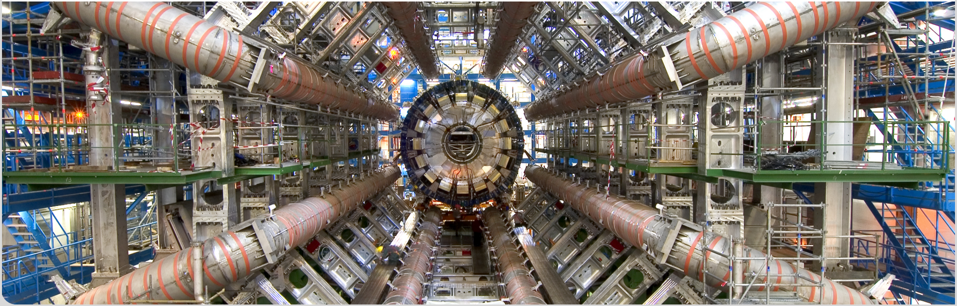
rootJS - Specification

PSE - Software Engineering Practice

C. Wolff, M. Früh, S. Rajgopal, C. Haas, J. Schwabe, T. Beffart | December 15, 2015

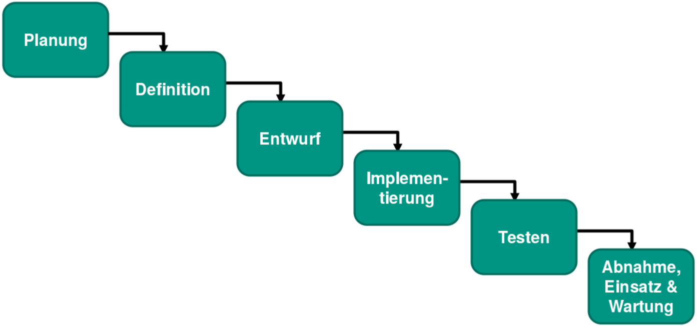
STEINBUCH CENTER FOR COMPUTING



About PSE

Praxis der Softwareentwicklung(PSE) = Software Engineering Practice

- Waterfall model
  - Planning/definition



Planung

Definition

Entwurf

Implementierung

Testen

Abnahme, Einsatz & Wartung

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++.

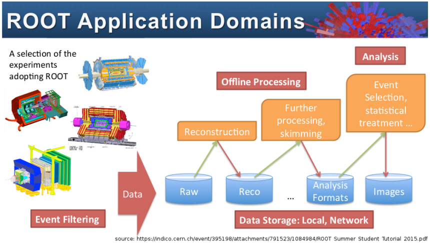
- Scientists (e.g. particle physicists)
- Researchers
- Web-developers interested in creating applications based on ROOT

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



ROOT Application Domains

A selection of the experiments adopting ROOT

Analysis

Offline Processing

Event Selection, statistical treatment ...

Further processing, skimming

Reconstruction

Data

Raw

Reco

...

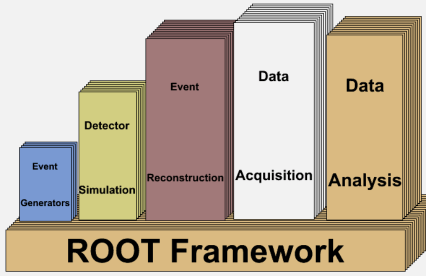
Analysis Formats

Images

Event Filtering

Data Storage: Local, Network

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



Event Generators

Detector Simulation

Event Reconstruction

Data Acquisition

Data Analysis

ROOT Framework

Node.js

- open source runtime environment
    - develop server side web applications
    - act as a stand alone web server

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- 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

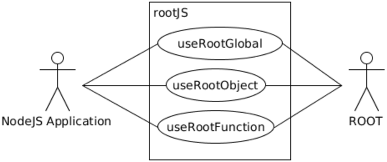
Product data

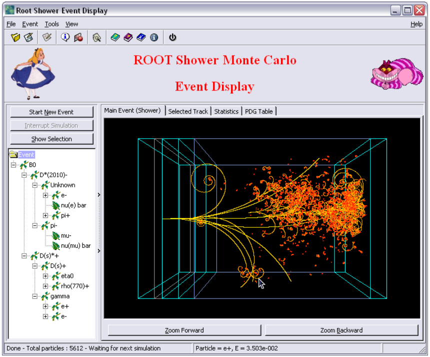
The following data will be stored by the rootJS bindings

- 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

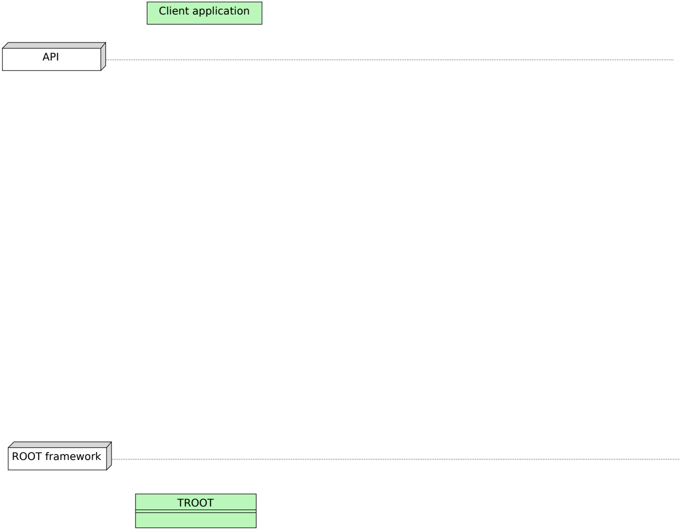




Done - Total particles : 5612 - Waiting for next simulation

Particle = e+, E = 3.503e-002

Basic Architecture



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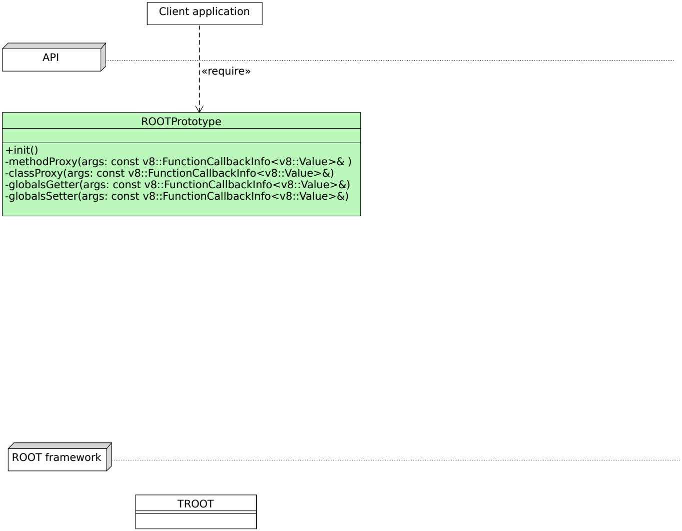

Client application

API

«require»

ROOTPrototype

+init()
-methodProxy(args: const v8::FunctionCallbackInfo<v8::Value>&)
-classProxy(args: const v8::FunctionCallbackInfo<v8::Value>&)
-globalsGetter(args: const v8::FunctionCallbackInfo<v8::Value>&)
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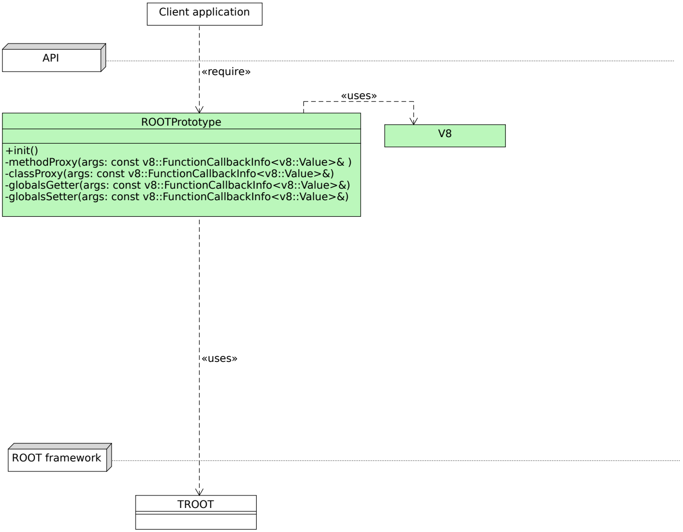
ROOT framework

TROOT

Basic Architecture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V8
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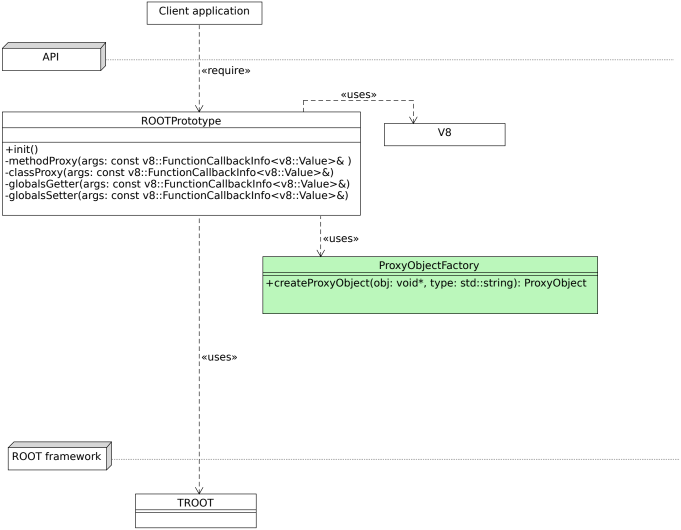
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ProxyObjectFactory
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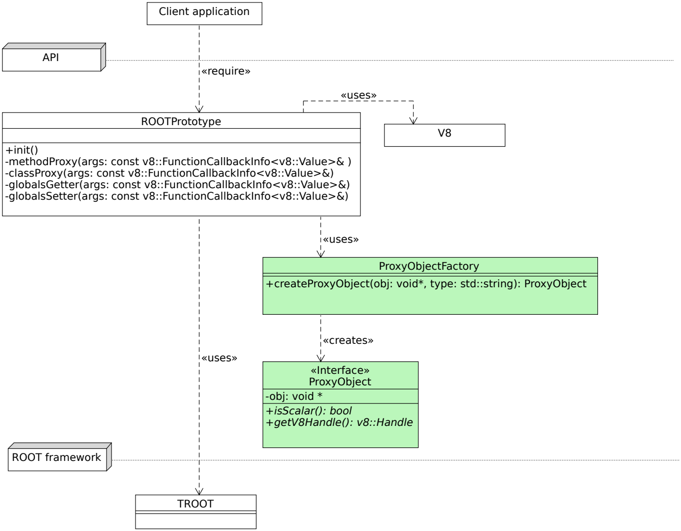

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«Interface»
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+isScalar(): bool
+getV8Handle(): v8::Handle

ROOT framework

TROOT

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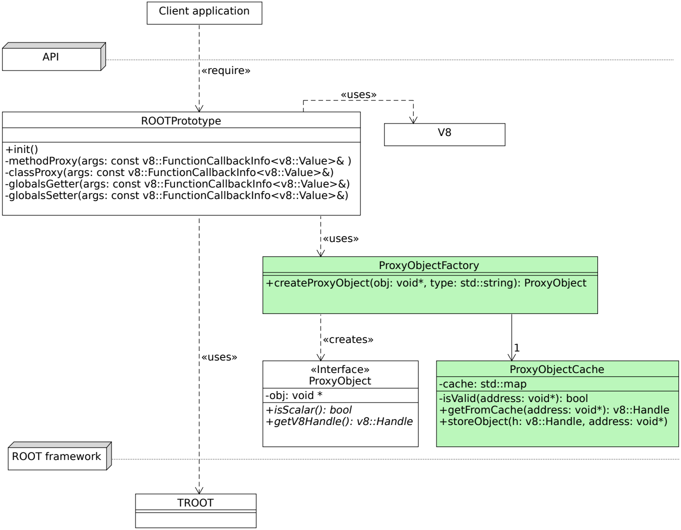

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+getV8Handle(): v8::Handle

ProxyObjectCache

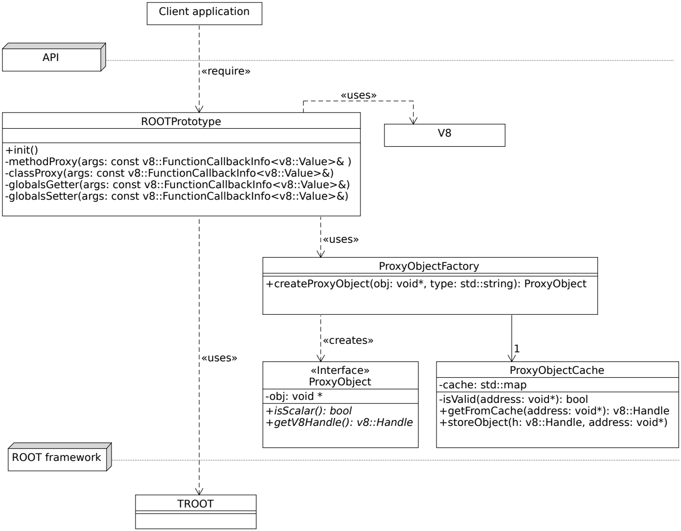
-cache: std::map

-isValid(address: void*): bool
+getFromCache(address: void*): v8::Handle
+storeObject(h: v8::Handle, address: void*)

ROOT framework

TROOT

Basic Architecture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  - Global variables
  - Global functions
  - Classes

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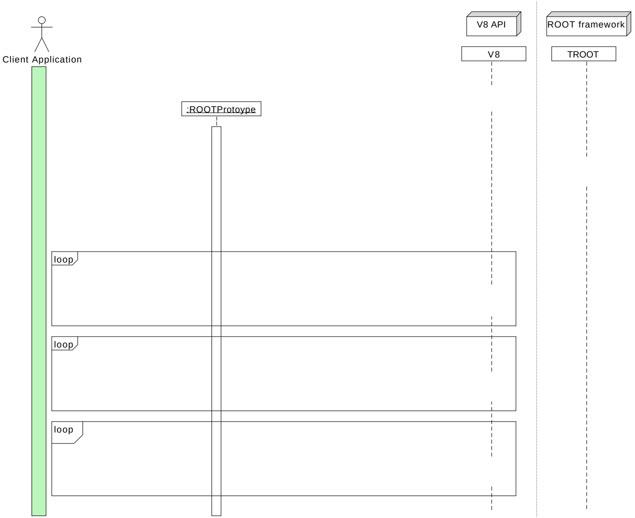
Names

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

rootJS init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V8 API
V8
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TROOT
loop
loop
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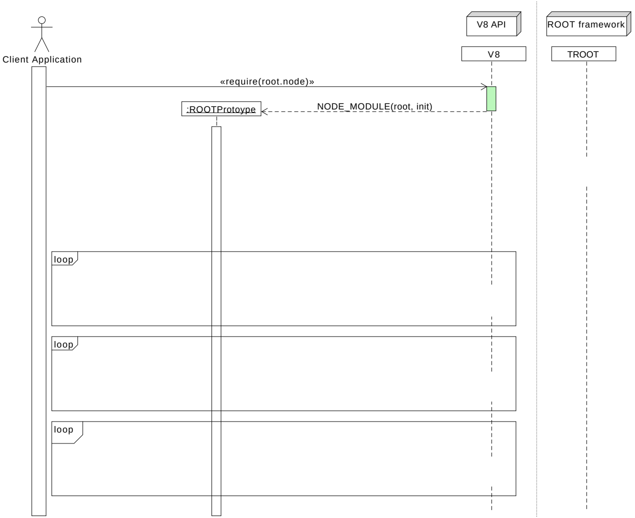
rootJS init



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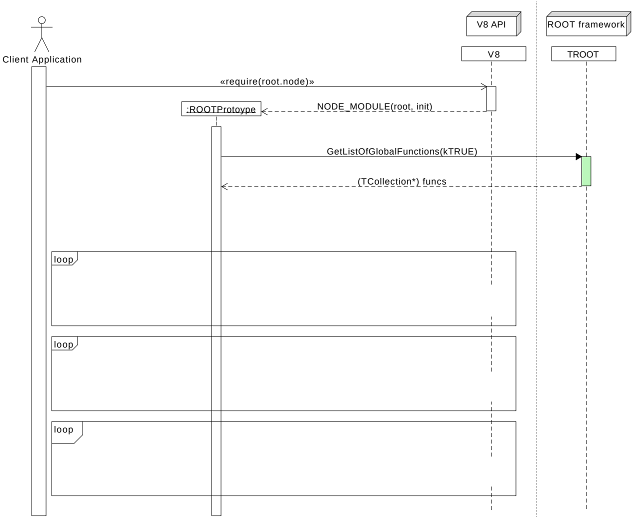

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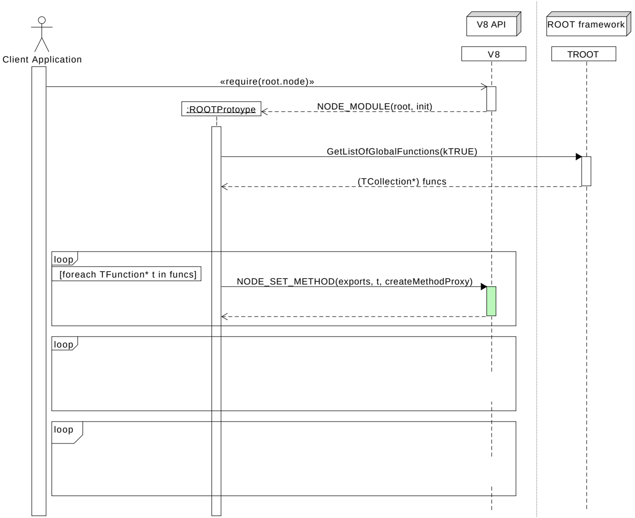
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loop

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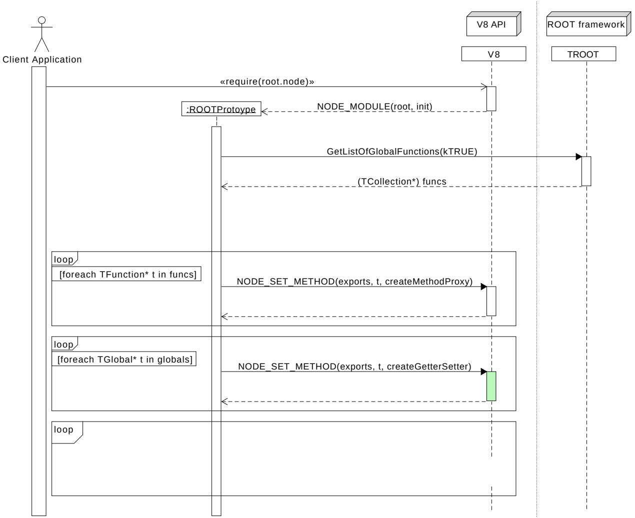
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loop
[foreach TGlobal* t in globals]
NODE_SET_METHOD(exports, t, createGetterSetter)
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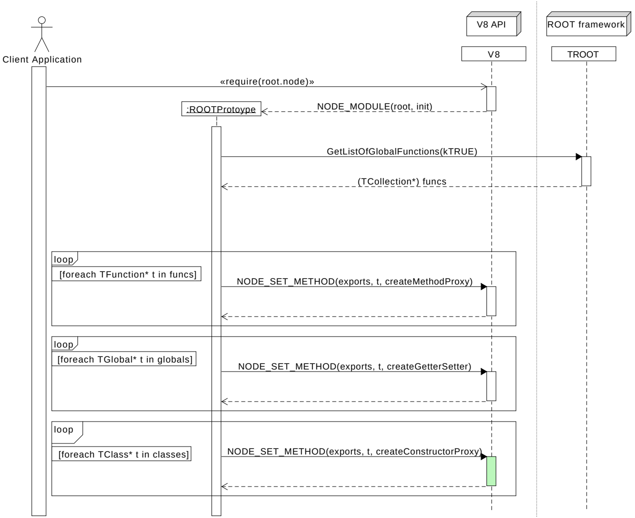
rootJS init



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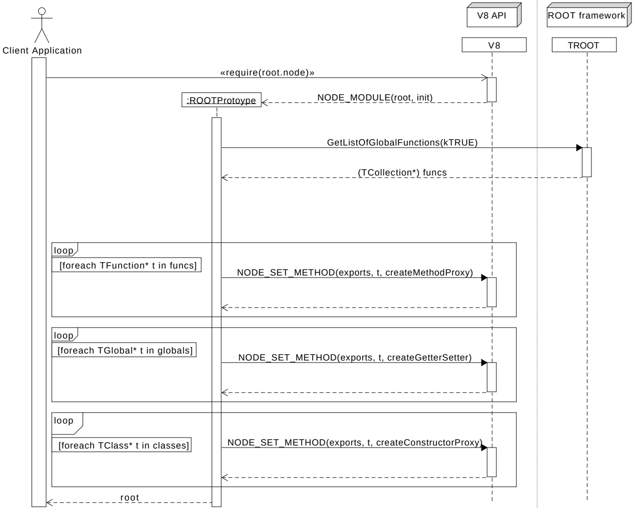

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root

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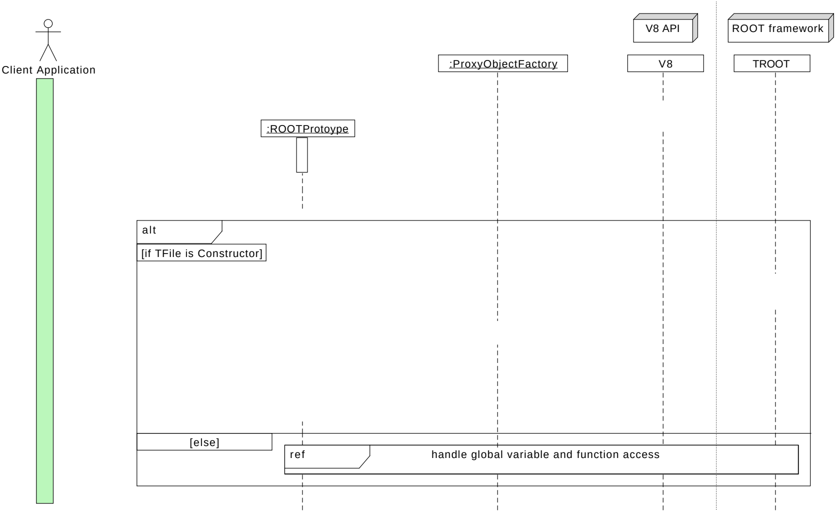
- The proxy method will eventually call a root function and pass the result to our ObjectFactory
- By looking at the object type an corresponding v8::Handle will be generated and returned to node
  - If the result is an object this will be done recursively

proxied file access



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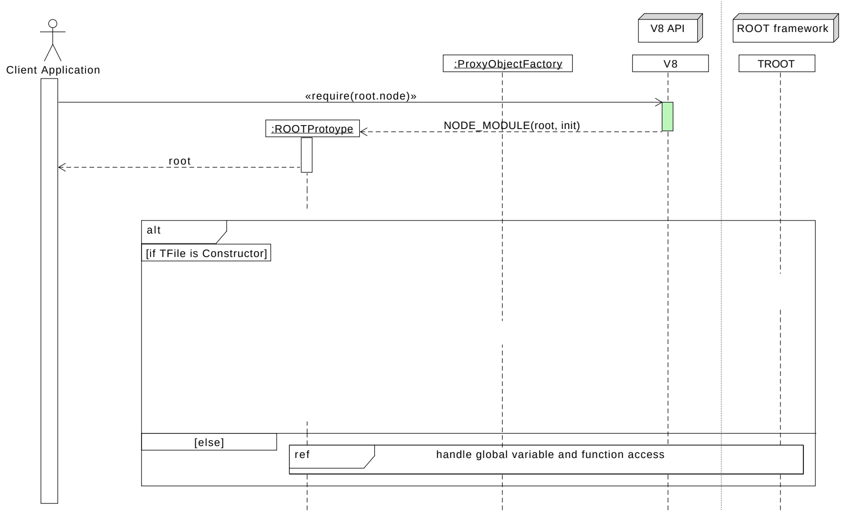

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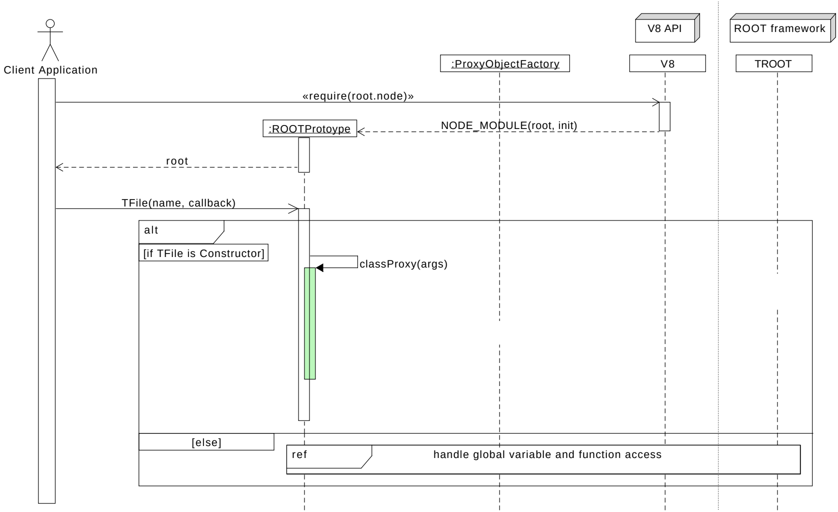

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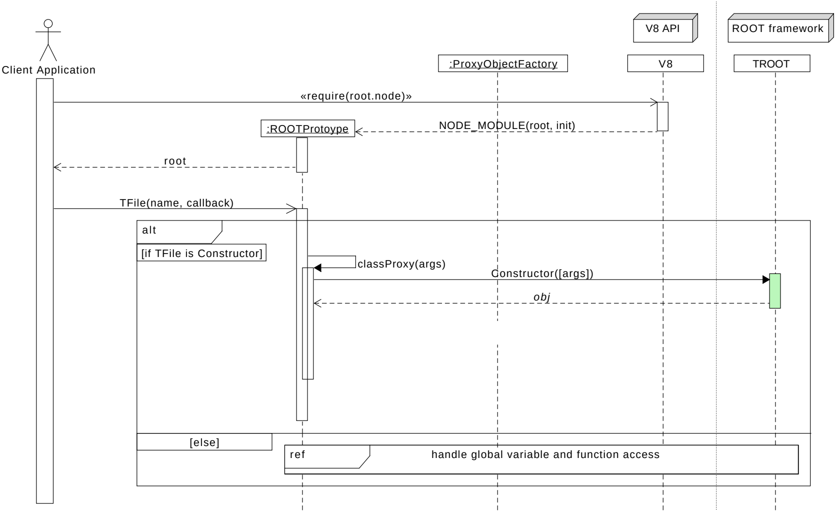

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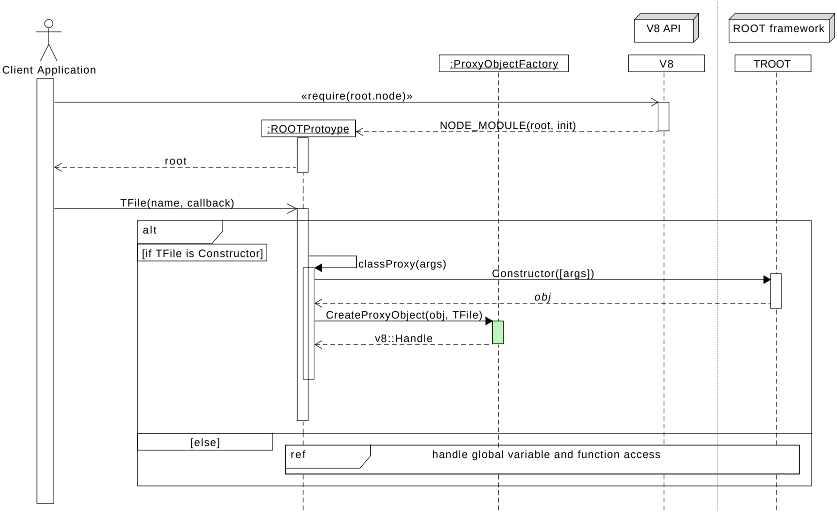

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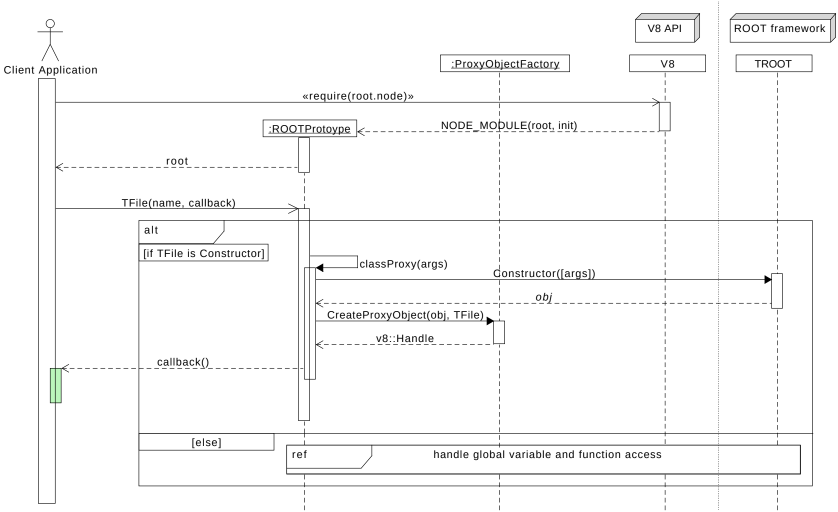

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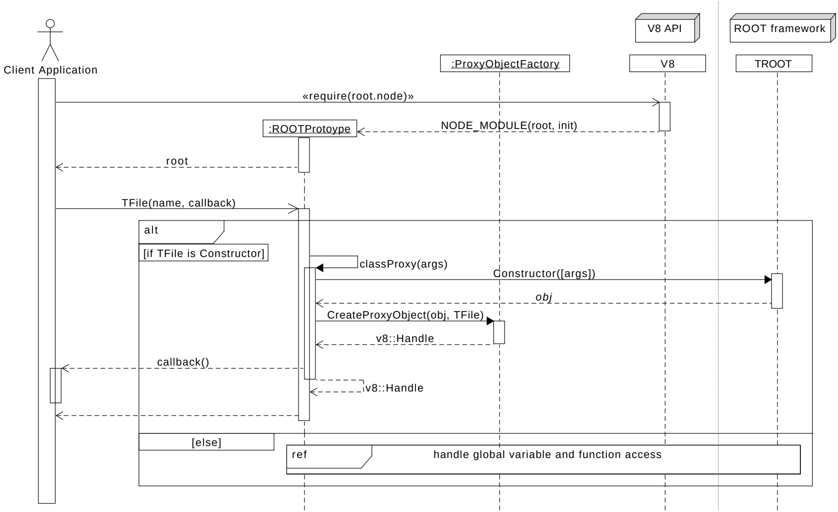
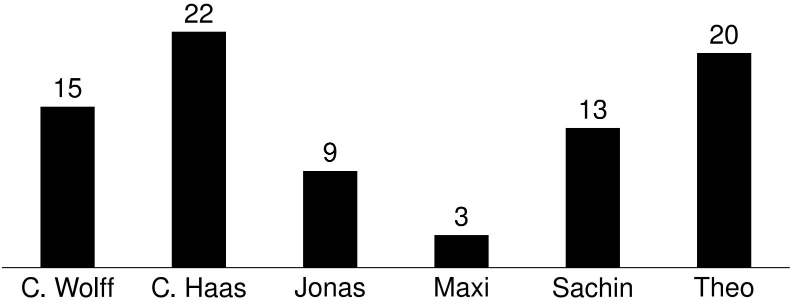
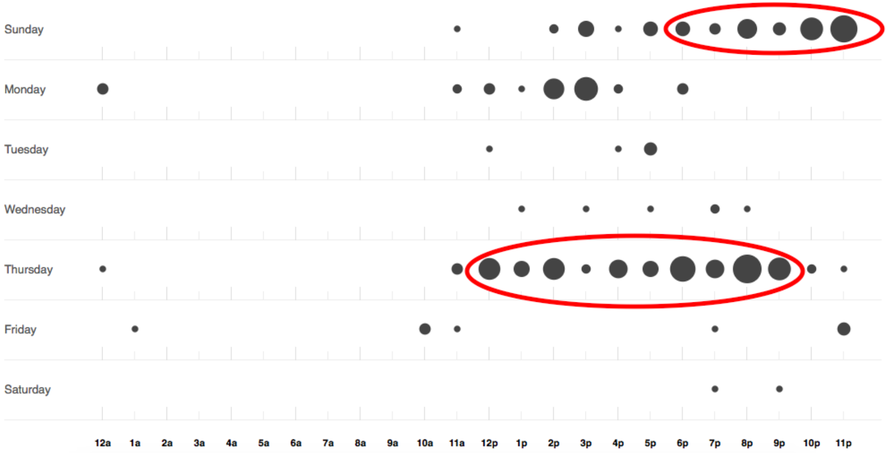


Test Cases

Merges



Punchcard


Sunday
Monday
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10a
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References I