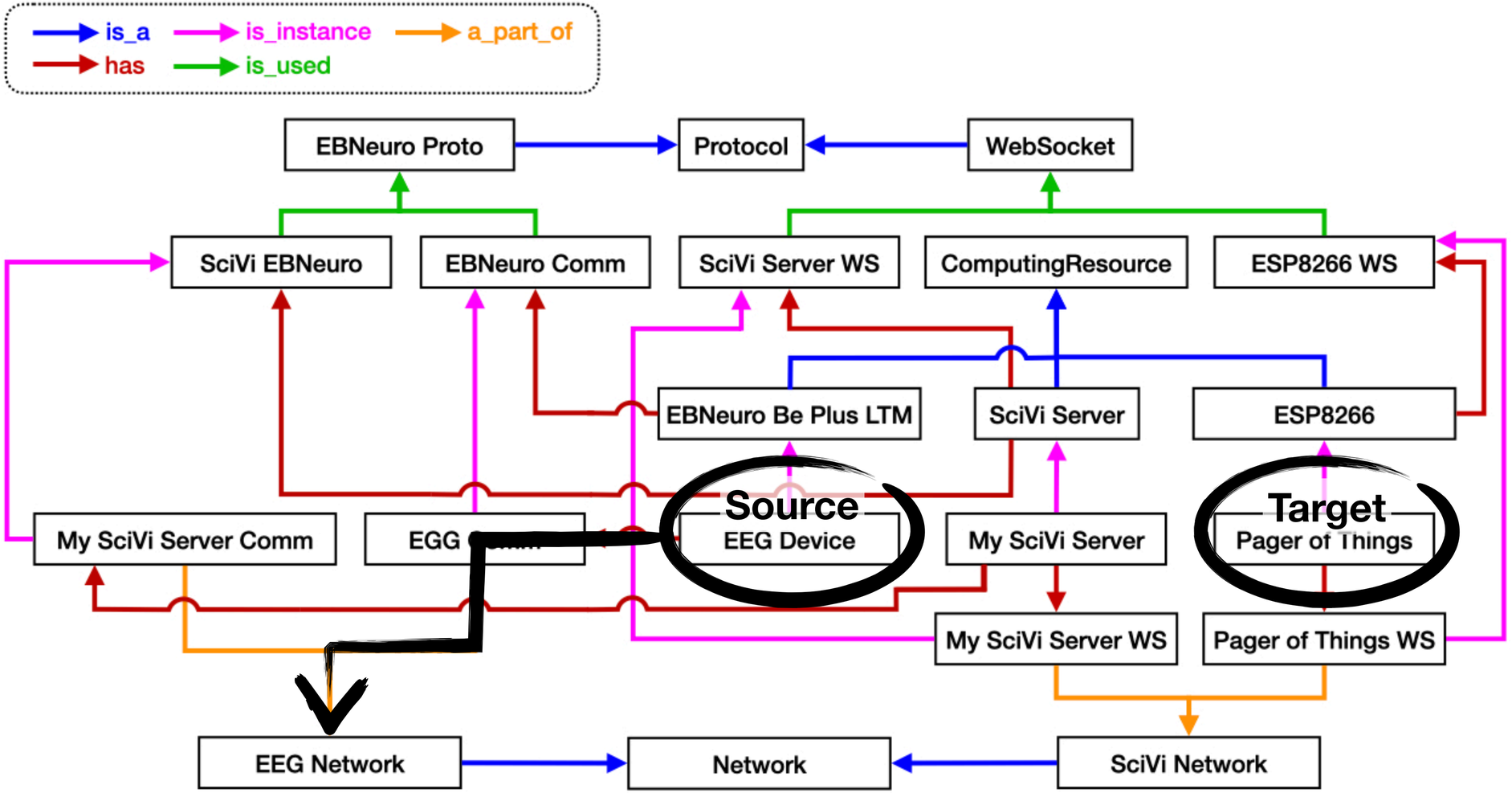

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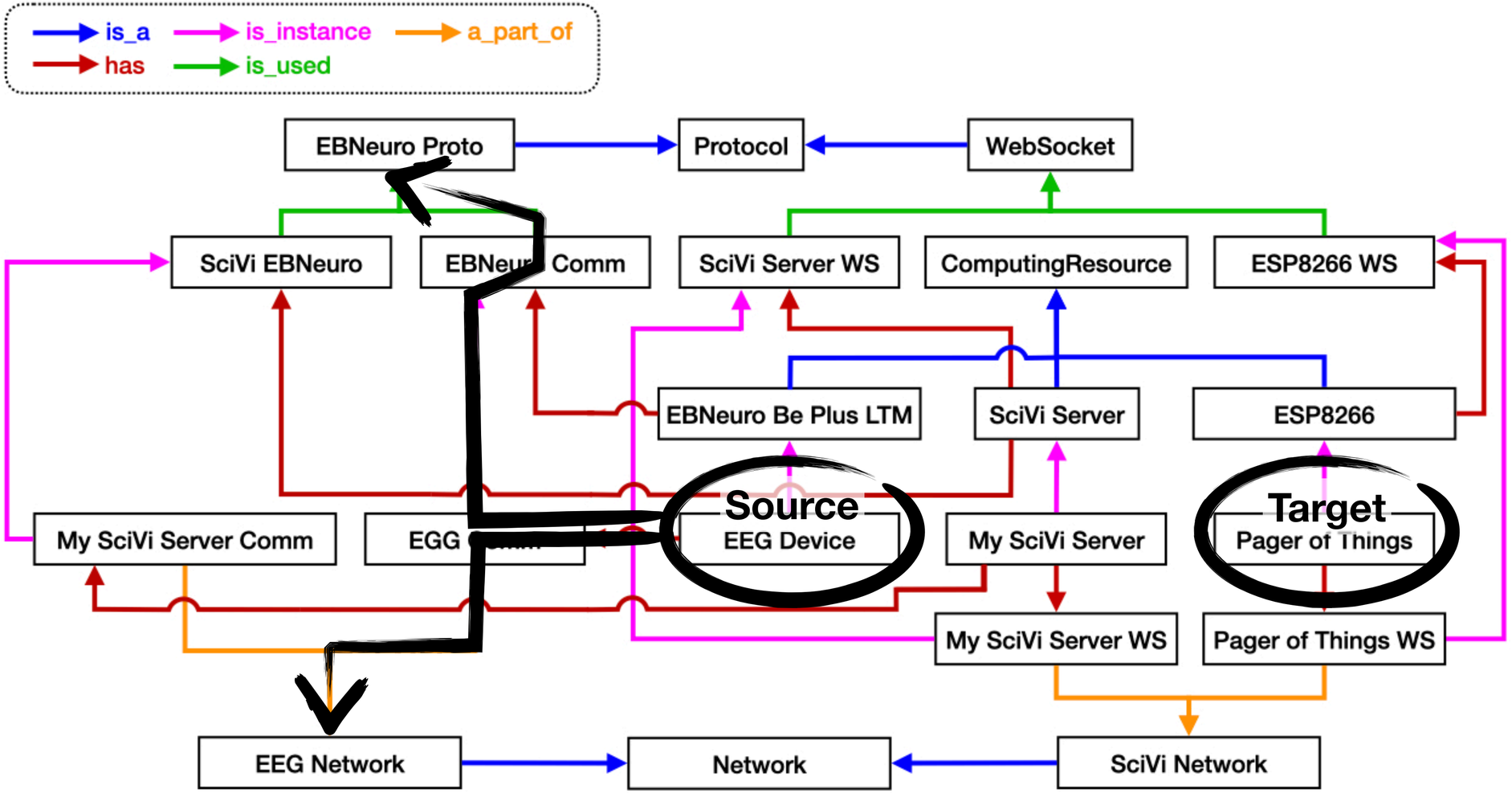

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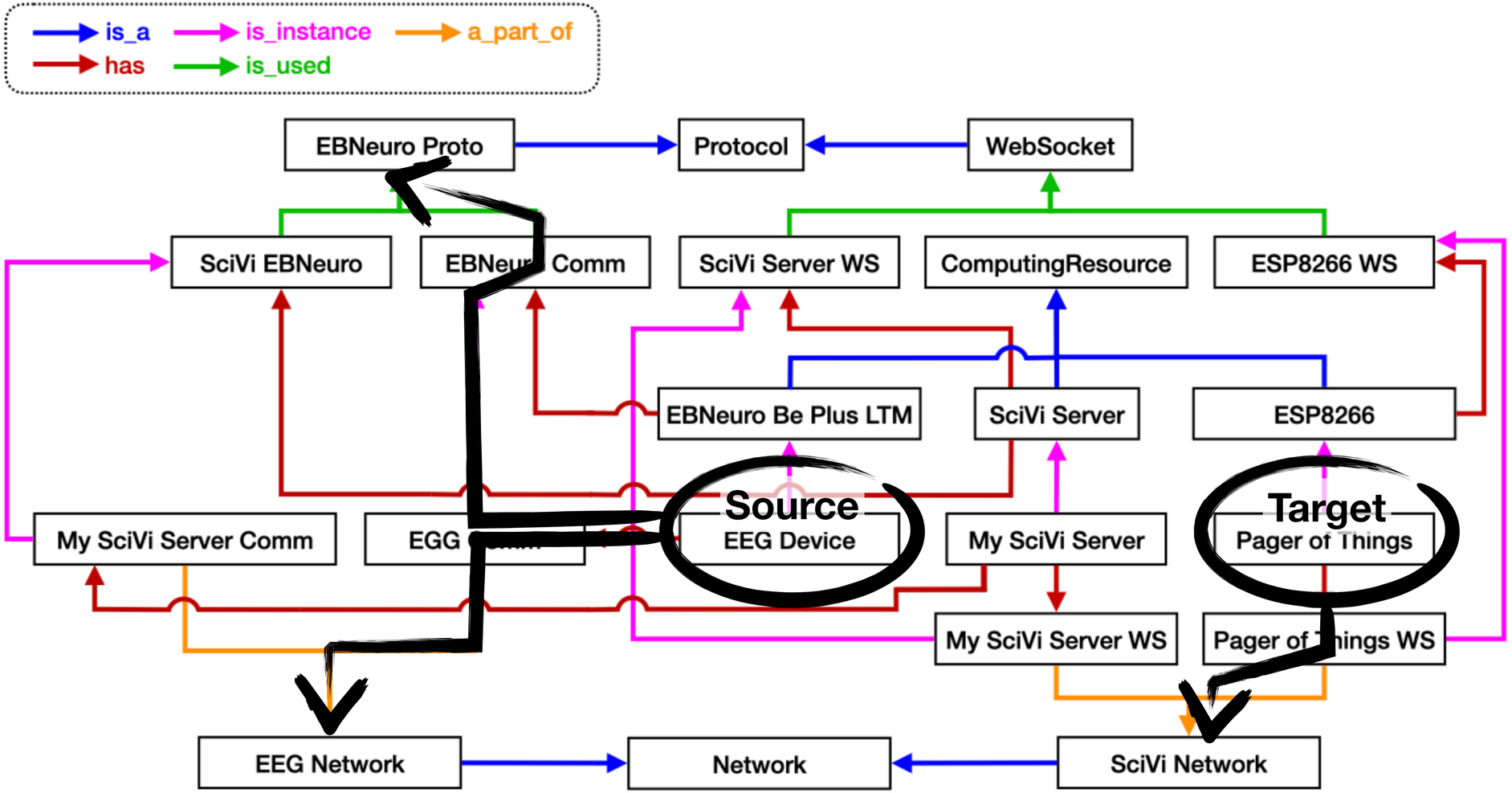

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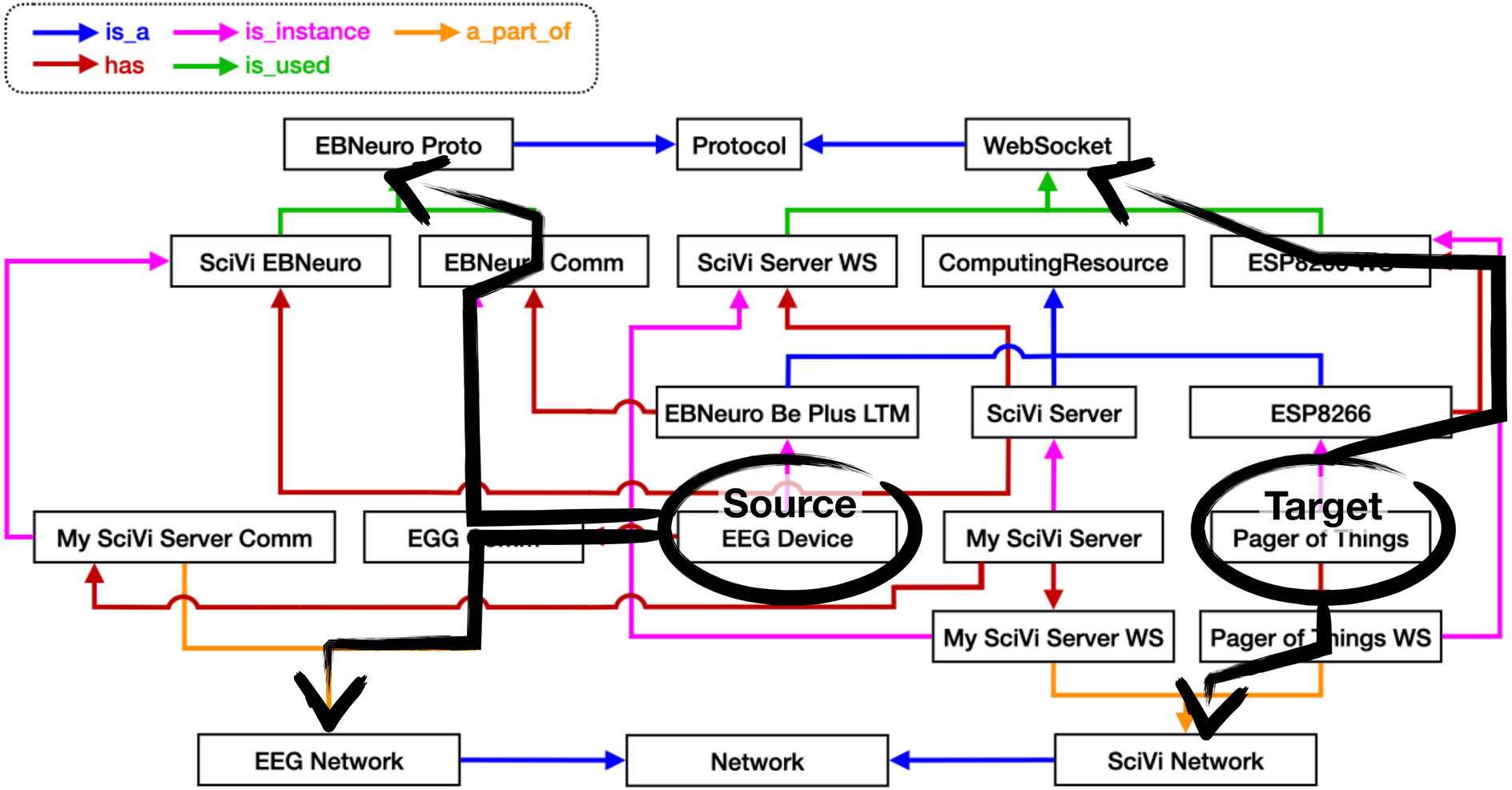

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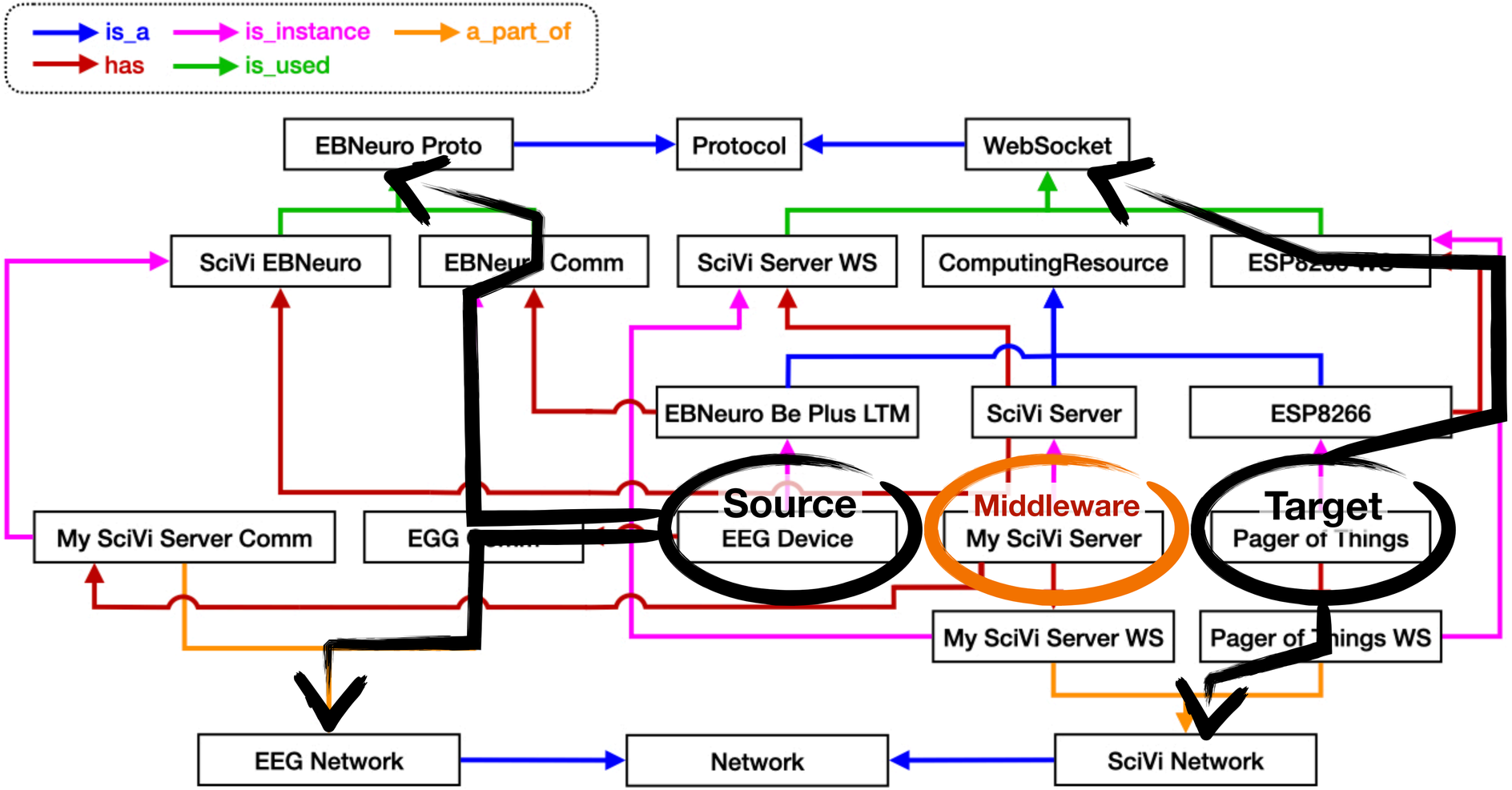

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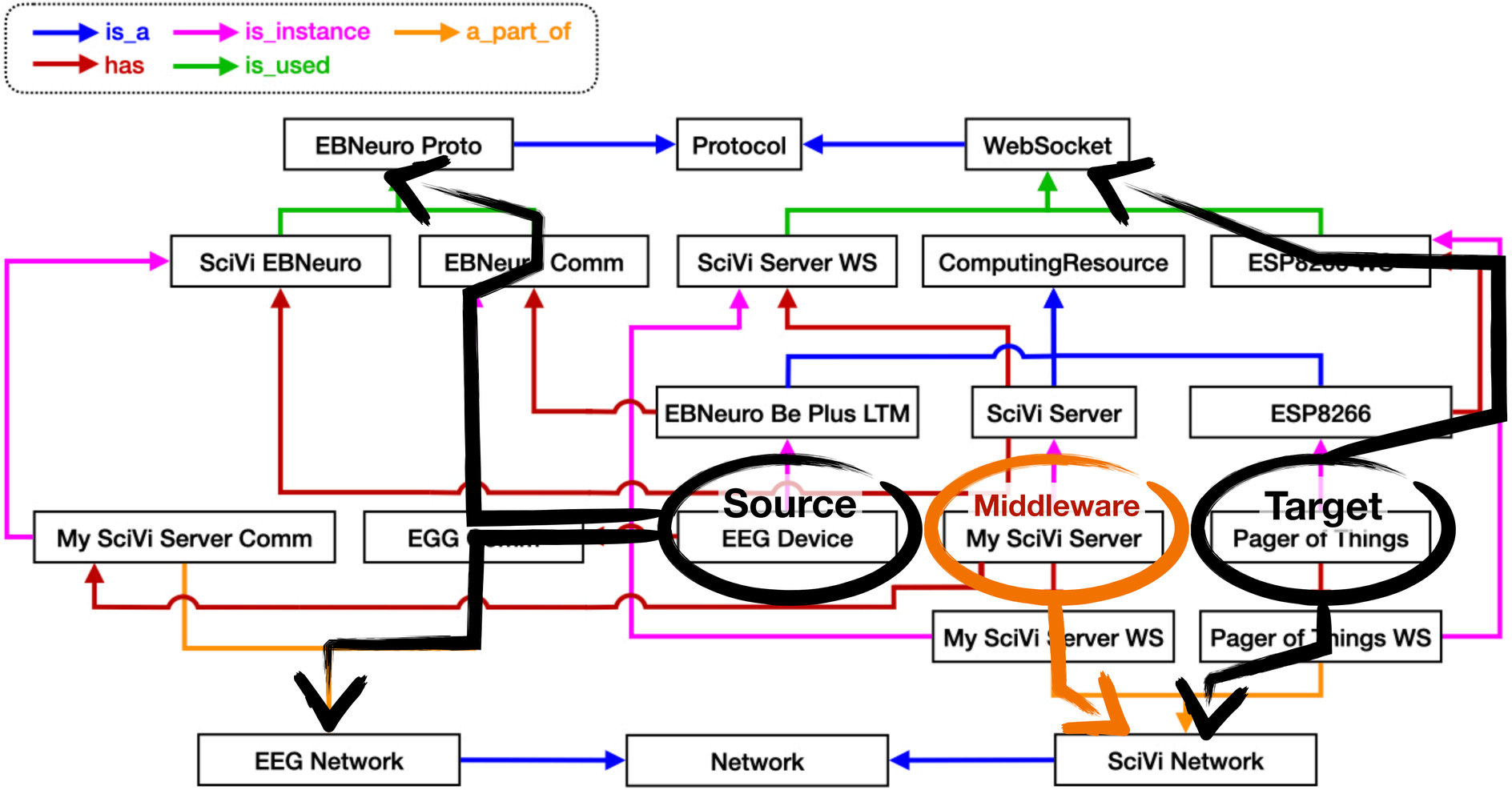

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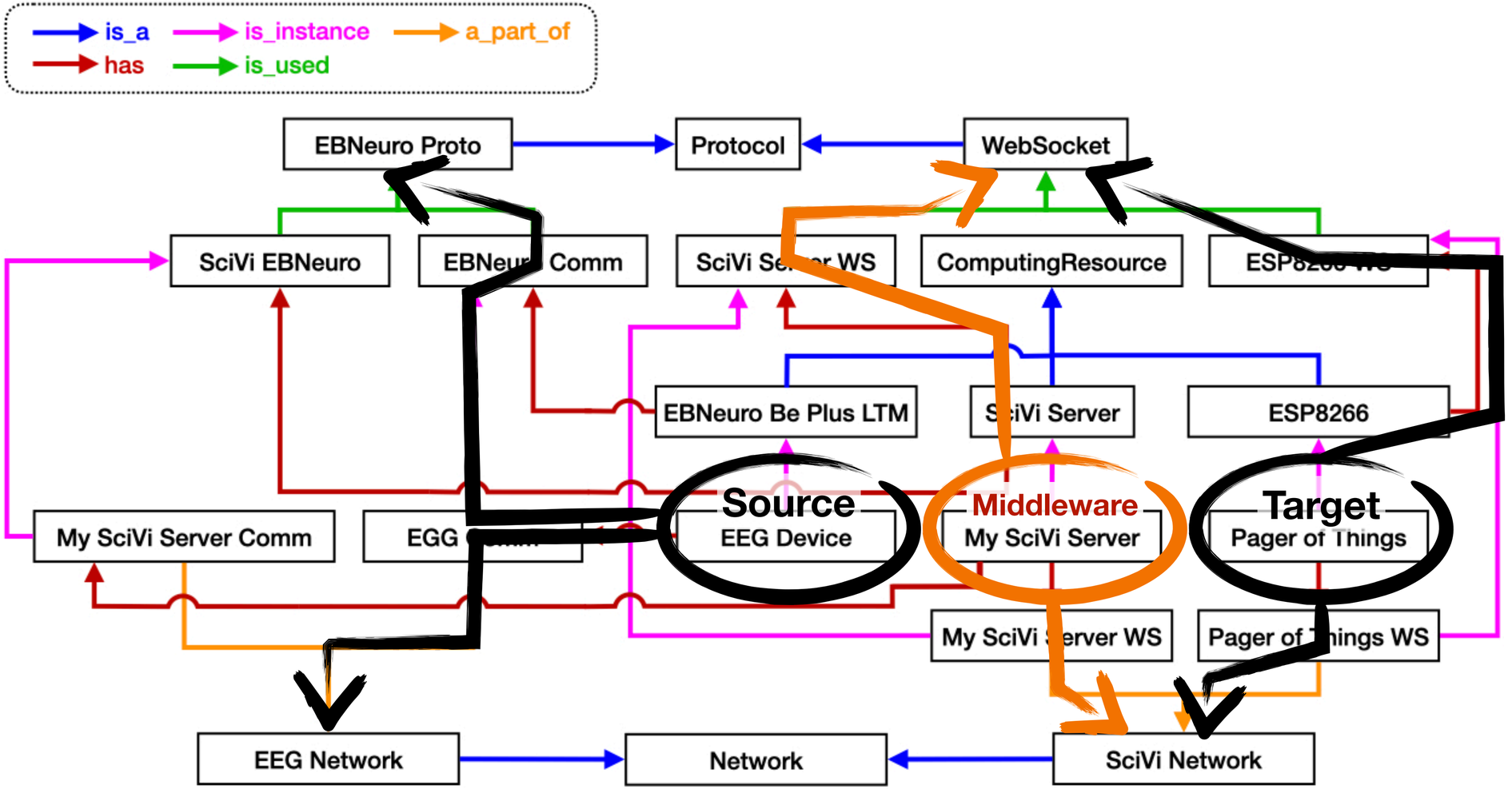

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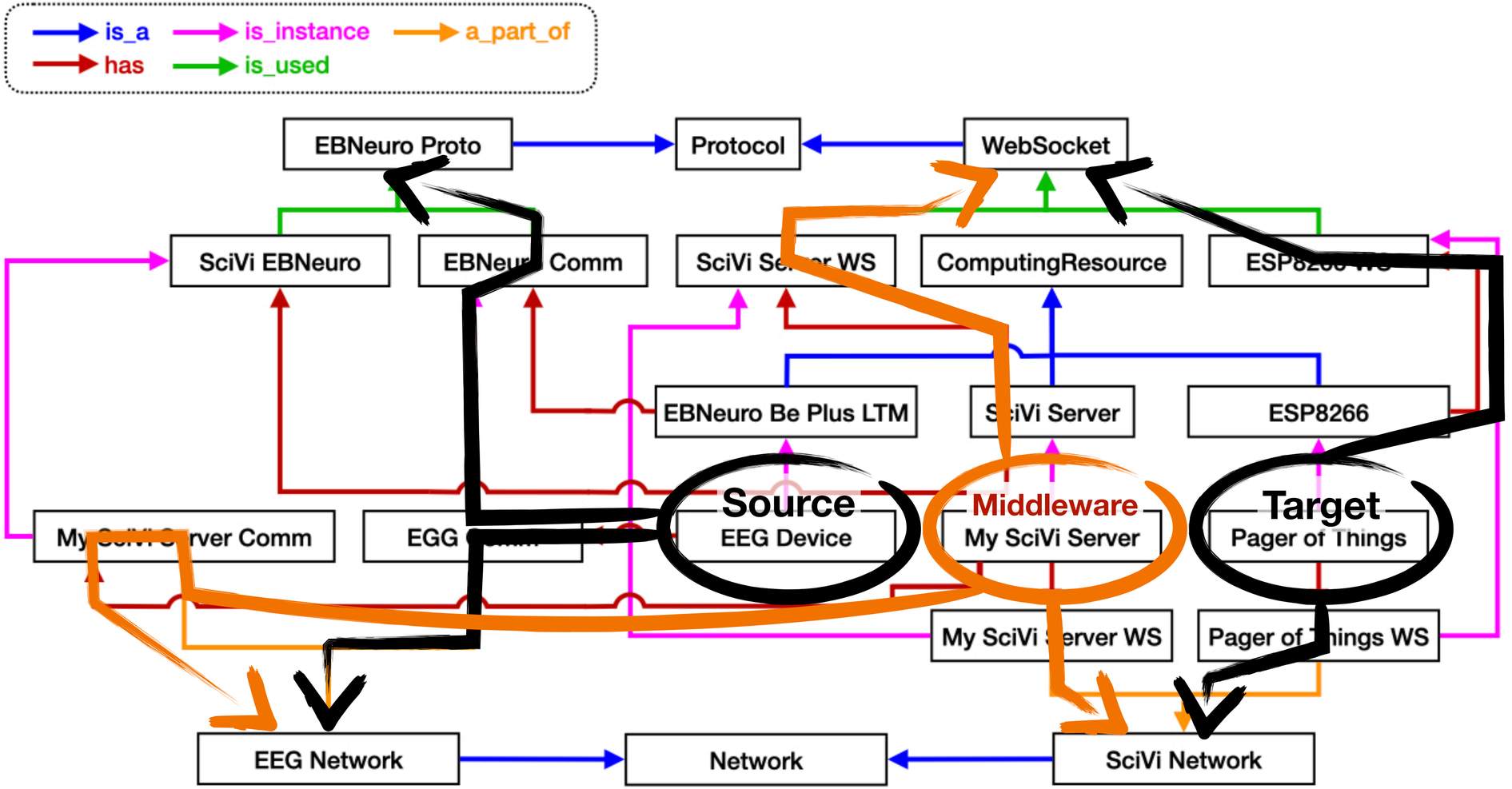

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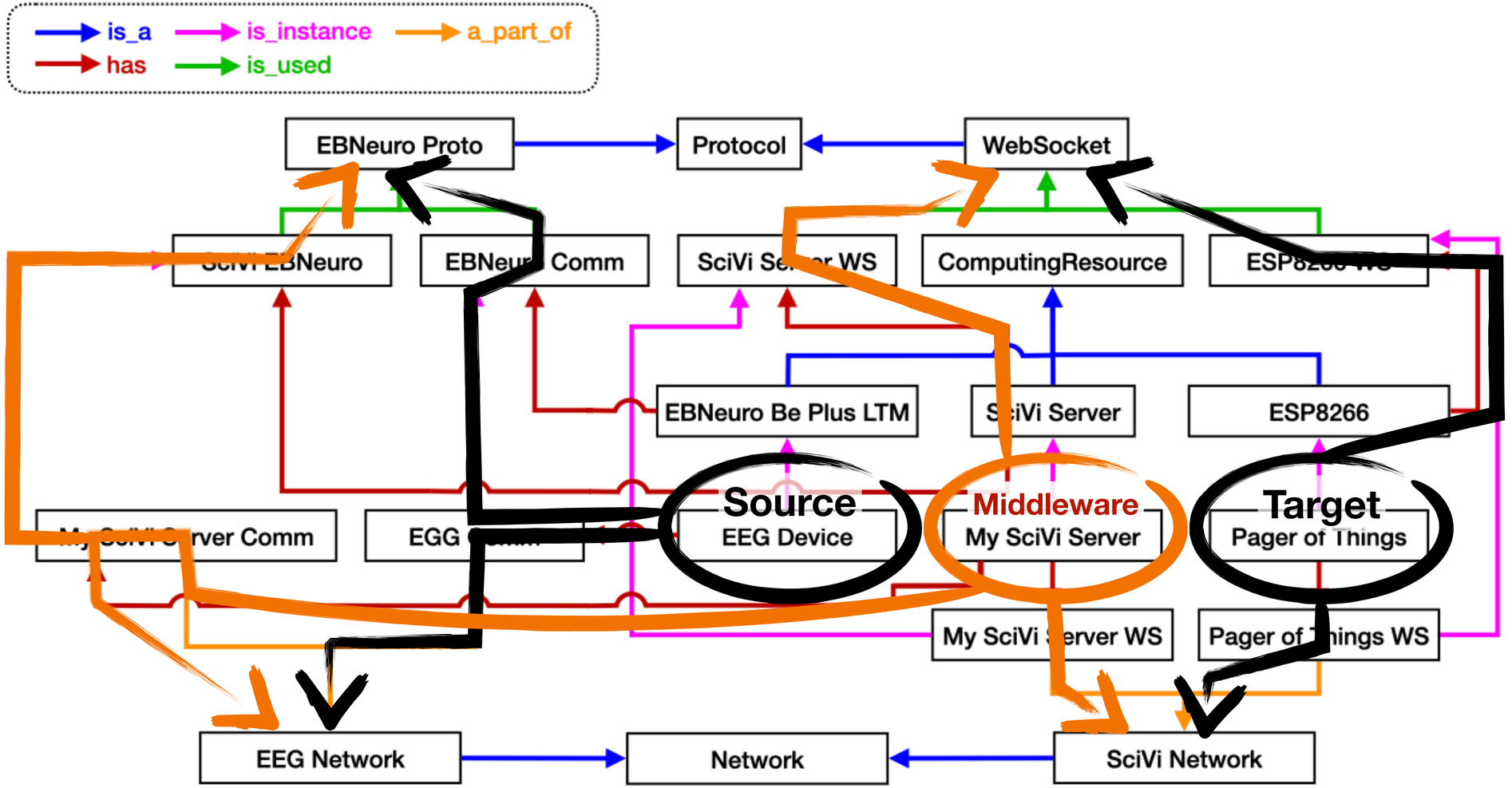
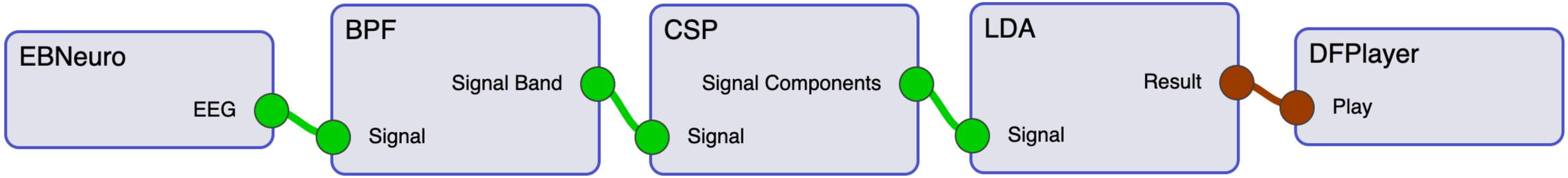


Step 2 Building the common task ontology



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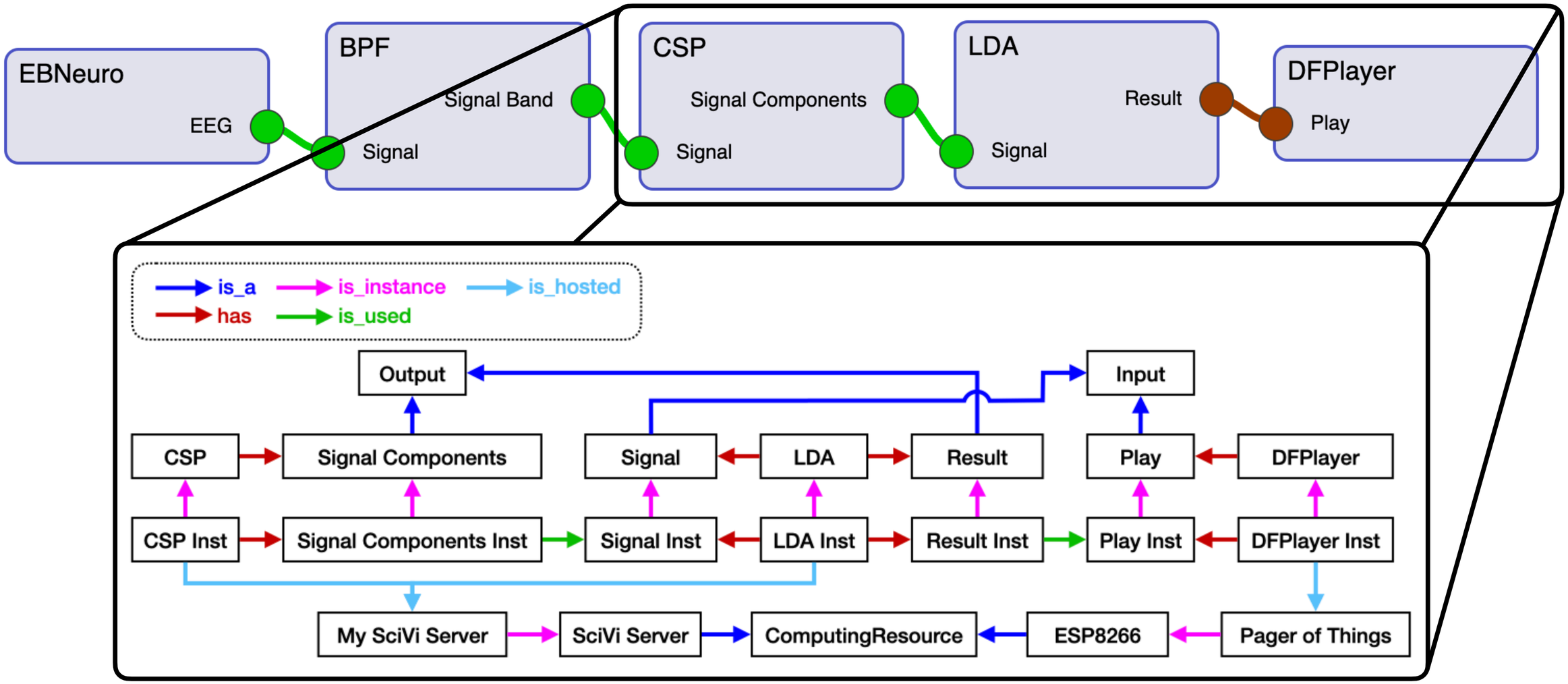

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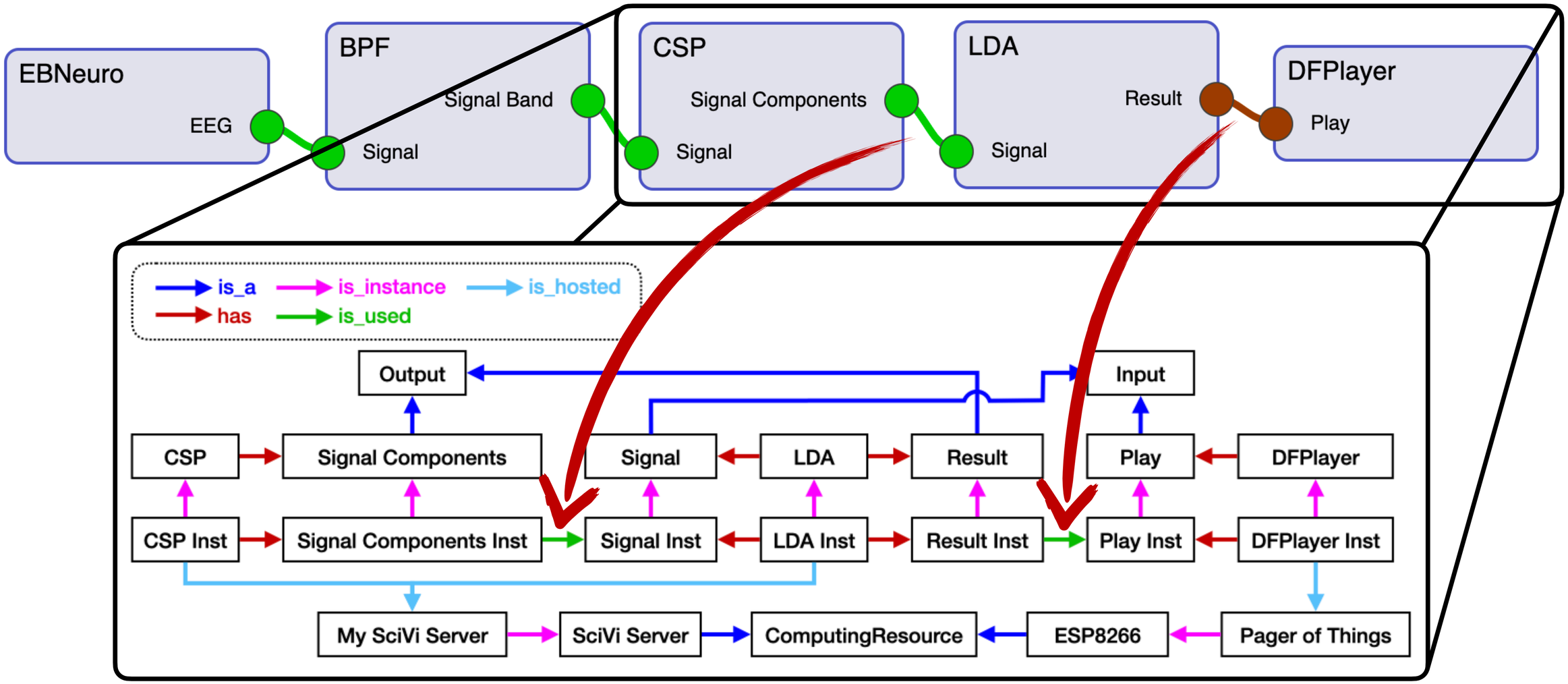

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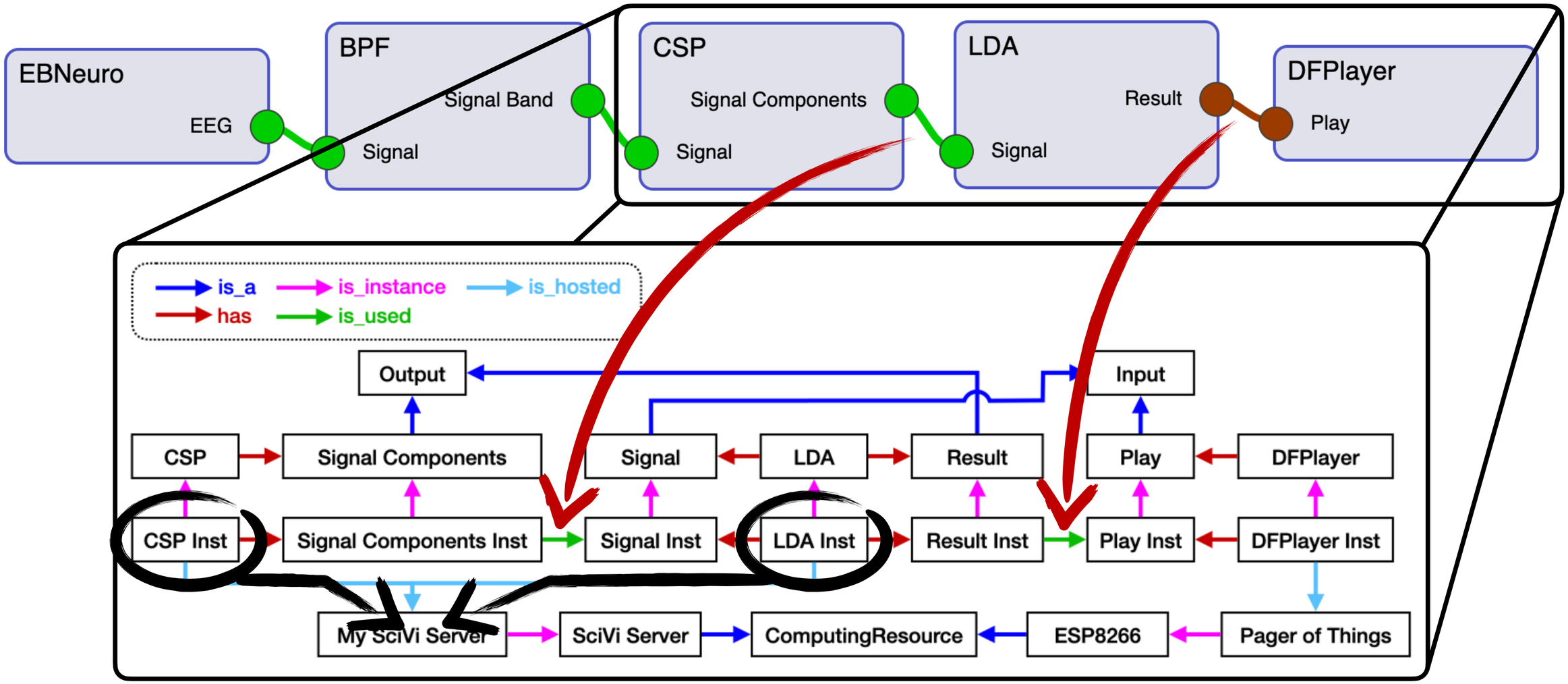

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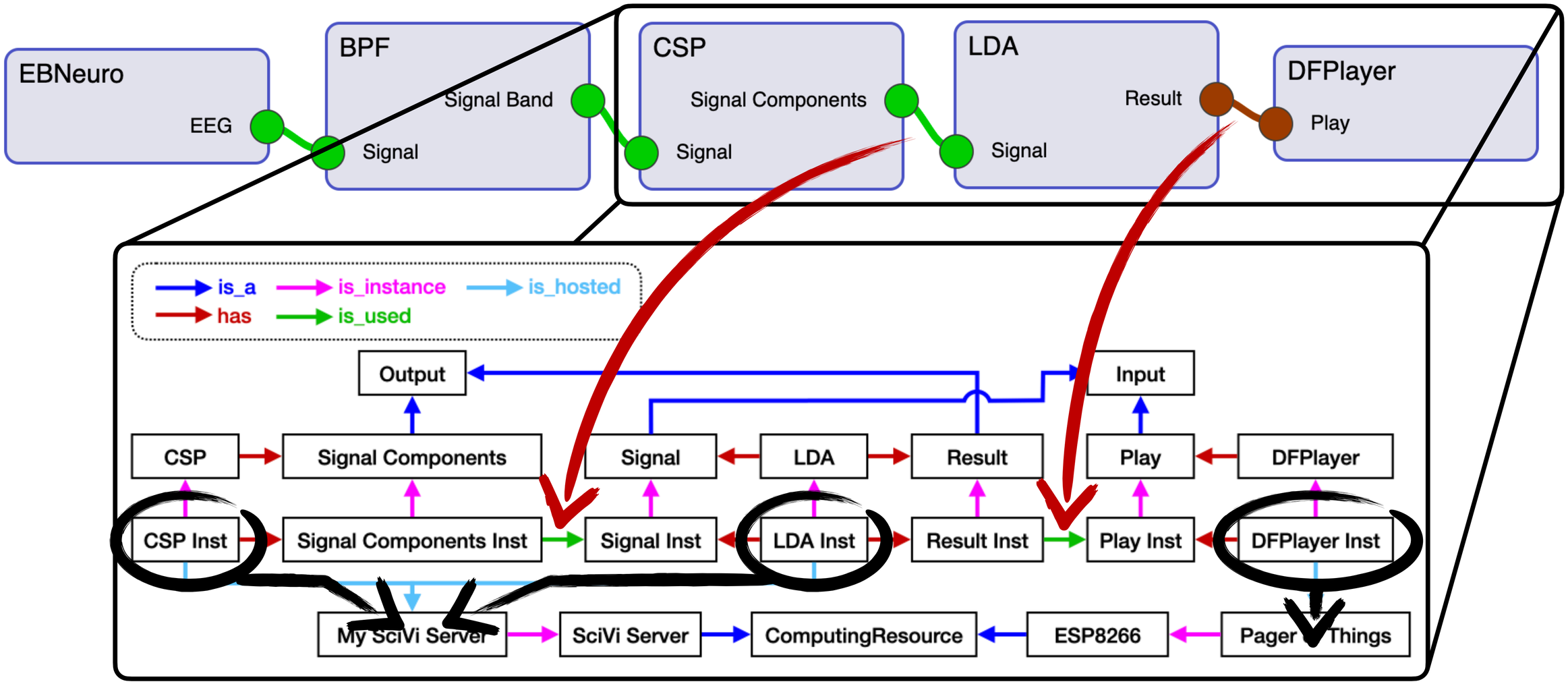

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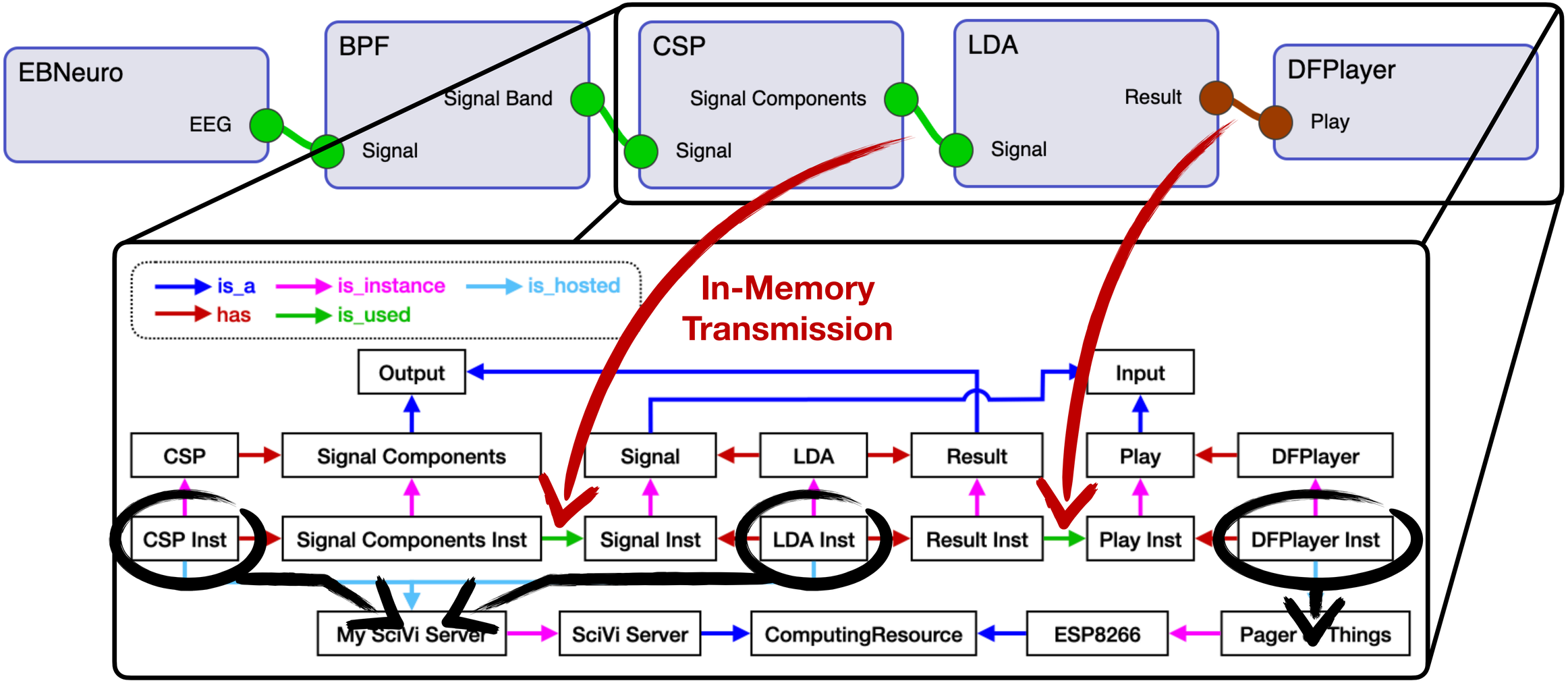

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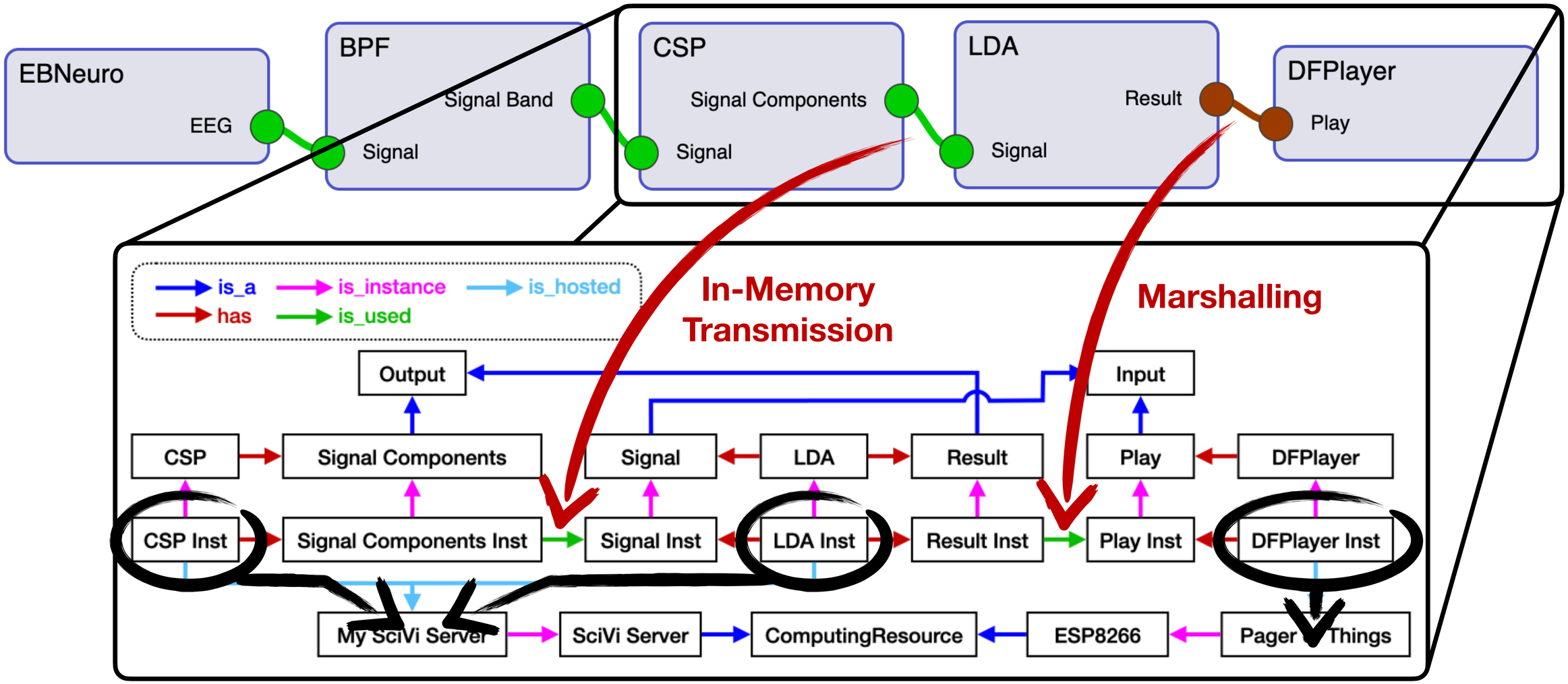
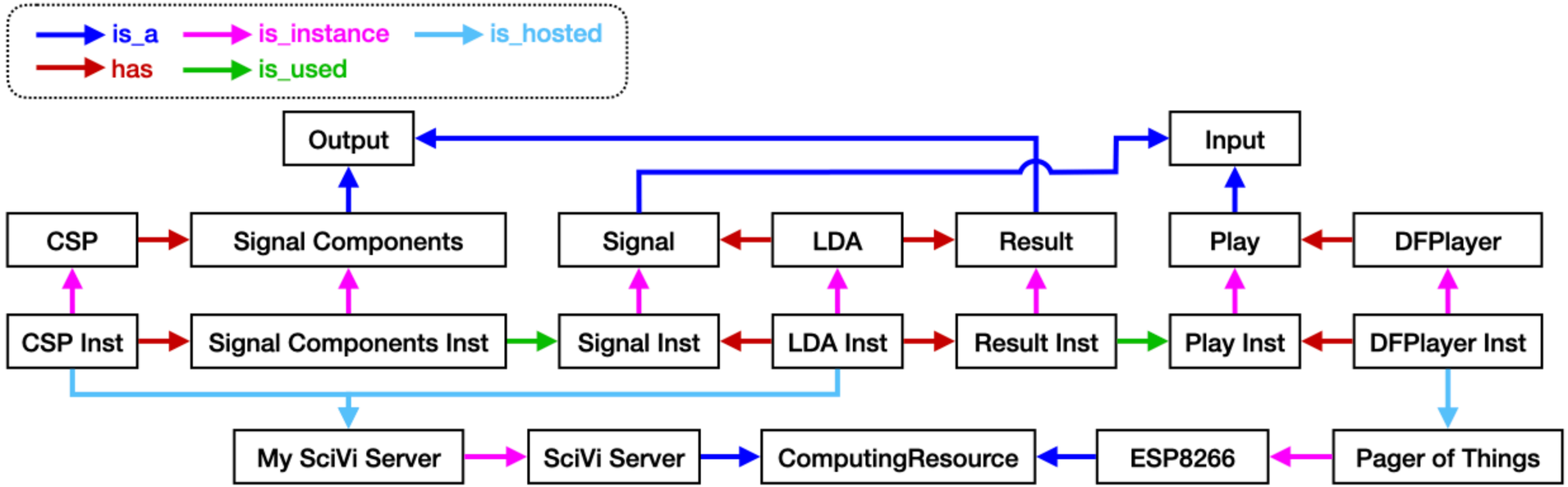


Step 3 **Splitting the common task ontology into the parts for individual computing resources**



Integration of Heterogeneous Computing Resources

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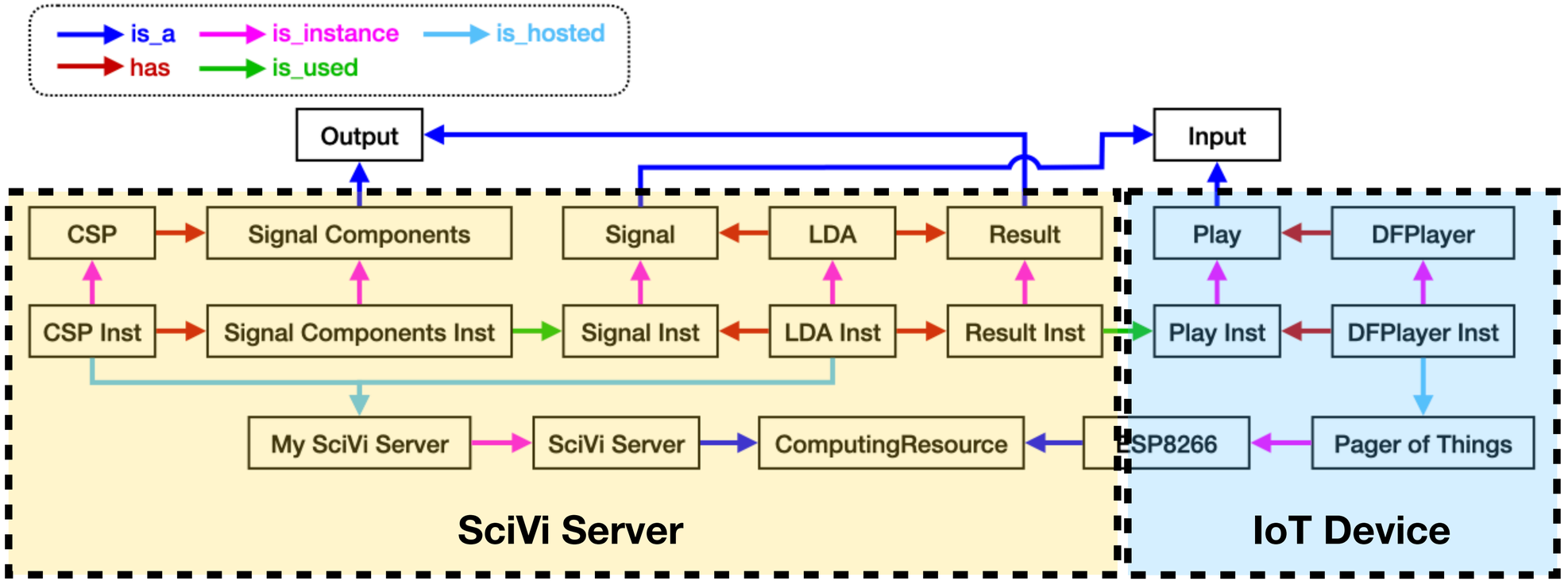

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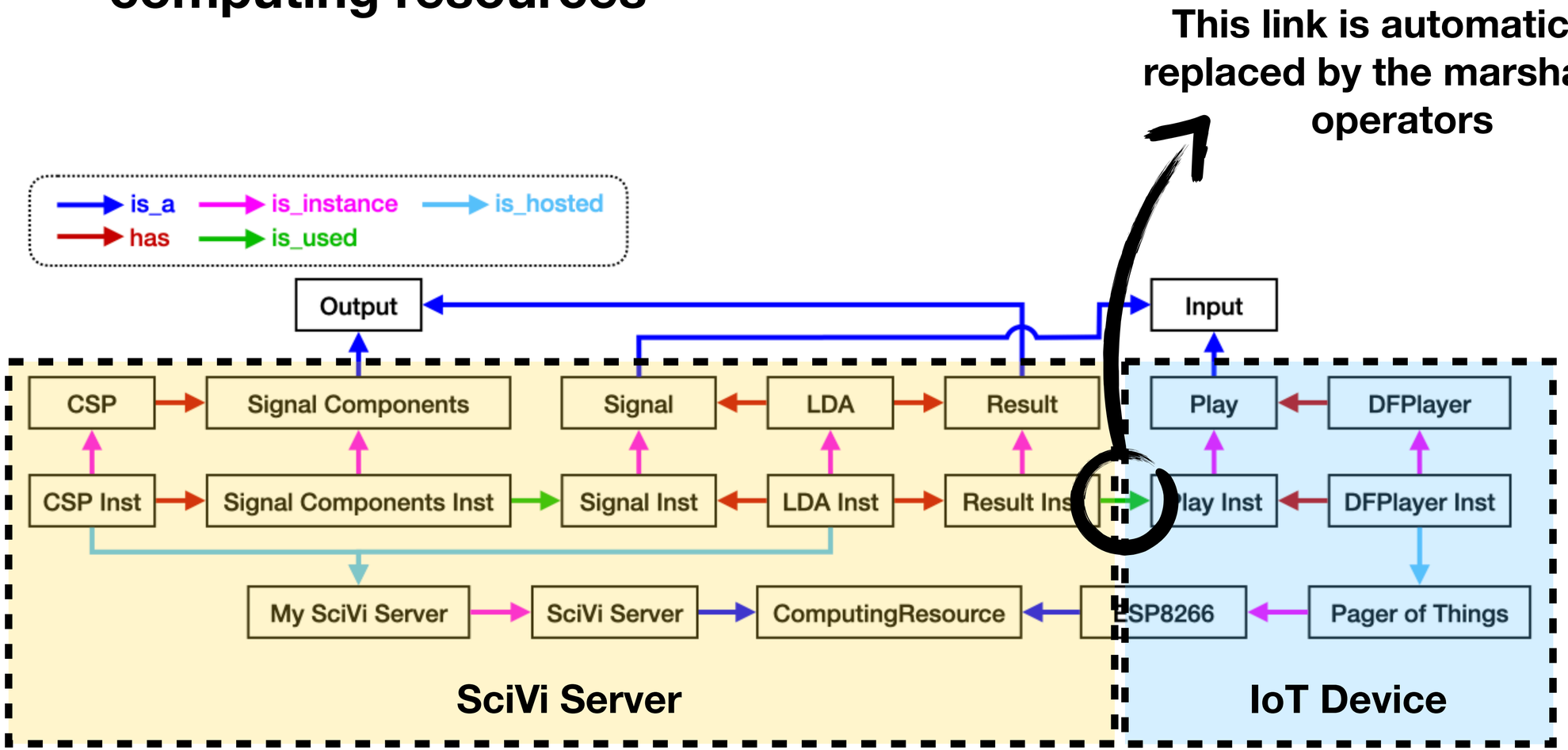
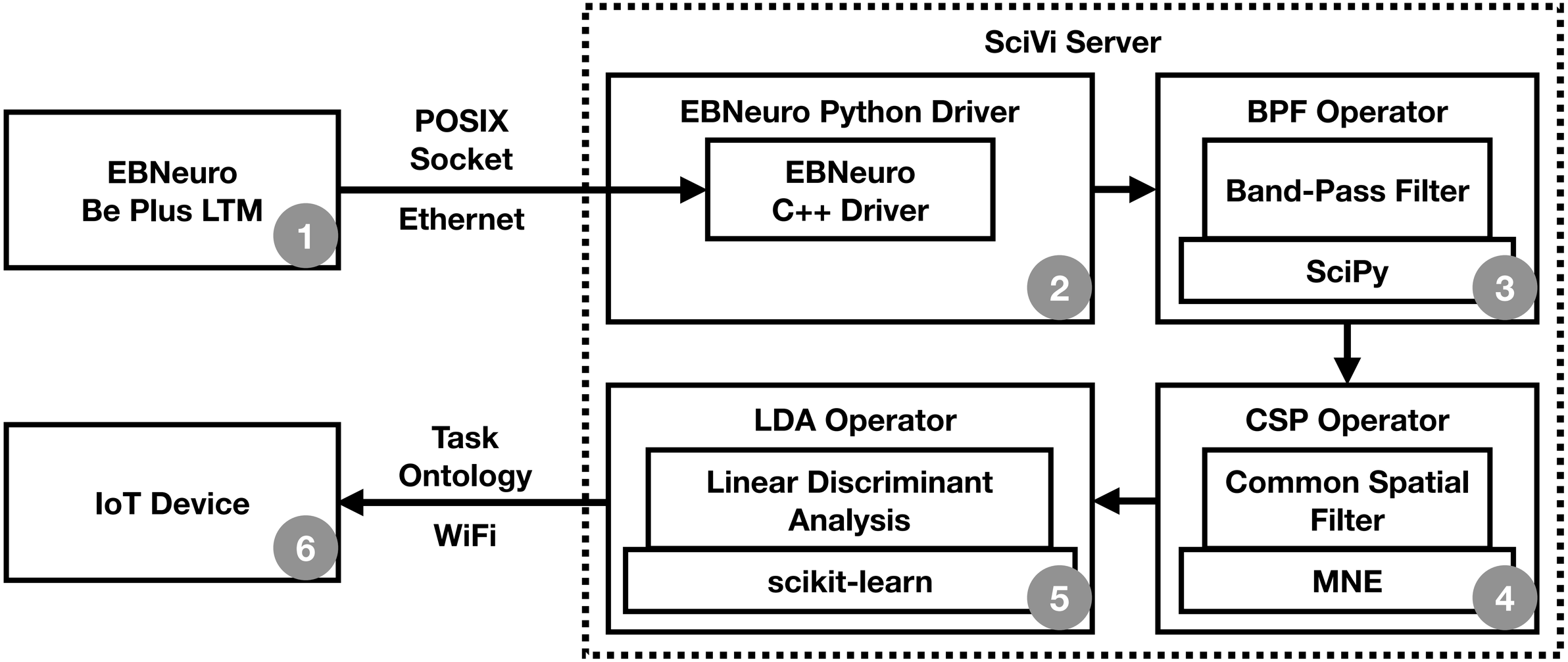
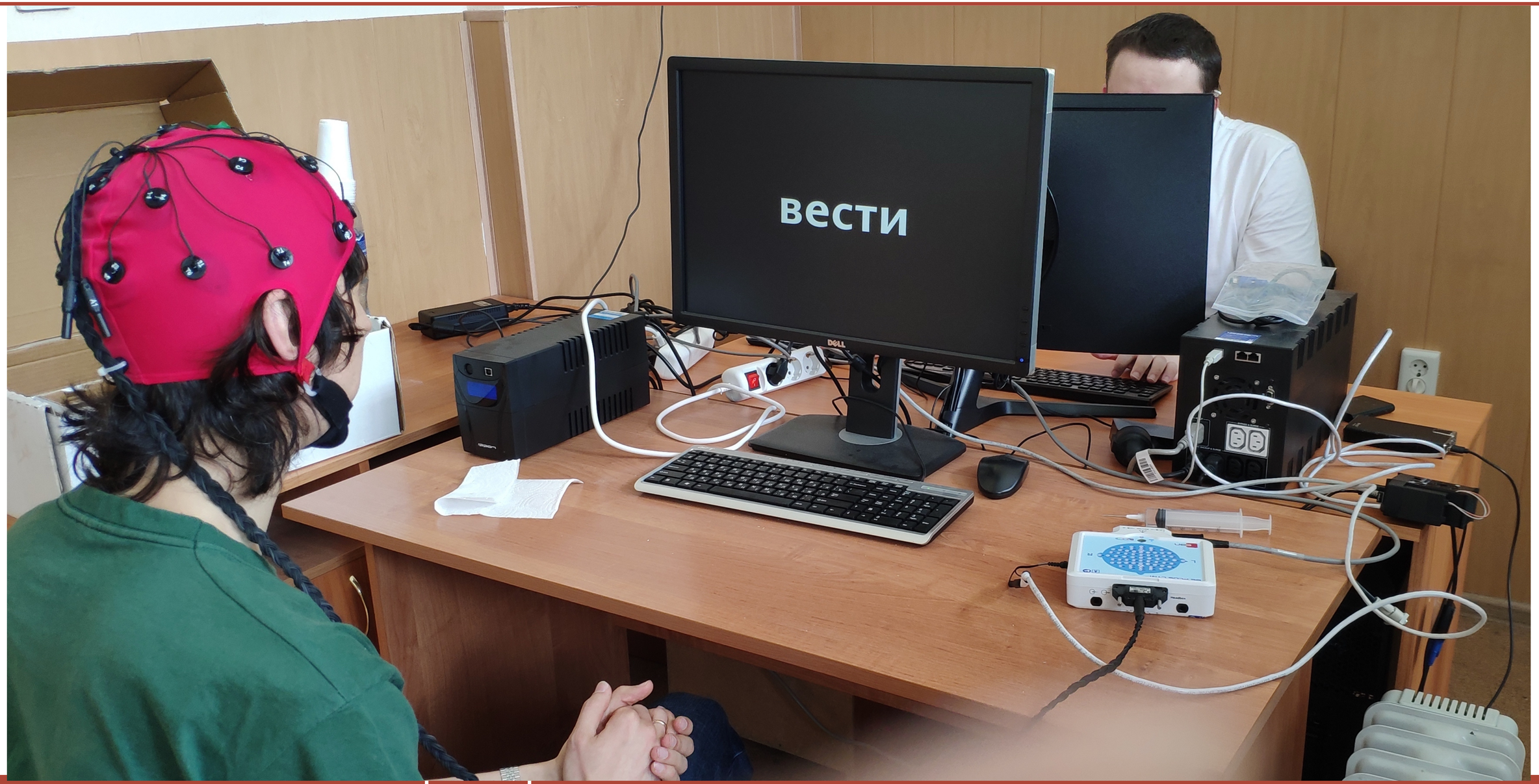


Brain-Computer Interface for the Pager of Things

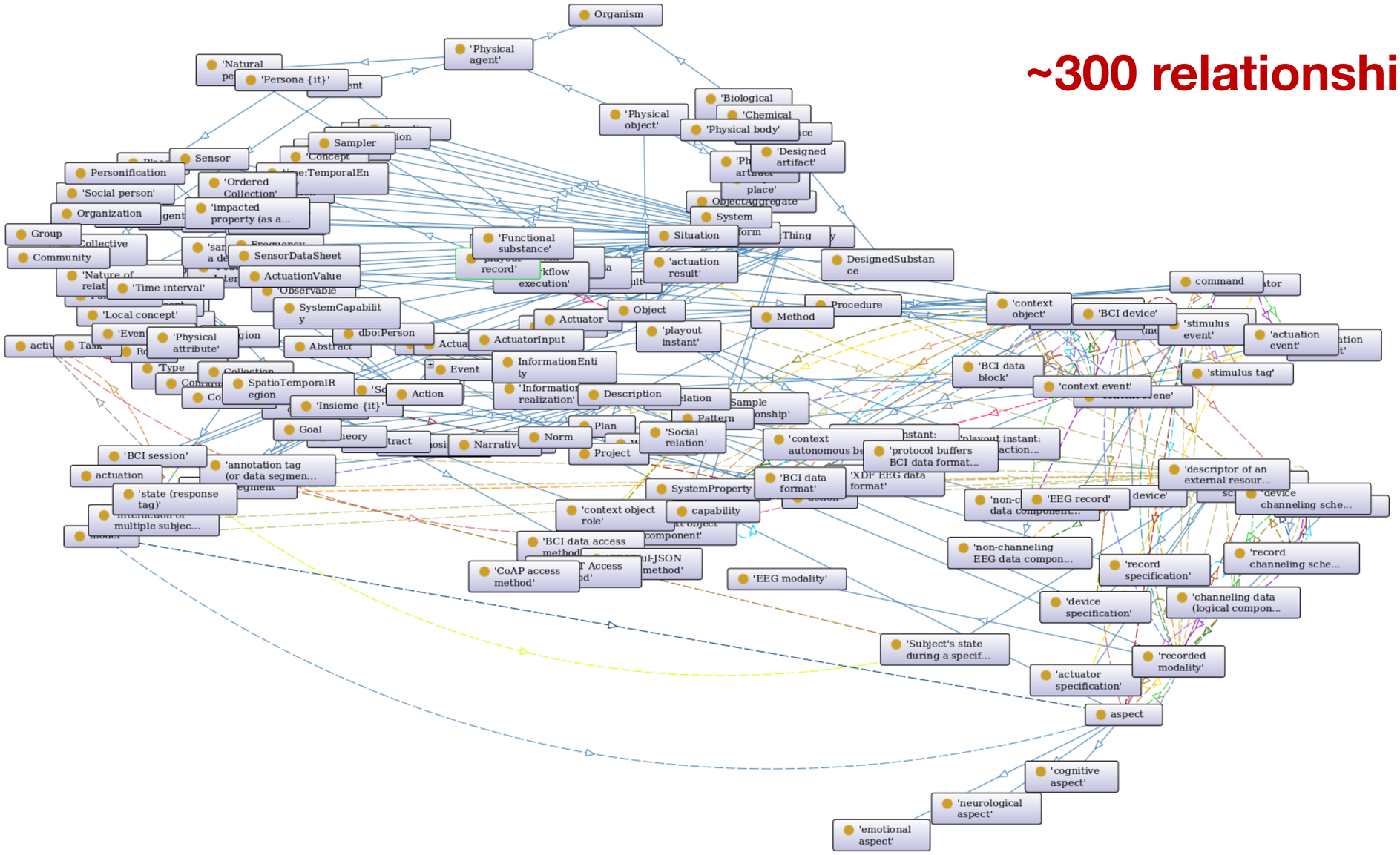


Experiment Setup



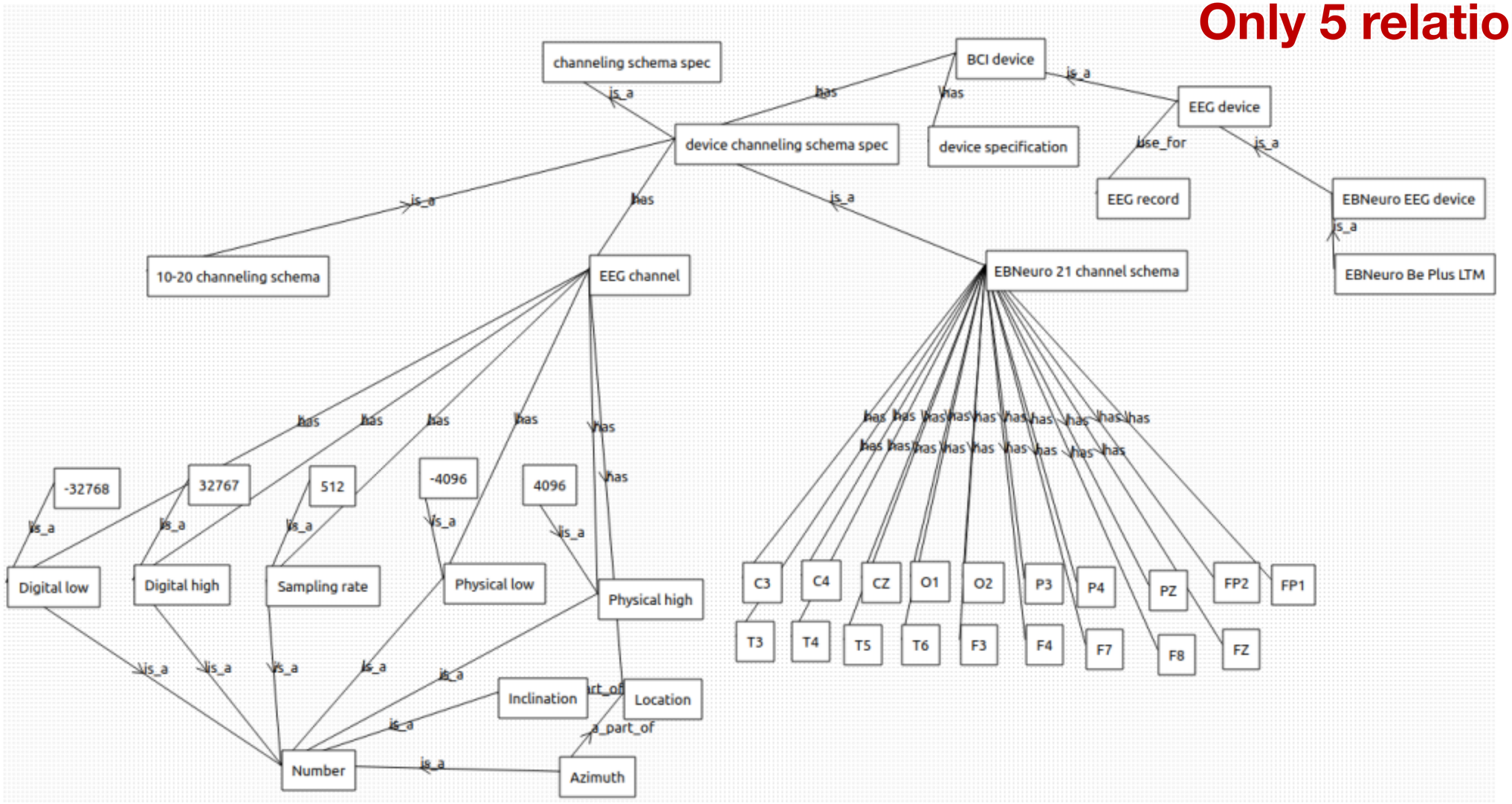
BCI Knowledge Graph

~300 relationship types



Cognitive Compression of EEG Knowledge Graph

Only 5 relationship types



Conclusion

New SciVi feature:

Transparent ontology-driven interoperation of IoT devices

Workflow:

- **User declares the chain of data processing operators only**
- **SciVi takes care about the target computing nodes these operators are going to be executed on**

Example (under development):

Pager of Things IoT device controlled by BCI

Thank you for attention!

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