How and Why we built the tipi.build cloud in C++

Azure Zürich User Group
29.06.2021 @ *PXL Vision*

www.tipi.build

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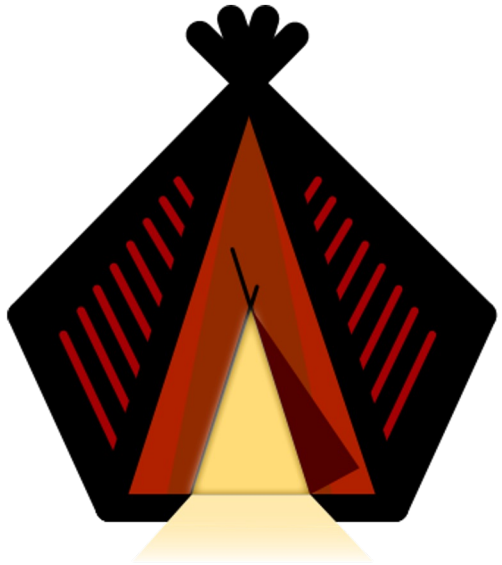
+41 (0) 78 984 08 13



Tipi

Our Founders

Damien Buhl
CEO & CTO

Yannic Staudt
COO & Business Development

cesi

EH

n|w Fachhochschule Nordwestschweiz

boost C++ libraries

Qt

staudt engineering

MARQUARDT

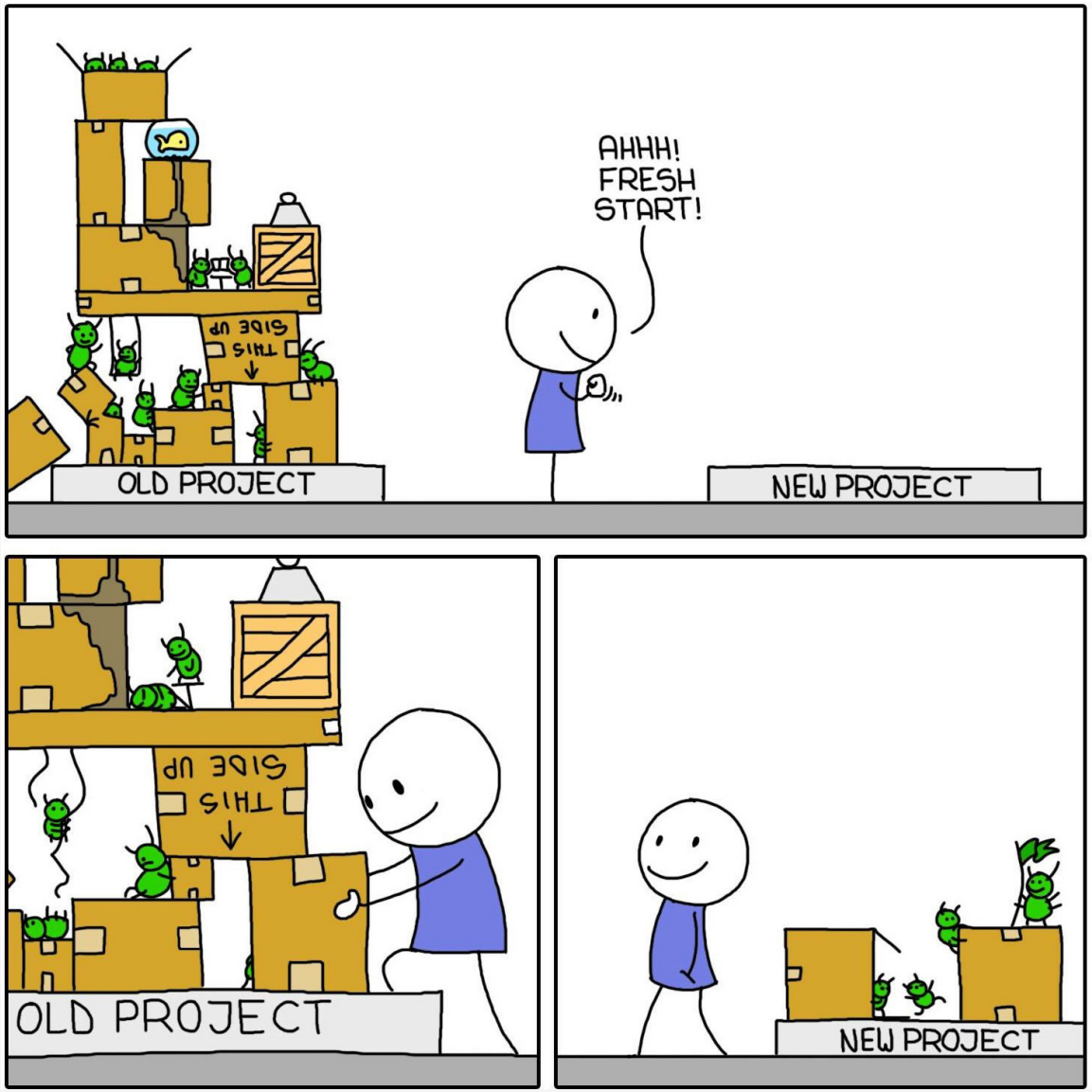
Cppcon The C++ Conference

CppCast

KICKSTARTER

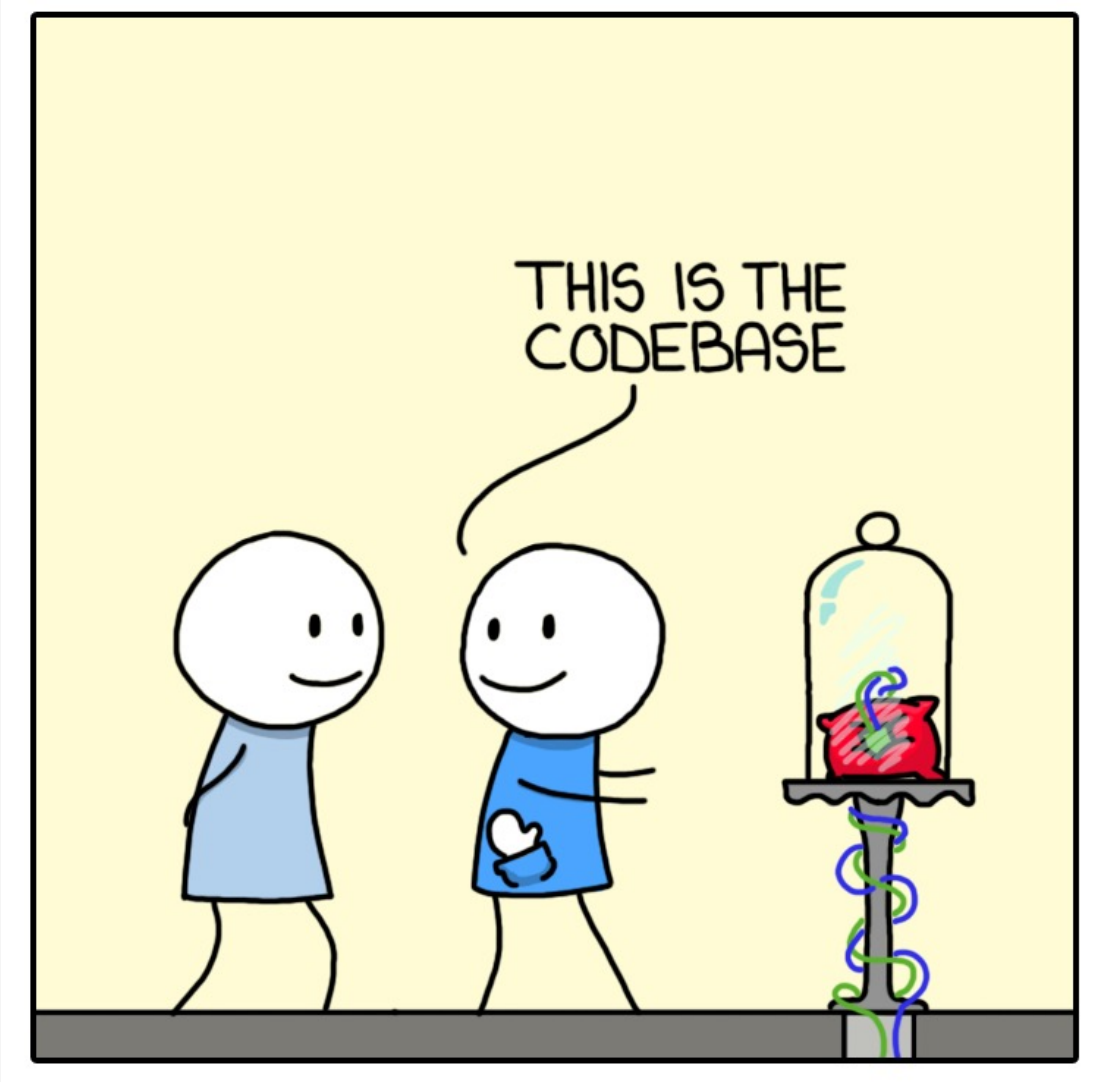
3 problems with C & C++

Code Reuse

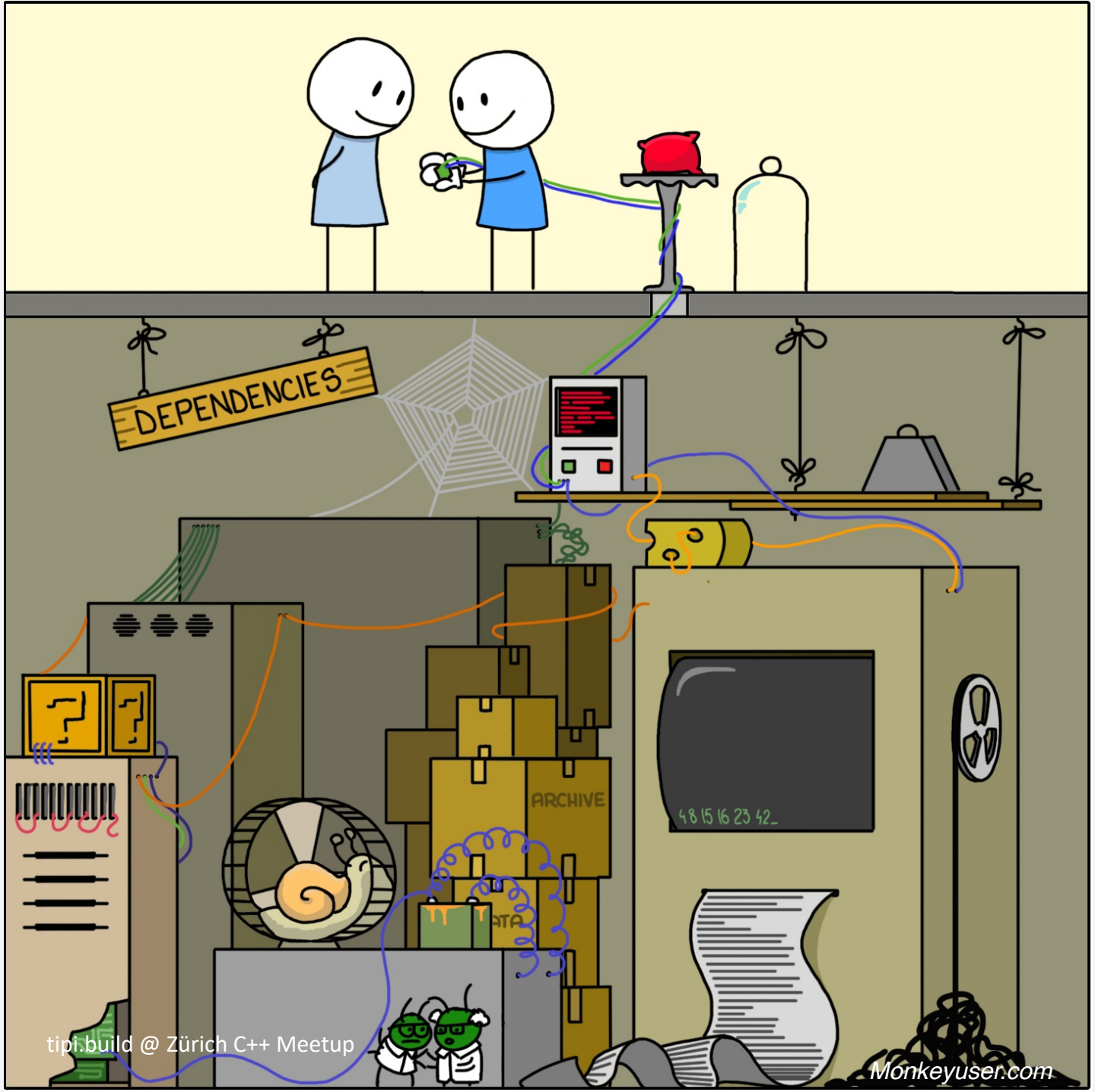


Comics from Monkeyuser.com

Dependencies & Environments



Comics from Monkeyuser.com


DEPENDENCIES
ARCHIVE
4 8 15 16 23 42_
Monkeyuser.com

Build & Test Time

Comics from xkcd.com

A fragmented ecosystem

Damien

Yannic

A crazy idea

A crazy idea

No build scripts

Code.
Reuse.
Build.

Tipi

Simple dependencies management

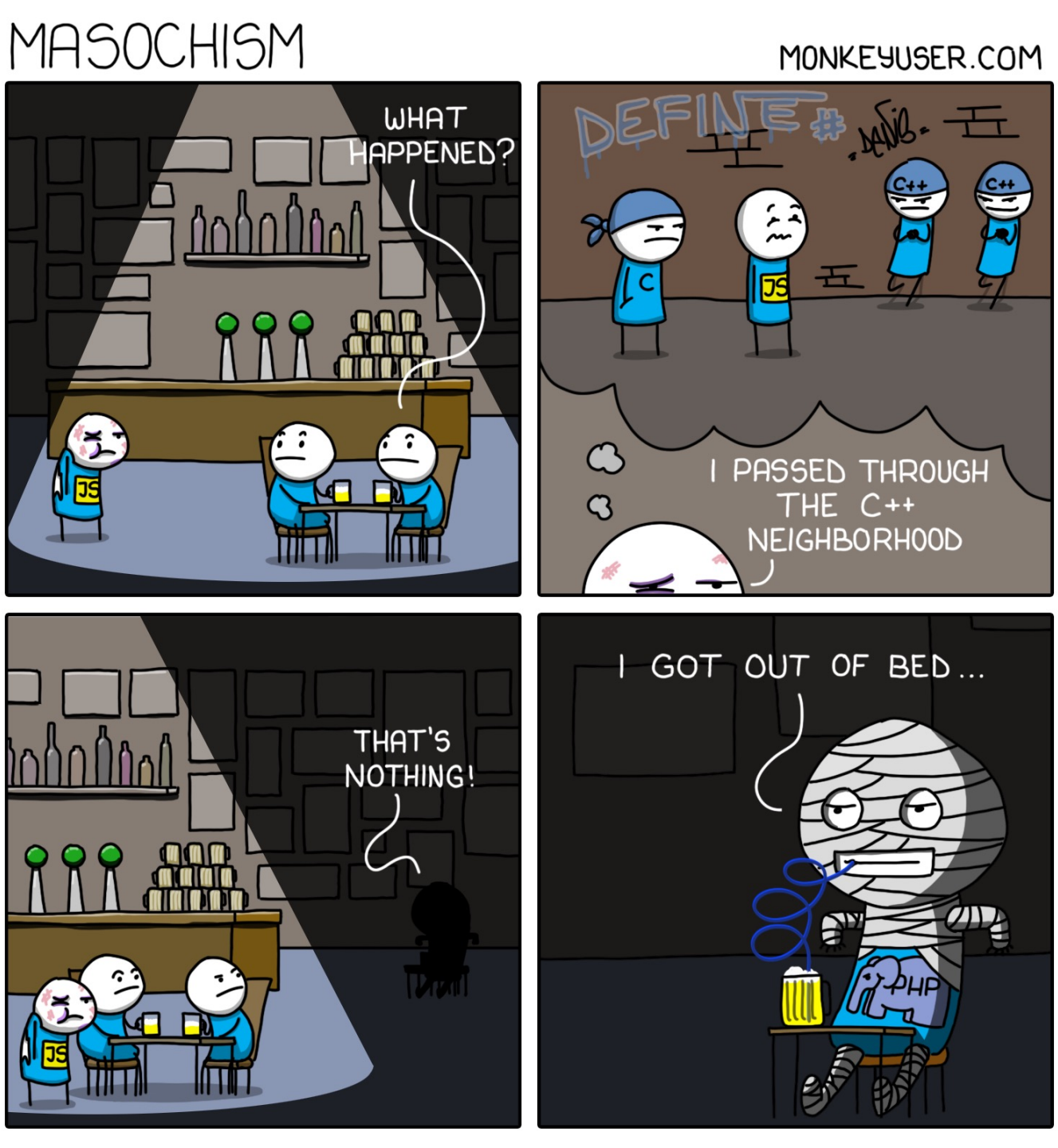
Code.
Reuse.
Build.

Tipi

Blazing fast cloud builds

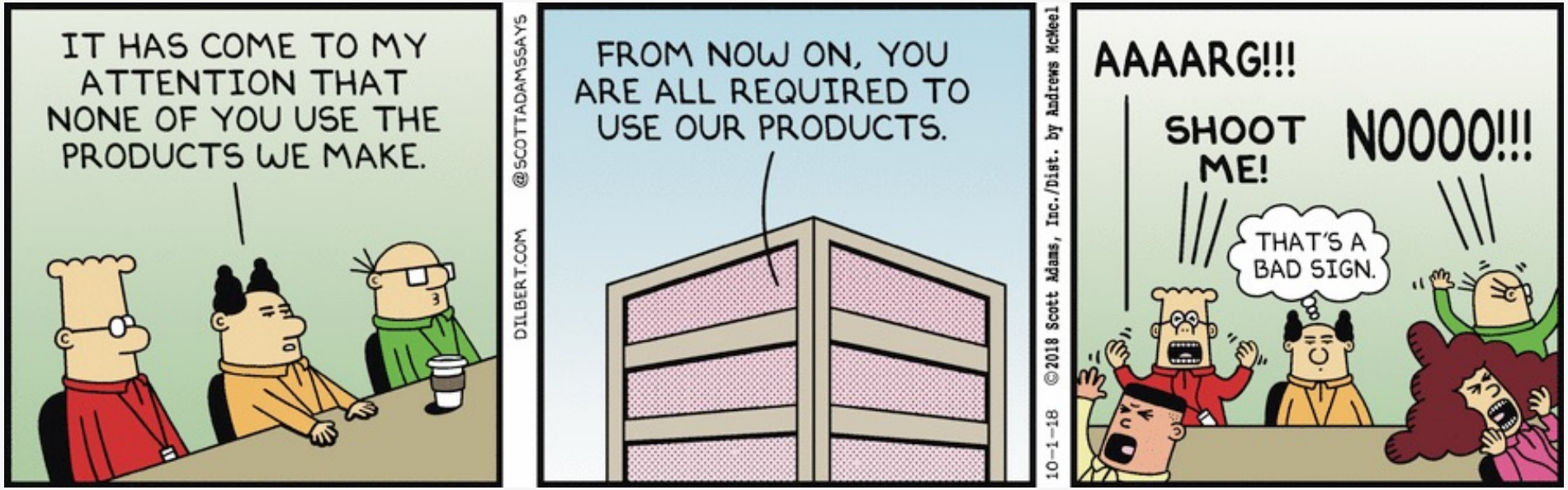
Code.
Reuse.
Build.

Why we built  Tipi.build in C++ ?


MASOCHISM
MONKEYUSER.COM
WHAT HAPPENED?
JS
DEFINE #
C
JS
C++
C++
I PASSED THROUGH THE C++ NEIGHBORHOOD
THAT'S NOTHING!
JS
I GOT OUT OF BED...
PHP

Seriously !
Why C++ for webapps ?

Dogfooding !


IT HAS COME TO MY ATTENTION THAT NONE OF YOU USE THE PRODUCTS WE MAKE.
DILBERT.COM @SCOTTADAMSSAYS
FROM NOW ON, YOU ARE ALL REQUIRED TO USE OUR PRODUCTS.
10-1-18 ©2018 Scott Adams, Inc./Dist. by Andrews McMeel
AAAARG!!!
SHOOT ME!
NOOOO!!!
THAT'S A BAD SIGN.

Really why !?!?
Why C++ for webapps ?

Tipi

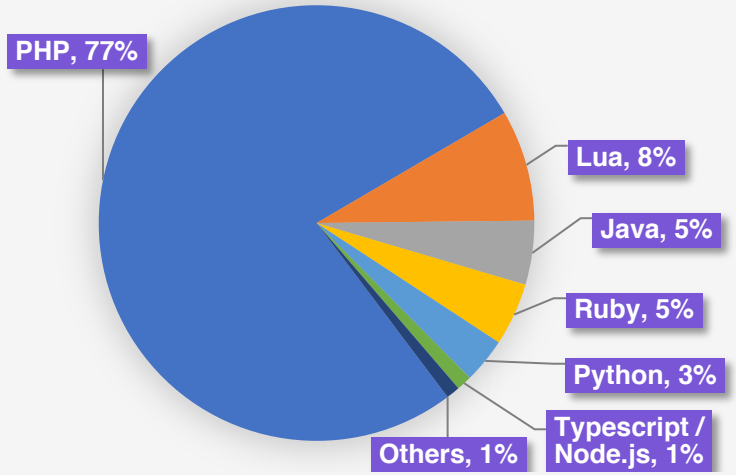
Efficiency !

Carbon footprint

Enabling environmentally friendly software

1.32bn CO_2 tons
Yearly Global Emissions by Internet [1]

47'000 CO_2 tons
Yearly Emissions addressable [2] with C++



186M
Of all internet requests by seconds served by non-native technologies globally [3]

[1] The Shift Project, Lean ICT, March 2019
[2] Cisco Annual Internet Report 2020 + HTTP Archive, State of The Web 11.2020
[3] W3Techs, server-side programming languages distribution, top 10 Millions websites, 11.2020

Carbon footprint

Case study on a typical web application

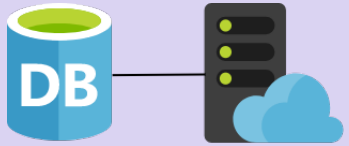
To serve 43 000 web requests / seconds with common cloud hardware :

Dell R440 Xeon Gold
1480 kWh Energy Demand / year

State of the art (e.g. PHP, Python, TS, Ruby)

12’880 kgCO2e / year

C++



1’840 kgCO2e / year

Dell estimated product carbon footprint & single query TechEmpower Web Framework Benchmark (May 2020)

First part of our journey : Microservices vs Monoliths

Microservices vs Monoliths

Monoliths

- Vertical scalability only
- Availability issues

+ Simplicity
+ Everything in the same memory space

Microservices vs Monoliths

Microservices

- Lot of Marshalling code between services
- Shared state data races

~ Prone to Conway's Law

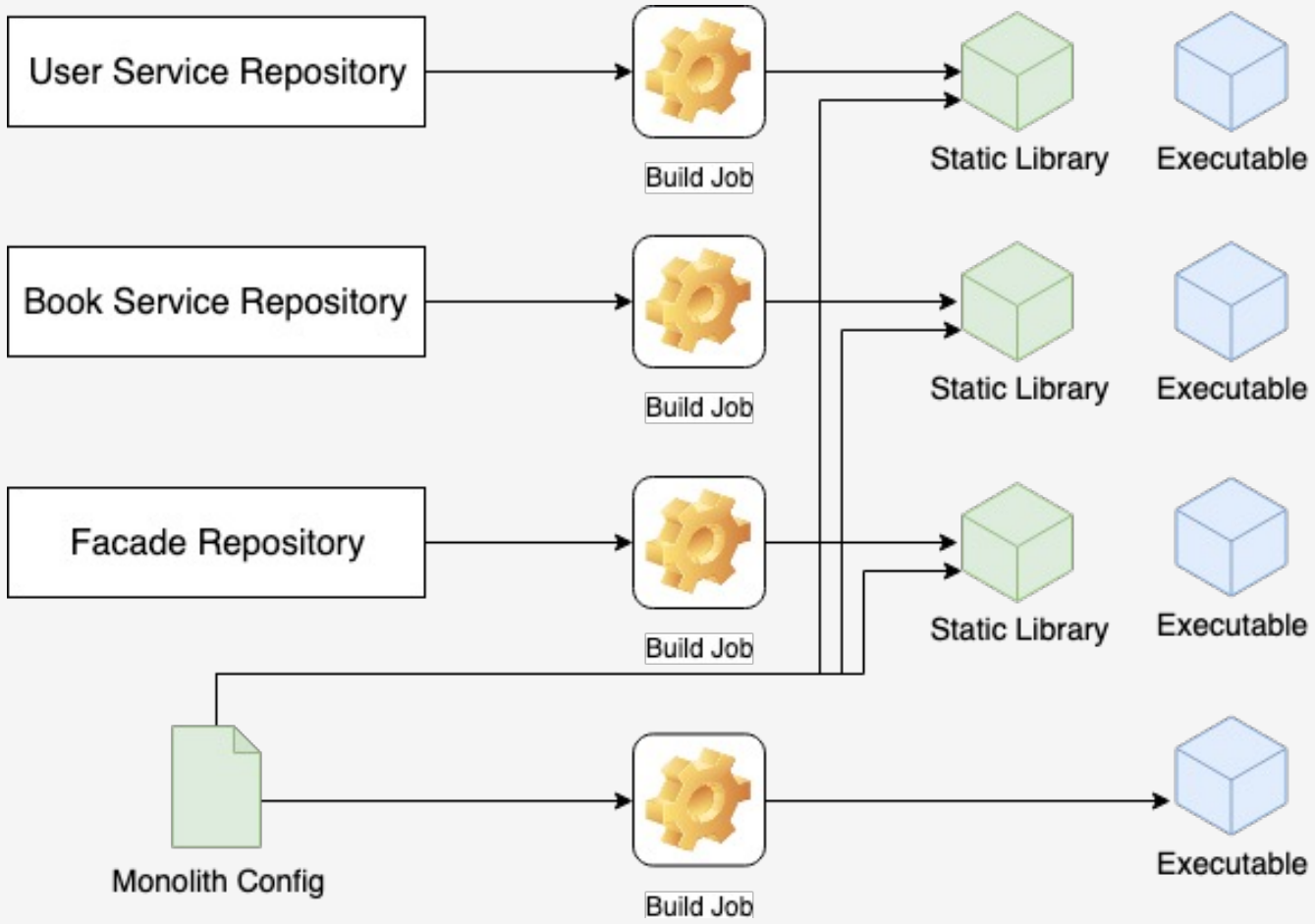
+ Horizontal scalability
+ High Availability
+ Degraded operation mode

Monolithization

Term coined by Leonid Stryzhevskyi (@lganzzzo)

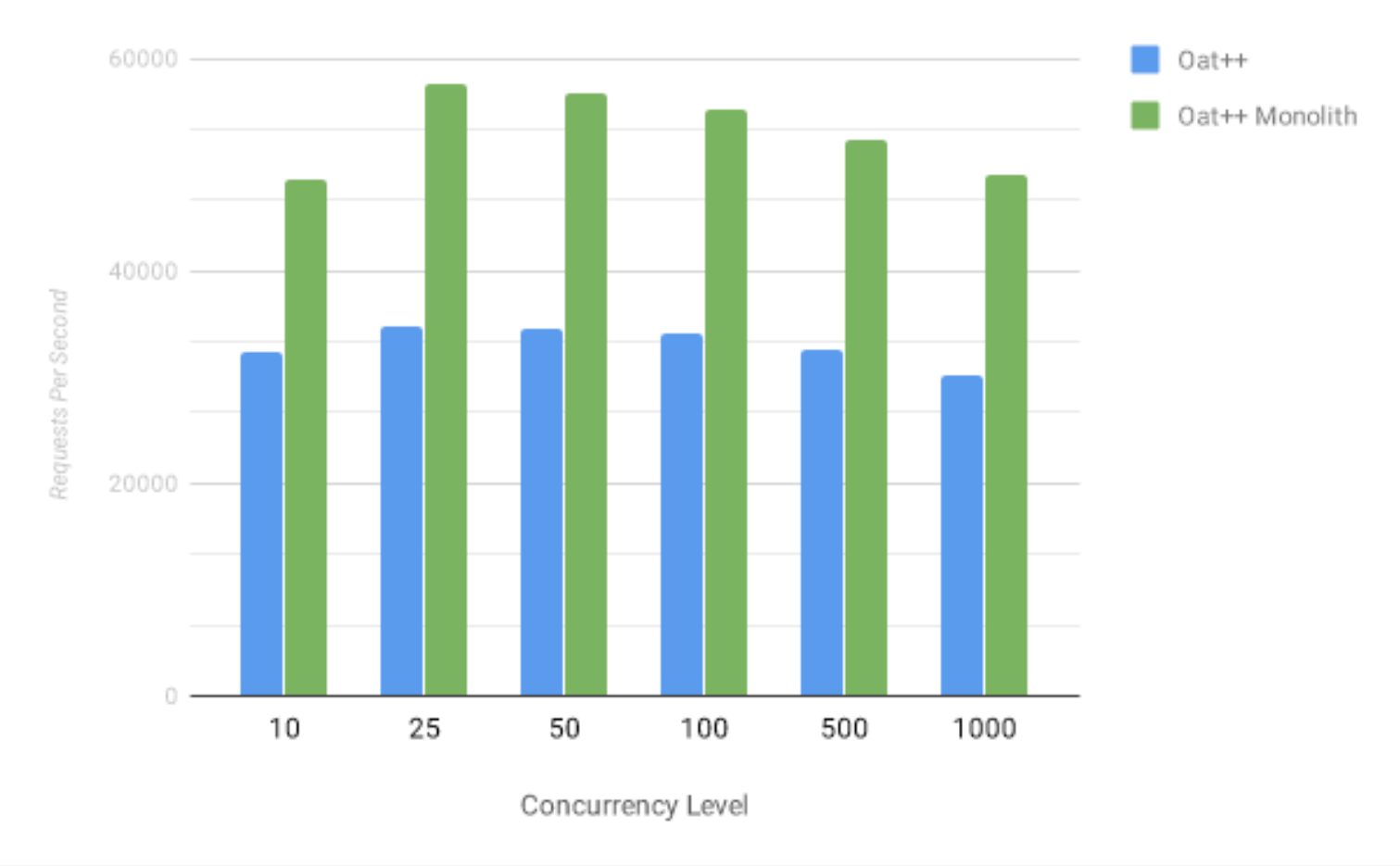
https://oatpp.io/docs/monolithization/

Monolithization



Source : oatpp.io

Monolithization

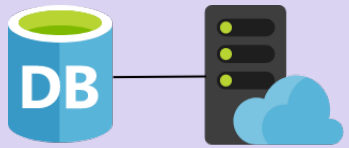


Source : oatpp.io

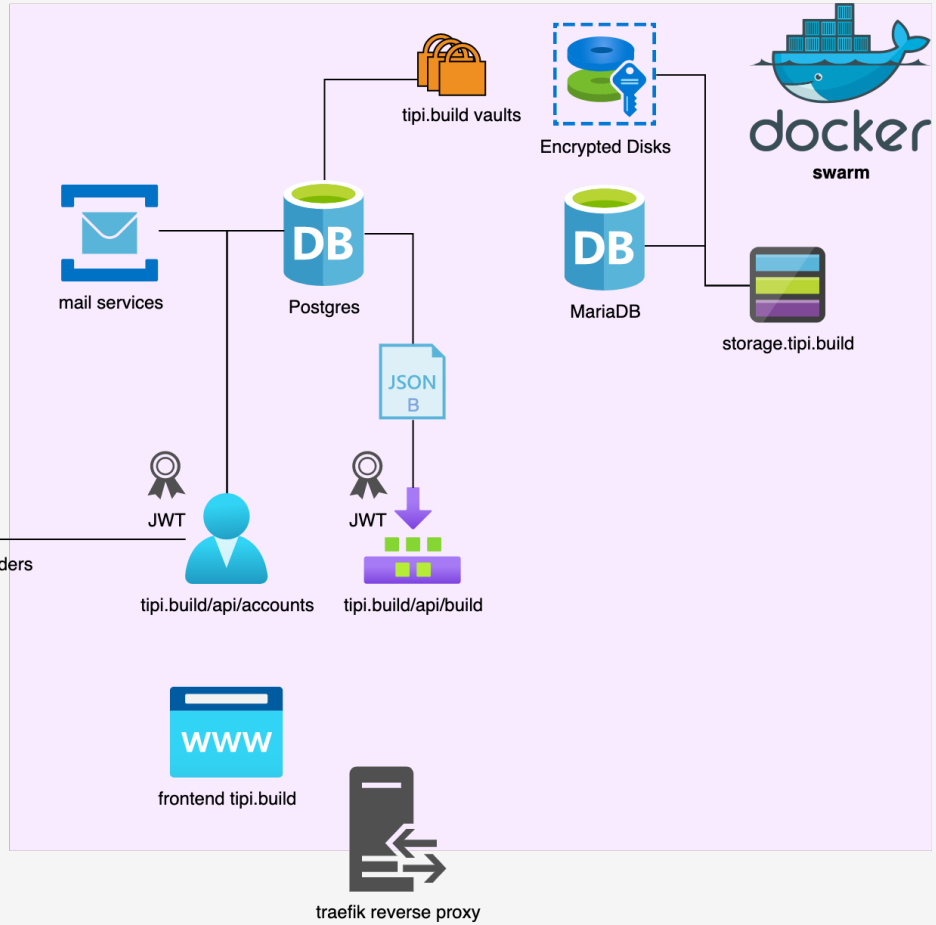
Tipi

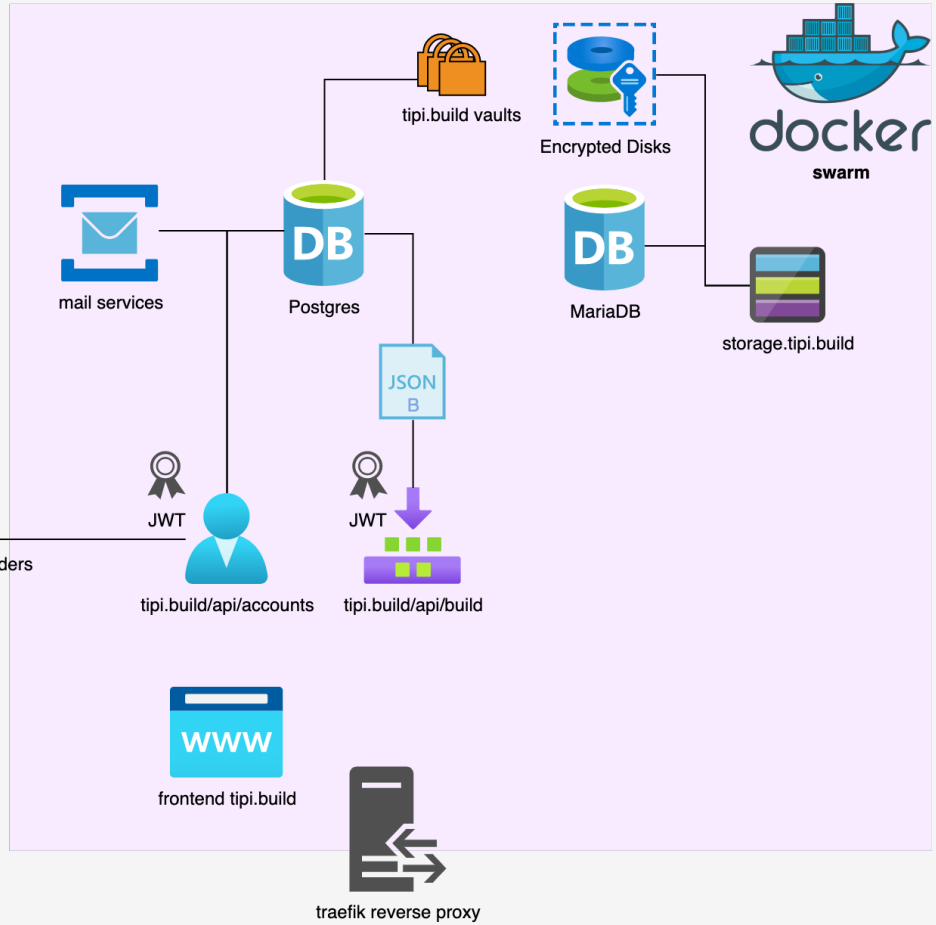
Microservices

Monoliths



How is  Tipi.build built ?


tipi.build vaults
Encrypted Disks
docker
swarm
mail services
DB
Postgres
DB
MariaDB
storage.tipi.build
JSON
B
JWT
JWT
Identity Providers
tipi.build/api/accounts
tipi.build/api/build
WWW
frontend tipi.build
traefik reverse proxy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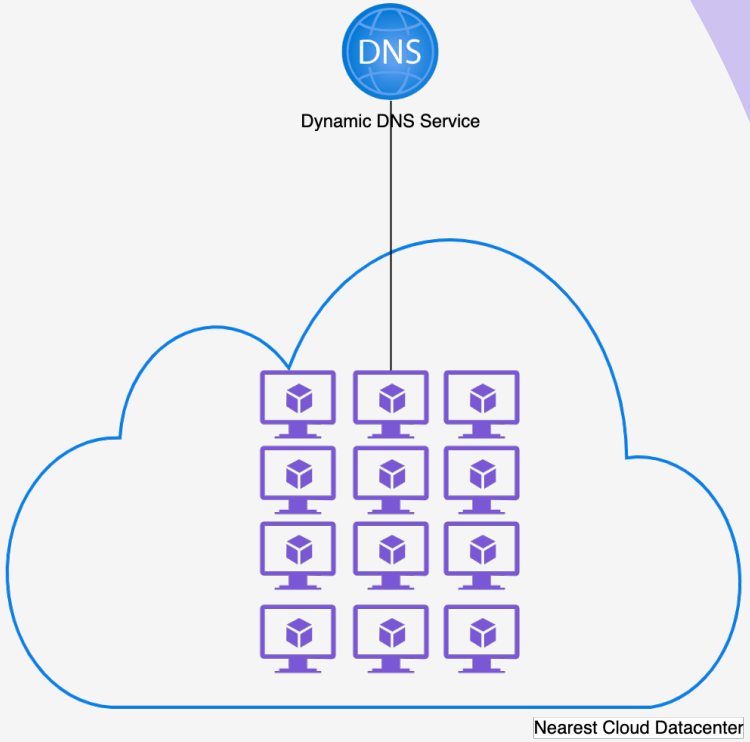
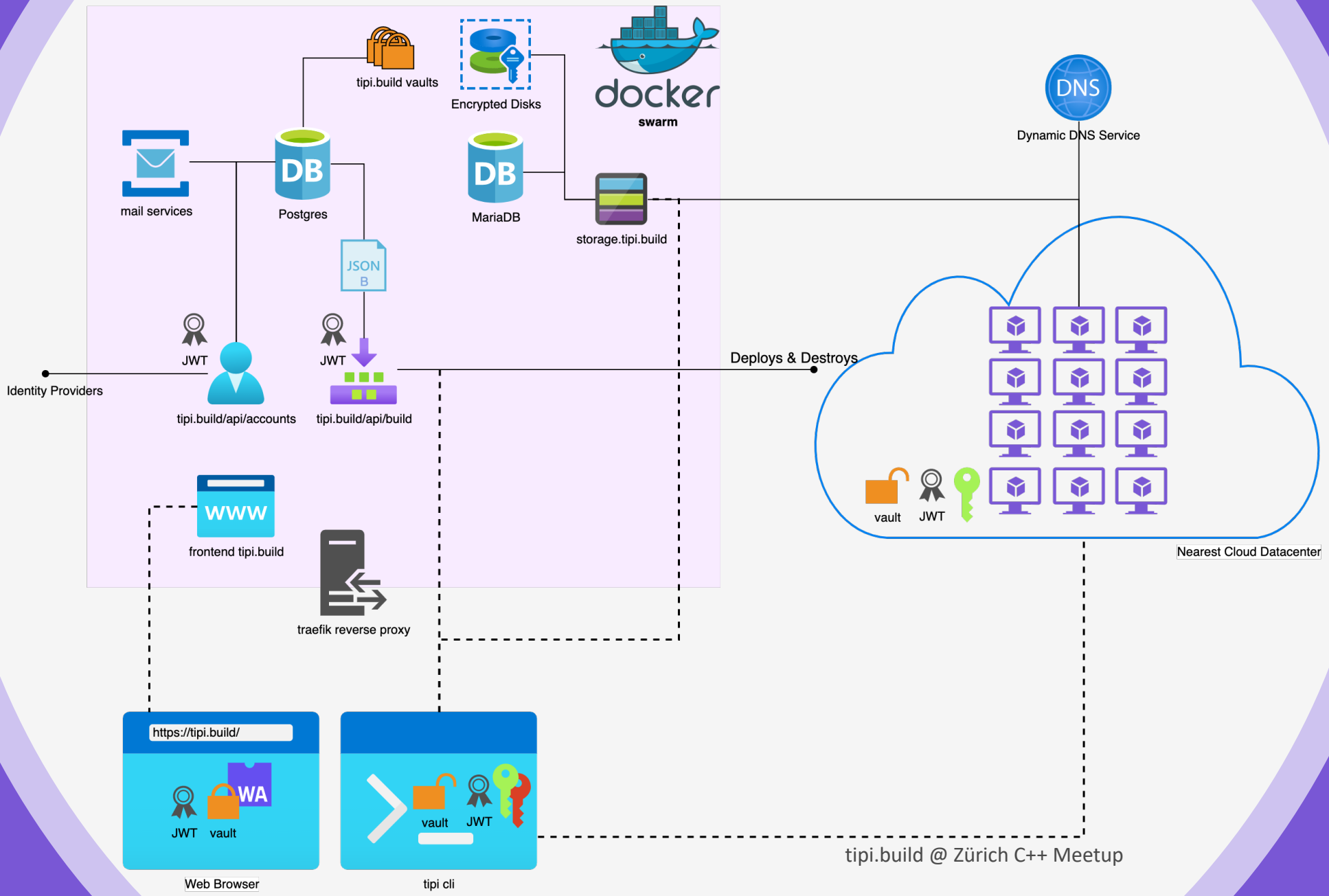

DNS
Dynamic DNS Service
Nearest Cloud Datacenter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Encrypted Disks
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Identity Providers
tipi.build/api/accounts
tipi.build/api/build
Deploys & Destroys
vault
JWT
Nearest Cloud Datacenter
WWW
frontend tipi.build
traefik reverse proxy
https://tipi.build/
WA
JWT
vault
Web Browser
vault
JWT
tipi cli

How is  Tipi.build built ?

C++

Technology Stack

Tipi.build helps reusing code.
Reuse code !

C++

Technology stack

Oat++

```
1 {
2   "oatpp/oatpp" : { "@" : "1.3.0" }
3 }
```

Oatpp-starter at https://github.com/tipi-build/oatpp-starter

C++

Technology stack


Oat++

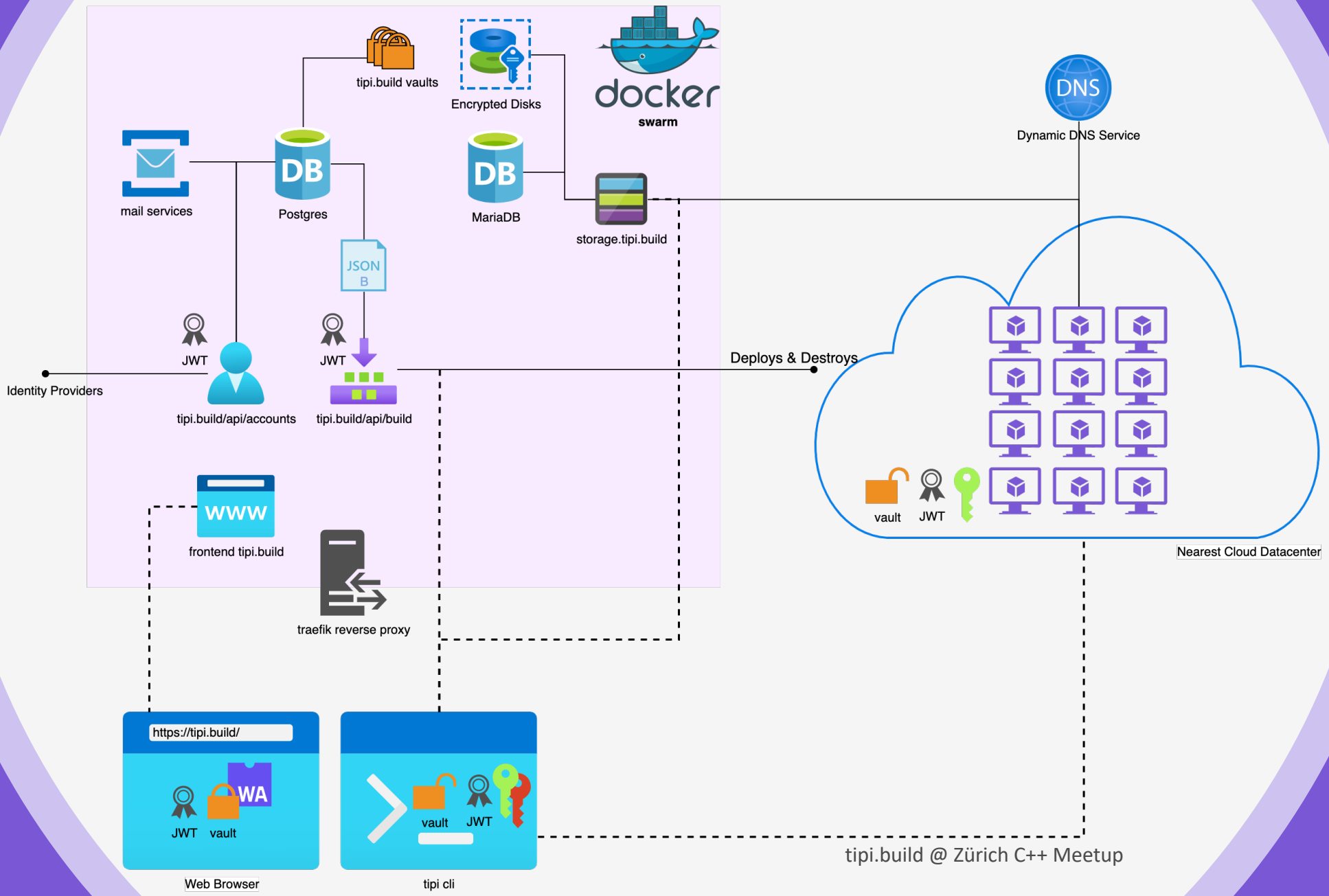
WebAssembly


NuxtJS


HashiCorp Terraform


HashiCorp Packer


Tipi.build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Nearest Cloud Datacenter
WWW
frontend tipi.build
traefik reverse proxy
https://tipi.build/
WA
JWT
vault
Web Browser
vault
JWT
tipi cli

Tipi.build

is

built with

Tipi.build

We dogfood but…

Tipi.build needs you !

https://tipi.build/

Register & Learn More

Endress+Hauser

The impressive factor 8 compilation speedup allows us to focus on what matters: beautiful and carefully tested code.

Andreas Büchin
Team Leader TDG Technology Gateways
Endress+Hauser Digital Solutions

REST Server

Oat++ RESTful Webservice

```
1 class Controller
2   : public oatpp::web::server::api::ApiController {
3
4   public:
5   ENDPOINT("GET", "/", root) {
6     auto dto = Dto::createShared();
7     dto->statusCode = 200;
8     dto->message = "Hello from tipi.build !";
9     return createDtoResponse(Status::CODE_200, dto);
10  }
11
12 };
```

```
1 class Dto : public oatpp::DTO {
2   DTO_INIT(Dto, DTO)
3
4   DTO_FIELD(Int32, statusCode);
5   DTO_FIELD(String, message);
6 };
```

Data Transfer Object

OpenAPI REST

OpenAPI REST

Oat++ OpenAPI Server

```cpp
class MyController : public oatpp::web::server::api::ApiController {
  public:
  ENDPOINT_INFO(root) {
    info->summary = "Greets the world! ";

    info->addResponse<Object<Dto>>(Status::CODE_200, "application/json");
    info->addSecurityRequirement("bearer");
  }
  ENDPOINT("GET", "/", root) {
    auto dto = Dto::createShared();
    dto->statusCode = 200;
    dto->message = "Hello World!";
    return createDtoResponse(Status::CODE_200, dto);
  }
};
```

To learn more about OpenAPI Clients with C++20

Watch our CppCon2021 talk

Our Adventures With REST API in C++ : Making it Easy

JWT

JSON Web Token

JWT: HTTP Bearer Auth

```cpp
namespace tipi::accounts {
  struct jwt {
    size_t iat;
    size_t exp;
    std::string aud;
    std::string iss;
    //! subject is user id
    std::string sub;
  };
}

namespace tipi::accounts {
  struct jwt_access : public jwt {
    std::string nick;
    std::string email;
    std::vector<std::string> organizations;
    std::string grant;
  };
}
```

JSON Web Token

Adding support to Oat++

```
{
  "arun11299/cpp-jwt": {
    "@": "master",
    "requires": {
      "nlohmann/json": { "@": "v3.1.2" },
      "platform": [
        "OpenSSL::+SSL",
        "OpenSSL::+Crypto"
      ]
    }
  }
}
```

Oat++ BearerAuthorizationHandler

```cpp
class TipiAuthorizationHandler
  : public oatpp::web::server::handler::BearerAuthorizationHandler {

  public:
  std::shared_ptr<AuthorizationObject> authorize(const oatpp::String &token) override {
    using namespace jwt::params;

    std::error_code ec;
    jwt::decode(token, algorithms({"ES384"}), ec, verify(true), secret(pub_key));

    return (!ec) ?
      std::make_shared<AuthorizationObject>()
      : nullptr;
  }
};

//... In Controller Constructor

setDefaultAuthorizationHandler(std::make_shared<TipiAuthorizationHandler>());
```

ORM

Object-Relational Mapping

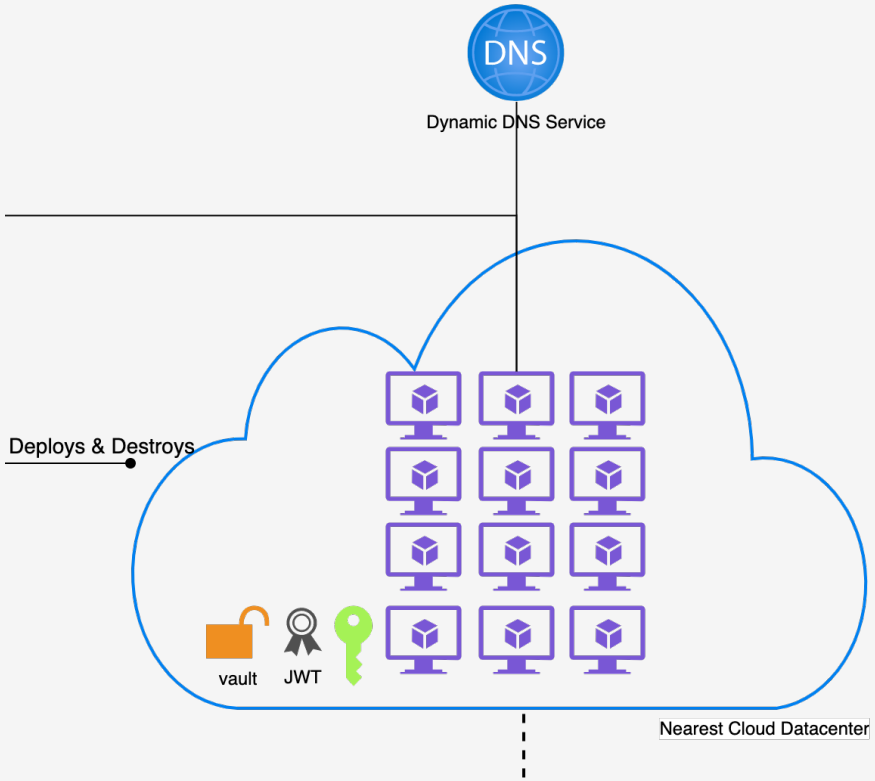
ORM

Thing that maps SQL Tables to Classes

NoORM for NoSQL

We'll store objects directly

tipi.build machines



JSON and a bit of SQL

```cpp
struct machine_t {
  std::string id{ to_string(boost::uuids::random_generator()()) };

  cloud_vendor_t cloud_vendor{};
  machine_type_t machine_type{};

  //! the running environment
  std::string environment_name;
  std::string environment_hash;

  //! when the machine was kept alive by an active user session at last
  std::chrono::milliseconds::rep last_keep_alive{};

  std::string job_id{};
  execution_status_t status{execution_status_t::STOPPED};

  std::optional<std::string> fqdn{};

  //! the machine name in AZ dns (without domain)
  std::optional<std::string> dns_name{};
  std::string address{};
  std::size_t port{};

  std::optional<std::string> subscription_id{};
};
```

```sql
CREATE TABLE IF NOT EXISTS machine(
  data jsonb);

CREATE INDEX machine_idx
    ON machine
    USING gin(data jsonb_path_ops);

CREATE UNIQUE INDEX machine_uuid_idx
    ON machine(((data->>'id')));
```

JSON and a bit of SQL

```
1 QUERY(create_machine,
2   R"(INSERT INTO machine (data) VALUES (CAST(:data_to_insert as json)) RETURNING *;)",
3   PREPARE(true),
4   PARAM(oatpp::String,data_to_insert))
5
6  tipi::build::service::machine_t create_machine(const machine_t &machine) {
7   tipi::build::service::machine_t machine_for_db = machine;
8
9   std::string machine_string = pre::json::to_json(machine_for_db).dump();
10  auto dbResult = m_database->create_machine(machine_string.c_str());
11
12  OATPP_ASSERT_HTTP(dbResult->isSuccess(), Status::CODE_500, dbResult->getErrorMessage());
13  return machine_for_db;
14 }
```

To serialize JSON like the cool kids with C++20

Watch our CppCon2021 talk

Our Adventures With REST API in C++ : Making it Easy

https://github.com/tipi-build/openapipp/

C++20 better [de]serialization

```cpp
#include <pre/json/from_json.hpp>

struct person {
  pre_json_key(std::string, name);
  pre_json_key(std::size_t, age);
  pre_json_key(std::string, address);
};

//...
auto person = pre::json::from_json<person>(R"(
    { "name" : "Edouard",
      "age" : 31,
      "address" : "hello@tipi.build"
    }
)");
```

JSONB advantages

- Postgres JSONB performance
  - Faster than mongodb
  - Same speed as columns
- Simplicity
- Who needs data migration when you have std::optional ?

Tipi.build deploys many manycores machines !

tipi.build environments

linux-cxx17.cmake

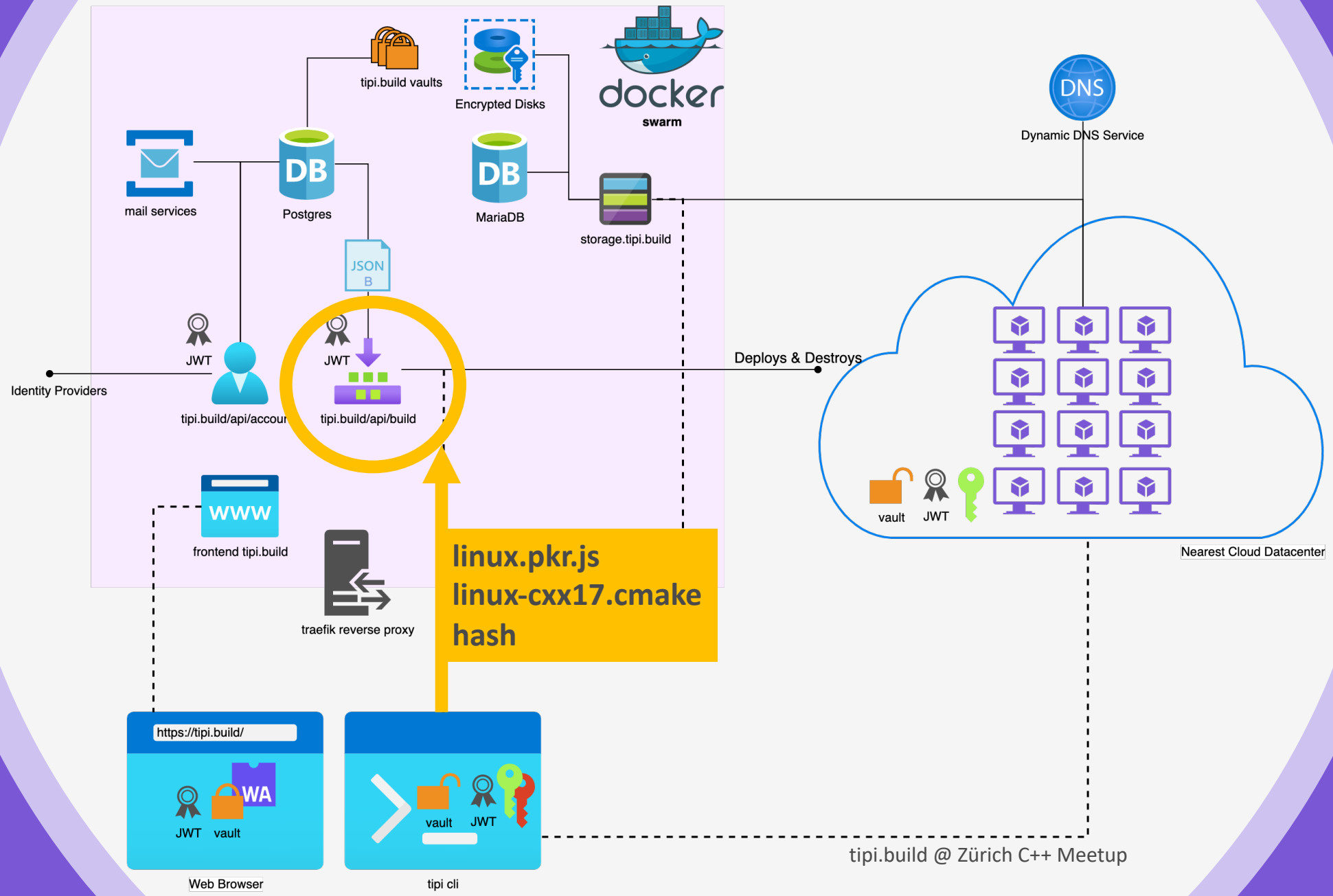
```
if(DEFINED POLLY_CLANG_CXX17_CMAKE_)
  return()
else()
  set(POLLY_CLANG_CXX17_CMAKE_ 1)
endif()

include("${CMAKE_CURRENT_LIST_DIR}/utilities/polly_init.cmake
polly_init(
    "clang / c++17 support"
    "Unix Makefiles"
)
include("${CMAKE_CURRENT_LIST_DIR}/utilities/polly_common.cma

include("${CMAKE_CURRENT_LIST_DIR}/compiler/clang.cmake")
include("${CMAKE_CURRENT_LIST_DIR}/flags/cxx17.cmake")
```

linux.pkr.js

```
{
  "variables": { },
  "builders": [
    {
      "type": "docker",
      "image": "tipibuild/tipi-ubuntu",
      "commit": true
    }
  ],
  "post-processors": [
    {
      "type": "docker-tag",
      "repository": "linux",
      "tag": "latest"
    }
  ]
  ,"_tipi_version":"{{tipi_version_hash}}"
}
```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tipi.build/api/build
Deploys & Destroys
vault
JWT
Nearest Cloud Datacenter
WWW
frontend tipi.build
traefik reverse proxy
linux.pkr.js
linux-cxx17.cmake
hash
https://tipi.build/
WA
JWT
vault
Web Browser
vault
JWT
tipi cli


Zombies in tipi.build !

$> tipi build . -t macos –j 128

```
namespace tipi::util {

  void enable_stacktrace_on_crash() {
    std::set_terminate(&detail::on_terminate_print_stacktrace);
    ::signal(SIGSEGV, &detail::on_crash);
    ::signal(SIGABRT, &detail::on_crash);
  }

  namespace detail {
    inline void on_terminate_print_stacktrace() {
      boost::stacktrace::safe_dump_to("./crash.dump");
      try {
          std::cerr << boost::stacktrace::stacktrace();
      } catch (...) {}
      std::abort();
    }

    inline void on_crash(int signum) {
      ::signal(signum, SIG_DFL);
      detail::on_terminate_print_stacktrace();
      ::raise(SIGABRT);
    }
  }
}
```

$> tipi build . -t macos –j 128

```cpp
namespace tipi::util {

  void enable_stacktrace_on_crash() {
    std::set_terminate(&detail::on_terminate_print_stacktrace);
    ::signal(SIGSEGV, &detail::on_crash);
    ::signal(SIGABRT, &detail::on_crash);
  }

  namespace detail {
    inline void on_terminate_print_stacktrace() {
      boost::stacktrace::safe_dump_to("./crash.dump");
      try {
          std::cerr << boost::stacktrace::stacktrace();
      } catch (...) {}
      std::abort();
    }

    inline void on_crash(int signum) {
      ::signal(signum, SIG_DFL);
      detail::on_terminate_print_stacktrace();
      ::raise(SIGABRT);
    }
  }
}
```

addr2line
addr2line
addr2line
addr2line
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addr2line


Zombies in tipi.build !

Tipi.build needs you !

https://tipi.build/

Register & Learn More

COUPON CODE: THANKS4YOURTIME

4 MONTHS

Manycores cloud builds for free

local builds + dependency management always free

Thanks

Tipi

www.tipi.build

Damien Buhl

damien@tipi.build

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