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Ontology-Driven Automation of IoT-Based Human-Machine Interfaces Development

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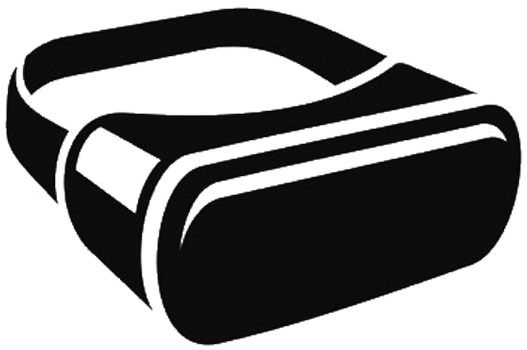
Faro – 2019

Custom Hardware Human-Machine Interface?

Motivation



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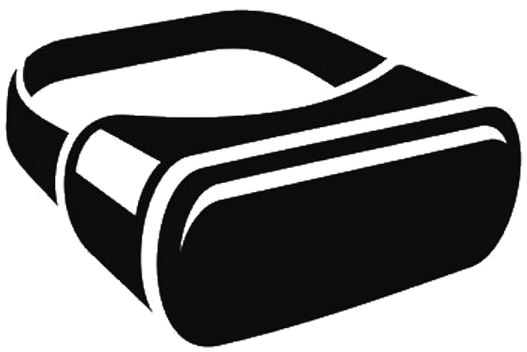
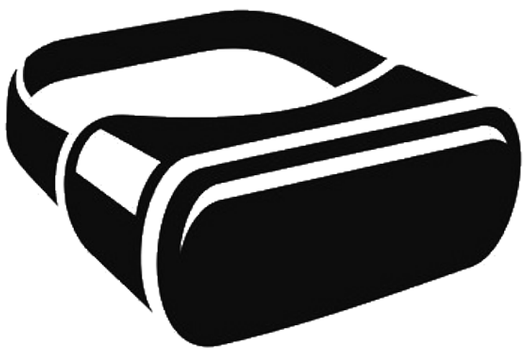


Virtual Reality

Simulators

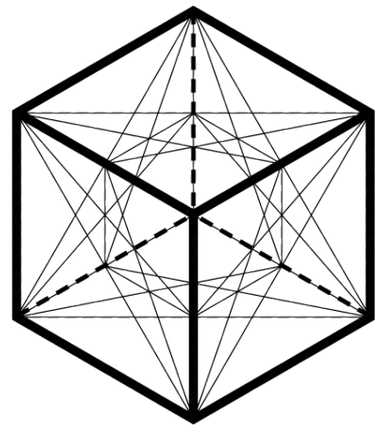
Custom Hardware Human-Machine Interface?

Motivation



Virtual Reality

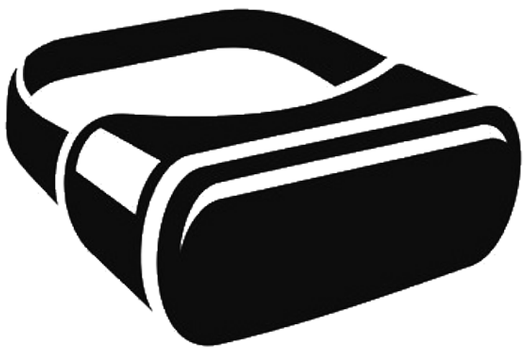
Simulators



Complex Data Analytics

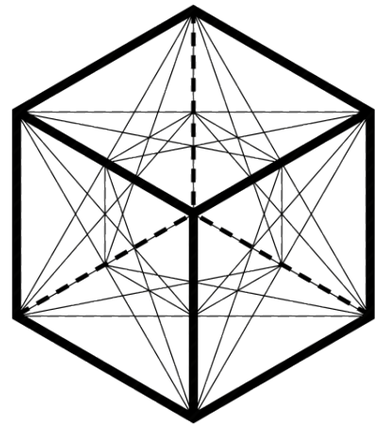
Custom Hardware Human-Machine Interface?

Motivation



Virtual Reality

Simulators

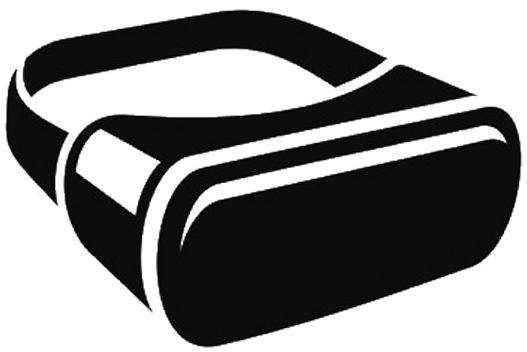


Complex Data Analytics

Custom Hardware Human-Machine Interface?

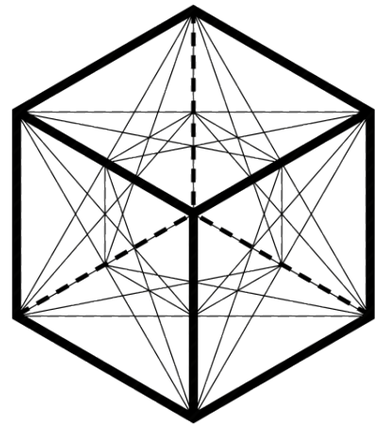
Human-Centric IoT

Motivation



Virtual Reality

Simulators



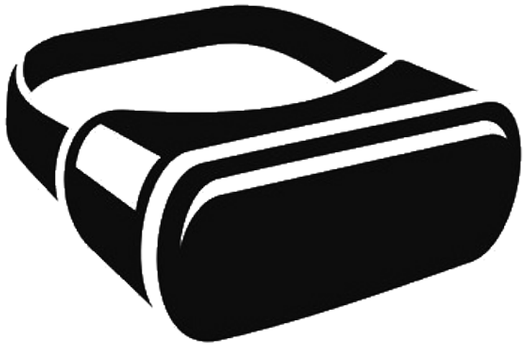
Complex Data Analytics

Custom Hardware Human-Machine Interface?

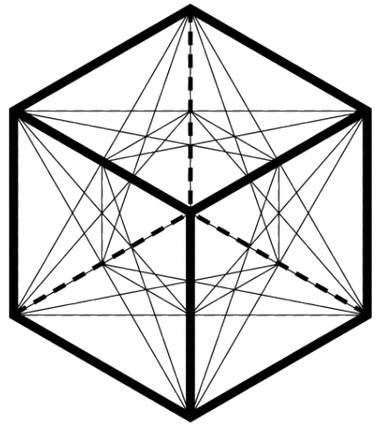
Human-Centric IoT

Interactive Exhibits

Motivation



Simulators



Vi ta

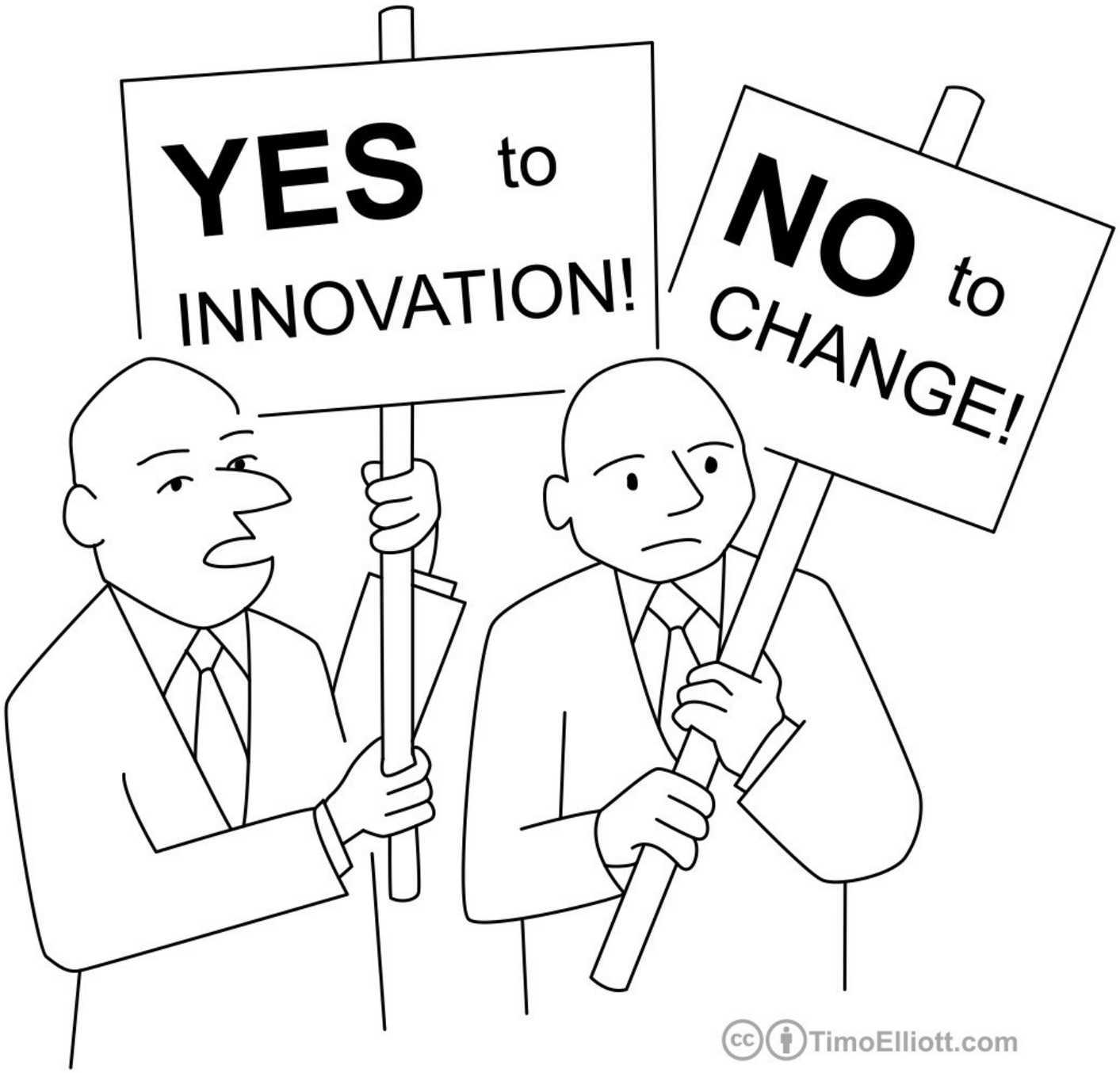
Developers: high technical qualification needed

Electronic Components: cheap and versatile

Human-Centric IoT

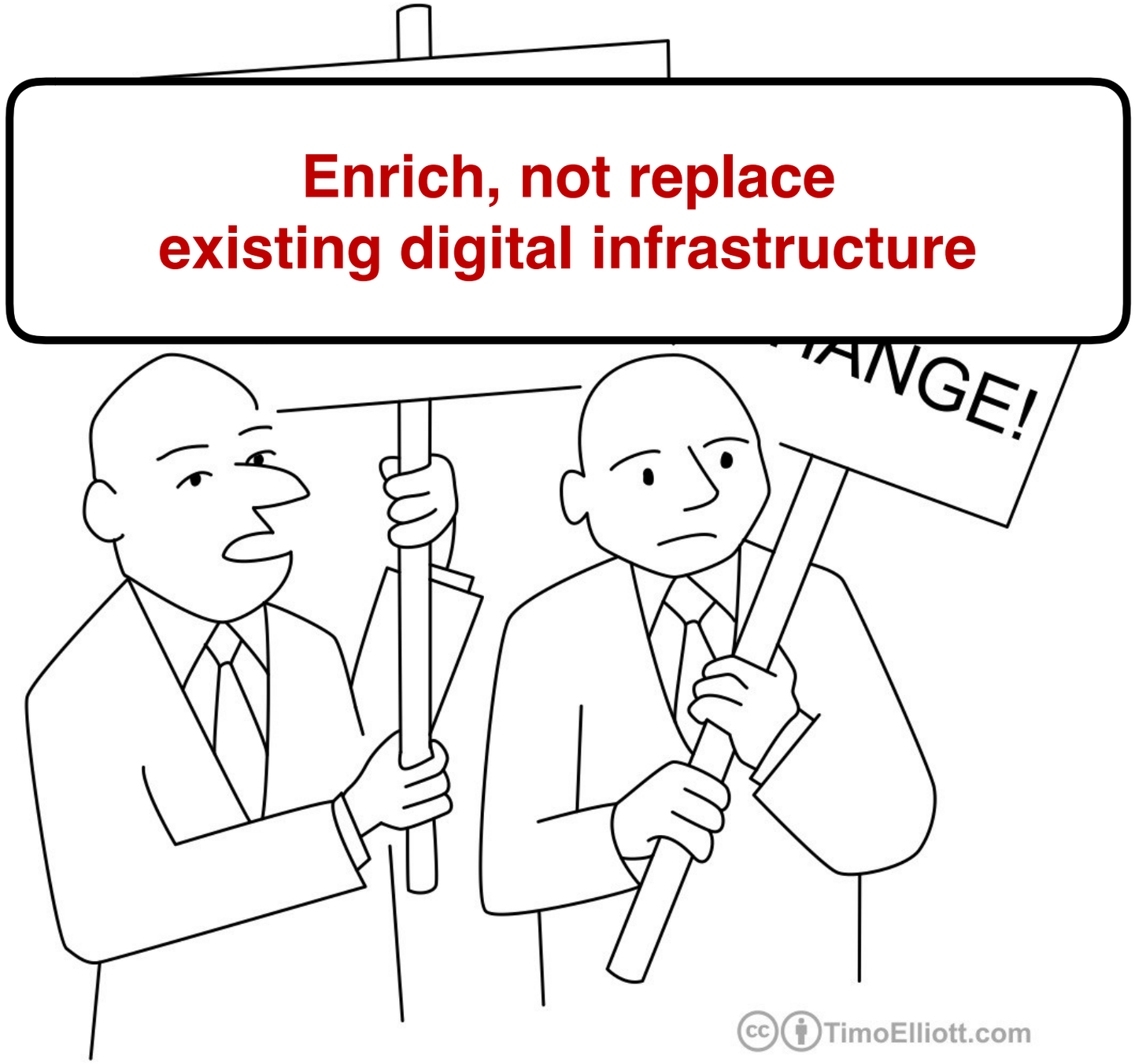
Interactive Exhibits

Motivation



“We only have two demands!
Why don't people just give us what we want?”

Motivation

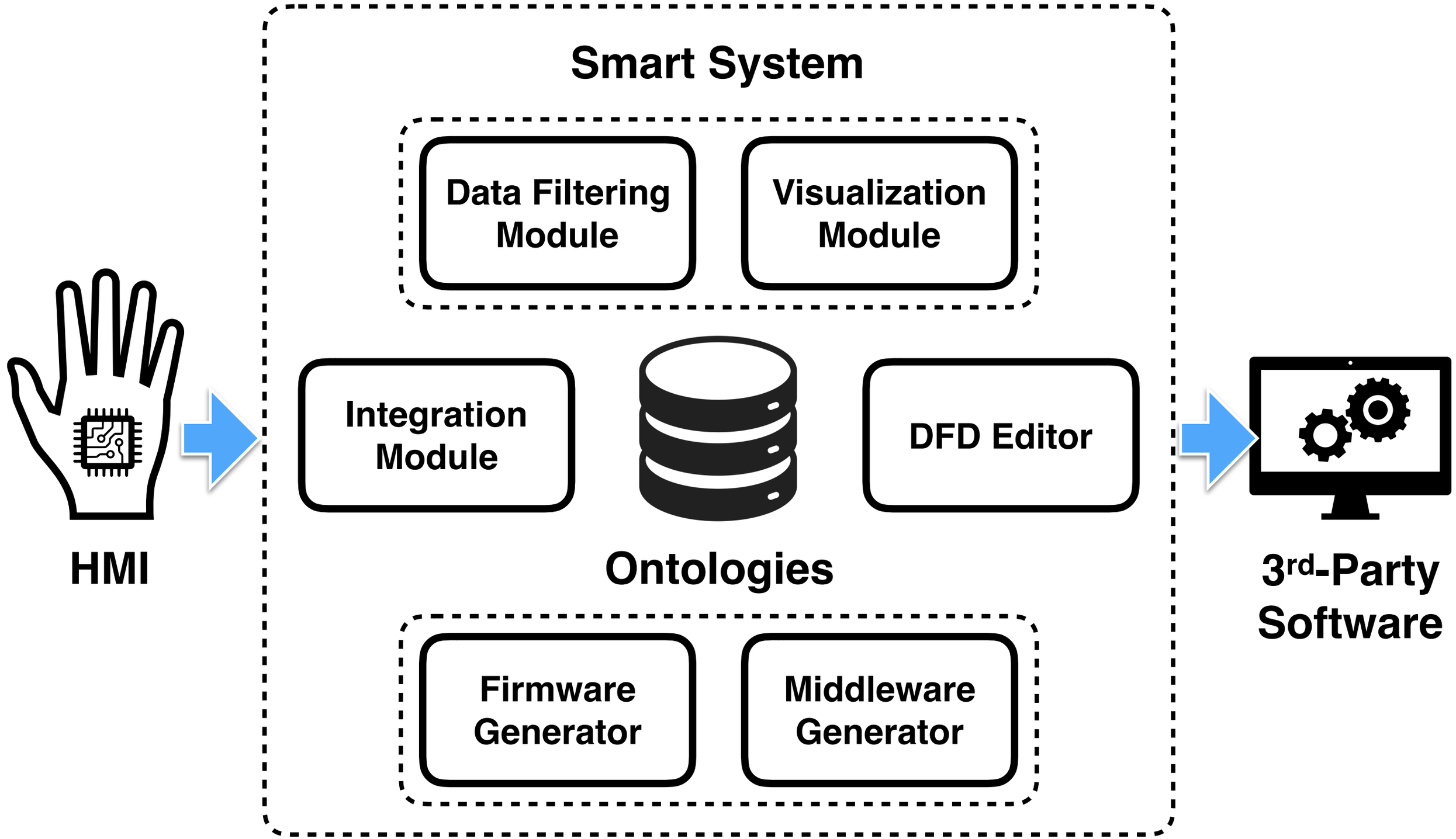


"We only have two demands!
Why don't people just give us what we want?"

Objectives

1. Increase the level of HMI development tools
2. Propose the approach of smart systems building to automate:
   - 2.2. IoT devices firmware generation
   - 2.3. Middleware generation
   - 2.4. Using IoT devices as HMI to steer third-party software
3. Create the smart system according to the proposed approach
4. Test smart system as a middleware to marry custom IoT-based HMI with third-party software

Idea


Smart System
Data Filtering Module
Visualization Module
Integration Module
DFD Editor
Ontologies
Firmware Generator
Middleware Generator
HMI
3rd-Party Software

Idea

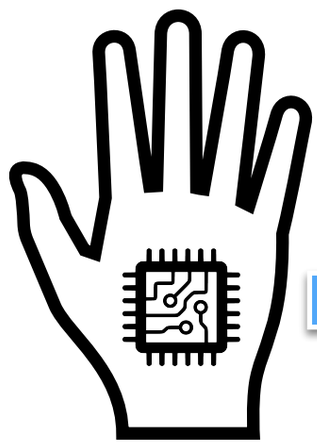
Ontology – formal model of application domain
(T.R. Gruber, 1993)

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

T – thesaurus of application domain concepts

R – set of relations between concepts

A – set of axioms



HMI

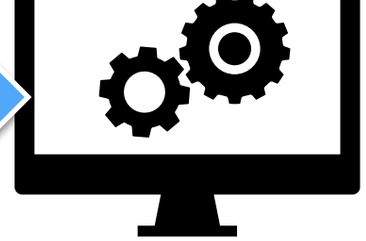
Integration Module

Ontologies

DFD Editor

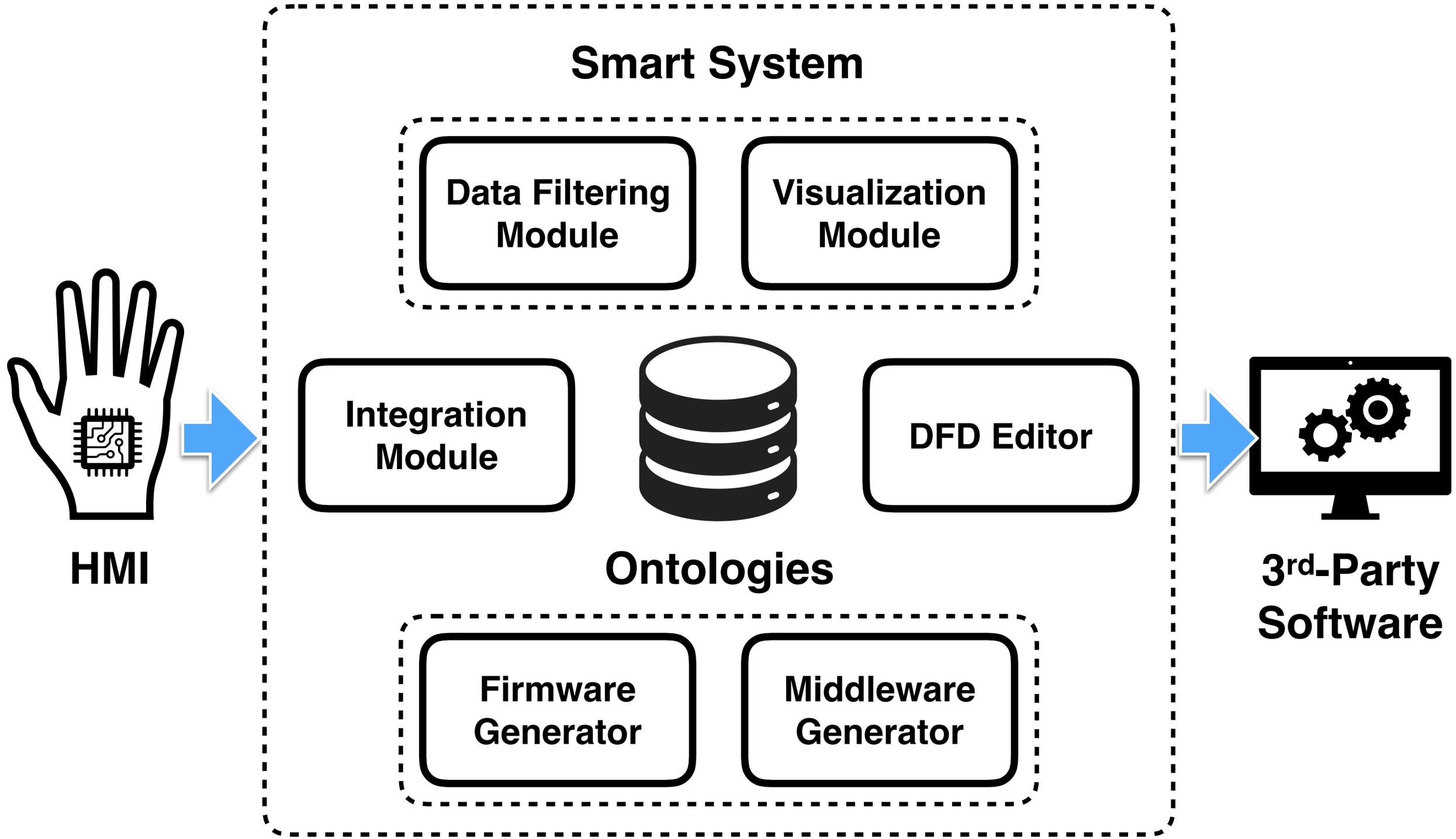
Firmware Generator

Middleware Generator



3rd-Party Software

Idea


Smart System
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Ontologies
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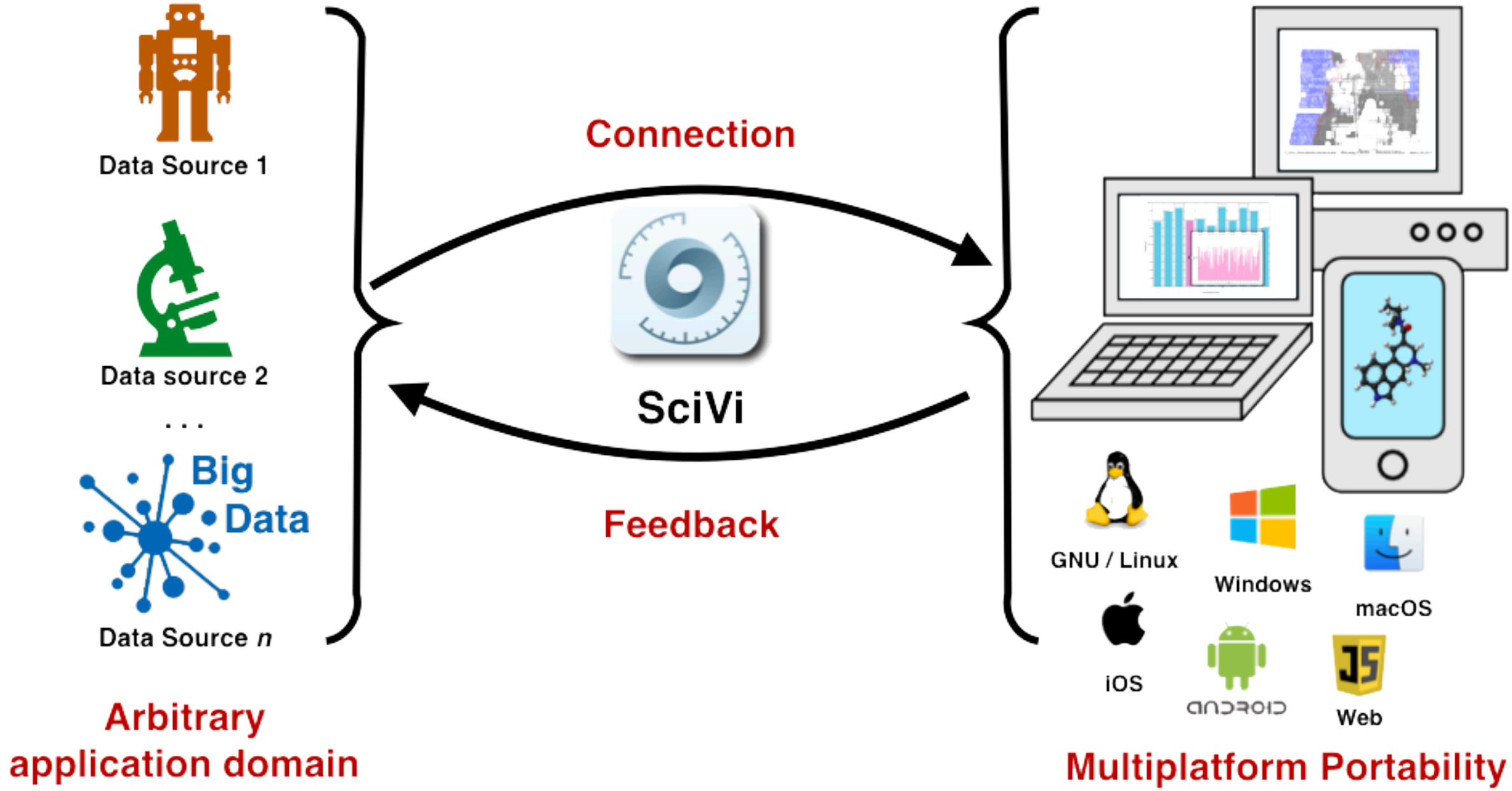
Middleware Generator
HMI
3rd-Party Software

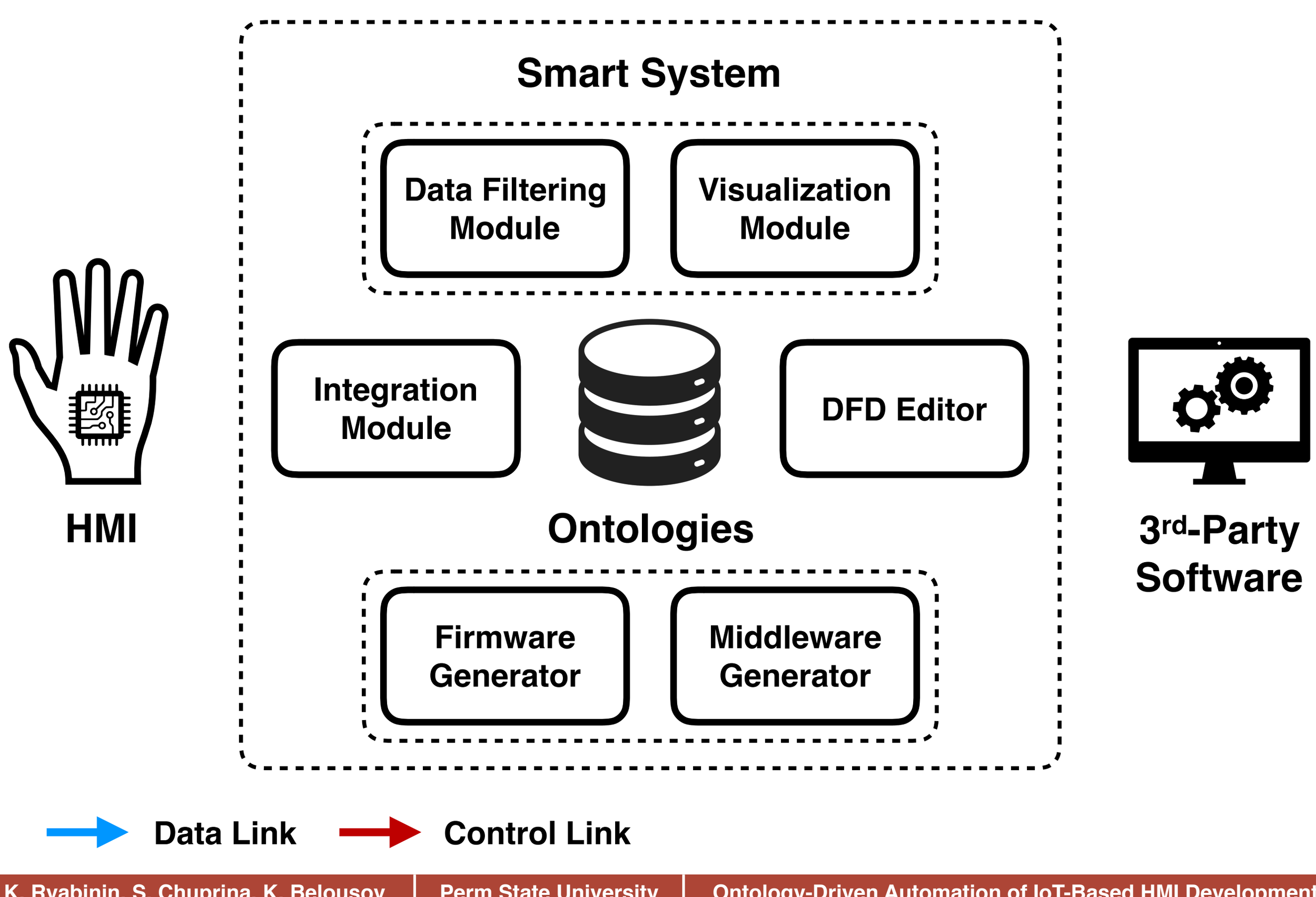
Background: SciVi System

Multiplatform client-server adaptive scientific visualization system SciVi

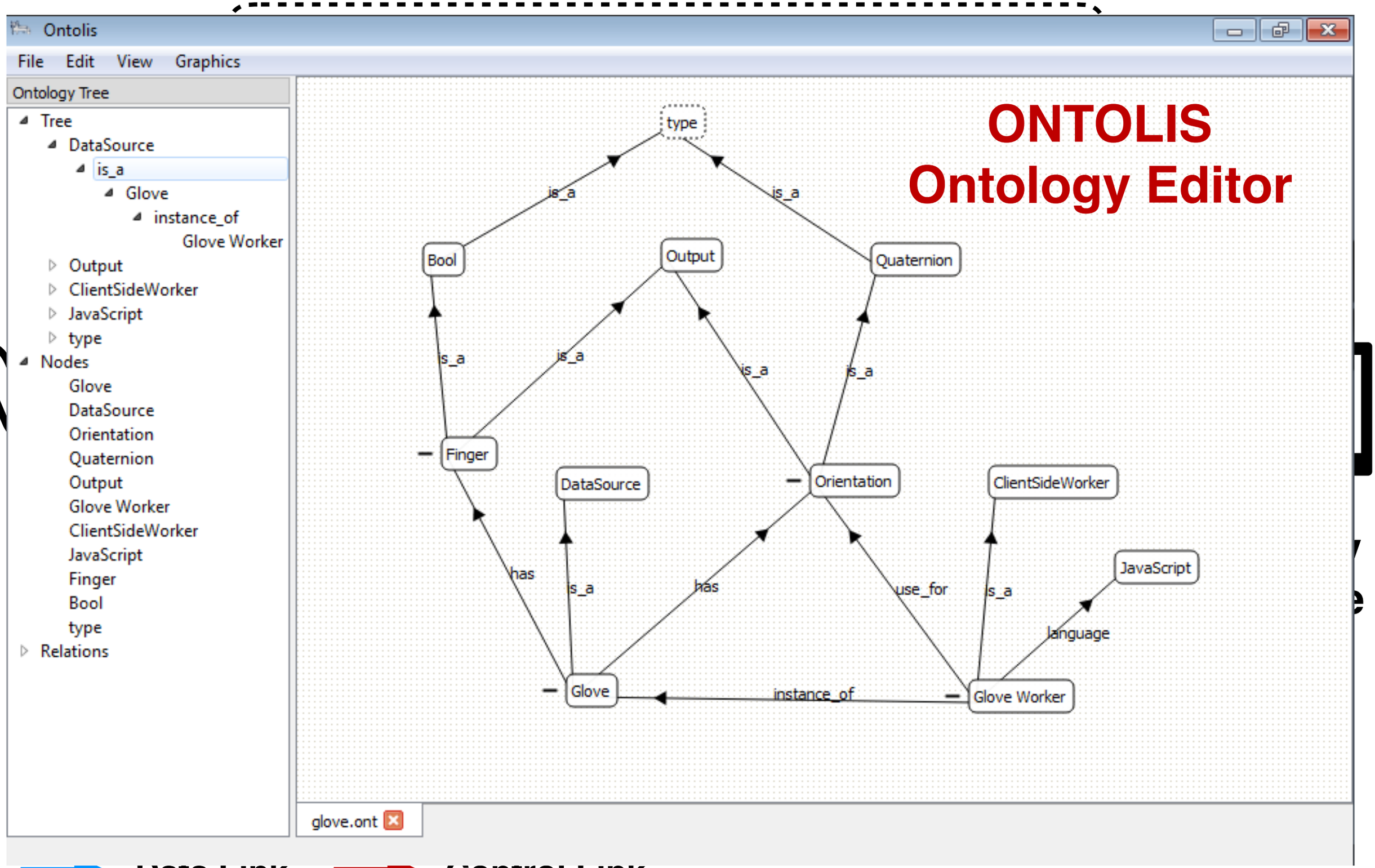
Ryabinin, K., Chuprina, S.: Development of Ontology-Based Multiplatform Adaptive Scientific Visualization System. Journal of Computational Science 10, 370–381 (2015). https://doi.org/10.1016/j.jocs.2015.03.003



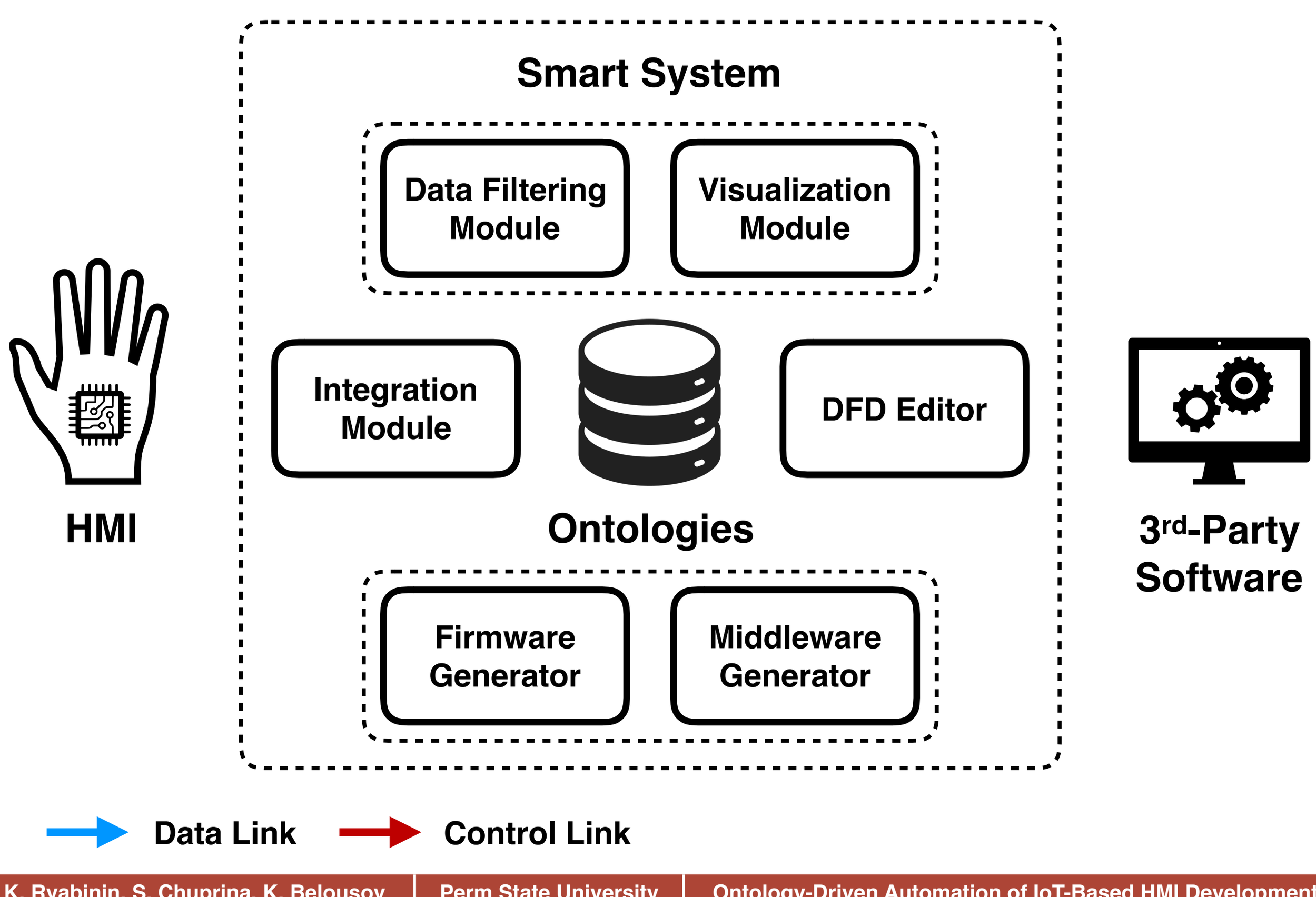
Device Integration Stage



Device Integration Stage



Device Integration Stage



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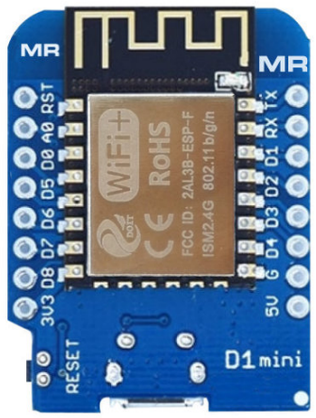
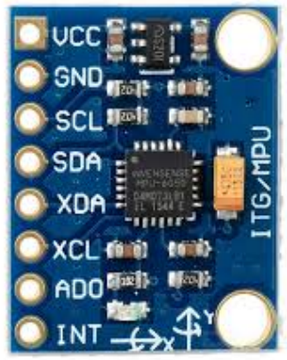


ESP8266

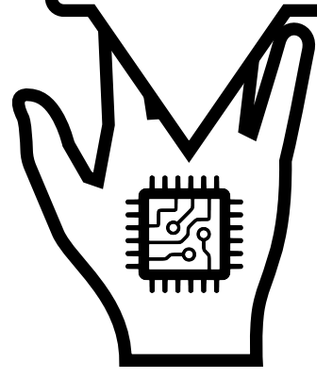


MPU6050

Push Button

m

ualization
Module



HMI

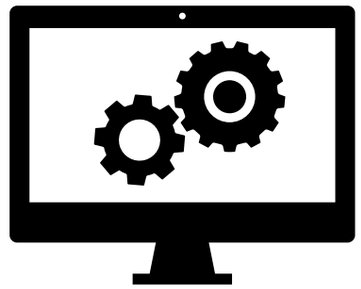
Integration Module

DFD Editor

Ontologies

Firmware Generator

Middleware Generator

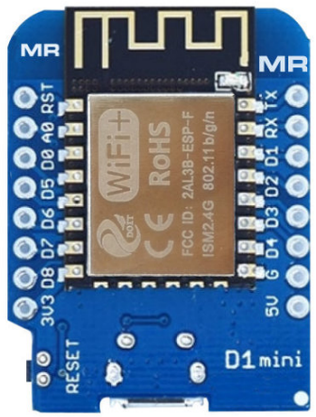


3rd-Party Software

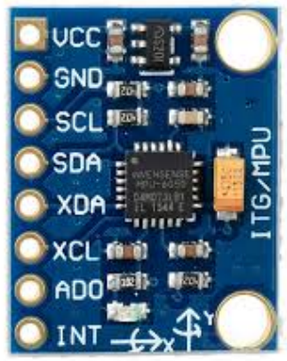
Data Link

Control Link

Device Integration Stage



ESP8266



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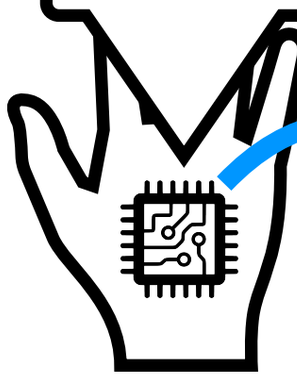
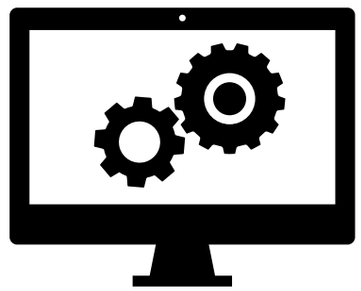


HMI

Integration Module

DFD Editor



3rd-Party Software

Ontologies

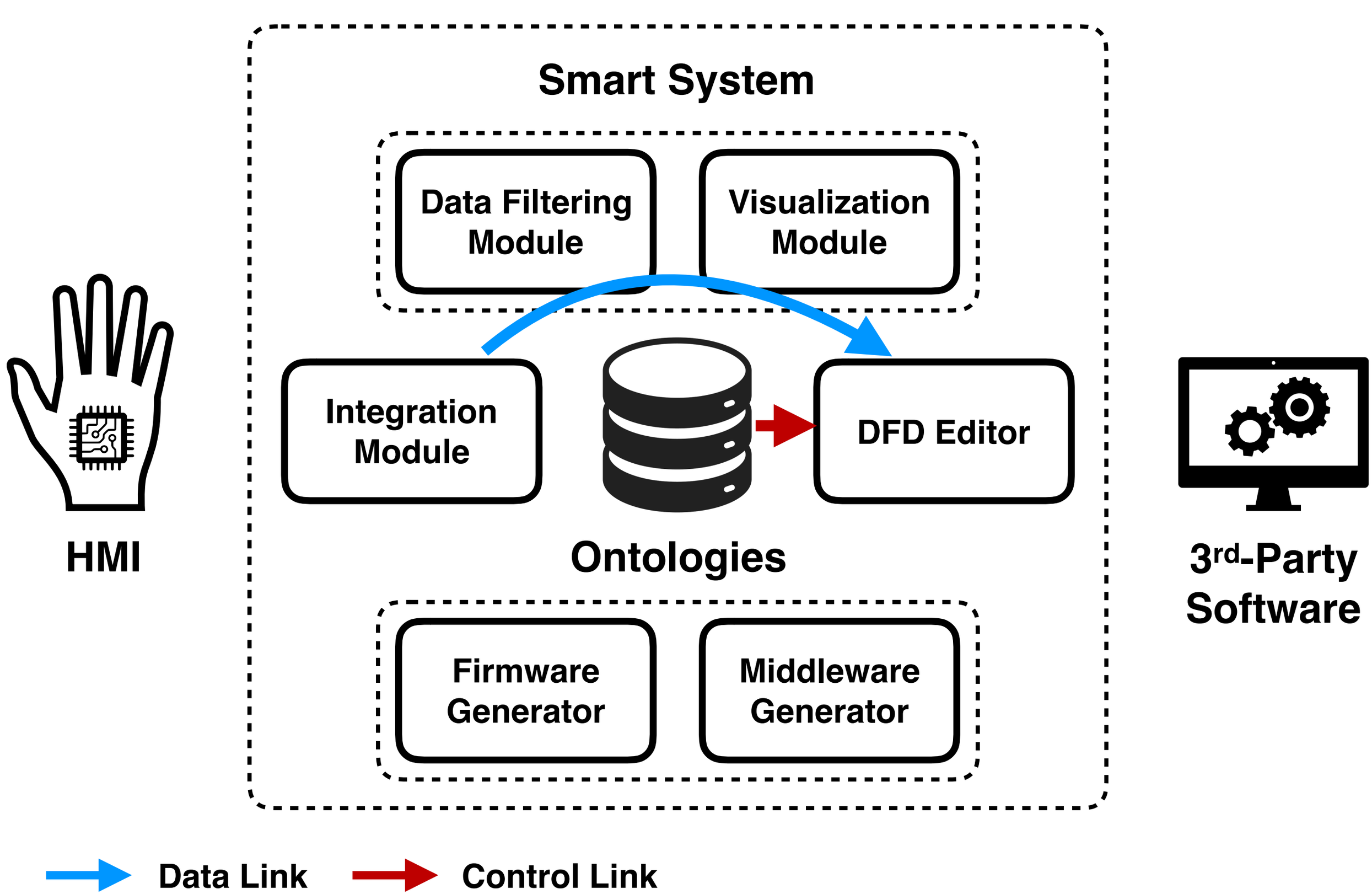
Firmware Generator

Middleware Generator

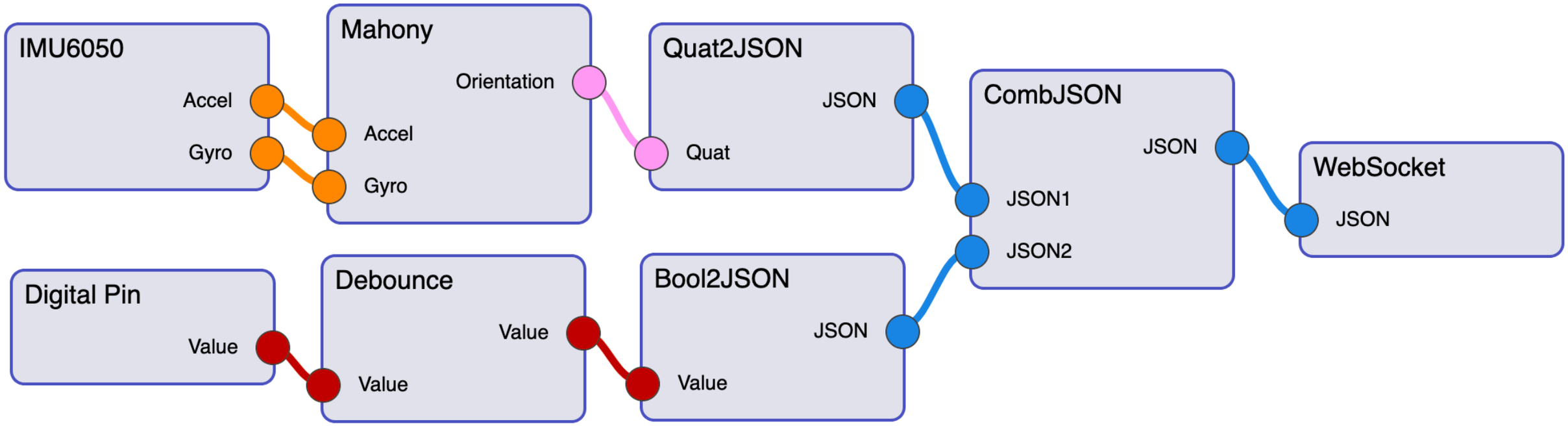
Data Link

Control Link

Device Integration Stage



Firmware Composing Stage



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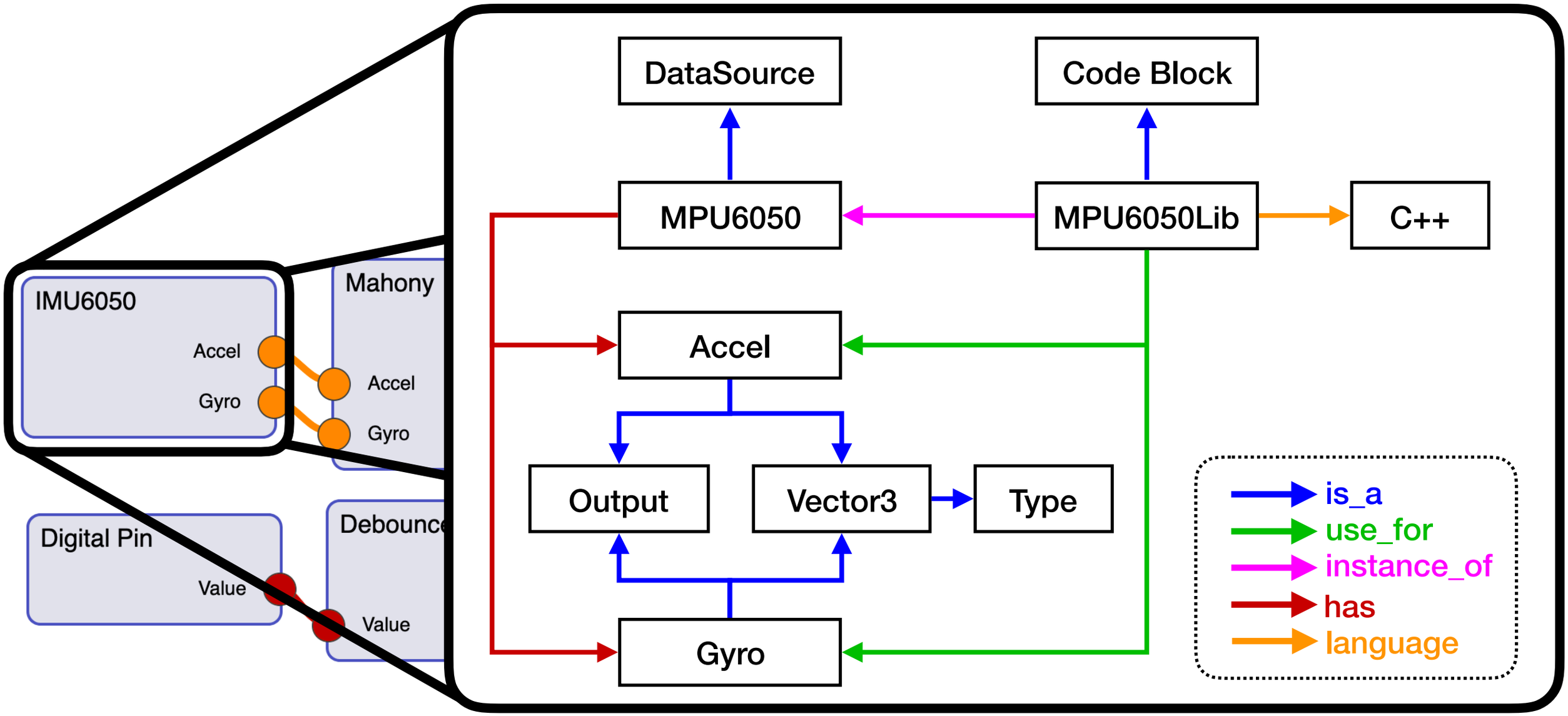

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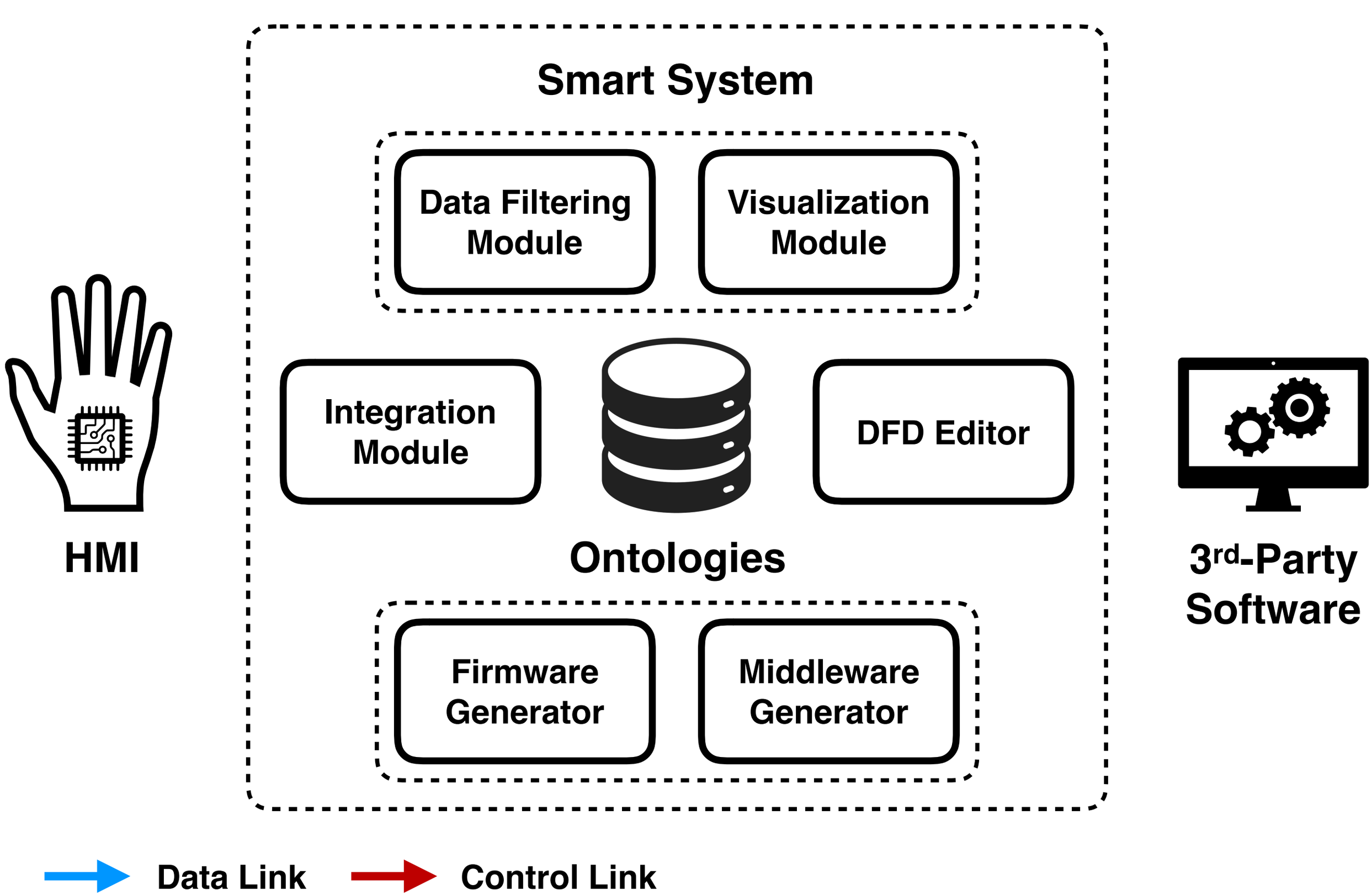

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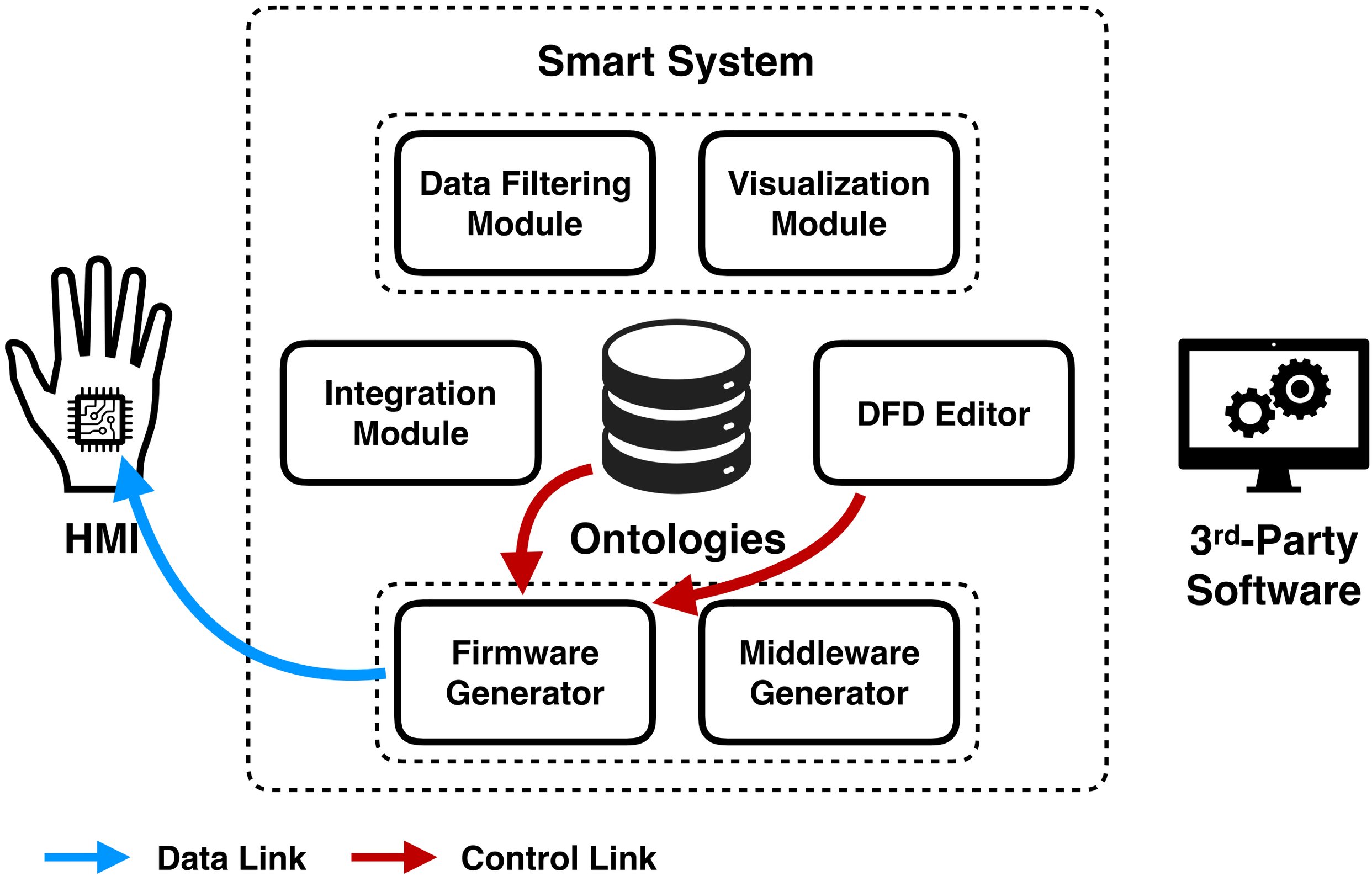
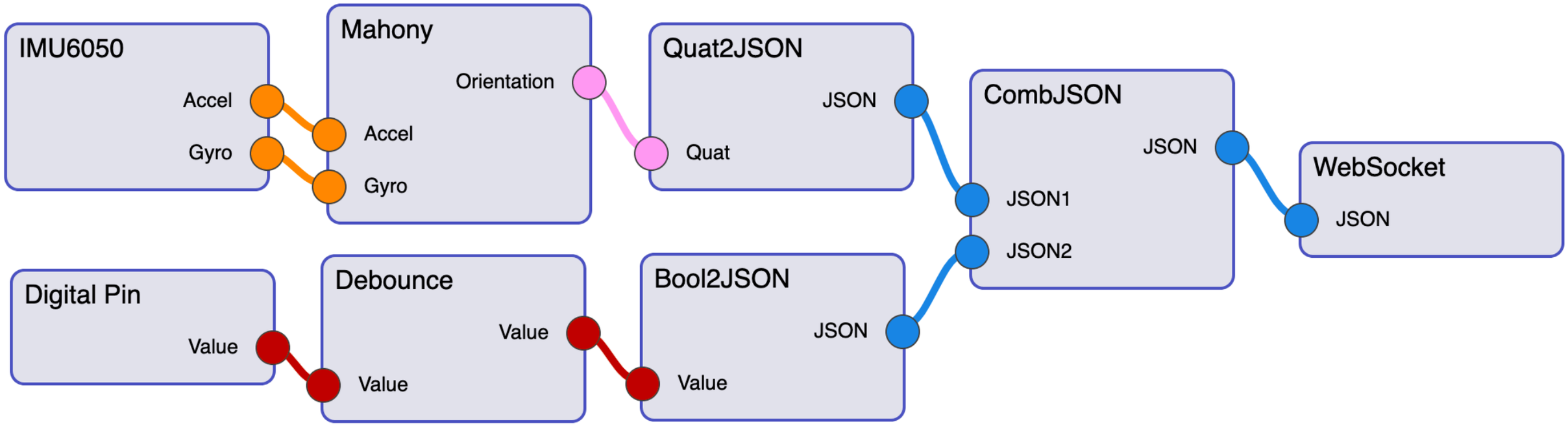


Ontological Profile of IoT Device



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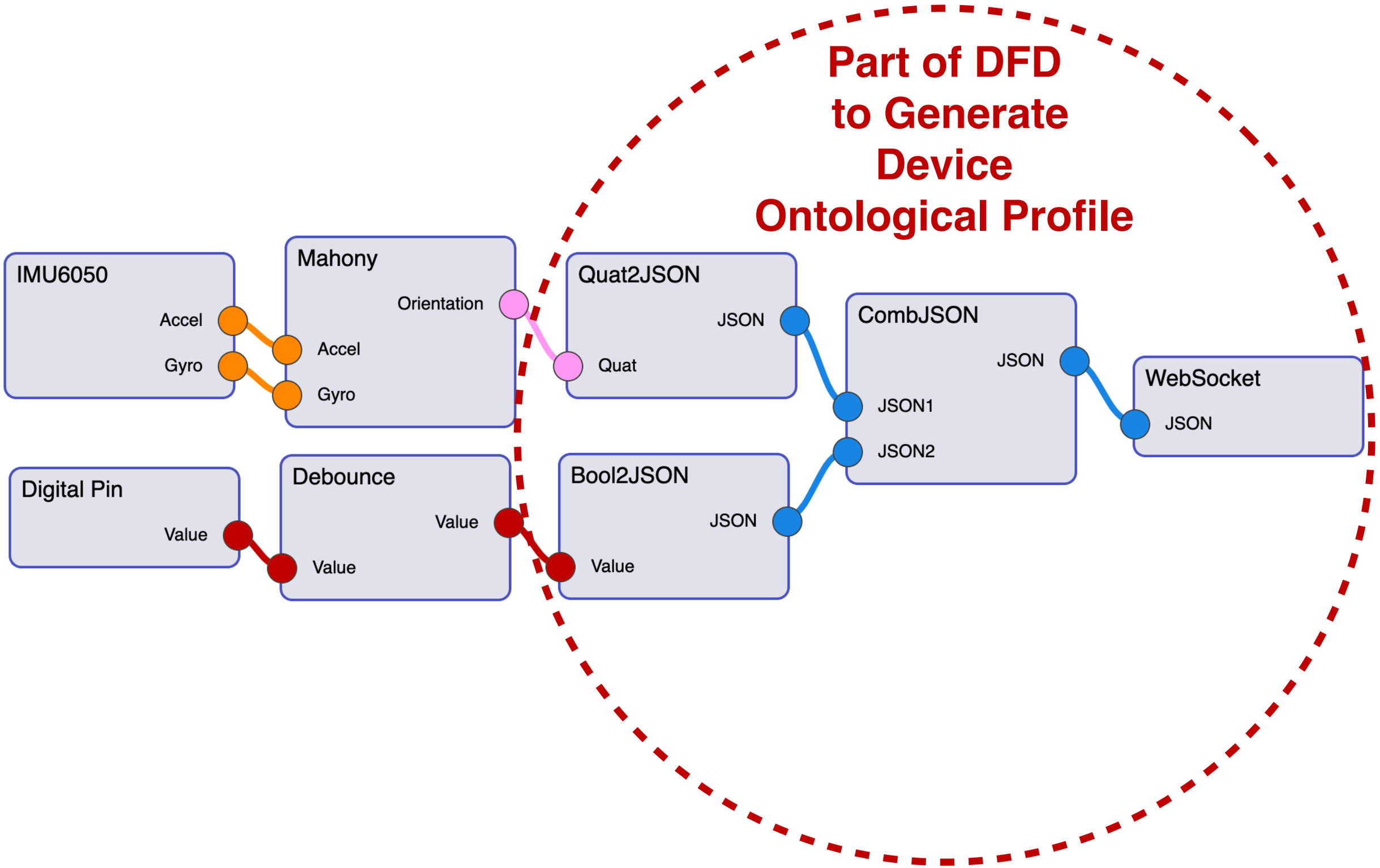

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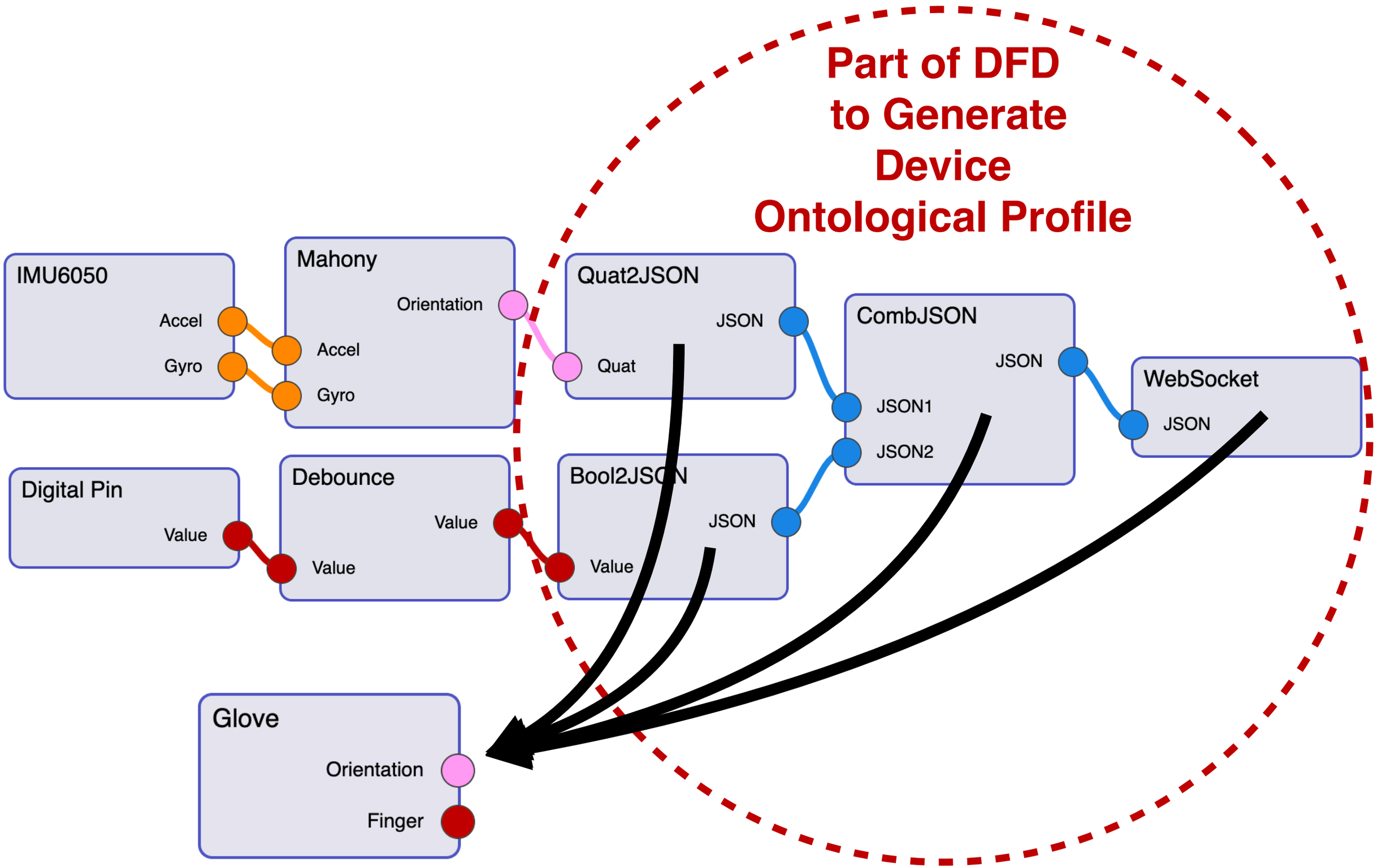

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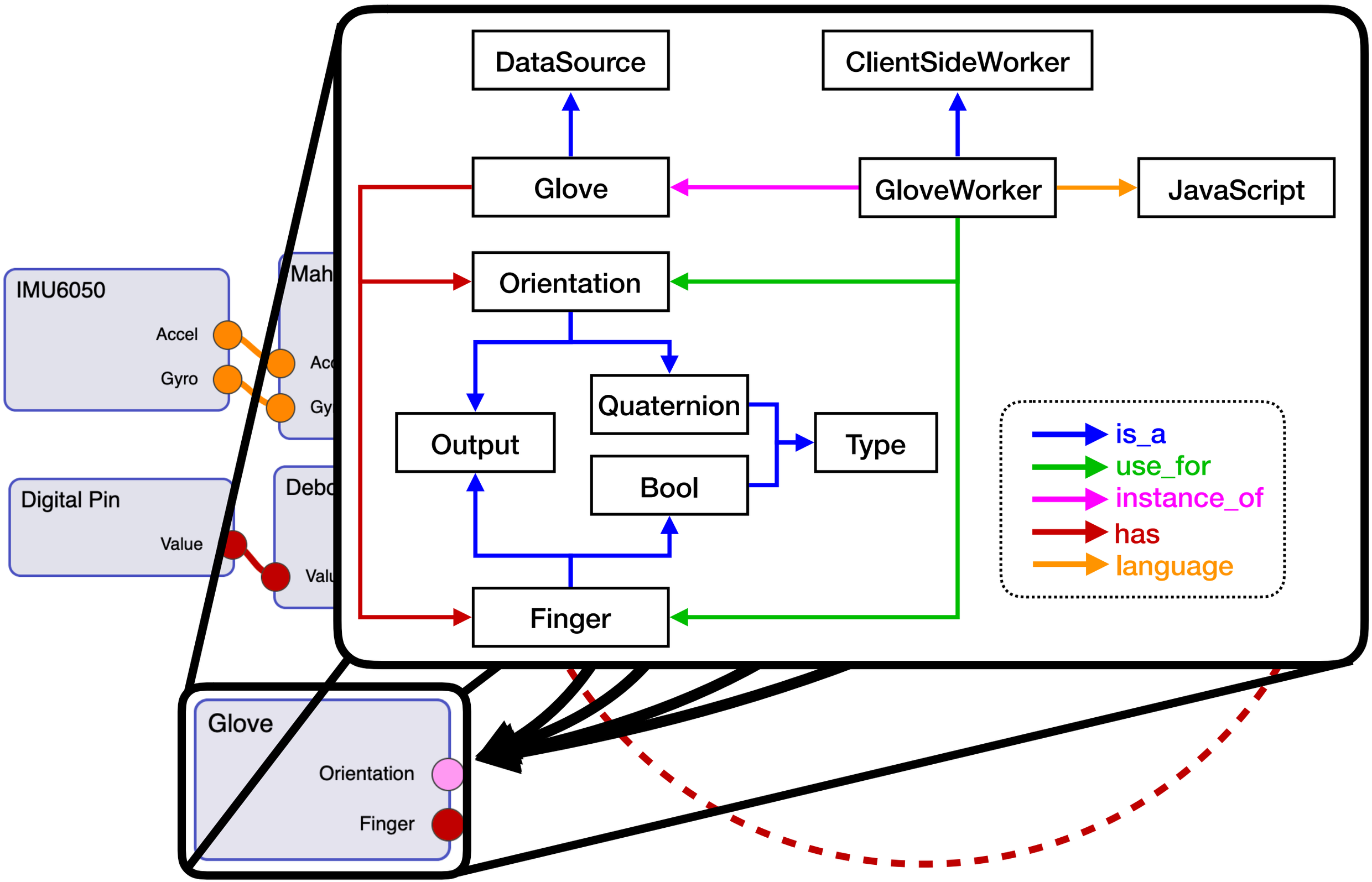
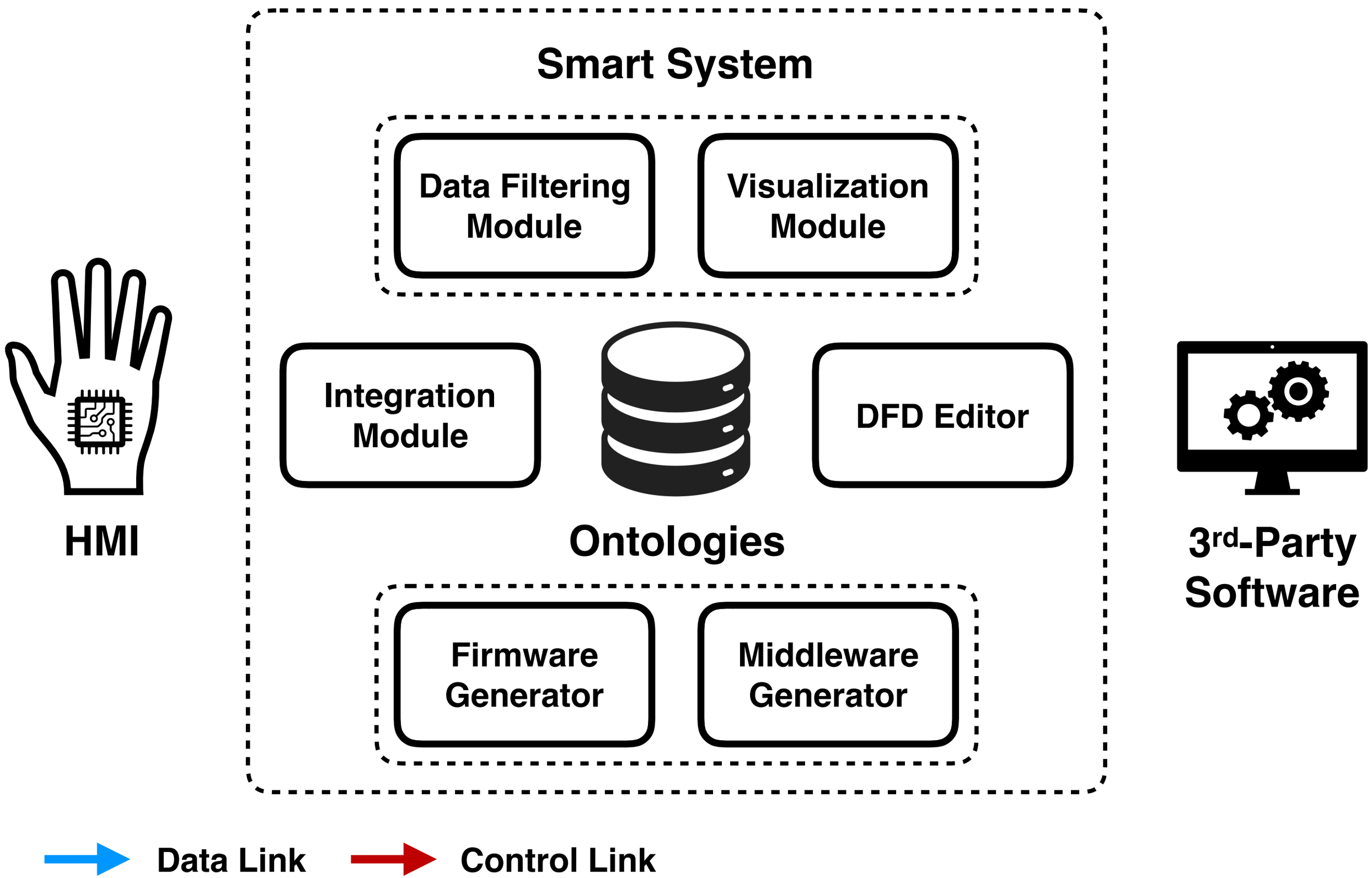


Firmware Debug Stage



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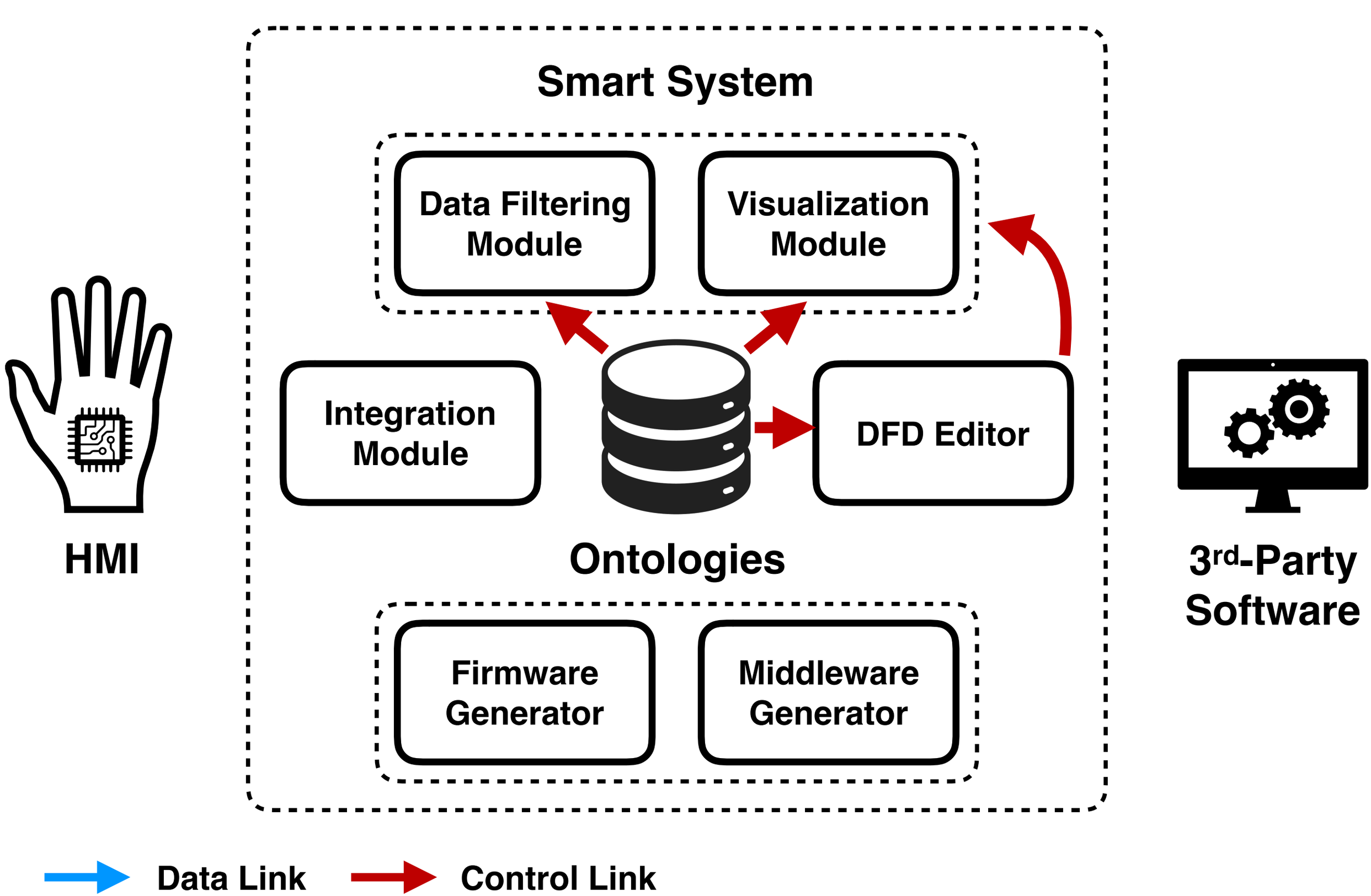

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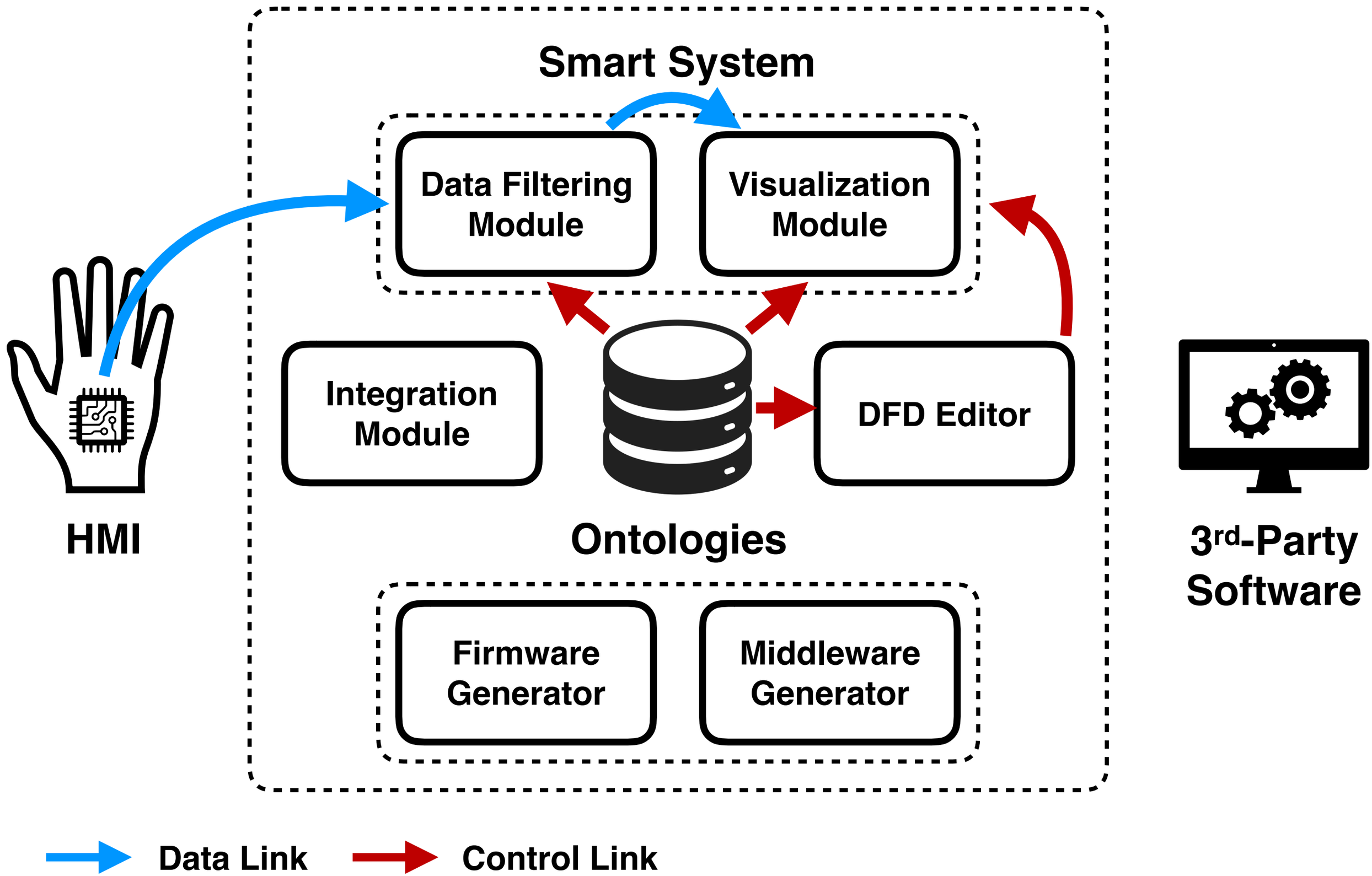

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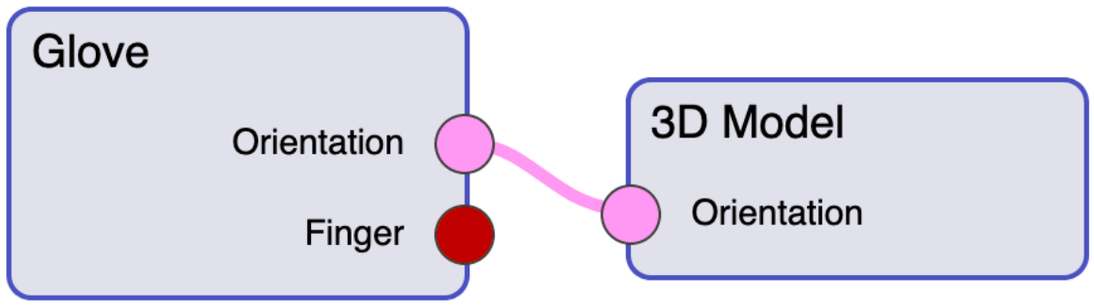

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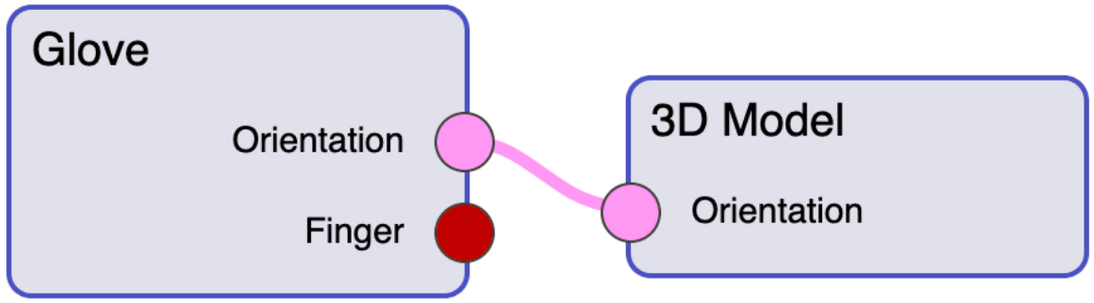
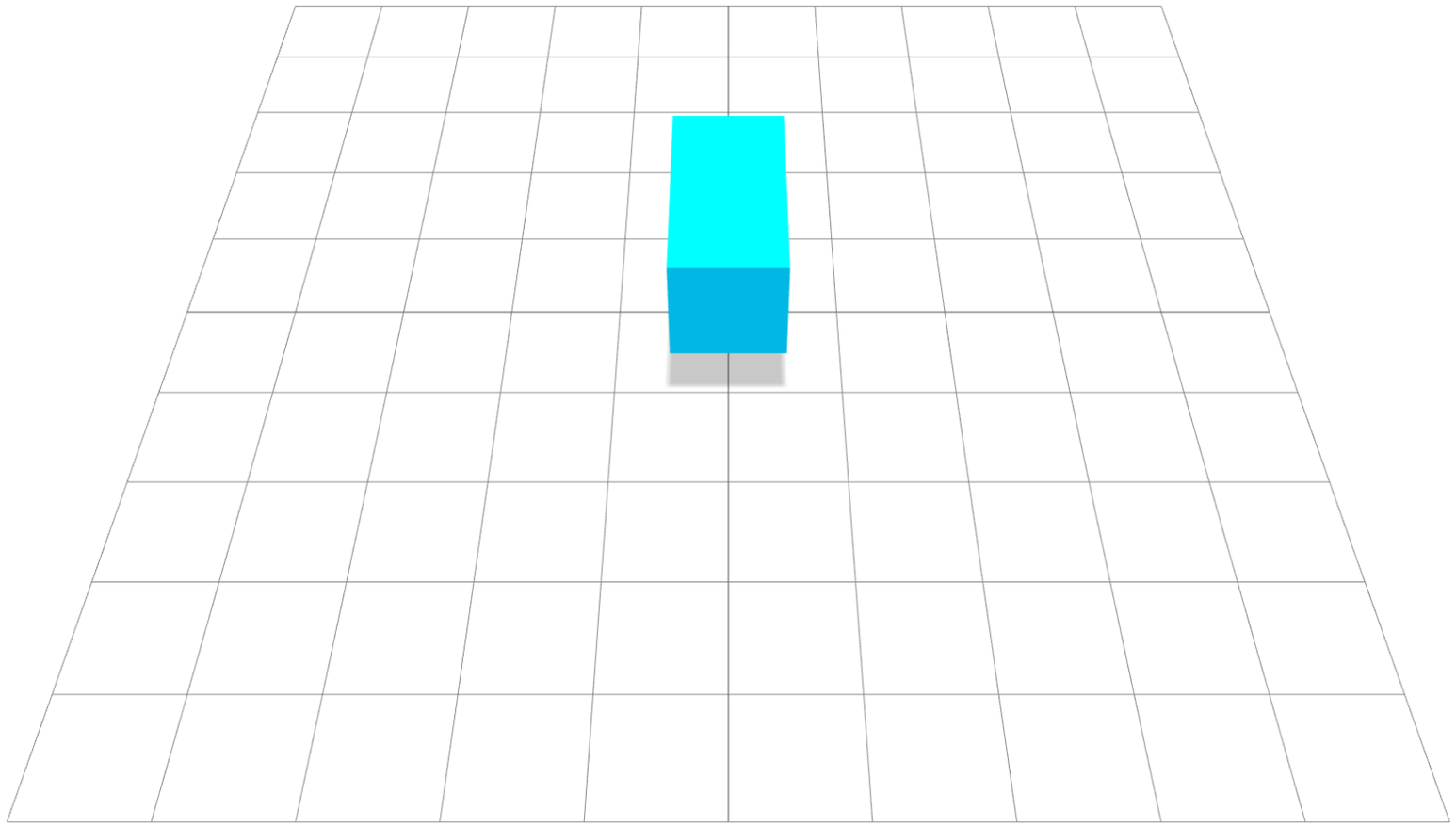
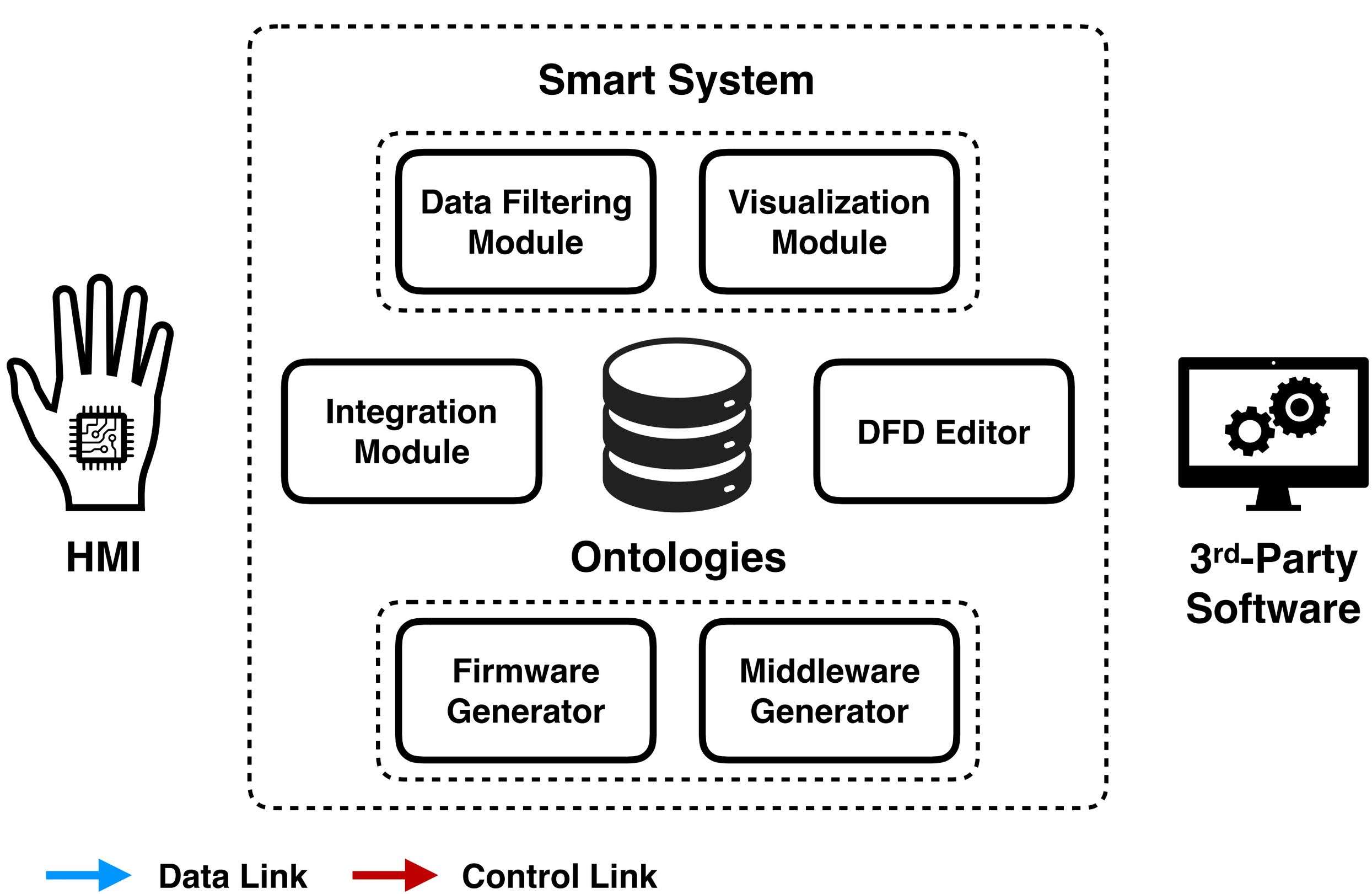




Software Integration Stage



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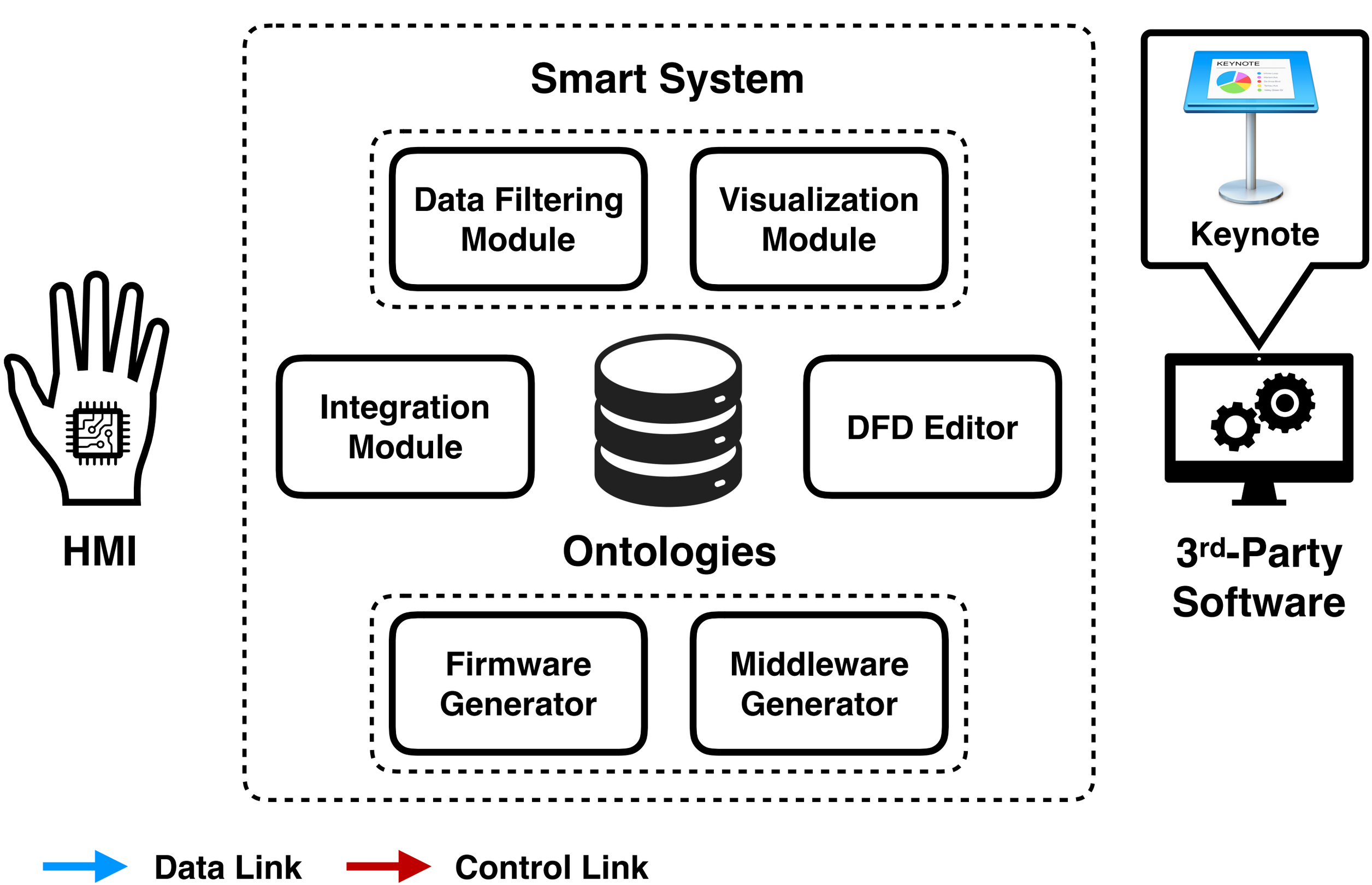

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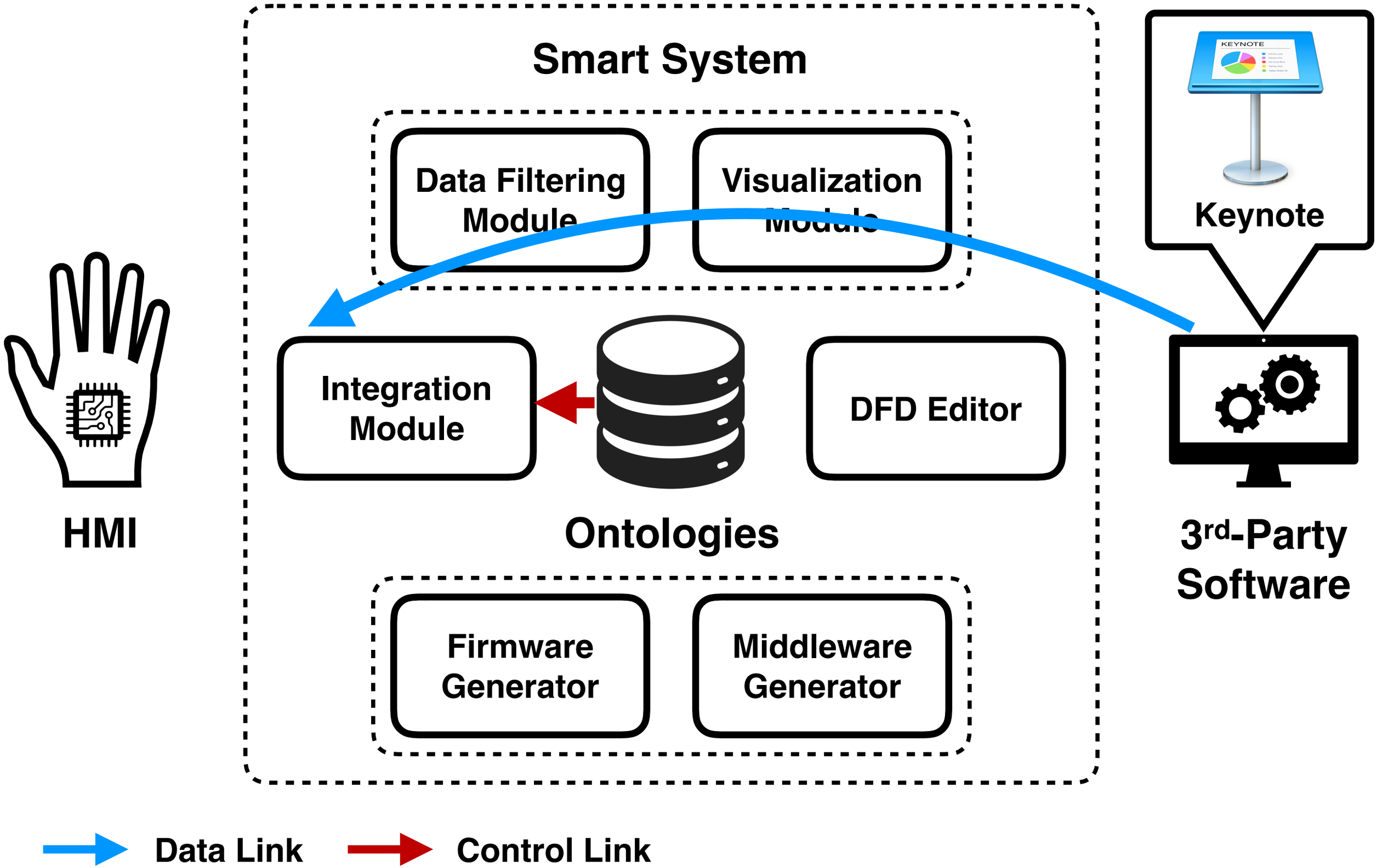

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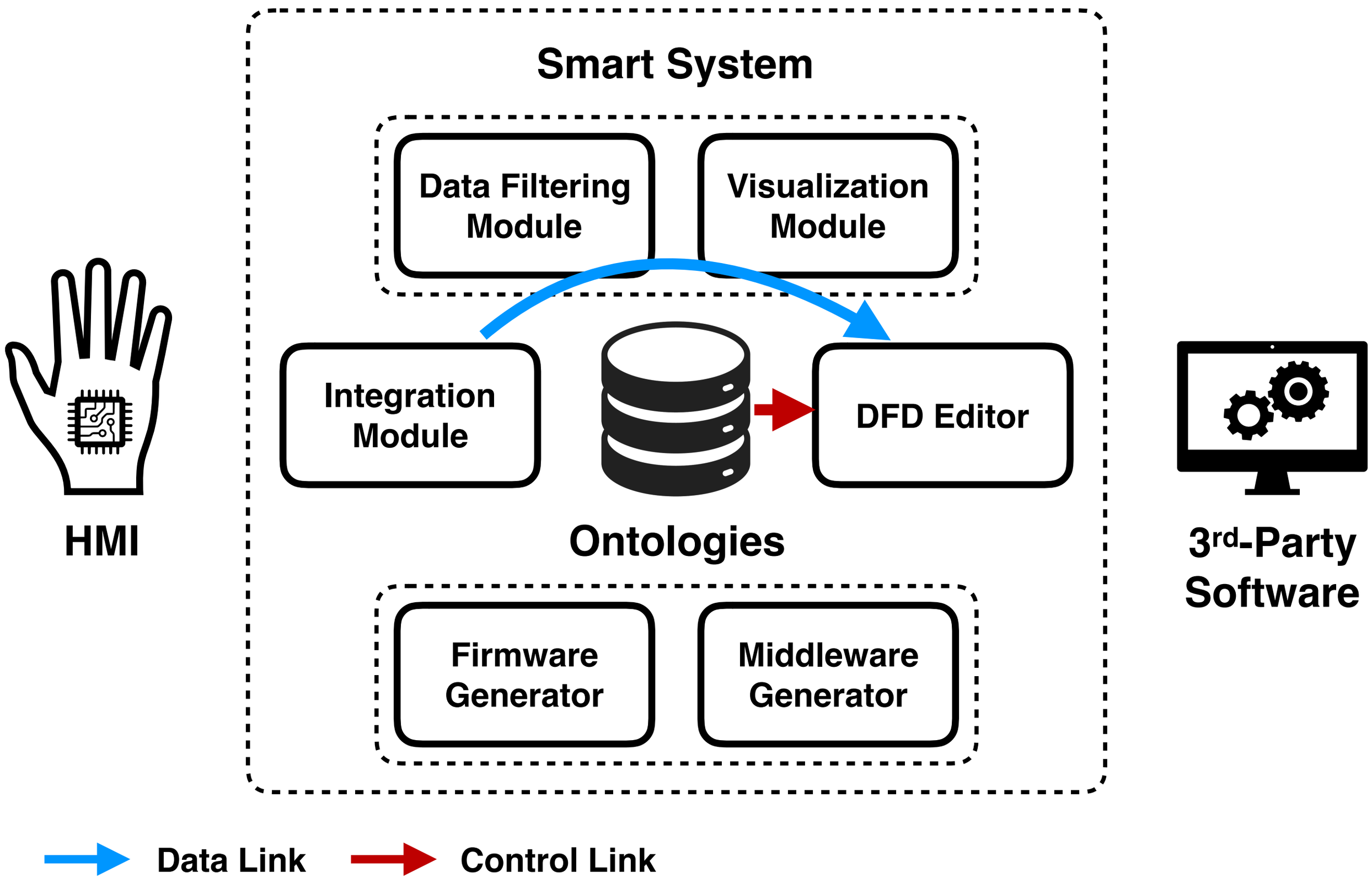
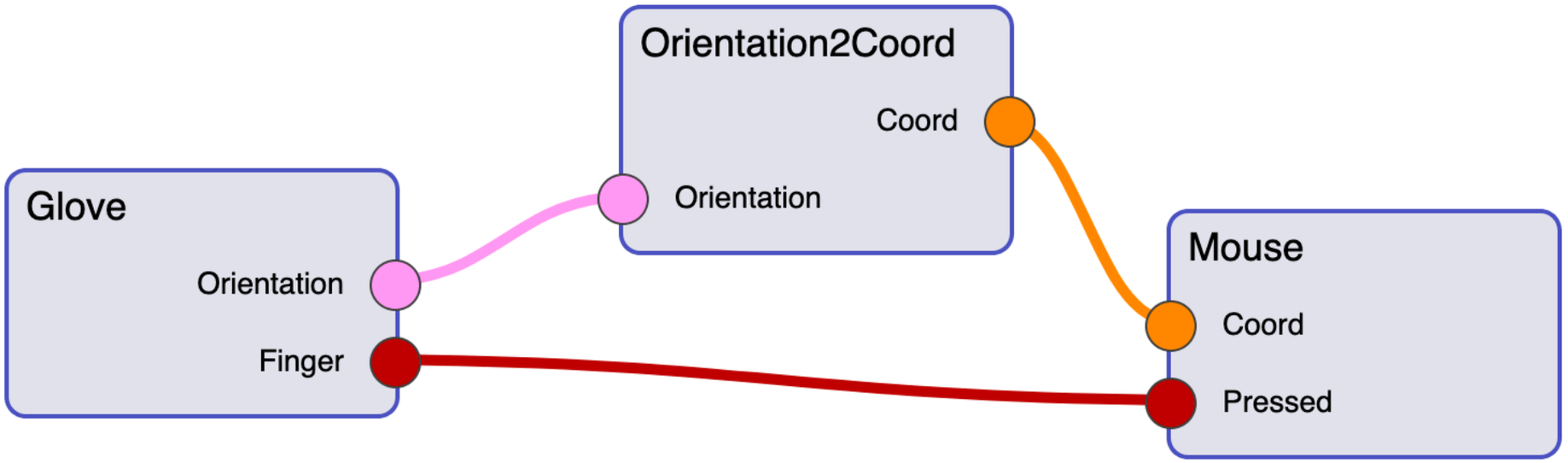
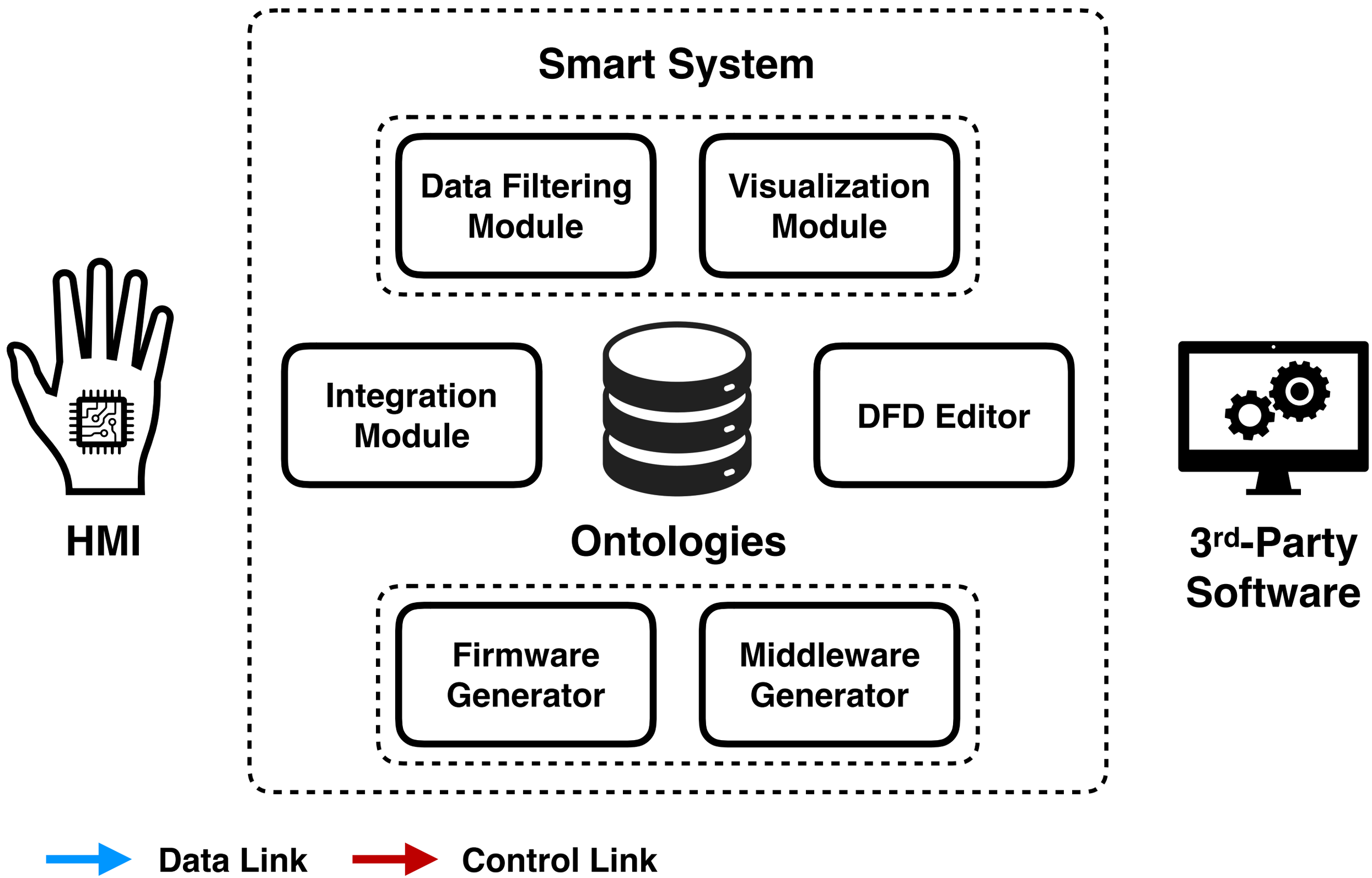


Middleware Composing Stage



Middleware Generation Stage



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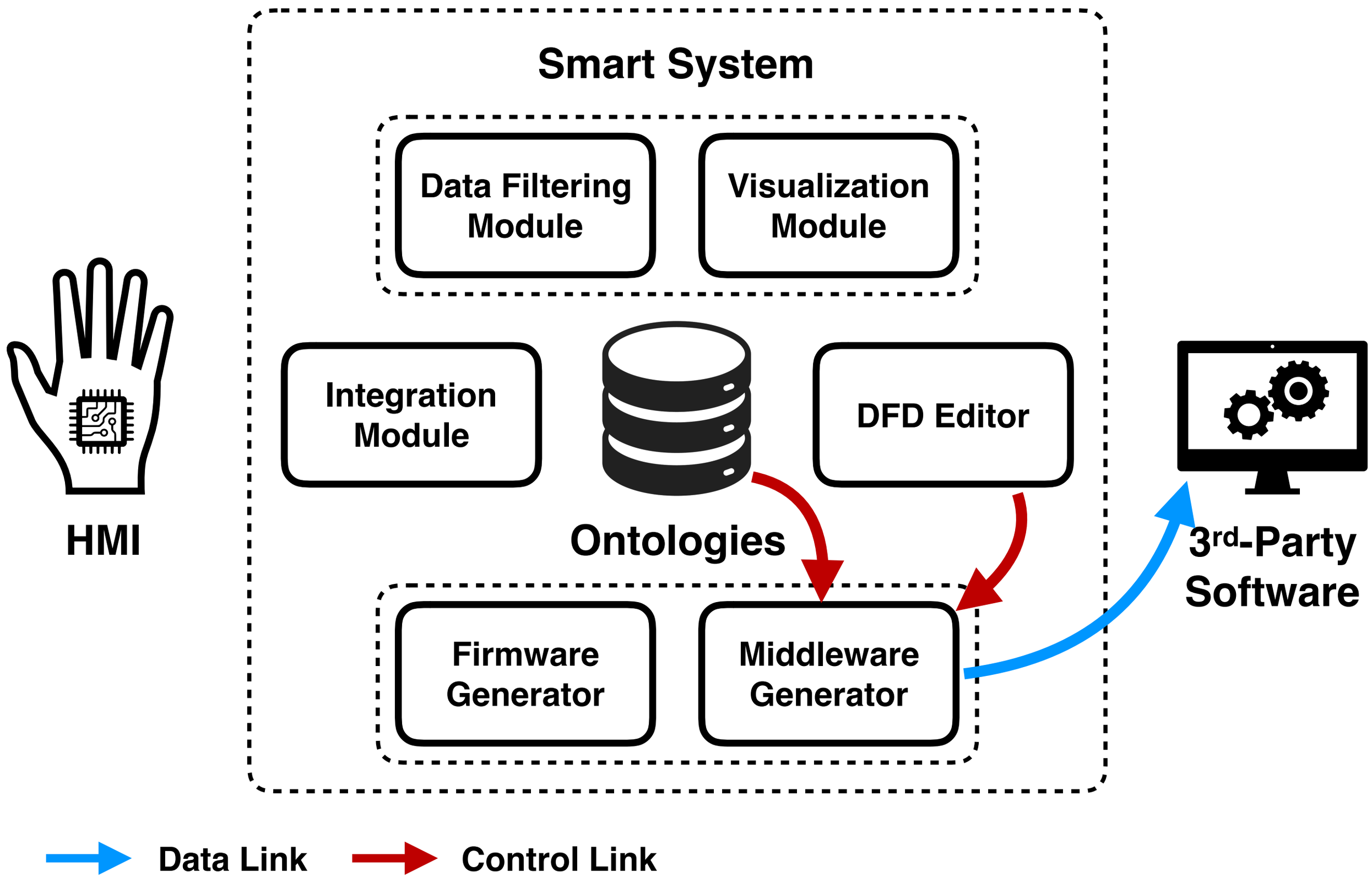
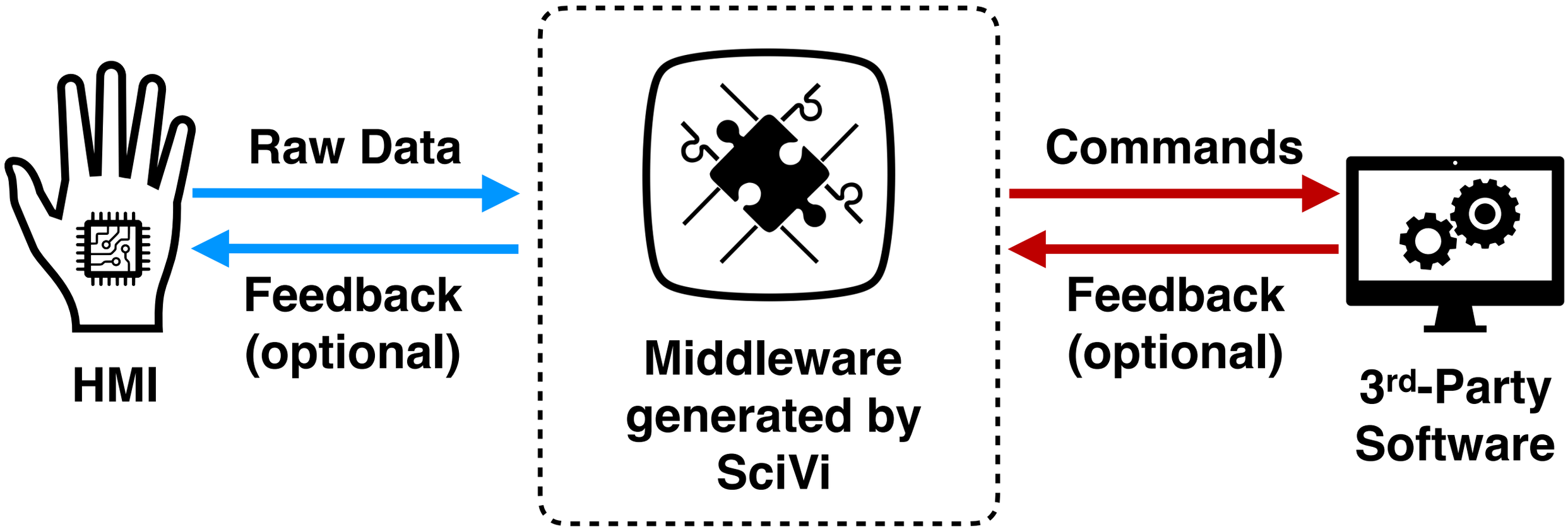


HMI Usage



Data Link Control Link

Use Case

Task:

Discover relationships between psychological characteristics of social network users and their verbal behavior

Instruments:

1. **Semograph computer linguistics system**
2. **SciVi visual analytics system**

Data:

1. **18'000 posts from VKontakte social network made by 800 users**
2. **Big Five personality traits (psychological profiles) of these users:**
   - 2.1. **Openness**
   - 2.2. **Conscientiousness**
   - 2.3. **Extraversion**
   - 2.4. **Agreeableness**
   - 2.5. **Neuroticism**

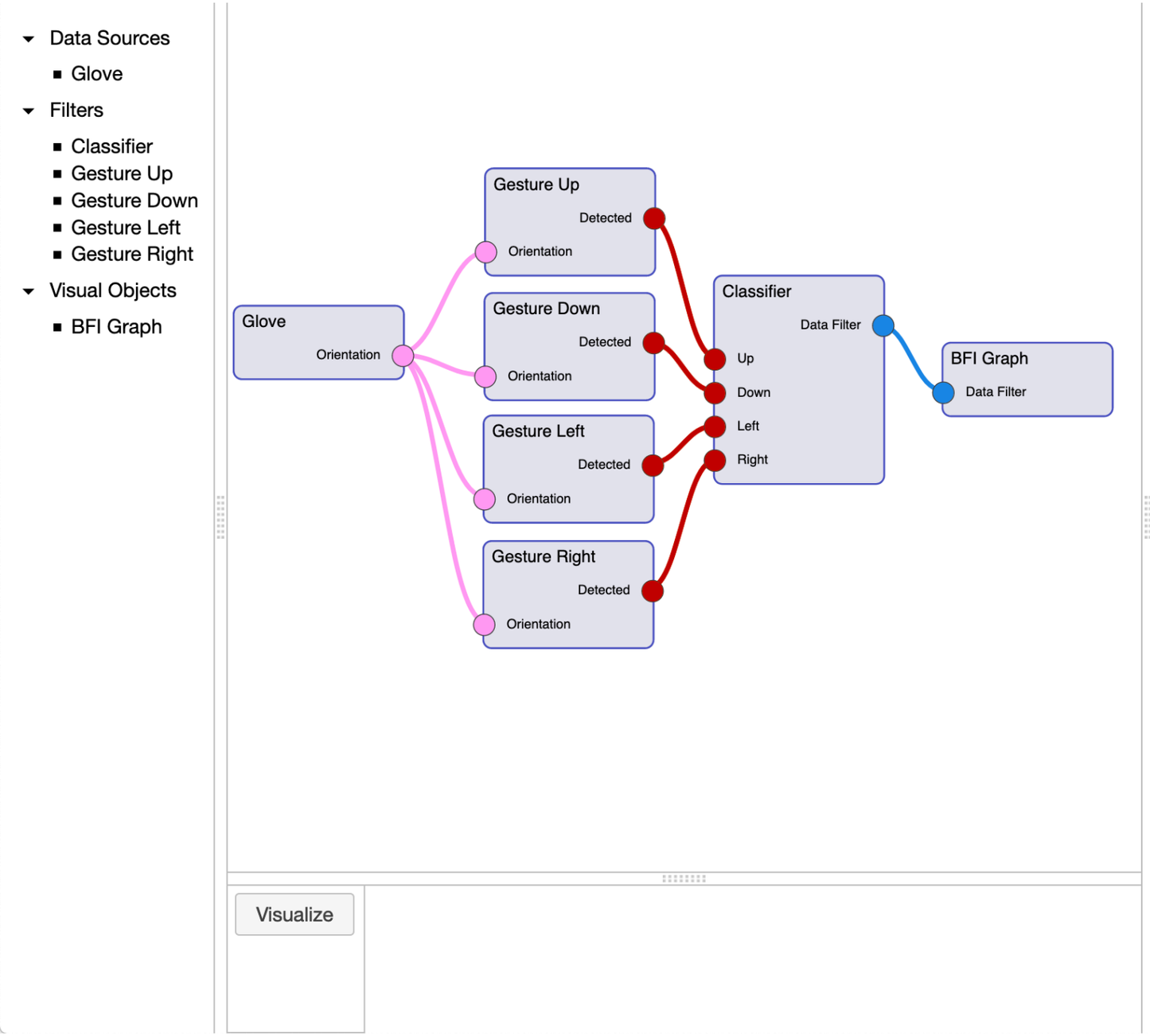
Preprocessing:

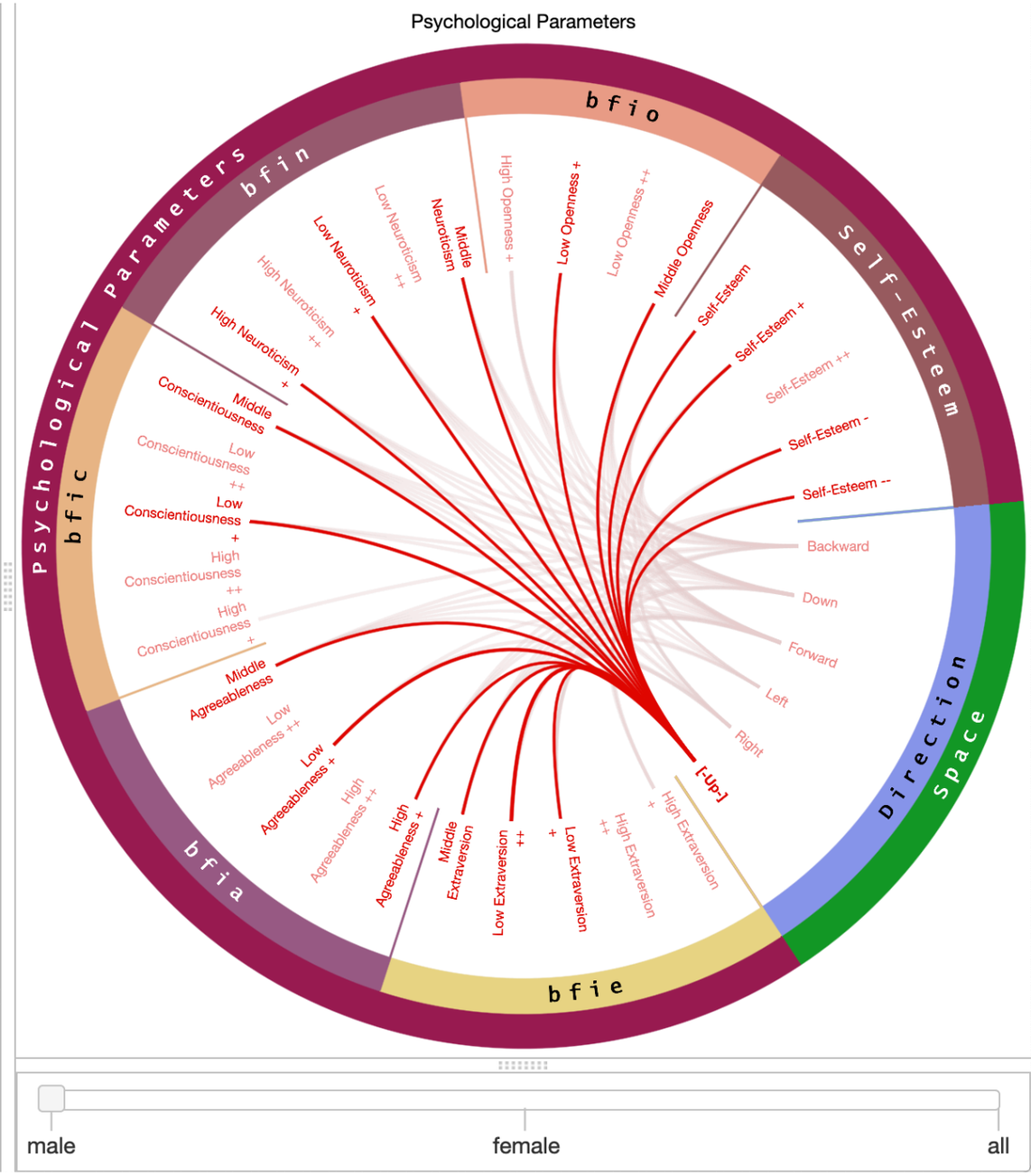
Correlation analysis resulting in the graph where psychological characteristics are connected with verbal patterns

Use Case

Verbal behavior patterns are classified into semantic groups

HMI: Use gestures to activate groups with specific spatial semantics





Conclusion

What we have:

1. Approach to building ontology driven smart systems for automating hardware HMI creation
2. Single smart system with high-level graphical toolset to
   - 2.1. Program
   - 2.2. Debug
   - 2.3. Monitor

   } hardware HMI
   - 2.4. Create middleware to steer 3rd-party systems (including legacy ones)
3. Perceptive-cognitive HMI for multimodal analytics

What we plan:

1. Tackle problems of transforming M2M IoT systems into Human-Centric ones
2. Create IoT-based healthcare monitoring systems
3. Create HMI for virtual reality applications

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Thank You for Attention!

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Faro – 2019