



rootJS - Functional Specification

PSE - Software Engineering Practice

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STEINBUCH CENTER FOR COMPUTING

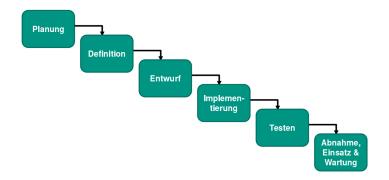


About PSE



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

Environment Data Interface Scenarios Use Cases

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)

Scenarios Use Cases

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)

Environment Data Interface Scenarios Use Cases

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Limiting criteria



The bindings should not

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

Environment Data Interface Scenarios Use Cases

Product usage



- It's JavaScript, so most likely web-applications
- Expose processed data and then visualize it locally
- Interact with remote data (i.e. streamed via RPC)

Interface

Accessible on 'unconvential' devices (mobile phones/tablets)

Scenarios Use Cases

Audience



- Scientists (e.g. particle physicists) and Researchers
- Typical user will know ROOT and JavaScript rather technology proficient
- Web-developers



PSE Purpose Usage

Operating conditions



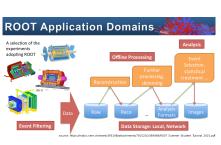
- Servers that run ROOT
- ROOT6 is currently only available on Mac and Linux, so that's our focus

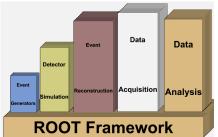
Interface Scenarios Use Cases

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







Node.js



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





Node.js



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- Google V8 engine to execute JavaScript code





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++





Interface

Hardware



- Task: encapsulation of ROOT objects and functions
 - → scanning ROOT structures during initialization
 - → encapsulating objects with heavily nested object structures

Environment Data Interface Scenarios Use Cases System Model

→ introduce (proxy) object cache

Usage

Hardware



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

⇒ generally negligible hardware requirements of the bindings themselves

Environment Data Interface Scenarios Use Cases

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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

Scenarios Use Cases

Data

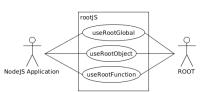
Interface

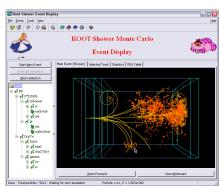
Product interface



Event Viewer







UseROOTGlobal



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Use case name	UseROOTGlobal
Participating actor	Initiated by NodeJSApplication; Pro-
instances	cessed by rootJS; Communicates with
	ROOT
Flow of events	
	 The NodeJSApplication requests access to a global variable of ROOT. rootJS sends a request to the corresponding ROOT variable. ROOT returns the requested variable value.
	The value is passed from rootJS to the NodeJSApplication.

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PSE Purpose Usage Environment Data Interface Scenarios Use Cases System Model

UseROOTGlobal



Entry condition	rootJS has been initialized.
Exit condition	The value has been returned to the
	NodeJSApplication.

PSE Purpose Usage Environment Data Interface Scenarios Use Cases System Model

UseROOTObject



Use case name	UseROOTObject
Participating actor	Initiated by NodeJSApplication; Pro-
instances	cessed by rootJS, ProxyObject; Commu-
	nicates with ROOT
Flow of events	
	The NodeJSApplication requests access to a ROOT object by calling a constructor function.
	ProotJS encapsulates the requested ROOT object within a ProxyObject that was created recursively.



PSE Purpose Usage Environment Data Interface Scenarios Use Cases System Model

UseROOTObject



Flow of events

- TootJS stores the created ProxyObject in a cache memory.
- 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.



PSE Purpose

Usage

Environment Data Interface Scenarios Use Cases

UseROOTFunction



Use case name	UseR00TFunction
Participating actor	Initiated by NodeJSApplication; Pro-
instances	cessed by rootJS, ProxyObject; Commu-
	nicates with ROOT
Flow of events	
	The NodeJSApplication requests access to a ROOT function.
	ProotJS calls the corresponding ROOT function.
	3 ROOT responds.

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UseROOTFunction



Flow of events

- rootJS encapsulates the returned ROOT object within a ProxyObject.
- 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.

Scenarios Use Cases



Environment Data Interface

Usage

UseJIT



Use Case name	UseJIT
Participating actor	Initiated by NodeJSApplication; Pro-
instances	cessed by rootJS, Cling; Communicates with ROOT
Flow of events	
	The NodeJSApplication wants to execute ROOT specific C++ code (given as string) during runtime.
	2 rootJS forwards the instructions to Cling.
	© Cling evaluates the received instructions using JIT compilation concepts and dynamically modifies the state of ROOT.

PSE Purpose Usage Environment Data Interface Scenarios Use Cases System Model

UseJIT

PSE Purpose

Usage



Flow of events

- TootJS takes care of encapsulating exceptions possibly thrown by Cling or ROOT during evaluation and execution.
- TootJS 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 ex-
	ecution of the specified instructions
	or forwards thrown exceptions to the
	NodeJSApplication.



Environment Data Interface Scenarios Use Cases



Client application

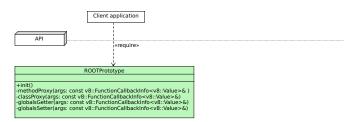
ROOT framework

TROOT

PSE Purpose Usage Environment Data Interface Scenarios Use Cases System Model





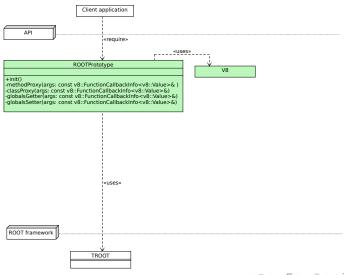




TROOT







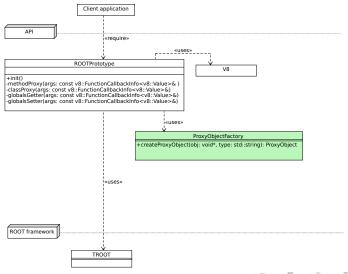
Scenarios Use Cases

System Model



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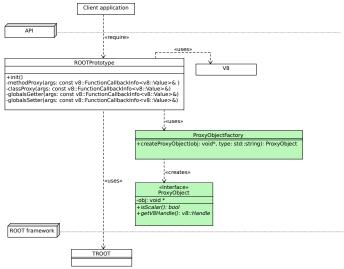




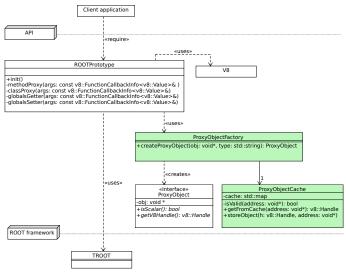
Data

Interface

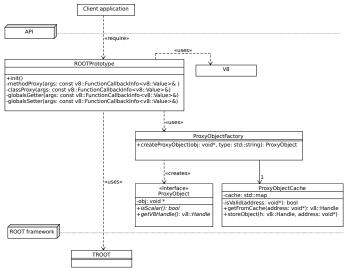












Initialization



- Expose all
 - Global variables
 - Global functions
 - Classes

Initialization



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- Each are bound to corresponding proxy methods
- An object which members are the exposed features is beeing passed to node

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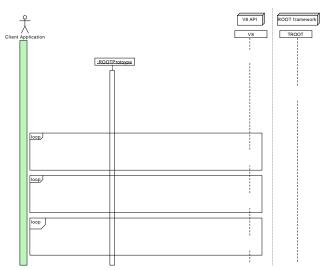
Names

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

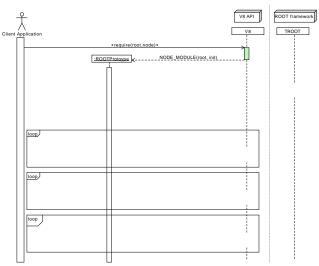


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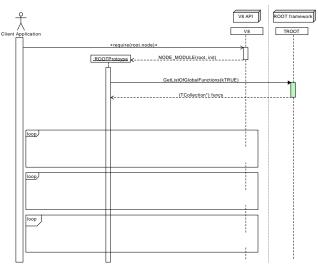






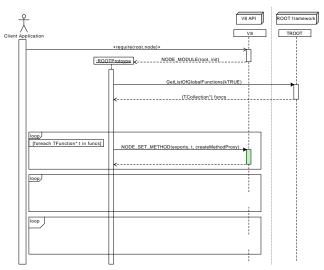










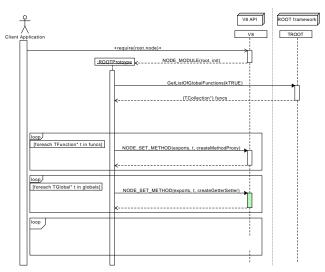




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Test Cases Statistics



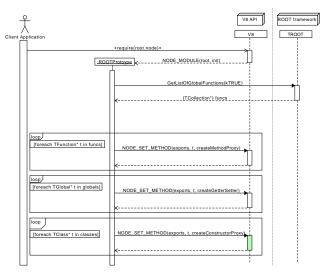




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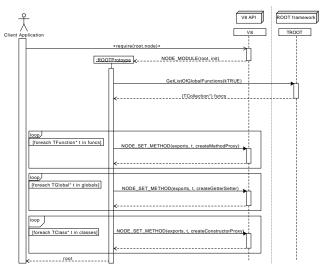
Test Cases Statistics













Call a feature



All features in node are mapped to a proxy method that will be called

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Environment Data Interface Scenarios Use Cases

Call a feature



- All features in node are mapped to a proxy method that will be called
- The proxy method will eventually call a root function and pass the result to our ObjectFactory

Scenarios Use Cases

Interface

Call a feature

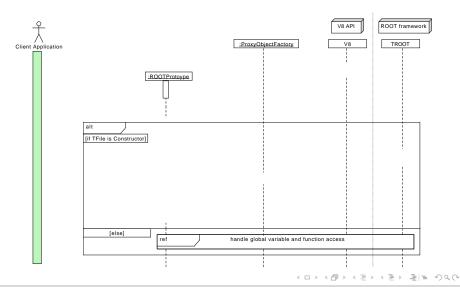


- All features in node are mapped to a proxy method that will be called
- The proxy method will eventually call a root function and pass the result to our ObjectFactory
- By looking at the object type an corresponding v8::Handle will be generated and returned to node
 - If the result is an object this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

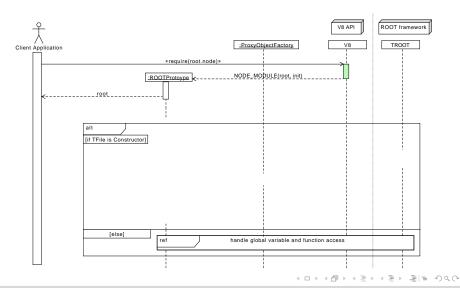
Scenarios Use Cases

Environment Data Interface

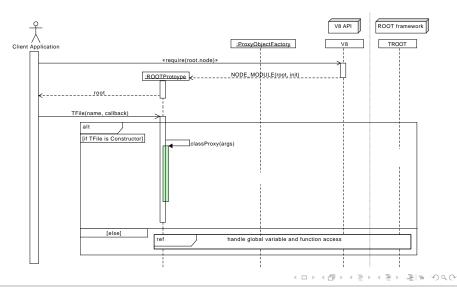




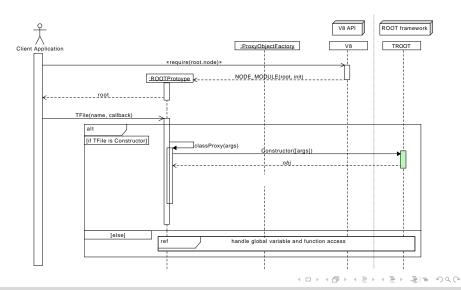




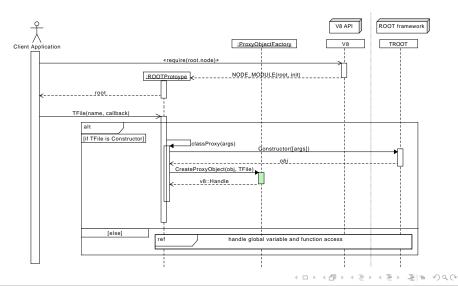




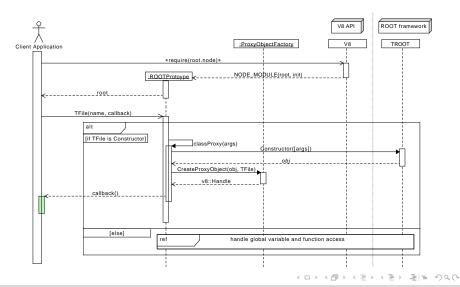




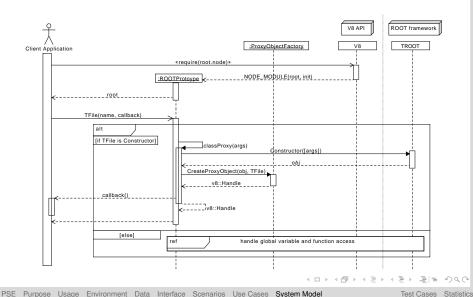












Test Cases



- 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

Interface Scenarios Use Cases

References I



