Karlsruhe Institute of Technology

Steinbuch Centre for Computing

# rootJS - Functional Specification

PSE - Software Engineering Practice

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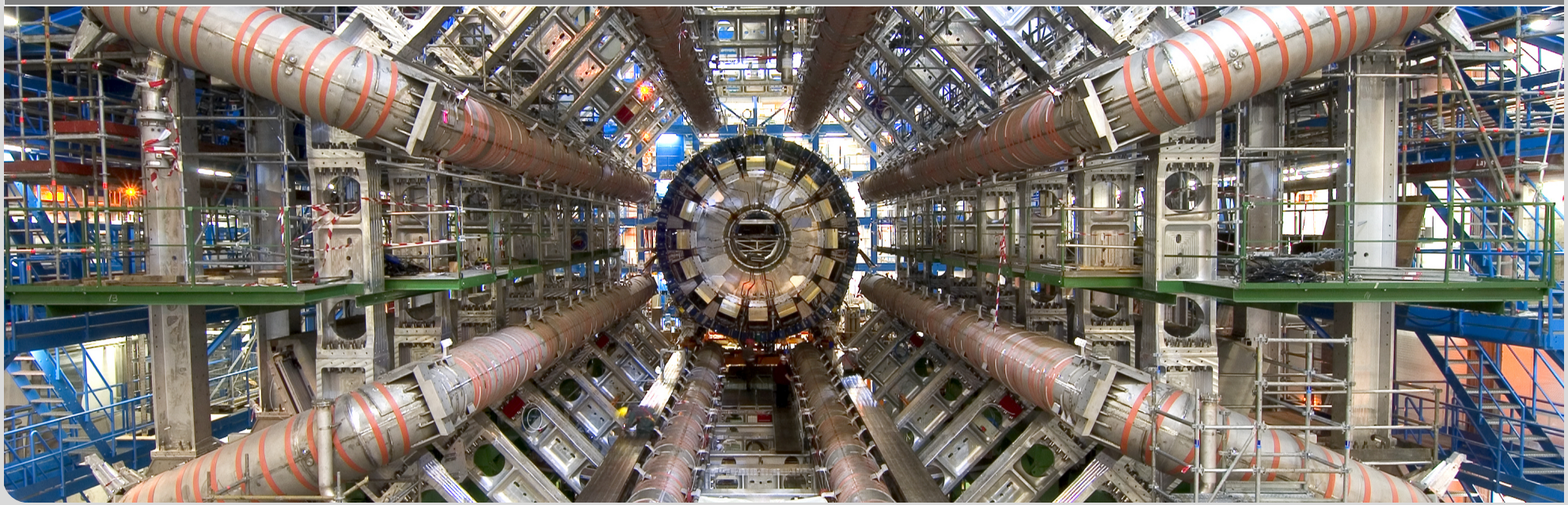
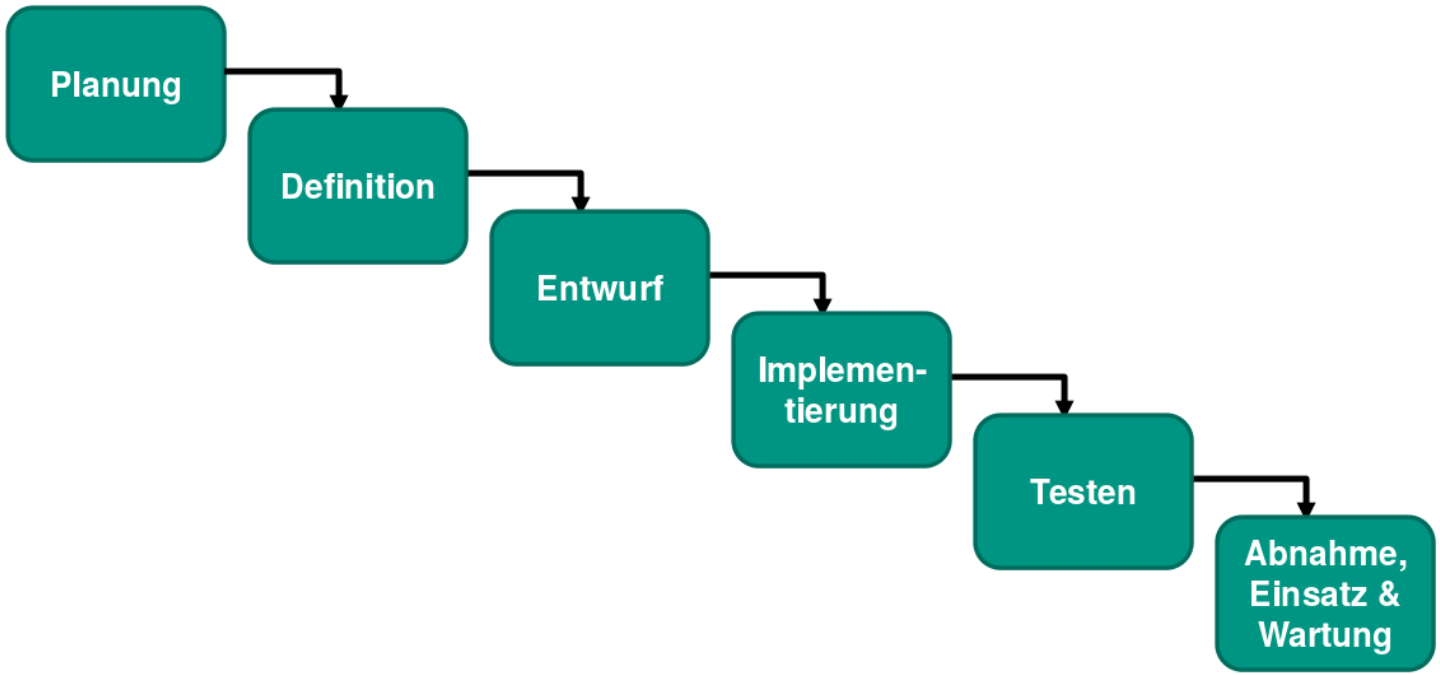
STEINBUCH CENTER FOR COMPUTING



# About PSE

Praxis der Softwareentwicklung(PSE) = Software Engineering Practice

- Waterfall model
  - Planning/definition



# Purpose

Node.js bindings for ROOT

- be able to write ROOT code in Node.js programs
- integrate ROOT into Node.js based web applications

# Required Criteria

The bindings must

- work on Linux
- allow the user to interact with any ROOT class from the Node.js JavaScript interpreter
- accept C++ code for just-in-time compilation
- update dynamically following changes to C++ internals
- provide asynchronous wrappers for common I/O operations (i.e. file and tree access)

# Optional Criteria

The bindings should

- support the streaming of data in JavaScript Object Notation (JSON) format compatible with JavaScript ROOT
- implement a web server based on Node.js to mimic the function of the ROOT HTTP server
- work OS independent (i.e. support Mac OS X, Linux operating systems)

# Limiting criteria

The bindings should not

- add any extending functionality to the existing ROOT framework
- necessarily support previous/future ROOT versions

# Product usage

rootJS will be used to create web-applications that can:

- Expose processed data (that might otherwise be hard to access) and then visualize it locally
- Interact with data both stored somewhere accessible for the server or streamed via remote procedure call (RPC)
- Run on any platform that supports a browser

# Audience

Most users of rootJS will be used to working in Linux and with web servers. At the very least, they will be able to install ROOT and also be proficient in programming languages like JavaScript and C++.

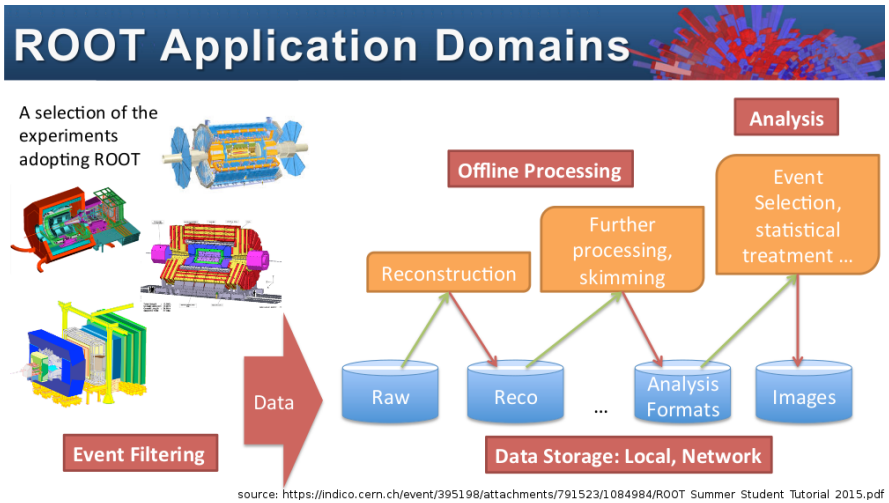
- Scientists (e.g. particle physicists)
- Researchers
- Web-developers interested in creating applications based on ROOT

# Operating conditions

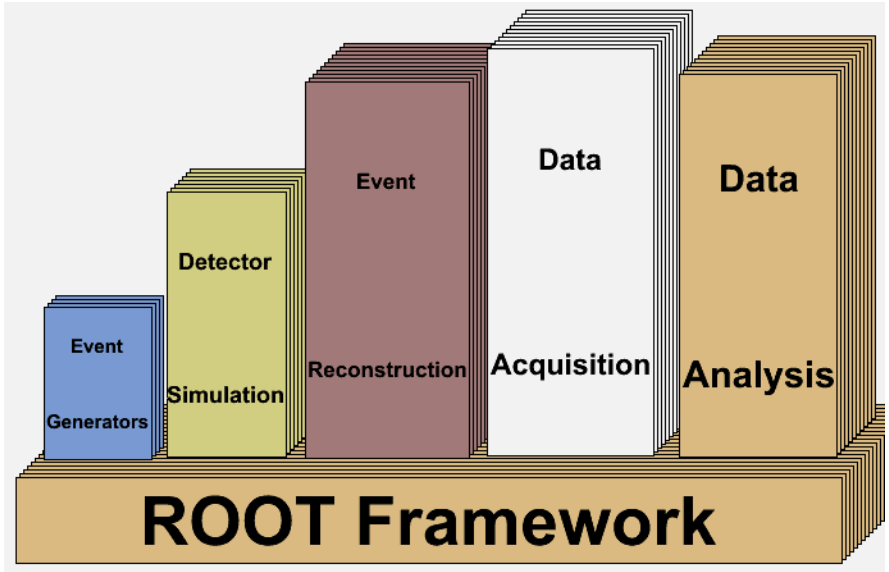
- rootJS will be used on servers that run ROOT and have access to the required data sources.
- As ROOT 6 currently runs on Linux and OS X only, usage of the bindings is limited to those platforms.

# ROOT

- process and visualize large amounts of scientific data (CERN)
- features a C++ interpreter (CLING) - i.e. used for rapid and efficient prototyping
- persistency mechanism for C++ objects



source: https://indico.cern.ch/event/395198/attachments/791523/1084984/ROOT Summer Student Tutorial 2015.pdf



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- open source runtime environment
  - develop server side web applications
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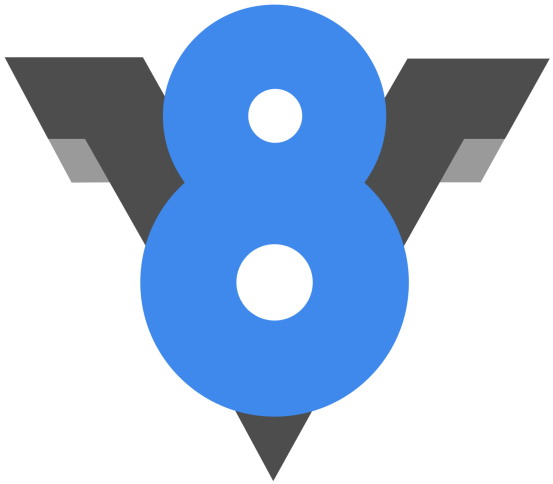
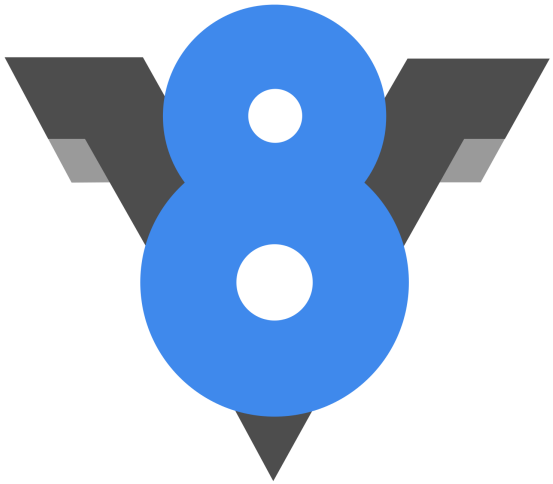


# Node.js

- open source runtime environment
  - develop server side web applications
  - act as a stand alone web server
- Google V8 engine to execute JavaScript code
- rootJS bindings realized as native Node.js module written in C++



# Hardware

- Task: encapsulation of ROOT objects and functions
  - → scanning ROOT structures during initialization
  - → encapsulating objects with heavily nested object structures
  - → introduce (proxy) object cache

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⇒ generally negligible hardware requirements of the bindings themselves

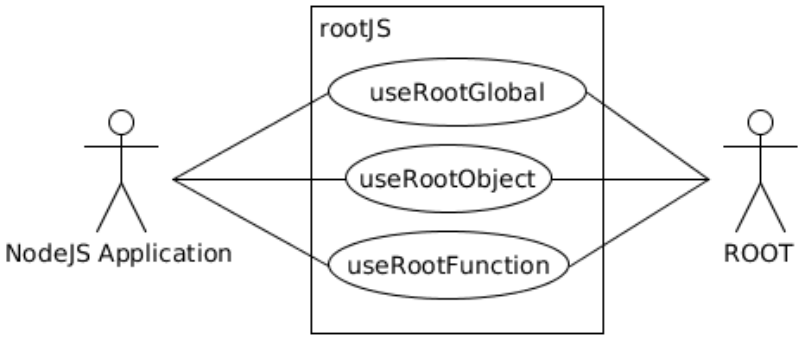
# Product data

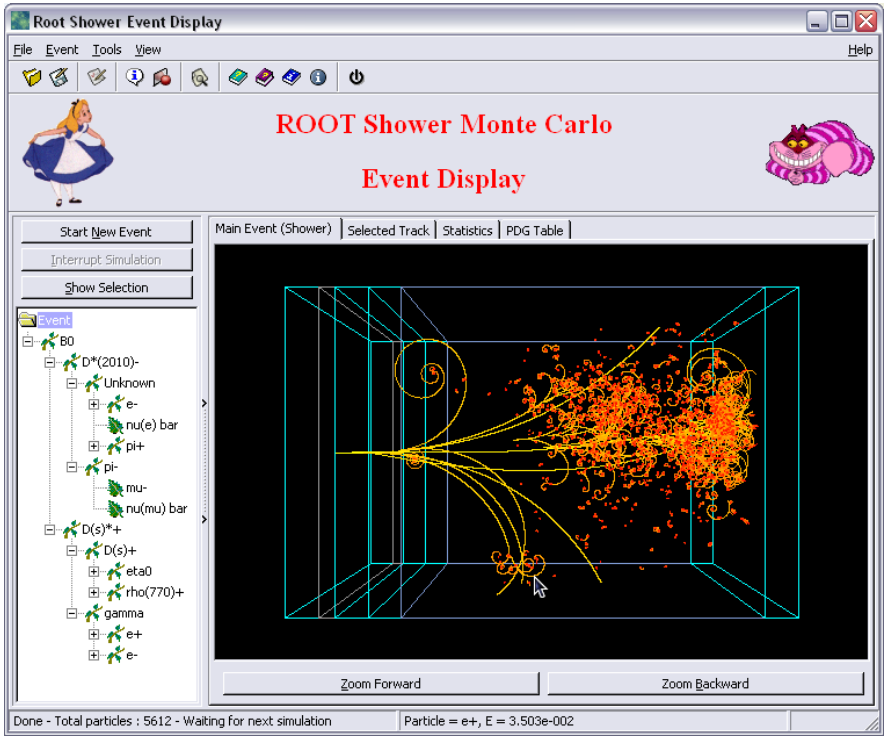
The following data will be stored by the rootJS bindings

- All ROOT classes and methods as they dynamically mapped to their JavaScript equivalents
- ROOT environment state
- Application context is derived from TApplication
- Map of v8::handles 2 identified by the address of ROOT objects

# Product interface

# Event Viewer



# UseROOTGlobal

| | |
|---|---|
| *Use case name* | `UseROOTGlobal` |
| *Participating actor instances* | Initiated by `NodeJSApplication`; Processed by `rootJS`; Communicates with `ROOT` |
| *Flow of events* | |

1. The `NodeJSApplication` requests access to a global variable of `ROOT`.
2. `rootJS` sends a request to the corresponding `ROOT` variable.
3. `ROOT` returns the requested variable value.
4. The value is passed from `rootJS` to the `NodeJSApplication`.

# UseROOTGlobal

| | |
|---|---|
| *Entry condition* | `rootJS` has been initialized. |
| *Exit condition* | The value has been returned to the `NodeJSApplication`. |

# UseROOTObject

| *Use case name* | `UseROOTObject` |
|---|---|
| *Participating actor instances* | Initiated by `NodeJSApplication`; Processed by `rootJS`, `ProxyObject`; Communicates with `ROOT` |

*Flow of events*

1. The `NodeJSApplication` requests access to a `ROOT` object by calling a constructor function.
2. `rootJS` encapsulates the requested `ROOT` object within a `ProxyObject` that was created recursively.

# UseROOTObject

*Flow of events*

3. `rootJS` stores the created `ProxyObject` in a cache memory.
4. The `ProxyObject` is exposed to the `NodeJSApplication`.

| | |
|---|---|
| *Entry condition* | `rootJS` has been initialized. |
| *Exit condition* | The reference of the `ProxyObject` has been return to the `NodeJSApplication`. |

# UseROOTFunction

| | |
|---|---|
| *Use case name* | `UseROOTFunction` |
| *Participating actor instances* | Initiated by `NodeJSApplication`; Processed by `rootJS`, `ProxyObject`; Communicates with `ROOT` |
| *Flow of events* | |

1. The `NodeJSApplication` requests access to a `ROOT` function.
2. `rootJS` calls the corresponding `ROOT` function.
3. `ROOT` responds.

# UseROOTFunction

*Flow of events*

4. `rootJS` encapsulates the returned `ROOT` object within a `ProxyObject`.
5. The `ProxyObject` is exposed to the `NodeJSApplication`.

| | |
|---|---|
| *Entry condition* | `rootJS` has been initialized. |
| *Exit condition* | The reference of the `ProxyObject` has been return to the `NodeJSApplication`. |

# UseJIT

| *Use Case name* | `UseJIT` |
|---|---|
| *Participating actor instances* | Initiated by `NodeJSApplication`; Processed by `rootJS`, `Cling`; Communicates with `ROOT` |
| *Flow of events* | |

1. The `NodeJSApplication` wants to execute `ROOT` specific C++ code (given as string) during runtime.
2. `rootJS` forwards the instructions to `Cling`.
3. `Cling` evaluates the received instructions using JIT compilation concepts and dynamically modifies the state of `ROOT`.

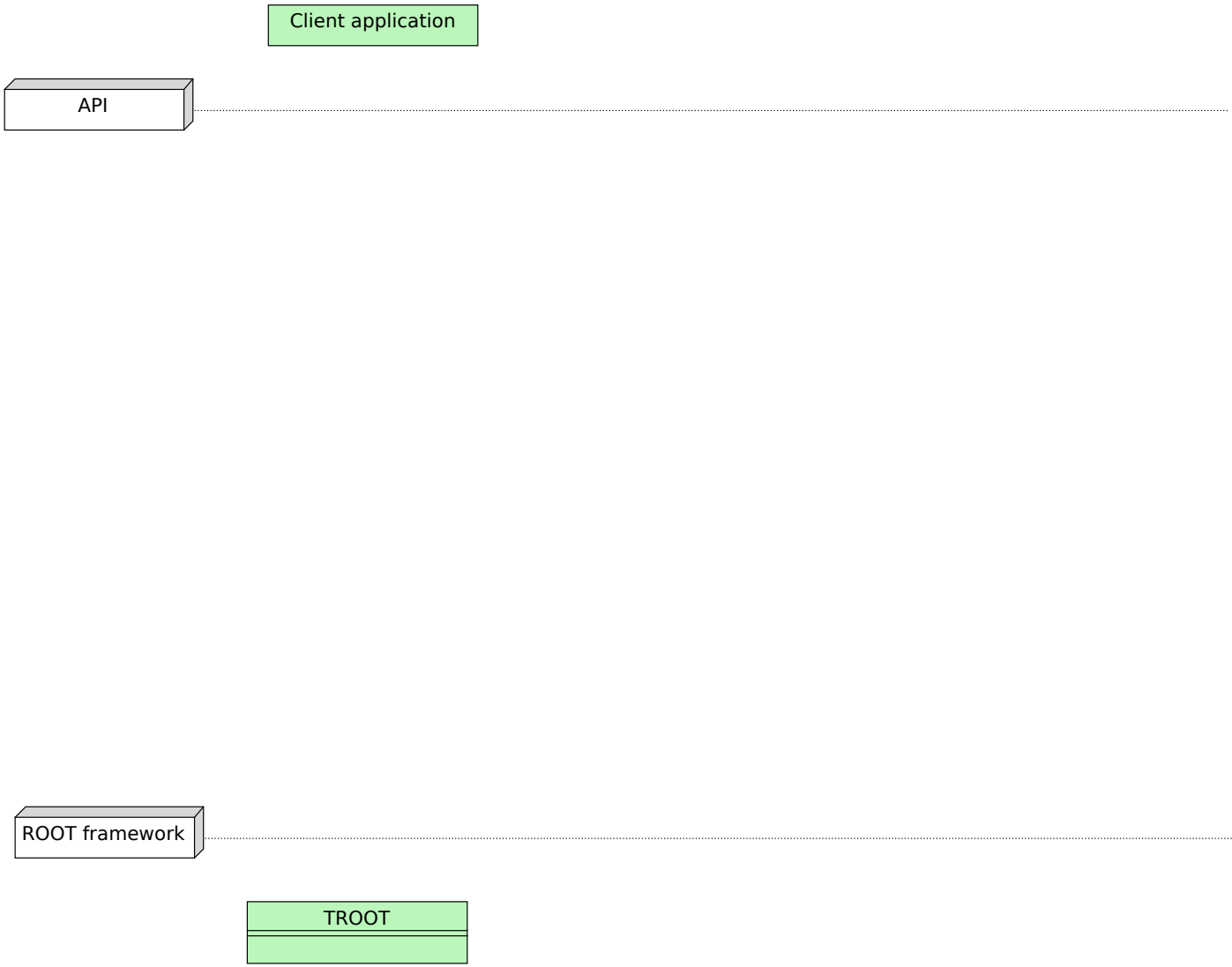
# UseJIT

*Flow of events*

3. `rootJS` takes care of encapsulating exceptions possibly thrown by `Cling` or `ROOT` during evaluation and execution.
4. `rootJS` provides the evaluation results and corresponding return values to the `NodeJSApplication`.

| | |
|---|---|
| *Entry condition* | `rootJS` and `Cling` have been initialized. |
| *Exit condition* | `rootJS` either confirms the proper execution of the specified instructions or forwards thrown exceptions to the `NodeJSApplication`. |

# Basic Architecture



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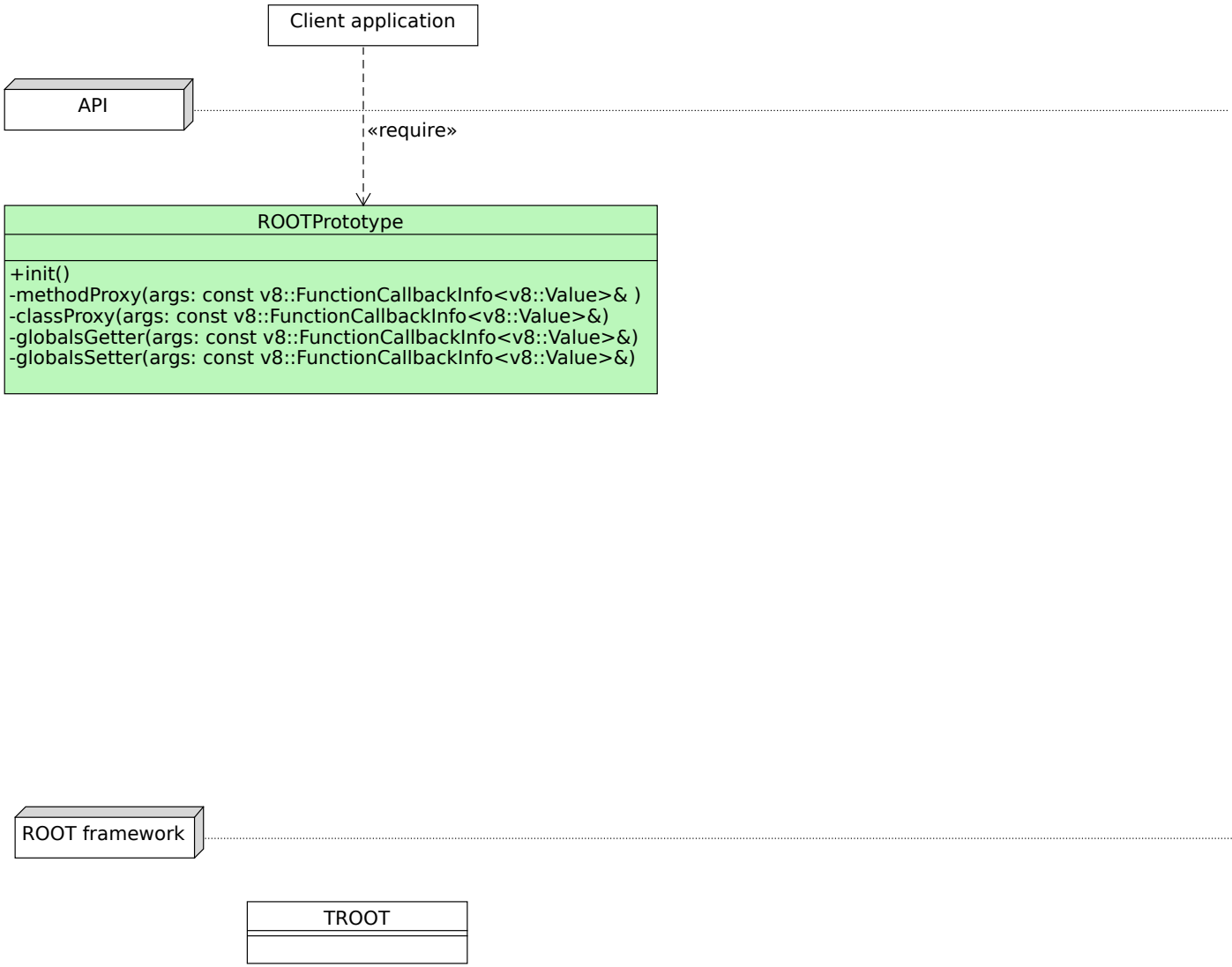

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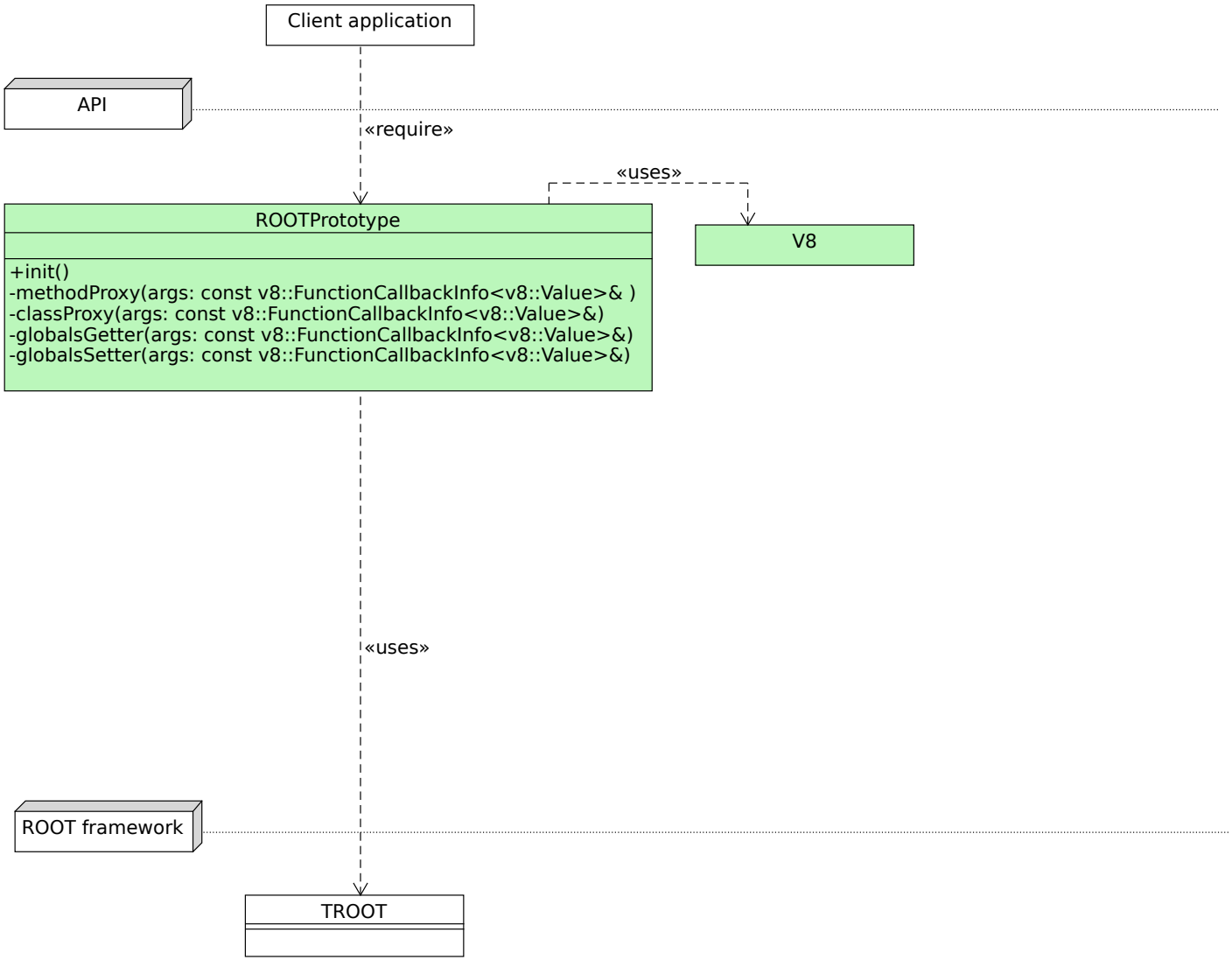

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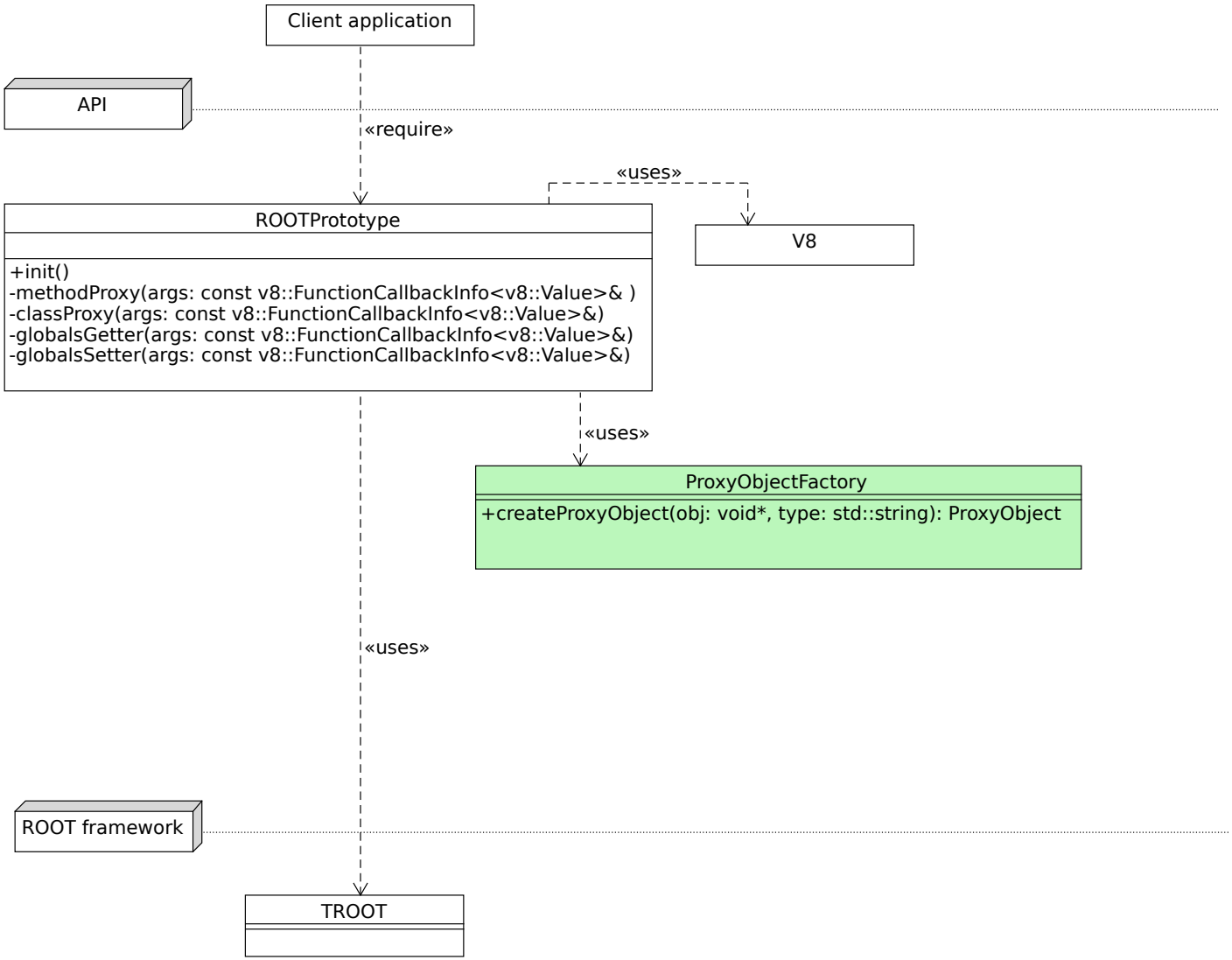

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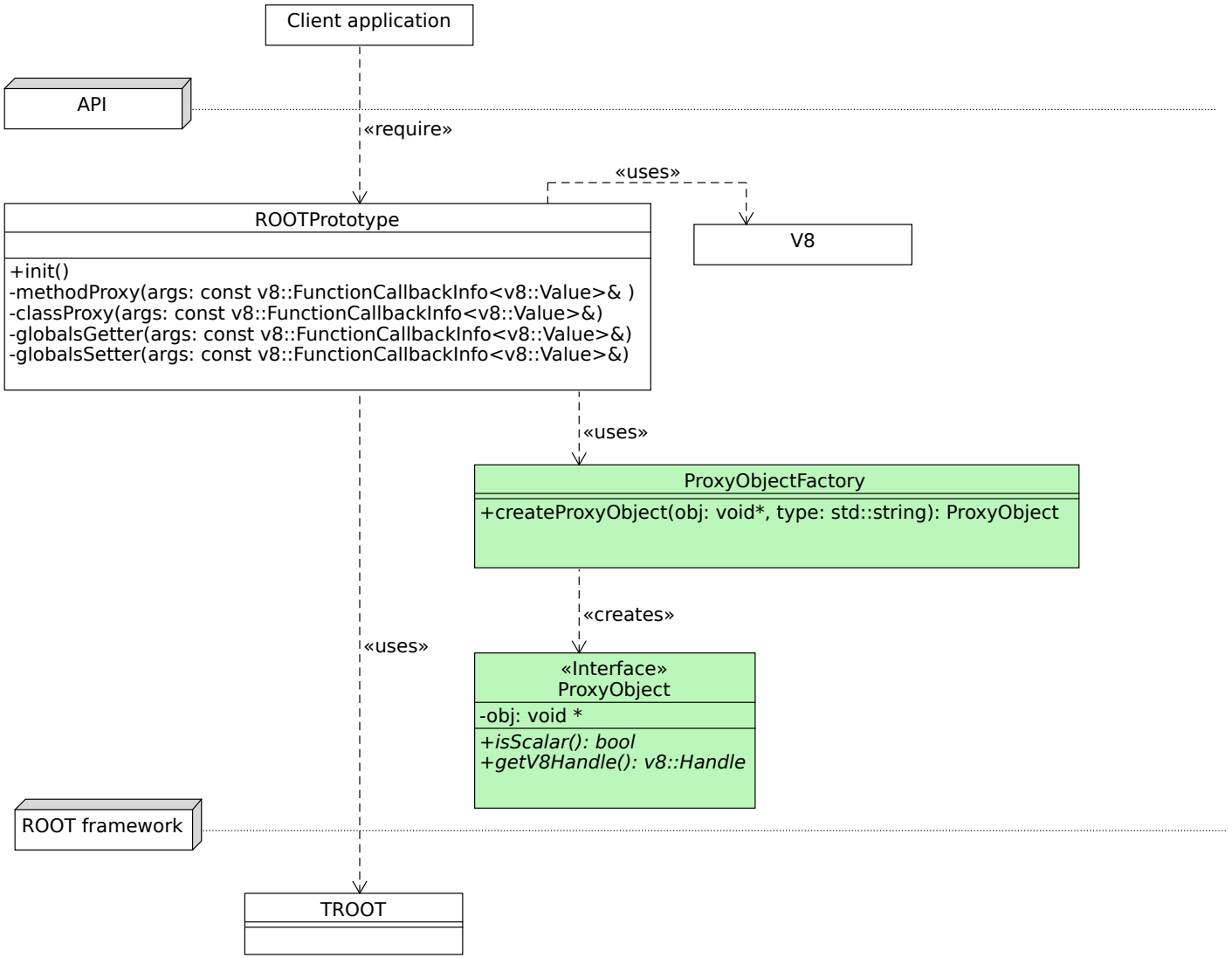

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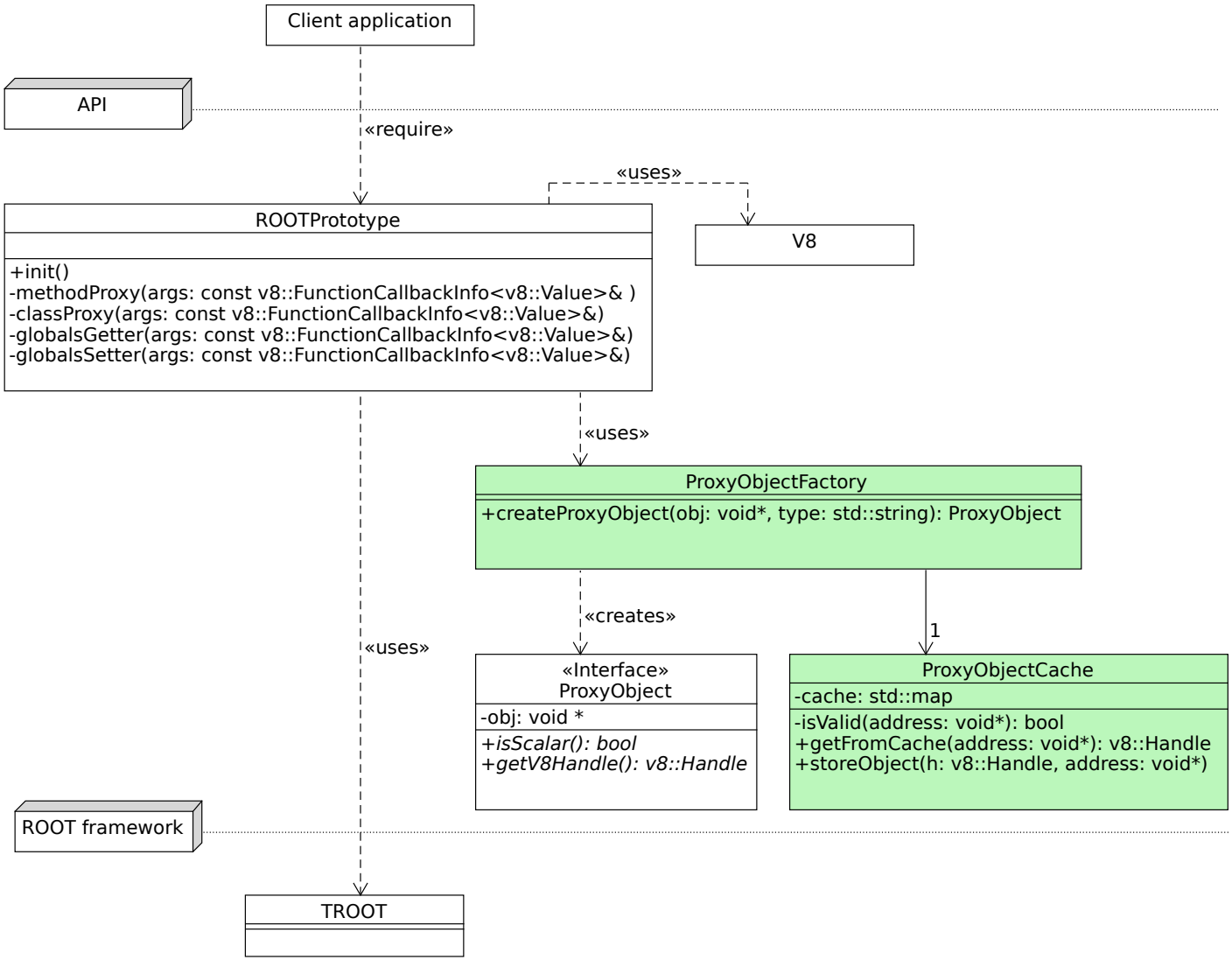

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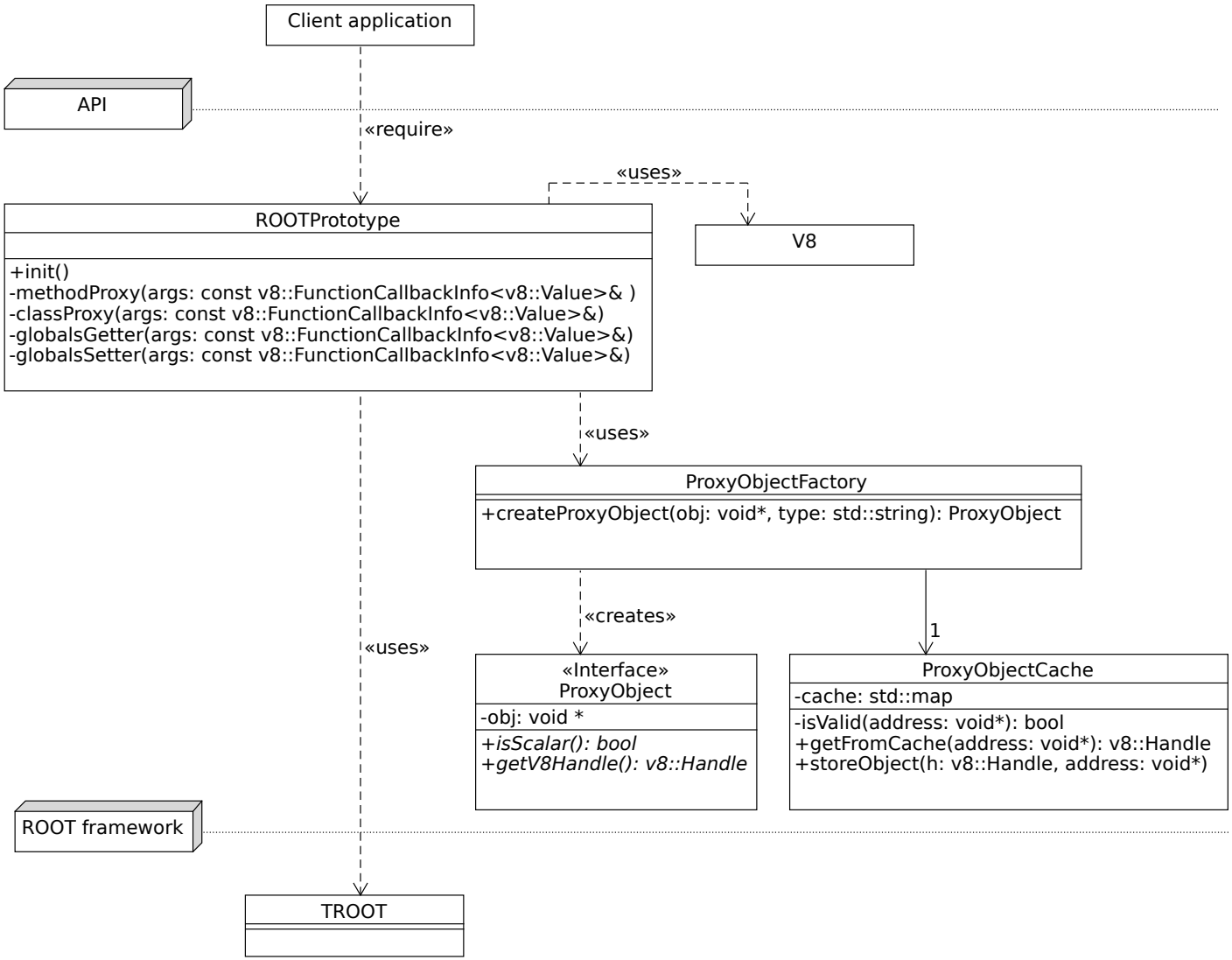

# Initialization

- Expose all
  - Global variables
  - Global functions
  - Classes

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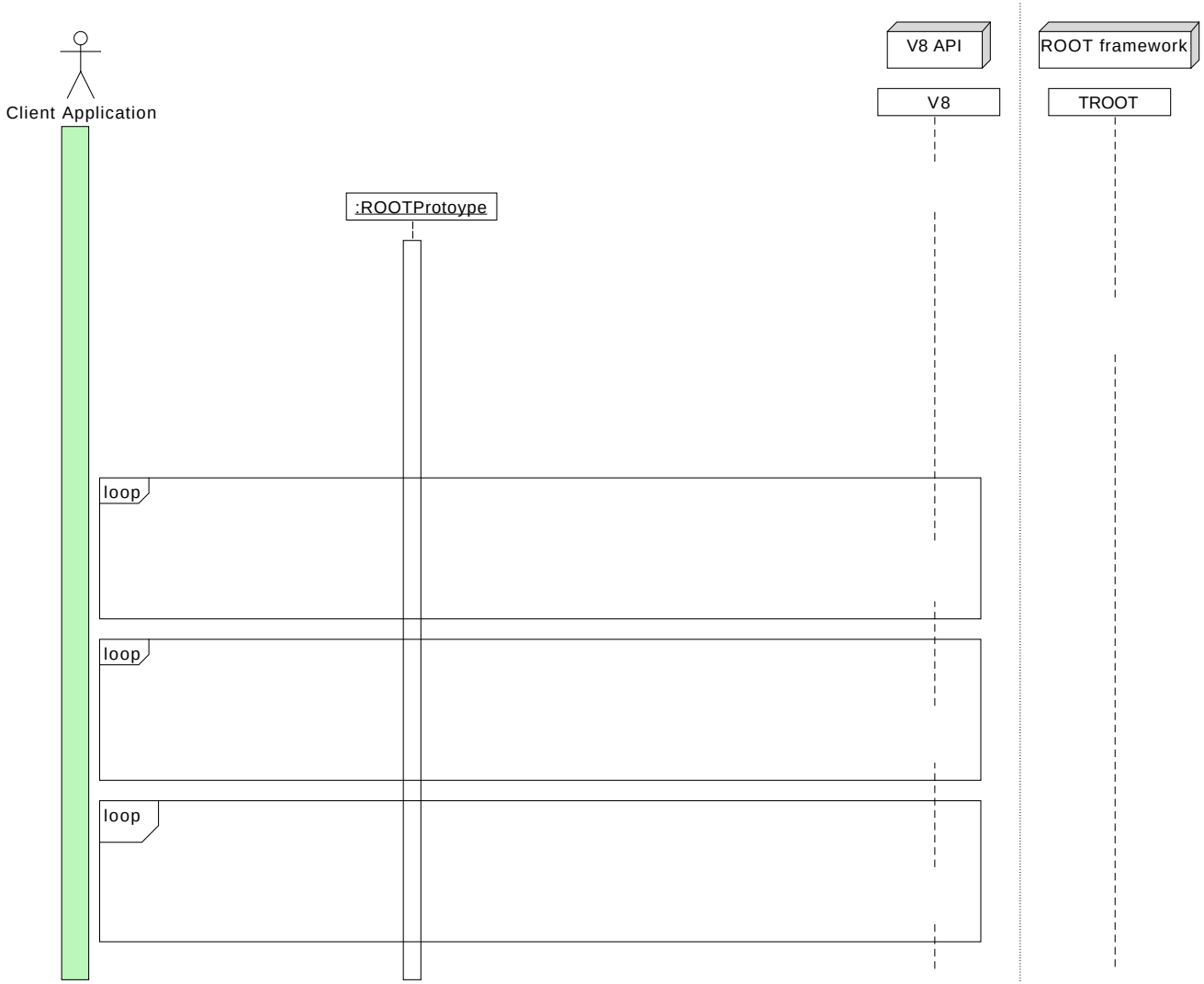
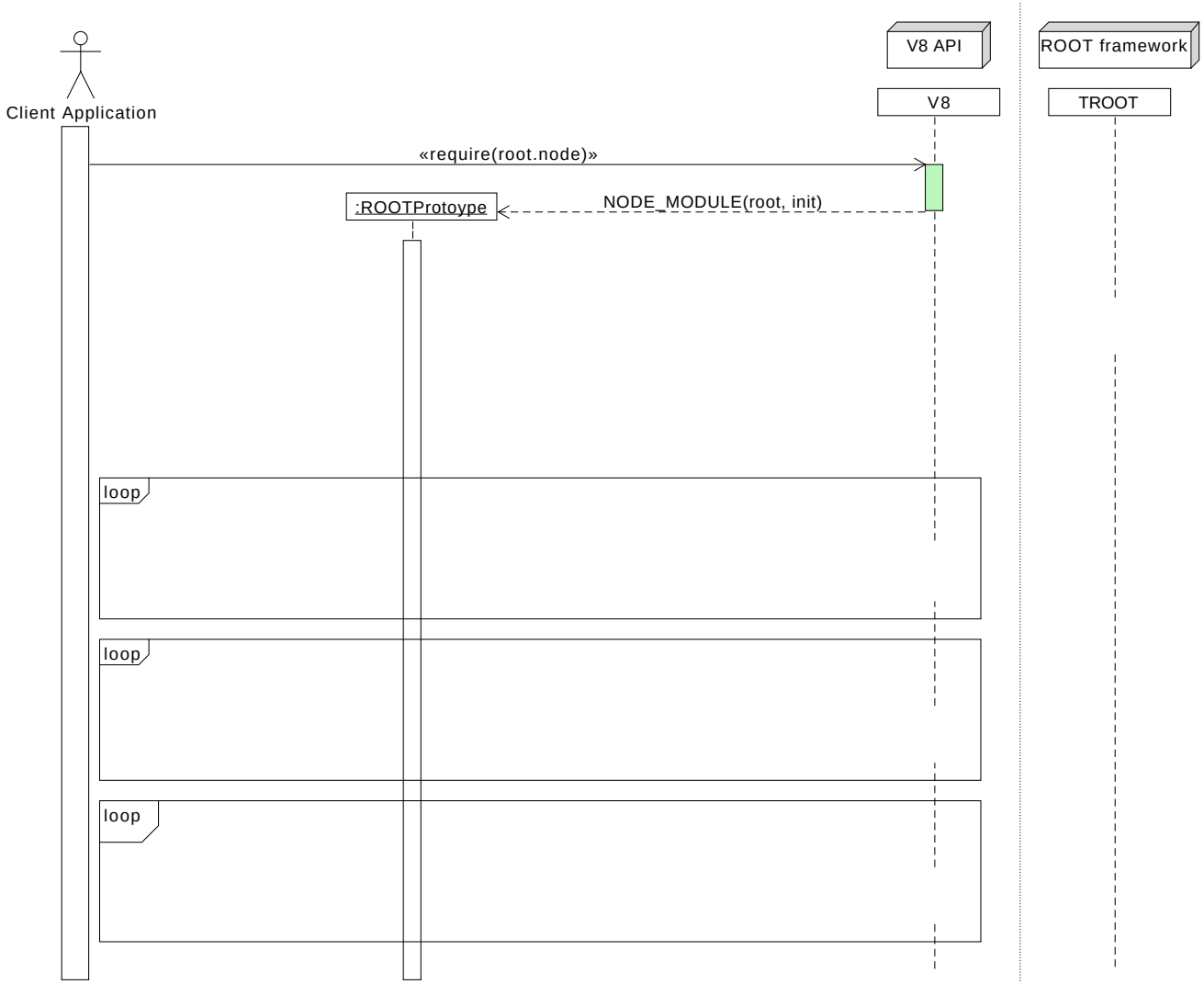
## Names

- Functions and classes have the same name as in Root
- Global variables can be called using Get[Variable] and Set[Variable] methods

# rootJS init


Client Application
V8 API
V8
ROOT framework
TROOT
:ROOTPrototype
loop
loop
loop

# rootJS init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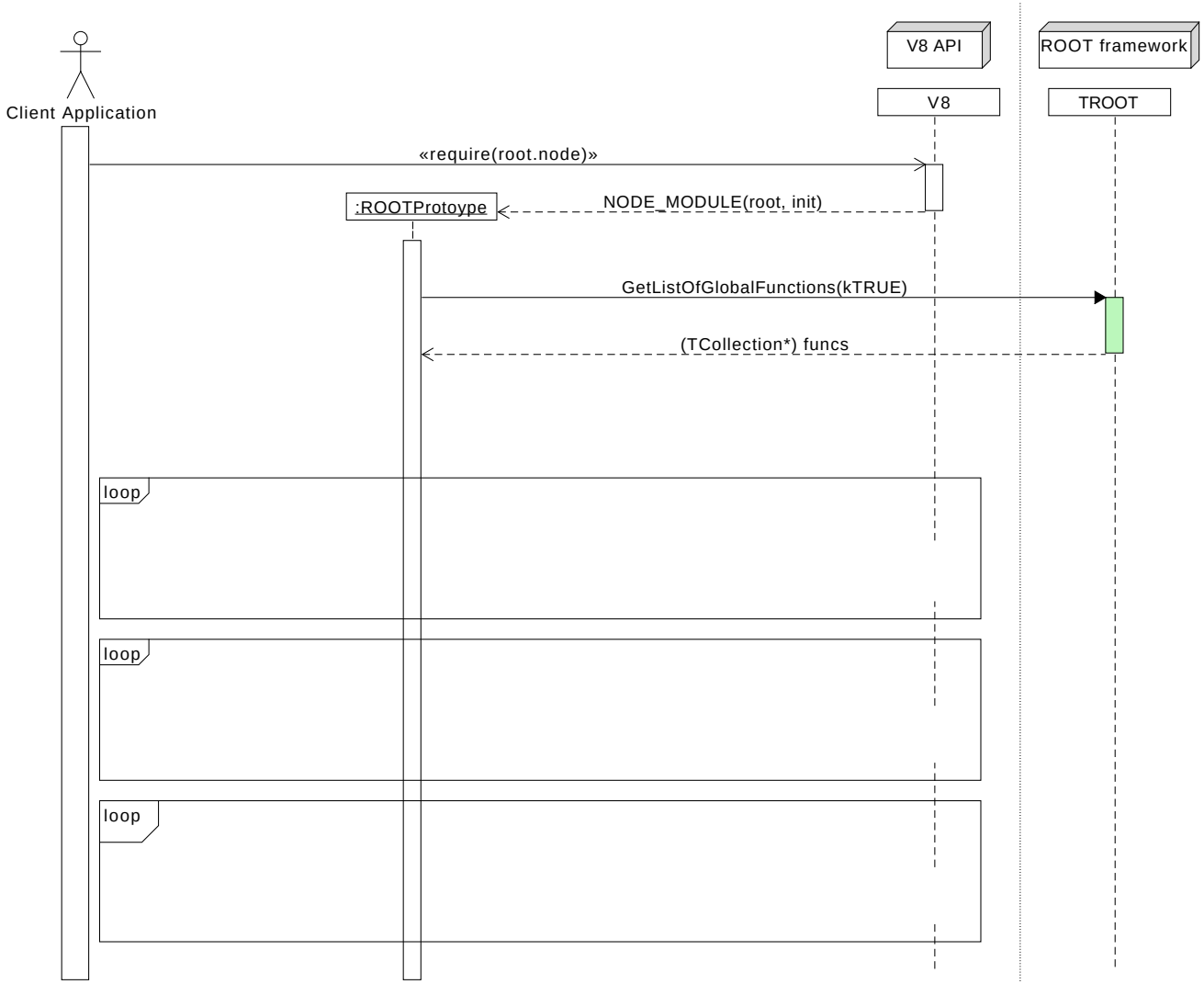
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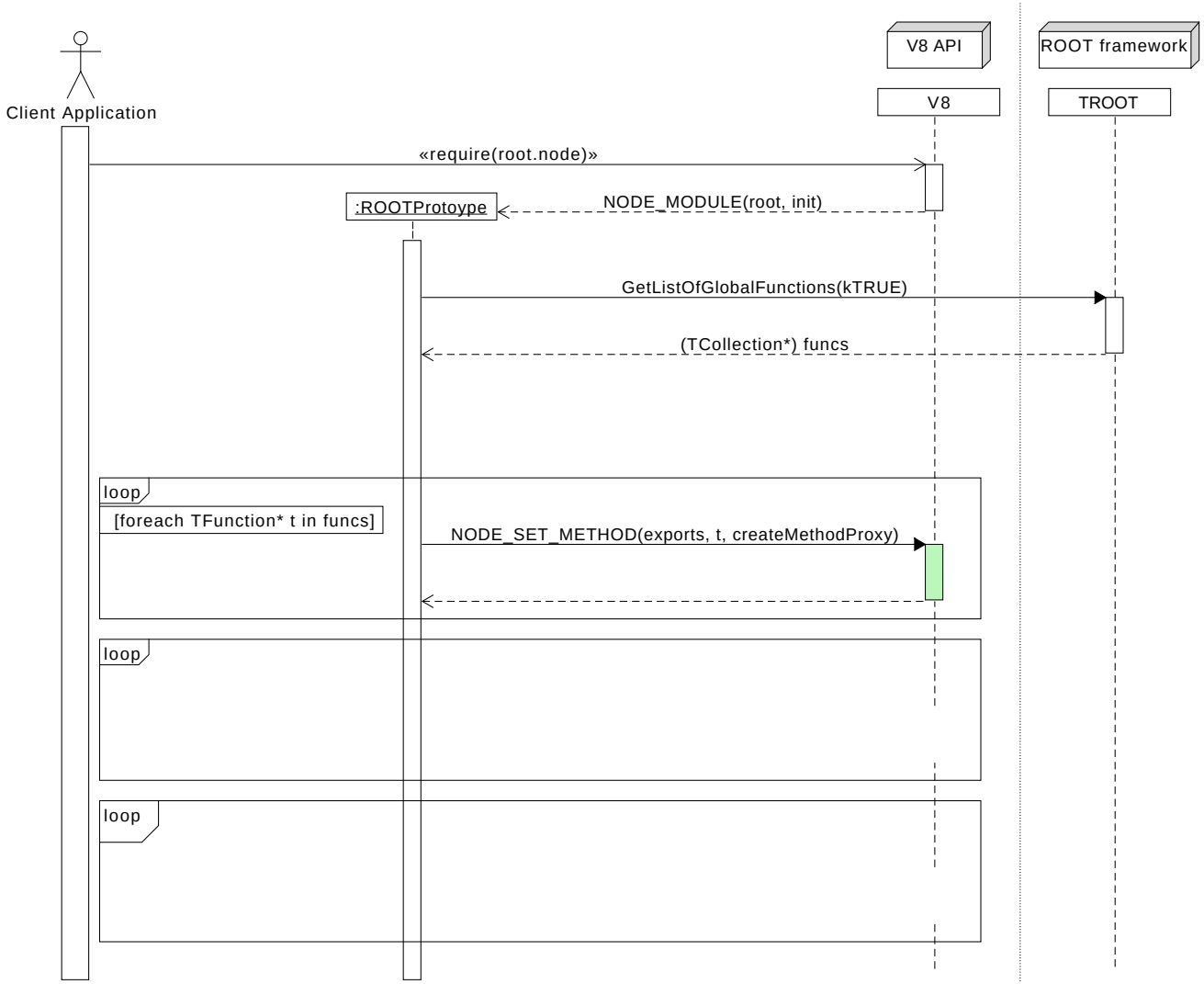
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NODE_SET_METHOD(exports, t, createMethodProxy)
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loop

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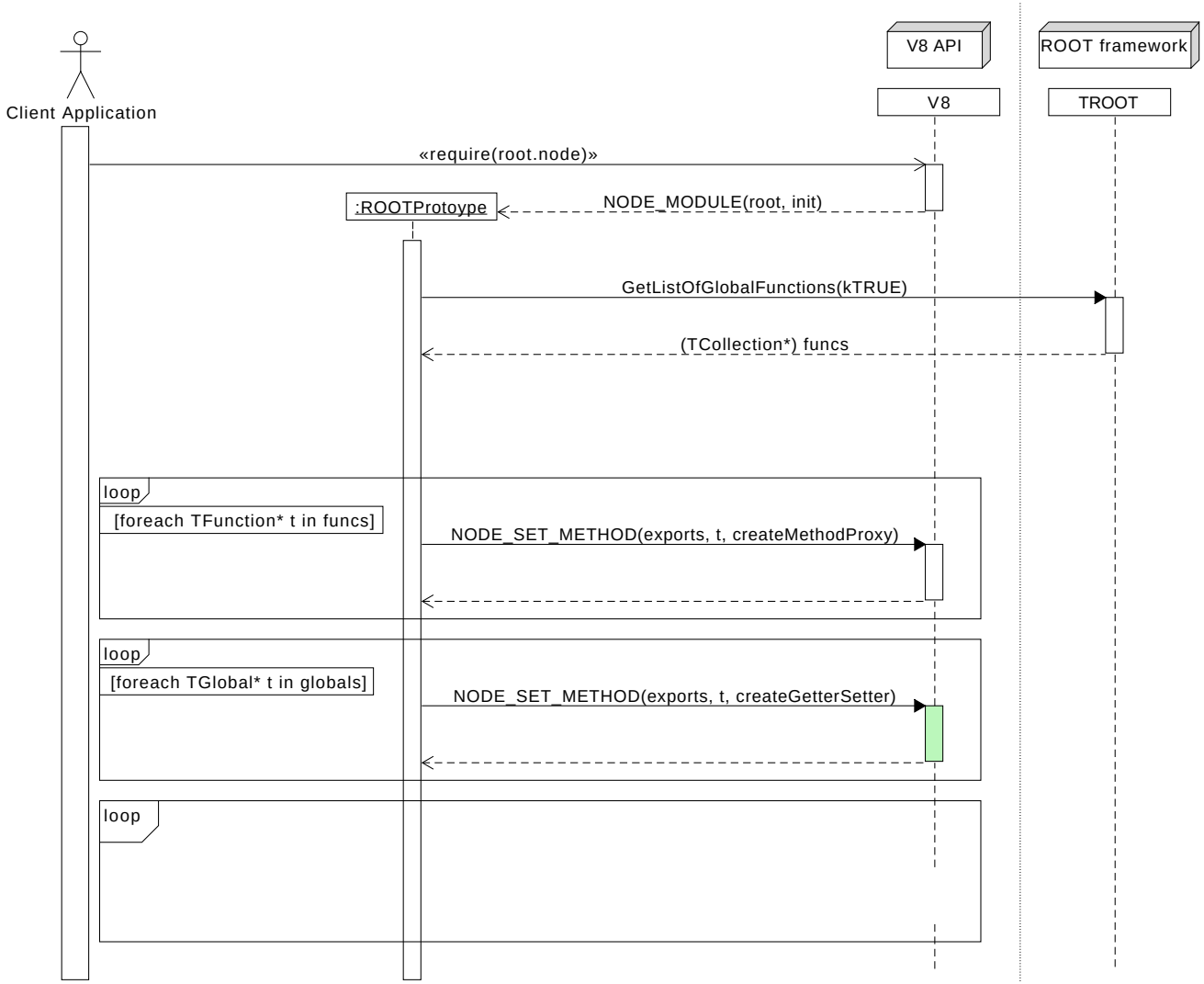
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NODE_SET_METHOD(exports, t, createGetterSetter)
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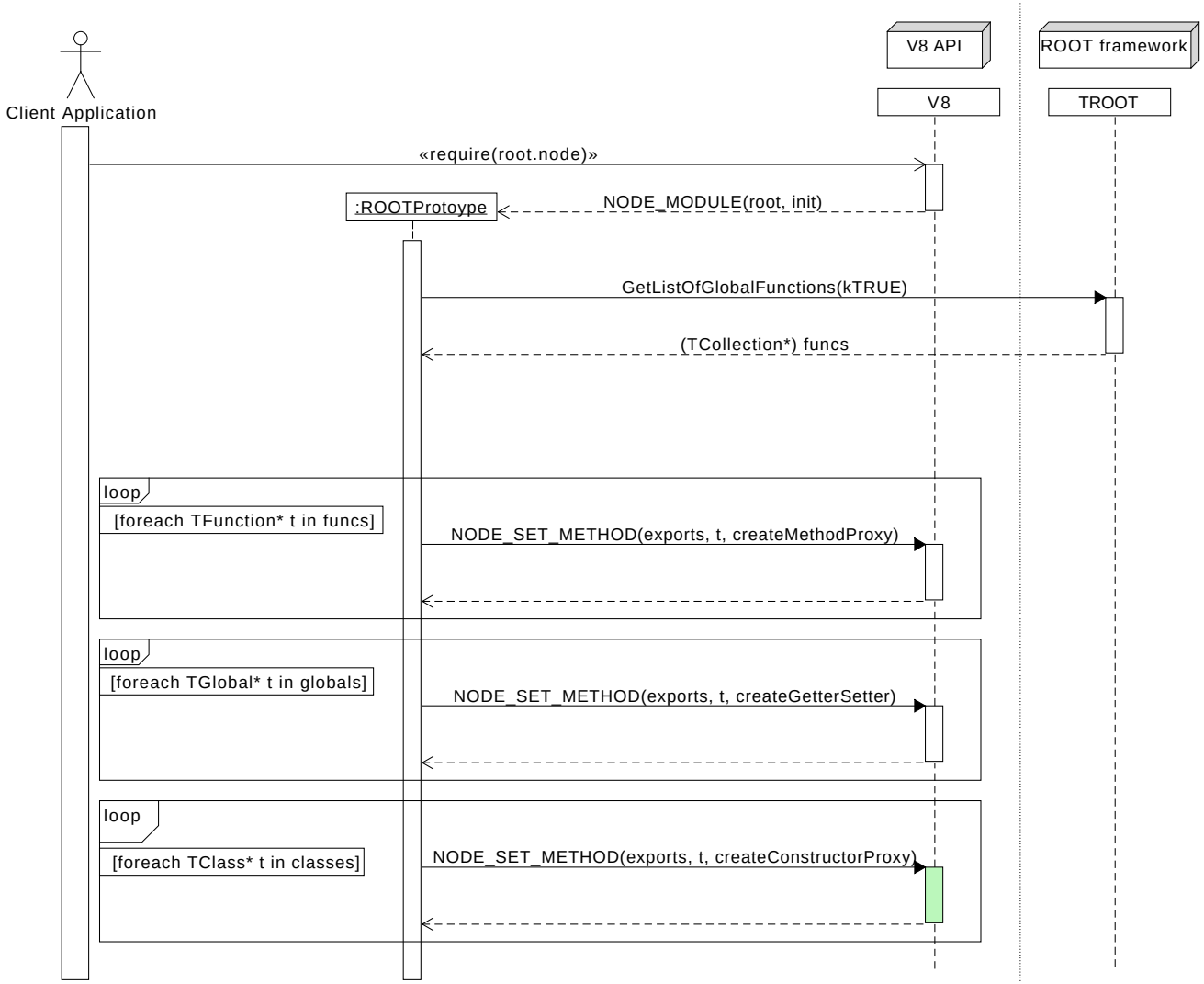
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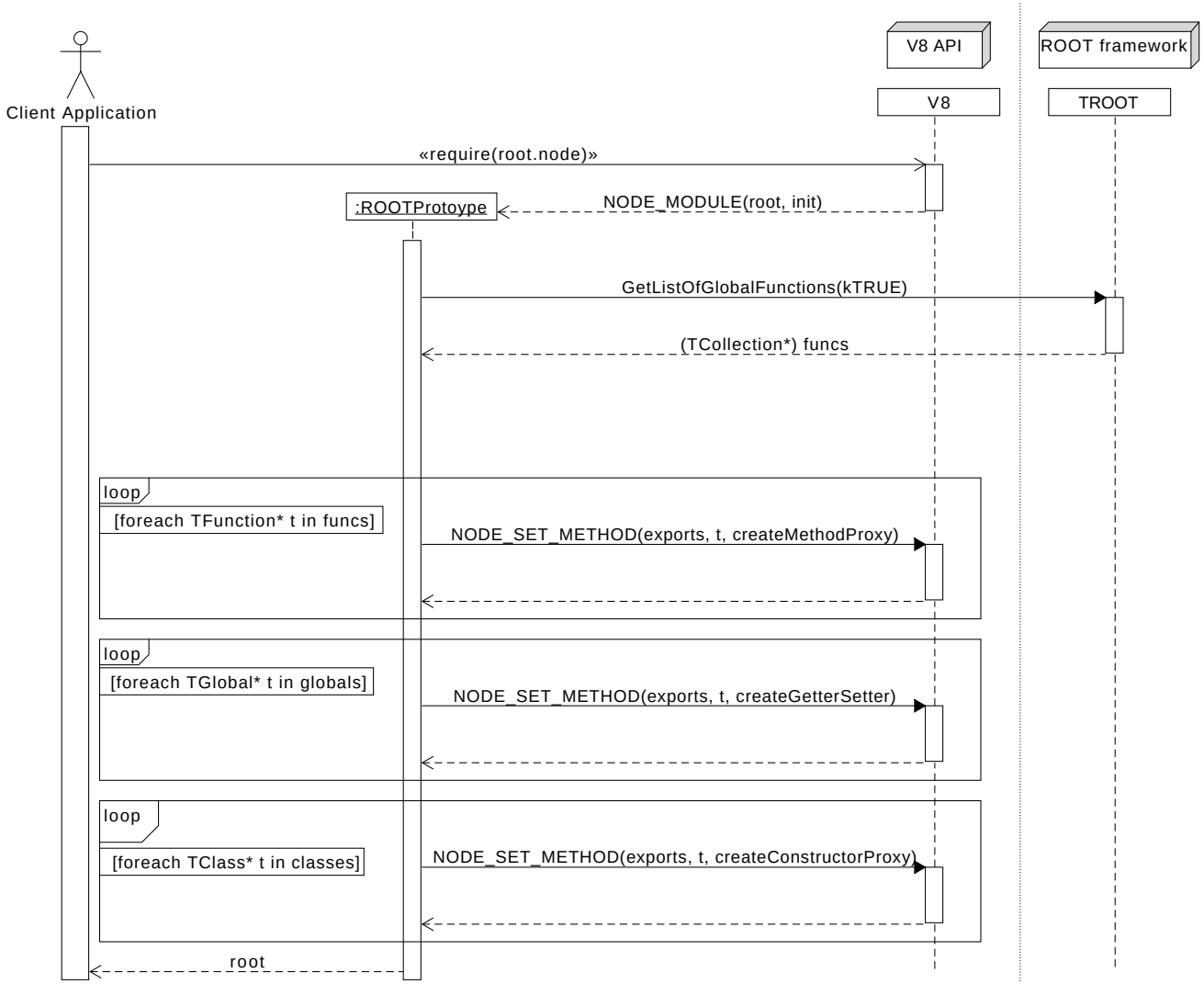
loop
[foreach TClass* t in classes]
NODE_SET_METHOD(exports, t, createConstructorProxy)

# rootJS init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root

# Call a feature

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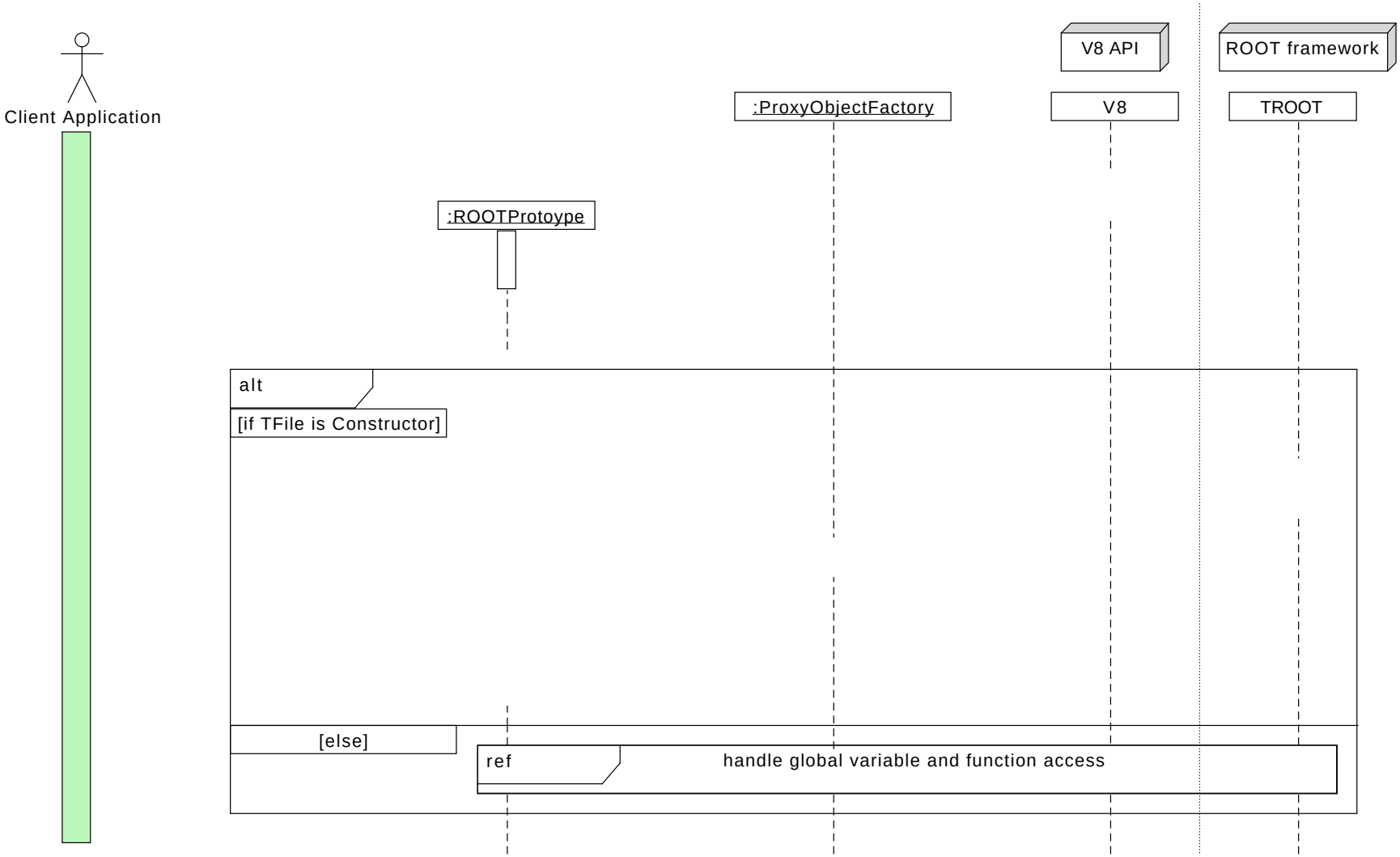
- The proxy method will eventually call a root function and pass the result to our ObjectFactory
- By looking at the object type an corresponding v8::Handle will be generated and returned to node
  - If the result is an object this will be done recursively

# proxied file access



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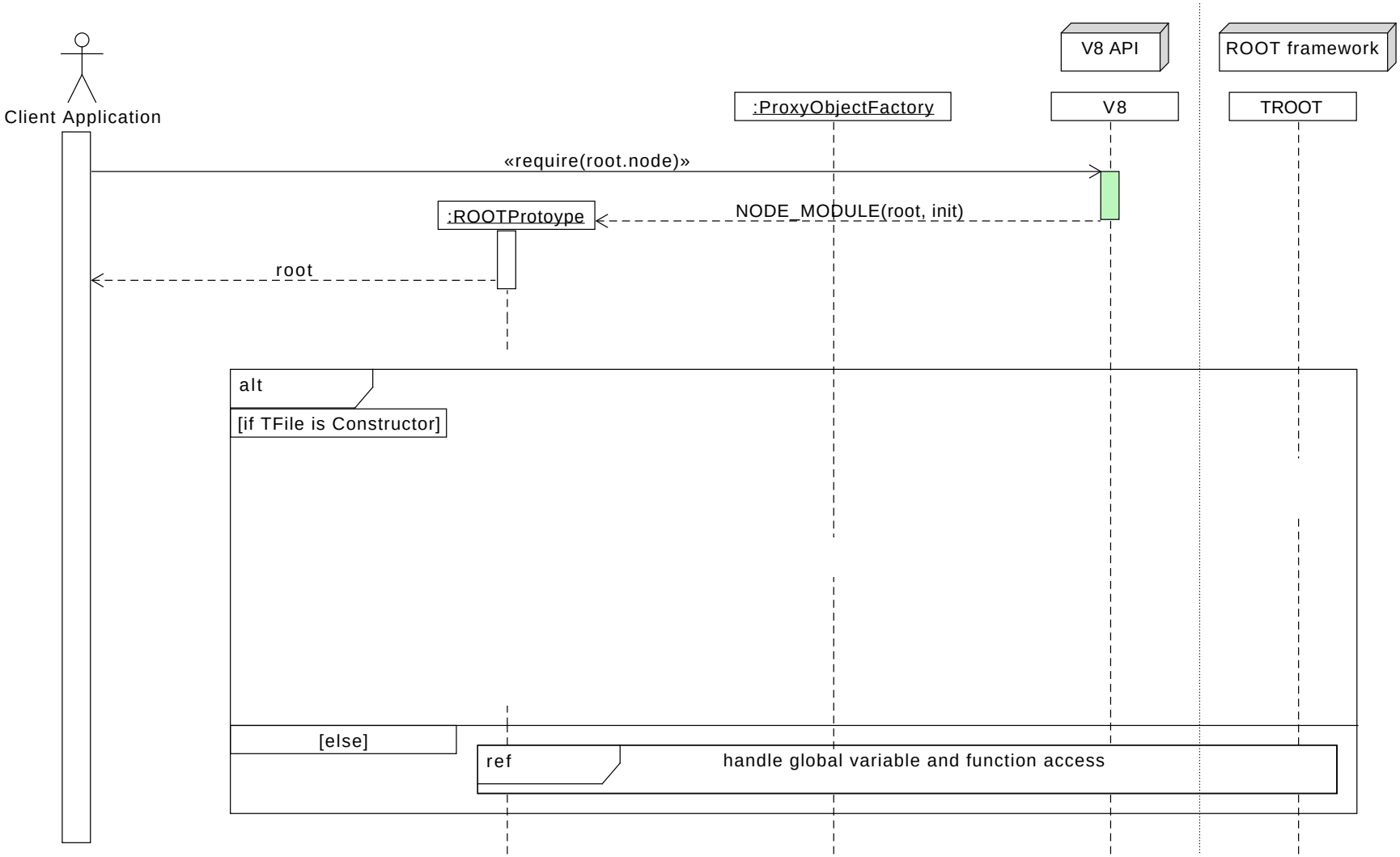

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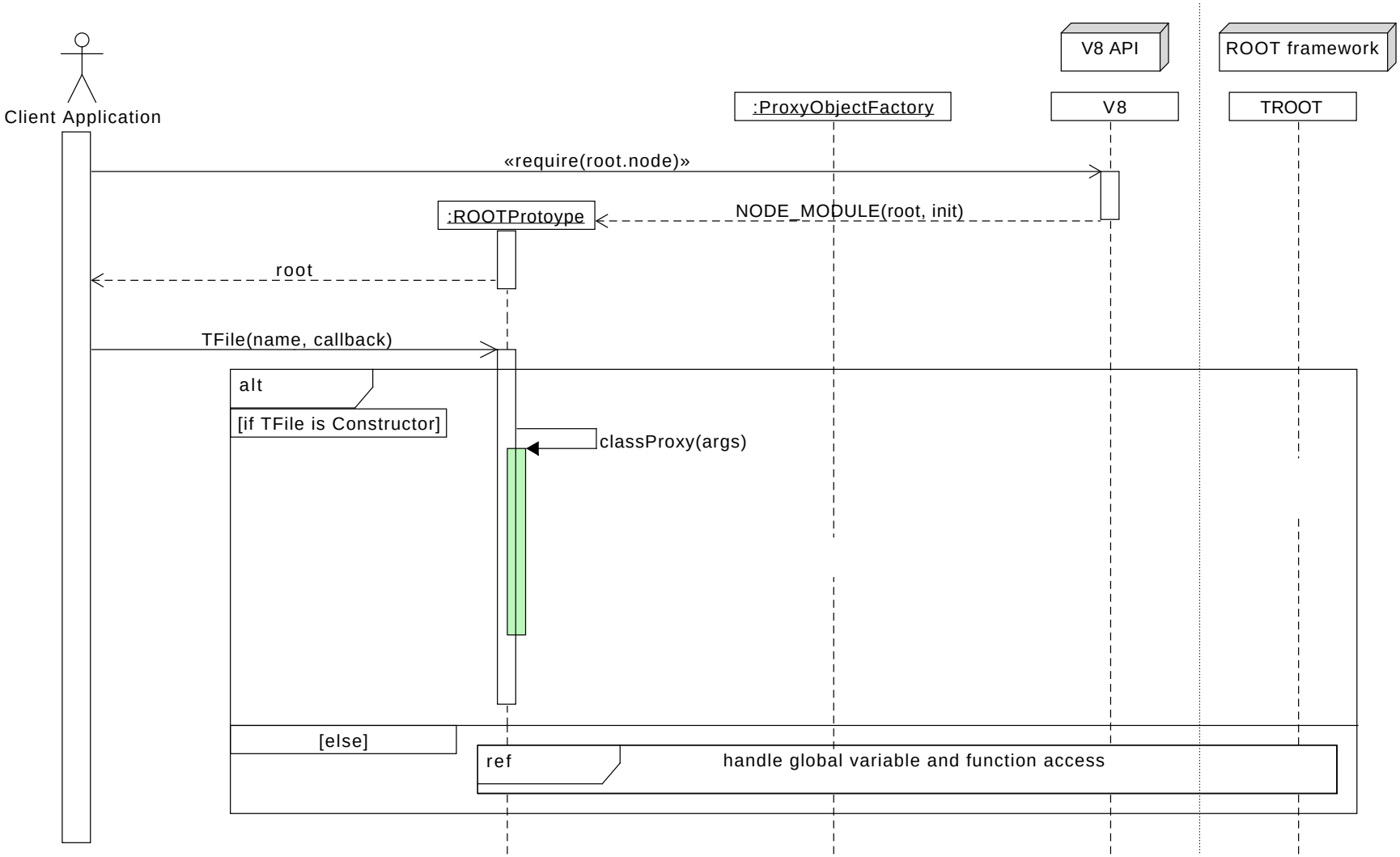

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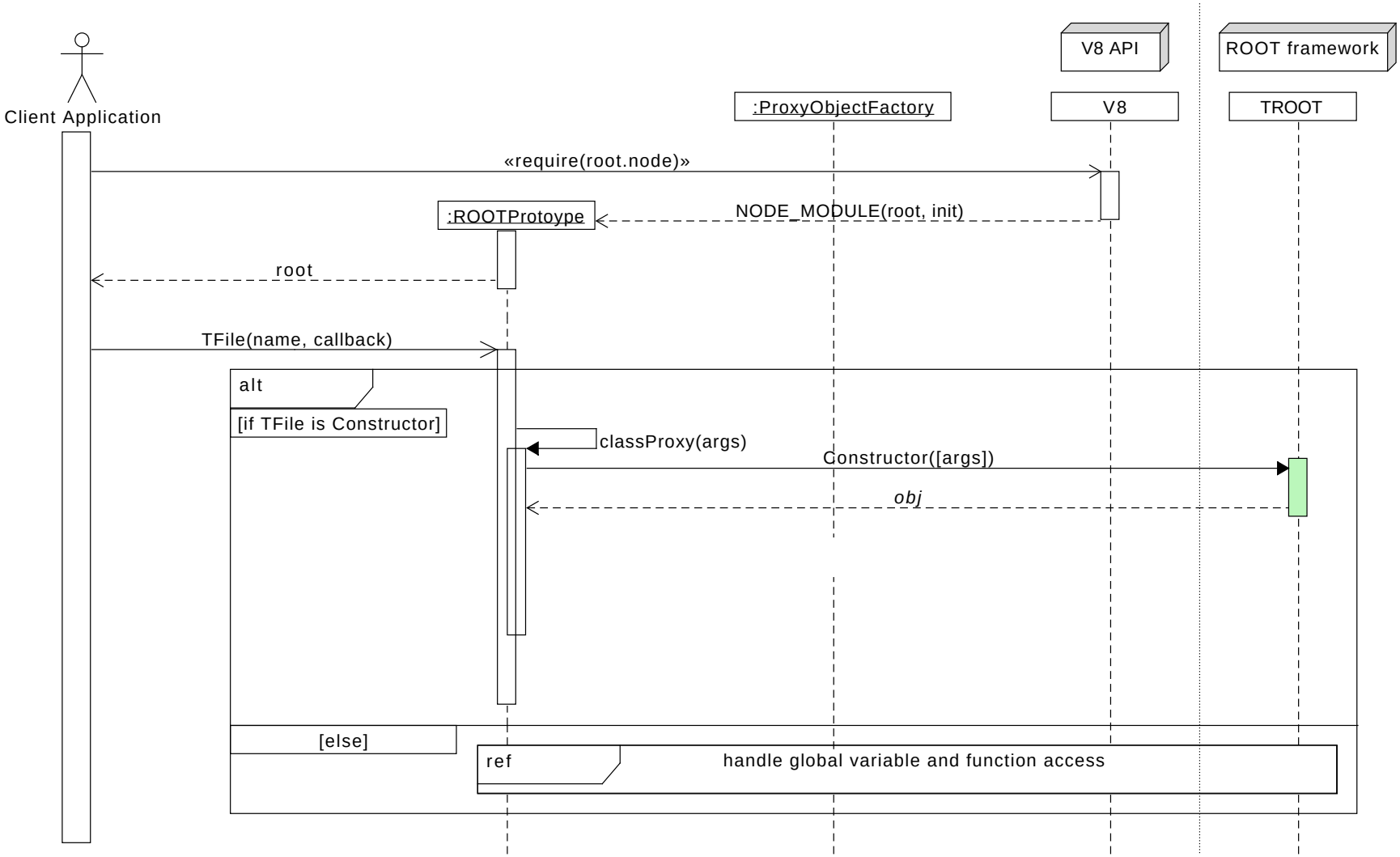

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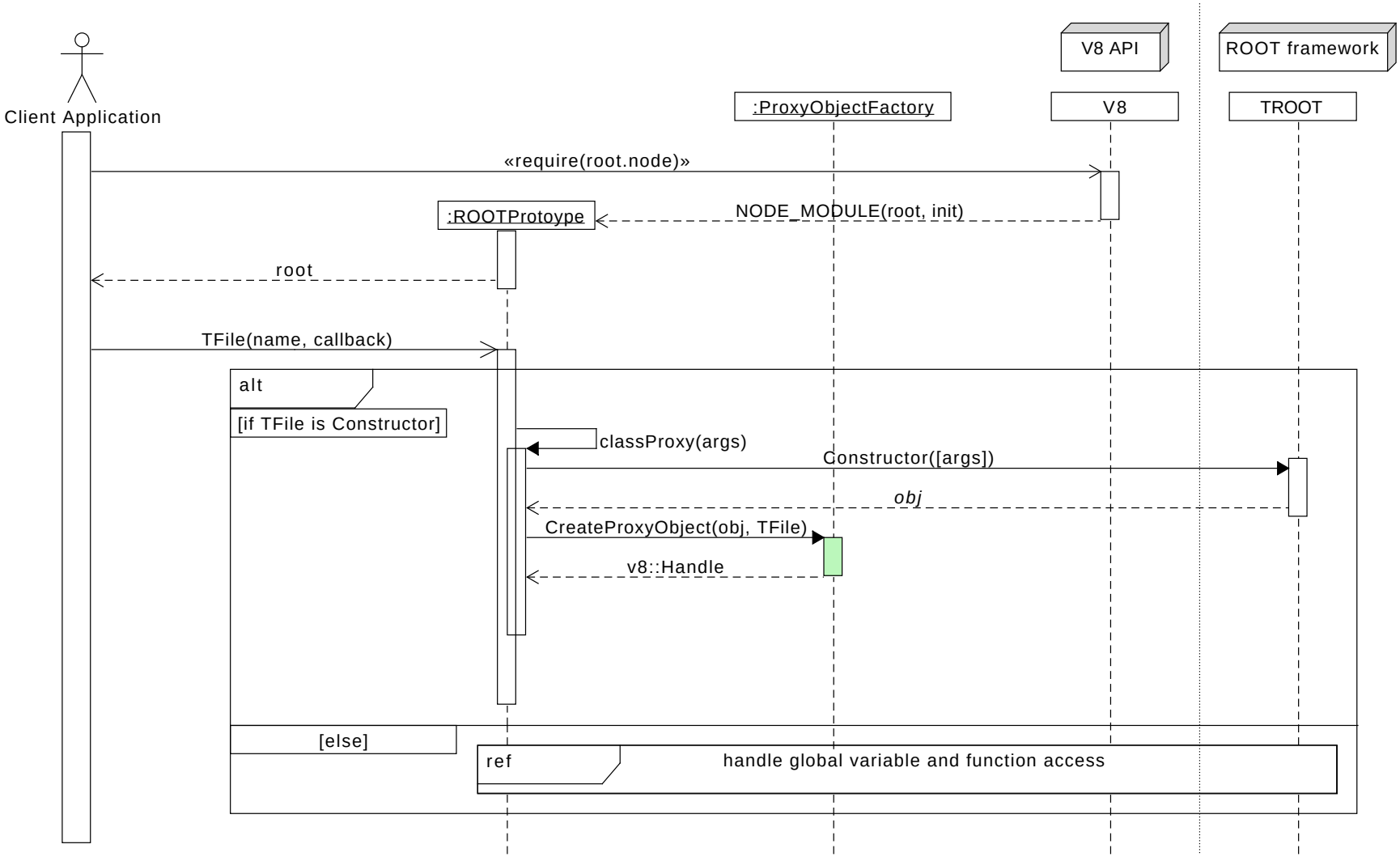

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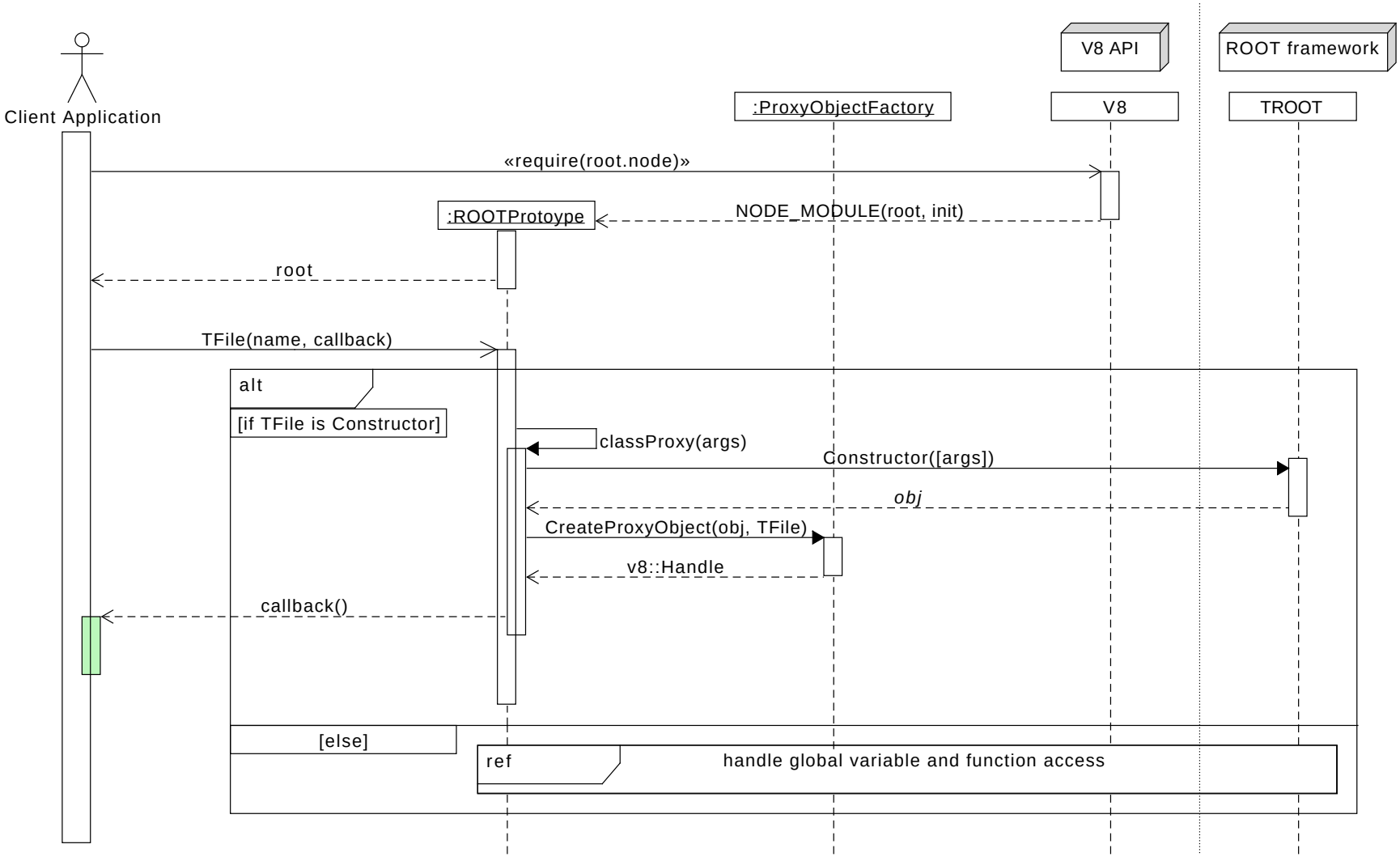

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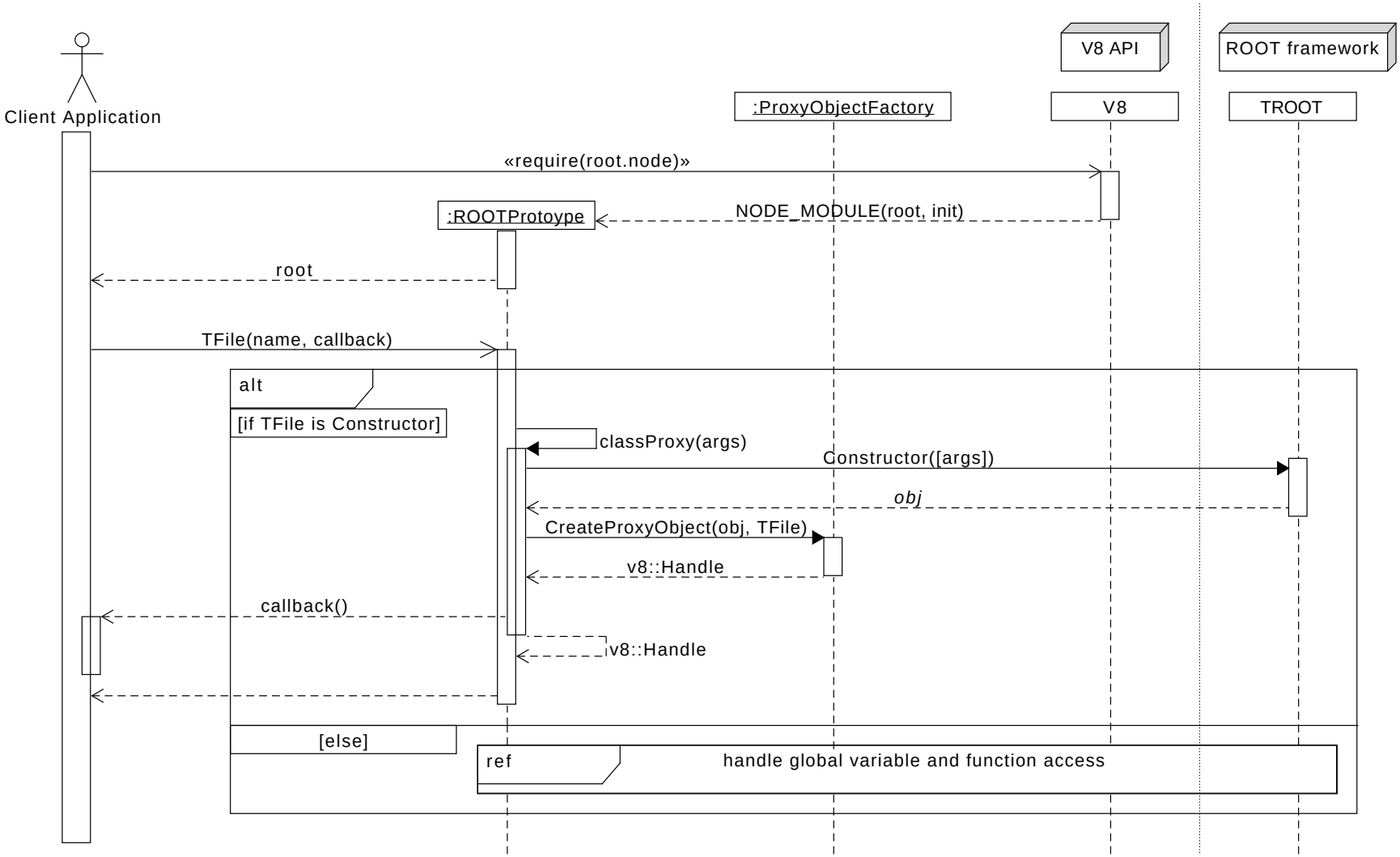
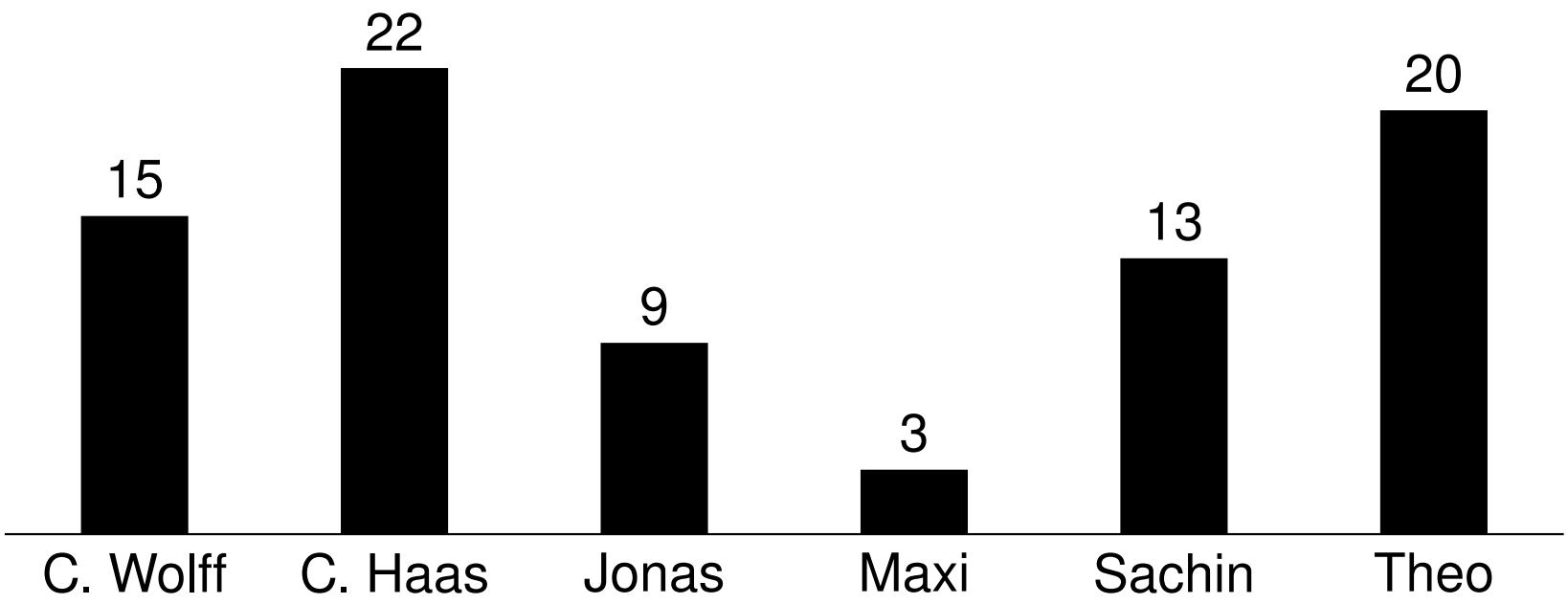


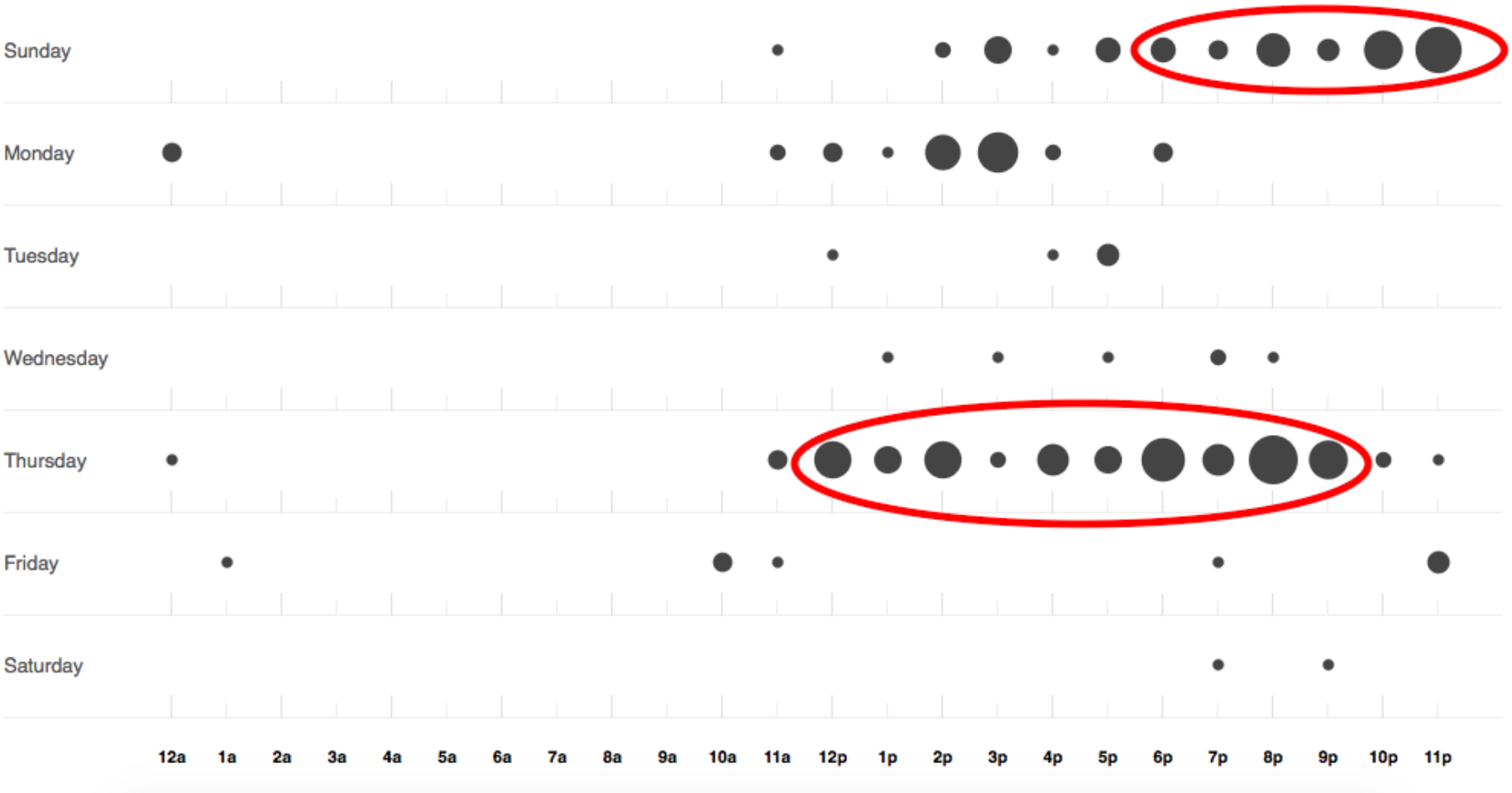
# Test Cases

- Make sure all elements are callable without crashing
- To verify results of function calls and calculations, we would need to run ROOT's testcases
- Porting all ROOT testcases would make no sense!
- Only port a subset to make sure the bindings are working and leave the rest to the ROOT developers

# Merges



# Punchcard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