Karlsruhe Institute of Technology

SCC
Steinbuch Centre for Computing

RootJS: Node.js Bindings for ROOT 6

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Steinbuch Centre for Computing (SCC)

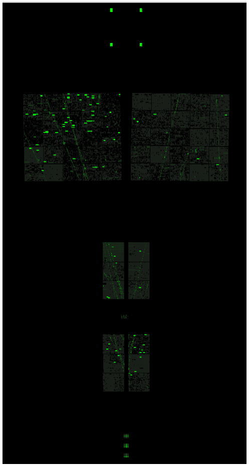
Background

- ROOT — scientific software framework from CERN
  - *de facto* standard tool in particle physics
  - written mainly in C++
  - essentially a library of classes
  - integrated C++ interpreter based on LLVM (ROOT 6)
  - bindings exist for Python, R, Ruby, ...
- Node.js — high-performance runtime environment for Web applications
  - user code in JavaScript
  - internals in C++ — Google V8 engine
  - non-blocking, asynchronous I/O
  - popular in modern large-scale systems
- Web applications in high-energy physics
  - numerous — *e.g.* data browsers, quality assurance, ...
  - back-end processing with ROOT frequently desired

Project Overview

- **RootJS: Node.js bindings for ROOT 6**
  - JavaScript access to all ROOT classes
  - inject, JIT-compile and execute C++ macros
  - dynamically updated state
  - asynchronous
- Native Node.js module written in C++
- System requirements:
  - OS supporting ROOT 6
    - tested under Linux, Mac OS X
  - Node.js 4–6
    - v4 LTS recommended

Use-case Examples



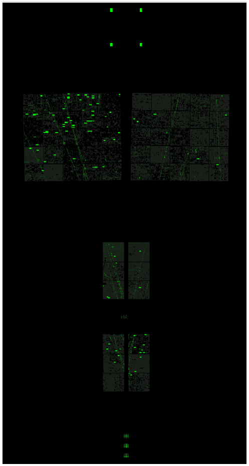
Live event viewer

- Important for monitoring, basic QA
- Typically, standalone ROOT application
- Limited portability:
  - needs ROOT and dependencies installed
  - requires access to data source
- Alternative — modern Web application:
  - back-end processing: ROOT, close to detector
  - front-end *anywhere in the world*
  - only require a Web browser

Analytics in Web applications

- Take advantage of ROOT in machine learning, statistical analysis, linear algebra, ...
- Gain access to XRootD, PROOF *etc.*

Use-case Examples



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Related Work

JavaScript ROOT

JSROOT

- Web client
- reimplementation
- feature set limited by design:
  - ROOT graphics
  - basic file input
  - THttpServer interface

RootJS

- standalone, or Web server
- wrapper
- all features of ROOT 6

- **Highly complementary!**
- Example: Web application with RootJS back-end and JSROOT front-end.

Related Work

Jupyter Notebook

ROOT in Jupyter

- Web client *and* server
- sophisticated interactive interface
- not meant for scripting/batch
- limited access to third-party libraries
    - but: Python 2 kernel + PyROOT + ...

RootJS

- standalone, or Web server
- no interactive interface (yet)
- aimed at scripted/batch processing
- full access to the Node.js ecosystem

- Some overlap
- Different context — interactive *vs* scripted
- **Jupyter + Javascript kernel + RootJS + ...**

Related Work

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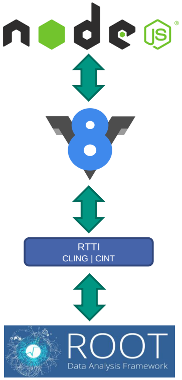
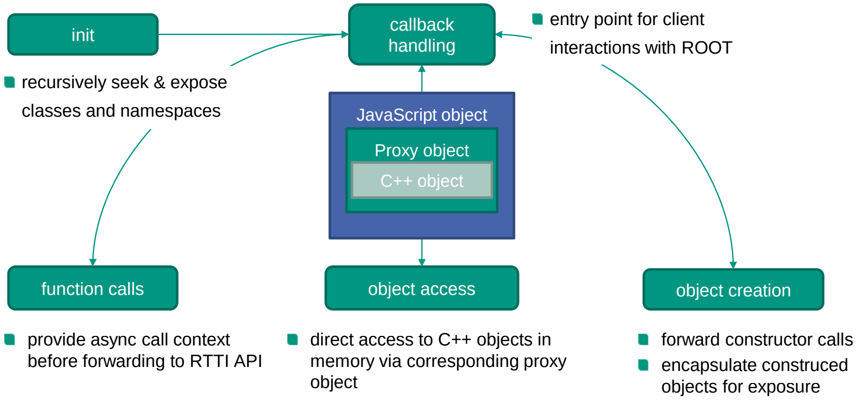
Design Overview



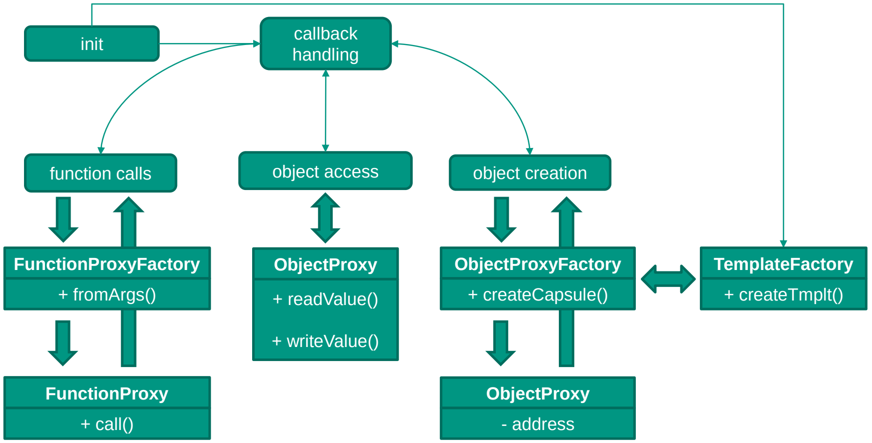
- Basic architecture requirements:
  - dynamic object creation and encapsulation
  - non-blocking function calls via callbacks
- Fundamental language differences
  - different type systems (dynamic *vs* static)
  - a *functional* language
  - classless objects, prototype functions
- "Need an adapter"
  - software design pattern
  - help incompatible interfaces work together
- Environment:
  - V8 API — object exposure and callback handling
  - ROOT RTTI interface — class, namespace, global and member variable information

Fulfilment of Requirements



- recursively seek & expose classes and namespaces
- entry point for client interactions with ROOT
- provide async call context before forwarding to RTTI API
- direct access to C++ objects in memory via corresponding proxy object
- forward constructor calls
- encapsulate constructed objects for exposure

Core Architecture



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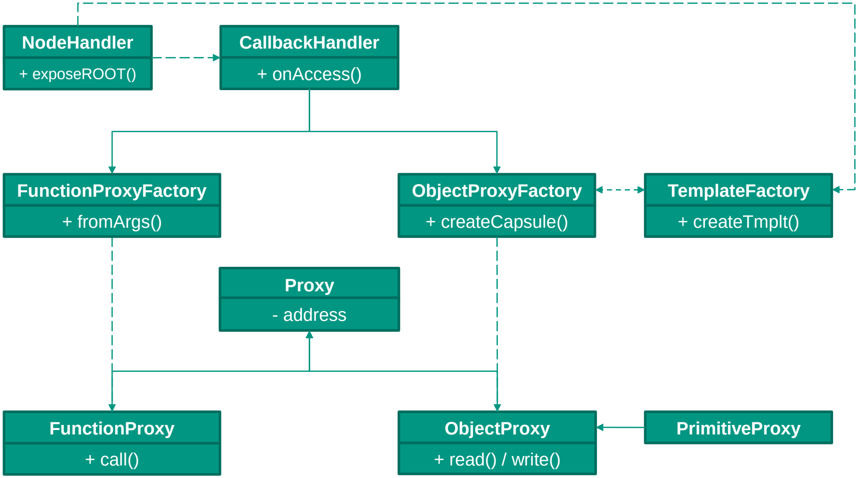


Non-blocking Execution

- Killer feature of Node.js
- RootJS: can add a callback to *any* exposed function
- Asynchronous workers
- Worker–V8 message passing using `libuv`
  - integrates well with Node.js
  - no need to actively wait for threads
  - based on signals — non-blocking, no waste of CPU time

Installation and Invocation

- We are on npmjs.com — easy!

```
npm install rootjs
```

- Requirements: Node.js, npm, C++ compiler, ROOT 6, libuv headers
- Loaded the standard Node.js way:

```
var root = require('rootjs');
```

- All ROOT variables and classes now accessible through `root`
- Need more libraries? No problem:

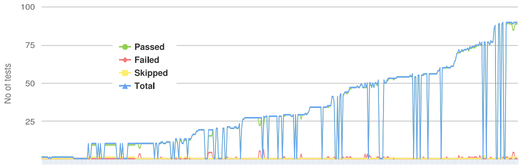
```
root.loadlibrary("libMathCore.so"); // load it...
root.ROOT.Math.Pi(); // ...and use it!
```

- Callback example:

```
root.TFile.Open("foo.root", function (fin) {
  fin.ls();
});
```

Infrastructure

- Source-code repository: Git
  - primary: GitHub
  - mirror: CERN GitLab
  - currently: ≈4000 lines of code
- Issue tracker: GitHub
- Continuous integration: CERN Jenkins
  - integration tests
  - code coverage
  - Doxygen documentation
  - currently: 90 tests, 76 % line coverage



THANK YOU

https://github.com/rootjs/rootjs
https://www.npmjs.com/package/rootjs