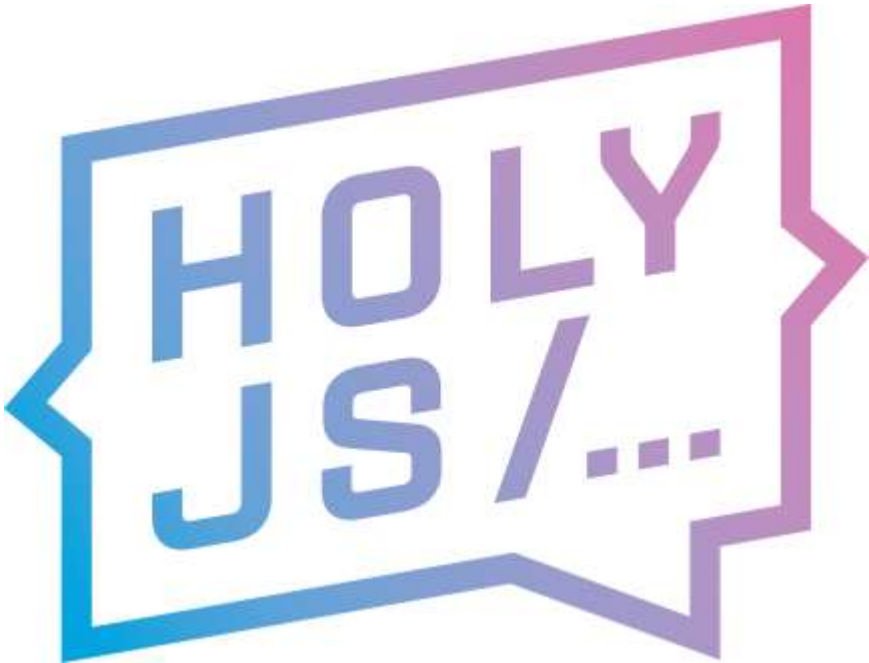
Разработка под WebAssembly: реальные грабли и примеры

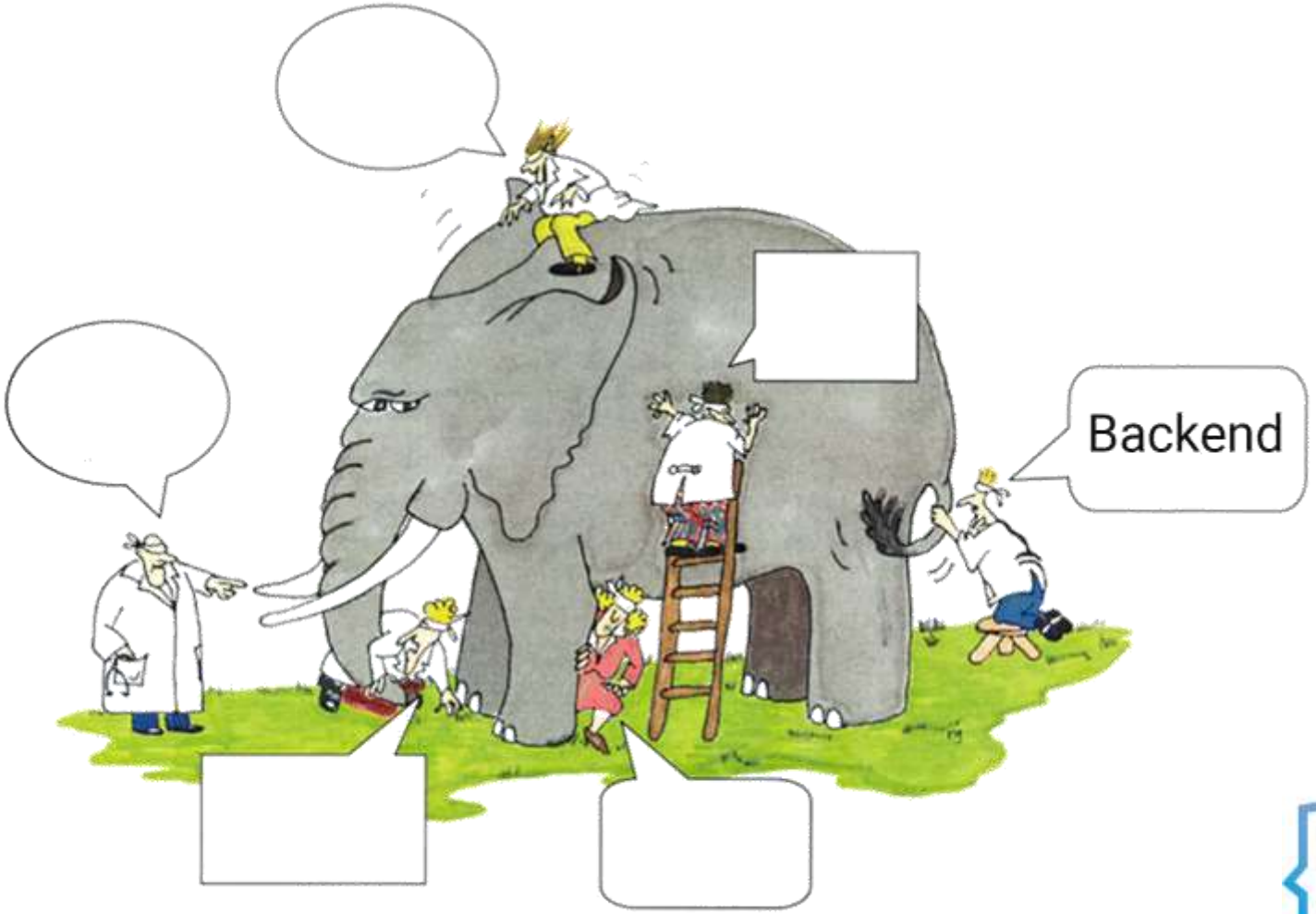
Андрей Нагих (Инетра)

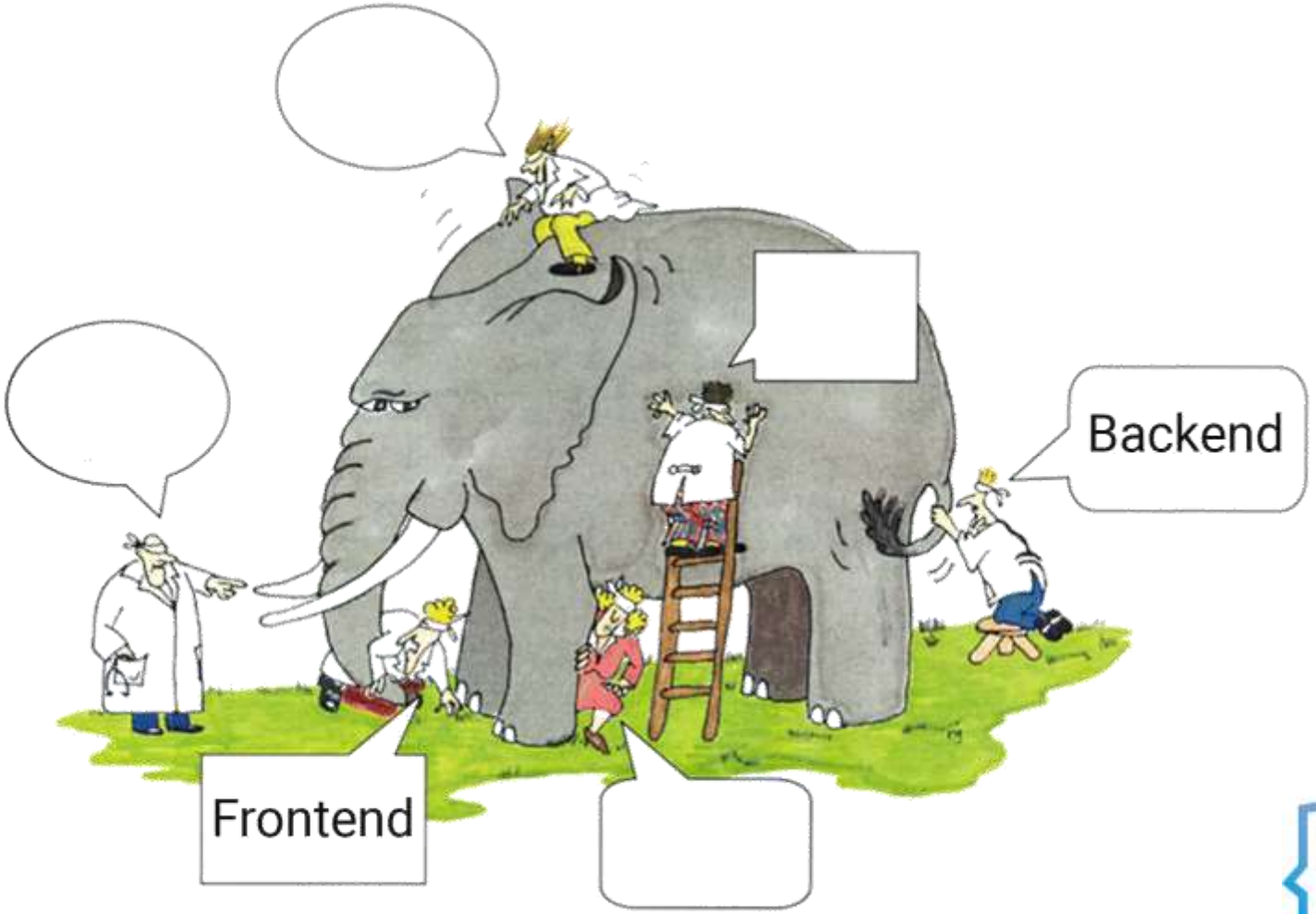


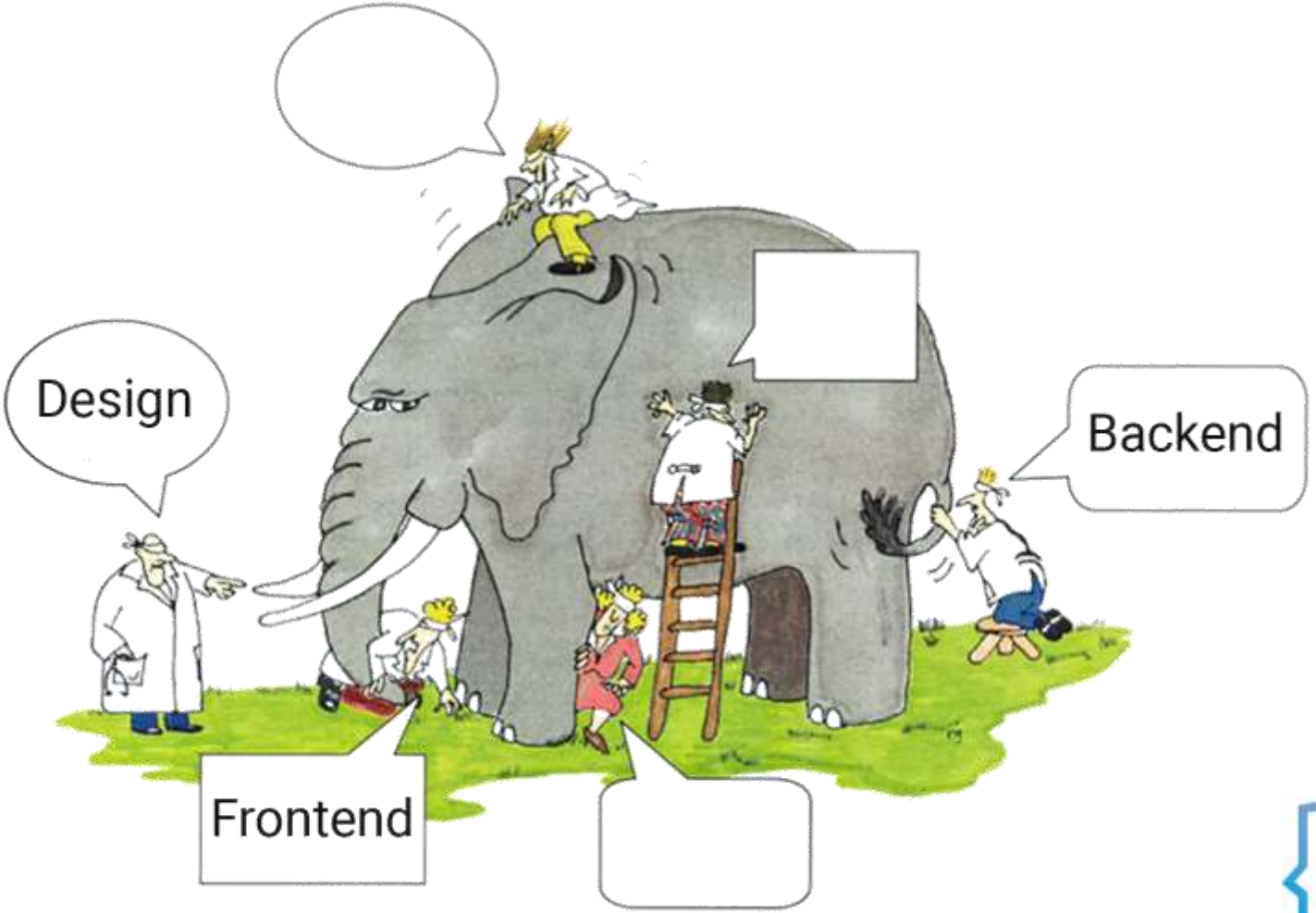
Немного обо мне

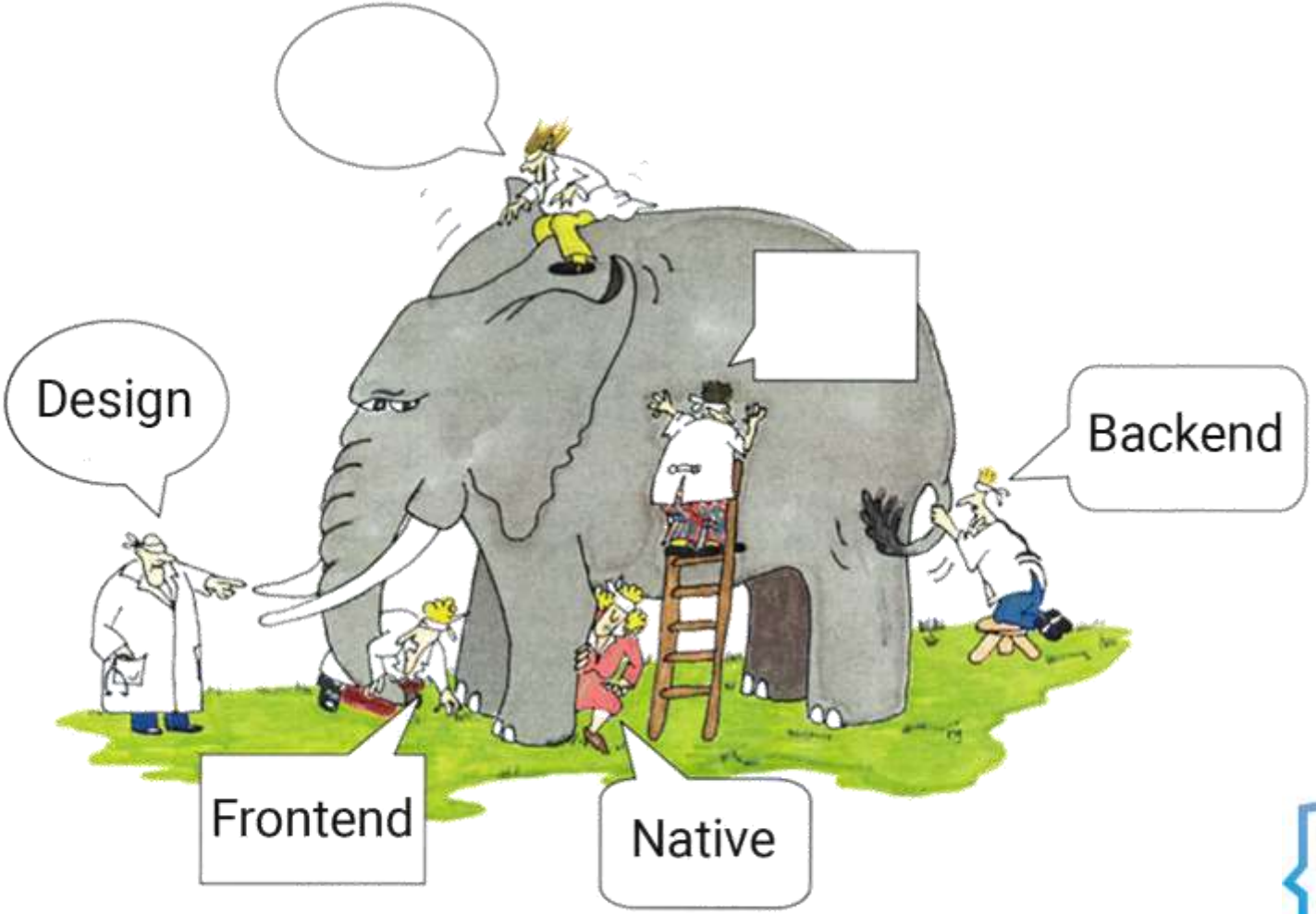
- Занимаюсь вебом с прошлого века

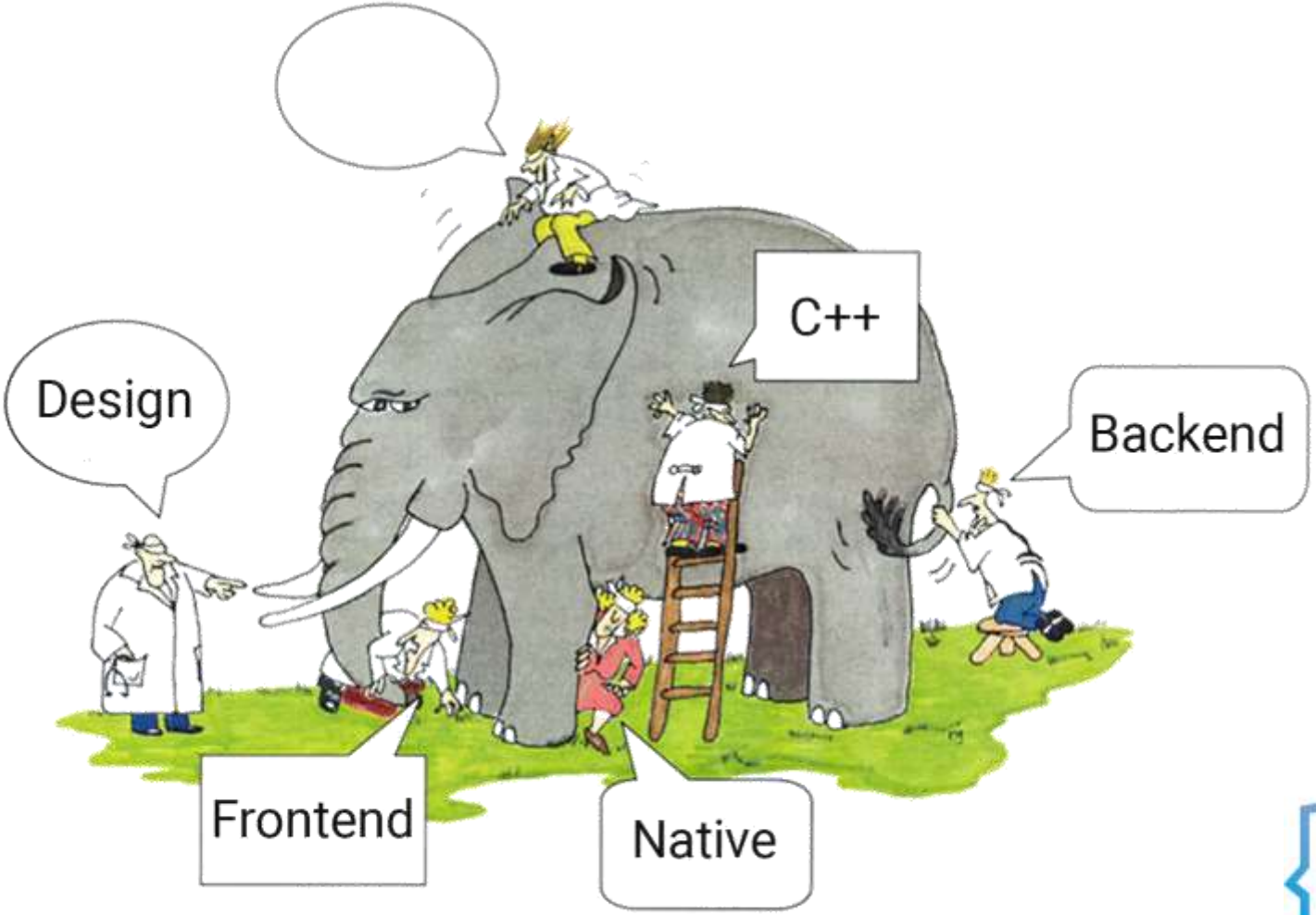

UNDER CONSTRUCTION
UNDER CONSTRUCTION
UNDER CONSTRUCTION
5318008
sin
cos
tan
Alcohol 40° or Higher
Any Browser
MATCHES
Not Online
C.L. Maderal Oleaga "XIX de la Les
Andrew Boyd's (latest homepage
W E N D Y
Welcom
What's New?
Download
Installation
Useful Tips
Using OWL
The Ricky Martin World!
Choose your destiny...
ENTRANCE for MS IE4
ENTRANCE for NETSCAPE 4
Updated 4th Oct 1998
Updated 27th Sept 1999
Friday 20th August, 1999
Production of the page commenced, i began looking for a simple way to generate mouseover code, cause I am not an expert at javascript.
The page cannot be displa
HOW THE INTERNET WORKS
I'm the coolest in the world and everything i do is cool. So the following page of pictures of me and my friends is cool.
Registration Information
About The Program
Parkville Newsletter
The Parkville Home Page
FREE searches powered by Google!
Enter search phrase here
Click the spider to search the WEB!
INDEX
MUSIC
SOUNDS
MORE
AND MORE
Juice
HAVE YOU SEEN MY BALLS?
It's A Hebe World After All
M3dia
Wellcum to m
The Beatles and The
Kamran's Home
Hello! Welcome to my net home.
This is a IN SYNC WITH *N SYNC site
Want to join "IN SYNC WITH *N SYNC" the webring?

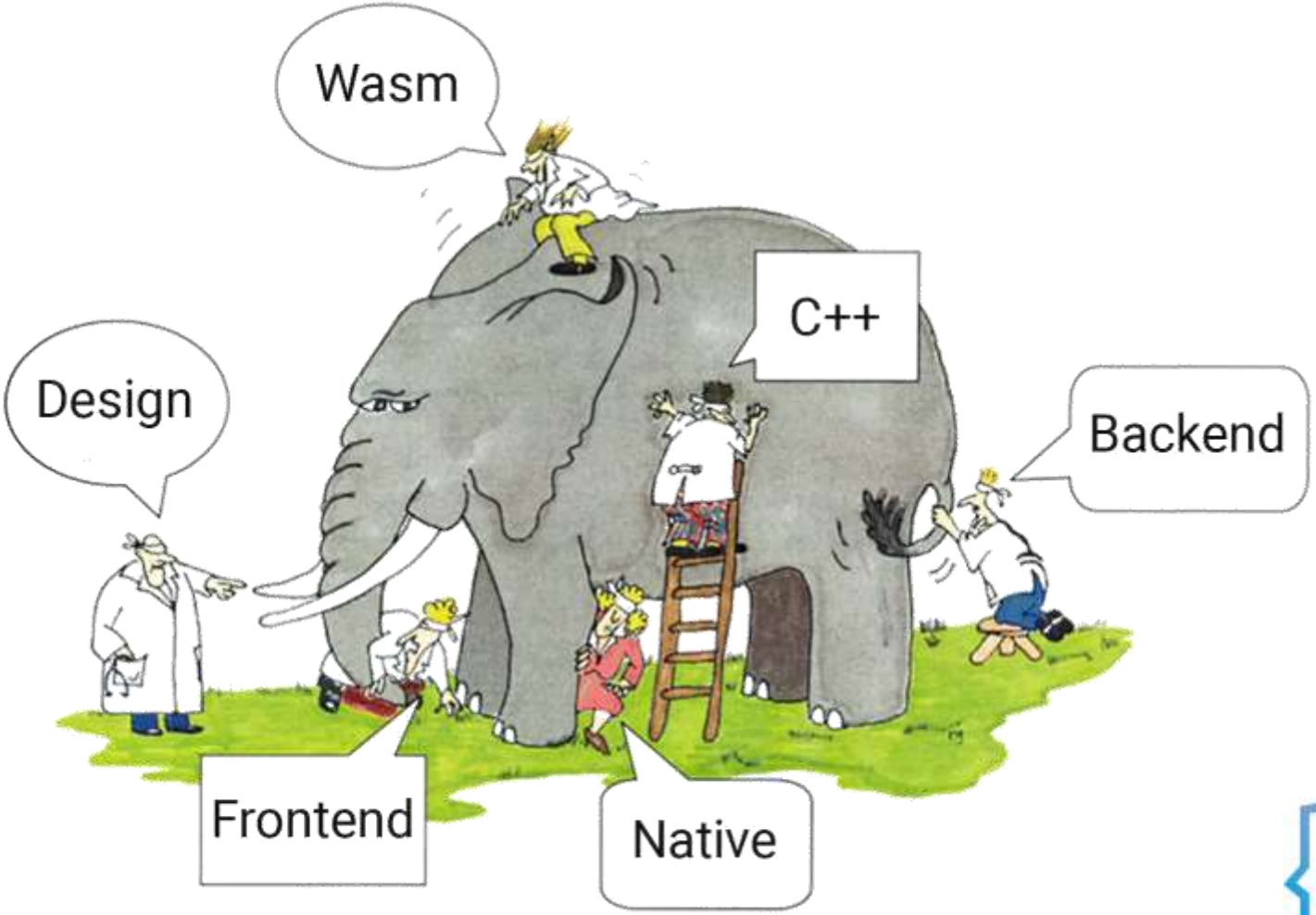

Backend


Backend
Frontend


Design
Backend
Frontend


Design
Backend
Frontend
Native


Design
C++
Backend
Frontend
Native


Wasm
C++
Design
Backend
Frontend
Native

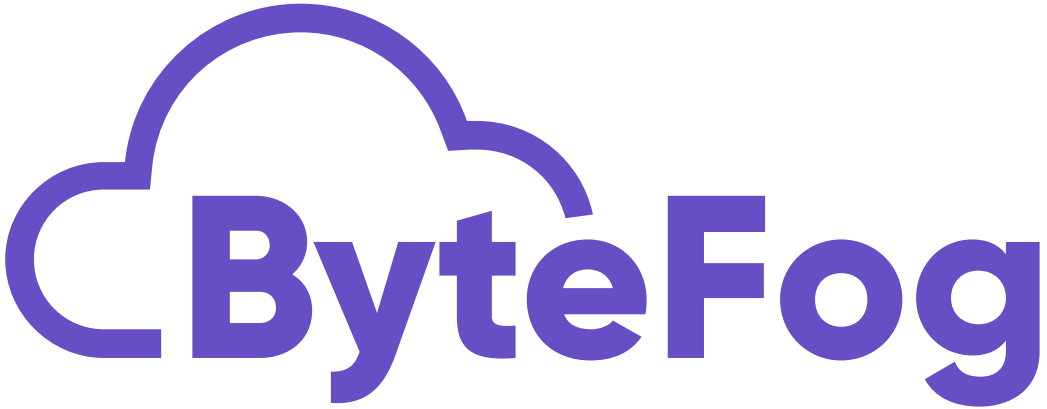
— Типографика «рулит»!

Stefan Kühn

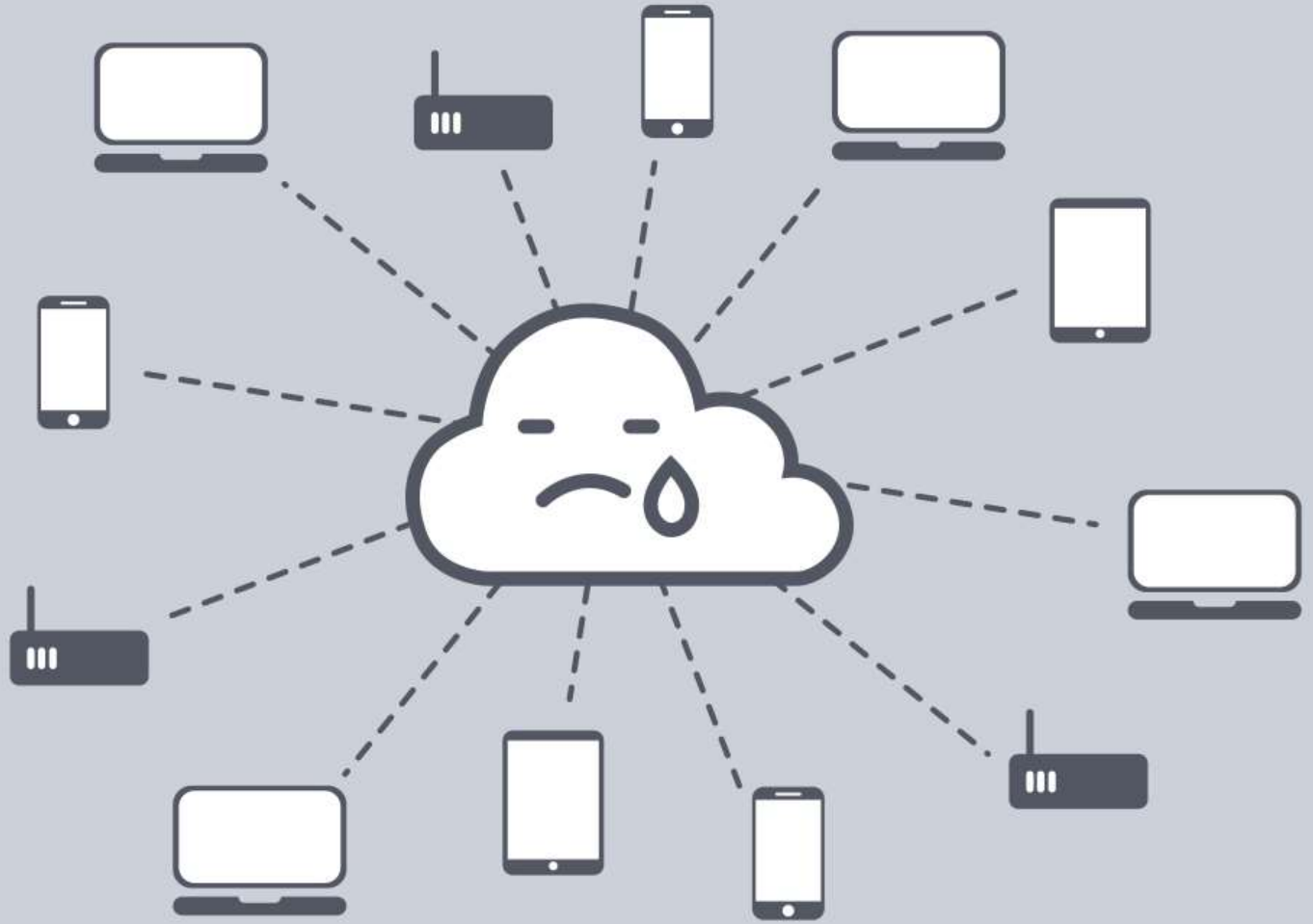
План доклада

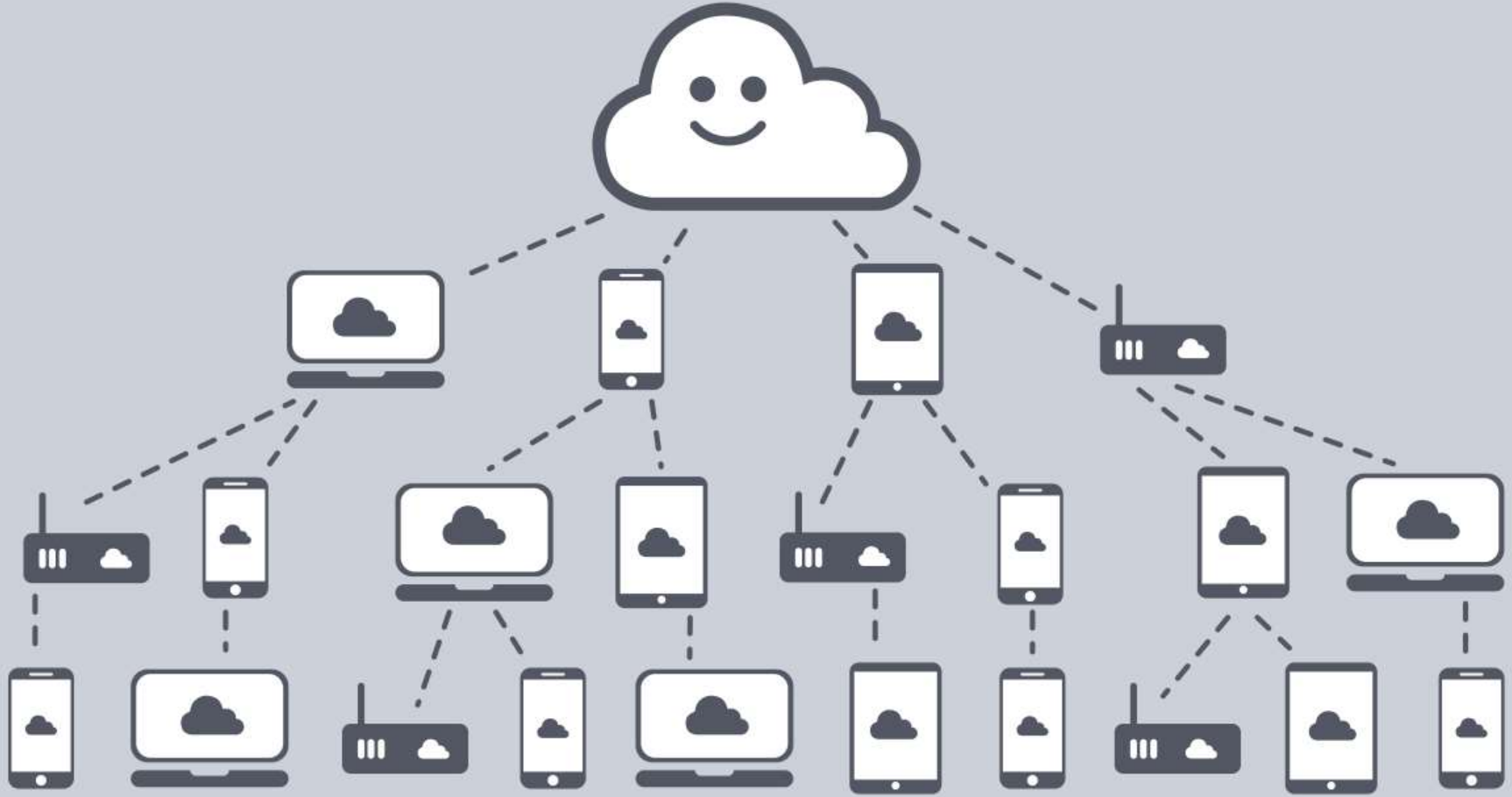
1. Как мы внедряли Webassembly
2. Зачем оно вам
3. Как повторить у себя

Работаю в Инетре, в Новосибирске



peer-to-peer доставка видео





Платформы

Windows, Linux, Android, iOS, Web, Tizen






Bytefog

900+

классов

95k+

строк кода

Платформы

Windows, Linux, Android, iOS, Web, Tizen



Платформы

Windows, Linux, Android, iOS, Web, Tizen

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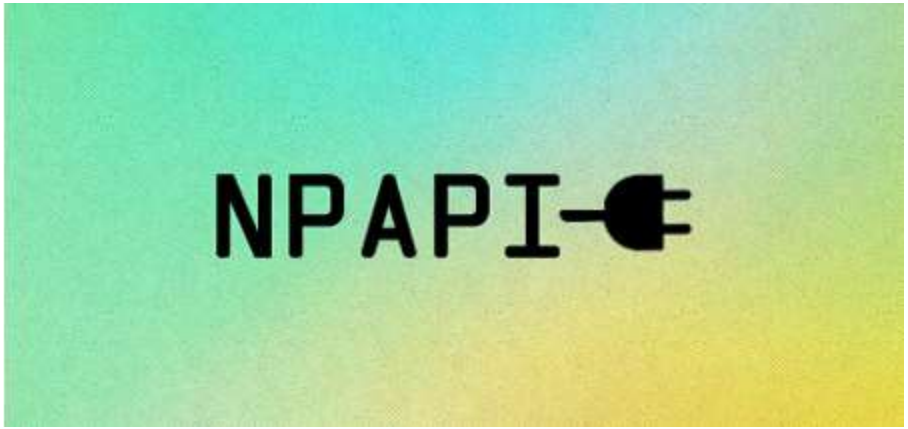
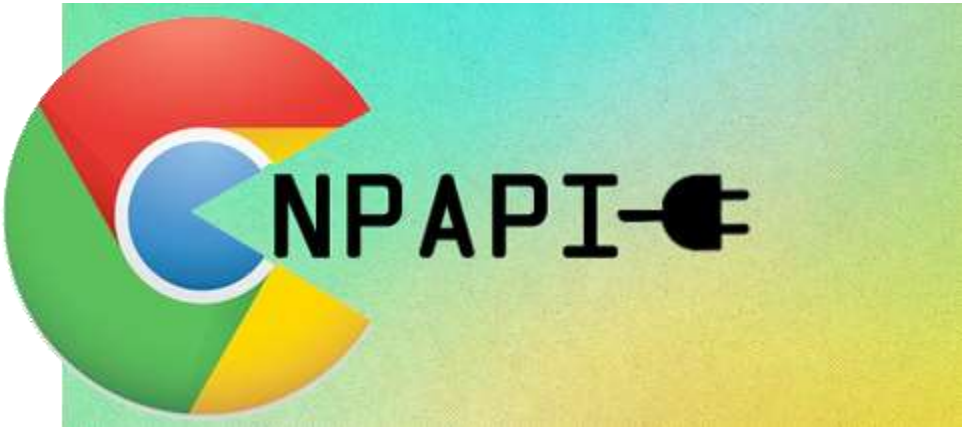

NPAPI


NPAPI


WEBASSEMBLY

Поддержка браузерами

52

57

16

11

Задача

Портировать C++ приложение в браузер,
взять максимум готового кода

- Воссоздаст среду для C++ приложения
- Пробросит объекты из C++ в JS
- Даст вызвать JS-код из C++

Первая мысль

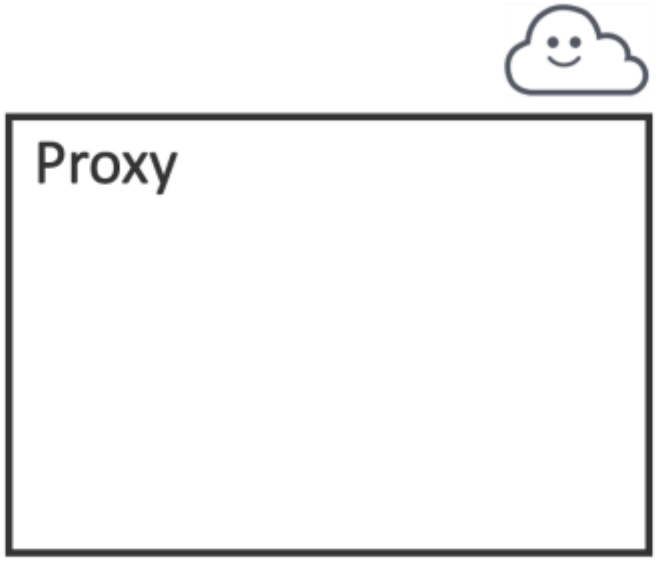
«Сейчас просто скомпилируем через Emscripten и всё заработает!»

НАШИ ГРАБЛИ

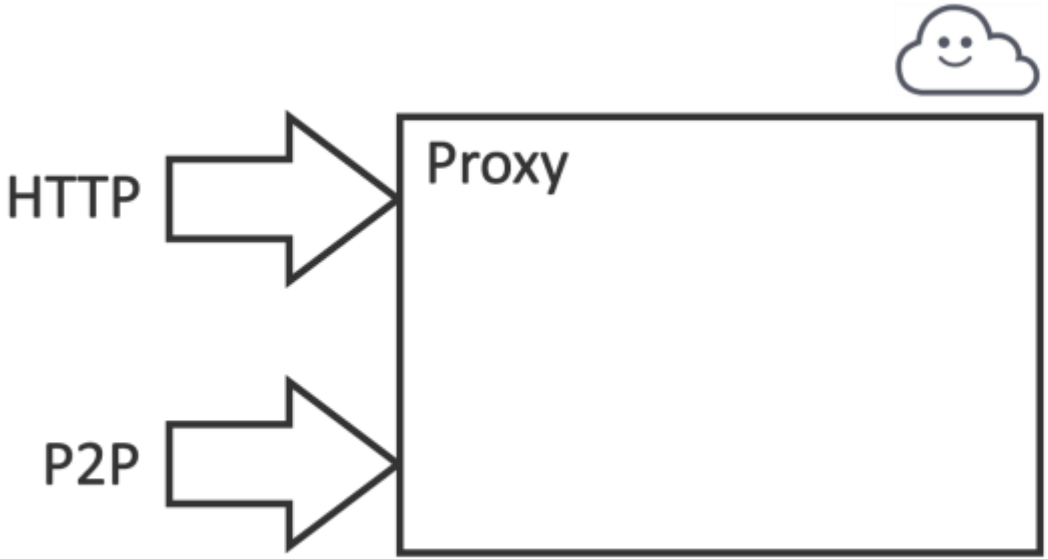
Зависимости

Максимально уменьшить размер кодовой базы

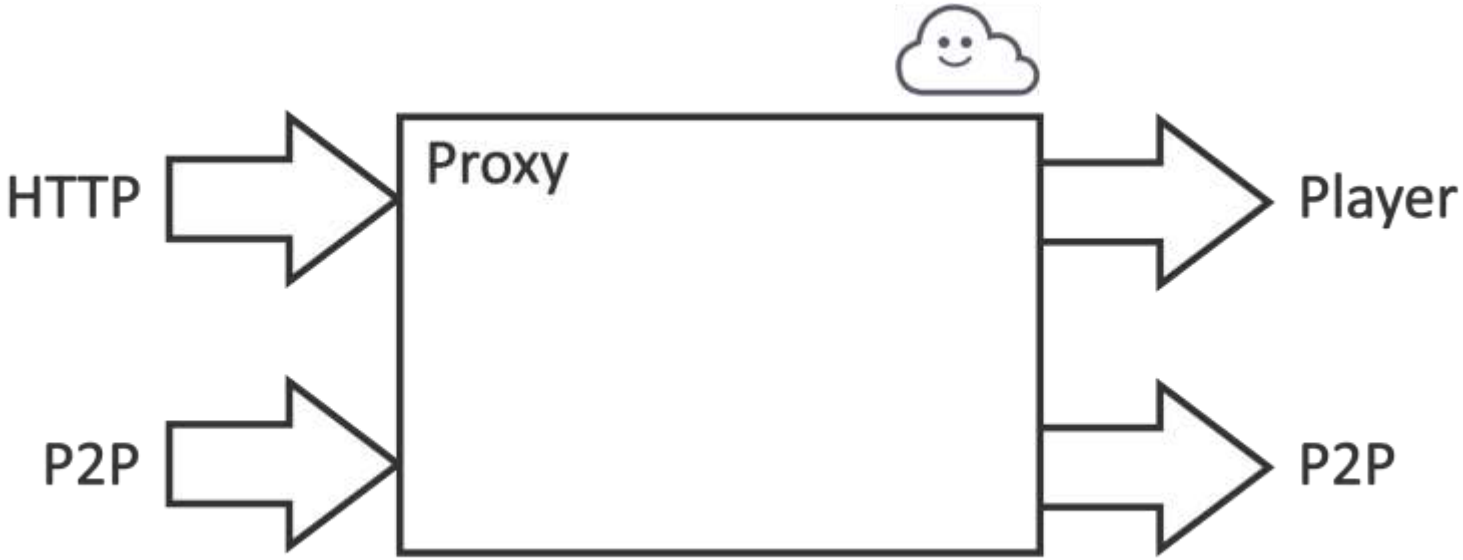
Архитектура



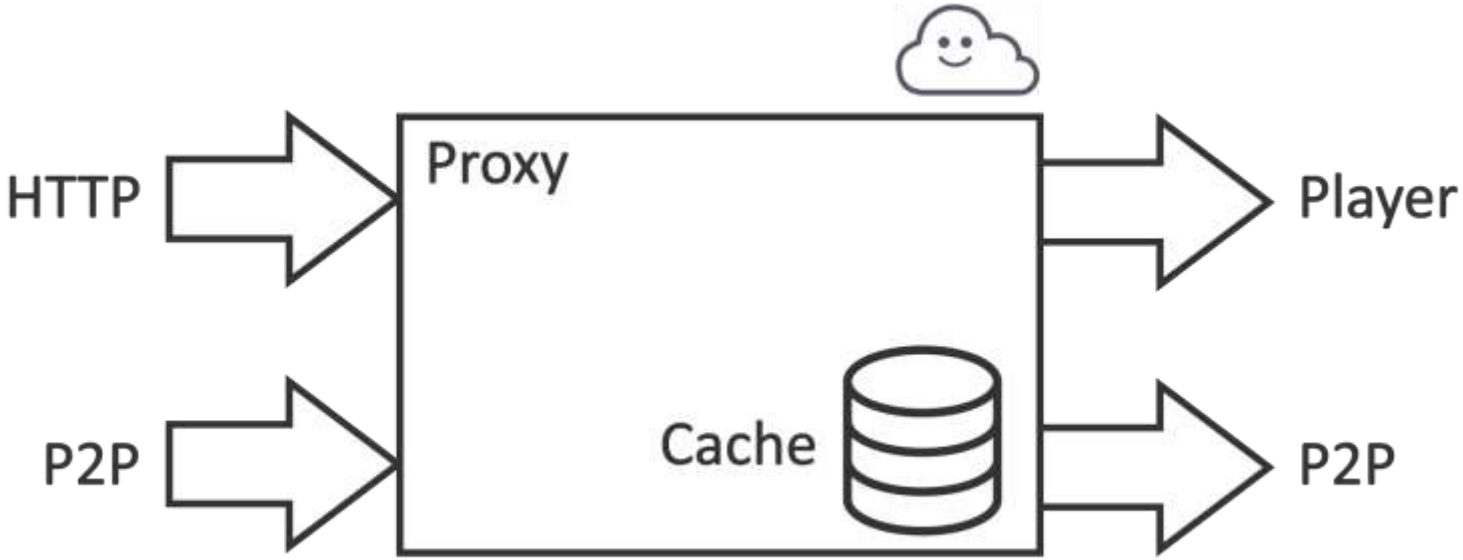
Архитектура



Архитектура



Архитектура



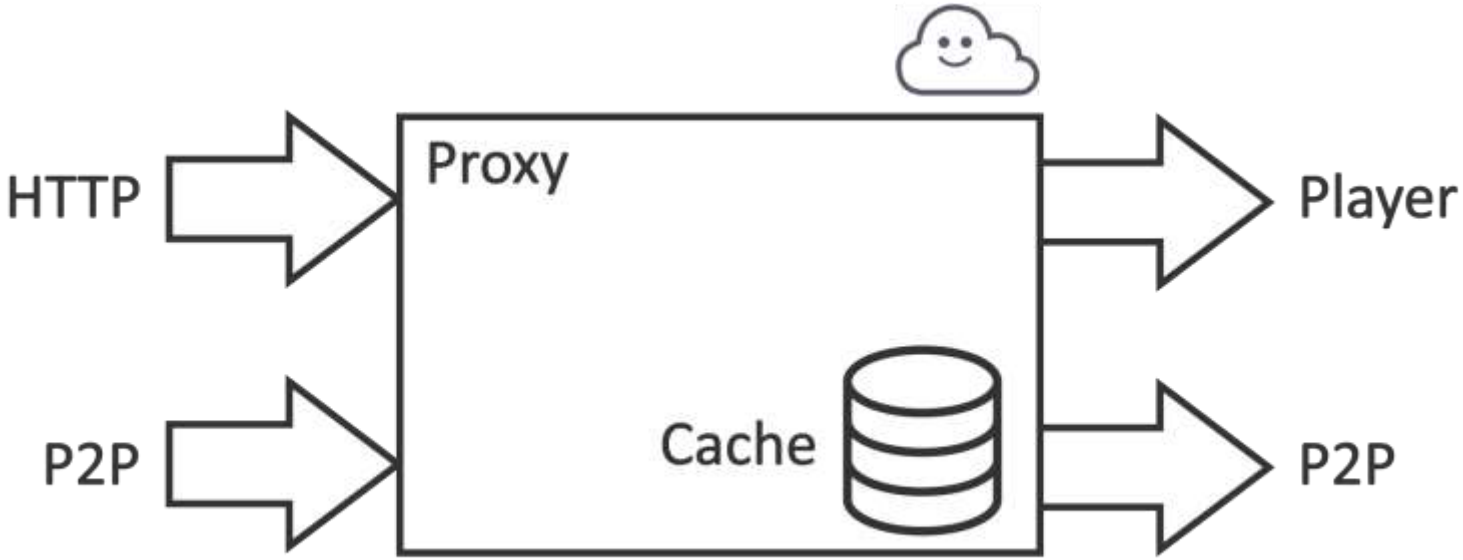
Ограничения Wasm

- Выполняется в песочнице браузера
- **Не может больше, чем может JavaScript**

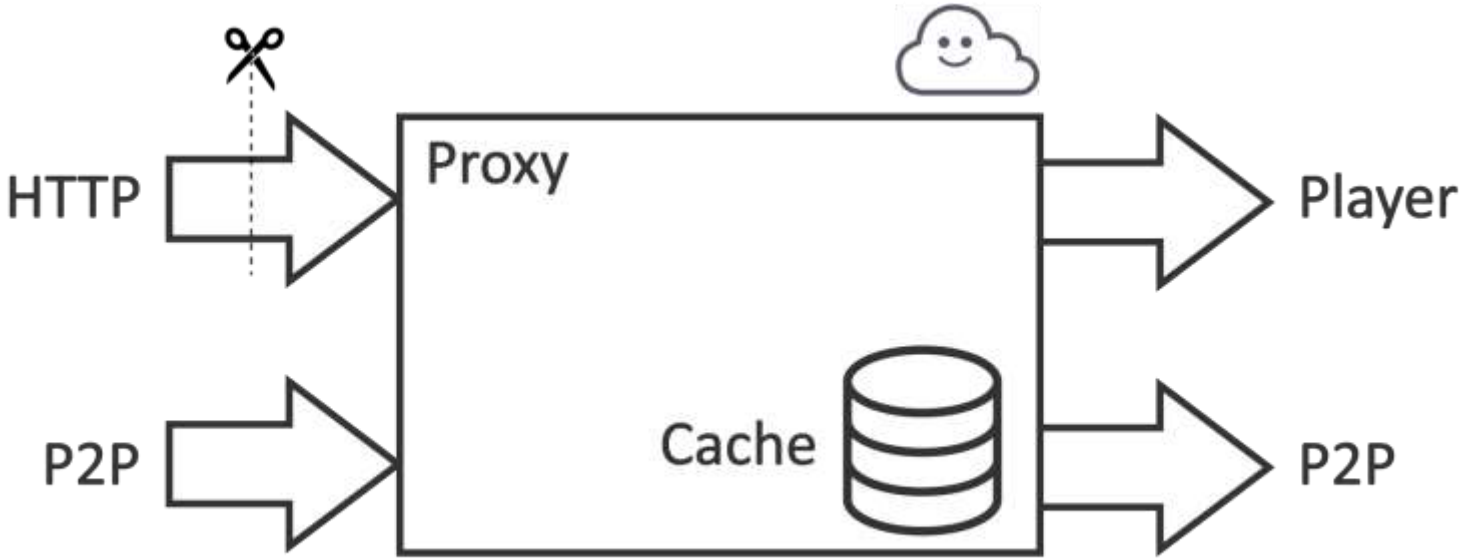
Чем заменяем?

C++	Wasm + JS
FileSystem	Cookie, LocalStorage, IndexedDB
Network	XHR, fetch, WebSocket
Random	Math.random()
Async	Poll + setTimeout()
3D	Canvas, WebGL

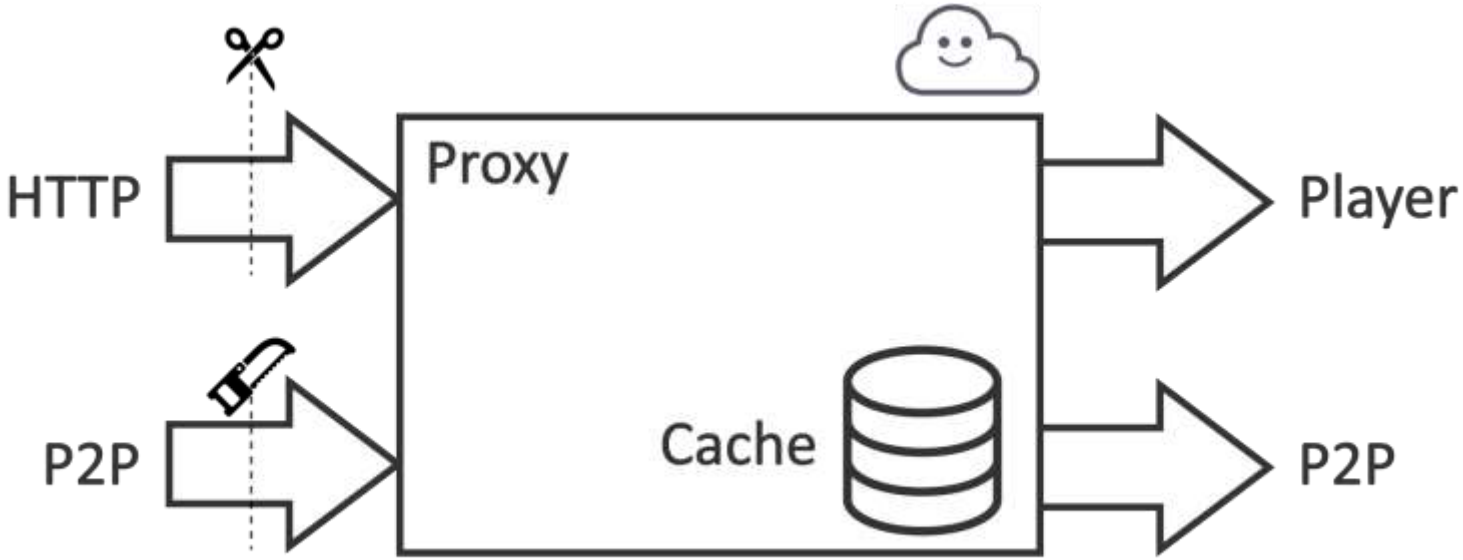
Находи!



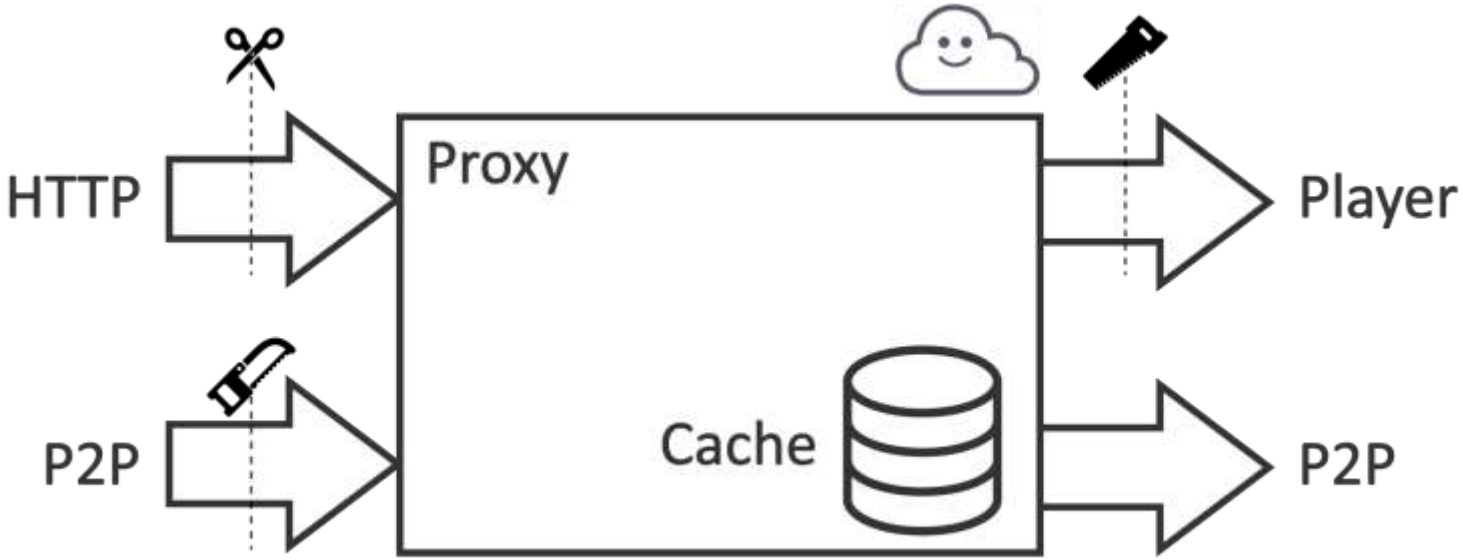
Отпиливай!



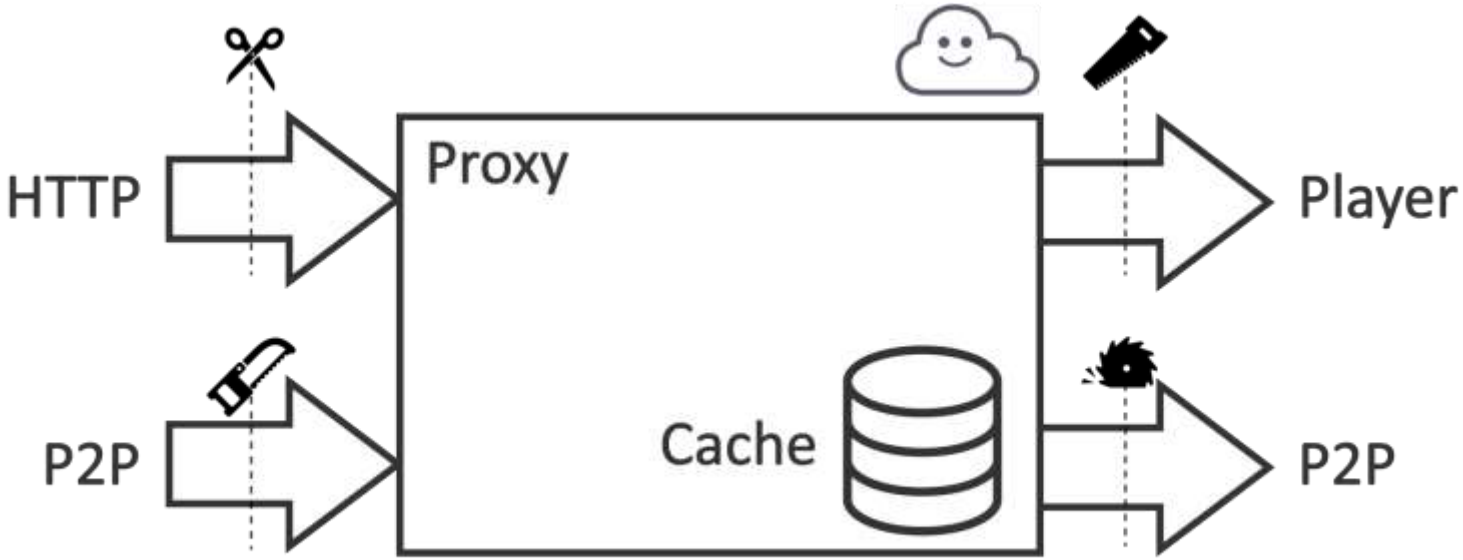
Отпиливай!



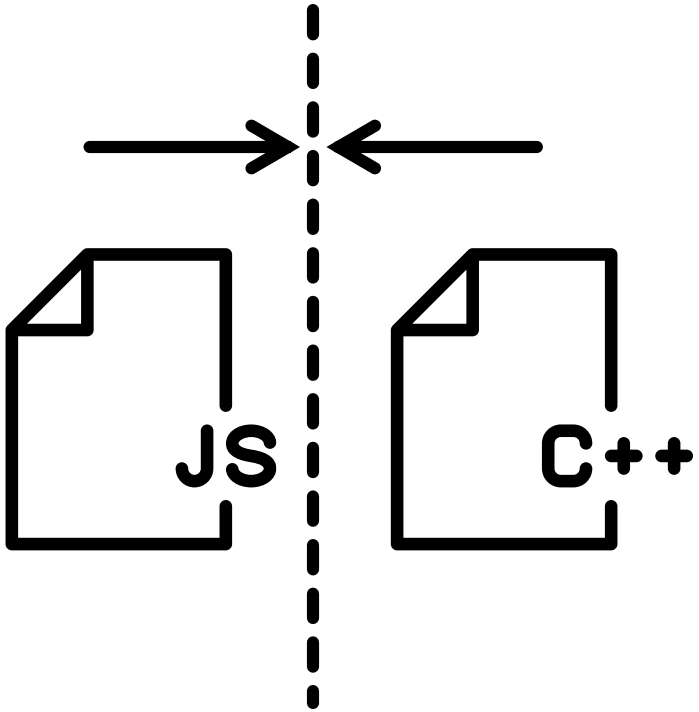
Отпиливай!



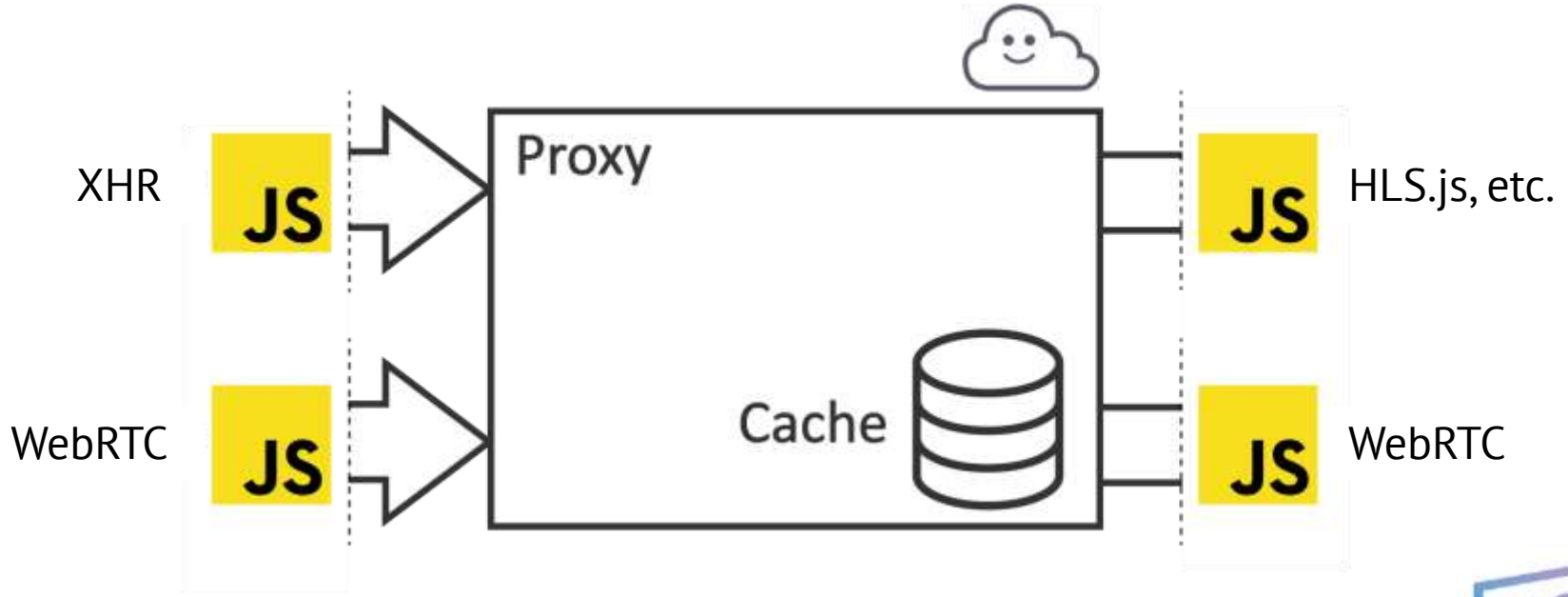
Отпиливай!



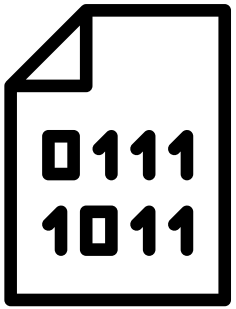
Реализуй!



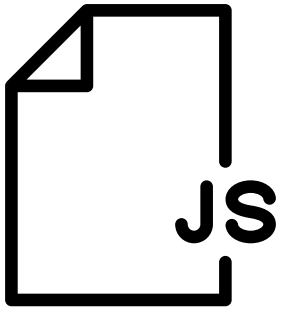
Реализуй!



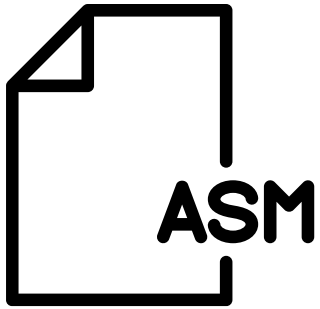
Результат компиляции



.wasm



.js



.wast

.map

Собрать JS

- ES5
- Отдельный файл
- Глобальная переменная

Webpack

- MODULARIZE
- Babel ignore

SINGLE_FILE

100 МБ в бандл!

- кэширование
- заголовки
- сжатие
- потоковая компиляция

Thenable

- .then()
- Но это не Promise
- Обернём сами

Промифицируем

```
return new Promise((resolve, reject) => {
   Module(config).then((module) => {
      resolve(module);
   });
});
```

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   });
});
```


HOLY
JS /...

Старт модуля

```
Module['then'] = function(func) {
  if (Module['calledRun']) {
    func(Module);
  } else {
    Module['onRuntimeInitialized'] = function() {
      func(Module);
    };
  }
  return Module;
};
```

Старт модуля

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Module['then'] = function(func) {
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  }
  return Module;
};
```
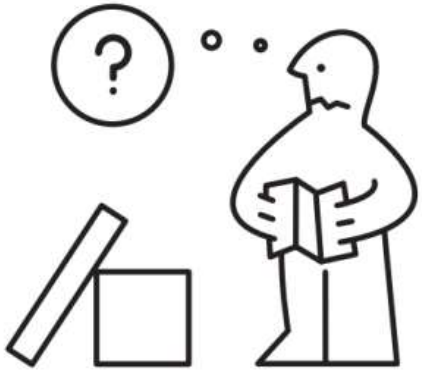


Читаем документацию

If a promise is resolved with a thenable that participates in a circular thenable chain, such that the recursive nature of `[[Resolve]](promise, thenable)` eventually causes `[[Resolve]](promise, thenable)` to be called again, following the above algorithm will lead to infinite recursion. Implementations are encouraged, but not required, to detect such recursion and reject `promise` with an informative `TypeError` as the reason. [3.6]



https://promisesaplus.com/#point-65

Рекурсия

Promise: resolve(module) → Thenable?

Рекурсия

Promise: resolve(module) → Thenable?

→ module.then(resolve)

Рекурсия

Promise: resolve(module) → Thenable?

→ module.then(resolve) → Module.calledRun!

Рекурсия

Promise: resolve(module) → Thenable?

→ module.then(resolve) → Module.calledRun!

→ resolve(module)

Рекурсия

Promise: resolve(module) → Thenable?

→ module.then(resolve) → Module.calledRun!

→ resolve(module) → Thenable? → …

Итак:

- Модуль скомпилировали
- JS собрали
- …
- PROFIT?

КАК СВЯЗАТЬ ДВА МИРА

Как связать два мира?

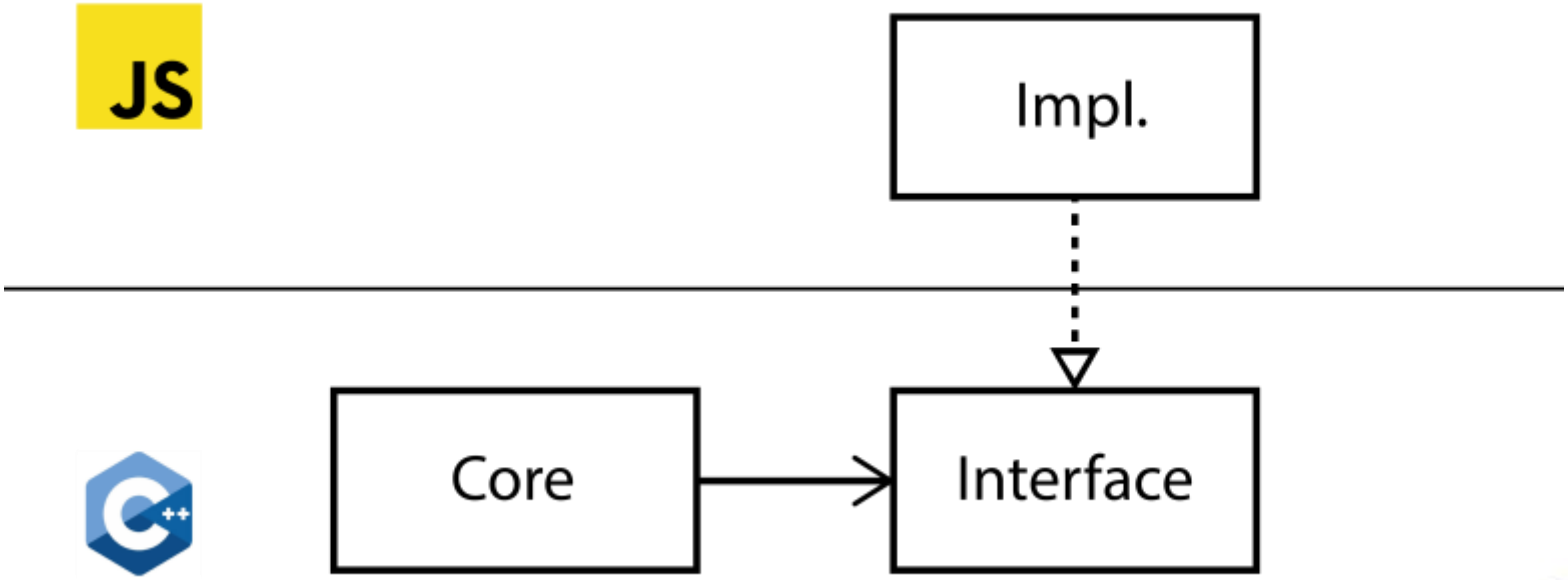
- ccall + cwrap (plain C functions)
- WebIDL Binder (C++ functions, classes)
- **Embind** (C++ ↔ JS)

Embind

- Вызывать в JS функции C++
- Создавать JS-объекты из C++ классов
- Обращаться из C++ кода к API браузера
- Реализовать на JS интерфейс C++


Warning
Beware of C++

Интерфейс C++ в JS



Интерфейс в C++

```
class HTTPClient {
public:
  virtual std::string get(std::string url) = 0;
};
```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Wrapper

```
class HTTPClientWrapper
: public wrapper<HTTPClient> {

  EMSCRIPTEN_WRAPPER(HTTPClientWrapper);

  std::string get(std::string url) {
    return call<std::string>("get", url);
  }
};
```


Wrapper

```
class HTTPClientWrapper
: public wrapper<HTTPClient> {

  EMSCRIPTEN_WRAPPER(HTTPClientWrapper);

  std::string get(std::string url) {
    return call<std::string>("get", url);
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  std::string get(std::string url) {
    return call<std::string>("get", url);
  }
};
```


Binding

```
EMSCRIPTEN_BINDINGS(HTTPClient) {
  class_<HTTPClient>("HTTPClient")
    .function("get",
              &HTTPClient::get,
              pure_virtual() )
    .allow_subclass<HTTPClientWrapper>
              ("HTTPClientWrapper");
}
```


Binding

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}
```


В JS (extend)


```
var HTTPClient =
  Module.HTTPClient.extend("HTTPClient", {
    get: function(url) { … },
  });

var client1 = new HTTPClient();
var client2 = new HTTPClient();
```


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В JS (extend)


```
var HTTPClient =
  Module.HTTPClient.extend("HTTPClient", {
    get: function(url) { … },
  });

var client1 = new HTTPClient();
var client2 = new HTTPClient();
```


B JS (implement)


```
var impl = {
    get: function(url) { … }
};

var client = Module.HTTPClient.implement(impl);
```


B JS (implement)


```
var impl = {
    get: function(url) { … }
};

var client = Module.HTTPClient.implement(impl);
```


В JS (implement)


```
var impl = {
    get: function(url) { … }
};

var client = Module.HTTPClient.implement(impl);
```


B JS (implement)


```
var impl = {
    get: function(url) { … }
};

var client = Module.HTTPClient.implement(impl);
```


Передать в C++


```
var app = Module.makeApp(client, …)
```


Передать в C++


```
var app = Module.makeApp(client, …)
```


Передать в C++


```
var app = Module.makeApp(client, …)
```


Передать в C++


```
var app = Module.makeApp(client, …)
```


Вызов JS из C++

```
val client = val::global("client");

client.call<std::string>("get", val(...) );
```


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```
val client = val::global("client");

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```


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Ошибки биндинга

```
▶ TypeError: webNode.initialize is not a function
    at Bytefog.initWebNode (Bytefog.js:197)
    at Bytefog.create (Bytefog.js:99)
    at Bytefog.js:74
```

```
▶ Uncaught (in promise) TypeError: handle[name] is not a function                VM2955:6
    at methodCaller_unsigned$int_$JSHlsClientListener_std$$string$ (eval at new_ (bytefog-web
node.js:6453), <anonymous>:6:26)
```

```
▼ BindingError
    message: "function WebNode.initialize called with 4 arguments, expected 5 args!"
    name: "BindingError"
    stack: "BindingError: function WebNode.initialize called with 4 arguments, expected
```

```
▼ UnboundTypeError {name: "UnboundTypeError", message: "Cannot call JSSecondaryChannel.onIncommingConnecti…S
  Cannot call JSSecondaryChannel.o…://l49-145-77.cn.ru:8080/dist/bytefog.js:2757:10)"}
    message: "Cannot call JSSecondaryChannel.onIncommingConnection due to unbound types: NSt3__210shared_ptrI
    name: "UnboundTypeError"
    stack: "UnboundTypeError: Cannot call JSSecondaryChannel.onIncommingConnection due to unbound types: NSt3
```

Избегаем ошибок

- Совпадают имена
- Совпадают типы
- Совпадает количество параметров
- Корректный синтаксис Embind
- JS-реализация

Extend vs. Implement

- **extend** расширяет интерфейс
- скрывает ошибки биндинга

Решение:

- использовать **implement**, он стреляет сразу
- писать тесты на каждый метод

Extend и ES6

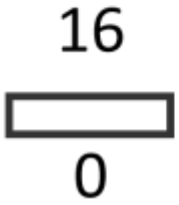
- **extend** несовместим с классами
- Внимание: костыль!

```
function enumerateProto(obj) {
  Object.getOwnPropertyNames(obj.prototype)
    .forEach(prop =>
      Object.defineProperty(obj.prototype, prop,
        {enumerable: true})
)}
```

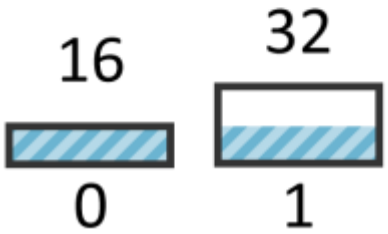
Память

- SD-качество — все хорошо
- FullHD — out of memory
- TOTAL_MEMORY
- ALLOW_MEMORY_GROWTH

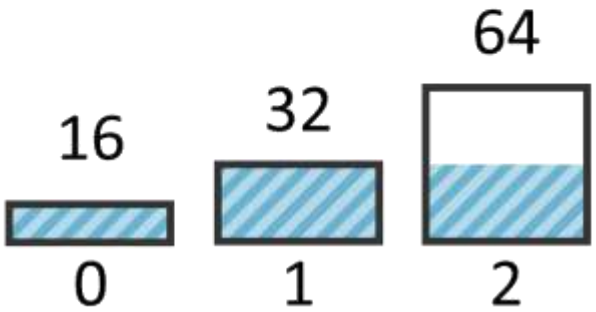
ALLOW_MEMORY_GROWTH



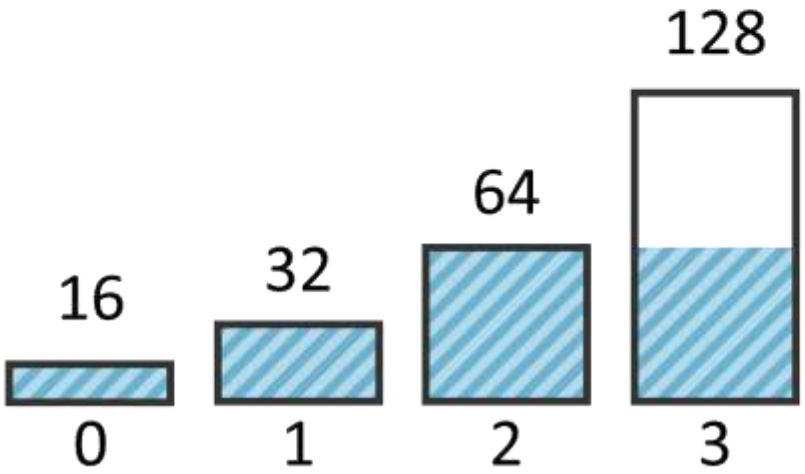
ALLOW_MEMORY_GROWTH



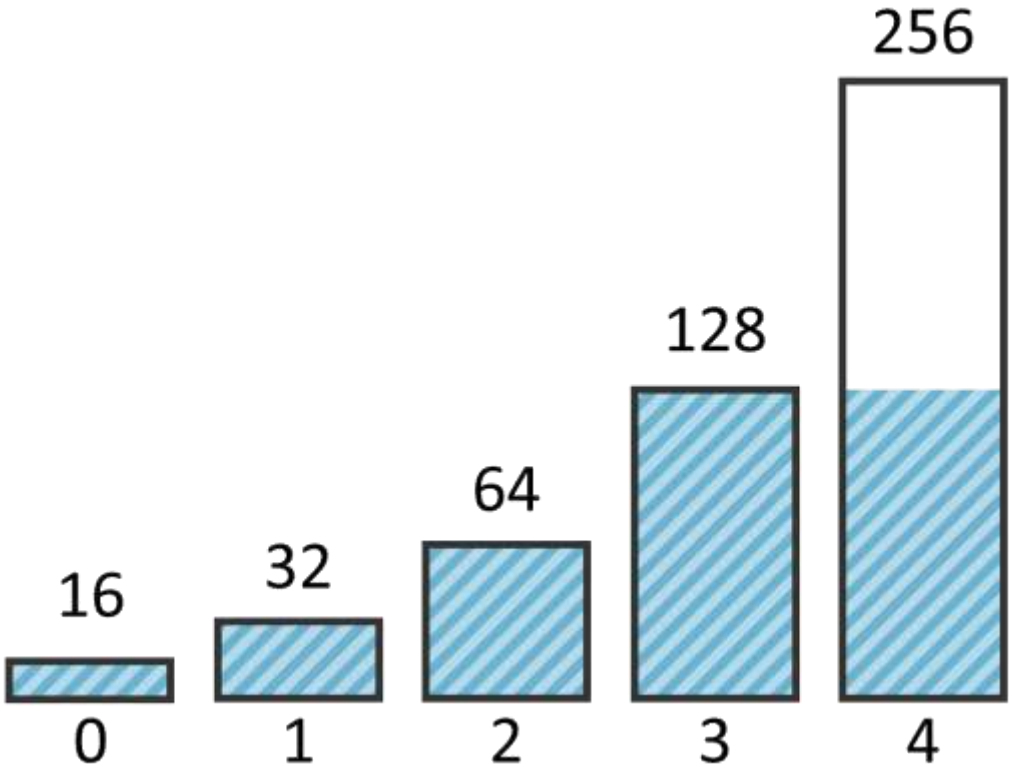
ALLOW_MEMORY_GROWTH



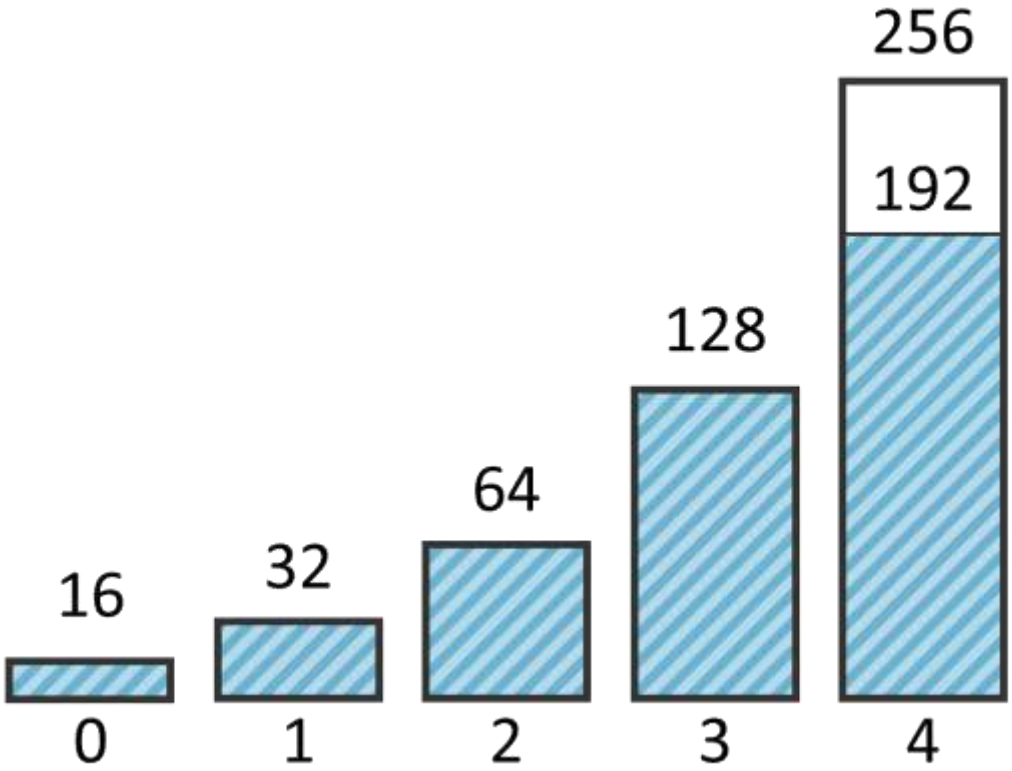
ALLOW_MEMORY_GROWTH



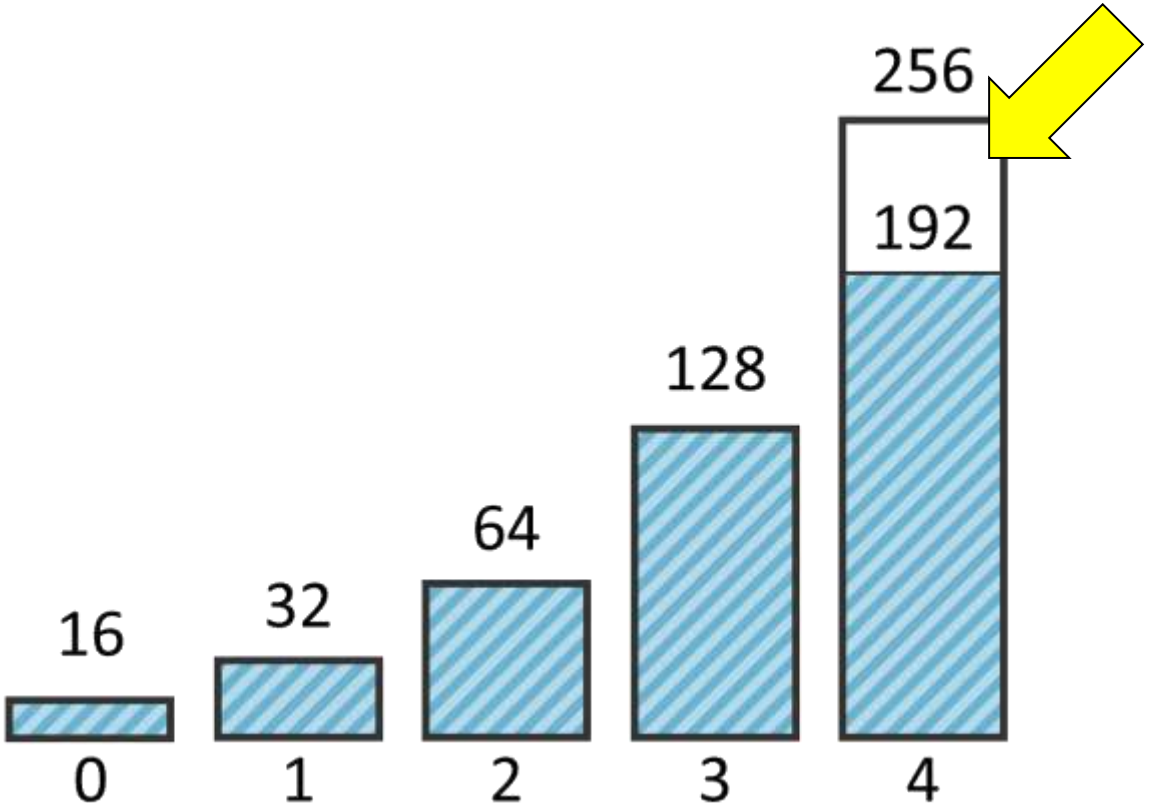
ALLOW_MEMORY_GROWTH



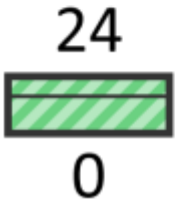
ALLOW_MEMORY_GROWTH



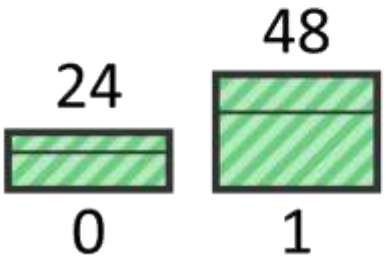
ALLOW_MEMORY_GROWTH



TOTAL_MEMORY *= 1.5



TOTAL_MEMORY *= 1.5



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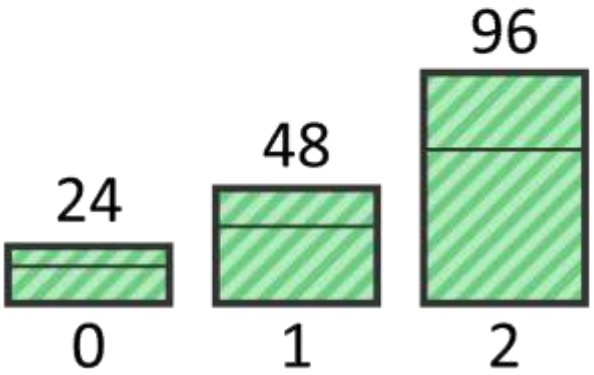
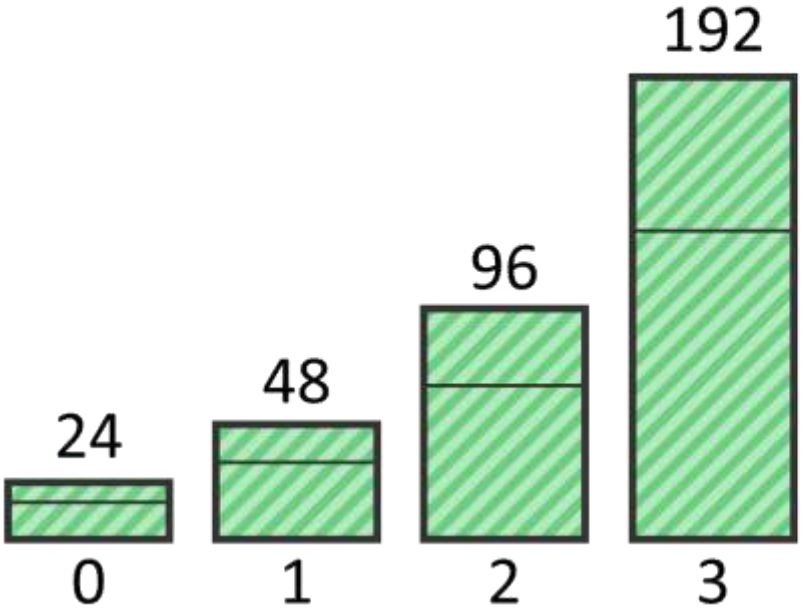


TOTAL_MEMORY *= 1.5



Память

- SD-качество — все хорошо
- FullHD — out of memory
- TOTAL_MEMORY
- ALLOW_MEMORY_GROWTH
- Используйте их комбинацию


ЕЩЁ ГРАБЛИ

DI

DI

```
class App {
  constructor(httpClient) {
    this.httpClient = httpClient
  }
}
```

DI

```
Module.App.extend(
   "App",
   new App(client)
)
```

Решение

```
class App {
  __construct(httpClient) {
    this.httpClient = httpClient
    this.__parent.__construct.call(this)
  }
}
```

Решение

```
class App {
  __construct(httpClient) {
    this.httpClient = httpClient
    this.__parent.__construct.call(this)
  }
}
```

Решение

```
class App {
  __construct(httpClient) {
    this.httpClient = httpClient
    this.__parent.__construct.call(this)
  }
}
```

Решение

```
const appConstr = Module.App.extend(
  "App",
  new App()
)

const app = new appConstr(client)
```

Решение

```
const appConstr = Module.App.extend(
  "App",
  new App()
)

const app = new appConstr(client)
```

Решение

```
const appConstr = Module.App.extend(
  "App",
  new App()
)

const app = new appConstr(client)
```


Передача указателя

```
std::string get(std::string url)

void get(std::string url, Listener listener)
```

Передача указателя

```
function get(url, listener) {
  fetch(url).then((result) => {
    listener.onResult(result)
  })
}
```

Передача указателя

```
function get(url, listener) {
  fetch(url).then((result) => {
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  })
}
```

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Передача указателя

```
function get(url, listener) {
  fetch(url).then((result) => {
    listener.onResult(result)
  })
}
```

Передача указателя

```
function get(url, listener) {
  fetch(url).then((result) => {
    listener.onResult(result) // error
  })
}
```

Решение

```
function get(url, listener) {
  const listenerCopy = listener.clone()
  fetch(url).then((result) => {
    listenerCopy.onResult(result)
    listenerCopy.delete()
  })
}
```

Решение

```
function get(url, listener) {
  const listenerCopy = listener.clone()
  fetch(url).then((result) => {
    listenerCopy.onResult(result)
    listenerCopy.delete()
  })
}
```

Решение

```
function get(url, listener) {
  const listenerCopy = listener.clone()
  fetch(url).then((result) => {
    listenerCopy.onResult(result)
    listenerCopy.delete()
  })
}
```

Решение

```
function get(url, listener) {
  const listenerCopy = listener.clone()
  fetch(url).then((result) => {
    listenerCopy.onResult(result)
    listenerCopy.delete()
  })
}
```

Записать в память WASM

```
var newData = new Uint8Array(…);

var size = newData.byteLength;
var ptr = Module._malloc(size);

var memory = new Uint8Array(
  Module.buffer, ptr, size
);
memory.set(newData);
```

Записать в память WASM

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var newData = new Uint8Array(…);

var size = newData.byteLength;
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var memory = new Uint8Array(
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var memory = new Uint8Array(
  Module.buffer, ptr, size
);
memory.set(newData);
```

- AdBlock, AdBlock Plus, uBlock Origin
- 3rd-party .wasm блокируется списком RU AdList

```
.wasm|$third-party,xmlhttprequest,domain=~lite.boxshot.com
```

- **Решение:** хранить на своем домене
- **Решение:** переименовать .wasm-файл

https://forums.lanik.us/viewforum.php?f=102


МЫ ВЫШЛИ В ПРОДАКШН!

Продакшн

- Не нужно устанавливать
- Единая кодовая база
- Отладка на разных платформах
- Быстрый релиз
- Быстрая обратная связь

ГДЕ ПРИМЕНИТЬ?

Доступные языки

- C/C++
- Rust
- Lua, Perl, Python, PHP, etc.
- Go
- Kotlin/Native

https://github.com/appcypher/awesome-wasm-langs
https://stackoverflow.com/a/47483989


UNREAL
ENGINE

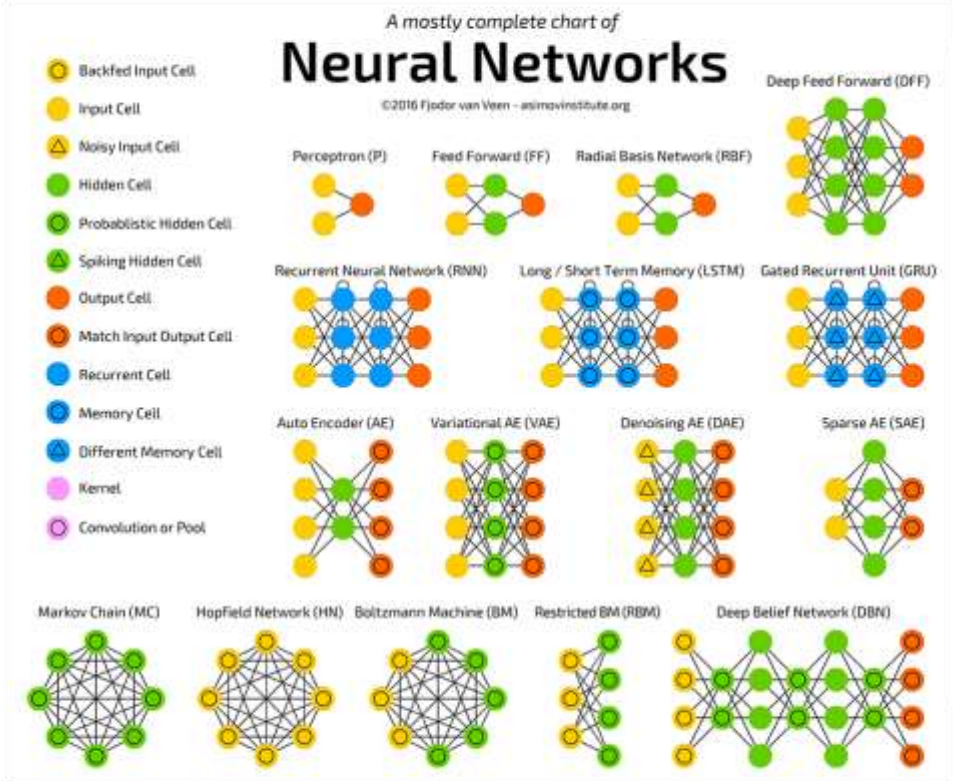

unity

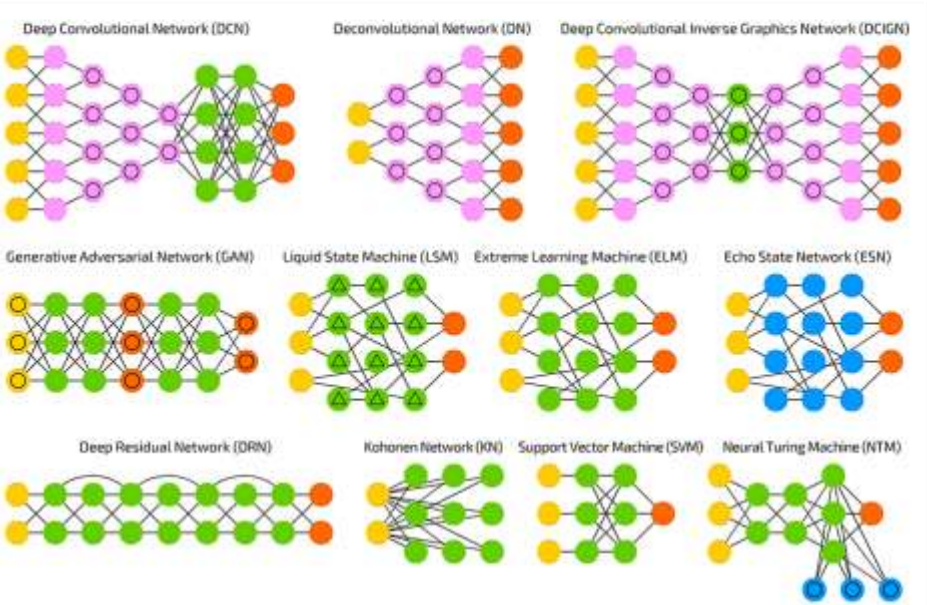

UNIGINE
engine of virtual worlds


HOLY
JS

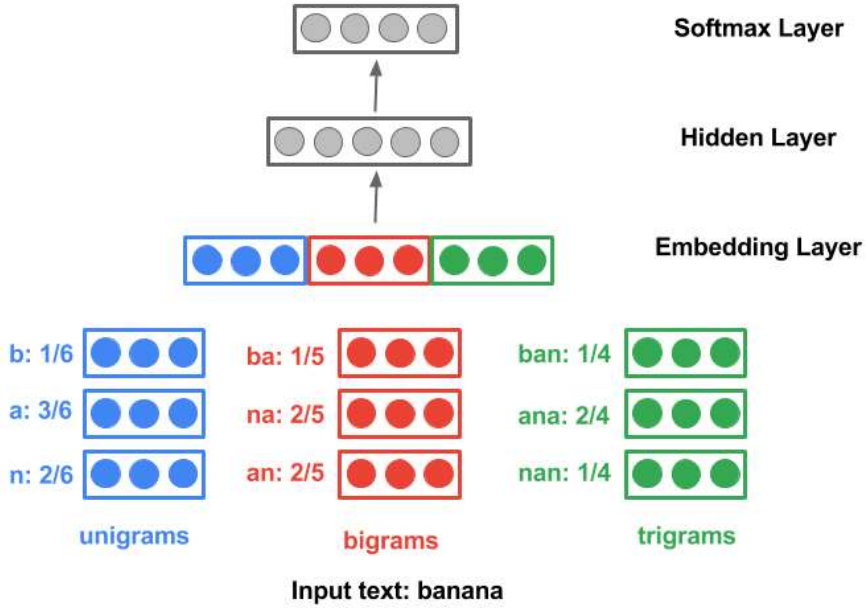
Обработка данных

- изображения
- звук
- видео
- архивы


A mostly complete chart of
Neural Networks
©2016 Fjodor van Veen – asimovinstitute.org
Backfed Input Cell
Input Cell
Noisy Input Cell
Hidden Cell
Probabilistic Hidden Cell
Spiking Hidden Cell
Output Cell
Match Input Output Cell
Recurrent Cell
Memory Cell
Different Memory Cell
Kernel
Convolution or Pool
Perceptron (P)
Feed Forward (FF)
Radial Basis Network (RBF)
Deep Feed Forward (DFF)
Recurrent Neural Network (RNN)
Long / Short Term Memory (LSTM)
Gated Recurrent Unit (GRU)
Auto Encoder (AE)
Variational AE (VAE)
Denoising AE (DAE)
Sparse AE (SAE)
Markov Chain (MC)
Hopfield Network (HN)
Boltzmann Machine (BM)
Restricted BM (RBM)
Deep Belief Network (DBN)


Deep Convolutional Network (DCN)
Deconvolutional Network (DN)
Deep Convolutional Inverse Graphics Network (DCIGN)
Generative Adversarial Network (GAN)
Liquid State Machine (LSM)
Extreme Learning Machine (ELM)
Echo State Network (ESN)
Deep Residual Network (DRN)
Kohonen Network (KN)
Support Vector Machine (SVM)
Neural Turing Machine (NTM)

Google
Compact Language Detector 3



Проверка орфографии

HunSpell


OpenSSL
Cryptography and SSL/TLS Toolkit

wot inspector.com

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начало > реплеи

реплеи blitz

На этой странице можно загружать свои реплеи Блитц или просматривать blitz реплеи, загруженные другими. Отправьте реплей на replays@wotinspector.com , чтобы он появился в базе данных, и получите ссылку на скачивание.

поиск

-- -- любой игрок и клан -- -- любой танк

▼ дата урон опыт ассист просмотры

IX AMX 30 1er prototype, Эшелон

Эшелон
AMX 30 1er prototype
Nightwalker181.eu
04:47

★ 592 xp
2 878 hp
-- hp
2 4

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посмотреть онлайн

VI Bagged another one on the 8th game😛😋


FFmpeg


opus


OpenCV


PDF


SQLite

CSS with superpowers

Sass is the most mature, stable, and powerful professional grade CSS extension language in the world.

Current Releases: **Dart Sass 1.15.1** **LibSass 3.5.5** **Ruby Sass 3.7.2** **Implementation Guide**

sass / node-sass

Node.js bindings to libsass https://npmjs.org/package/node-sass

node-sass libsass scss sass-files scss-files

2,394 commits 11 branches 188 releases 170 contributors MIT

Branch: master New pull request Create new file Upload files Find file Clone or download

xzyfer Update changelog Latest commit dfe1f05 4 days ago

.github	Remove custom issue template	5 months ago
bin	Clarify docs for --source-map. Closes #1026.	6 months ago
lib	feat: Add detecton for Node 11 (module 67)	14 days ago
media	add logo - fixes #327	5 years ago
memory-tests	Add Isolated Memory Leak Scenarios	a year ago
scripts	Fix wrong binary encoding	8 months ago

Supported Environments

OS	Architecture	Node
Windows	x86 & x64	0.10, 0.12, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
OSX	x64	0.10, 0.12, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
Linux*	x86 & x64	0.10, 0.12, 1, 2, 3, 4, 5, 6, 7, 8**, 9**, 10**^, 11**
Alpine Linux	x64	4, 6, 7, 8, 9, 10, 11
FreeBSD 10+	amd64	4, 6, 8, 9, 10
FreeBSD 10+	i386	4, 6, 8, 9, 10

Search or jump to... /

Pull requests Issues Marketplace Explore

kwonoj / libsass-asm

Watch 2 | Unstar 27 | Fork 1

Code | Issues 3 | Pull requests 1 | Projects 0 | Insights

WebAssembly based Javascript bindings for libsass

sass wasm webassembly libsass sassc

178 commits | 2 branches | 4 releases | 2 contributors | MIT

Branch: master | New pull request | Create new file | Upload files | Find file | Clone or download

kwonoj Merge pull request #57 from 0xflotus/patch-1 ... Latest commit a99daa2 13 days ago

.circleci	ci(circle): avoid bundler failure	24 days ago
.vscode	build(editor): editor config	4 months ago
spec	feat(cli): initial cli entrypoint	4 months ago
src	build(package): bump up dependencies	24 days ago
.gitignore	build(package): bump up libsass	24 days ago
.npmignore	build(ignore): update ignore list	23 days ago
CHANGELOG.md	build(release): release 0.0.4	24 days ago

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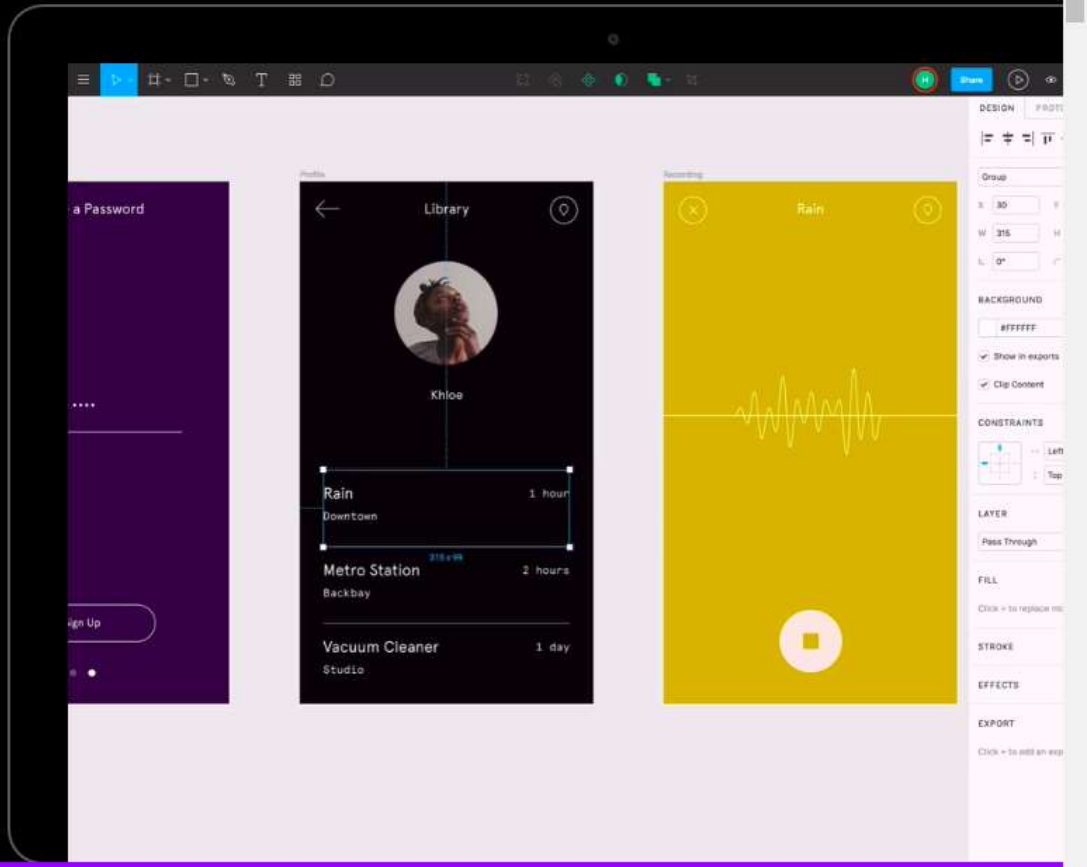

Version 1.29 is now available! Read about the new features and fixes from October.

Code editing. Redefined.

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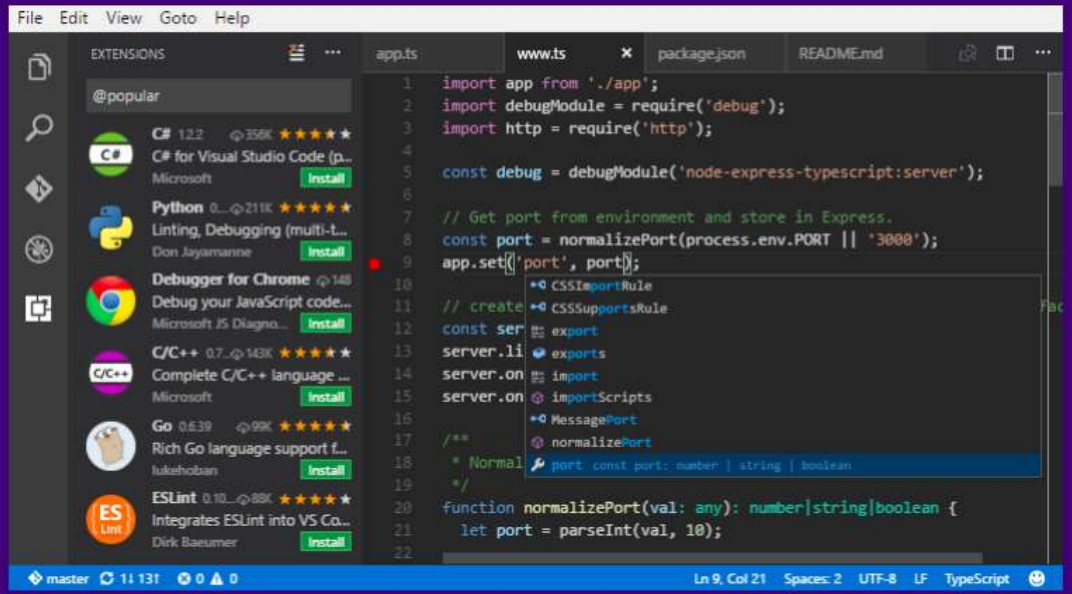
Stable Build

Other platforms and Insiders Edition

By using VS Code, you agree to its license and privacy statement.



IntelliSense

Debugging

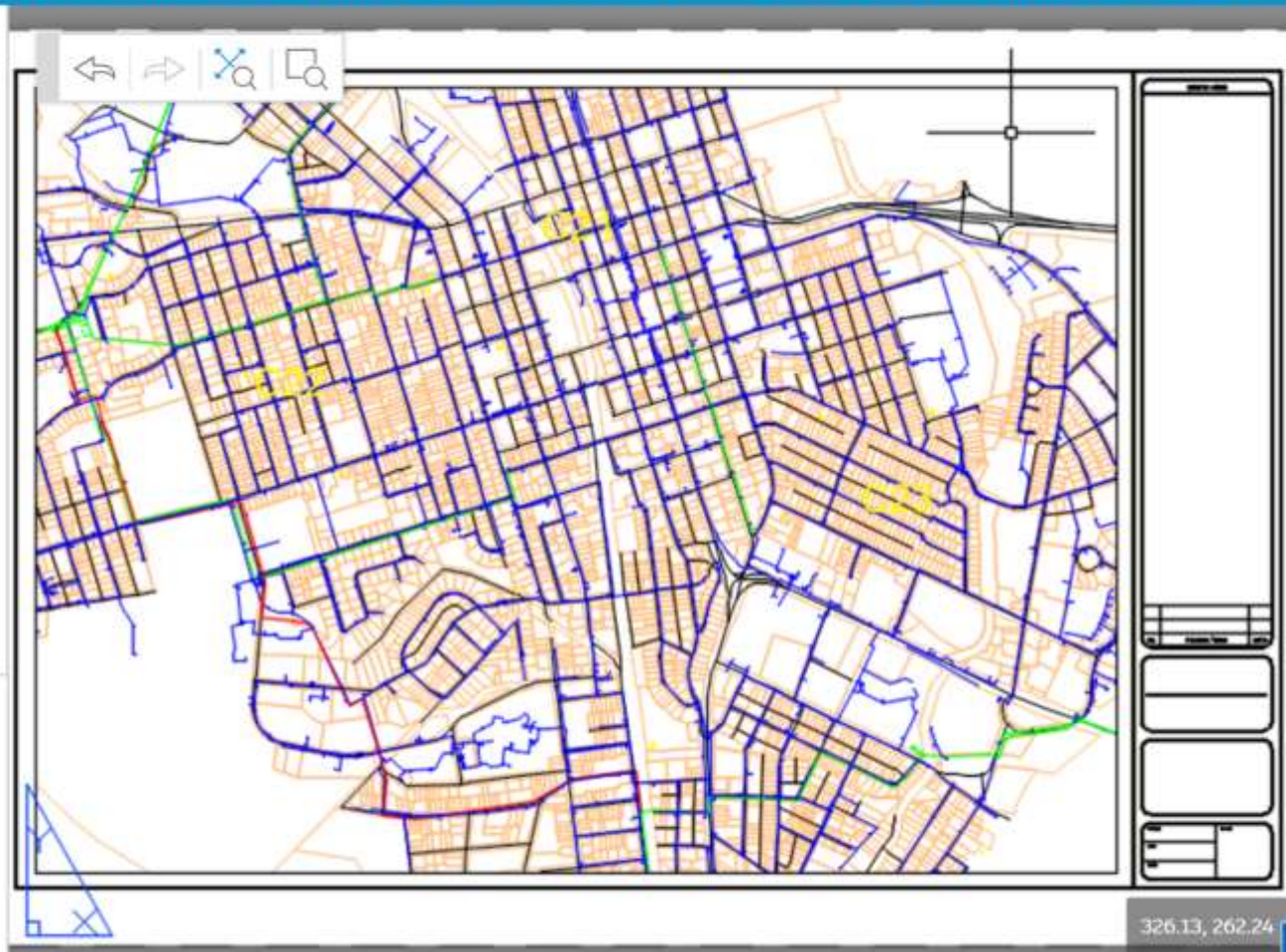
Built-in Git

Extensions

Views
Prop.
Layers
Settings

Object Properties

Layer	Waterlines
Color	ByLayer
Linetype	ByLayer
Linetype scale	1.0000
Dim style	Standard
Text style	Standard
Mleader style	Standard



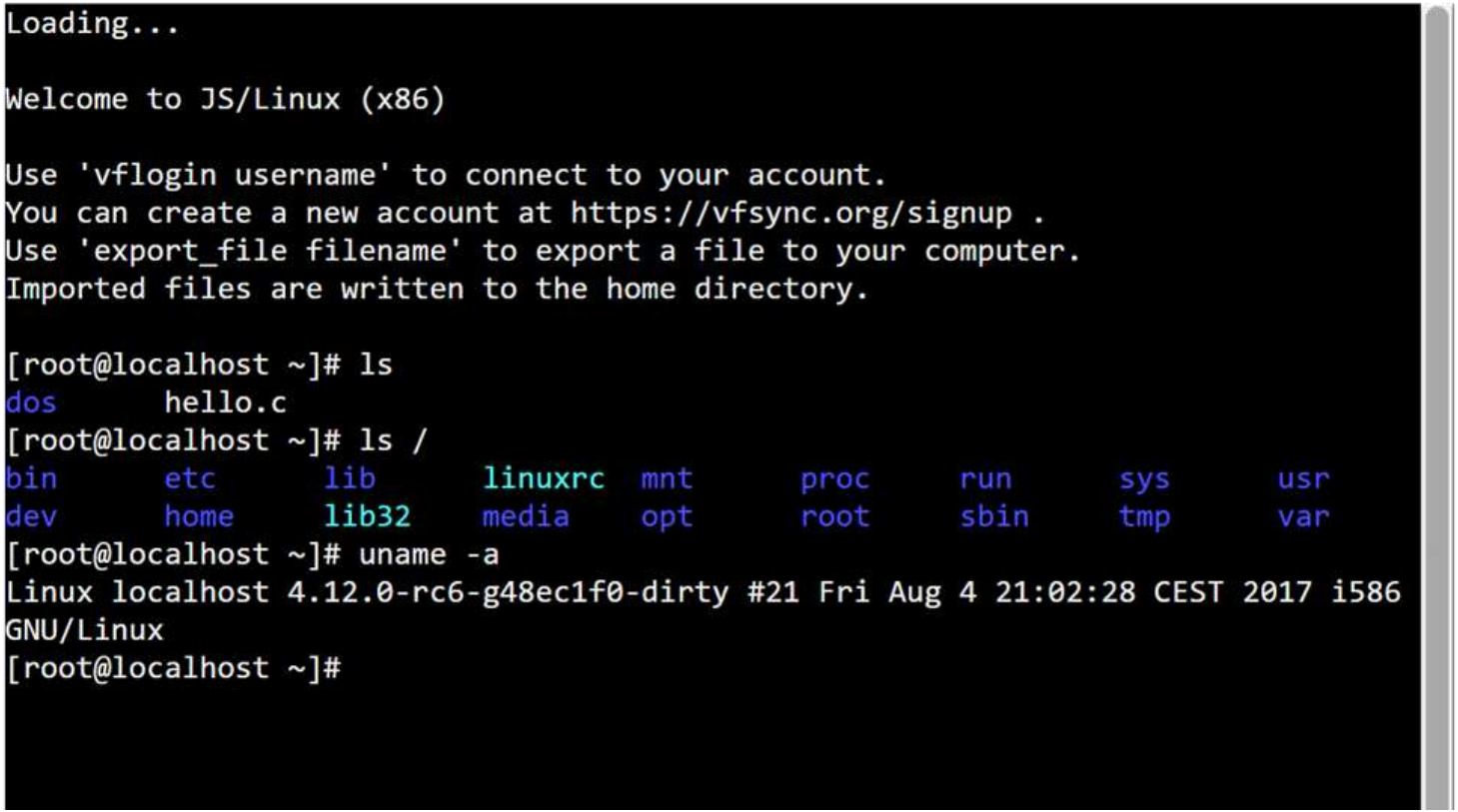
326.13, 262.24

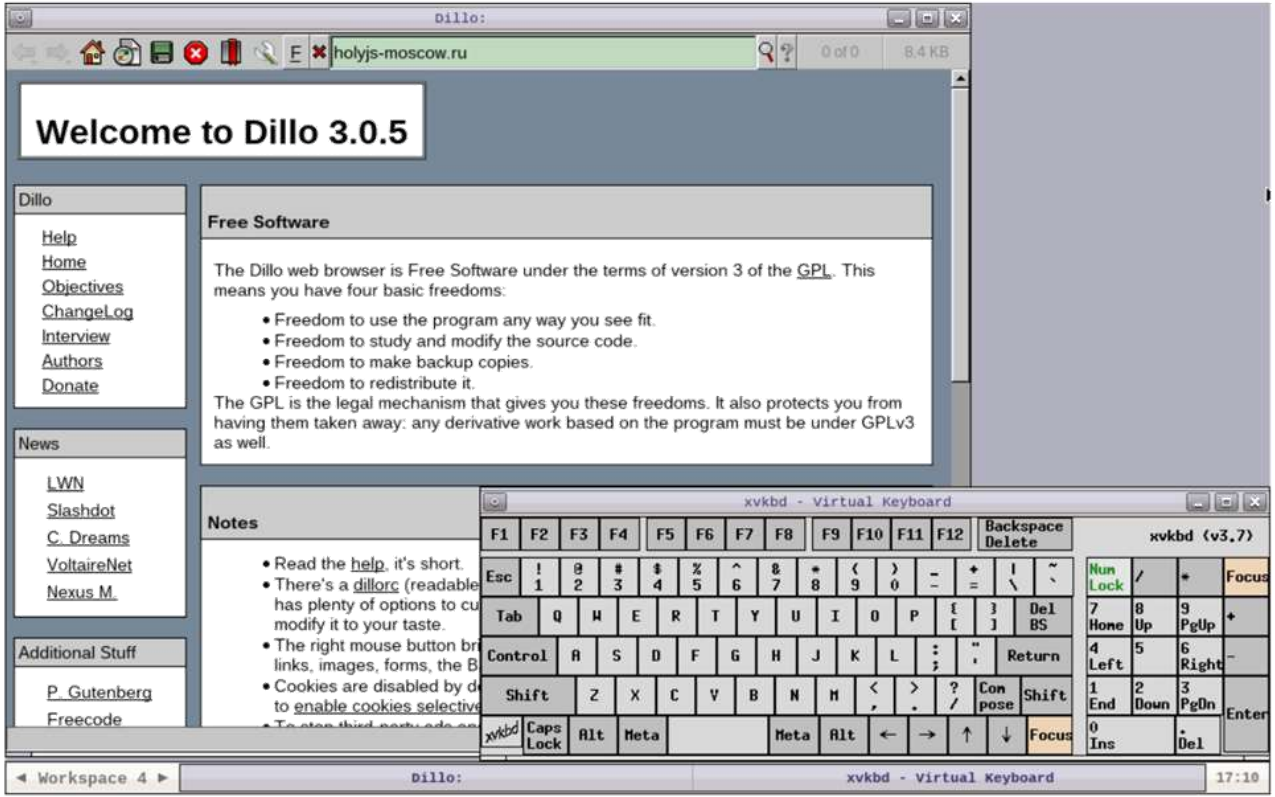
JSLinux

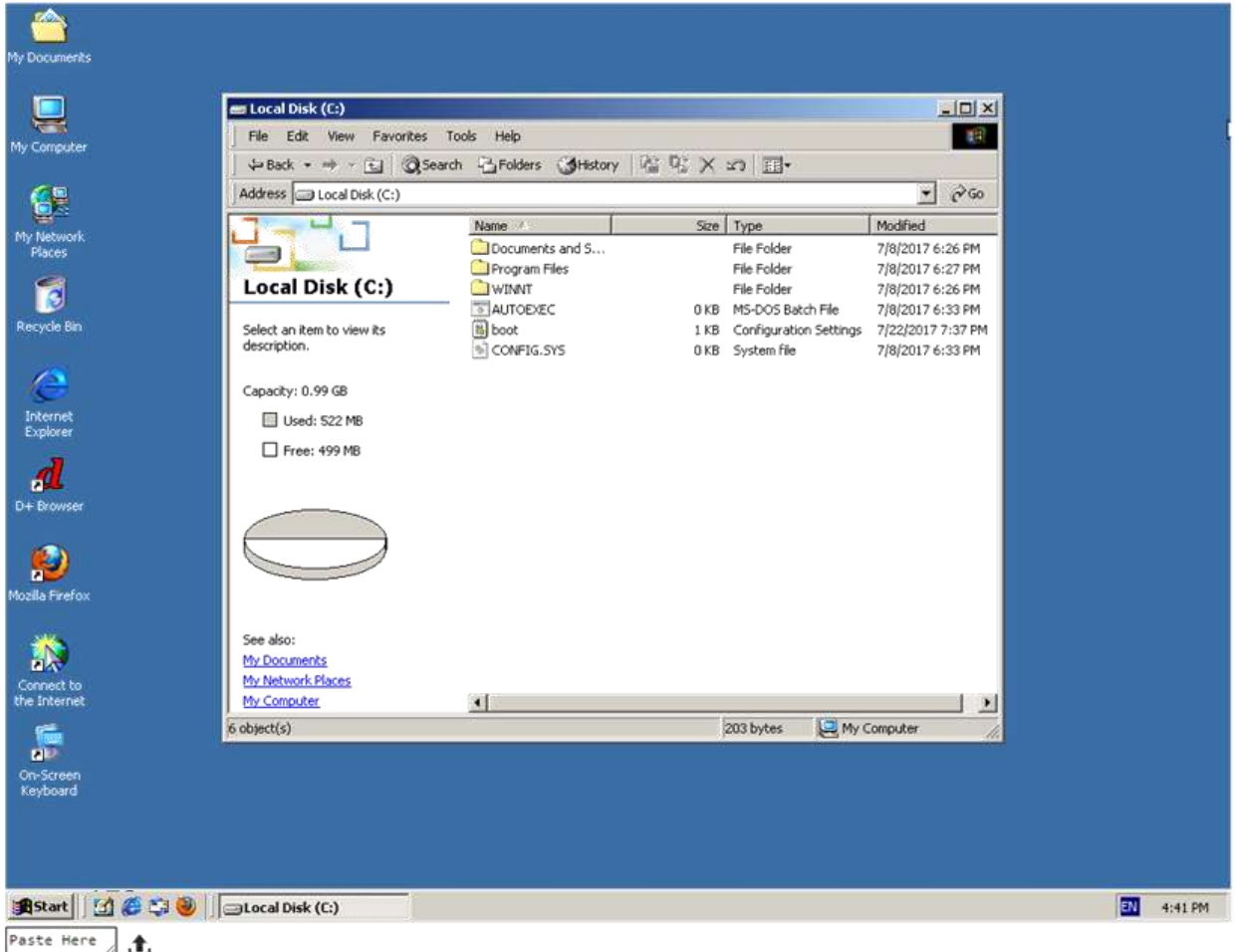
Run Linux or other Operating Systems in your browser!

The following emulated systems are available:

CPU	OS (Distribution)	User Interface	VFsync access	Startup Link	TEMU Config	Comment
x86	Linux 4.12.0 (Buildroot)	Console	Yes	click here	url	
x86	Linux 4.12.0 (Buildroot)	X Window	Yes	click here	url	Right mouse button for the menu.
x86	Windows 2000	Graphical	No	click here	url	Disclaimer.
x86	FreeDOS	VGA Text	No	click here	url	
riscv64	Linux 4.15.0 (Buildroot)	Console	Yes	click here	url	
riscv64	Linux 4.15.0 (Buildroot)	X Window	Yes	click here	url	Right mouse button for the menu.
riscv64	Linux 4.15.0 (Fedora 29)	Console	Yes	click here	url	Warning: longer boot time.
riscv64	Linux 4.15.0 (Fedora 29)	X Window	Yes	click here	url	Warning: longer boot time. Right mouse button for the menu.


JSLinux
https://bellard.org/jslinux/vm.html?url=https://bellard.org/jslinux/buildroot-x86.cfg
Loading...
Welcome to JS/Linux (x86)
Use 'vflogin username' to connect to your account.
You can create a new account at https://vfsync.org/signup .
Use 'export_file filename' to export a file to your computer.
Imported files are written to the home directory.
[root@localhost ~]# ls
dos hello.c
[root@localhost ~]# ls /
bin etc lib linuxrc mnt proc run sys usr
dev home lib32 media opt root sbin tmp var
[root@localhost ~]# uname -a
Linux localhost 4.12.0-rc6-g48ec1f0-dirty #21 Fri Aug 4 21:02:28 CEST 2017 i586
GNU/Linux
[root@localhost ~]#


JSLinux
https://bellard.org/jslinux/vm.html?url=https://bellard.org/jslinux/buildroot-x86-xwin.cfg&graphic=1
Dillo:
holyjs-moscow.ru
Welcome to Dillo 3.0.5
Dillo
Help
Home
Objectives
ChangeLog
Interview
Authors
Donate
News
LWN
Slashdot
C. Dreams
VoltaireNet
Nexus M.
Additional Stuff
P. Gutenberg
Freecode
Free Software
The Dillo web browser is Free Software under the terms of version 3 of the GPL. This means you have four basic freedoms:
• Freedom to use the program any way you see fit.
• Freedom to study and modify the source code.
• Freedom to make backup copies.
• Freedom to redistribute it.
The GPL is the legal mechanism that gives you these freedoms. It also protects you from having them taken away: any derivative work based on the program must be under GPLv3 as well.
Notes
xvkbd - Virtual Keyboard
xvkbd (v3.7)
Workspace 4
Dillo:
xvkbd - Virtual Keyboard
17:10
Paste Here
© 2011-2018 Fabrice Bellard - News - VM list - FAQ - Technical notes


JSLinux
https://bellard.org/jslinux/vm.html?url=https://bellard.org/jslinux/win2k.cfg&mem=192&graphic=1&w=1024&h=768
My Documents
My Computer
My Network Places
Recycle Bin
Internet Explorer
D+ Browser
Mozilla Firefox
Connect to the Internet
On-Screen Keyboard
Local Disk (C:)
File Edit View Favorites Tools Help
Back Search Folders History
Address Local Disk (C:)
Go
Local Disk (C:)
Select an item to view its description.
Capacity: 0.99 GB
Used: 522 MB
Free: 499 MB
See also:
My Documents
My Network Places
My Computer
Name Size Type Modified
Documents and S... File Folder 7/8/2017 6:26 PM
Program Files File Folder 7/8/2017 6:27 PM
WINNT File Folder 7/8/2017 6:26 PM
AUTOEXEC 0 KB MS-DOS Batch File 7/8/2017 6:33 PM
boot 1 KB Configuration Settings 7/22/2017 7:37 PM
CONFIG.SYS 0 KB System file 7/8/2017 6:33 PM
6 object(s)
203 bytes
My Computer
Start
Local Disk (C:)
EN
4:41 PM
Paste Here

Где можно применить?

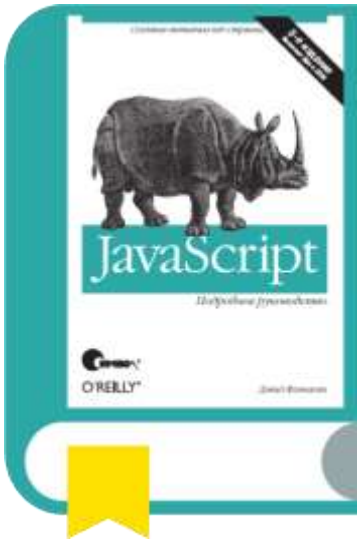
- 3D-графика
- Обработка данных, вычисления
- Нейросети в ML-модели в браузере
- Криптография в браузере
- Перенос вычислений к пользователю
- Нативные библиотеки в браузере
- Нативные модули Node.js кроссплатформенно
- Оптимизация производительности
- Портирование своего кода

КАК ВНЕДРИТЬ У СЕБЯ?

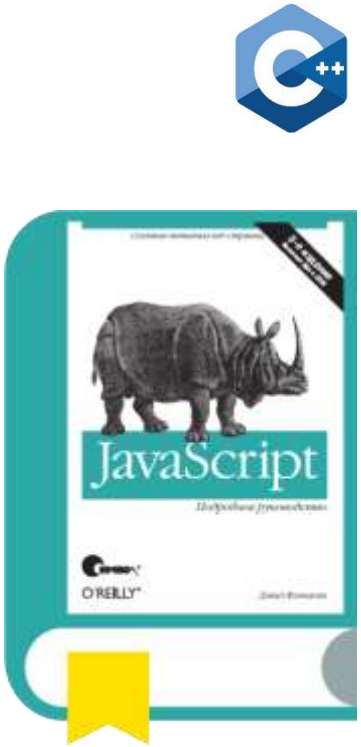
Команда

Команда

Идеальная команда



Идеальная команда



CI pipeline

→

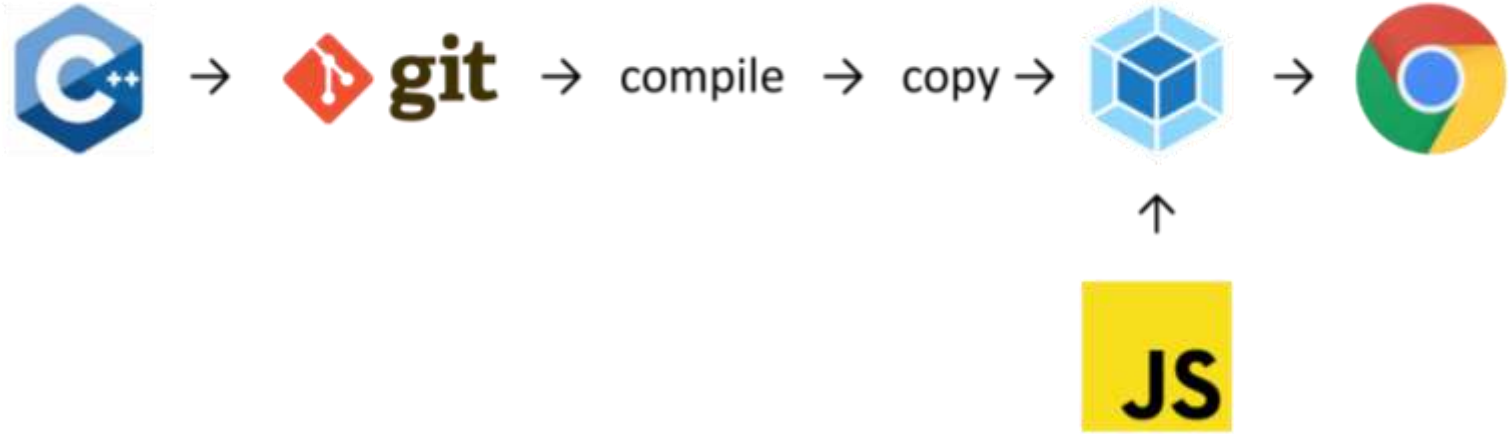
CI pipeline

CI pipeline

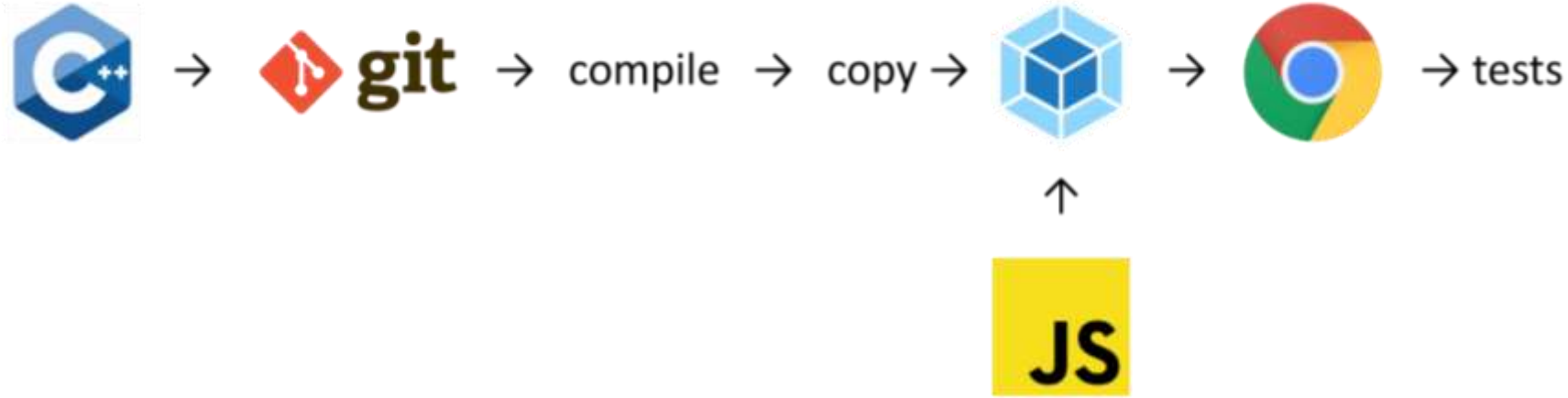
CI pipeline

CI pipeline

CI pipeline



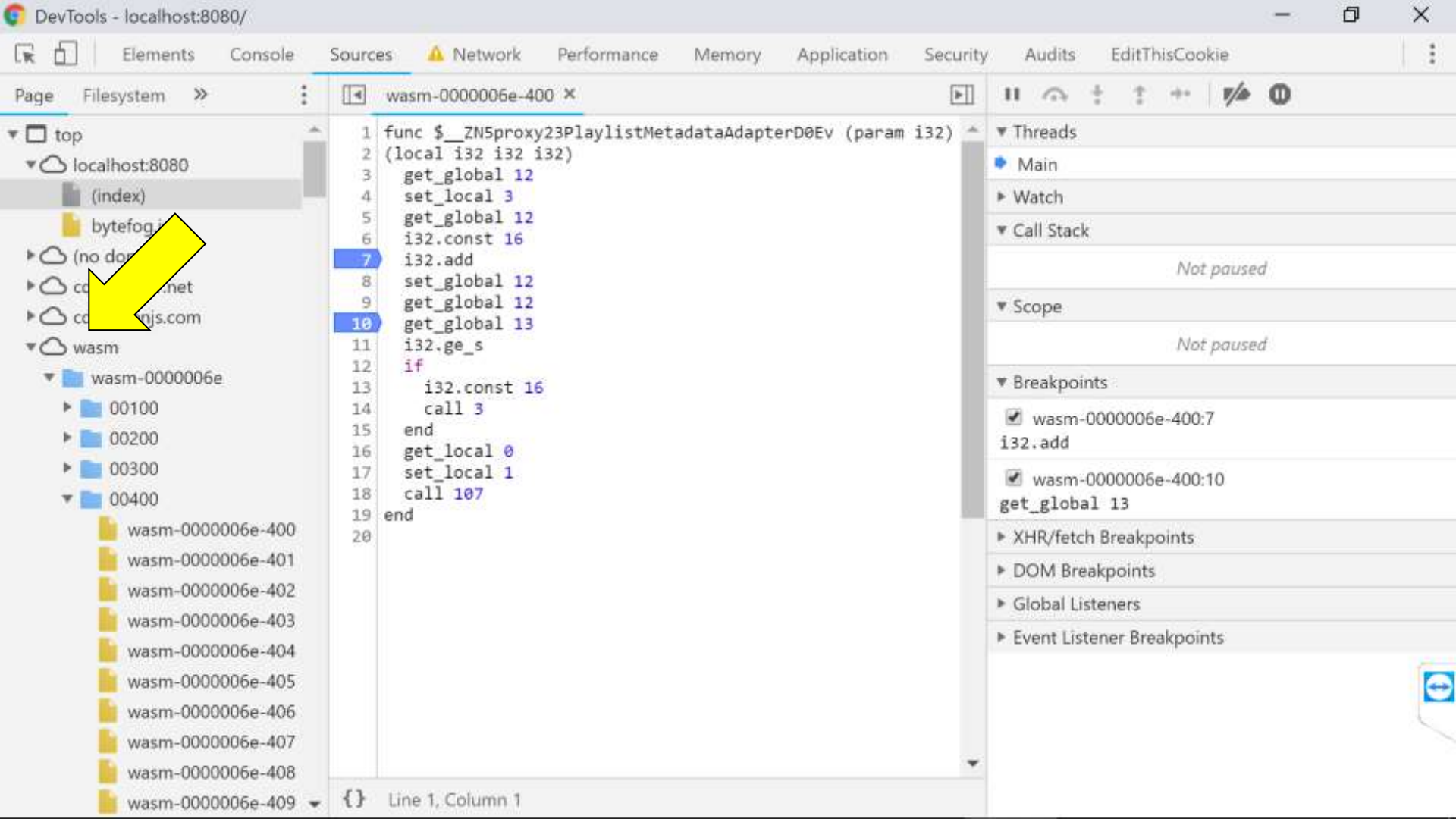
CI pipeline

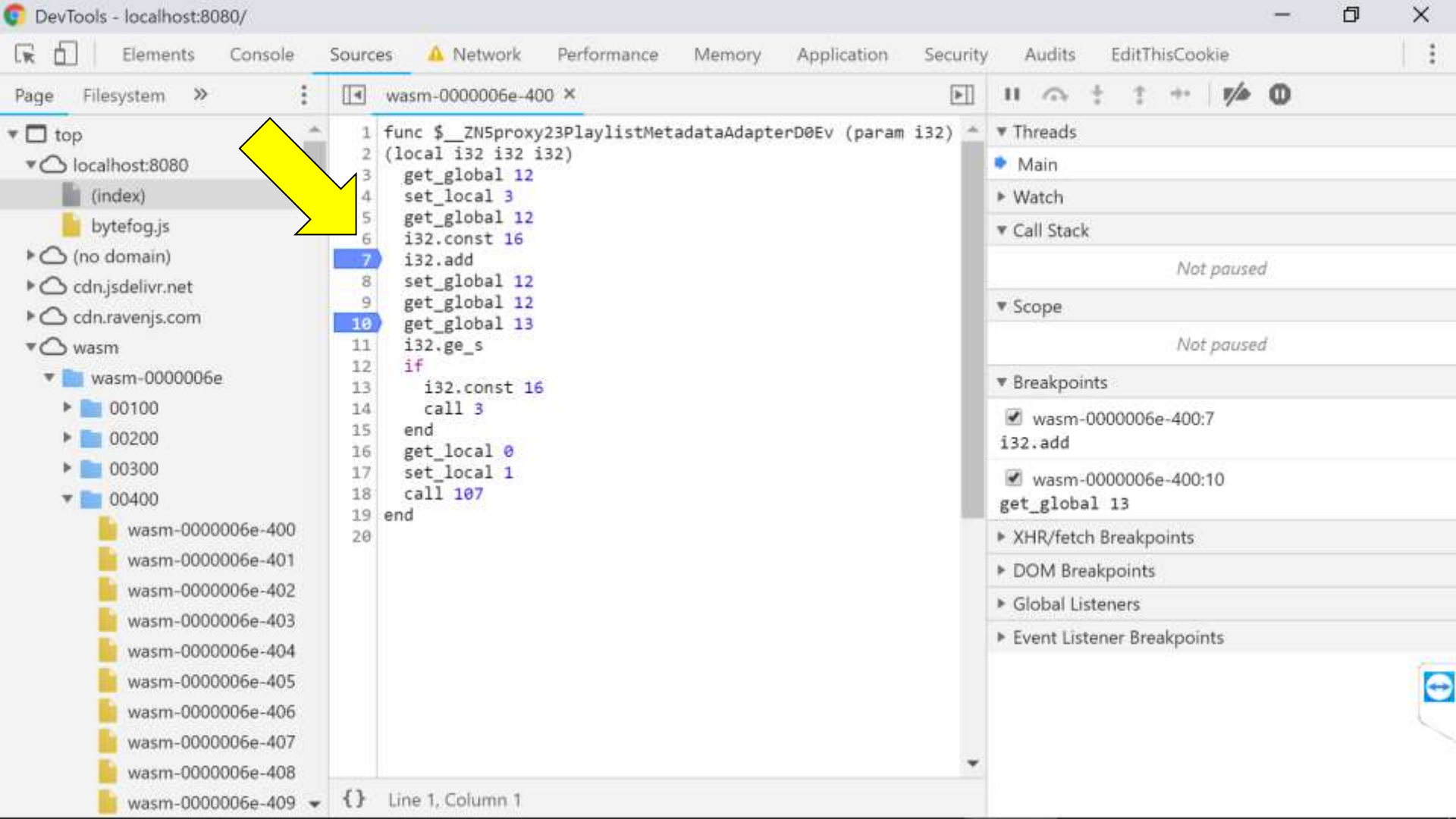


ОТЛАДКА

Отладка

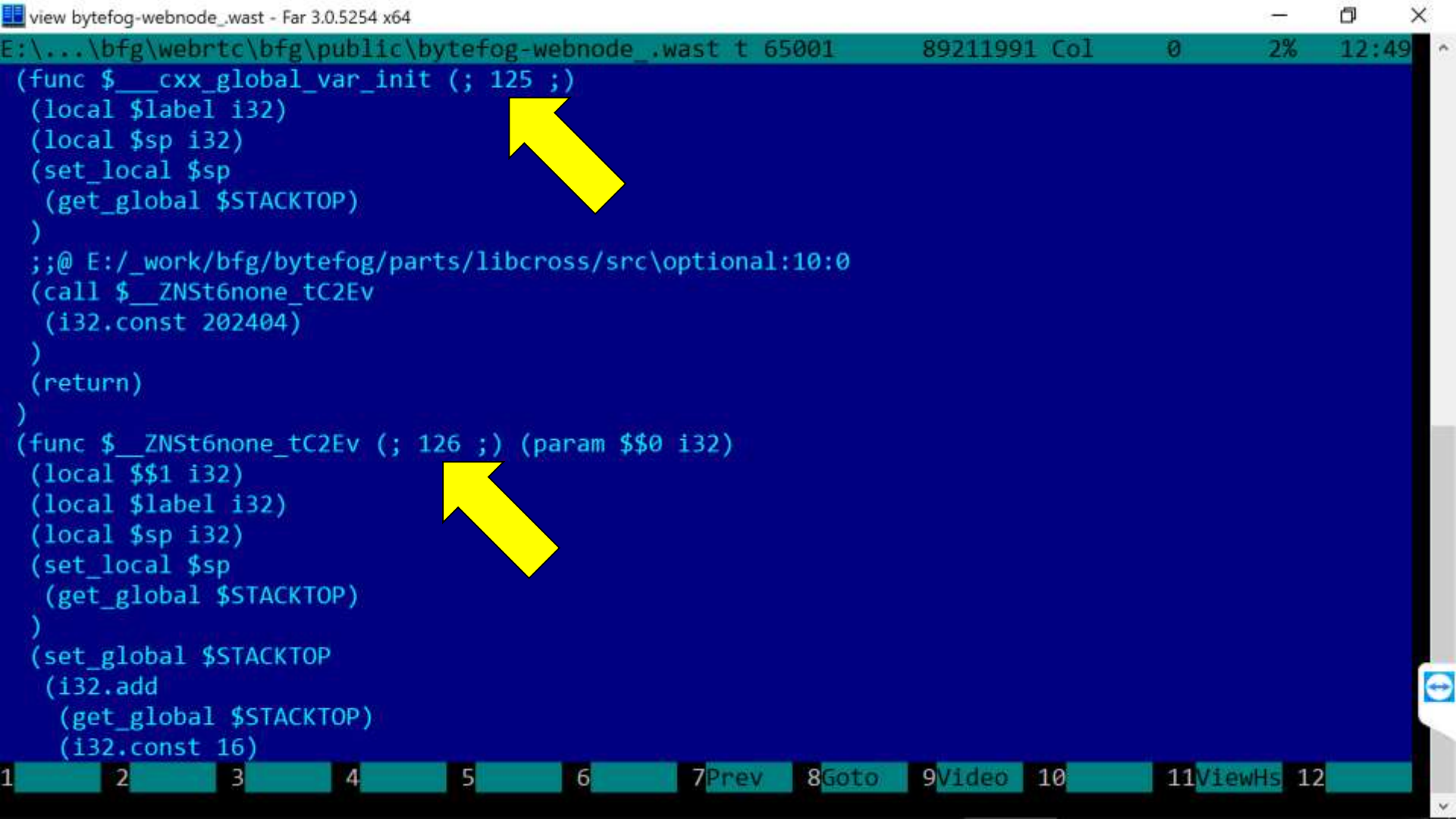
- Включить Chrome DevTools Experiments

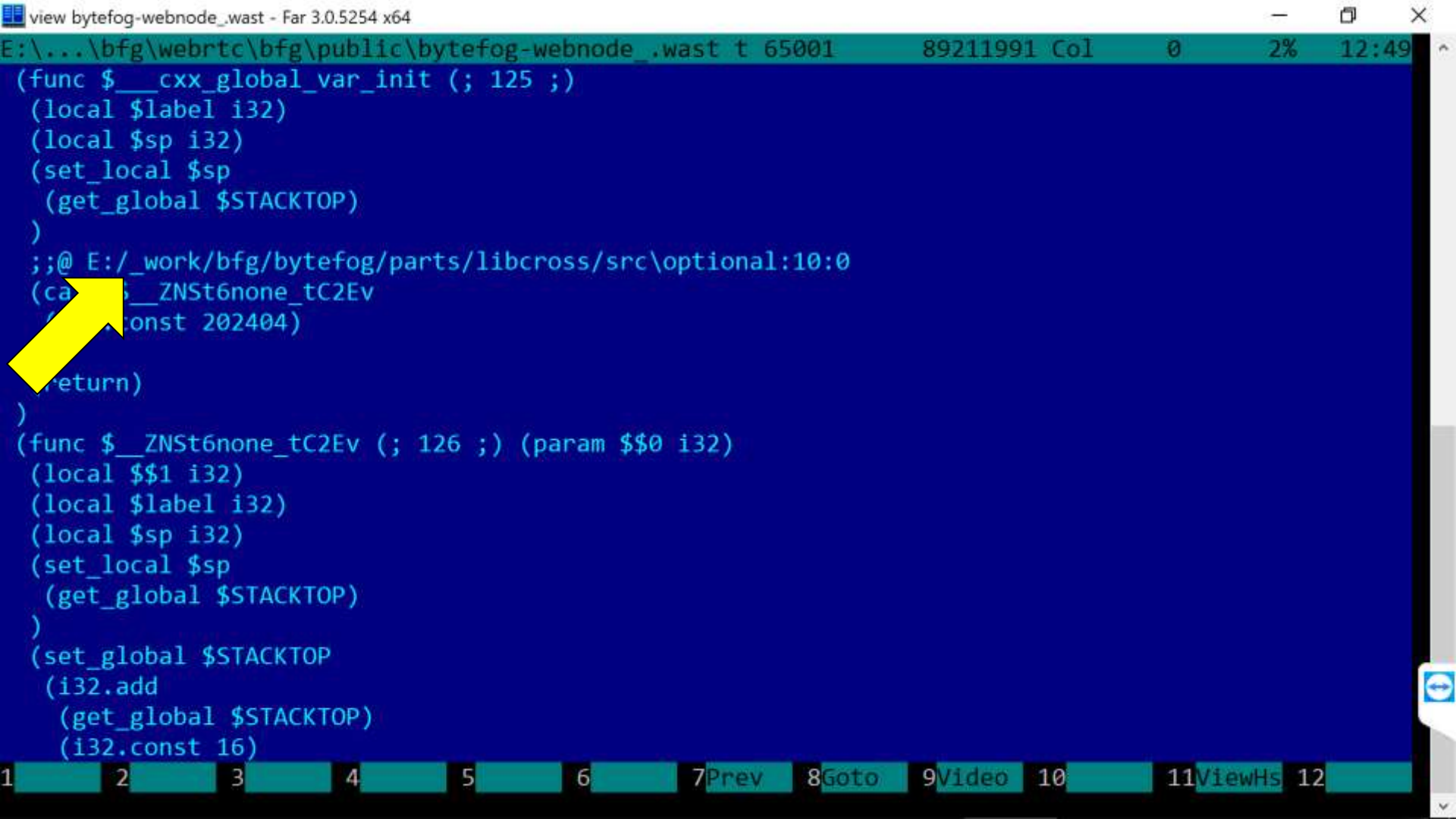

DevTools - localhost:8080/
Elements
Console
Sources
Network
Performance
Memory
Application
Security
Audits
EditThisCookie
Page
Filesystem
top
localhost:8080
(index)
wasm
wasm-0000006e
00100
00200
00300
00400
wasm-0000006e-400
wasm-0000006e-401
wasm-0000006e-402
wasm-0000006e-403
wasm-0000006e-404
wasm-0000006e-405
wasm-0000006e-406
wasm-0000006e-407
wasm-0000006e-408
wasm-0000006e-409
wasm-0000006e-400
func $__ZN5proxy23PlaylistMetadataAdapterD0Ev (param i32)
(local i32 i32 i32)
get_global 12
set_local 3
get_global 12
i32.const 16
i32.add
set_global 12
get_global 12
get_global 13
i32.ge_s
if
i32.const 16
call 3
end
get_local 0
set_local 1
call 107
end
Line 1, Column 1
Threads
Main
Watch
Call Stack
Not paused
Scope
Not paused
Breakpoints
wasm-0000006e-400:7
i32.add
wasm-0000006e-400:10
get_global 13
XHR/fetch Breakpoints
DOM Breakpoints
Global Listeners
Event Listener Breakpoints


DevTools - localhost:8080/
Elements
Console
Sources
Network
Performance
Memory
Application
Security
Audits
EditThisCookie
Page
Filesystem
top
localhost:8080
(index)
bytefog.js
(no domain)
cdn.jsdelivr.net
cdn.ravenjs.com
wasm
wasm-0000006e
00100
00200
00300
00400
wasm-0000006e-400
wasm-0000006e-401
wasm-0000006e-402
wasm-0000006e-403
wasm-0000006e-404
wasm-0000006e-405
wasm-0000006e-406
wasm-0000006e-407
wasm-0000006e-408
wasm-0000006e-409
wasm-0000006e-400
1 func $__ZN5proxy23PlaylistMetadataAdapterD0Ev (param i32)
2 (local i32 i32 i32)
3 get_global 12
4 set_local 3
5 get_global 12
6 i32.const 16
7 i32.add
8 set_global 12
9 get_global 12
10 get_global 13
11 i32.ge_s
12 if
13 i32.const 16
14 call 3
15 end
16 get_local 0
17 set_local 1
18 call 107
19 end
20
{}
Line 1, Column 1
Threads
Main
Watch
Call Stack
Not paused
Scope
Not paused
Breakpoints
wasm-0000006e-400:7
i32.add
wasm-0000006e-400:10
get_global 13
XHR/fetch Breakpoints
DOM Breakpoints
Global Listeners
Event Listener Breakpoints

Отладка

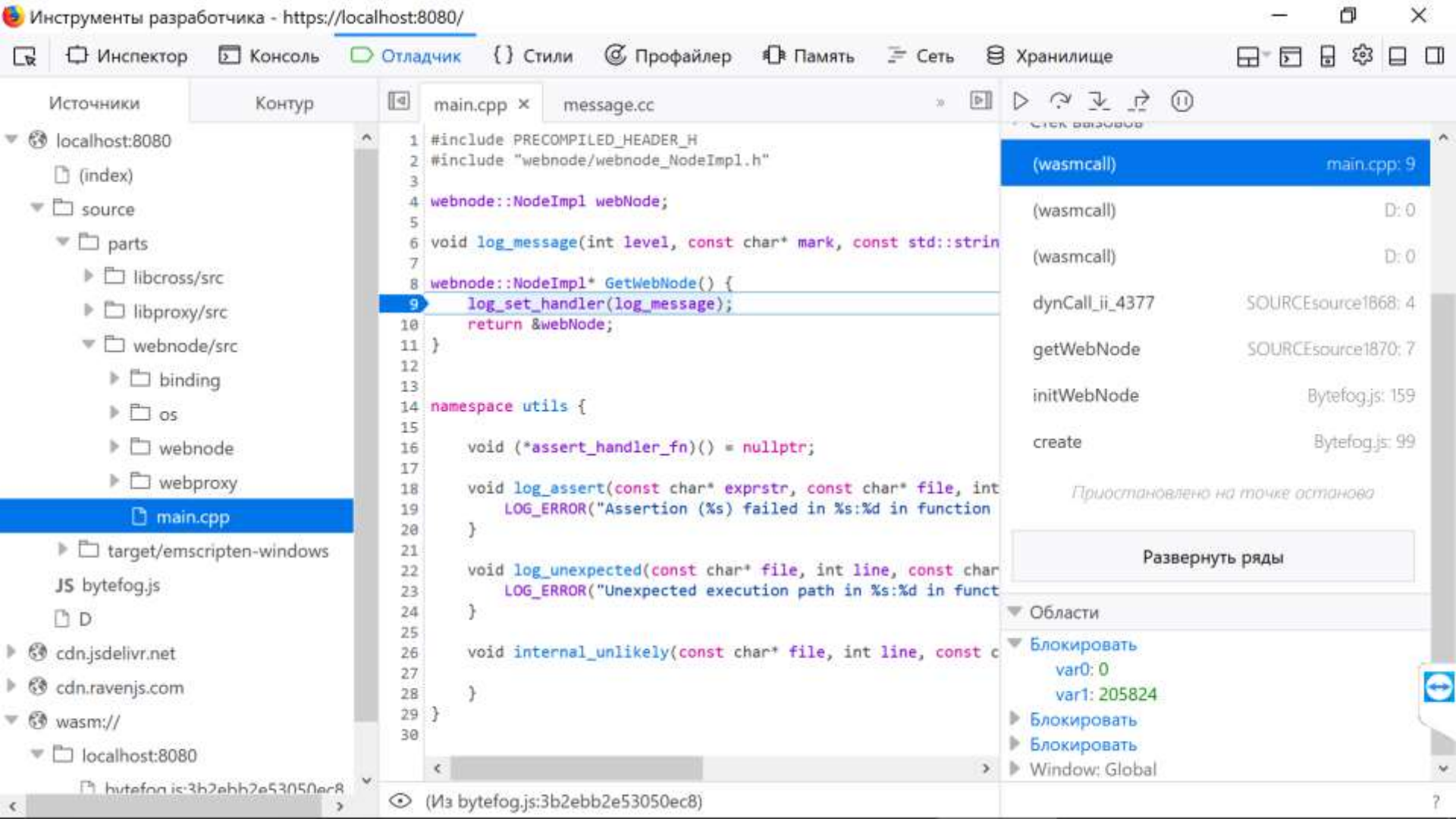
- Включить Chrome DevTools Experiment
- Ищем по номеру в .wast файле (-g4)

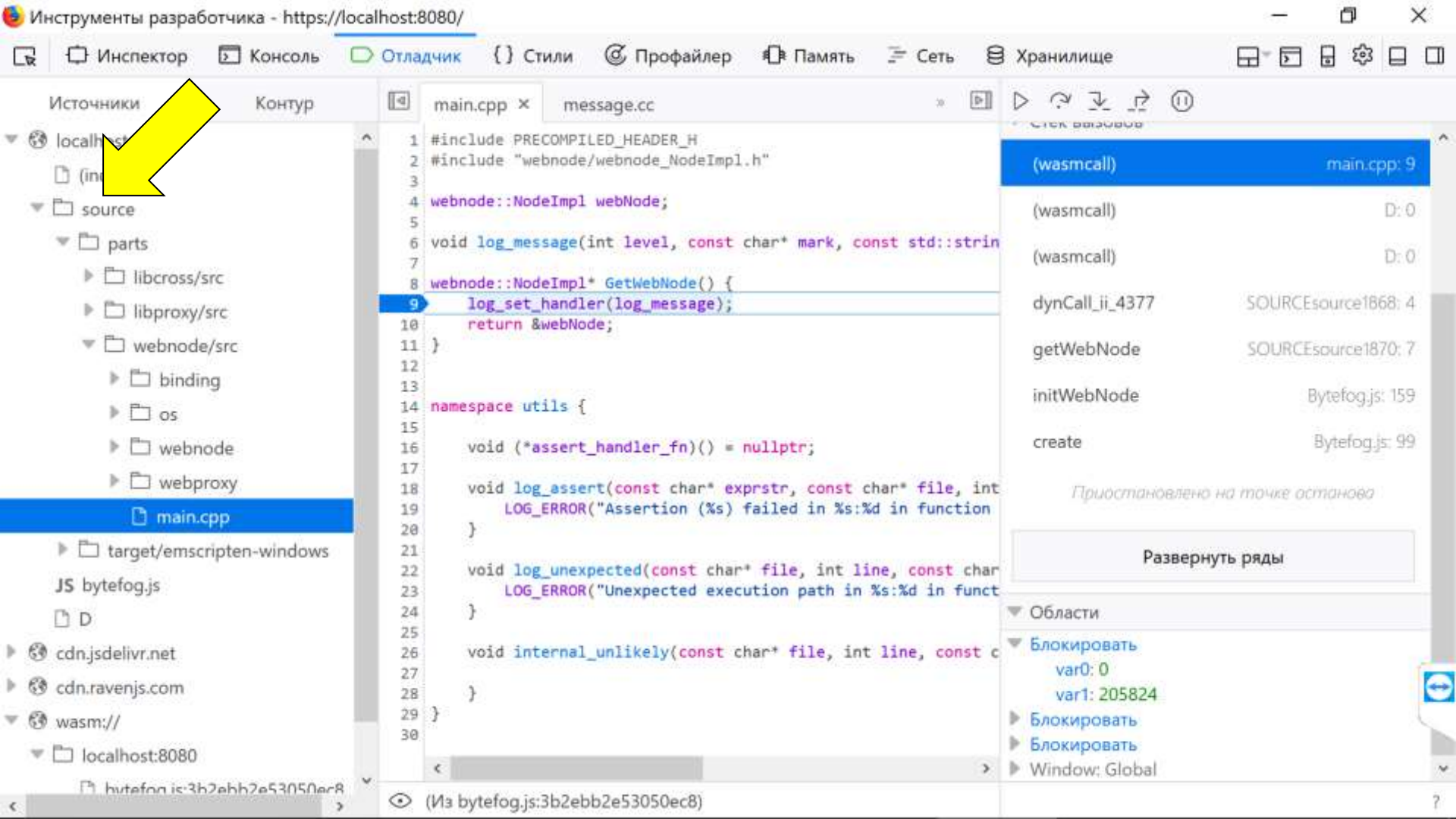

view bytefog-webnode_.wast - Far 3.0.5254 x64
E:\...\bfg\webrtc\bfg\public\bytefog-webnode_.wast t 65001 89211991 Col 0 2% 12:49
(func $___cxx_global_var_init (; 125 ;)
(local $label i32)
(local $sp i32)
(set_local $sp
(get_global $STACKTOP)
)
;;@ E:/_work/bfg/bytefog/parts/libcross/src\optional:10:0
(call $__ZNSt6none_tC2Ev
(i32.const 202404)
)
(return)
)
(func $__ZNSt6none_tC2Ev (; 126 ;) (param $$0 i32)
(local $$1 i32)
(local $label i32)
(local $sp i32)
(set_local $sp
(get_global $STACKTOP)
)
(set_global $STACKTOP
(i32.add
(get_global $STACKTOP)
(i32.const 16)
1 2 3 4 5 6 7Prev 8Goto 9Video 10 11ViewHs 12


view bytefog-webnode_.wast - Far 3.0.5254 x64
E:\...\bfg\webrtc\bfg\public\bytefog-webnode_.wast t 65001 89211991 Col 0 2% 12:49
(func $___cxx_global_var_init (; 125 ;)
(local $label i32)
(local $sp i32)
(set_local $sp
(get_global $STACKTOP)
)
;;@ E:/_work/bfg/bytefog/parts/libcross/src\optional:10:0
(ca __ZNSt6none_tC2Ev
onst 202404)
eturn)
)
(func $__ZNSt6none_tC2Ev (; 126 ;) (param $$0 i32)
(local $$1 i32)
(local $label i32)
(local $sp i32)
(set_local $sp
(get_global $STACKTOP)
)
(set_global $STACKTOP
(i32.add
(get_global $STACKTOP)
(i32.const 16)
1 2 3 4 5 6 7Prev 8Goto 9Video 10 11ViewHs 12

SourceMap

- Только в FireFox
- --sourcemap-base=http://localhost/
- Доступ к исходникам по http
- Абсолютные пути не годятся
- Проблема с «:» в путях


Инструменты разработчика - https://localhost:8080/
Инспектор
Консоль
Отладчик
Стили
Профайлер
Память
Сеть
Хранилище
Источники
Контур
localhost:8080
(index)
source
parts
libcross/src
libproxy/src
webnode/src
binding
os
webnode
webproxy
main.cpp
target/emscripten-windows
bytefog.js
D
cdn.jsdelivr.net
cdn.ravenjs.com
wasm://
localhost:8080
main.cpp
message.cc
#include PRECOMPILED_HEADER_H
#include "webnode/webnode_NodeImpl.h"
webnode::NodeImpl webNode;
void log_message(int level, const char* mark, const std::strin
webnode::NodeImpl* GetWebNode() {
log_set_handler(log_message);
return &webNode;
}
namespace utils {
void (*assert_handler_fn)() = nullptr;
void log_assert(const char* exprstr, const char* file, int
LOG_ERROR("Assertion (%s) failed in %s:%d in function
}
void log_unexpected(const char* file, int line, const char
LOG_ERROR("Unexpected execution path in %s:%d in funct
}
void internal_unlikely(const char* file, int line, const c
}
}
(wasmcall) main.cpp: 9
(wasmcall) D: 0
(wasmcall) D: 0
dynCall_ii_4377 SOURCEsource1868: 4
getWebNode SOURCEsource1870: 7
initWebNode Bytefog.js: 159
create Bytefog.js: 99
Приостановлено на точке останова
Развернуть ряды
Области
Блокировать
var0: 0
var1: 205824
Блокировать
Блокировать
Window: Global
(Из bytefog.js:3b2ebb2e53050ec8)


Инструменты разработчика - https://localhost:8080/
Инспектор
Консоль
Отладчик
Стили
Профайлер
Память
Сеть
Хранилище
Источники
Контур
source
parts
libcross/src
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os
webnode
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cdn.jsdelivr.net
cdn.ravenjs.com
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webnode::NodeImpl webNode;
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webnode::NodeImpl* GetWebNode() {
log_set_handler(log_message);
return &webNode;
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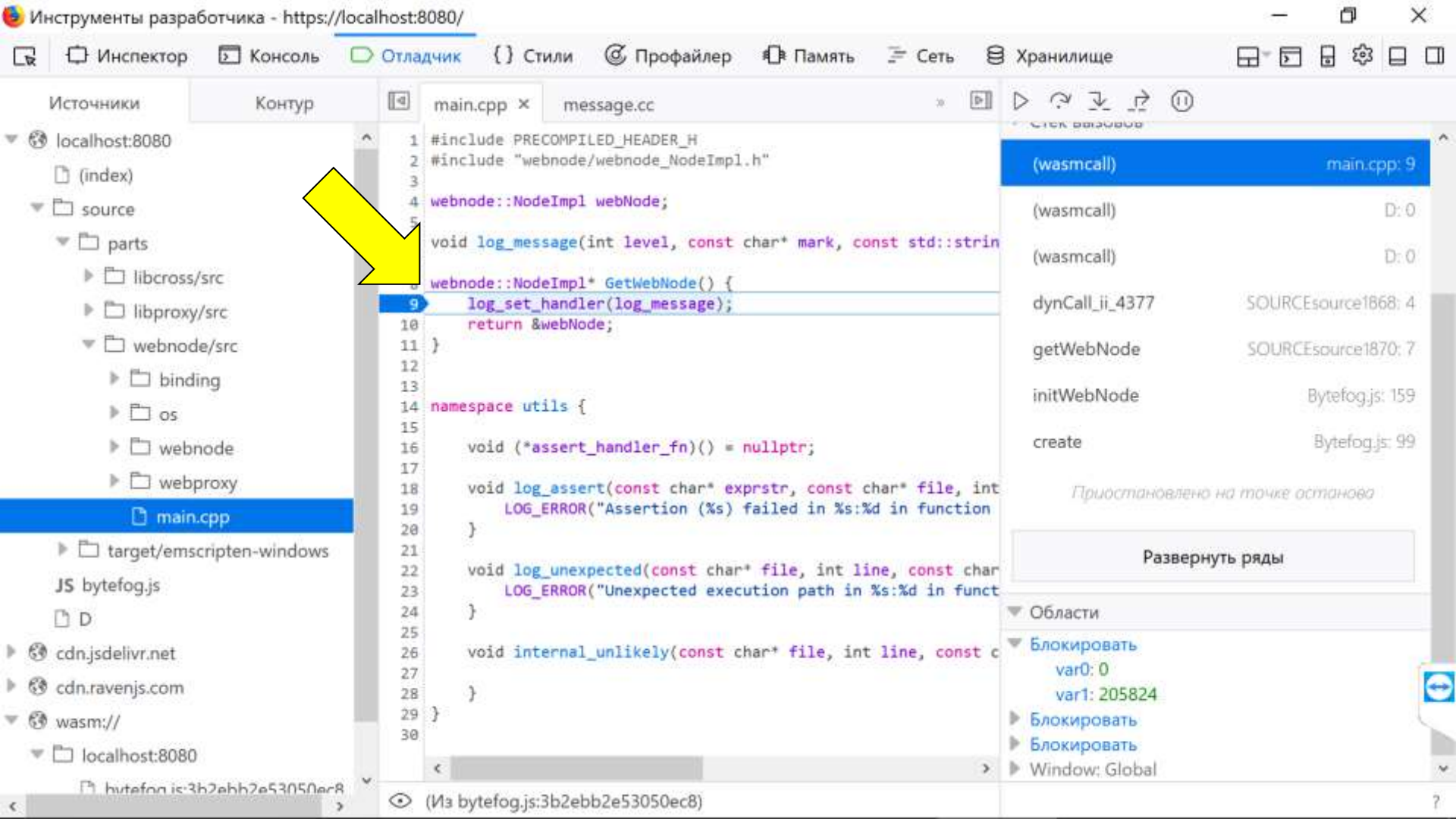
Инструменты разработчика - https://localhost:8080/
Инспектор
Консоль
Отладчик
Стили
Профайлер
Память
Сеть
Хранилище
Источники
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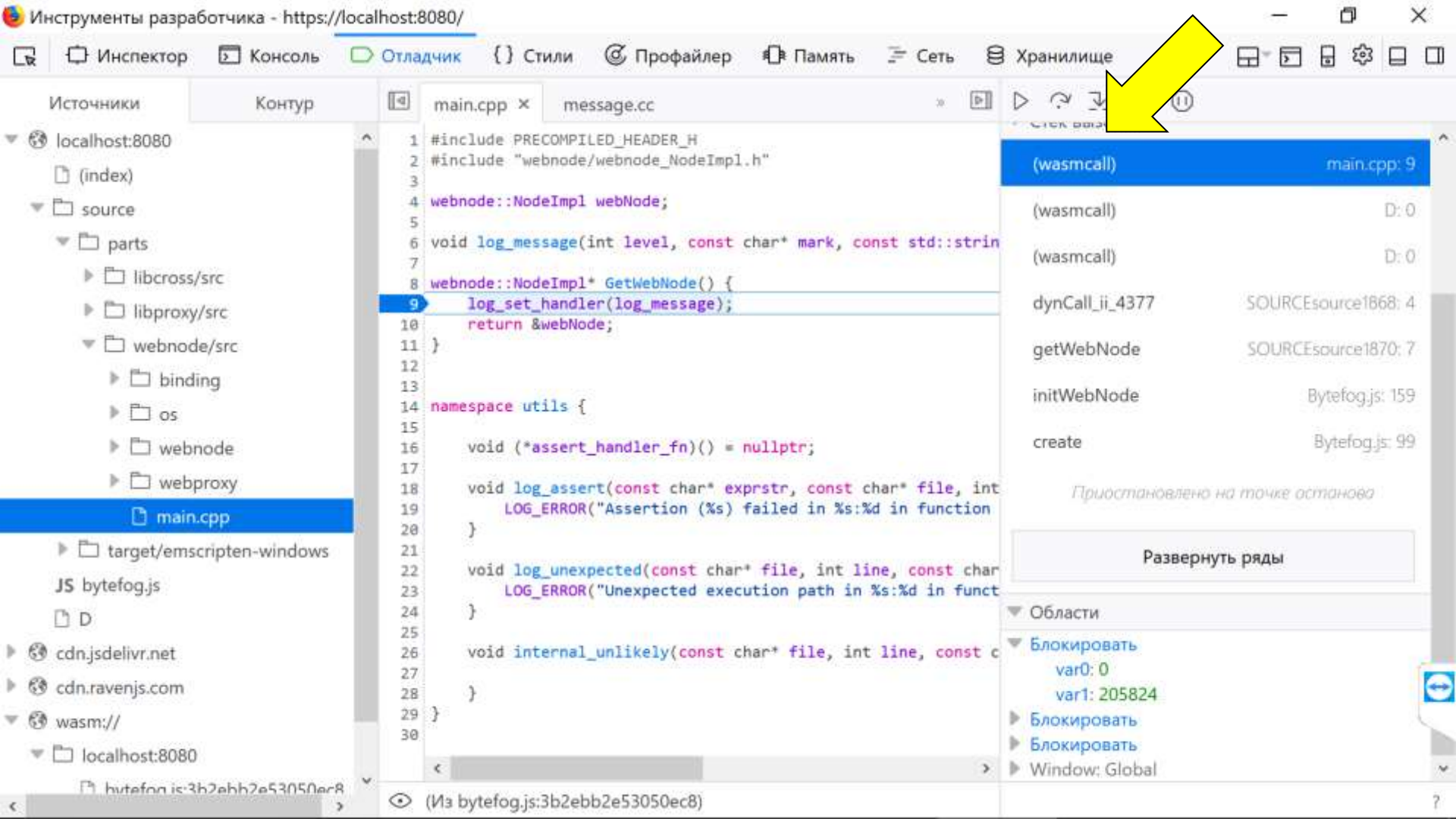
(Из bytefog.js:3b2ebb2e53050ec8)


Инструменты разработчика - https://localhost:8080/
Инспектор
Консоль
Отладчик
Стили
Профайлер
Память
Сеть
Хранилище
Источники
Контур
localhost:8080
(index)
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libcross/src
libproxy/src
webnode/src
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os
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bytefog.js
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cdn.ravenjs.com
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dynCall_ii_4377 SOURCEsource1868: 4
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create Bytefog.js: 99
Развернуть ряды
Области
Блокировать
var0: 0
var1: 205824
Блокировать
Блокировать
Window: Global
(Из bytefog.js:3b2ebb2e53050ec8)

Инструменты разработчика - https://localhost:8080/

Инспектор | Консоль | Отладчик | Стили | Профайлер | Память | Сеть | Хранилище

Источники | Контур

- localhost:8080
  - (index)
  - source
    - parts
      - libcross/src
      - libproxy/src
      - webnode/src
        - binding
        - os
        - webnode
        - webproxy
        - main.cpp
      - target/emscripten-windows
    - bytefog.js
    - D
- cdn.jsdelivr.net
- cdn.ravenjs.com
- wasm://
  - localhost:8080
    - bytefog.js:3b2ebb2e53050ec8

bytefog.js:3b2ebb2e53050ec8 × | bytefog.js | D

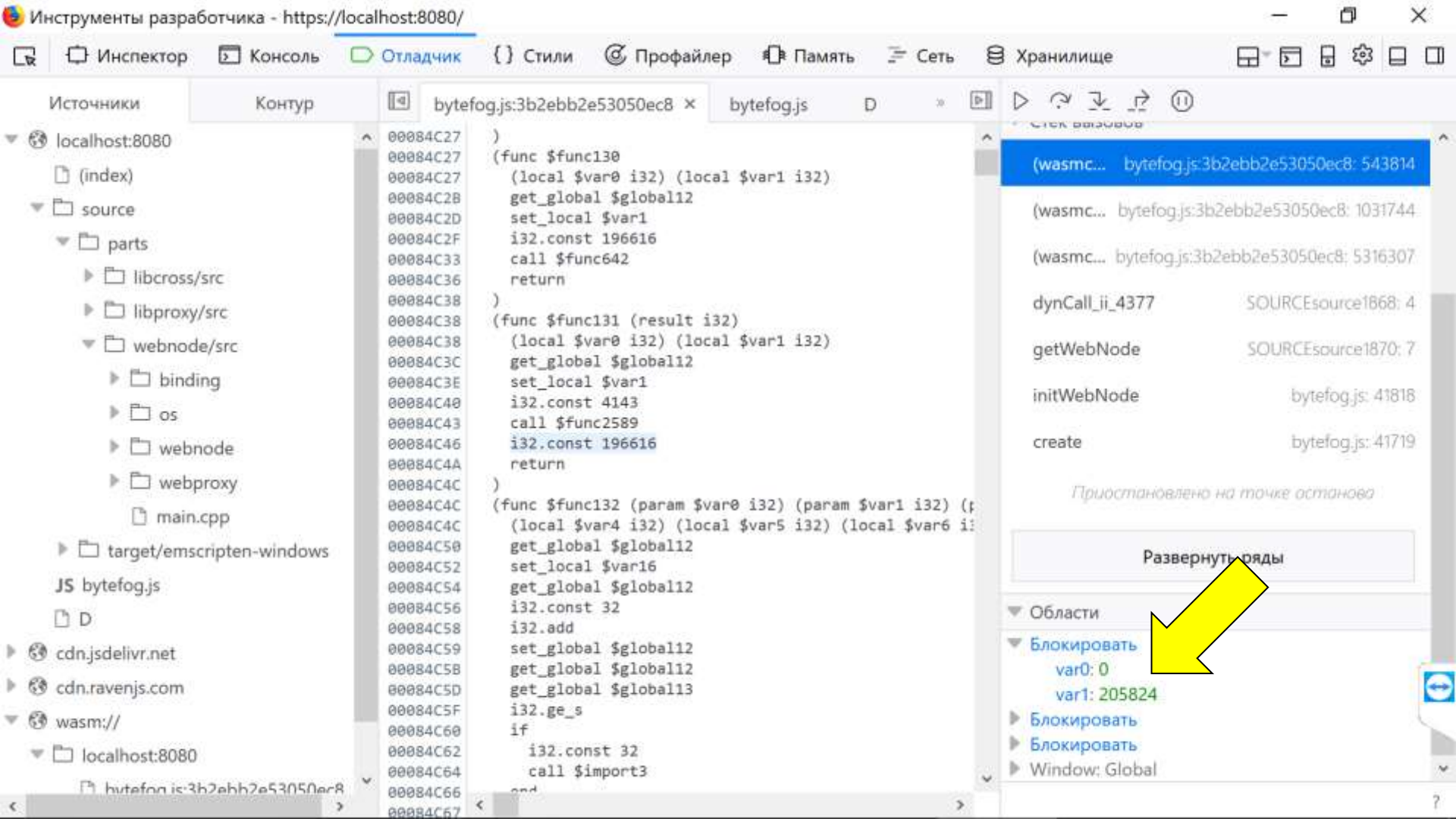
```
00084C27   )
00084C27   (func $func130
00084C27     (local $var0 i32) (local $var1 i32)
00084C2B     get_global $global12
00084C2D     set_local $var1
00084C2F     i32.const 196616
00084C33     call $func642
00084C36     return
00084C38   )
00084C38   (func $func131 (result i32)
00084C38     (local $var0 i32) (local $var1 i32)
00084C3C     get_global $global12
00084C3E     set_local $var1
00084C40     i32.const 4143
00084C43     call $func2589
00084C46     i32.const 196616
00084C4A     return
00084C4C   )
00084C4C   (func $func132 (param $var0 i32) (param $var1 i32) (p
00084C4C     (local $var4 i32) (local $var5 i32) (local $var6 i3
00084C50     get_global $global12
00084C52     set_local $var16
00084C54     get_global $global12
00084C56     i32.const 32
00084C58     i32.add
00084C59     set_global $global12
00084C5B     get_global $global12
00084C5D     get_global $global13
00084C5F     i32.ge_s
00084C60     if
00084C62       i32.const 32
00084C64       call $import3
00084C66     end
00084C67
```

(wasmc... bytefog.js:3b2ebb2e53050ec8: 543814
(wasmc... bytefog.js:3b2ebb2e53050ec8: 1031744
(wasmc... bytefog.js:3b2ebb2e53050ec8: 5316307
dynCall_ii_4377 SOURCEsource1868: 4
getWebNode SOURCEsource1870: 7
initWebNode bytefog.js: 41818
create bytefog.js: 41719

Приостановлено на точке останова

Развернуть ряды

Области
- Блокировать
  - var0: 0
  - var1: 205824
- Блокировать
- Блокировать
- Window: Global


Инструменты разработчика - https://localhost:8080/
Инспектор
Консоль
Отладчик
Стили
Профайлер
Память
Сеть
Хранилище
Источники
Контур
bytefog.js:3b2ebb2e53050ec8
bytefog.js
D
localhost:8080
(index)
source
parts
libcross/src
libproxy/src
webnode/src
binding
os
webnode
webproxy
main.cpp
target/emscripten-windows
bytefog.js
D
cdn.jsdelivr.net
cdn.ravenjs.com
wasm://
localhost:8080
00084C27)
00084C27 (func $func130
00084C27 (local $var0 i32) (local $var1 i32)
00084C2B get_global $global12
00084C2D set_local $var1
00084C2F i32.const 196616
00084C33 call $func642
00084C36 return
00084C38)
00084C38 (func $func131 (result i32)
00084C38 (local $var0 i32) (local $var1 i32)
00084C3C get_global $global12
00084C3E set_local $var1
00084C40 i32.const 4143
00084C43 call $func2589
00084C46 i32.const 196616
00084C4A return
00084C4C)
00084C4C (func $func132 (param $var0 i32) (param $var1 i32)
00084C4C (local $var4 i32) (local $var5 i32) (local $var6
00084C50 get_global $global12
00084C52 set_local $var16
00084C54 get_global $global12
00084C56 i32.const 32
00084C58 i32.add
00084C59 set_global $global12
00084C5B get_global $global12
00084C5D get_global $global13
00084C5F i32.ge_s
00084C60 if
00084C62 i32.const 32
00084C64 call $import3
(wasmc... bytefog.js:3b2ebb2e53050ec8: 543814
(wasmc... bytefog.js:3b2ebb2e53050ec8: 1031744
(wasmc... bytefog.js:3b2ebb2e53050ec8: 5316307
dynCall_ii_4377 SOURCEsource1868: 4
getWebNode SOURCEsource1870: 7
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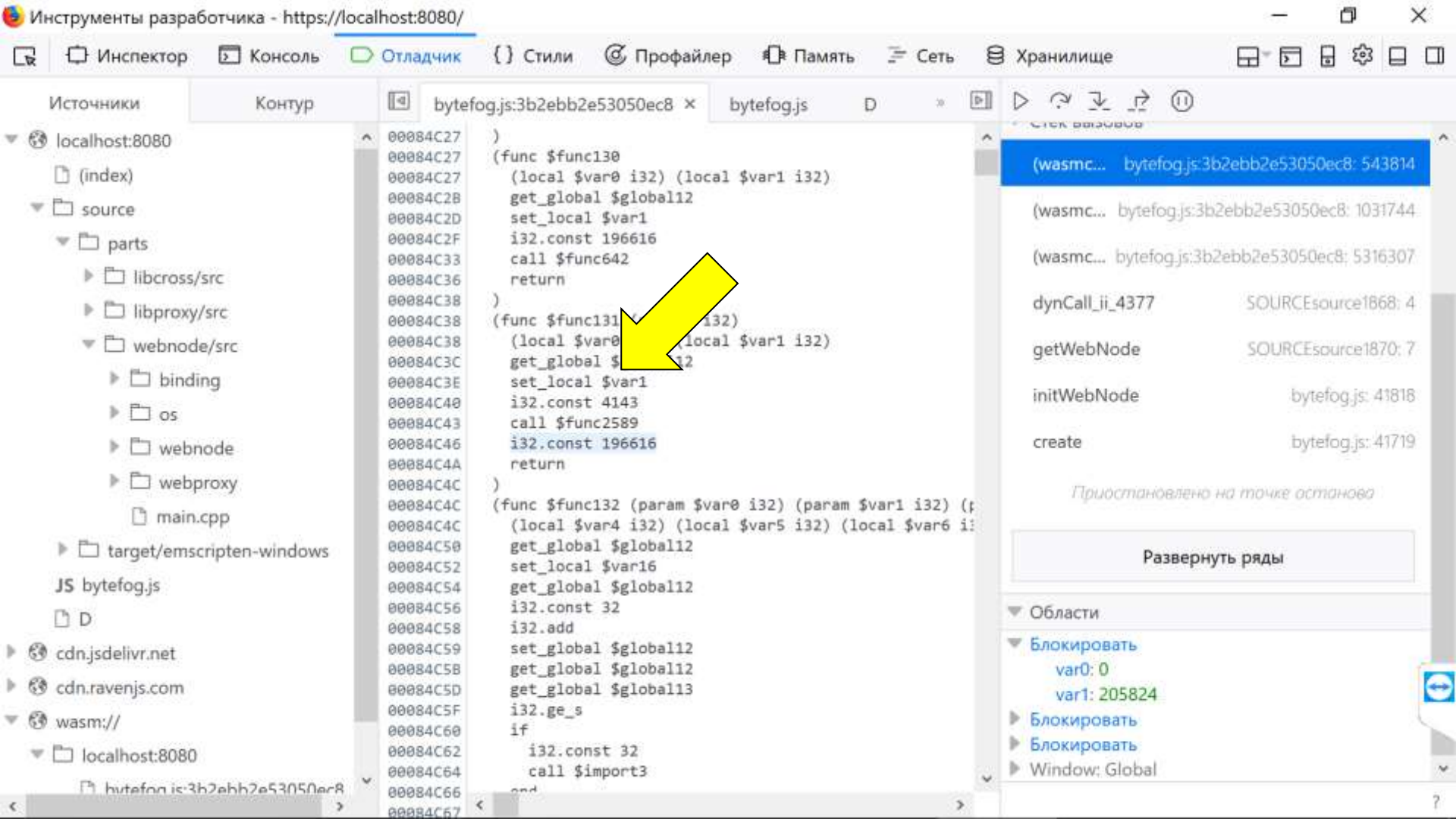
Приостановлено на точке останова
Развернуть ряды
Области
Блокировать
var0: 0
var1: 205824
Блокировать
Блокировать
Window: Global


Инструменты разработчика - https://localhost:8080/
Инспектор
Консоль
Отладчик
Стили
Профайлер
Память
Сеть
Хранилище
Источники
Контур
bytefog.js:3b2ebb2e53050ec8
bytefog.js
D
localhost:8080
(index)
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parts
libcross/src
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webnode
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D
cdn.jsdelivr.net
cdn.ravenjs.com
wasm://
localhost:8080
00084C27)
00084C27 (func $func130
00084C27 (local $var0 i32) (local $var1 i32)
00084C2B get_global $global12
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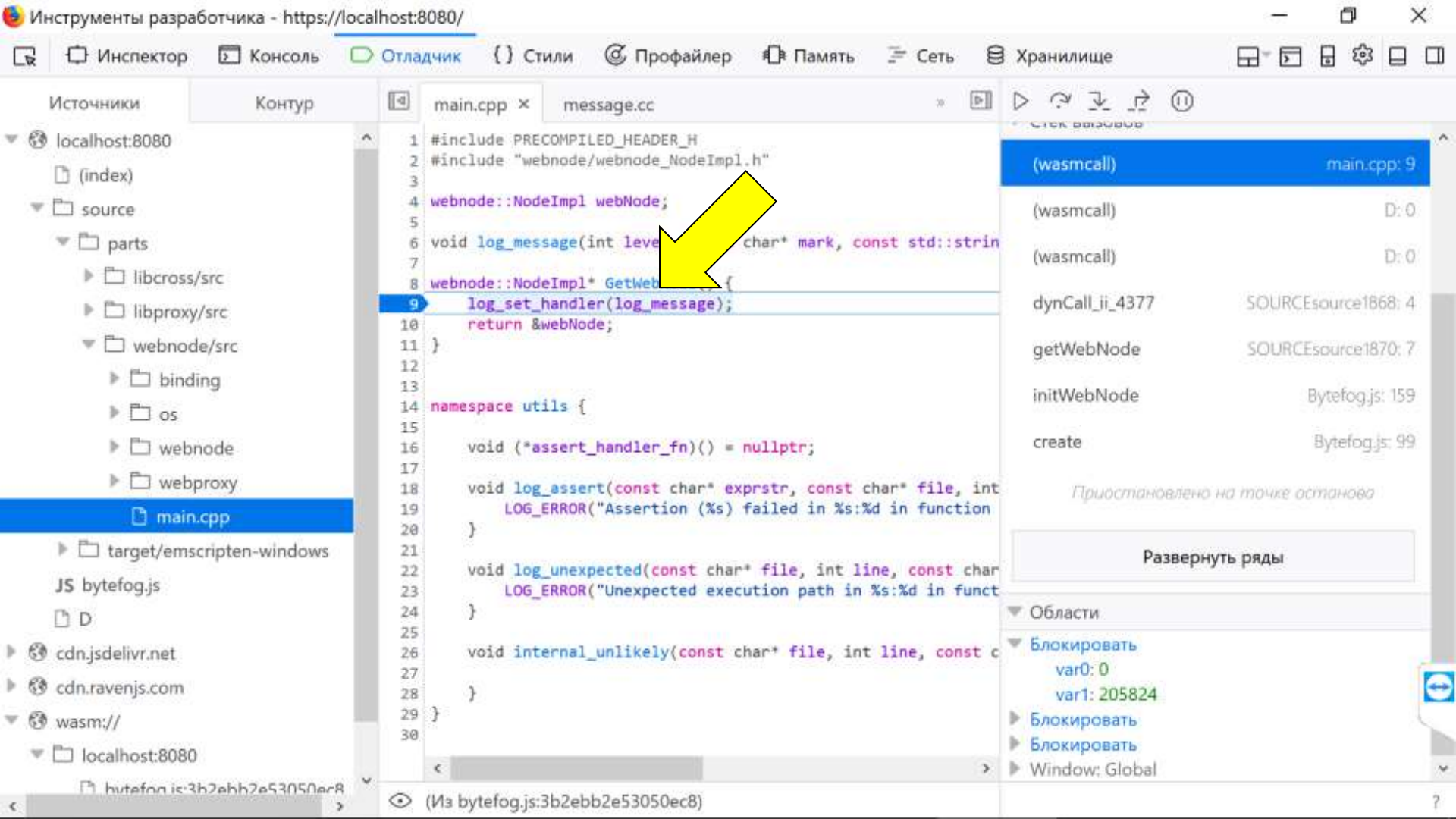
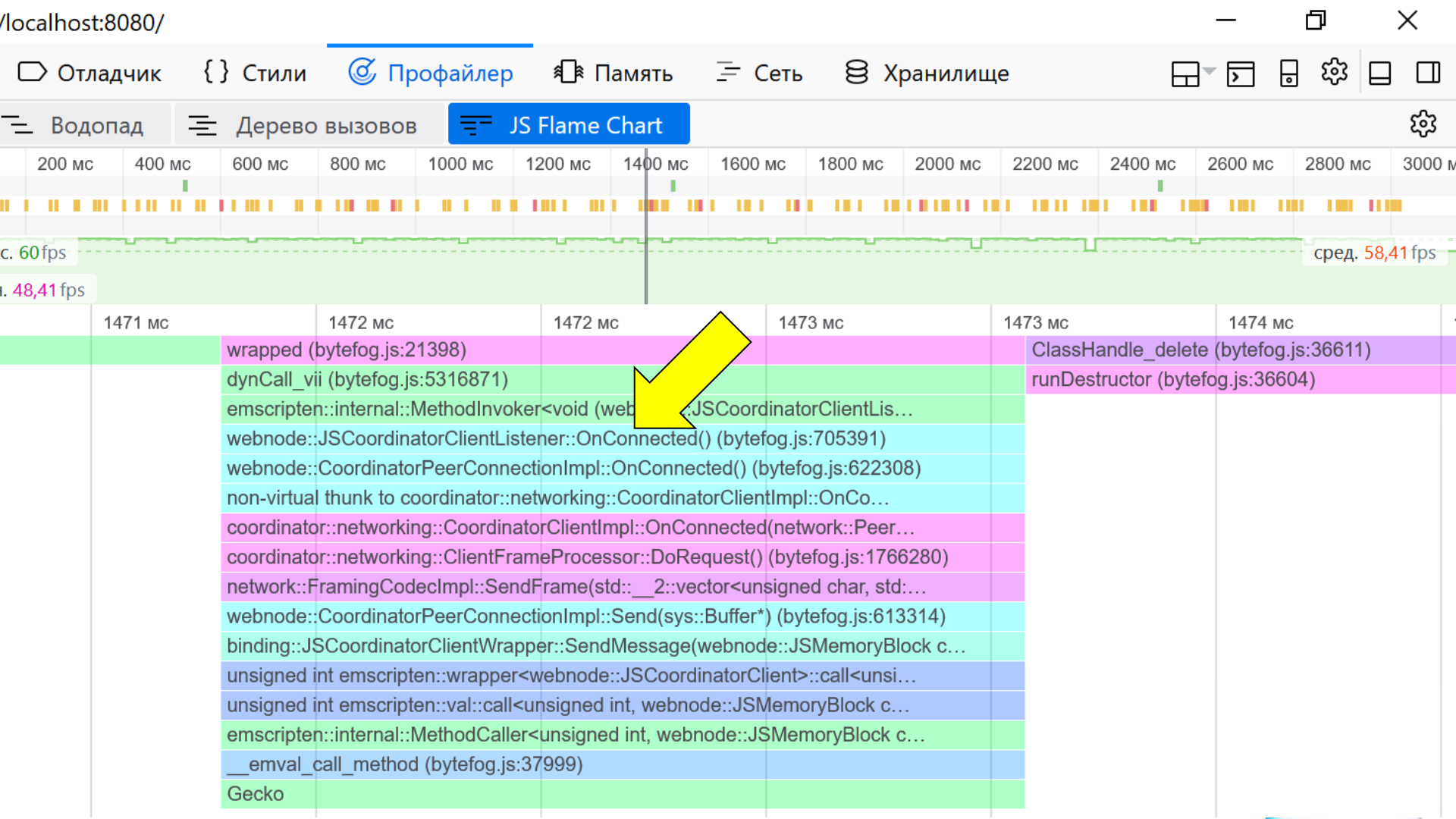
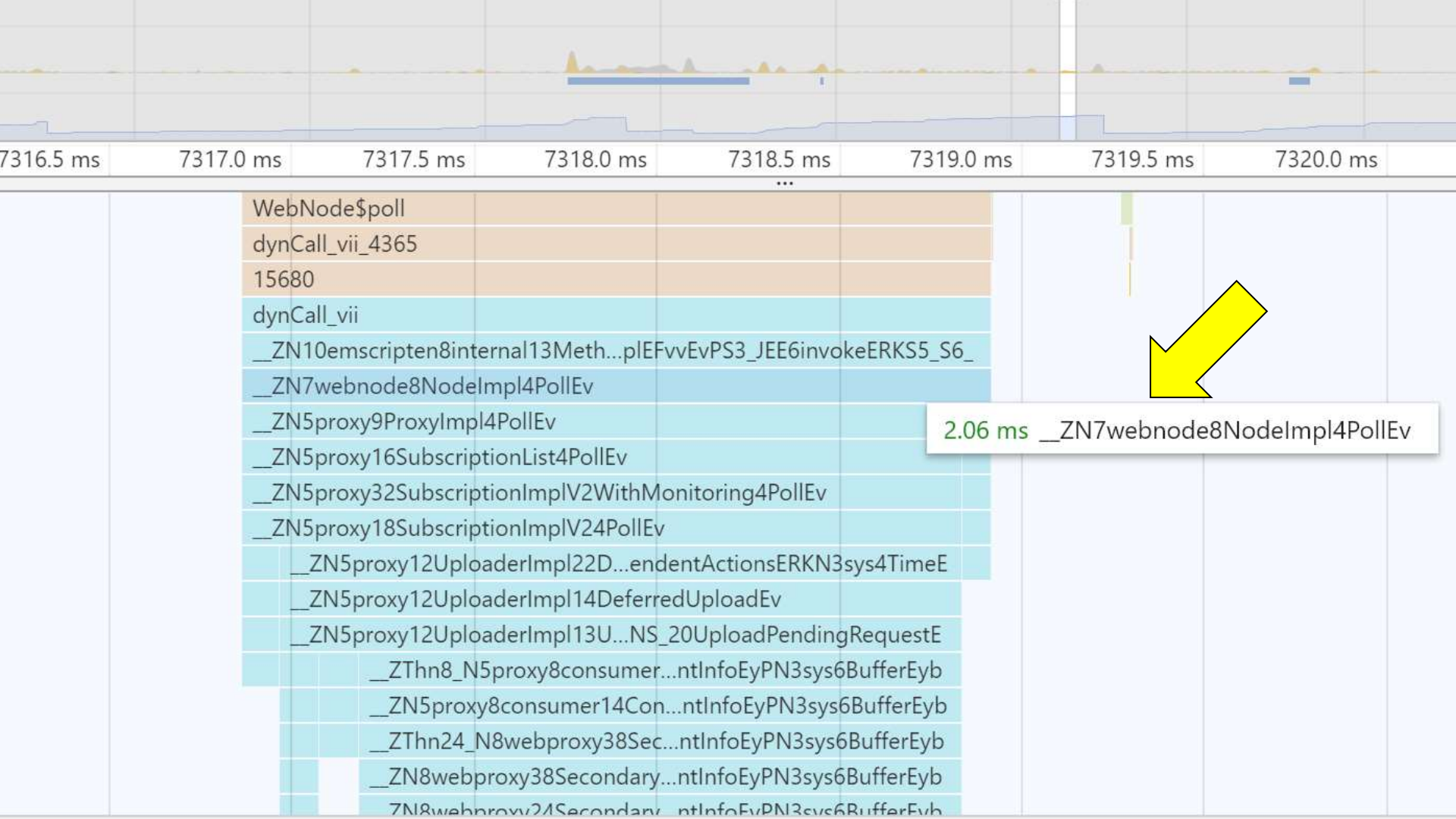
00084C2F i32.const 196616
00084C33 call $func642
00084C36 return
00084C38)
00084C38 (func $func131
00084C38 (local $var0
00084C3C get_global $
00084C3E set_local $var1
00084C40 i32.const 4143
00084C43 call $func2589
00084C46 i32.const 196616
00084C4A return
00084C4C)
00084C4C (func $func132 (param $var0 i32) (param $var1 i32)
00084C4C (local $var4 i32) (local $var5 i32) (local $var6
00084C50 get_global $global12
00084C52 set_local $var16
00084C54 get_global $global12
00084C56 i32.const 32
00084C58 i32.add
00084C59 set_global $global12
00084C5B get_global $global12
00084C5D get_global $global13
00084C5F i32.ge_s
00084C60 if
00084C62 i32.const 32
00084C64 call $import3
(wasmc... bytefog.js:3b2ebb2e53050ec8: 543814
(wasmc... bytefog.js:3b2ebb2e53050ec8: 1031744
(wasmc... bytefog.js:3b2ebb2e53050ec8: 5316307
dynCall_ii_4377 SOURCEsource1868: 4
getWebNode SOURCEsource1870: 7
initWebNode bytefog.js: 41818
create bytefog.js: 41719
Развернуть ряды
Области
Блокировать
var0: 0
var1: 205824
Блокировать
Блокировать
Window: Global


Инструменты разработчика - https://localhost:8080/
Инспектор
Консоль
Отладчик
Стили
Профайлер
Память
Сеть
Хранилище
Источники
Контур
localhost:8080
(index)
source
parts
libcross/src
libproxy/src
webnode/src
binding
os
webnode
webproxy
main.cpp
target/emscripten-windows
bytefog.js
D
cdn.jsdelivr.net
cdn.ravenjs.com
wasm://
localhost:8080
main.cpp
message.cc
#include PRECOMPILED_HEADER_H
#include "webnode/webnode_NodeImpl.h"
webnode::NodeImpl webNode;
void log_message(int leve
char* mark, const std::strin
webnode::NodeImpl* GetWeb
log_set_handler(log_message);
return &webNode;
}
namespace utils {
void (*assert_handler_fn)() = nullptr;
void log_assert(const char* exprstr, const char* file, int
LOG_ERROR("Assertion (%s) failed in %s:%d in function
}
void log_unexpected(const char* file, int line, const char
LOG_ERROR("Unexpected execution path in %s:%d in funct
}
void internal_unlikely(const char* file, int line, const c
}
}
(wasmcall) main.cpp: 9
(wasmcall) D: 0
(wasmcall) D: 0
dynCall_ii_4377 SOURCEsource1868: 4
getWebNode SOURCEsource1870: 7
initWebNode Bytefog.js: 159
create Bytefog.js: 99
Приостановлено на точке останова
Развернуть ряды
Области
Блокировать
var0: 0
var1: 205824
Блокировать
Блокировать
Window: Global
(Из bytefog.js:3b2ebb2e53050ec8)

Профайлер


/localhost:8080/
Отладчик
Стили
Профайлер
Память
Сеть
Хранилище
Водопад
Дерево вызовов
JS Flame Chart
200 мс
400 мс
600 мс
800 мс
1000 мс
1200 мс
1400 мс
1600 мс
1800 мс
2000 мс
2200 мс
2400 мс
2600 мс
2800 мс
3000 м
с. 60 fps
сред. 58,41 fps
. 48,41 fps
1471 мс
1472 мс
1472 мс
1473 мс
1473 мс
1474 мс
wrapped (bytefog.js:21398)
dynCall_vii (bytefog.js:5316871)
emscripten::internal::MethodInvoker<void (web
JSCoordinatorClientLis…
webnode::JSCoordinatorClientListener::OnConnected() (bytefog.js:705391)
webnode::CoordinatorPeerConnectionImpl::OnConnected() (bytefog.js:622308)
non-virtual thunk to coordinator::networking::CoordinatorClientImpl::OnCo…
coordinator::networking::CoordinatorClientImpl::OnConnected(network::Peer…
coordinator::networking::ClientFrameProcessor::DoRequest() (bytefog.js:1766280)
network::FramingCodecImpl::SendFrame(std::__2::vector<unsigned char, std:…
webnode::CoordinatorPeerConnectionImpl::Send(sys::Buffer*) (bytefog.js:613314)
binding::JSCoordinatorClientWrapper::SendMessage(webnode::JSMemoryBlock c…
unsigned int emscripten::wrapper<webnode::JSCoordinatorClient>::call<unsi…
unsigned int emscripten::val::call<unsigned int, webnode::JSMemoryBlock c…
emscripten::internal::MethodCaller<unsigned int, webnode::JSMemoryBlock c…
__emval_call_method (bytefog.js:37999)
Gecko
ClassHandle_delete (bytefog.js:36611)
runDestructor (bytefog.js:36604)


7316.5 ms
7317.0 ms
7317.5 ms
7318.0 ms
7318.5 ms
7319.0 ms
7319.5 ms
7320.0 ms
WebNode$poll
dynCall_vii_4365
15680
dynCall_vii
__ZN10emscripten8internal13Meth...plEFvvEvPS3_JEE6invokeERKS5_S6_
__ZN7webnode8NodeImpl4PollEv
__ZN5proxy9ProxyImpl4PollEv
__ZN5proxy16SubscriptionList4PollEv
__ZN5proxy32SubscriptionImplV2WithMonitoring4PollEv
__ZN5proxy18SubscriptionImplV24PollEv
__ZN5proxy12UploaderImpl22D...endentActionsERKN3sys4TimeE
__ZN5proxy12UploaderImpl14DeferredUploadEv
__ZN5proxy12UploaderImpl13U...NS_20UploadPendingRequestE
__ZThn8_N5proxy8consumer...ntInfoEyPN3sys6BufferEyb
__ZN5proxy8consumer14Con...ntInfoEyPN3sys6BufferEyb
__ZThn24_N8webproxy38Sec...ntInfoEyPN3sys6BufferEyb
__ZN8webproxy38Secondary...ntInfoEyPN3sys6BufferEyb
2.06 ms __ZN7webnode8NodeImpl4PollEv

ПЕРФОРМАНС

Photo by tengrinews.kz

Производительность

- Рантайм
- Потери на границе JS ↔ Wasm
- Технология развивается
- Wasm ускоряет старт
- В синтетике — на уровне JS

Производительность

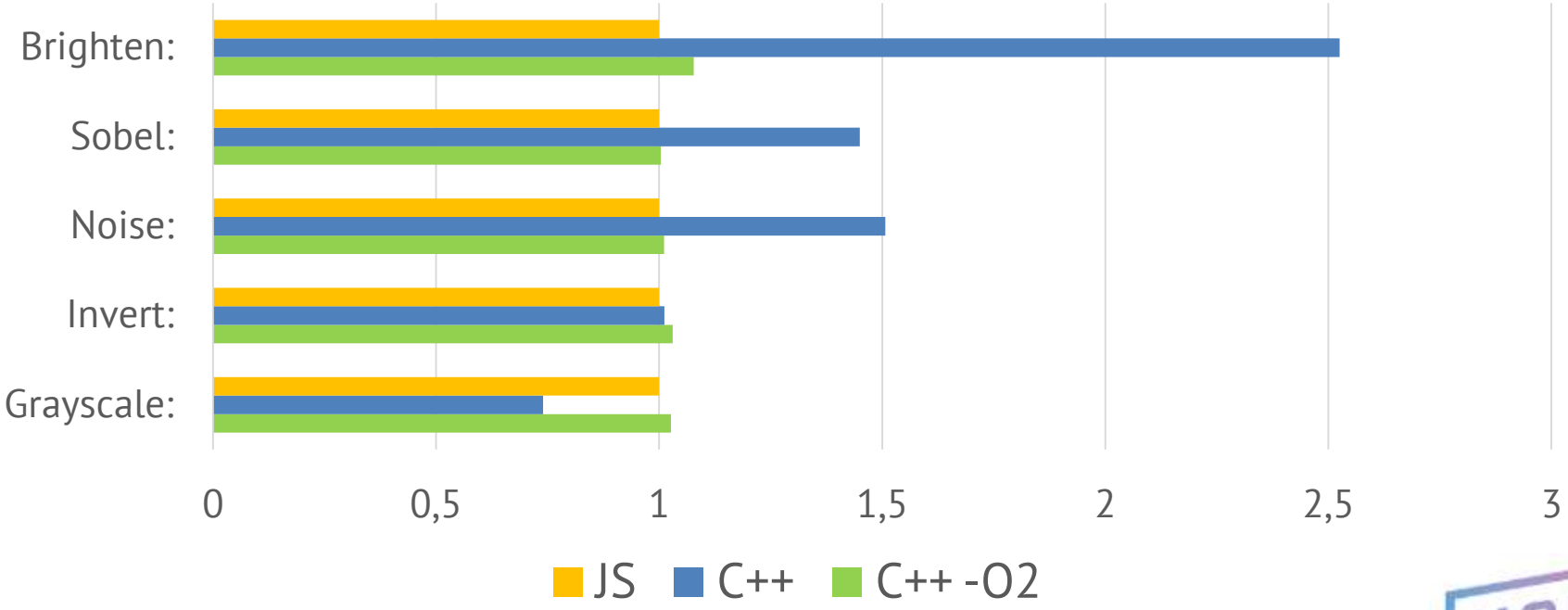
Графические фильтры

https://github.com/andrnag/wasm_cpp_bench

- Chrome 65.0.3325.181 (64-bit)
- Core i5-4690
- 24gb ram

5 замеров; отброшены max и min; усреднение

5472×3078 (меньше лучше; разы)




SENTRY

Sentry

- из стектрейсов пропадает wasm
- патч на traceKit в Raven
- применяем при **npm install**

MESSAGE

```
abort(29) at Error
    at https://bytefog.peers.tv/bytefog.js:1:187579
    at x (https://bytefog.peers.tv/bytefog.js:1:187711)
    at Fo (https://bytefog.peers.tv/bytefog.js:1:400376)
    at nullFunc_vii (https://bytefog.peers.tv/bytefog.js:1:28567
3)
    at wasm-function[5097]:3
    at wasm-function[506]:135
    at wasm-function[1381]:397
    at wasm-function[1389]:10
    at wasm-function[1256]:261
    at wasm-function[1255]:70
    at wasm-function[1246]:27
    at wasm-function[1081]:110
    at wasm-function[931]:56
    at wasm-function[1278]:8
    at wasm-function[198]:30
    at wasm-function[525]:69
    at wasm-function[5048]:15
    at dynCall_vii_840 (eval at <anonymous> (https://bytefog.peer
s.tv/bytefog.js:1:262416), <anonymous>:4:12)
    at WebNode$poll [as poll] (eval at er (https://bytefog.peers.
tv/bytefog.js:1:262956), <anonymous>:8:1)
    at e.value (https://bytefog.peers.tv/bytefog.js:1:178310)
    at https://bytefog.peers.tv/bytefog.js:1:178363
    at i (https://bytefog.peers.tv/bytefog.js:1:580393)
```

browser.name 100% Chrome

level 100% error

logger 100% javascript

os.name 100% Windows 10

url 100% https://peers.tv/show...

user 100% 178.34.148.143

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EXCEPTION (most recent call first)

Full | Raw

```
Uncaught abort() at Error
    at jsStackTrace
(http://localhost:8080/dist/bytefog.js:1159:13)
    at stackTrace (http://localhost:8080/dist/bytefog.js:1176:12)
    at Object.abort
(http://localhost:8080/dist/bytefog.js:11492:44)
    at _abort (http://localhost:8080/dist/bytefog.js:7521:22)
    at
__ZN4node22SupplierPeerMonitoring17SetPeerConnectionEPKN7network1
4PeerConnectionE
[node::SupplierPeerMonitoring::SetPeerConnection(network::PeerCon
nection const*)] (wasm-function[5362]:197)
    at
__ZN4node35StreamSupplierImplNewWithMonitoring20SwitchToServiceSt
ateEPNS_23ClientSideMessageSenderE
[node::StreamSupplierImplNewWithMonitoring::SwitchToServiceState(
node::ClientSideMessageSender*)] (wasm-function[5327]:96)
    at
__ZThn12_N4node35StreamSupplierImplNewWithMonitoring20SwitchToSer
viceStateEPNS_23ClientSideMessageSenderE [non-virtual thunk to
node::StreamSupplierImplNewWithMonitoring::SwitchToServiceState(n
ode::ClientSideMessageSender*)] (wasm-function[5334]:53)
    at
__ZN4node35StreamSupplierConnectingDirectState33OnEnteredToClient
SideServiceStateEPNS_23ClientSideMessageSenderE
[node::StreamSupplierConnectingDirectState::OnEnteredToClientSide
```

browser.name 100% Chrome

level 100% error

logger 100% javascript

os.name 100% Windows 10

transaction 100% http://localhost:8080...

url 73% http://localhost:8080/

user 100% 178.49.145.31

Notifications

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Выводы

- WebAssembly уже можно использовать в бою
- Портировать большое приложение — реально
- Мы сделали за 8 месяцев
- Инструменты пока слабые
- Скорость на уровне JS

Рекомендую

- Берите Emscripten и Embind
- Тесты на Emscripten — лучшая документация
- Для сбора ошибок подойдет Sentry
- Отлаживайте в FireFox

Спасибо! Вопросы?

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https://bit.ly/andrnag