[1] Perm State University
Bukireva Str. 15, 614990, Perm, Russia

[2] Perm Regional Museum /
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Monastyrskaya Str. 11, 614000, Perm, Russia

Museum
of Permian
Antiquities

Calibration and Monitoring of IoT Devices by Means of Embedded Scientific Visualization Tools

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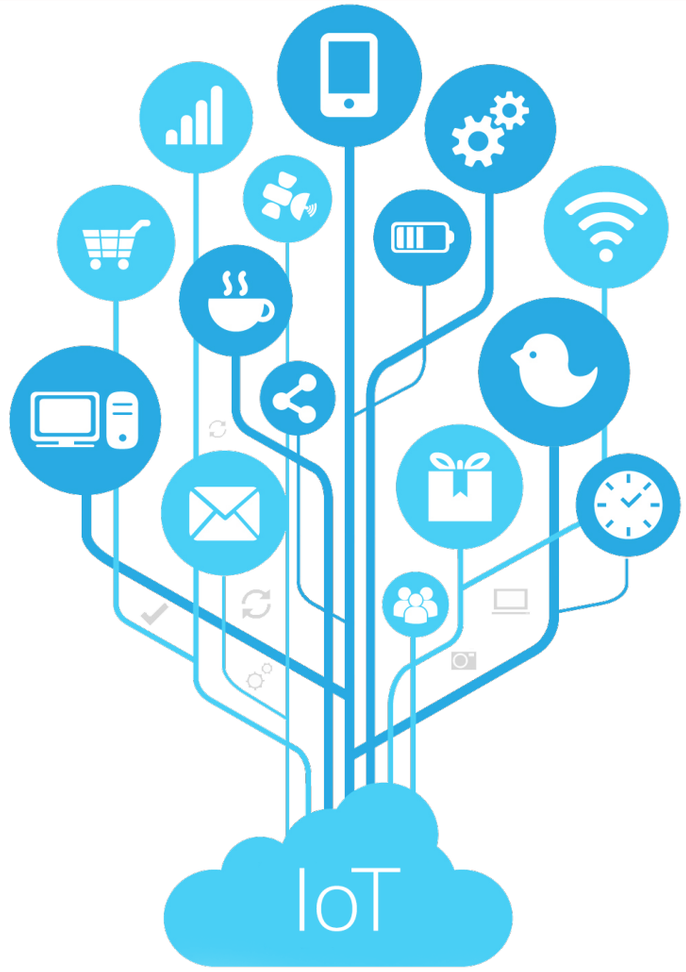
Wuxi – 2018

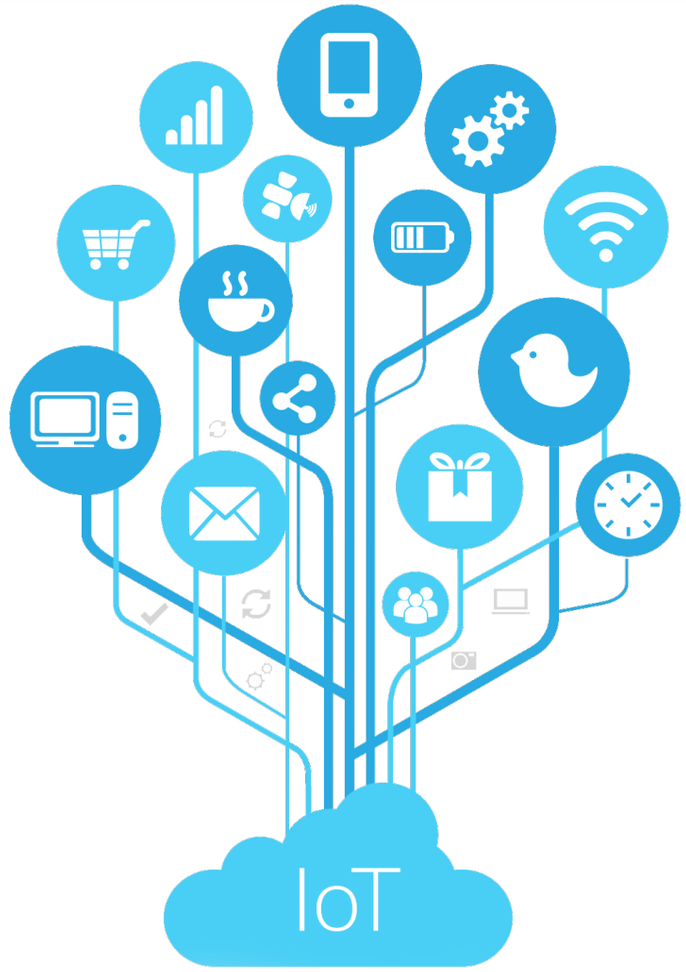
Motivation & Objectives



Motivation & Objectives

Challenge:

- **A lot IoT devices types**
- **But relatively few IoT programmers to help device makers**



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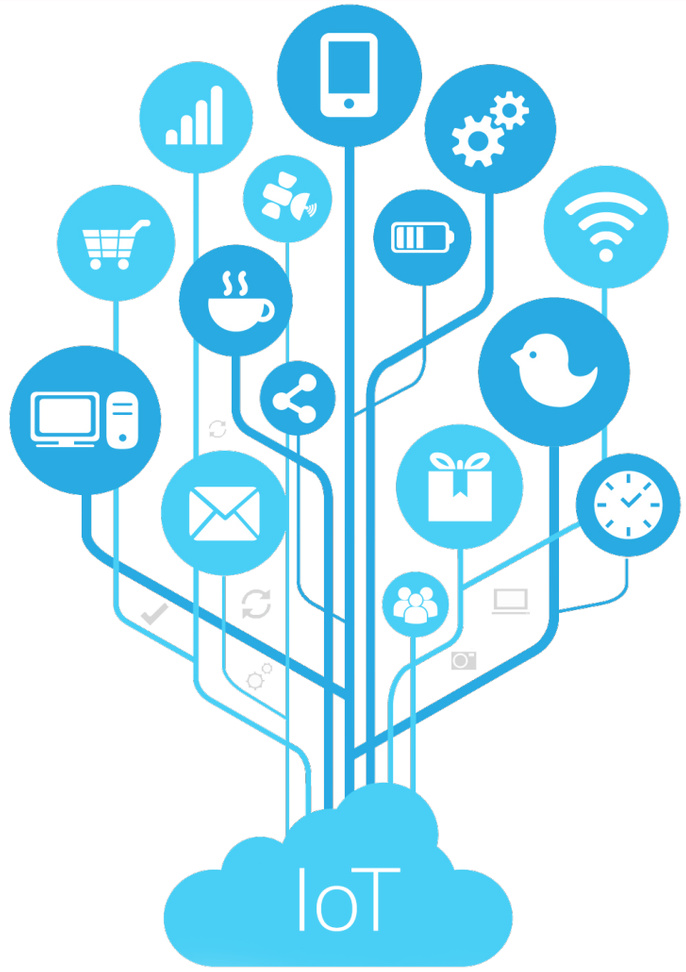
Given:
- Variety of devices and generated data
- Variety of low-level software and hardware solutions
- Variety of communication protocols



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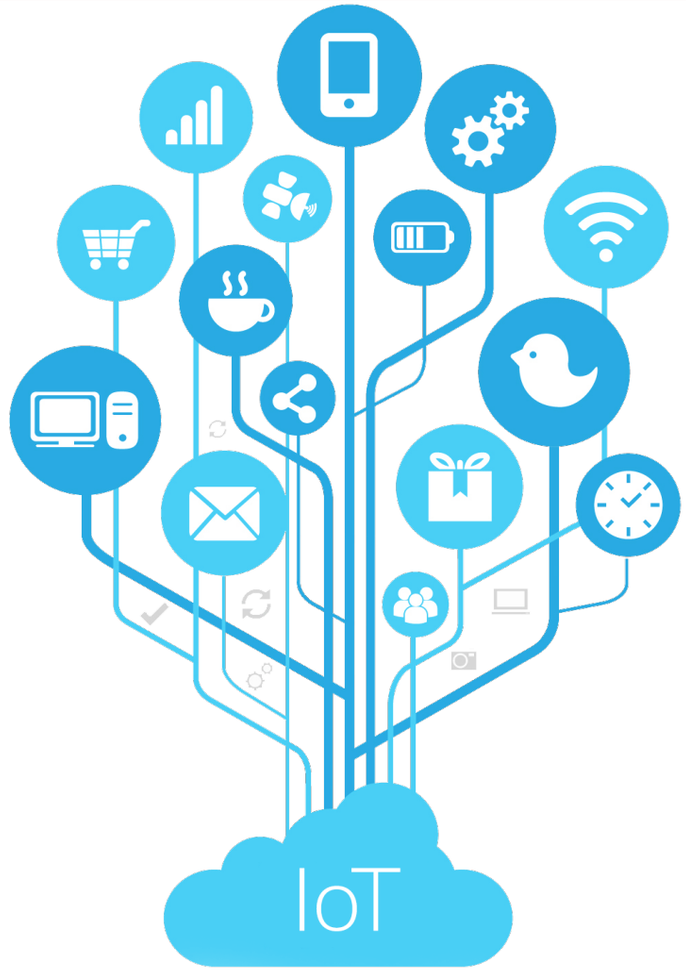
Demanded:
- Firmware generation solutions
- High-level tools for IoT ecosystem management



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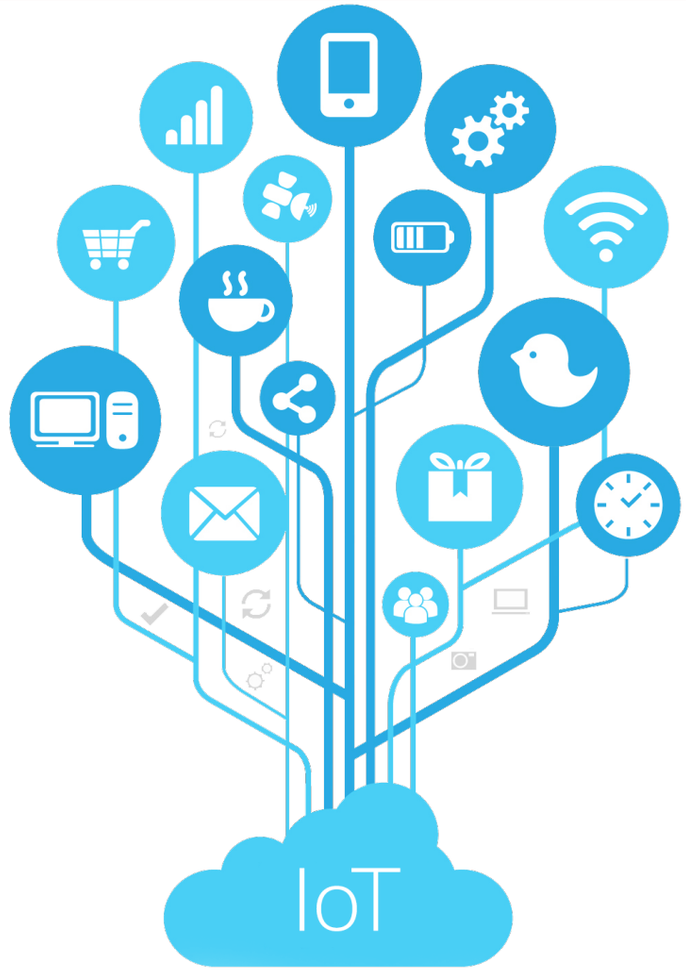


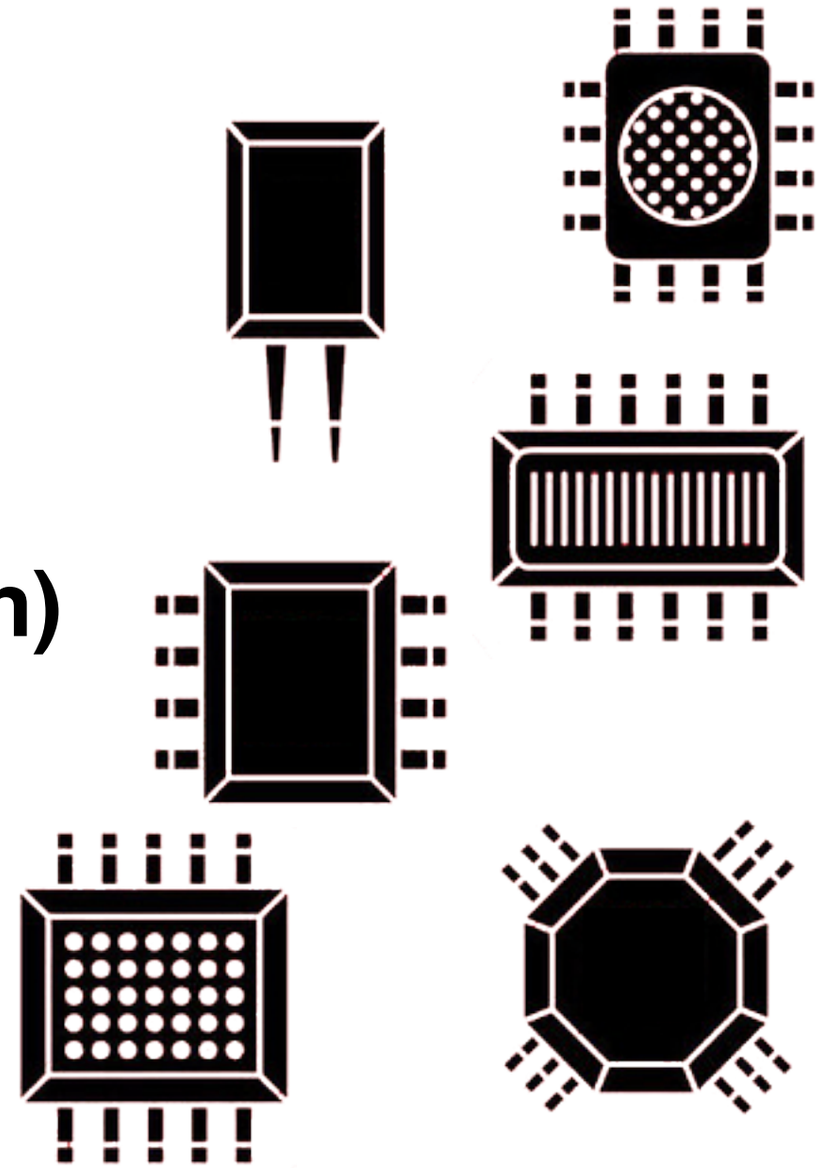
1. Suggest the adaptable visual analytics tools to observe and manage IoT networks
2. Improve the ways of IoT devices' calibration and monitoring using advanced scientific visualization tools
3. Develop self-service tools to automate IoT devices' firmware generation

IoT Devices

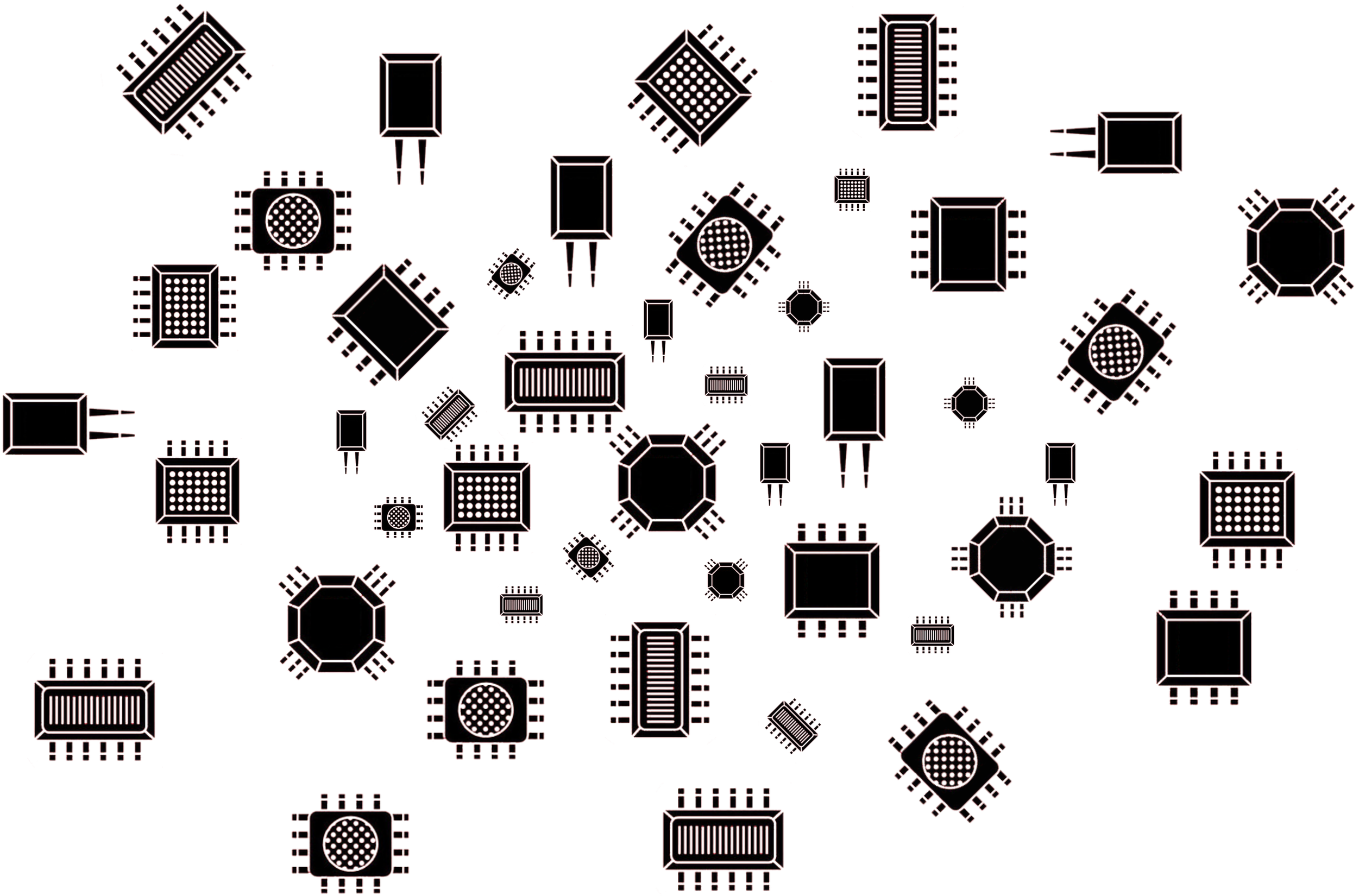
Sensor-based IoT devices are like Lego parts: one can build whatever he wants

But device makers need self-service high-level tools to manage

1. **Infrastructure of IoT ecosystem (complex interconnections)**
2. **Monitoring of generated data (including complex visualization)**
3. **Calibration of devices (including complex steering)**



Why scientific visualization?



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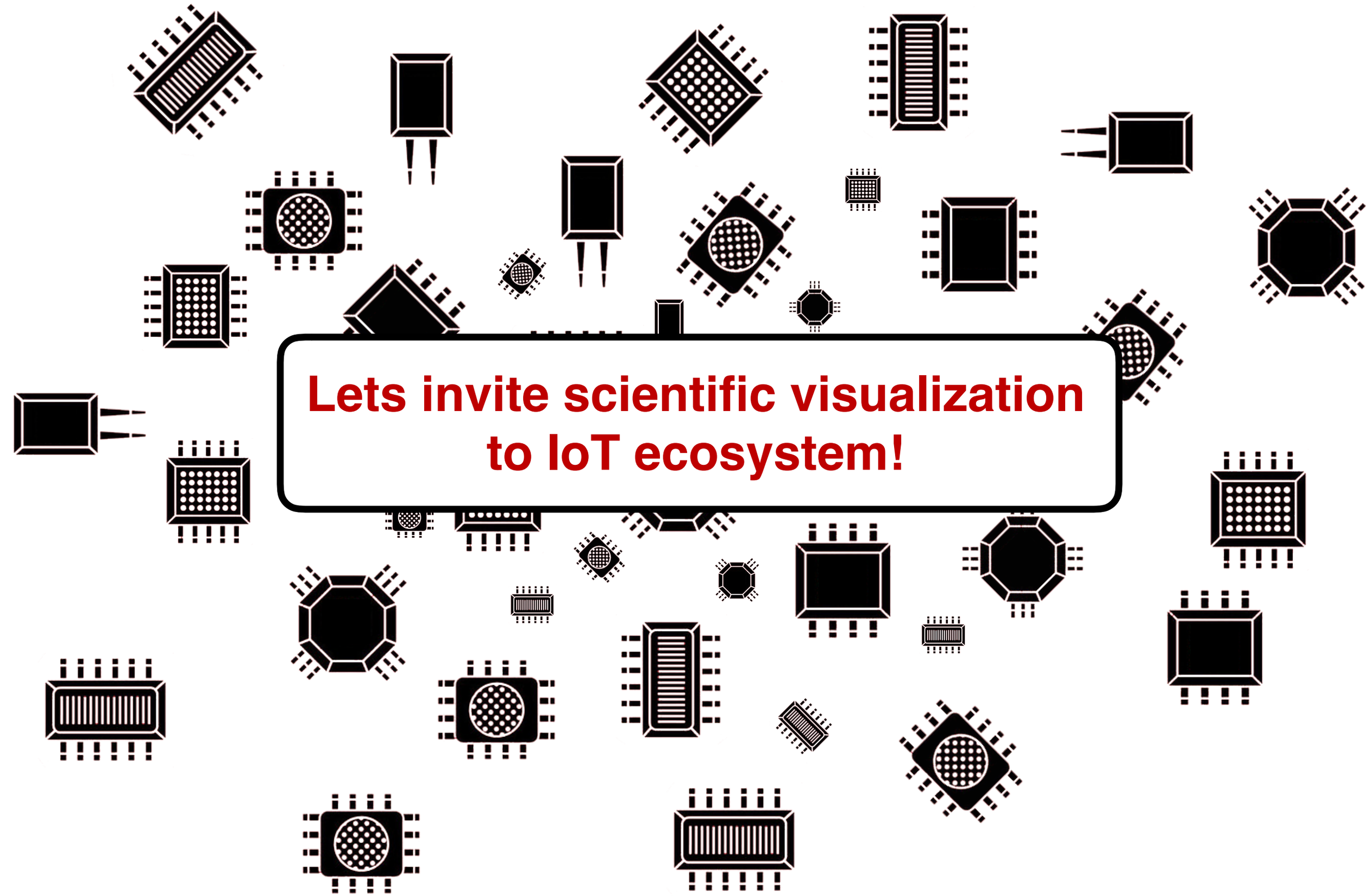
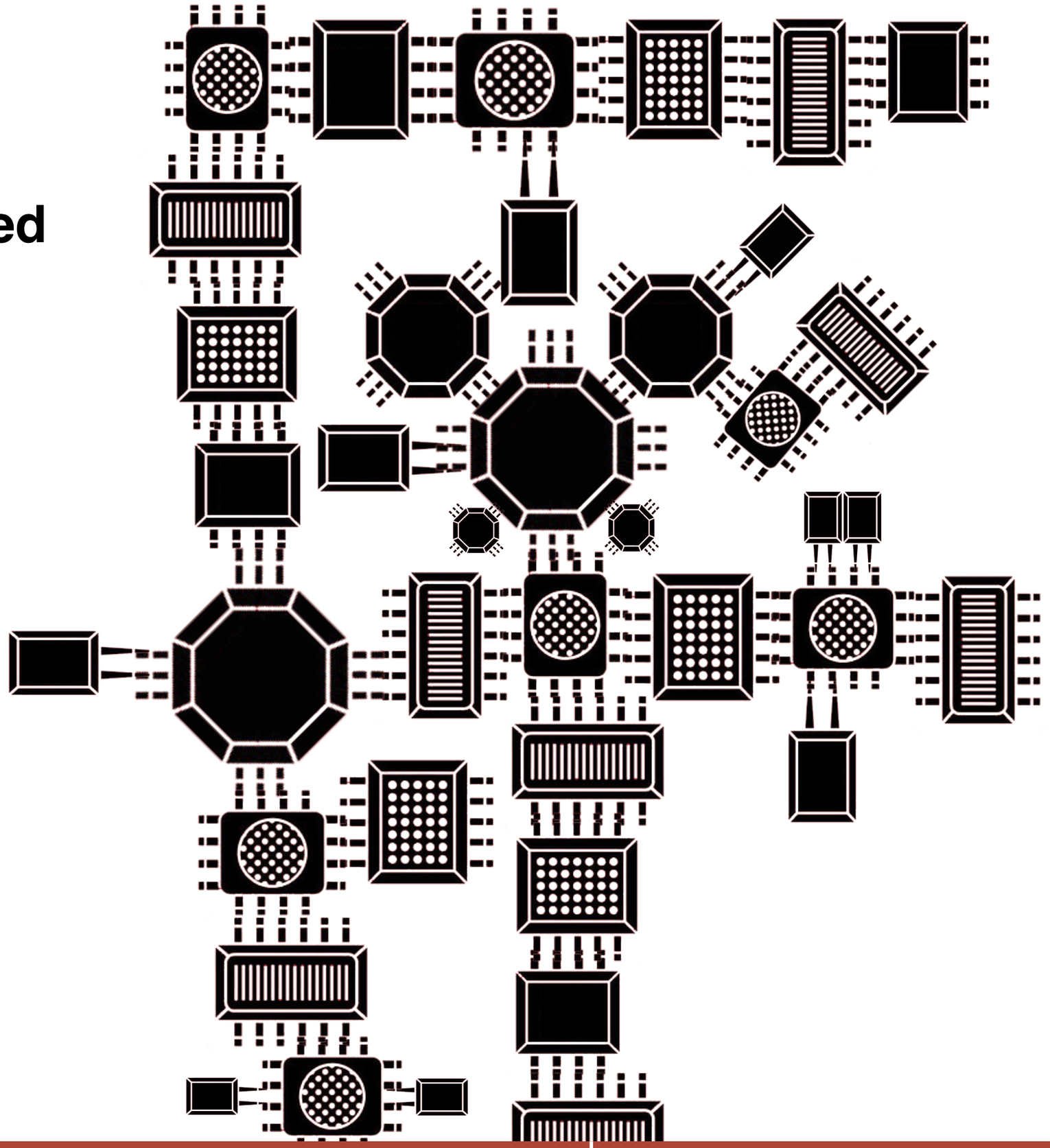


Why scientific visualization?

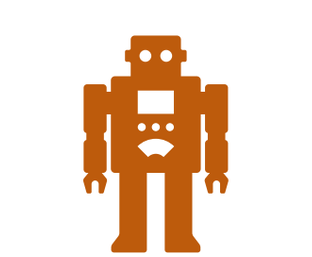
Scientific visualization based management tool



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



Data Source 1

Data source 2

. . .

Data Source *n*

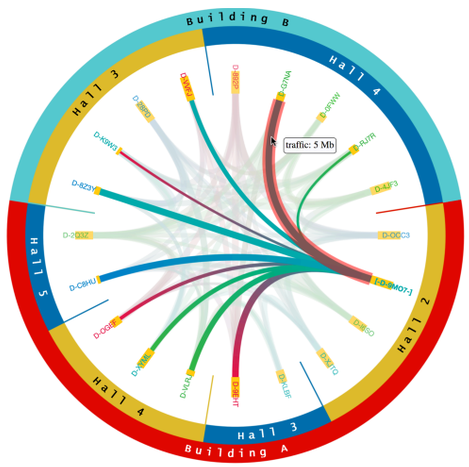
Arbitrary application domain

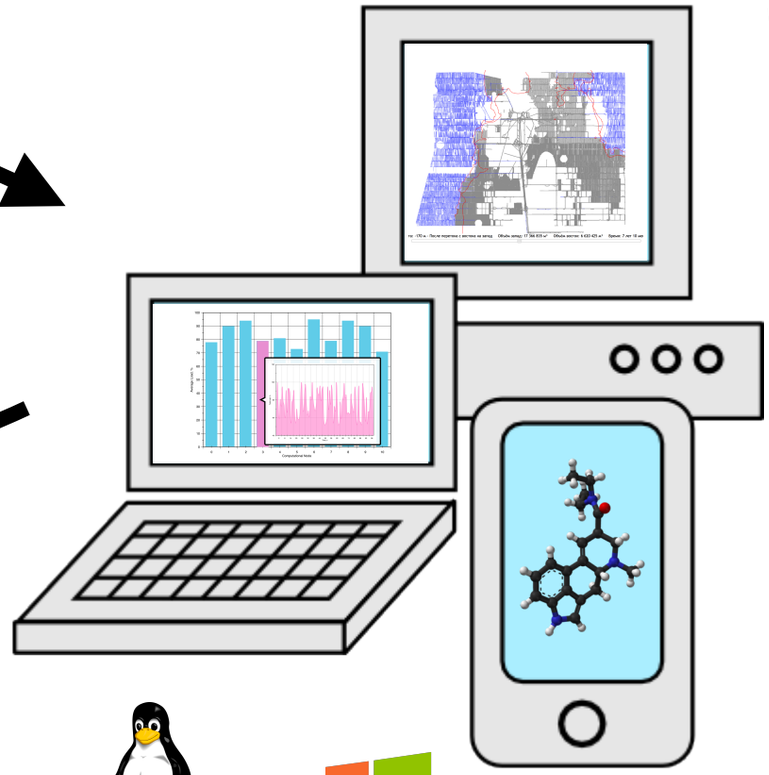
Connection

SciVi

Feedback

Visualization and Analytics





GNU / Linux

Windows

macOS

iOS

ANDROID

Web

Multiplatform Portability

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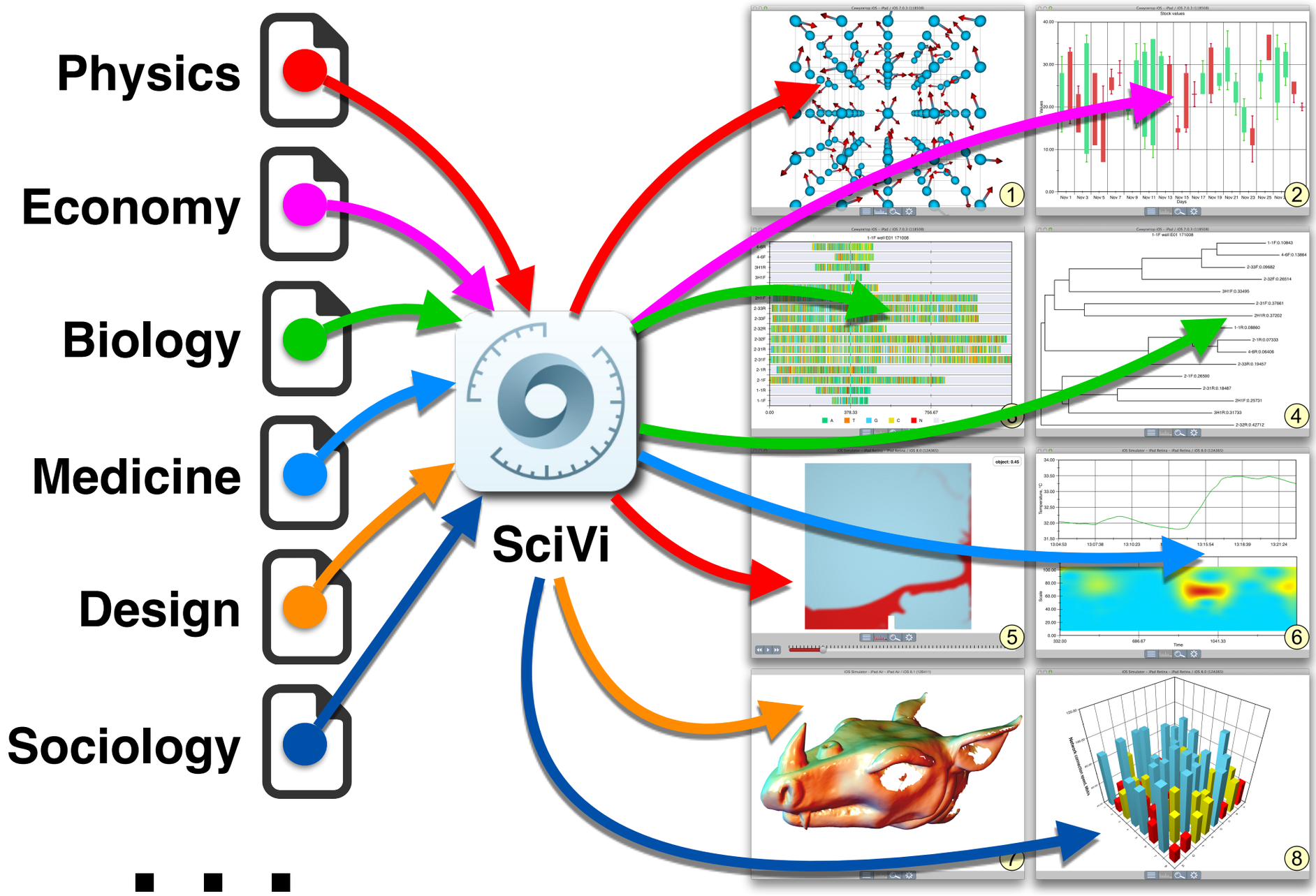

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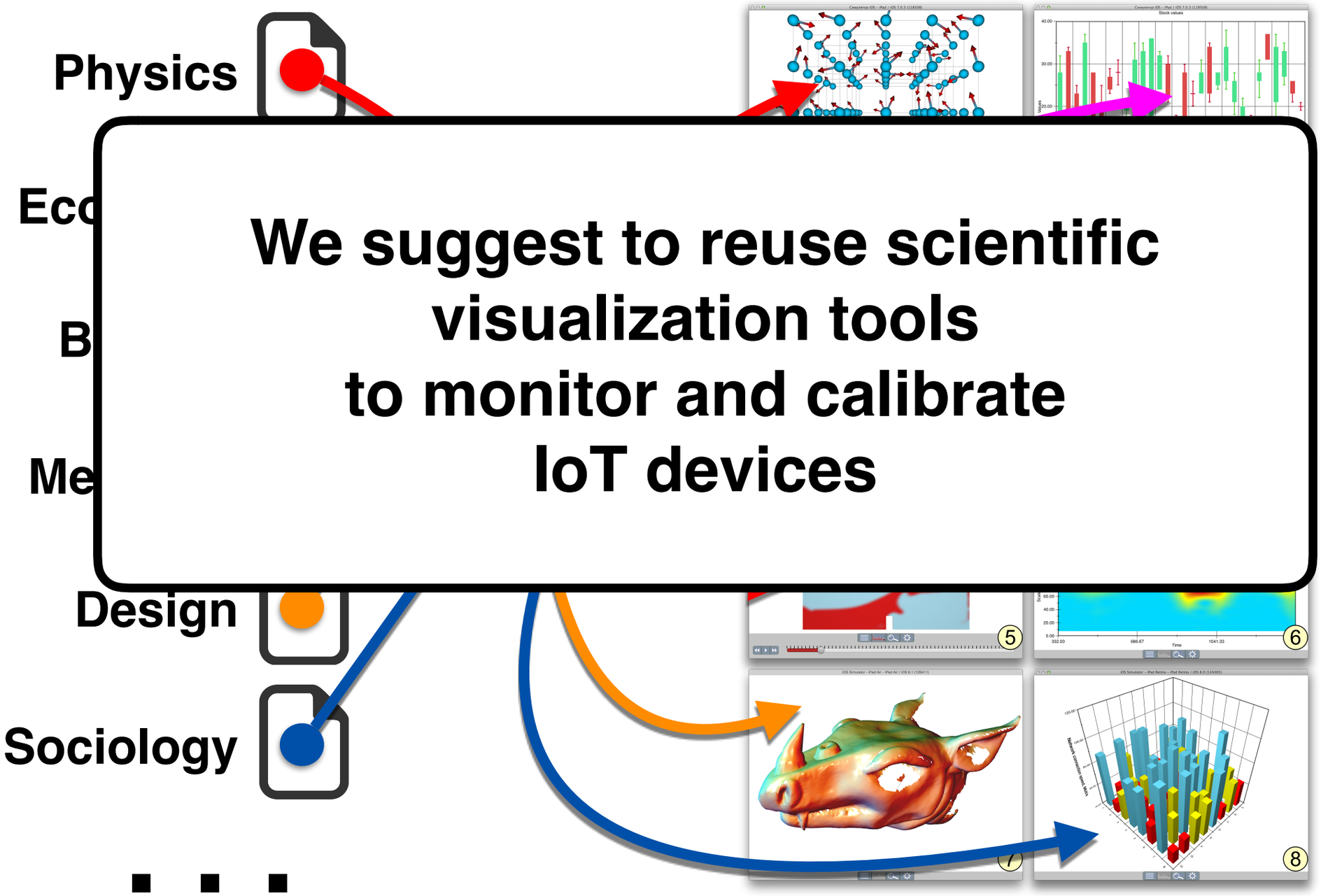


High-level IoT Management: Ontologies

SciVi is ontology-driven scientific visualisation platform, its behavior is governed by extensible knowledge base

Ontology engineering – knowledge management metodology based on ontologies

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

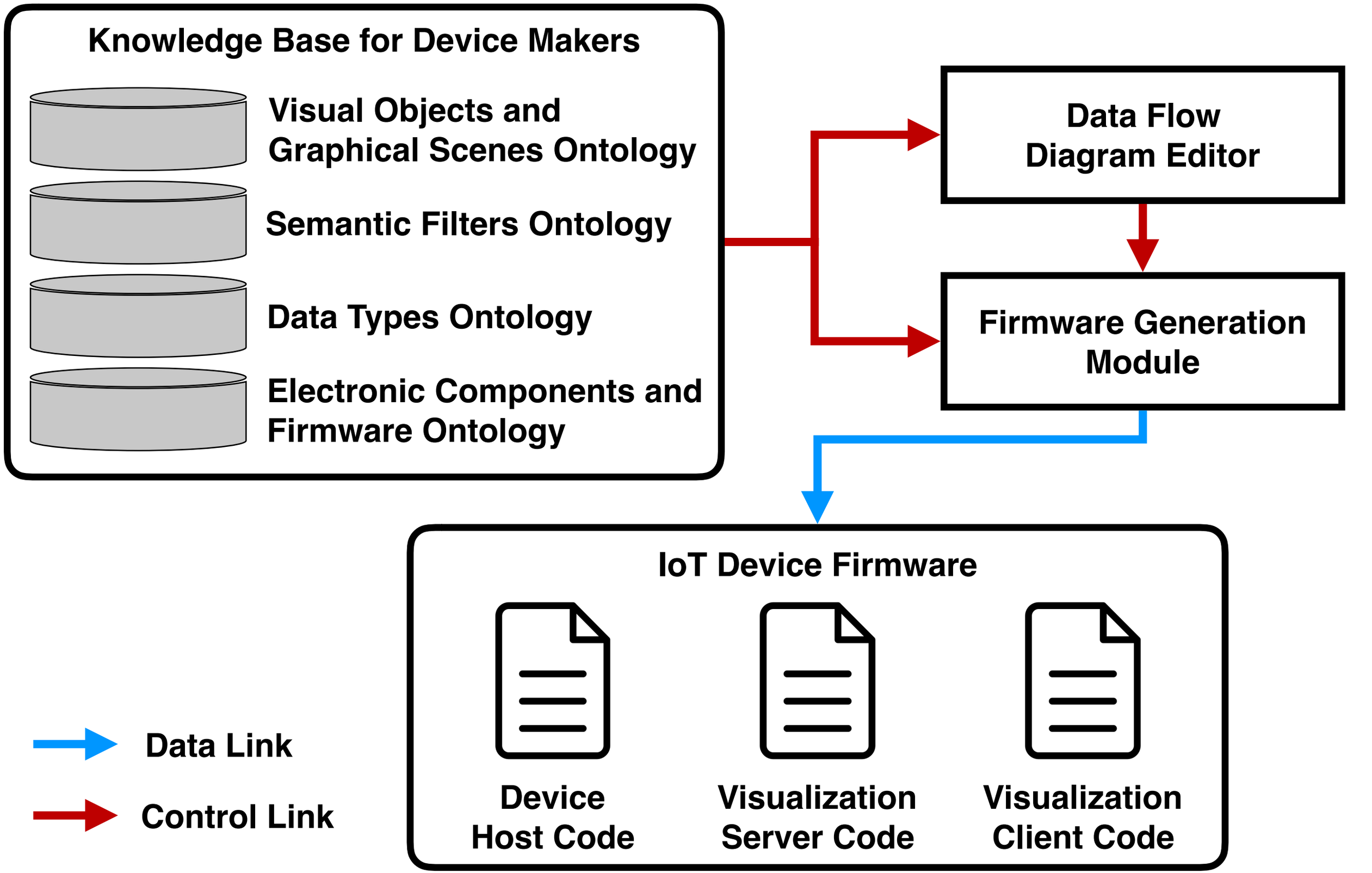
$O = \langle T, R, A \rangle$

T – thesaurus of application domain concepts

R – set of relations between concepts

A – set of axioms

IoT Devices Firmware Generation in SciVi



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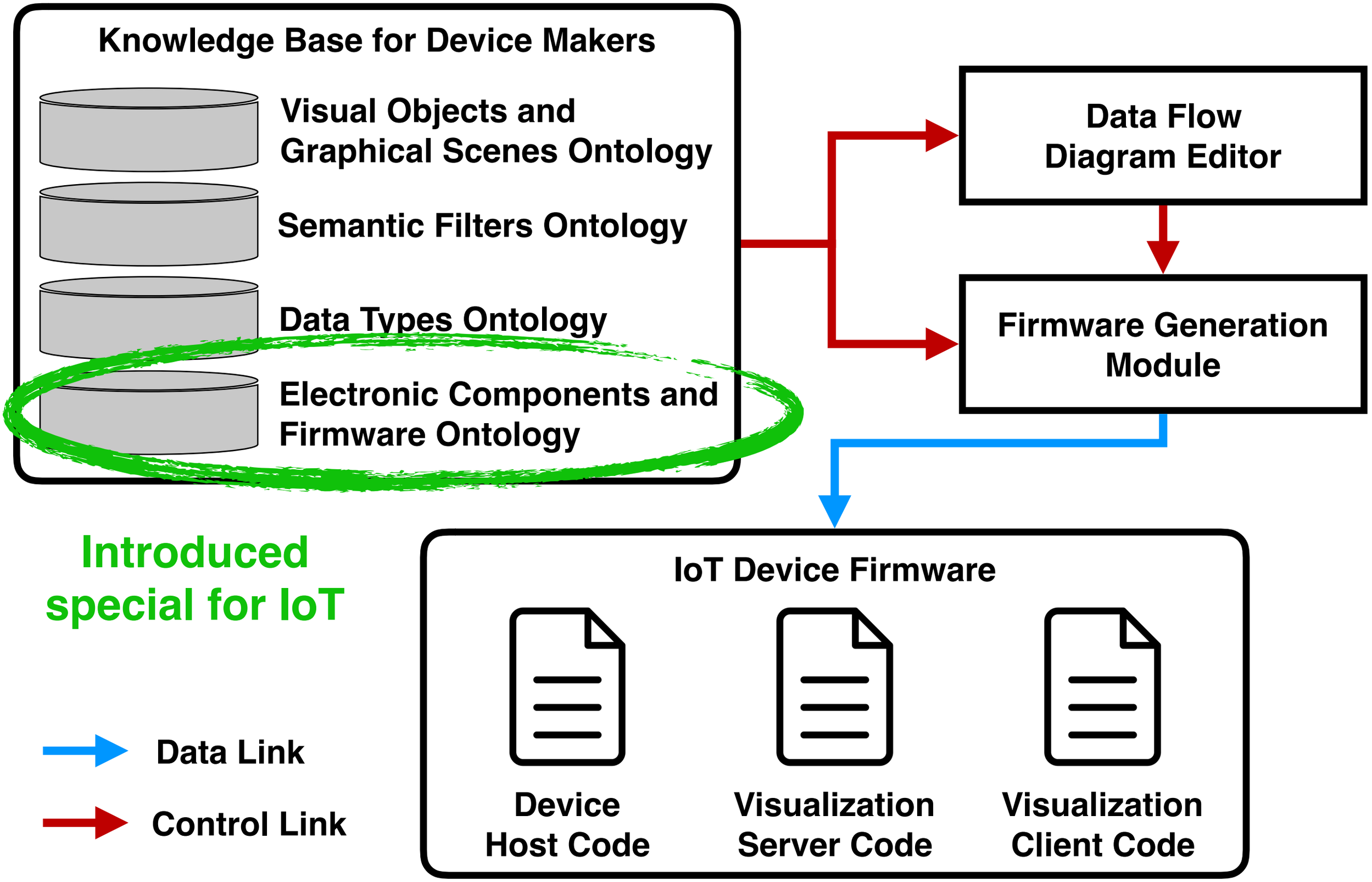
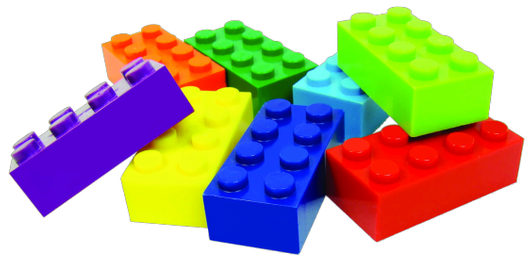
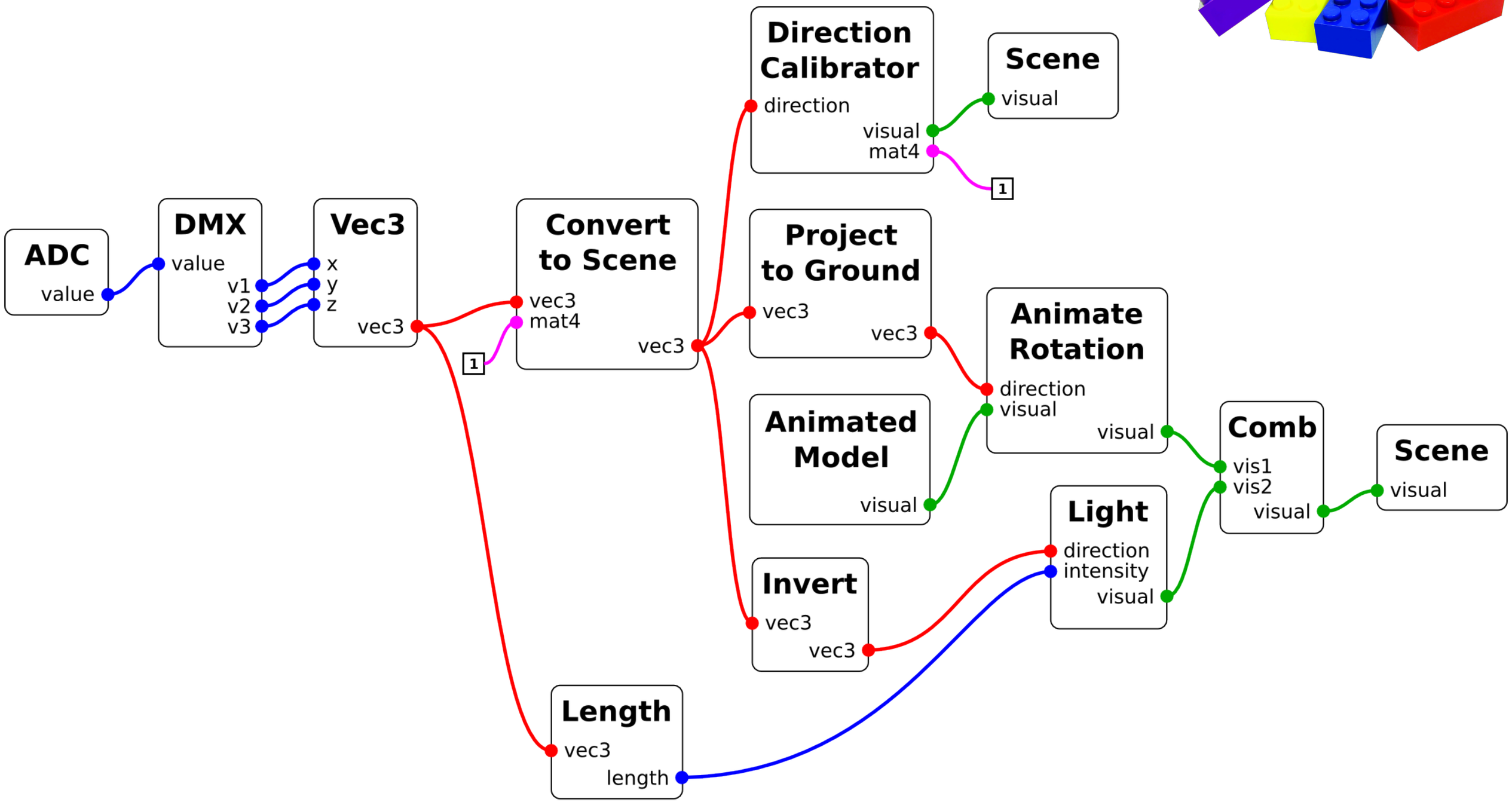


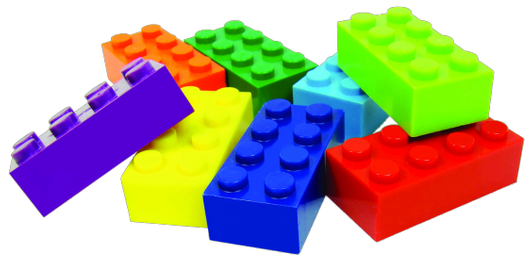
Visual Programming within SciVi

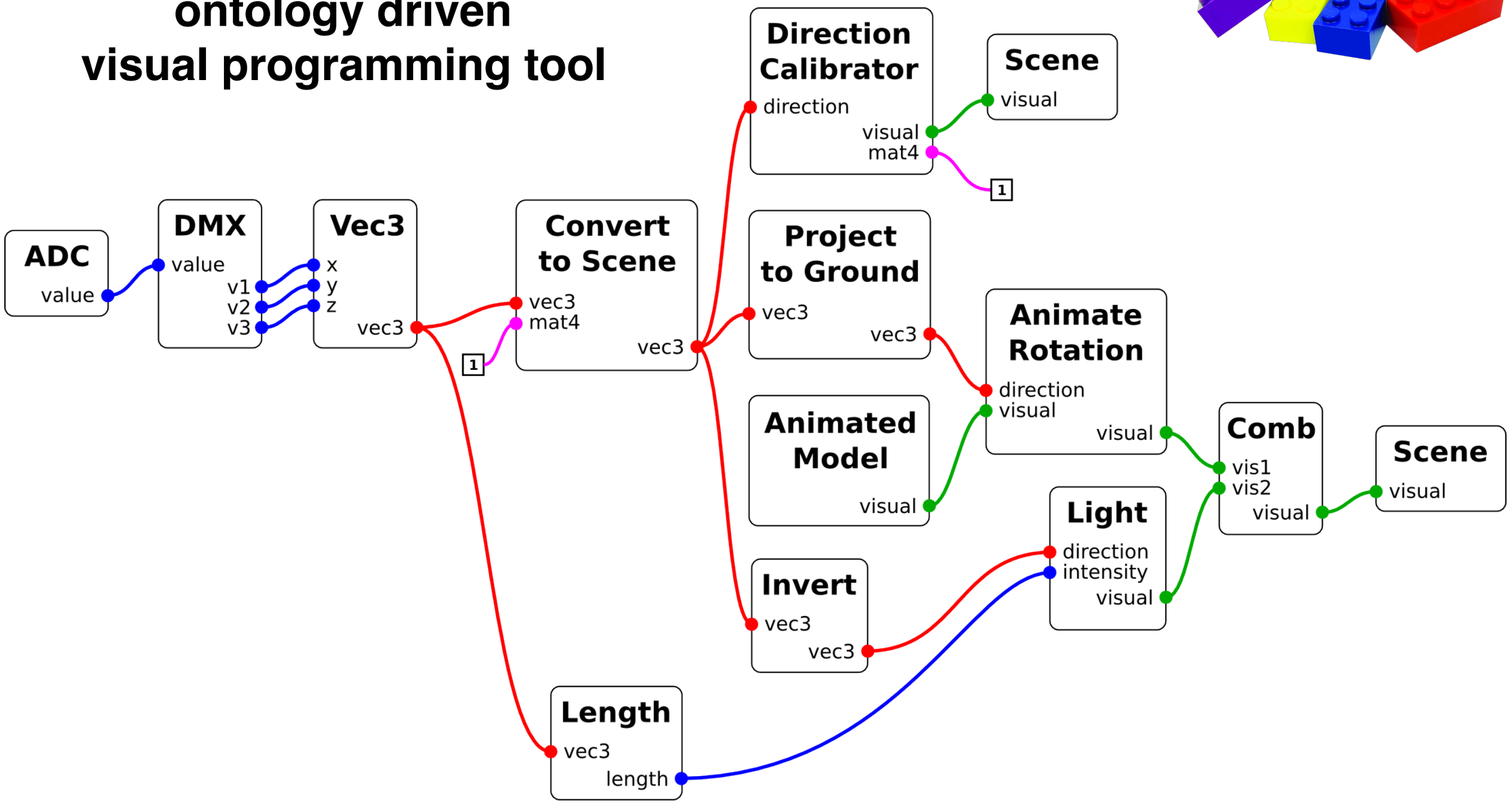




Visual Programming within SciVi

Data flow diagram in SciVi – ontology driven visual programming tool





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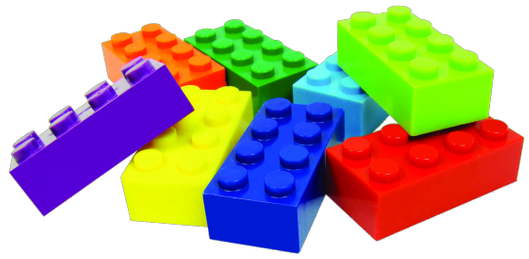

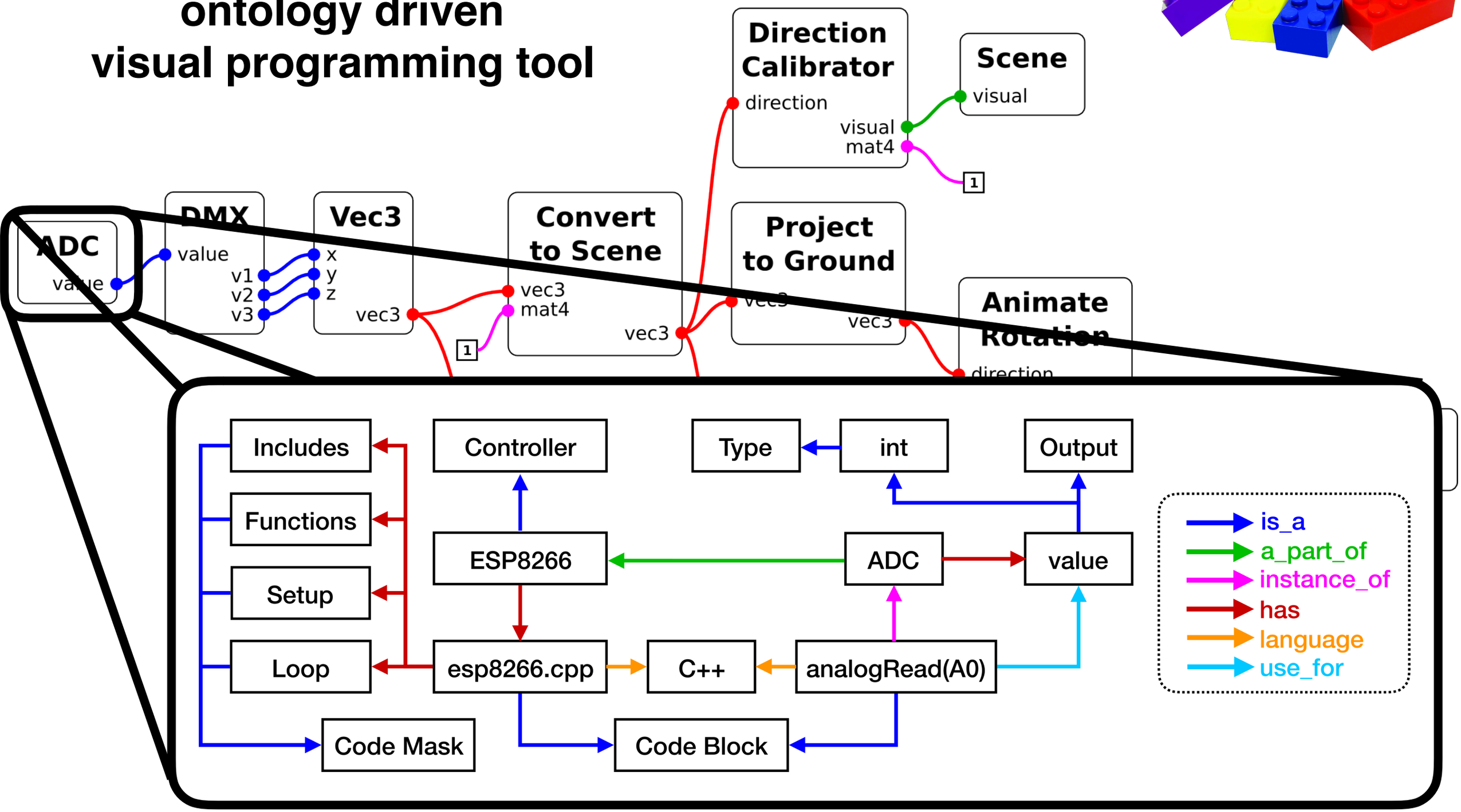

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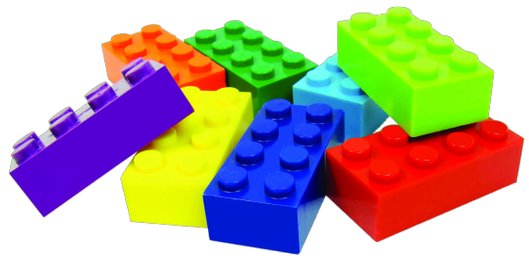

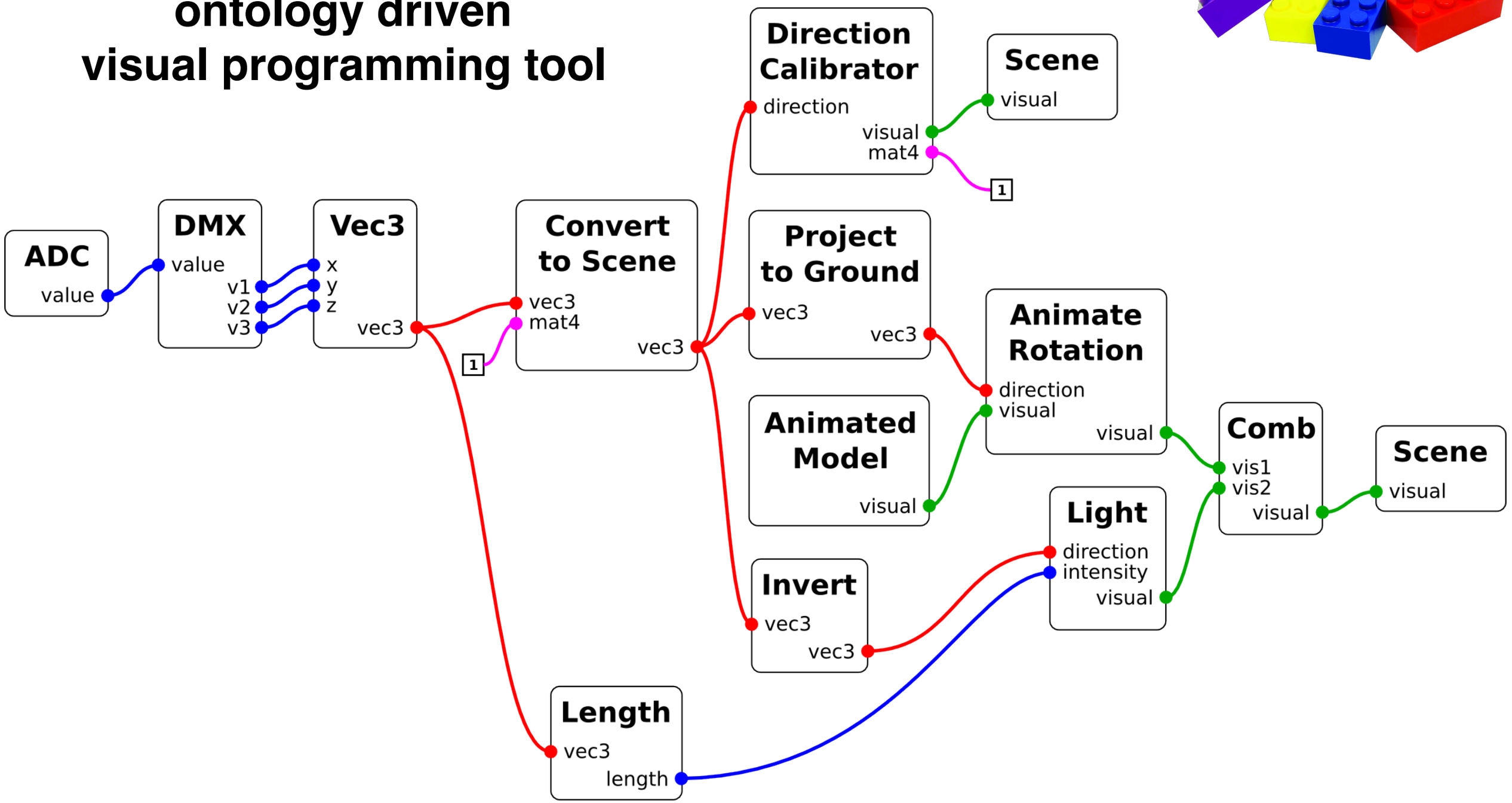

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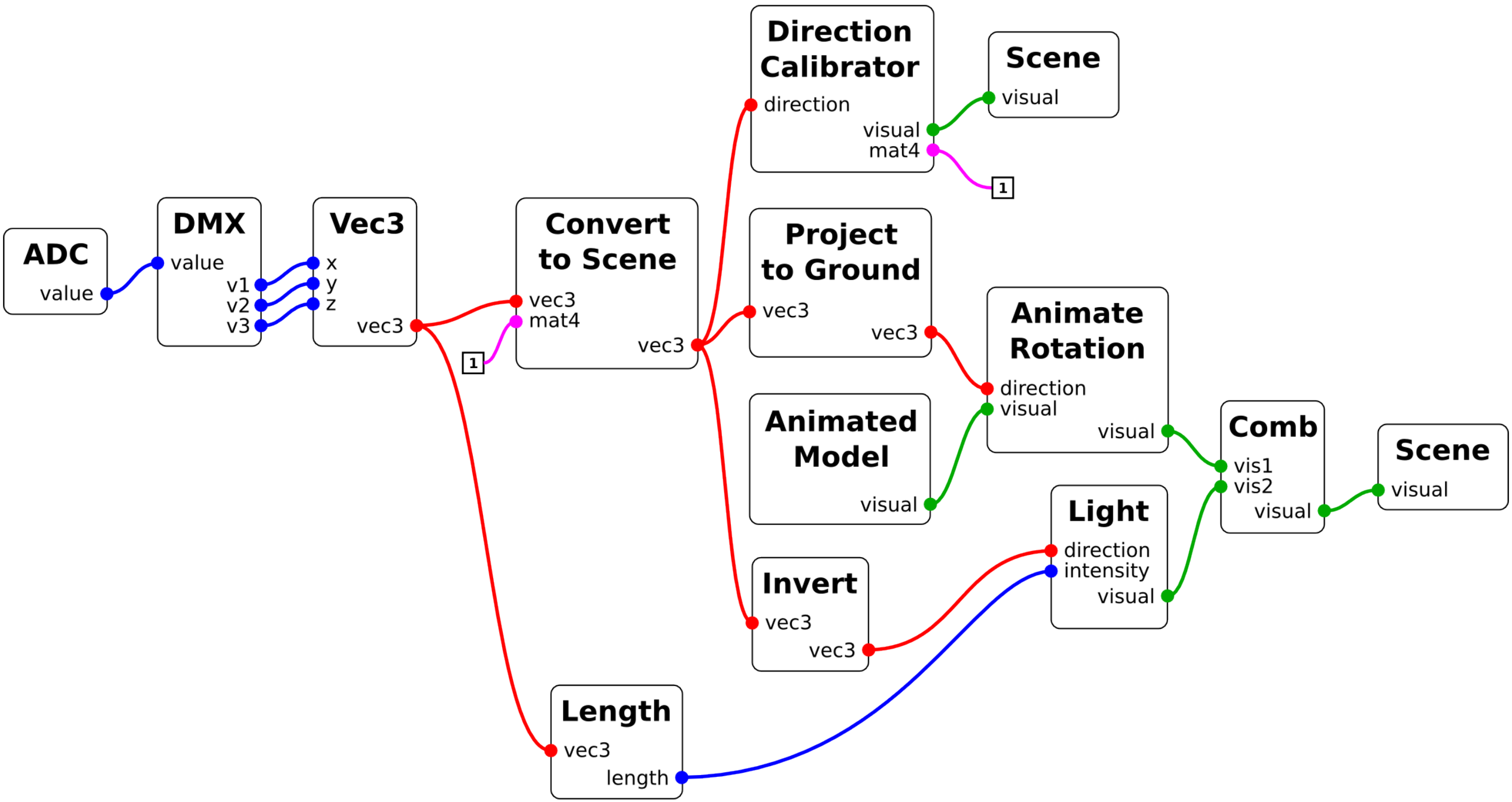

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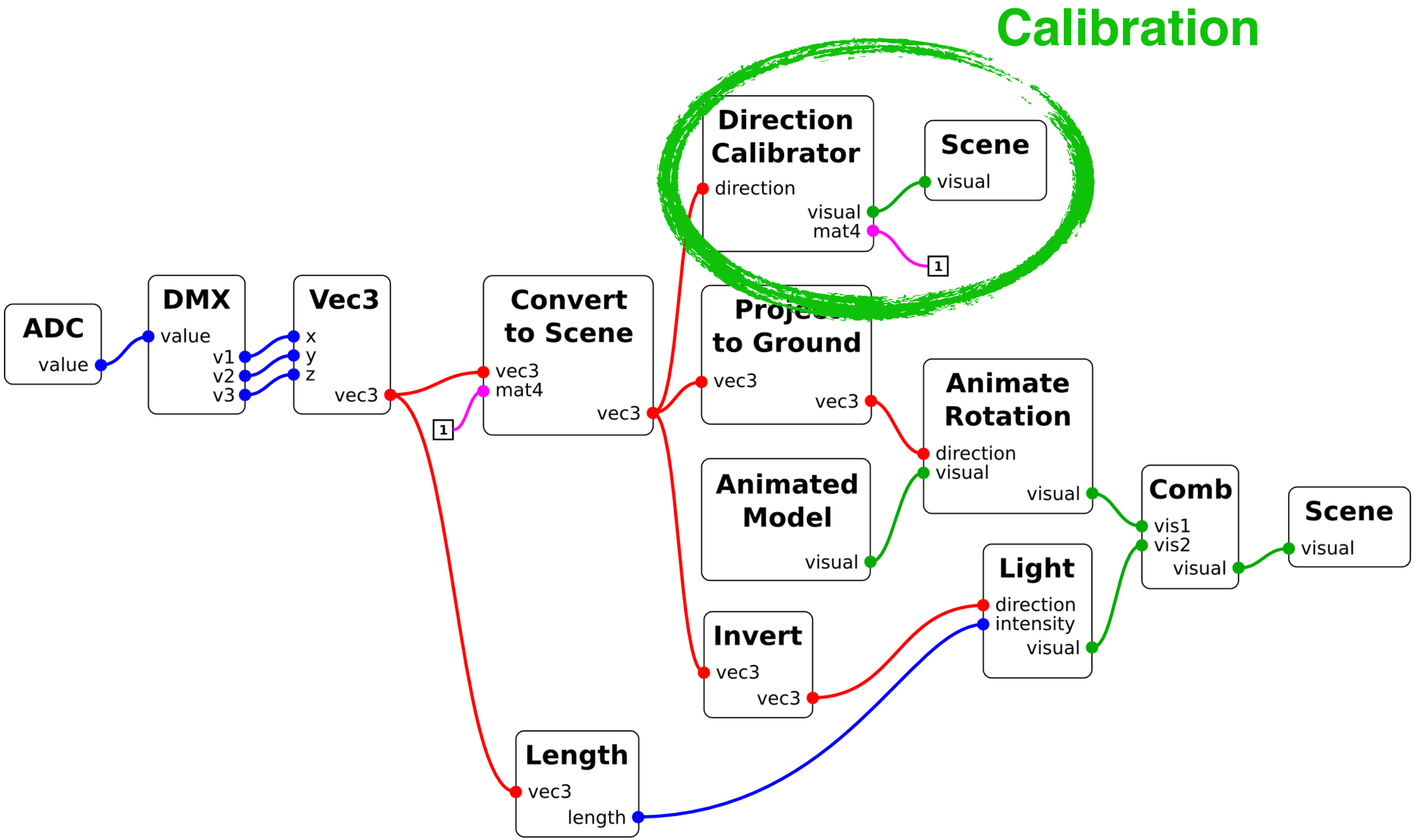

K. Ryabinin[1], S. Chuprina[1], M. Kolesnik[2] | [1]Perm State University, [2]Museum of Permian Antiquities | Scientific visualization for IoT

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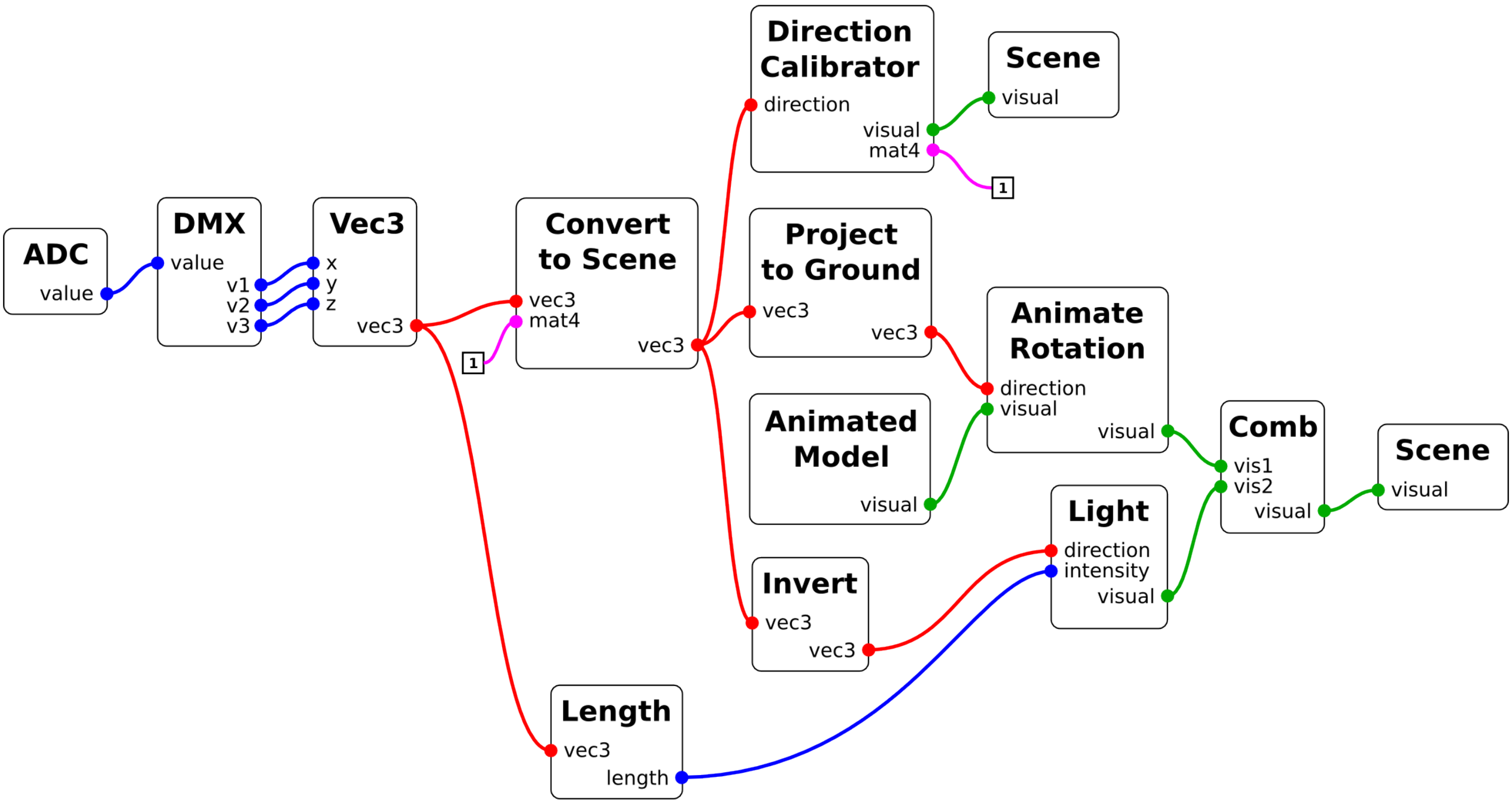

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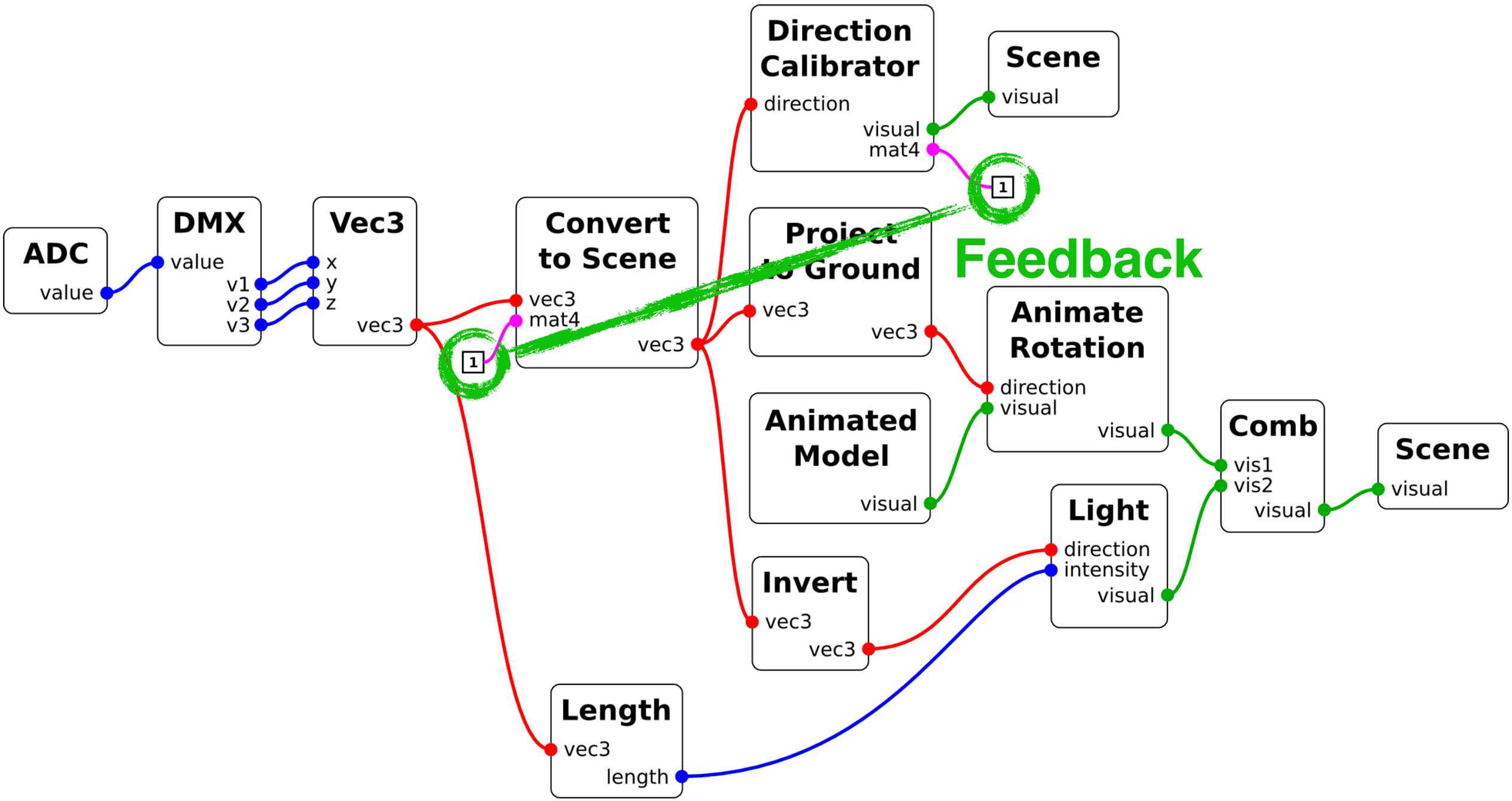

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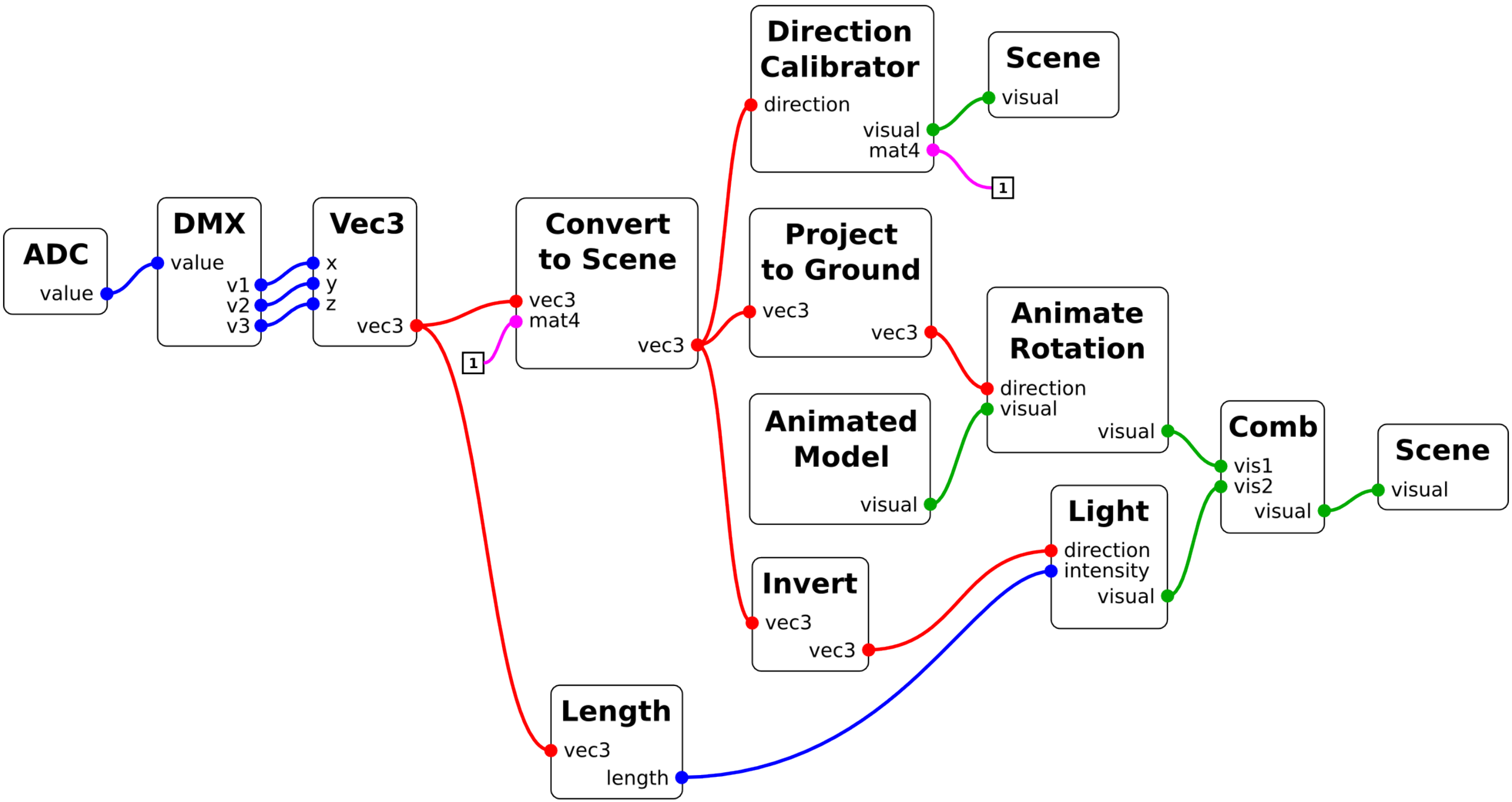

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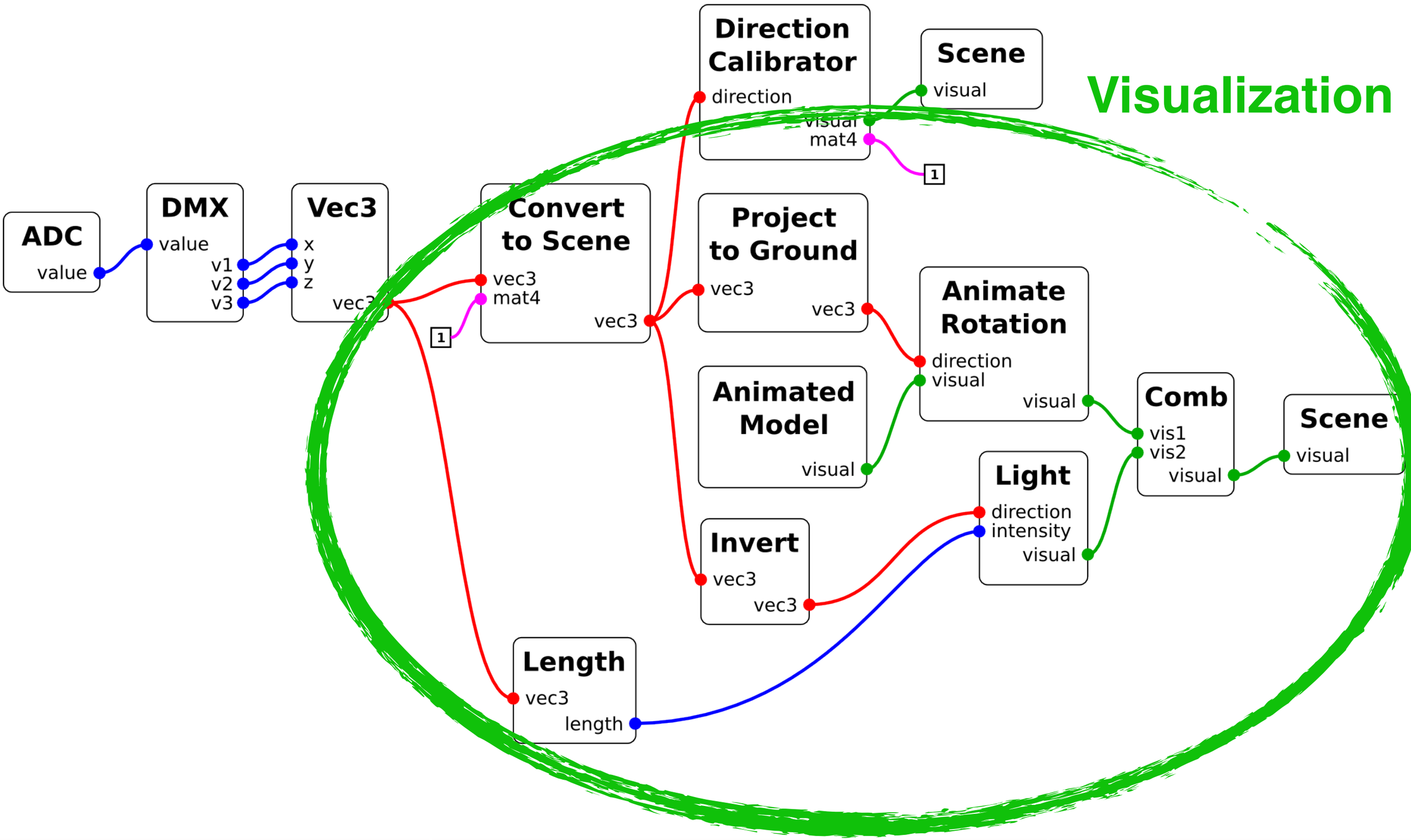


Result: Generated Firmware

Server

firmware.ino

ADC Demultiplexing
DNS Server
HTTP Server
WebSocket Server

Client

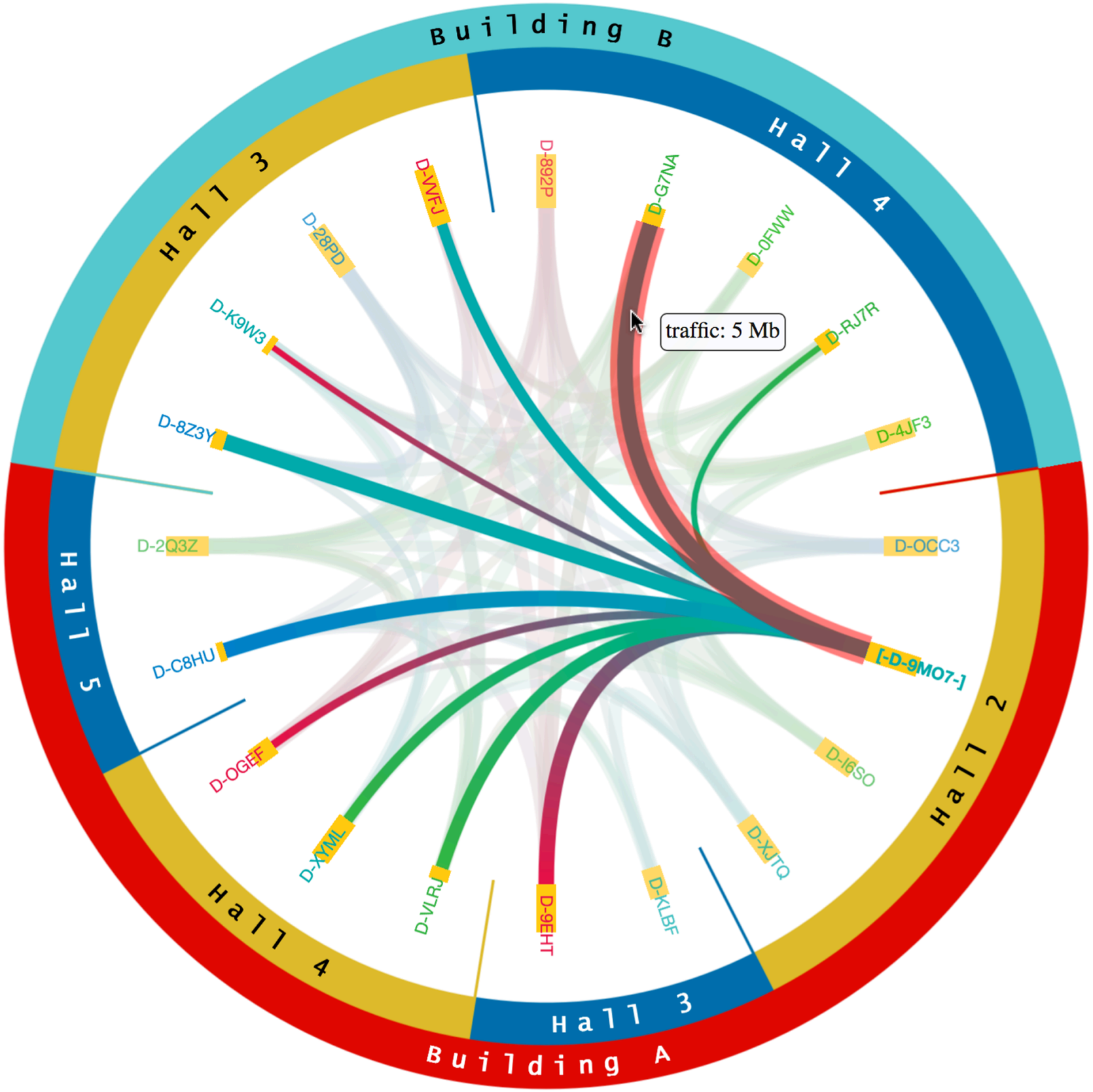
index.html

Rendering

calibration.html

Calibration

IoT Networks Visual Analytics in SciVi



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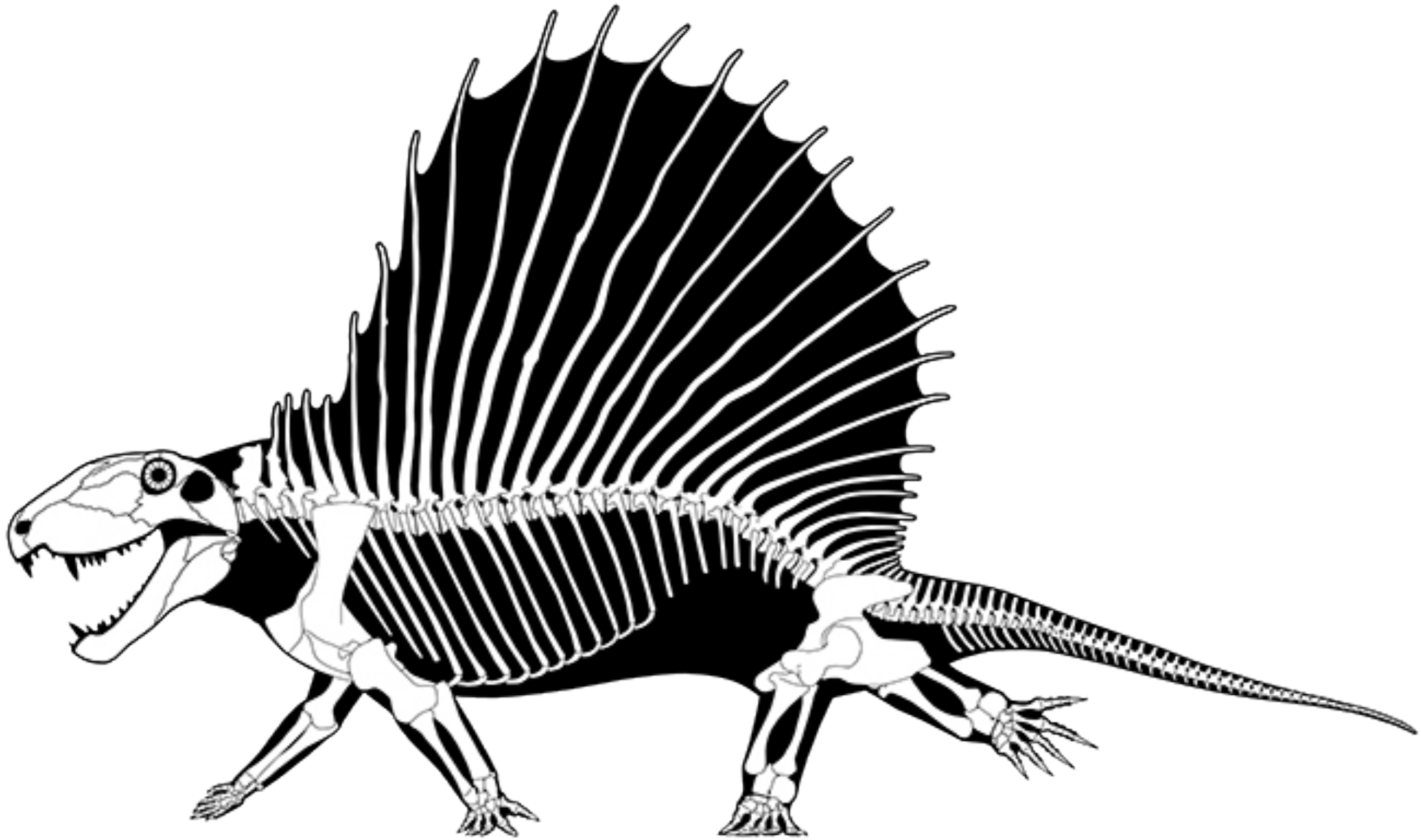

State-of-the-art skeleton reconstruction of *Dimetrodon grandis* by Scott Hartman

Hartman, S. Taking a 21st Century Look at Dimetrodon. Scott Hartman's Skeletal Drawing.com (2016), http://www.skeletaldrawing.com/home/ 21stcenturydimetrodon

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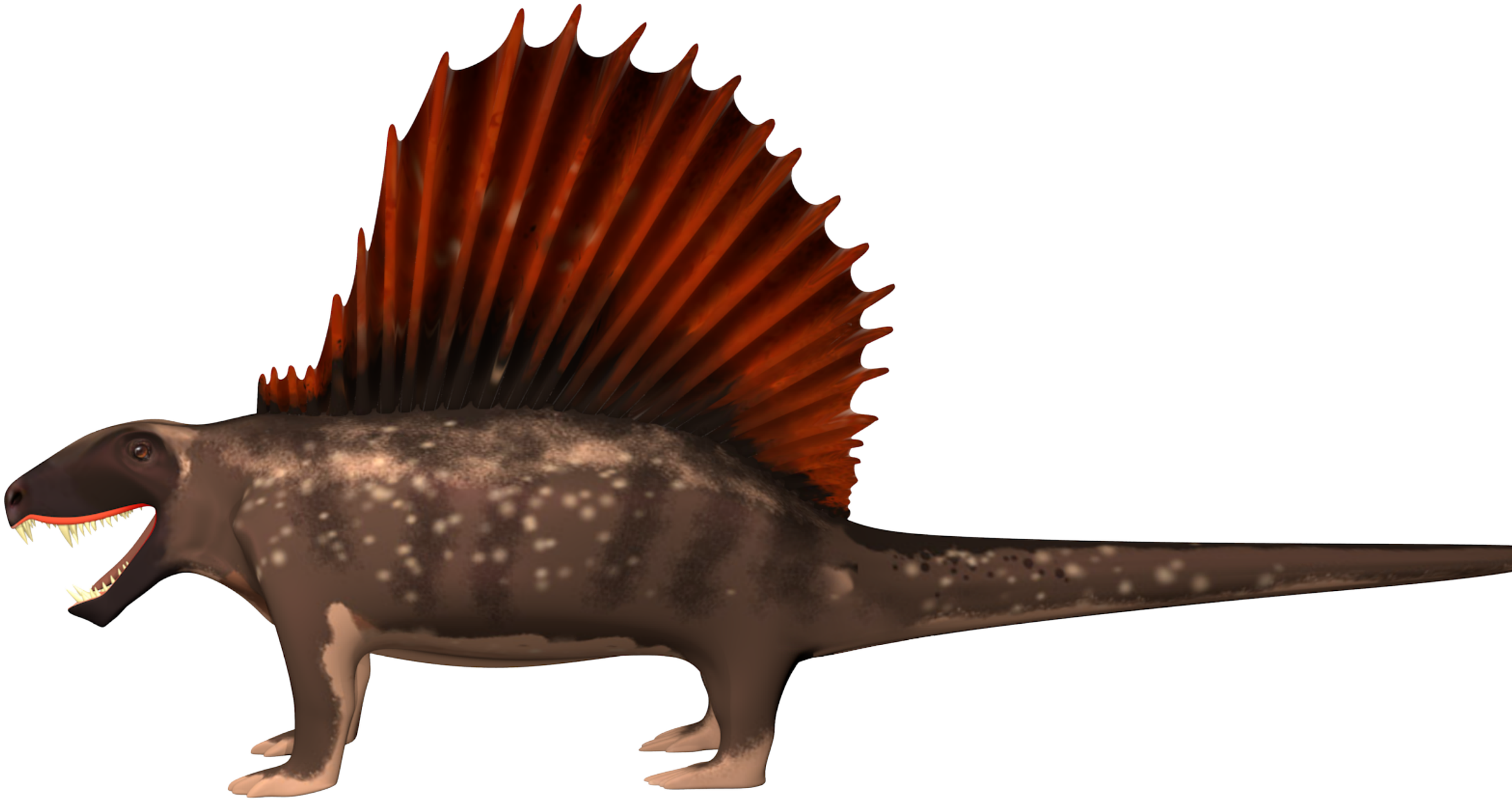

3D reconstruction of *Dimetrodon grandis* made in the Museum of Permian Antiquities by Mariia Kolesnik

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Dimetrodon Grandis IoT-Based Exhibit

Idea of exhibit:
Dimetrodon rotates toward the light

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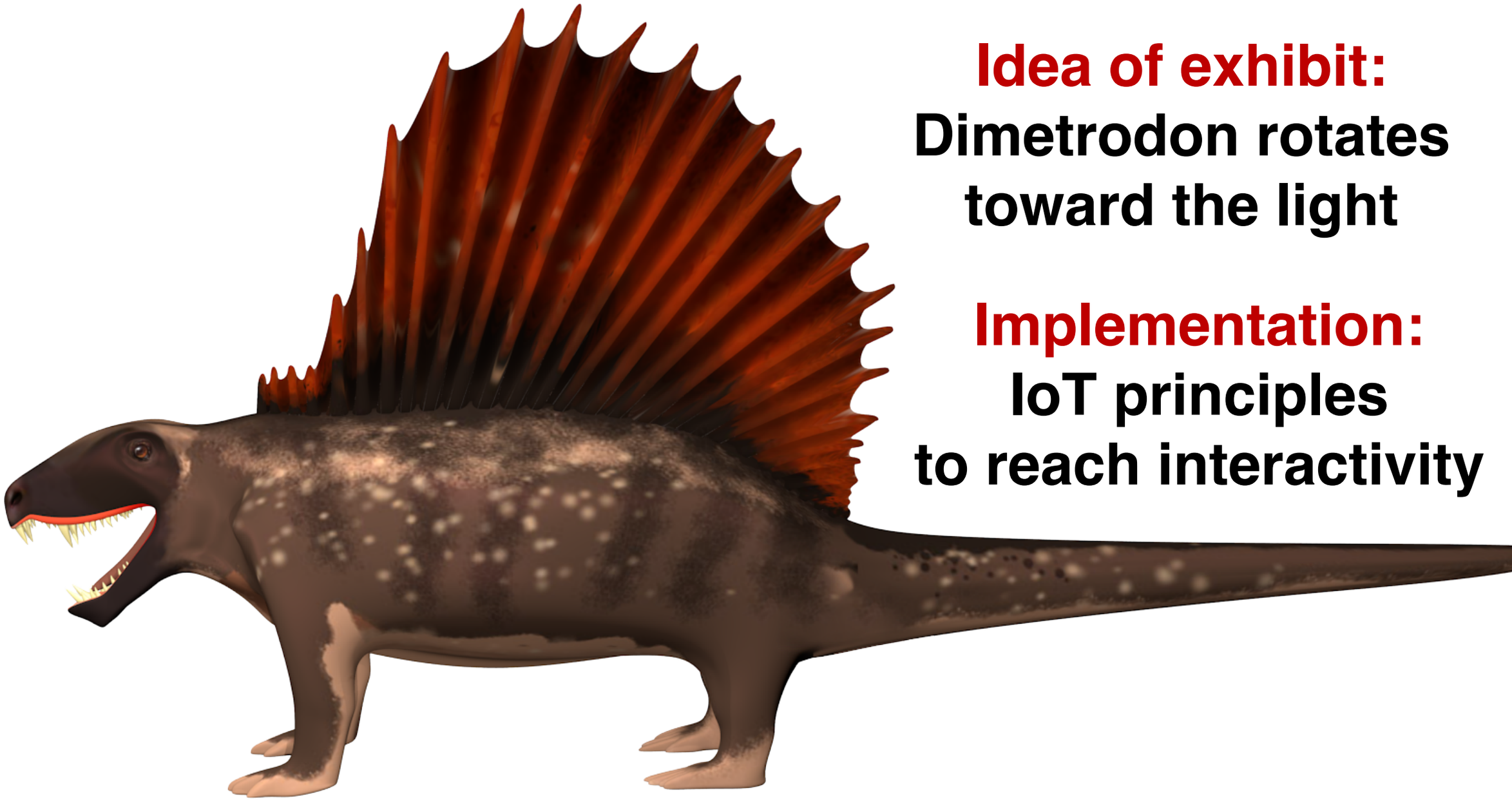

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Implementation:
IoT principles to reach interactivity

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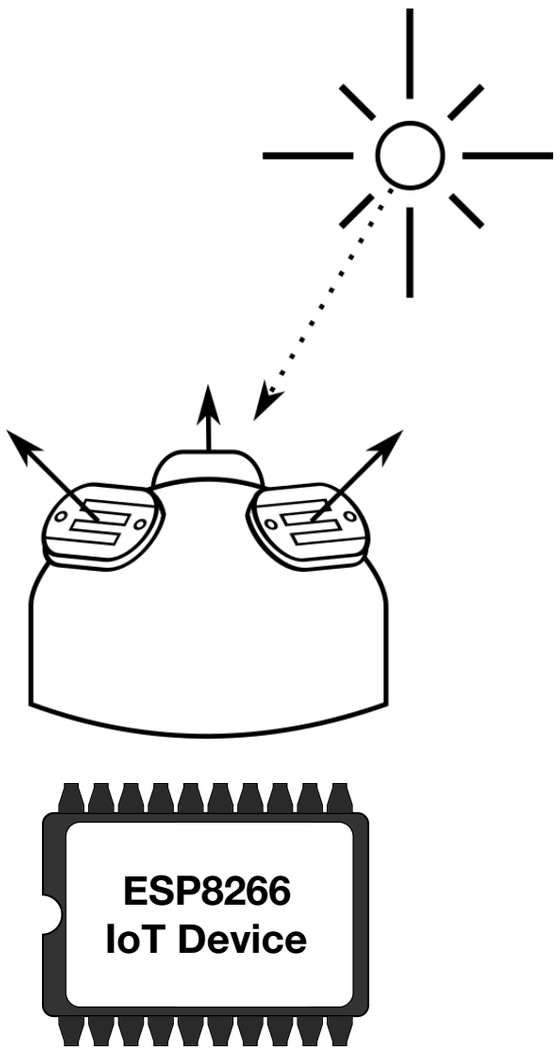

Light Direction and Intensity Sensor

WiFi

Client Rendering Dimetrodon Model

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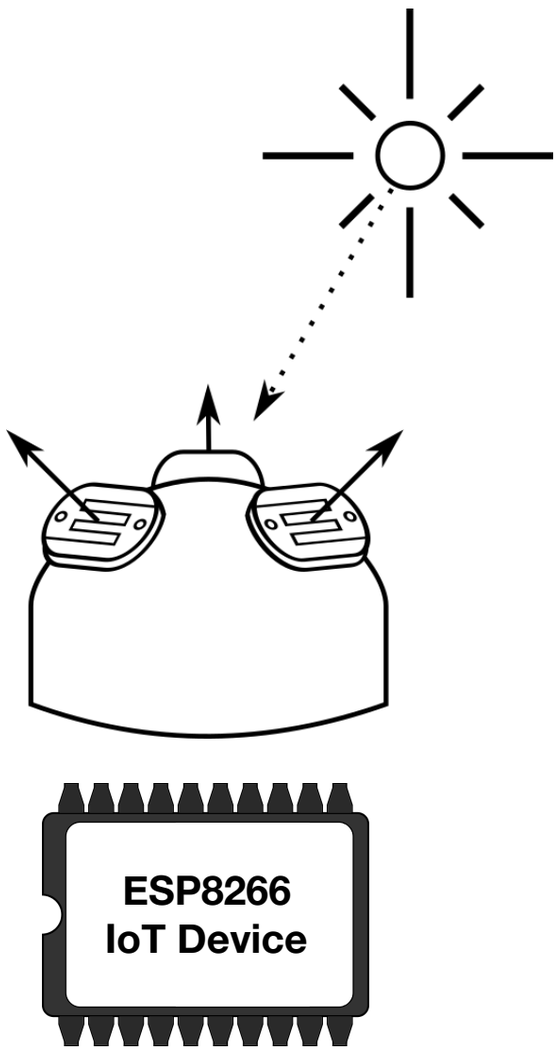
User
illuminates the light sensor with a flashlight



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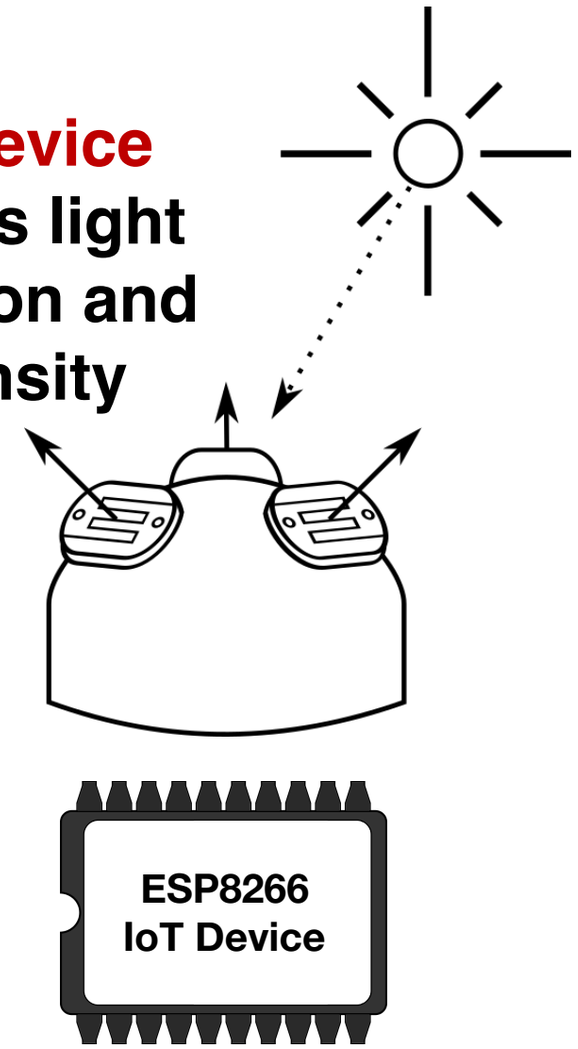
IoT device
detects light direction and intensity



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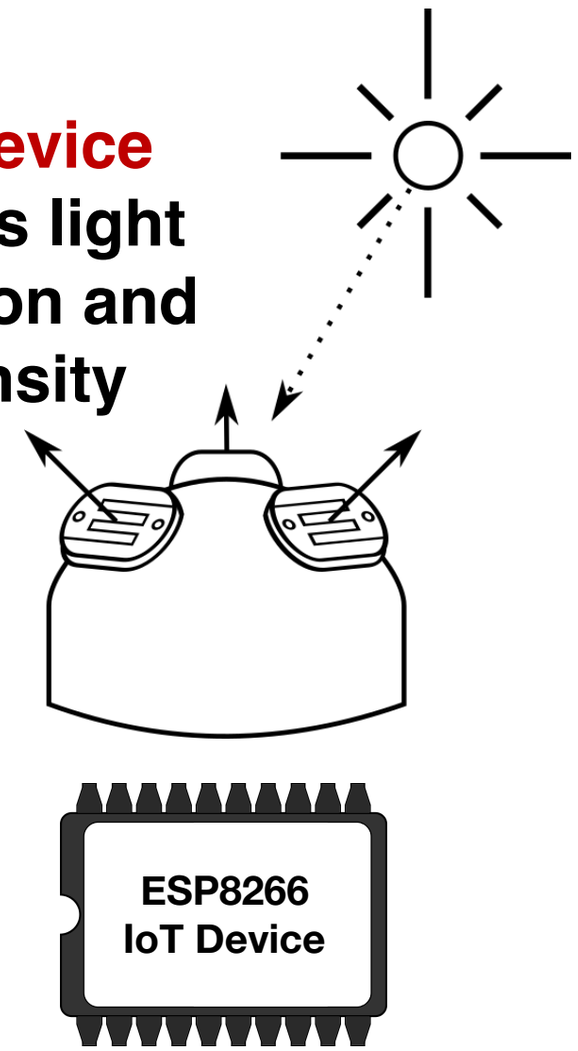

Light Direction and Intensity Sensor

IoT device
transmits data over
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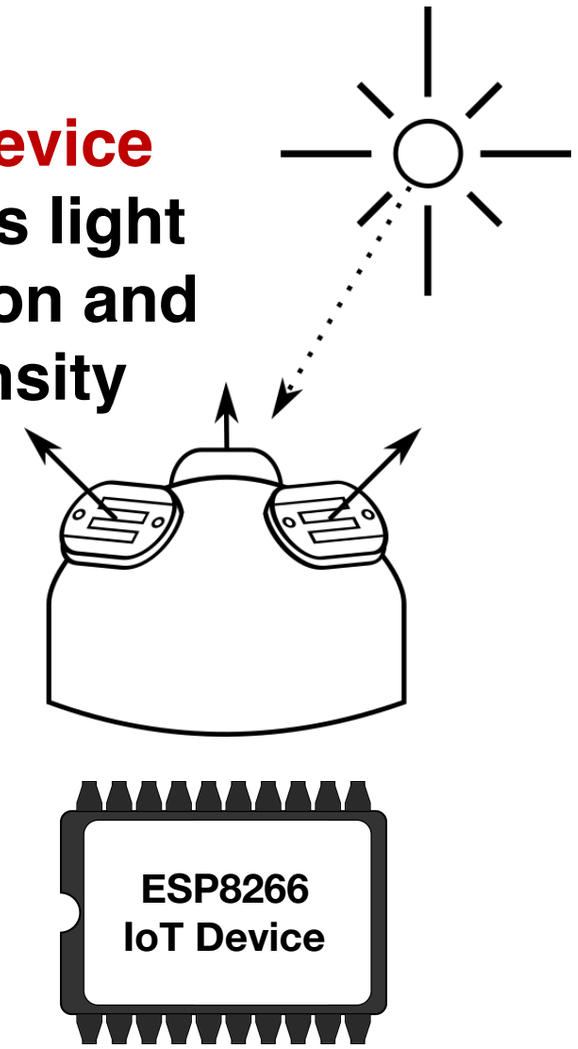

Light Direction and Intensity Sensor

IoT device
transmits data
over
WiFi

User's mobile device
integrates into IoT ecosystem
and renders the illuminated
3D model

Client Rendering Dimetrodon Model

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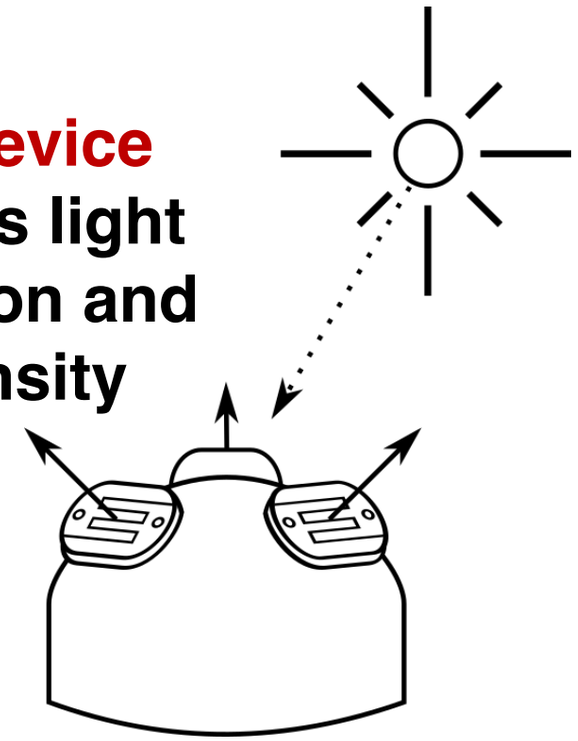

Light Direction and Intensity Sensor

IoT device
transmits data over
WiFi

SciVi enables different devices to communicate and to build interactive image

User's mobile device
integrates into IoT ecosystem and renders the illuminated 3D model

Client Rendering Dimetrodon Model

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Conclusion

SciVi + IoT:

1. Generating firmware
2. Simplifying complex algorithms for devices
3. Enabling calibration of devices via feedback
4. Allowing monitoring the device data
5. Supporting 2D and 3D visualization

Testing:

Real-world task of paleontological exhibit creation

Next steps:

1. Advanced IoT-based Smart Museum development
   (maybe even Smart City in the future)
2. Organizing IoT workshops for schoolchildren
   based on "Learning by doing" concept
3. Augmented Reality assistant for assembling IoT devices
4. Tackling IoT-related Big Data visual analytics problems:
   - 4.1. *Velocity*: SciVi can run on HPC thanks to multiplatform portability
   - 4.2. *Variety*: SciVi can be adapted to arbitrary data format
   - 4.3. *Volume*: SciVi filtering capabilities can help
     to reduce data size by aggregation, clamping, splitting, etc.

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Museum
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Thank You For Attention!

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