Please wait for the presentation to start...

Geofront:

Library Portability in a browser based visual programming language for geocomputation

Master Thesis Geomatics | P4

Jos Feenstra | October 7th 2022

TU Delft

Introduction

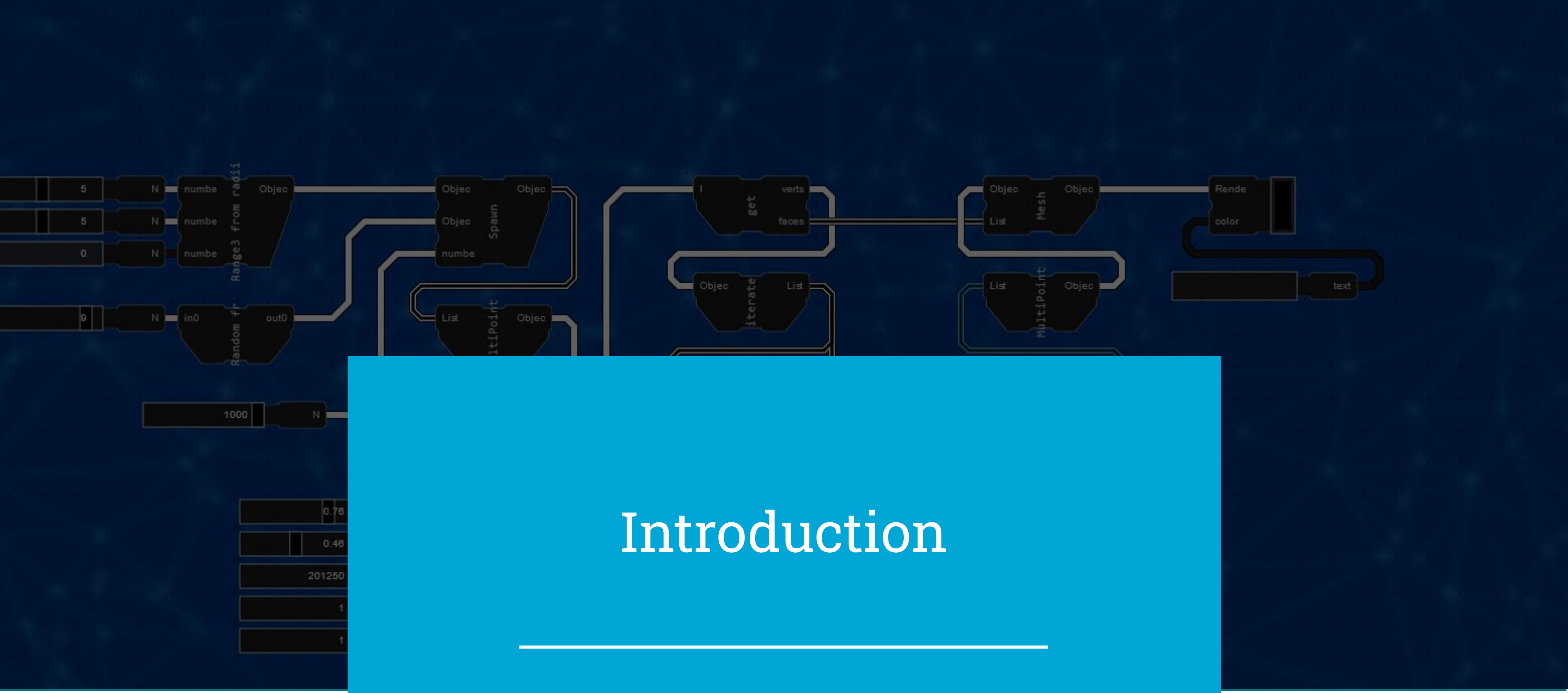
Research objective

Background

Methodology

Results

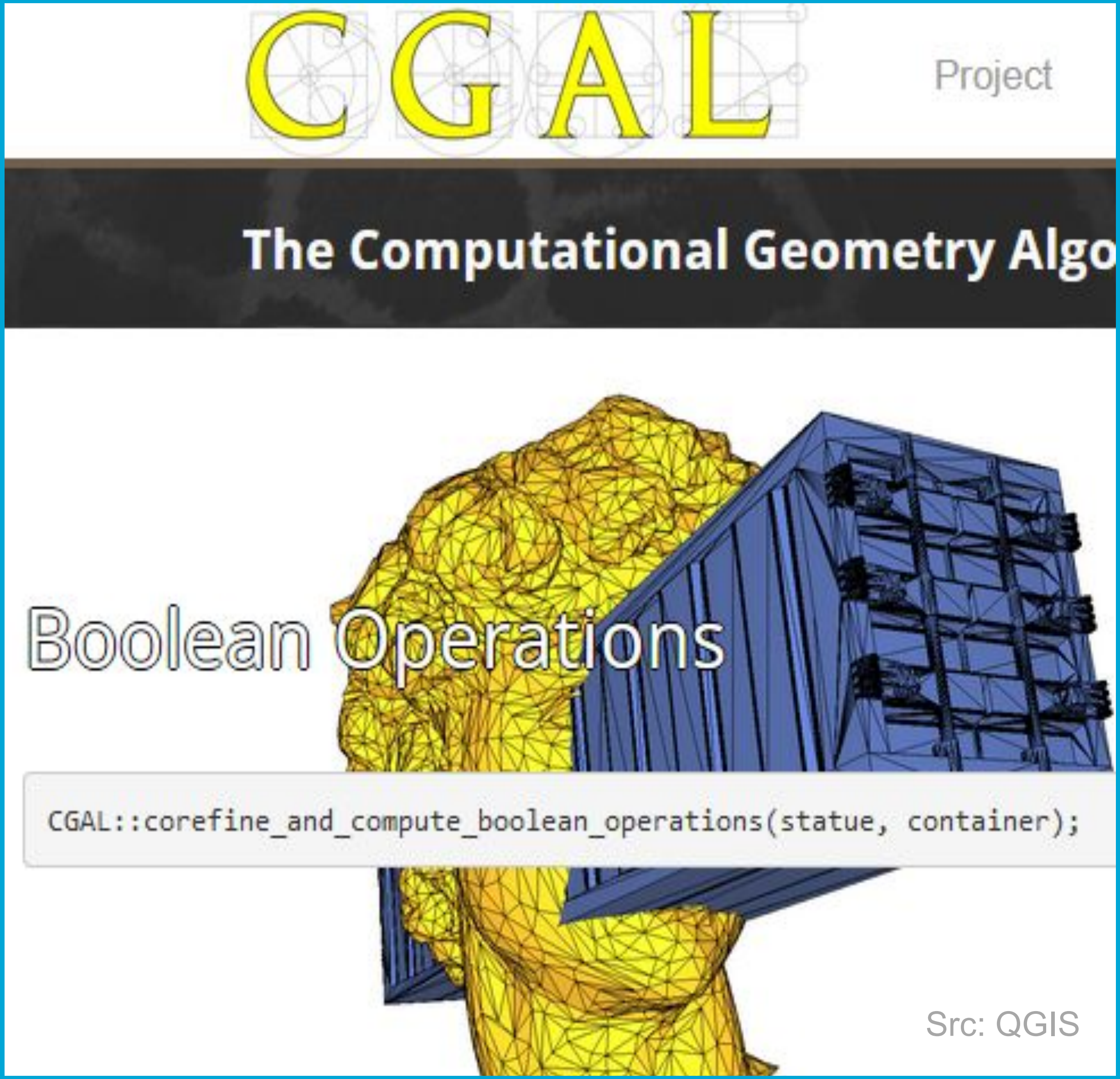
Conclusion



Introduction

Two Forms of GIS Software:

(intro influenced by Elliott C. (2007). Tangible Functional Programming)



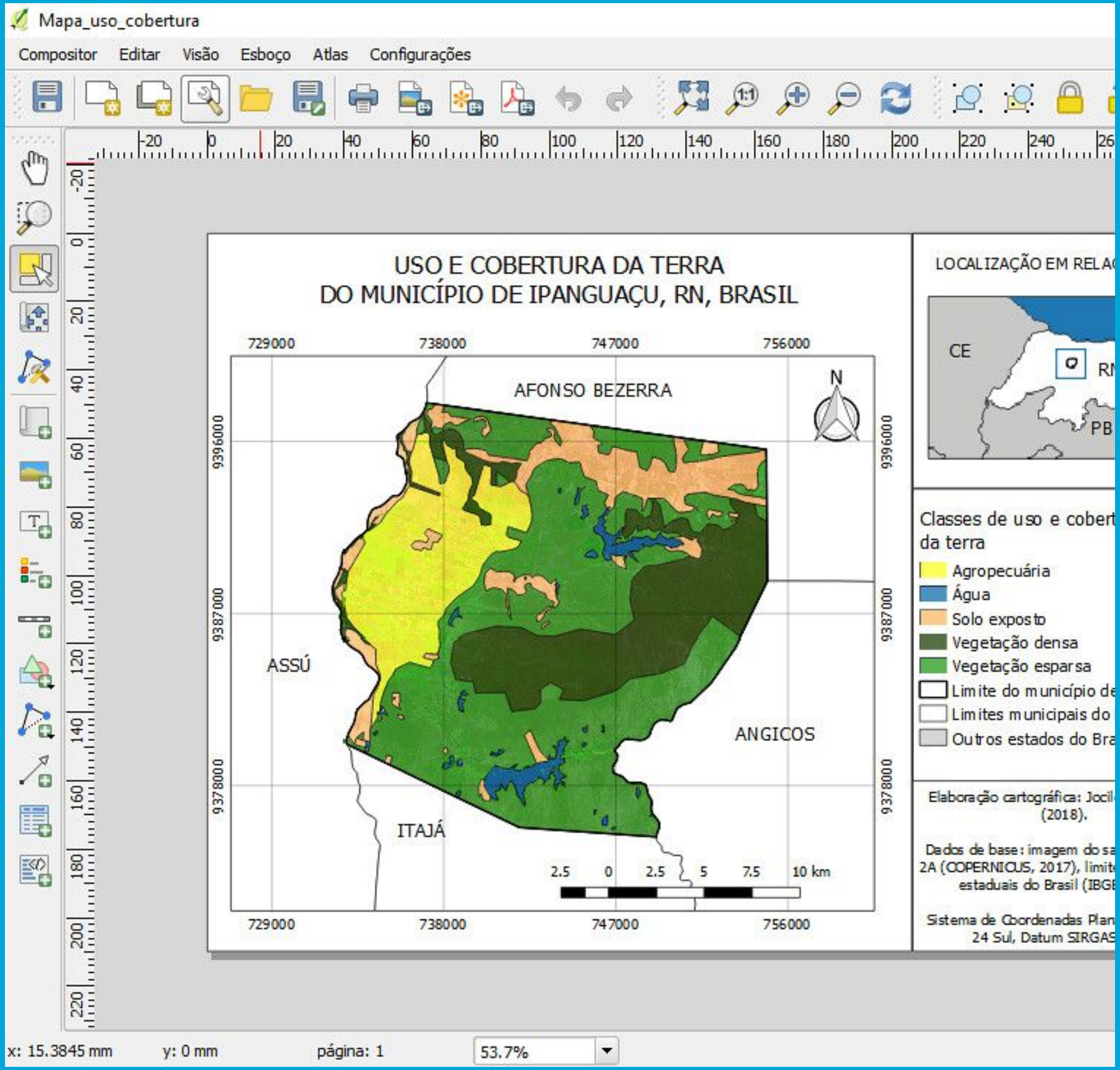
CGAL Project

The Computational Geometry Algo

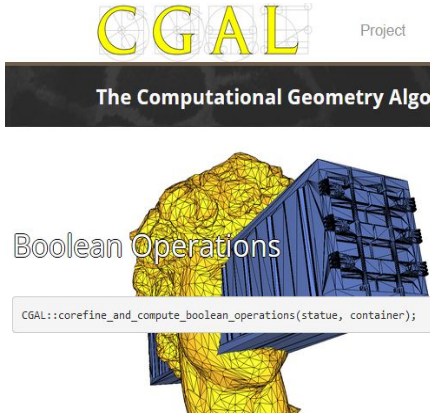
Boolean Operations

```
CGAL::corefine_and_compute_boolean_operations(statue, container);
```

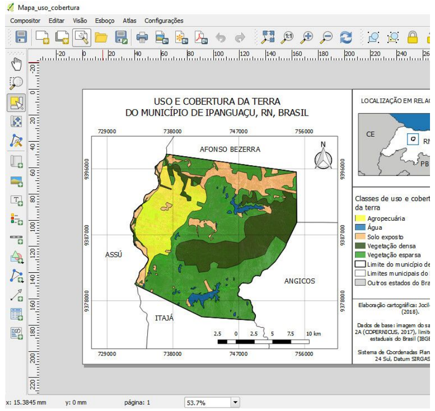
Src: QGIS



Different intentions



```
CGAL::corefine_and_compute_boolean_operations(statue, container);
```



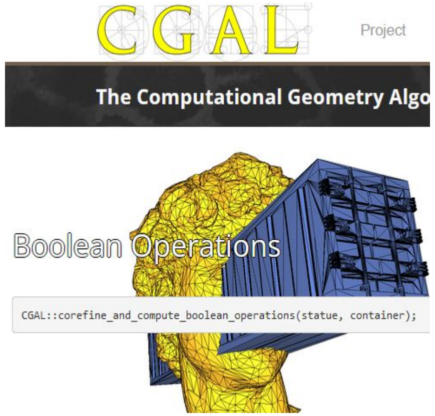
Software **Library**:

- Developers
- Composable

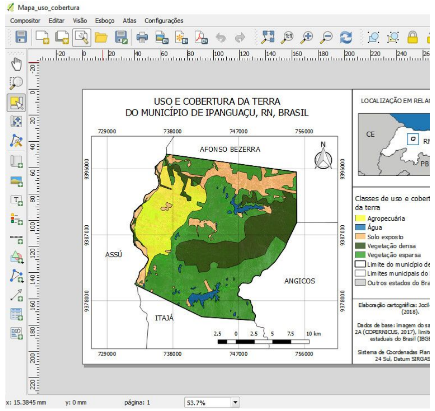
Software **Application**:

- End users
- Interactive (mouse picking, GUI)

Split



```
CGAL::corefine_and_compute_boolean_operations(statue, container);
```

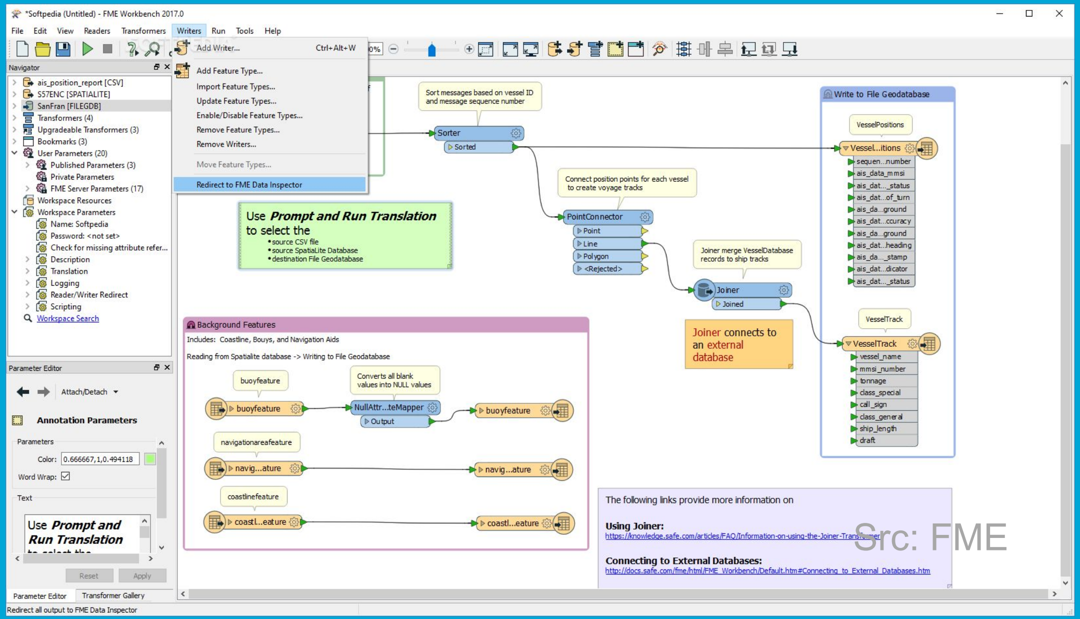


- Not usable: must be turned into application before usage
- No visualization / visual interaction

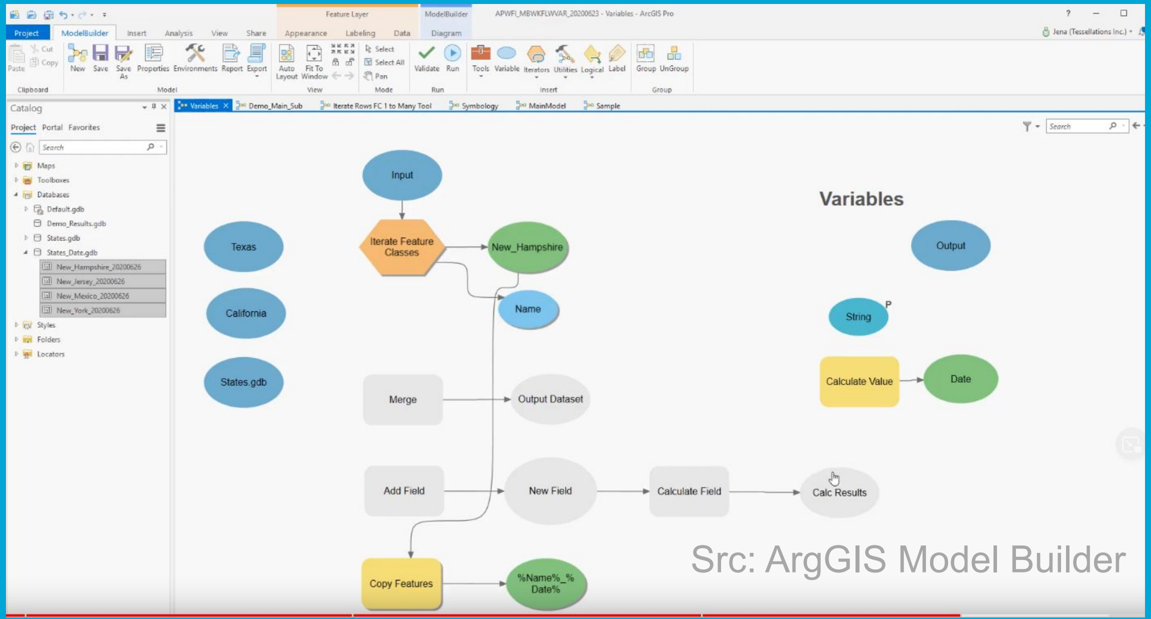
- Not ‘automatable’ or composable.
- Less functionality

Bridge?

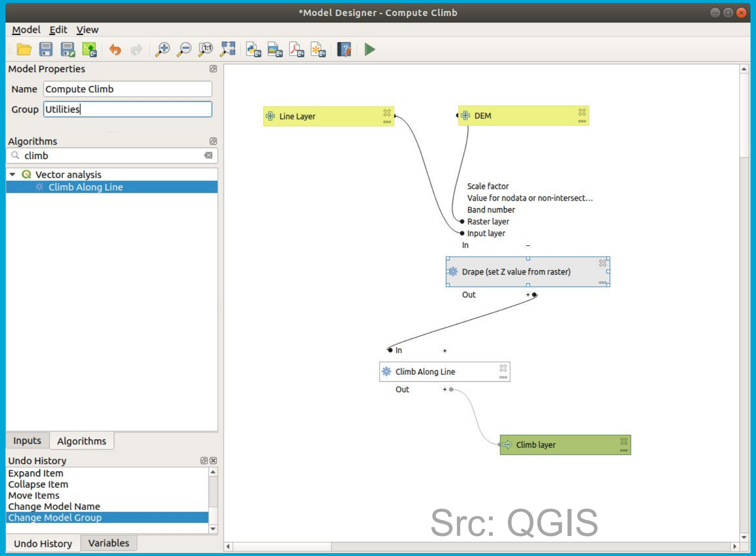
Bridge: Visual Programming Languages (VPLs)


*Softpedia (Untitled) - FME Workbench 2017.0
File Edit View Readers Transformers Writers Run Tools Help
Add Writer...
Add Feature Type...
Import Feature Types...
Update Feature Types...
Enable/Disable Feature Types...
Remove Feature Types...
Remove Writers...
Move Feature Types...
Redirect to FME Data Inspector
Navigator
ais_position_report [CSV]
S57ENC [SPATIALITE]
SanFran [FILEGDB]
Transformers (4)
User Parameters (20)
Workspace Parameters
Sort messages based on vessel ID and message sequence number
Sorter
Sorted
Connect position points for each vessel to create voyage tracks
PointConnector
Joiner merge VesselDatabase records to ship tracks
Joiner
Joined
Joiner connects to an external database
Use Prompt and Run Translation to select the
source CSV file
source SpatiaLite Database
destination File Geodatabase
Write to File Geodatabase
VesselPositions
VesselTrack
Background Features
Includes: Coastline, Bouys, and Navigation Aids
Reading from Spatialite database -> Writing to File Geodatabase
buoyfeature
Converts all blank values into NULL values
NullAttr...teMapper
navigationareafeature
coastlinefeature
The following links provide more information on
Using Joiner:
Connecting to External Databases:
Parameter Editor
Annotation Parameters
Use Prompt and Run Translation
Redirect all output to FME Data Inspector

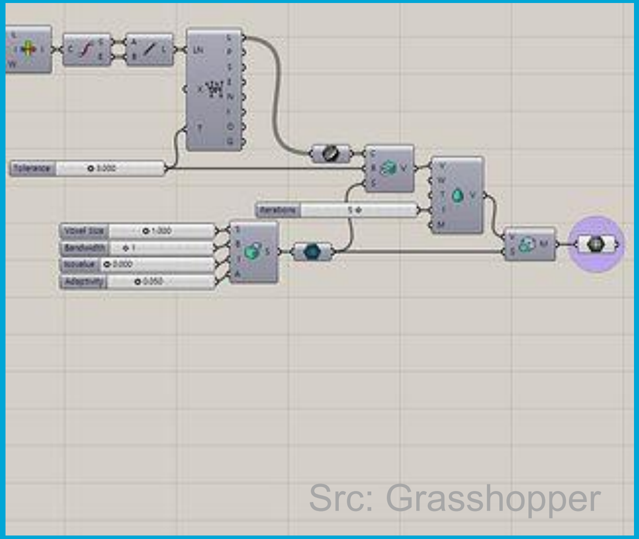
Src: FME



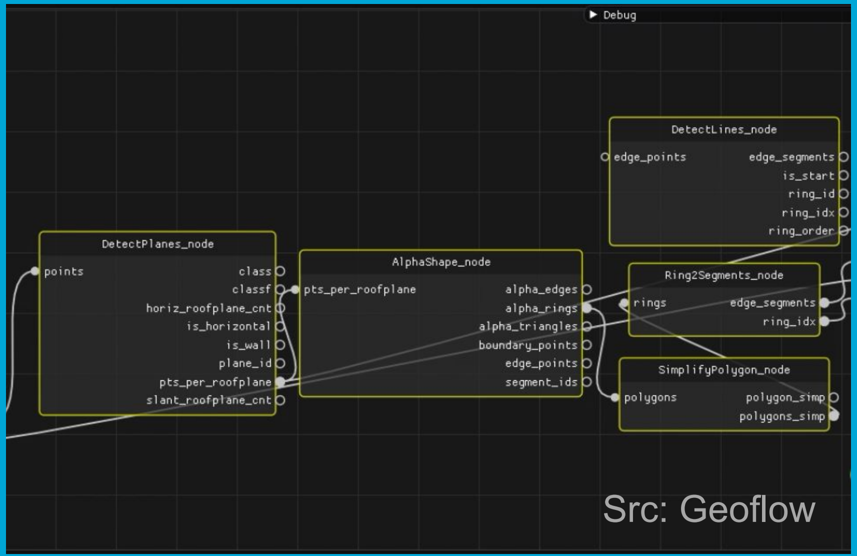
Src: ArgGIS Model Builder



Src: QGIS



Src: Grasshopper

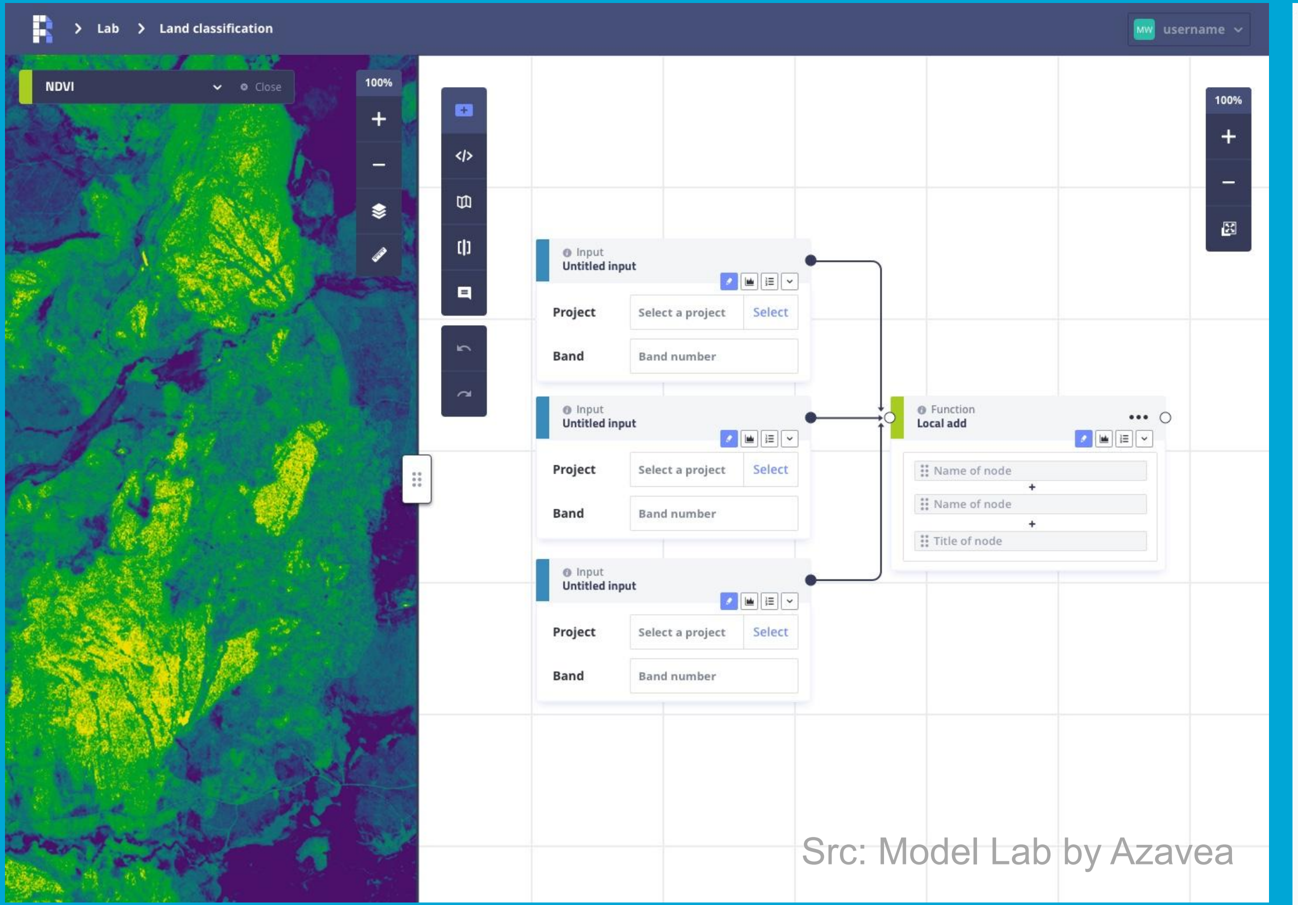


Src: Geoflow

VPL:

- Both application and programming / scripting language
- Multiple examples in GIS

Web-based VPLs



Input
Untitled input

Project: Select a project | Select
Band: Band number

Input
Untitled input

Project: Select a project | Select
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Input
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Project: Select a project | Select
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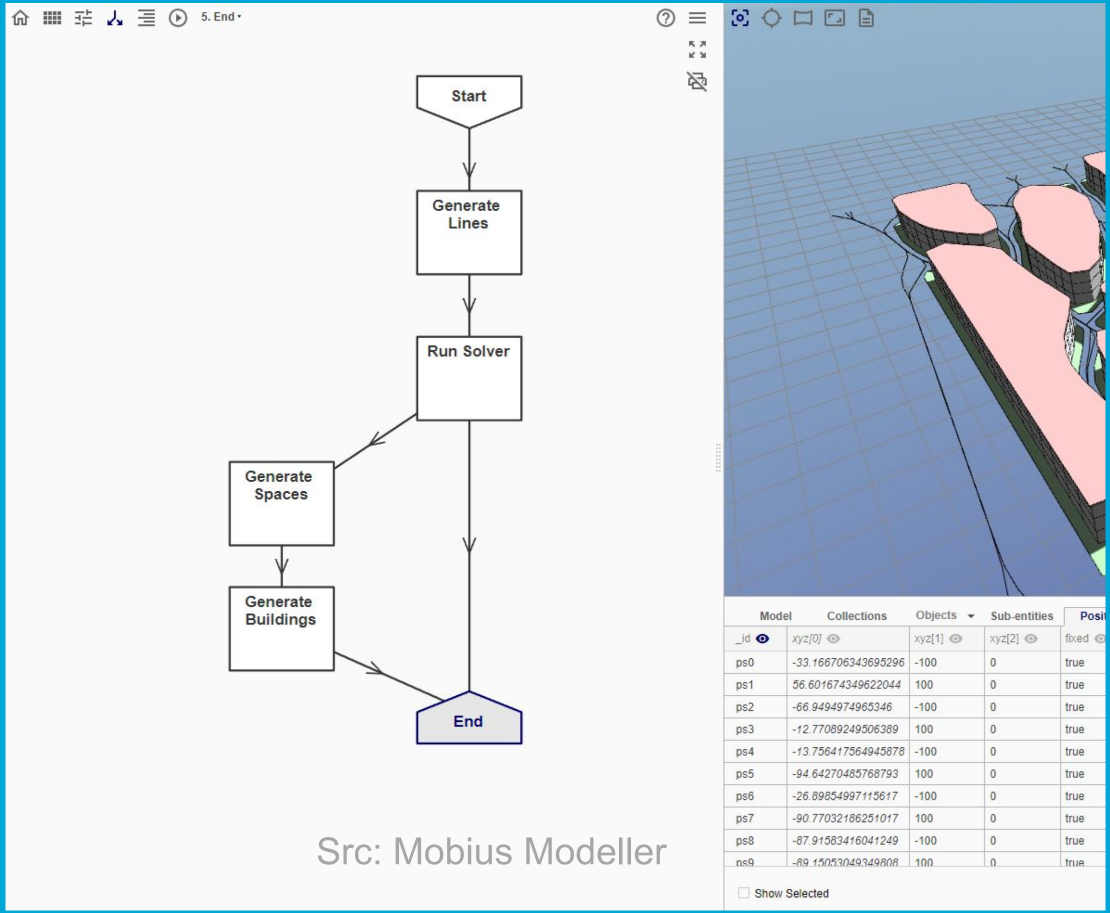
Function
Local add

Name of node
+
Name of node
+
Title of node

Src: Model Lab by Azavea



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ps0	-33.166706343695296	-100	0	true
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ps3	-12.77089249506389	100	0	true
ps4	-13.756417564945878	-100	0	true
ps5	-94.64270485768793	100	0	true
ps6	-26.89854997115617	-100	0	true
ps7	-90.77032186251017	100	0	true
ps8	-87.91583416041249	-100	0	true
ps9	-89.15053049349808	100	0	true

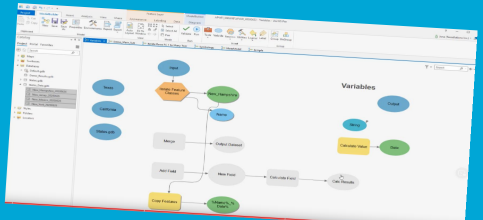
□ Show Selected

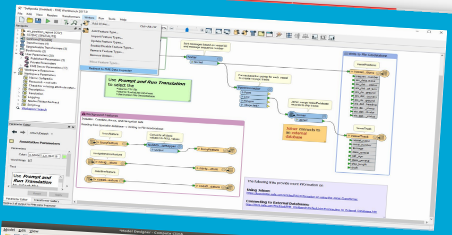
Src: Mobius Modeller

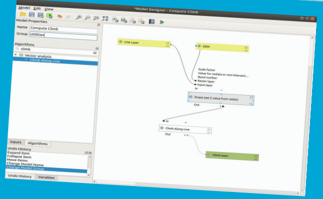
Web-based VPL

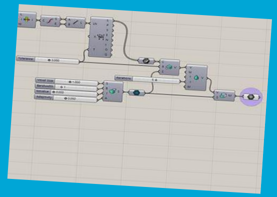
- Novel Development
- “Live alongside” Web GIS.

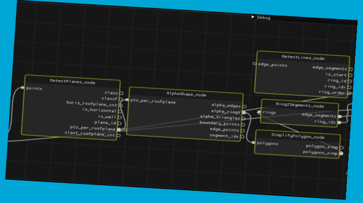
… Problem: Library portability

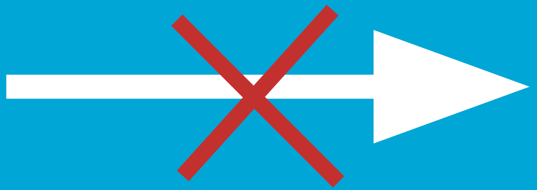




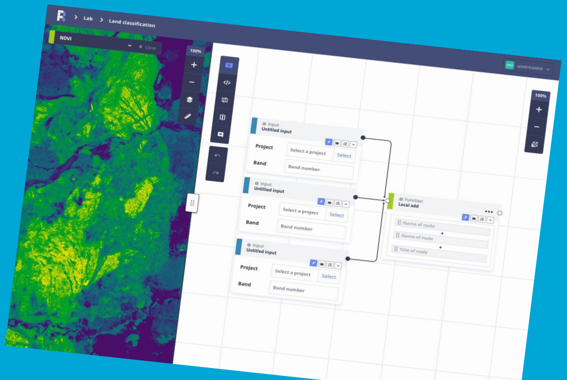


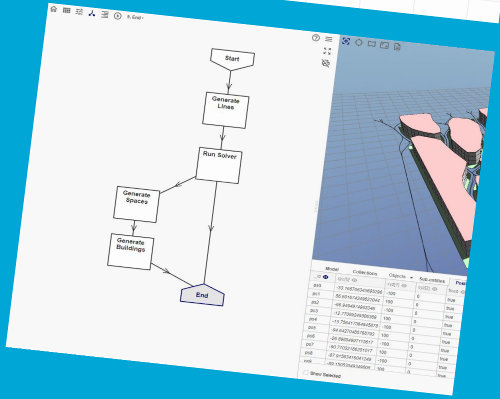






CGAL, GDAL, PROJ





Library portability

- Currently, no web-based VPLs uses native geocomputation libraries.
- This is a problem:
    - Hinders “library-application interoperability” goal.
    - Leads to web based duplicate libraries.

Research Objective

Objective: Attempt to solve the library portability problem for web-based VPLs.

In doing so:

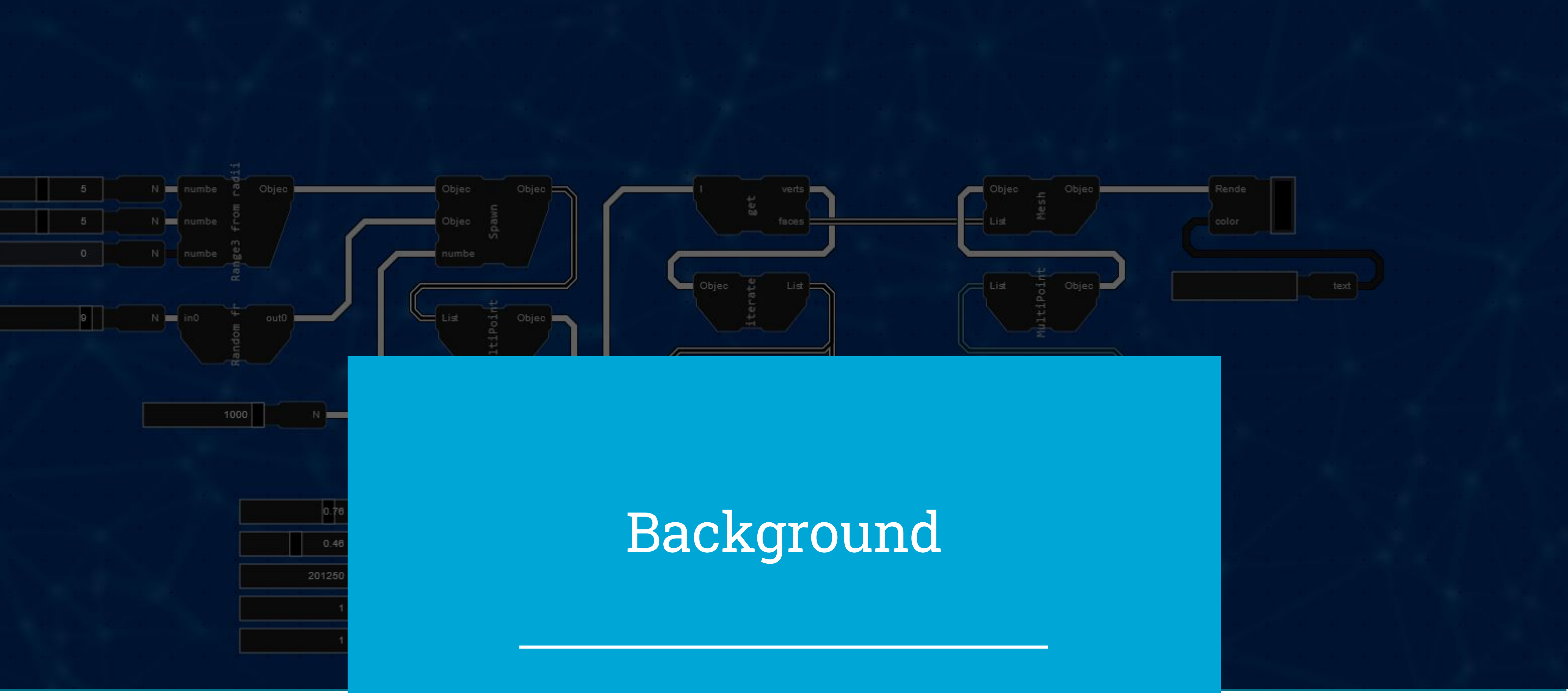
- Contribute to the quality of web-based VPLs
- Contribute to closing the gap between library and (web) application

Research question:

How can native geocomputation libraries be compiled, loaded, and utilized within a browser-based dataflow-VPL?

How

- Practical: **Design, implement,** and **examine** a possible solution.
- Three aspects of the solution, which will be regarded both separately and in conjunction:
  - **Compiling**
  - **Loading**
  - **Utilization**
- **Geo-libraries:** ‘industry standard’ geocomputation libraries, written in system level languages like **C++** or **Rust.**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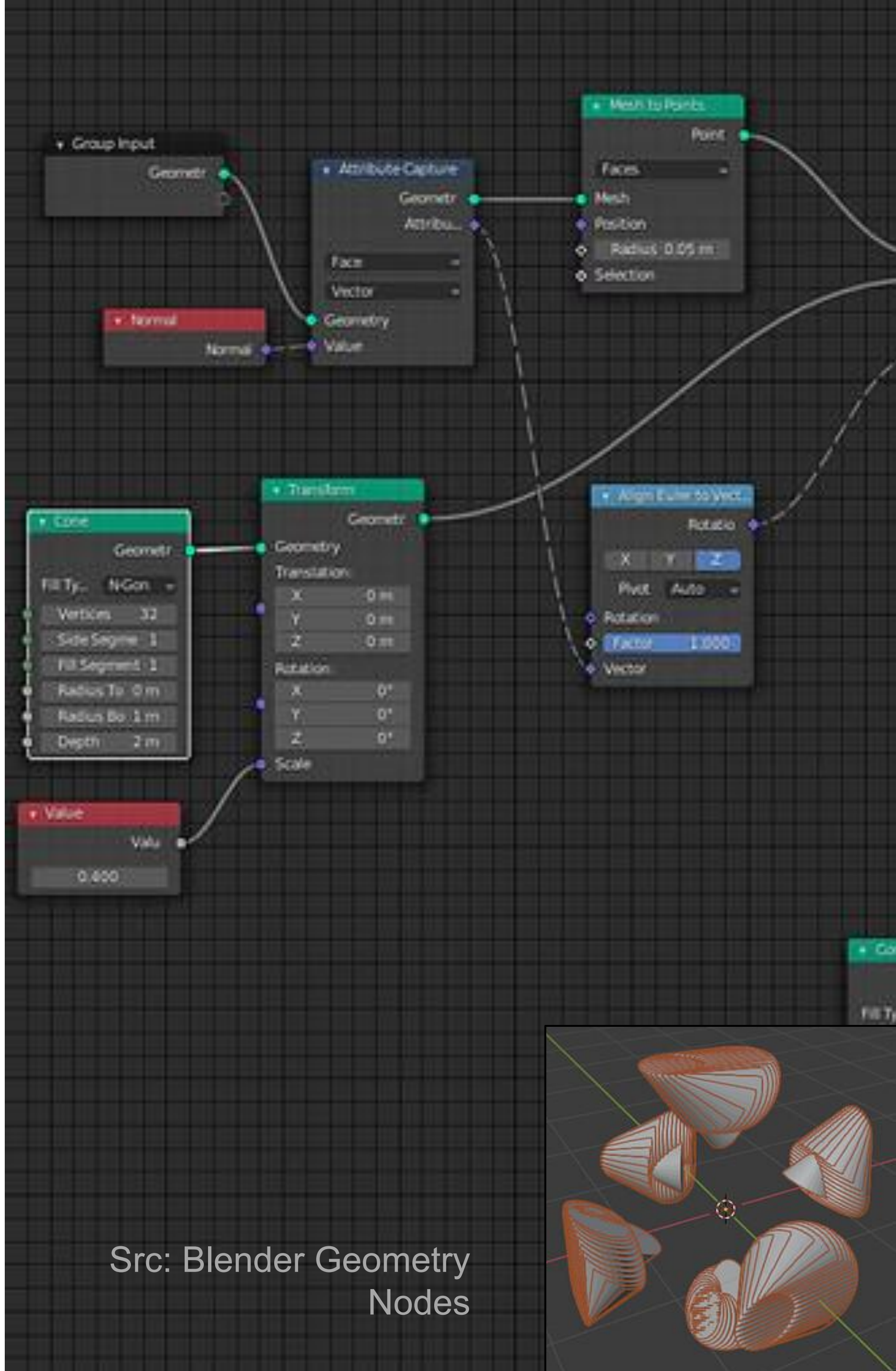
Background

Dataflow VPL

- Requirements:
  - A type of graph-based VPL with:
    - Immutable variables
    - Pure functions
- Functional programming qualities
- Clarity for both programmer and machine:

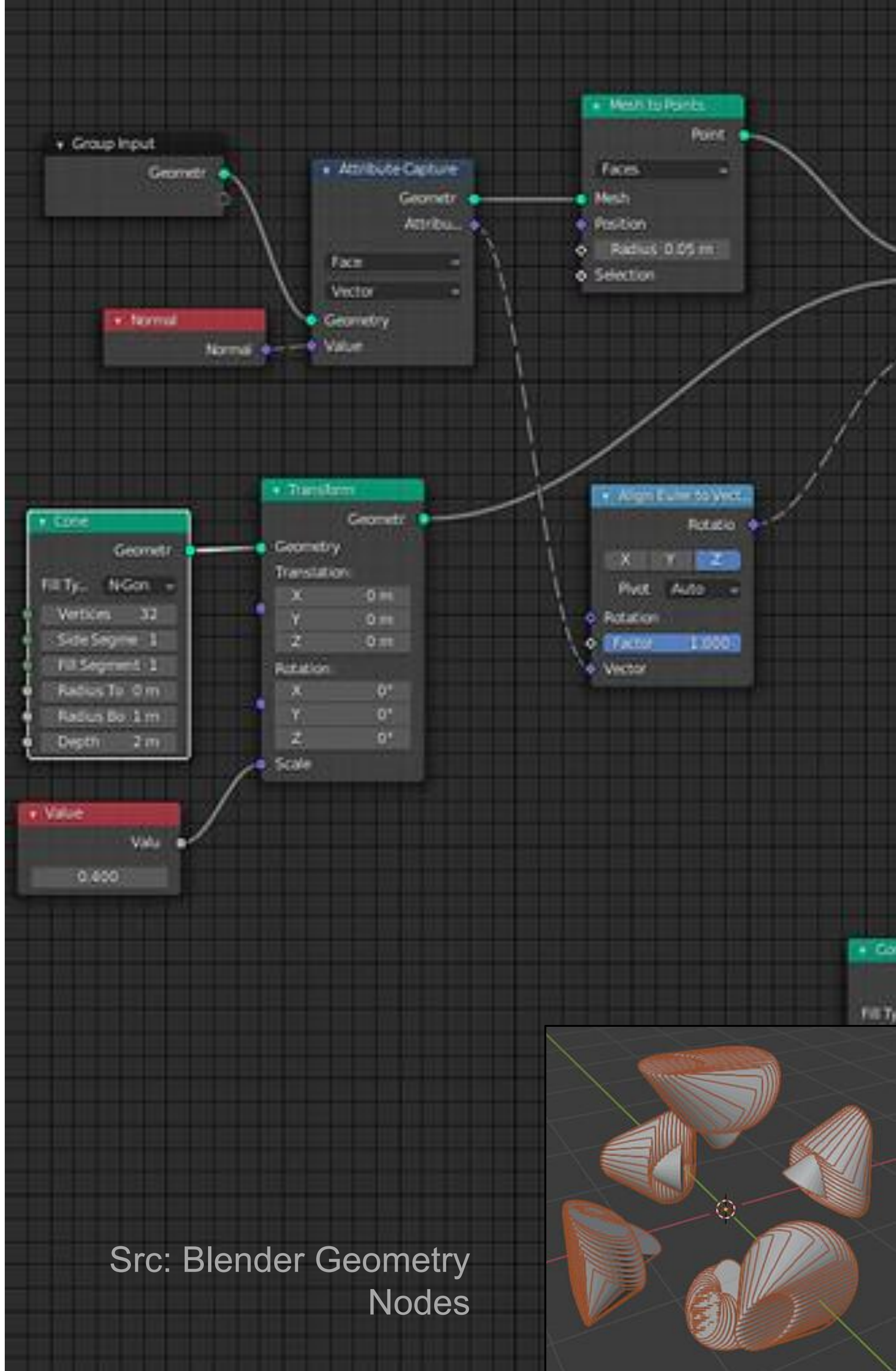
  Better performance and usage
  - ‘Free’ concurrency, compile time optimization, hot code deployment, debugging advantages, clear unit testing, etc.



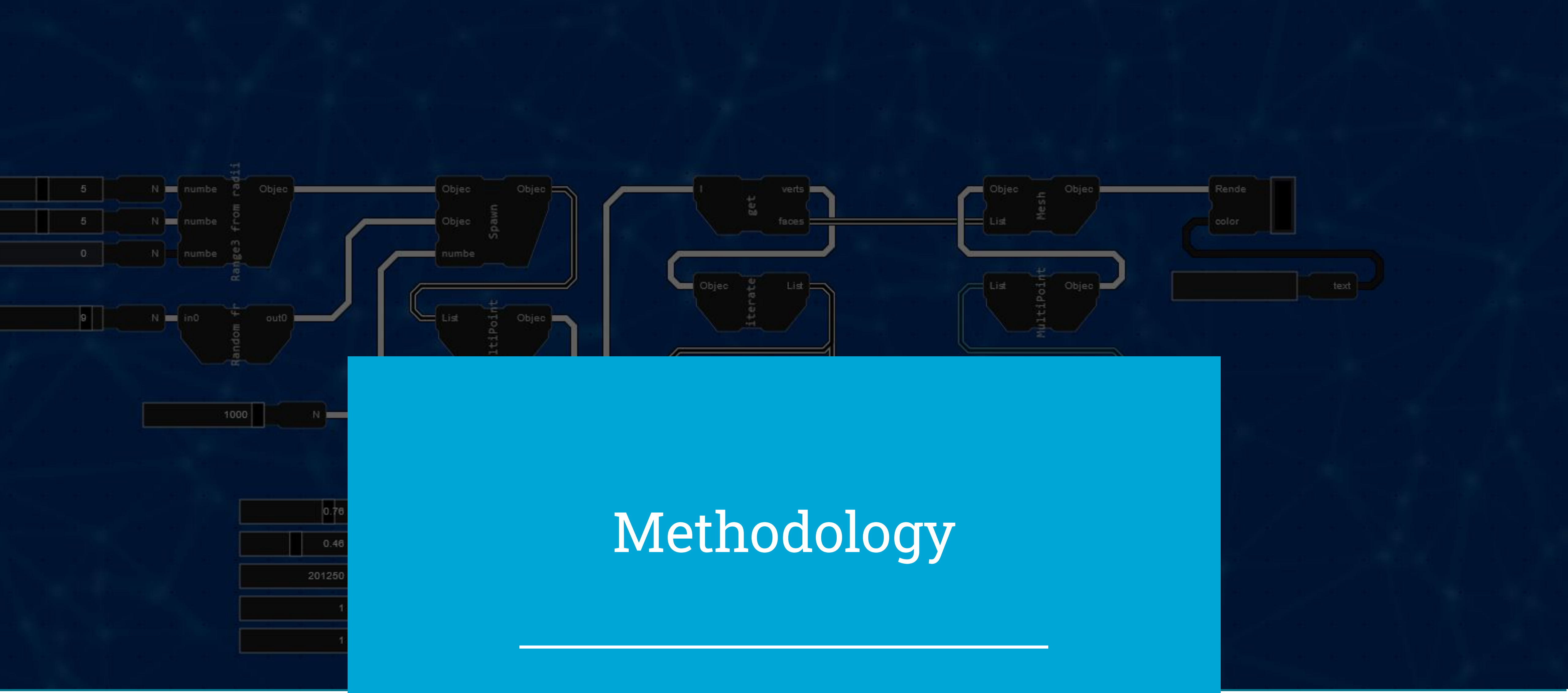
Src: Blender Geometry Nodes

Dataflow VPL

- Observation: Almost all VPLs handling geometry are *semi* dataflow VPLs:
    - Graph-based, immutable variables, mostly pure functions.



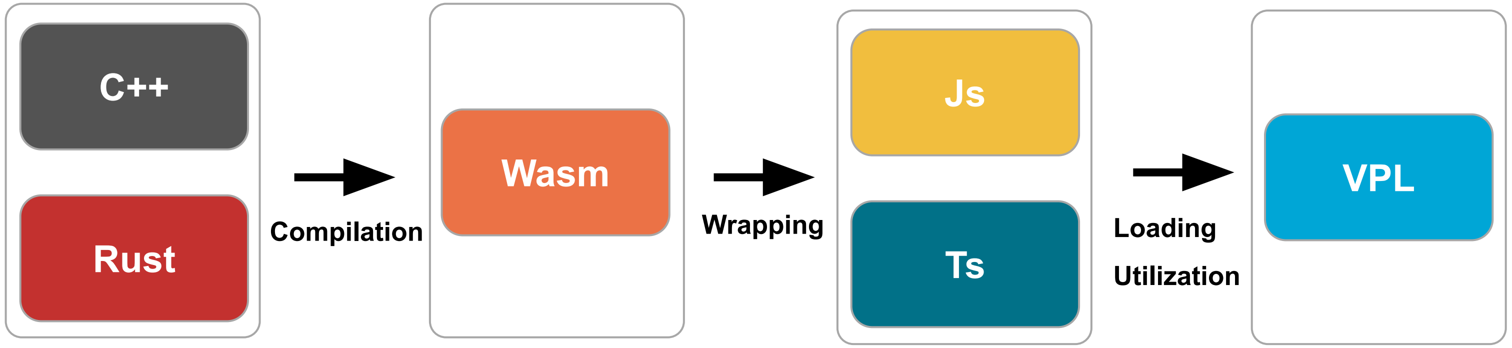
Src: Blender Geometry Nodes



Methodology

Methodology

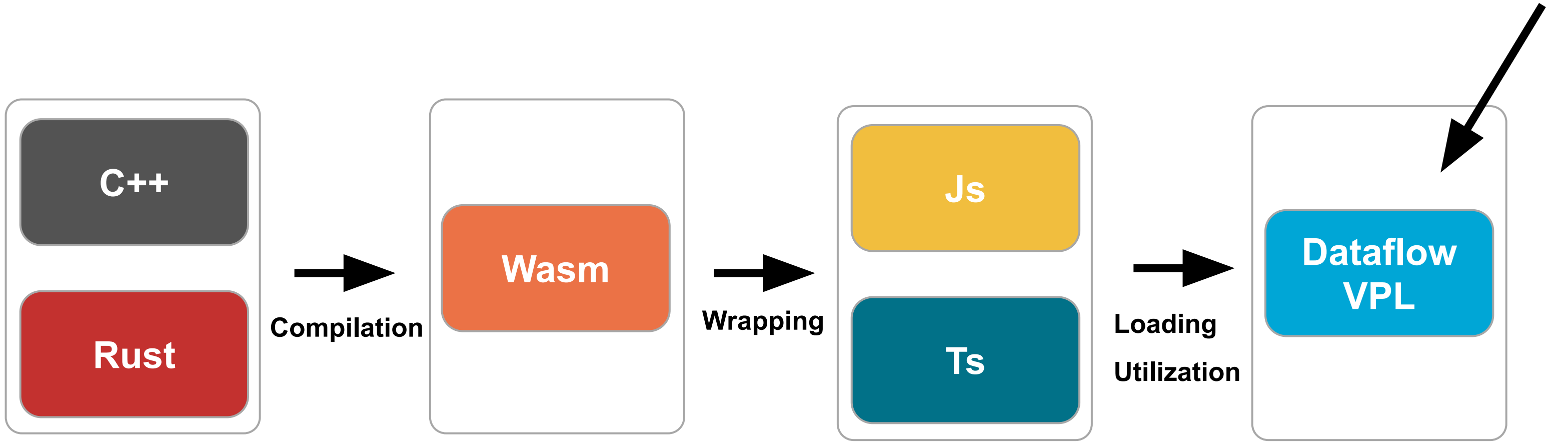
Address translation steps between language models



Methodology

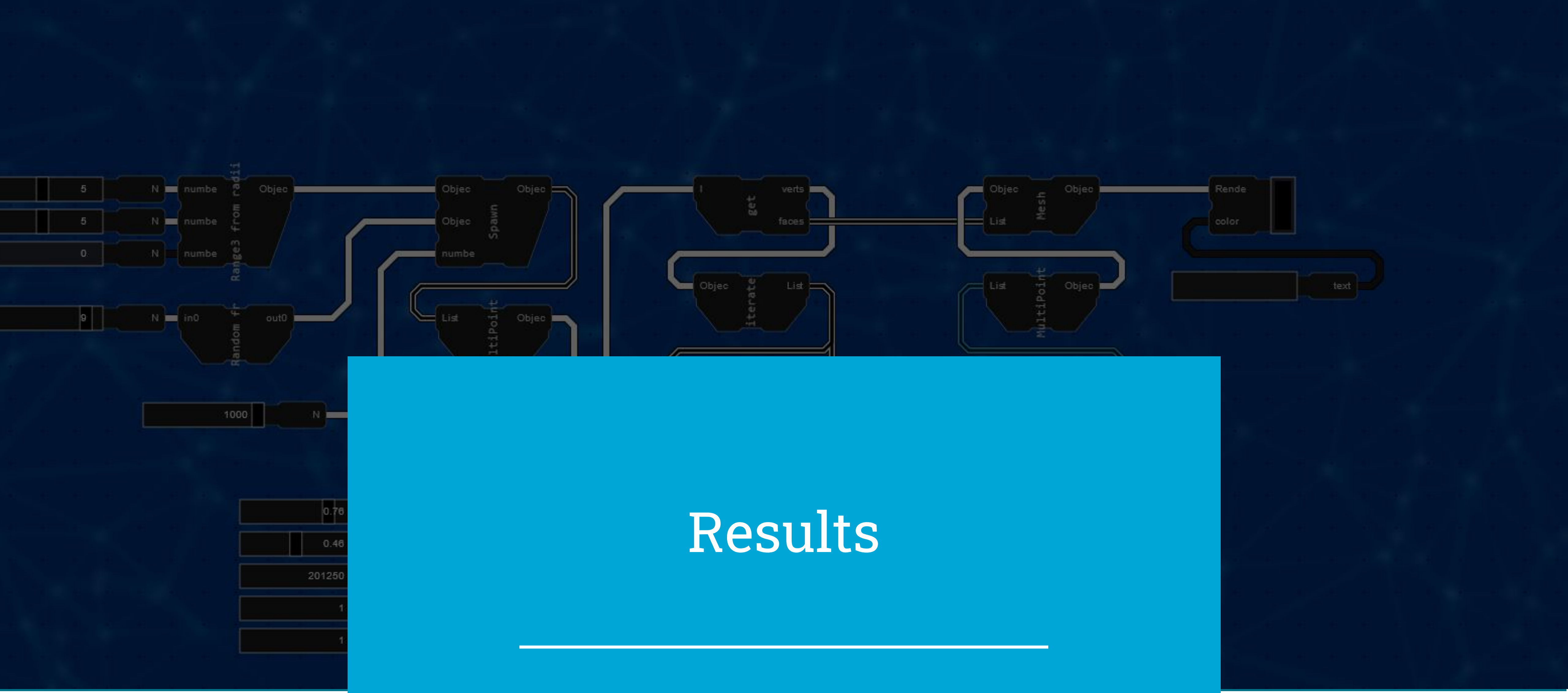
Define & construct

the VPL language model



Methodology

1. Base VPL:
   - Web-based Dataflow VPL
2. Library Plugin system:
   - Plugin loader
   - Plugin model
3. Tests:
   - The plugin system with different libraries.
   - The overall solution by using libraries.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verts
faces
iterate
Mesh
Rende
color
text

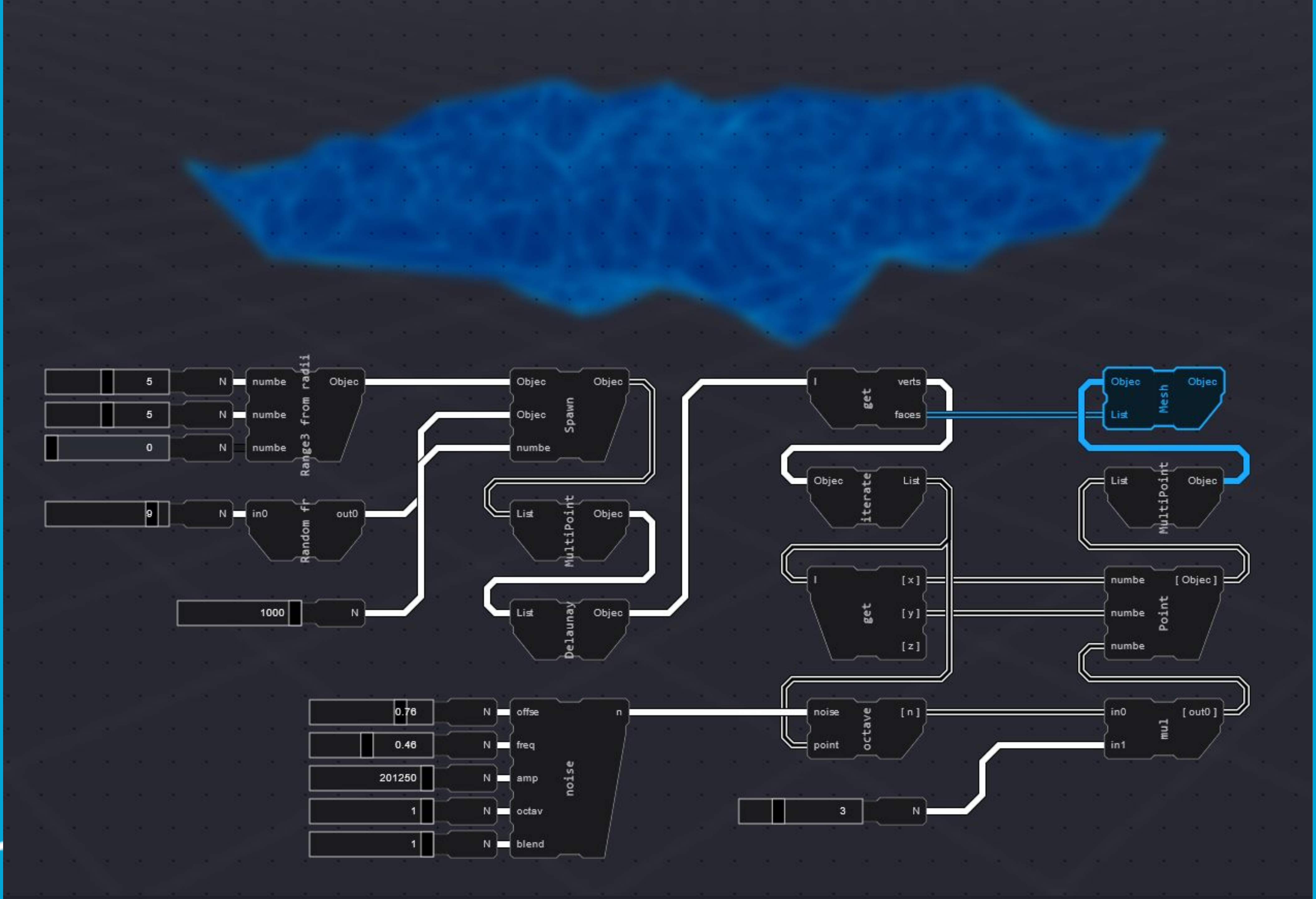
Results

1. Base VPL: Geofront

Geofront: Results

Javascript ←→ Dataflow VPL:

- Synergy:
  - + ‘Free’ HTML5 features
  - + Dynamic → hot plugin loading
- Friction:
  - Runtime reflection
  - JavaScript Types
  - No explicit Immutability



numbe 5
numbe 5
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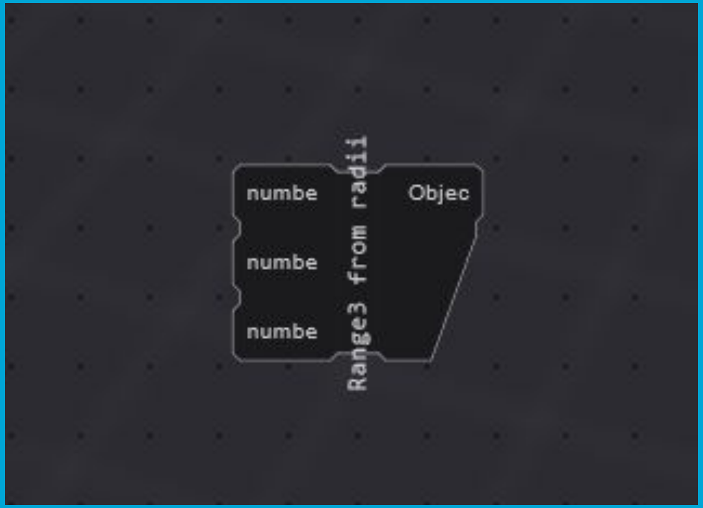
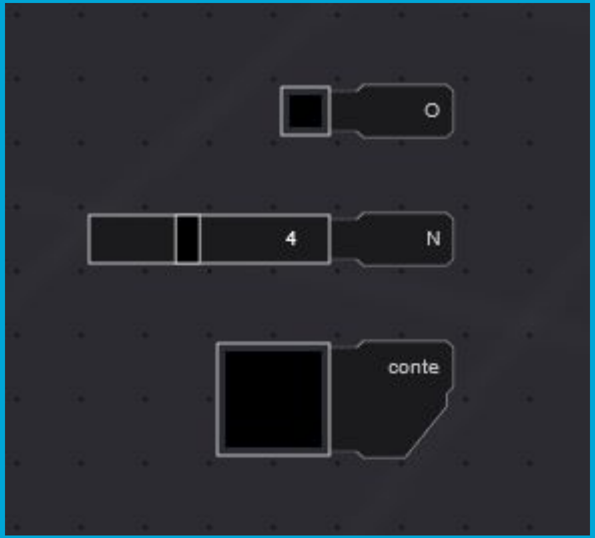
amp 201250
octav 1
blend 1
in1 3

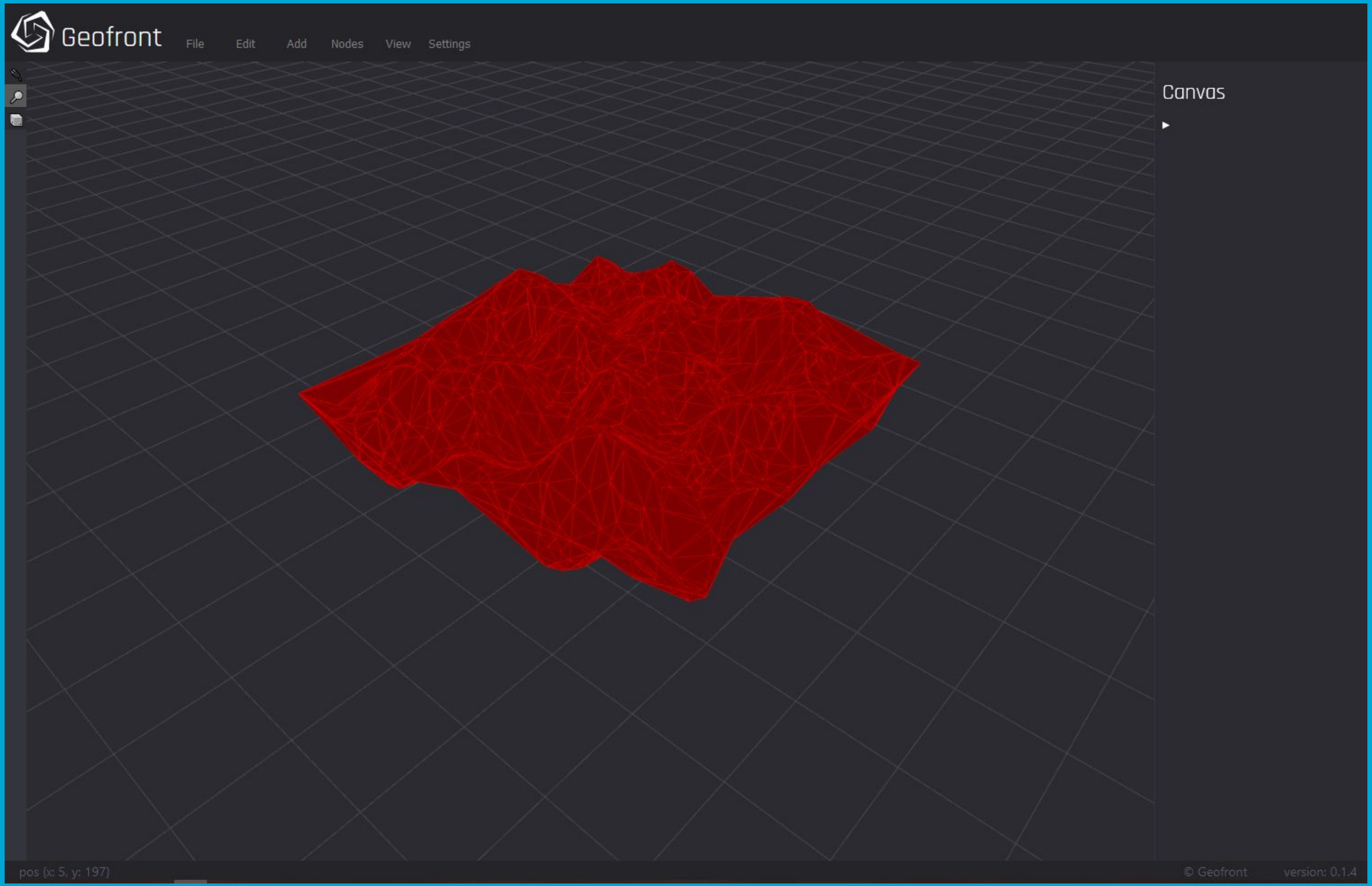
Node: Computation / pure function



Widget: Usability / side effects



Viewer


Geofront
File
Edit
Add
Nodes
View
Settings
Canvas
pos (x: 5, y: 197)
© Geofront
version: 0.1.4

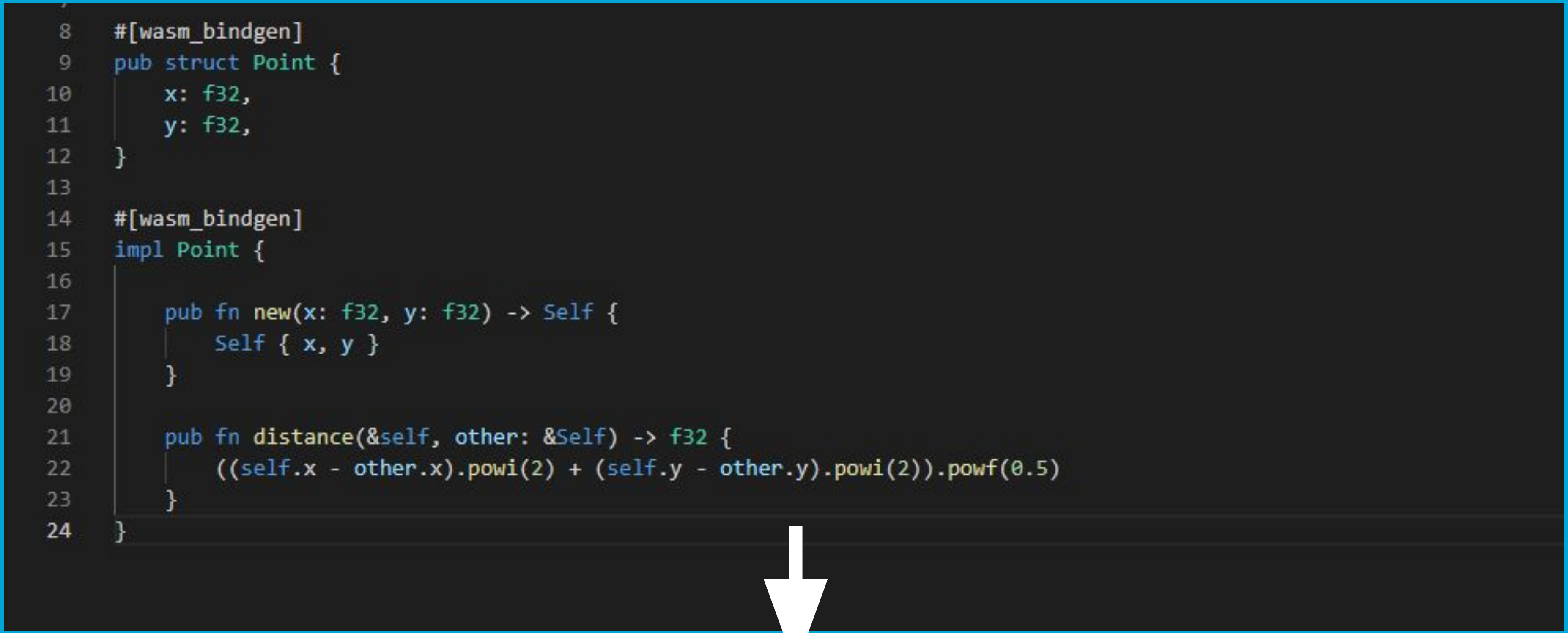
2. Plugin System

Plugin System: Results

Wasm-wrappers ←→ Dataflow VPL:

- Synergy:
  - + no configuration of mandatory aspects
- Friction:
  - Loader too lenient, no enforcement of dataflow properties
  - optional aspects still need some configuration (visualization)

Plugin System

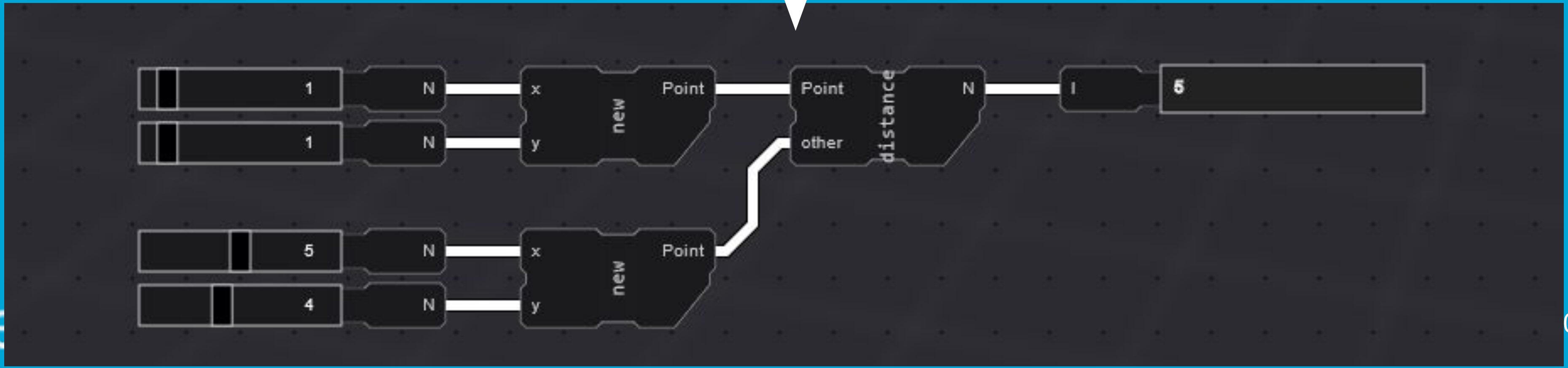


```rust
#[wasm_bindgen]
pub struct Point {
    x: f32,
    y: f32,
}

#[wasm_bindgen]
impl Point {

    pub fn new(x: f32, y: f32) -> Self {
        Self { x, y }
    }

    pub fn distance(&self, other: &Self) -> f32 {
        ((self.x - other.x).powi(2) + (self.y - other.y).powi(2)).powf(0.5)
    }
}
```



3. Tests

Tests: Results

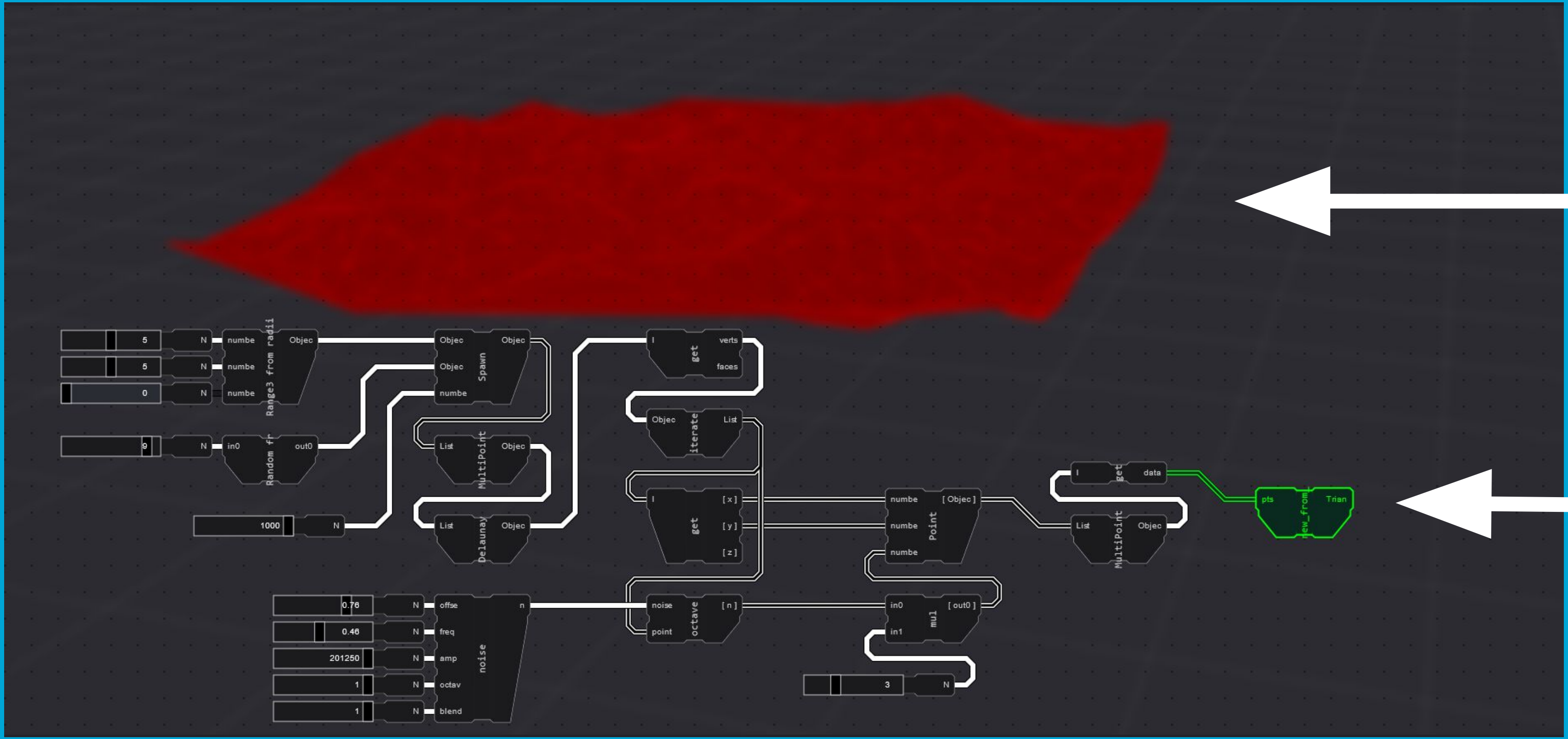
Rust ←→ Wasm-wrapper ←→ Dataflow VPL:

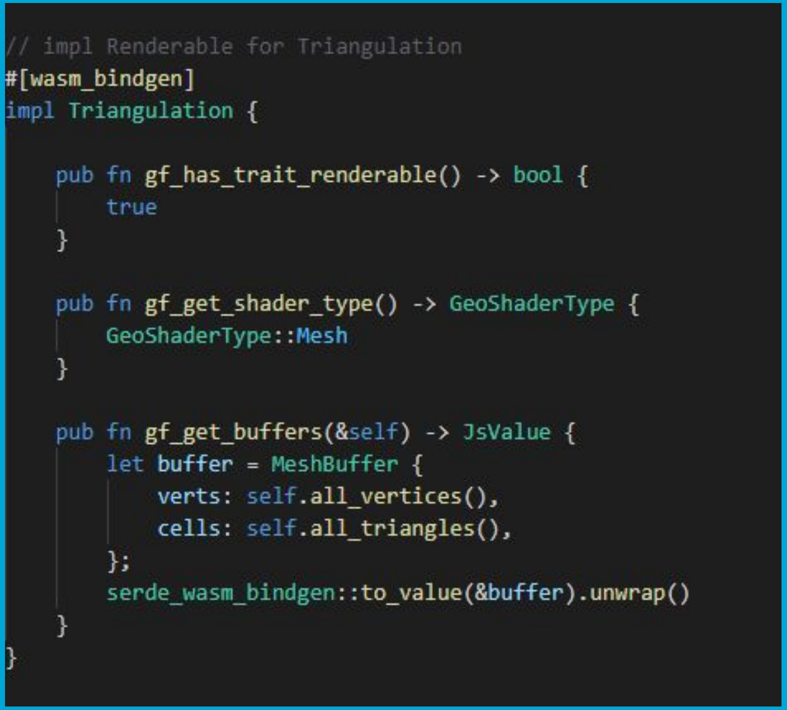
- Synergy:
  - + Worked almost immediately for almost any library
  - + Expressive bindings allow complex data types to be exchanged in a simple manner.
- Friction:
  - - Still some runtime overhead due to wrappers

C++ ←→ Wasm-wrapper ←→ Dataflow VPL:

- Synergy:
  - + Multiple workarounds eventually allowed some parts of CGAL to be run in geofront, if included in the source code
- Friction:
  - - No C++ library was able to be loaded with the plugin loader
  - - Requires many workarounds
  - - Sub-optimal support for bindings
  - - A lot of runtime overhead due to wrappers

Test Rust Library: Startin



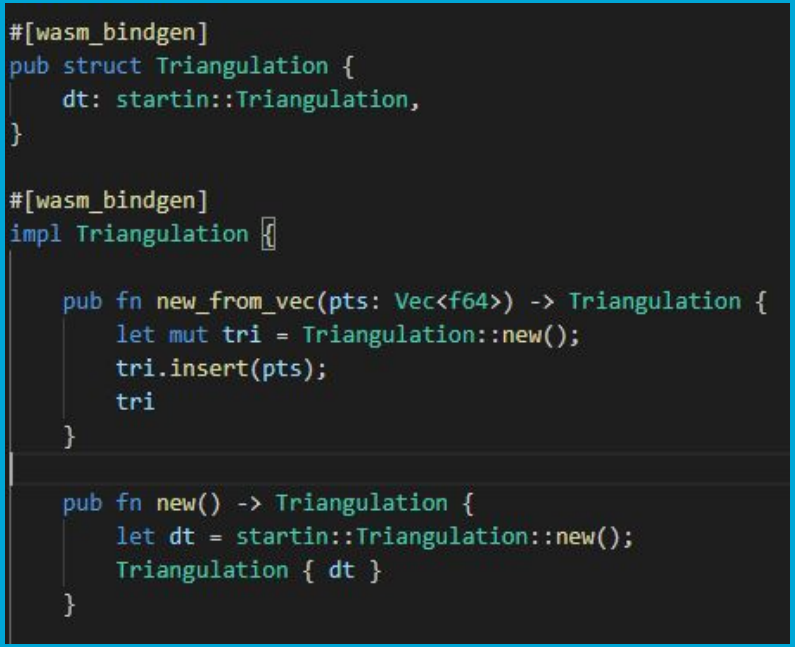


```rust
// impl Renderable for Triangulation
#[wasm_bindgen]
impl Triangulation {

    pub fn gf_has_trait_renderable() -> bool {
        true
    }

    pub fn gf_get_shader_type() -> GeoShaderType {
        GeoShaderType::Mesh
    }

    pub fn gf_get_buffers(&self) -> JsValue {
        let buffer = MeshBuffer {
            verts: self.all_vertices(),
            cells: self.all_triangles(),
        };
        serde_wasm_bindgen::to_value(&buffer).unwrap()
    }
}
```



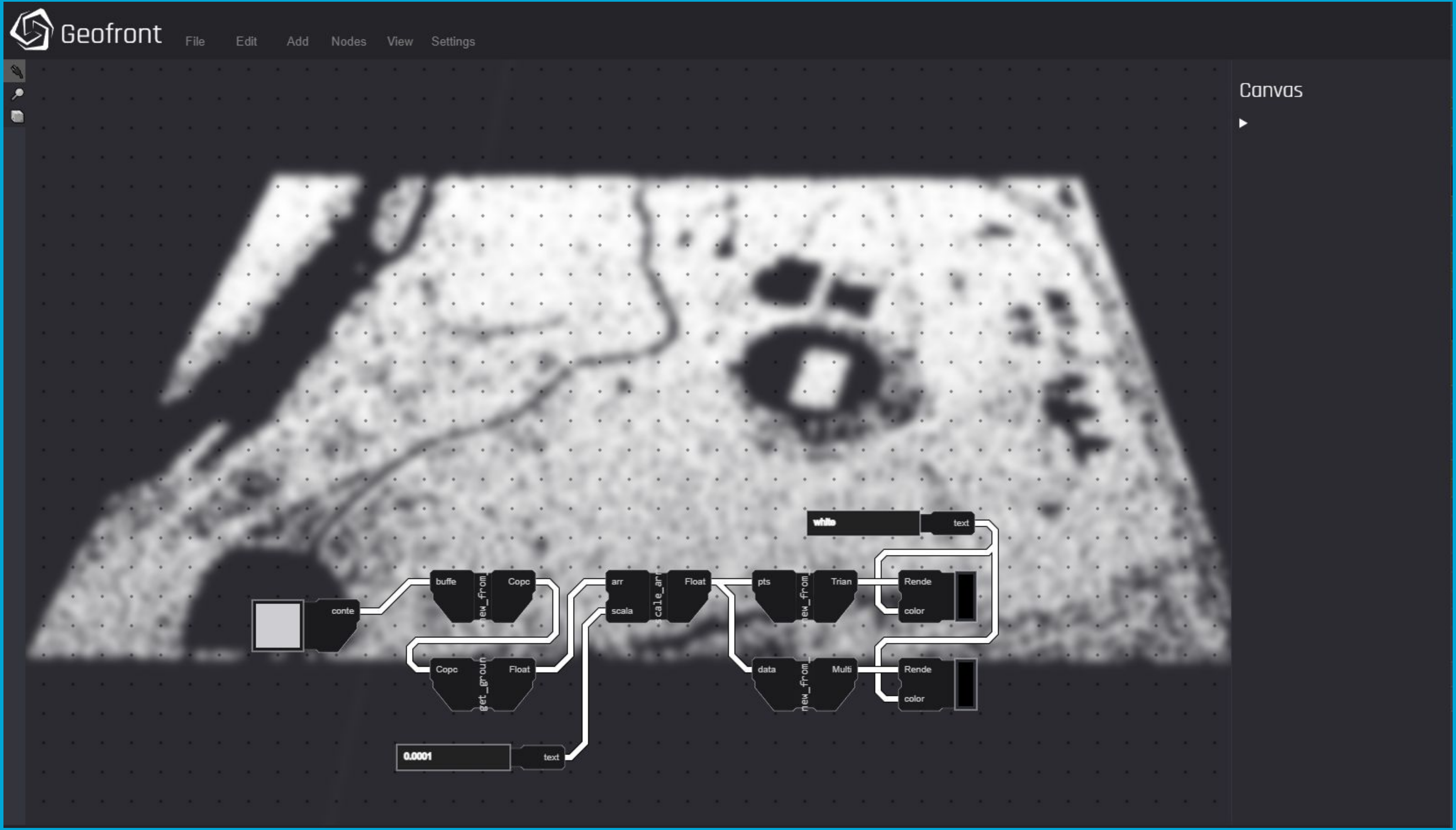
```rust
#[wasm_bindgen]
pub struct Triangulation {
    dt: startin::Triangulation,
}

#[wasm_bindgen]
impl Triangulation {

    pub fn new_from_vec(pts: Vec<f64>) -> Triangulation {
        let mut tri = Triangulation::new();
        tri.insert(pts);
        tri
    }

    pub fn new() -> Triangulation {
        let dt = startin::Triangulation::new();
        Triangulation { dt }
    }
```

Rust Library: copc-rs (Point cloud loader)



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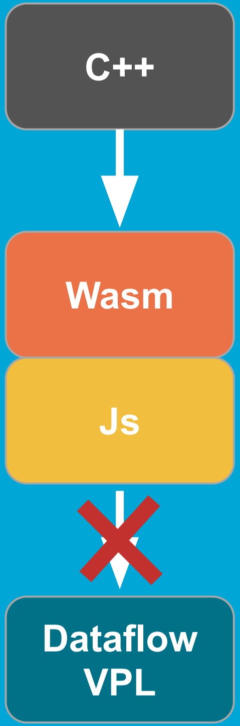
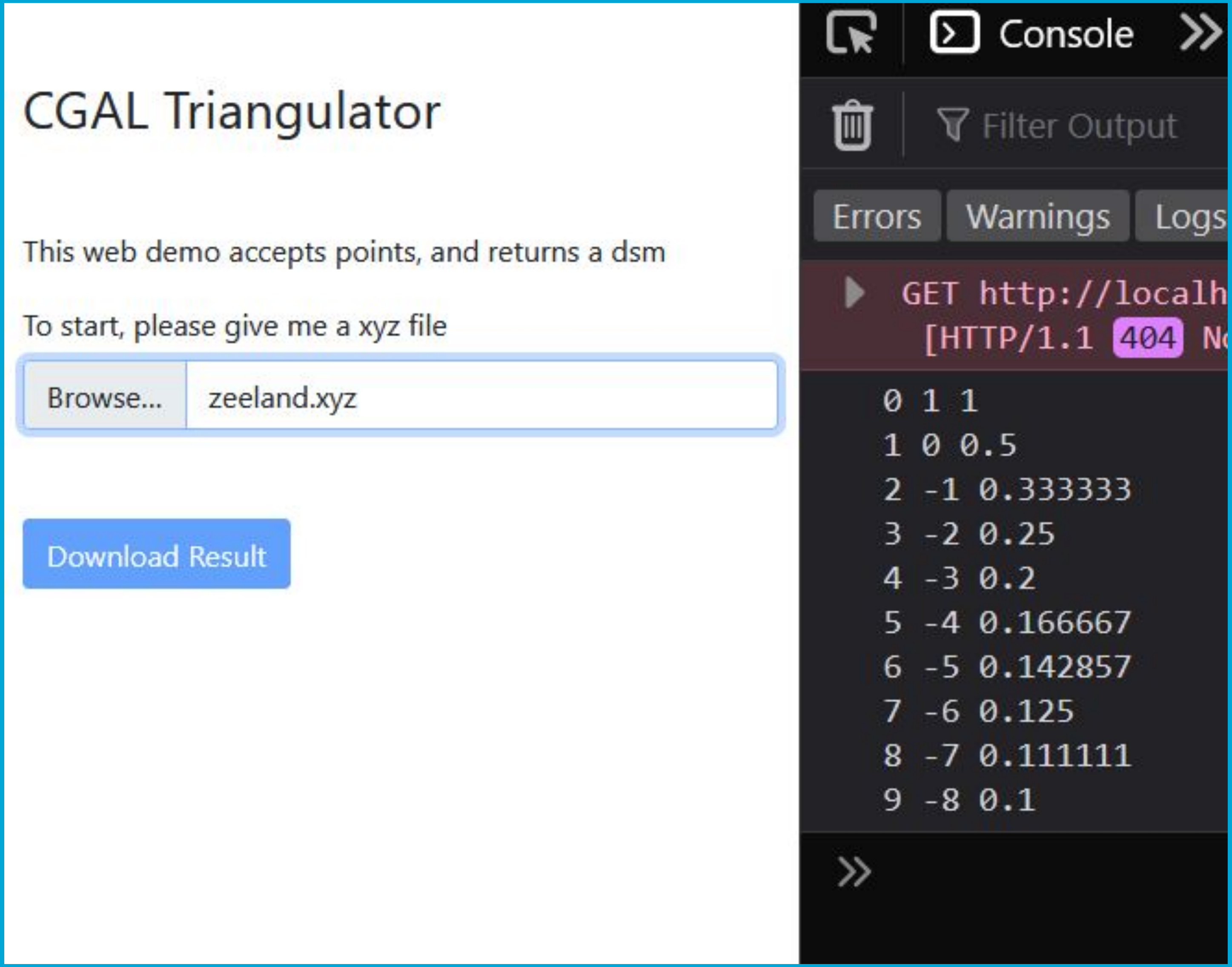
C++ Library: CGAL





CGAL Triangulator

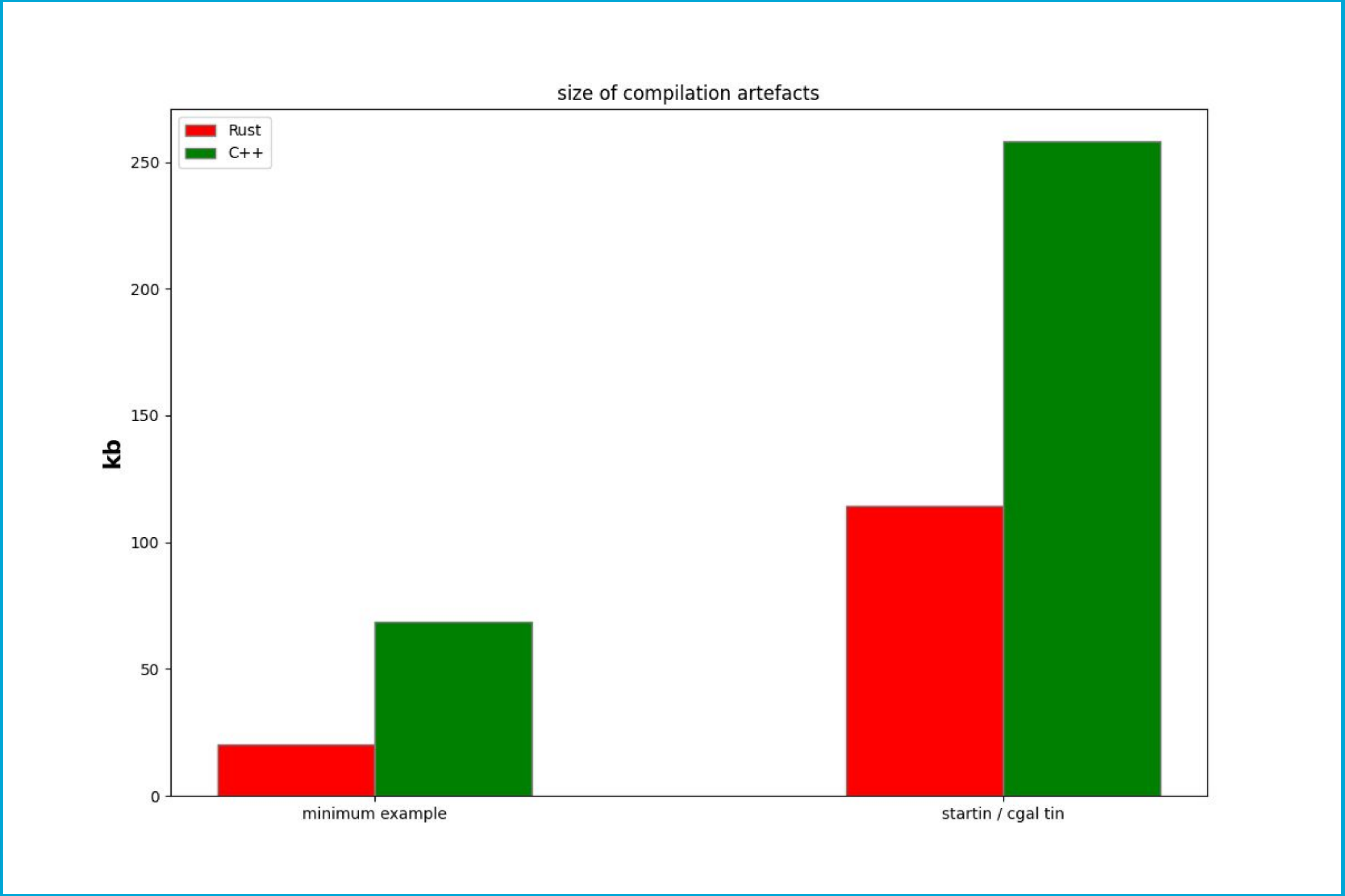
This web demo accepts points, and returns a dsm

To start, please give me a xyz file

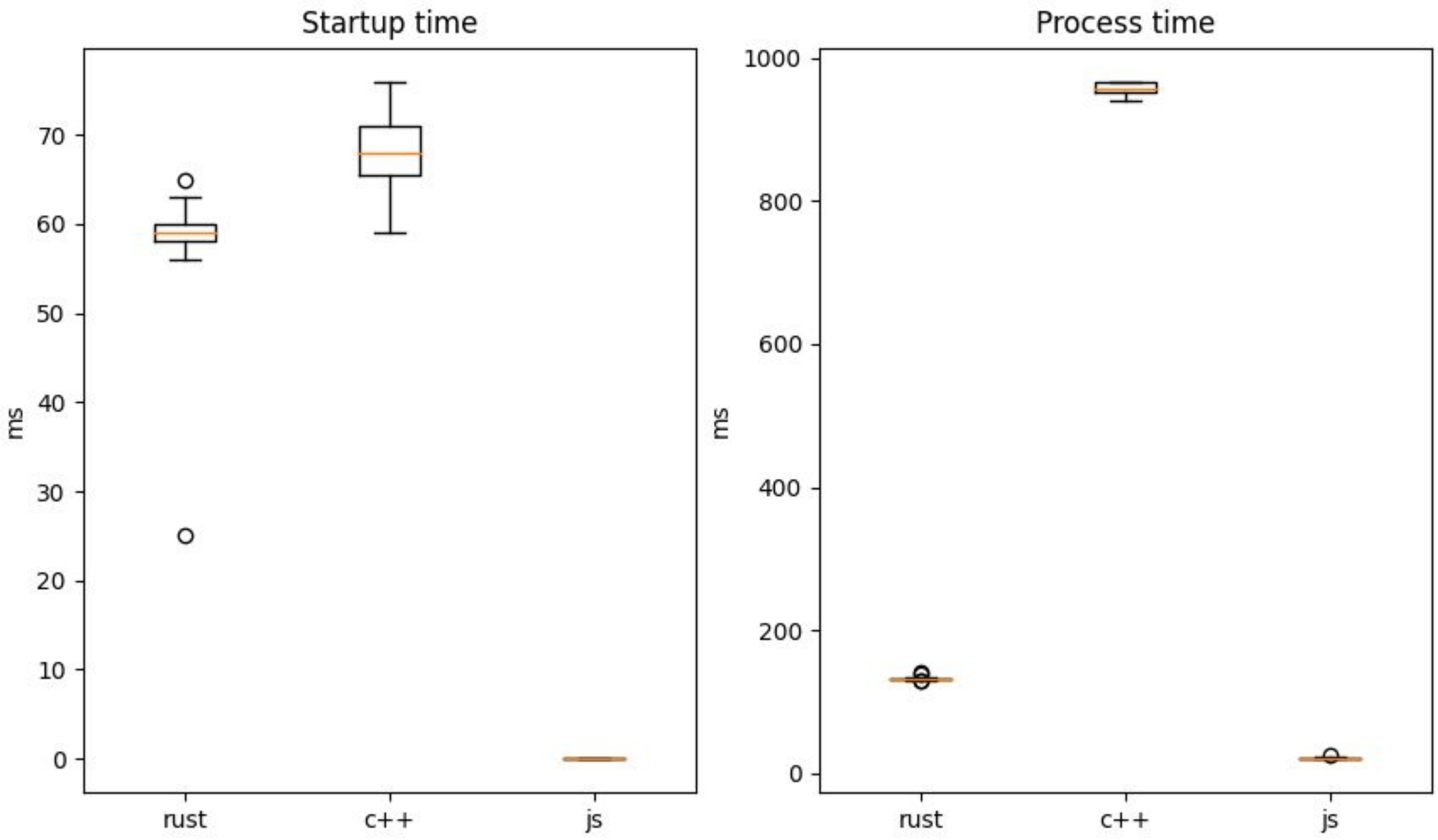
zeeland.xyz

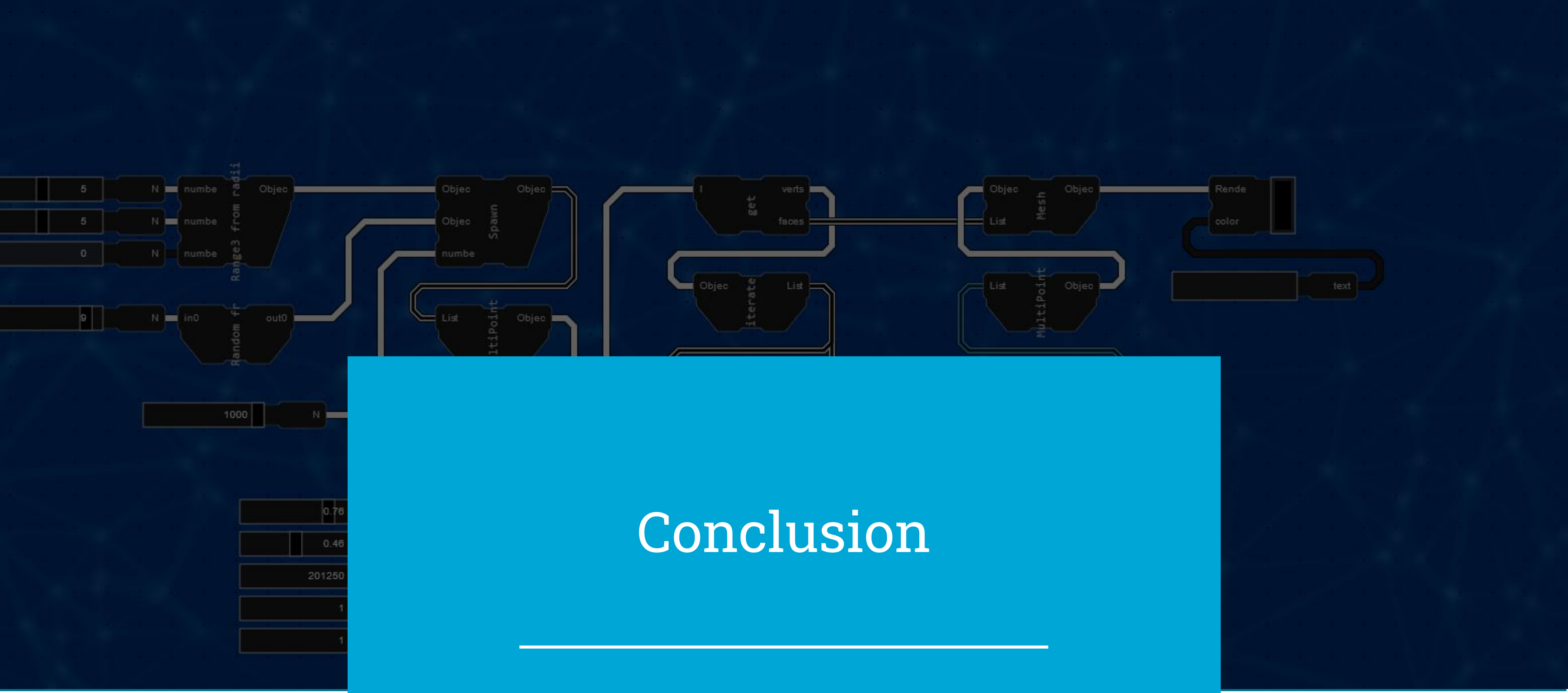
```
GET http://localh
  [HTTP/1.1 404 No
0 1 1
1 0 0.5
2 -1 0.333333
3 -2 0.25
4 -3 0.2
5 -4 0.166667
6 -5 0.142857
7 -6 0.125
8 -7 0.111111
9 -8 0.1
```

Rust compared to C++



Rust compared to C++





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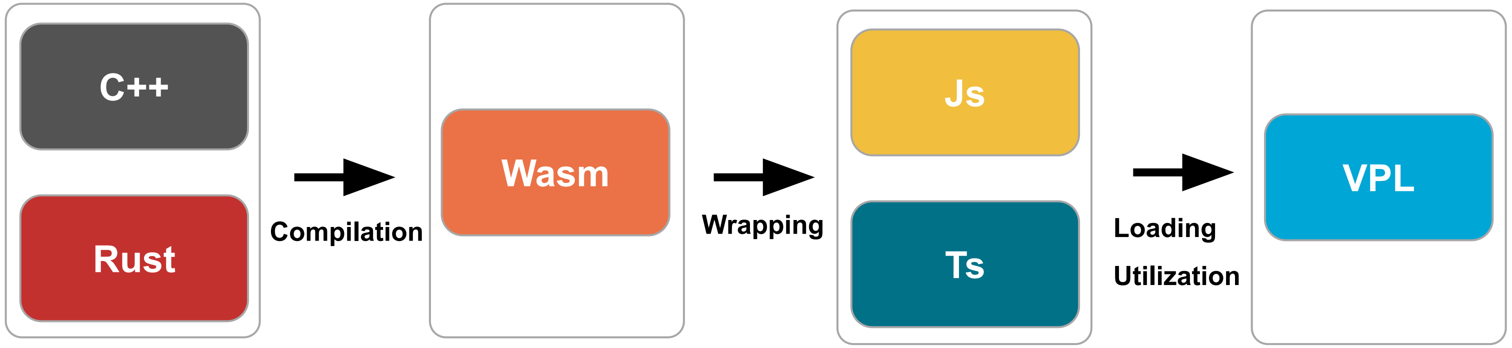
Conclusion

Answer to research question:

Q: ”How can native geocomputation libraries be compiled, loaded, and utilized within a browser-based dataflow-VPL?”

A: The **key** to successfully compiling, loading and using geo-libraries is to use the **synergies** and address the **frictions** between the four required groups of languages:



Answer to research question:

Q: ”How can native geocomputation libraries be compiled, loaded, and utilized within a browser-based dataflow-VPL?”

Frictions:

- Rust → Wasm wrappers
  - Success, but young libraries

- C++ → Wasm + Js / Ts
  - Further study

- Javascript ←→ Dataflow VPL
  - Advantages & Disadvantages

Thank you for your attention!

Questions

Range3 from radii
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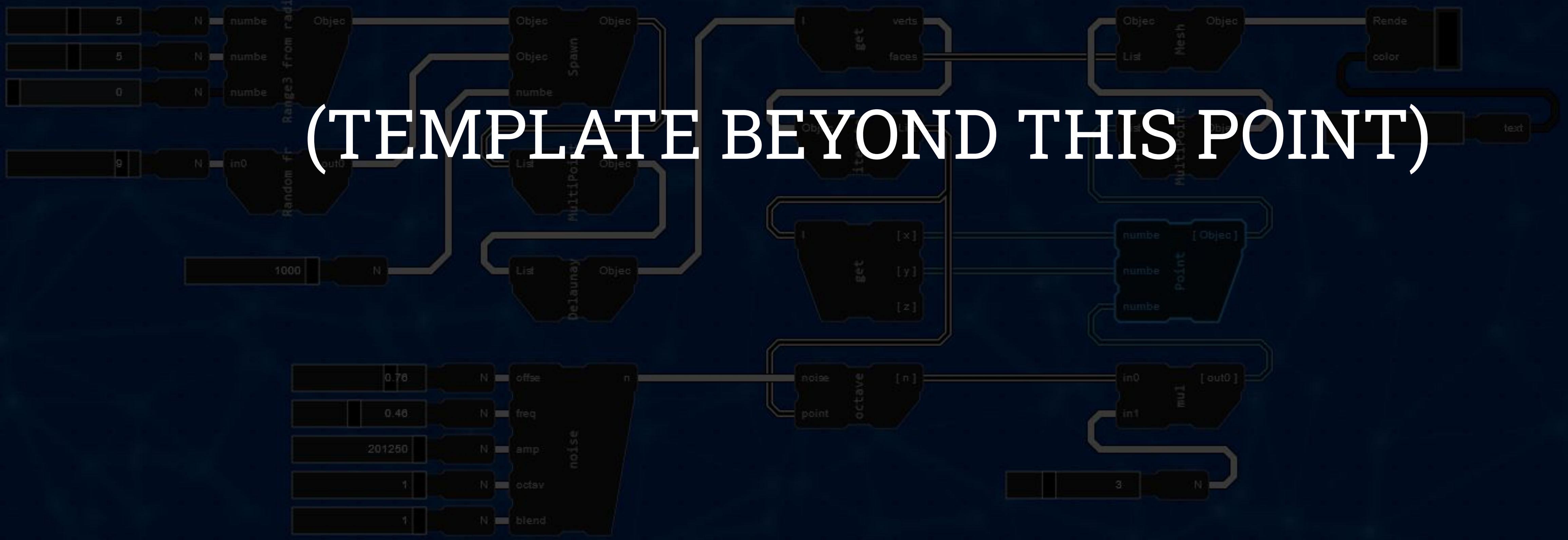
(TEMPLATE BEYOND THIS POINT)



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Plaats hier de titel van de presentatie

Naam van de spreker of datum

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Uiteindelijk heeft je werken-bij site doorgaans maar één primair doel: sollicitaties binnenhalen. Een secundair doel is vaak employer branding en de rest is bijzaak.

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TU Delft

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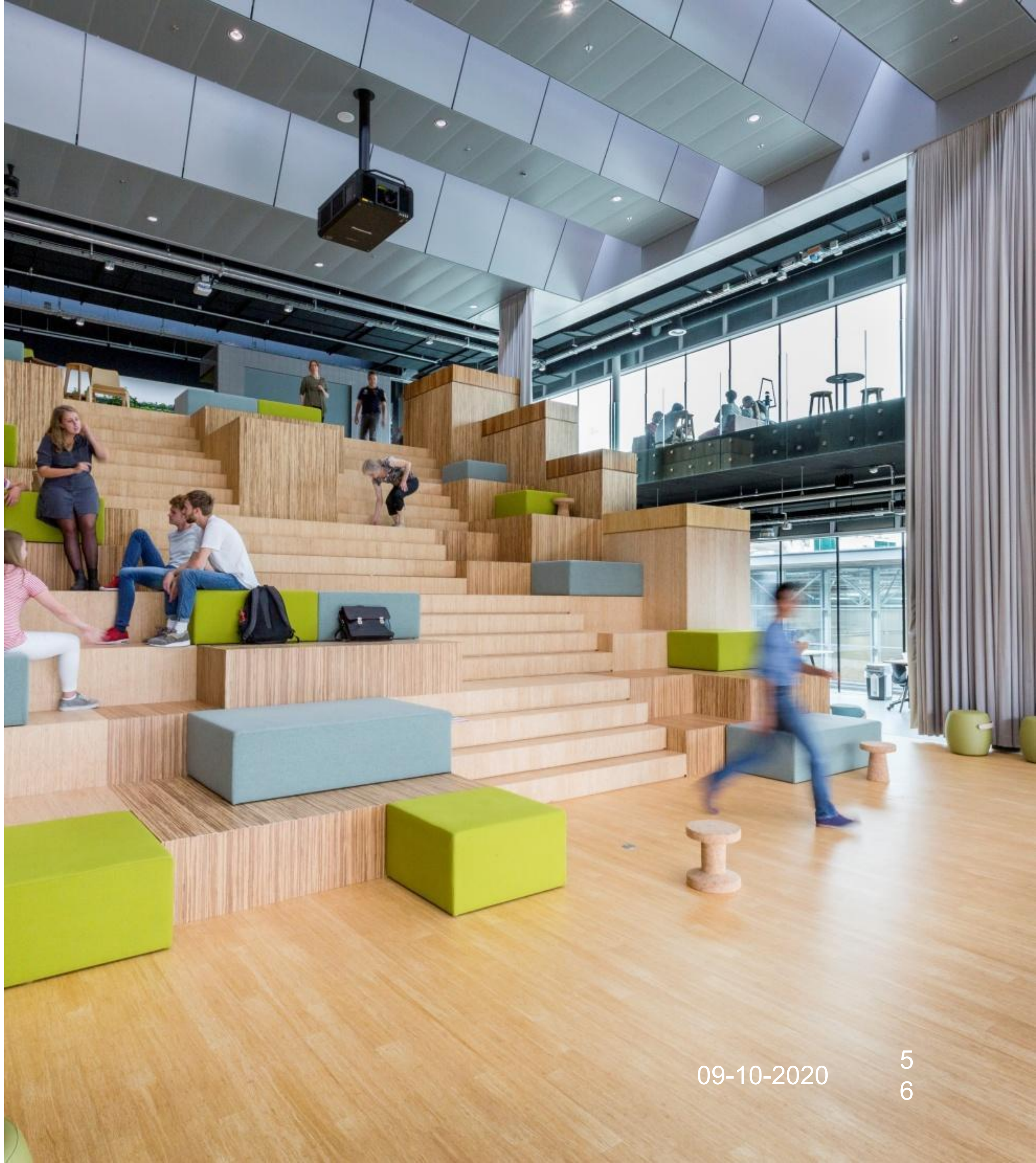

Korte titel

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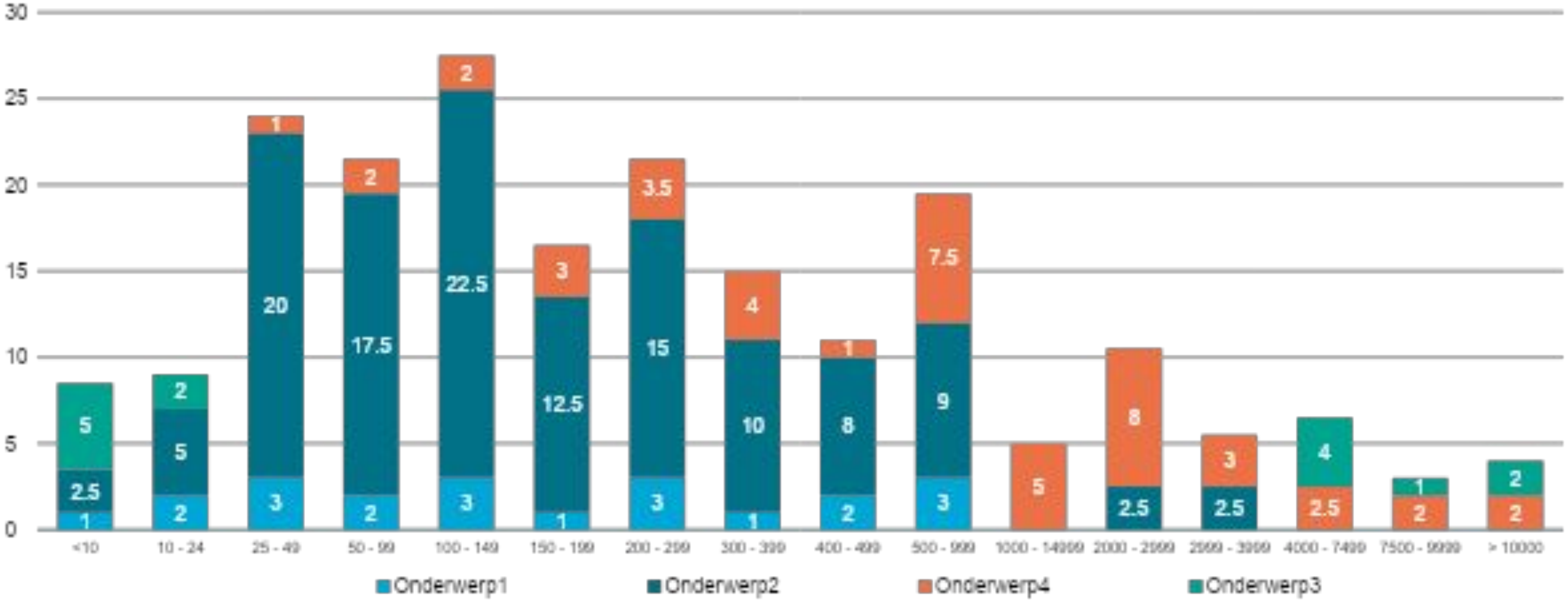
Plaats een hoofstuktitel hier, max. 2 regels

Ruimte voor een subtitel

Plaats hier een titel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