Tools for large-scale collection & analysis of source code repositories

OPEN SOURCE GIT REPOSITORY COLLECTION PIPELINE

Intro

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- engineer @source{d}

source{d}

- startup in Madrid
- builds the open-source components that enable large-scale code analysis and machine learning on source code

MOTIVATION: WHY COLLECTING SOURCE CODE

- ➔ Academia: material for research in IR/ML/PL communities
- ➔ Industry: fuel for building data-driven products (i.e for sourcing candidates for hiring)

VISION:

- ➔ OSS collection pipeline
- ➔ Use it to build public datasets industry and academia
- ➔ Use Git as “source of truth”, the most popular VCS
- ➔ A **crawler** (find URLs, git clone them), **Distributed** storage (FS, DB), **Parallel processing** framework

Tech Stack

tech stack

infrastructure	CoreOS K8s
collection	Rovers Borders go-git
storage	HDFS śiva
processing	Apache Spark source{d} Engine
analysis	Bblfsh Enry

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infrastructure

- ➔ Dedicated cluster (cloud becomes prohibitively expensive for storing ~100sTb)
- ➔ CoreOS provisioned on bare-menta \w Terraform
- ➔ Booting and OS configuration Matchbox and Ignition
- ➔ K8s deployed on top of that

More details at talk at CfgMgmtCamp

http://cfgmgmtcamp.eu/schedule/terraform/CoreOS.html

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- ➔ Rovers: search for Git repository URLs
- ➔ Borges: fetching repository \w “git pull”
- ➔ Git storage format & protocol implementation
- ➔ Optimize for on-disk size: forks that share history, saved together

go-git to talk Git Last year had a talk at FOSDEM

https://archive.fosdem.org/2017/schedule/event/go_git/

motivation

GIT LIBRARY FOR GO

- need to clone and analyze tens of millions of repositories with our core language Go
- be able to do so in memory, and by using custom filesystem implementations
- easy to use and stable API for the Go community
- used in production by companies, e.g.: keybase.io

features

PURE GO SOURCE CODE

- the most complete git library for any language after libgit2 and jgit
- highly extensible by design
- idiomatic API for plumbing and porcelain commands
- 2+ years of continuous development
- used by a significant number of open source projects

example

GO-GIT IN ACTION

example mimicking `git clone` using go-git:

```
// Clone the repo to the given directory

url := "https://github.com/src-d/go-git",
_, err := git.PlainClone(
    "/tmp/foo", false,
    &git.CloneOptions{
       URL: url,
       Progress: os.Stdout,
    },
)

CheckIfError(err)
```

output:

```
Counting objects: 4924, done.
Compressing objects: 100% (1333/1333), done.
Total 4924 (delta 530), reused 6 (delta 6),
pack-reused 3533
```

usage

TRY IT YOURSELF

```
# installation
$ go get -u gopkg.in/src-d/go-git.v4/...
```

- list of more go-git usage examples

resources

YOUR NEXT STEPS

- https://github.com/src-d/go-git
- go-git presentation at FOSDEM 2017
- go-git presentation at Git Merge 2017
- compatibility table of git vs. go-git
- comparing git trees in go

motivation

CODE COLLECTION AT SCALE

- collection and storage of repositories at large scale
- automated process
- optimal usage of storage
- optimal to keep repositories up-to-date with the origin

architecture

SEEK, FETCH, STORE

- distributed system similar to a search engine
- src-d/rovers retrieves URLs from git hosting providers via API, plus self-hosted git repositories
- src-d/borges producer reads URL list, schedules fetching
- borges consumer fetches and pushes repo to storage
- borges packer also available as a standalone command, transforming repository urls into siva files
- stores using src-d/śiva repository storage file format
- optimized for storage and keeping repos up-to-date

architecture

KEY CONCEPT

- **rooted repositories** are standard git repositories that store all objects from all repositories that share a common history, identified by same initial commit:

- a rooted repository is saved in a single śiva file
- updates stored in concatenated siva files: no need to rewriting the whole repository file
- distributed-file-system backed, supports GCS & HDFS

usage

SETUP & RUN

- set up and run rovers
- set up borges
- run borges producer
- run borges consumer

resources

YOUR NEXT STEPS

- https://github.com/src-d/rovers
- https://github.com/src-d/borges
- https://github.com/src-d/go-siva
- śiva: Why We Created Yet Another Archive Format

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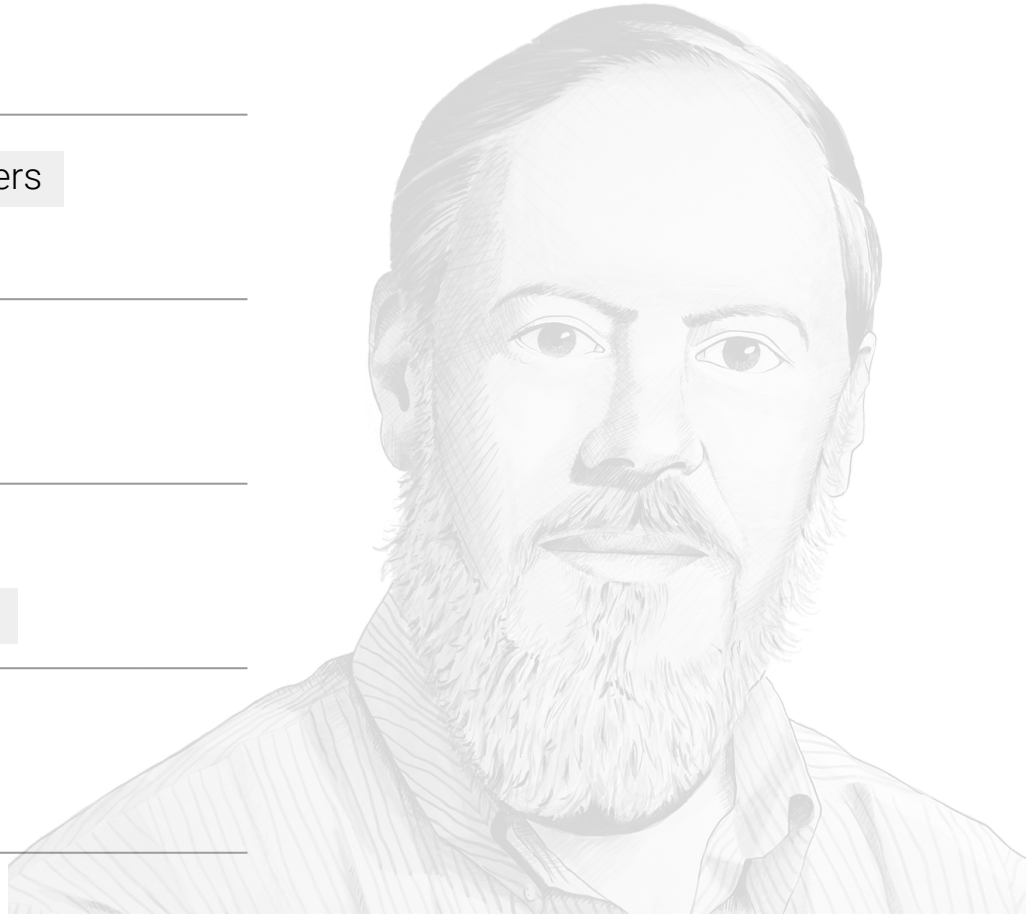


- ➔ Metadata: PostgreSQL
- ➔ Built small type-safe ORM for Go<->Postgres

  https://github.com/src-d/go-kallax

- ➔ Data: Apache Hadoop HDFS
- ➔ Custom (seekable, appendable) archive format: Siva 1 RootedRepository <-> 1 Siva file

motivation

SMART REPO STORAGE

- store a git repository in a single file
- updates possible without rewriting the whole file
- friendly to distributed file systems
- seekable to allow random access to any file position

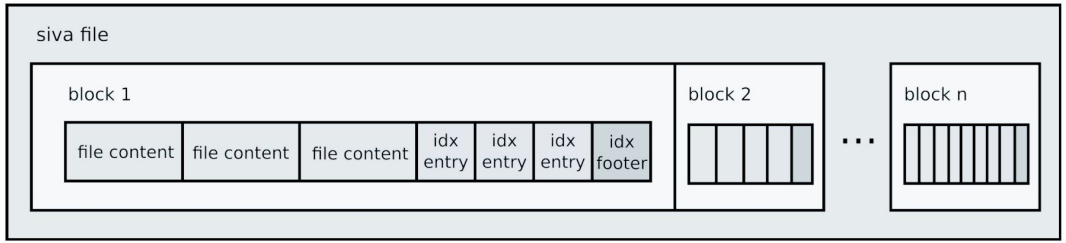
architecture

CHARACTERISTICS

- src-d/go-siva is an archiving format similar to tar or zip
- allows constant-time random file access
- allows seekable read access to the contained files
- allows file concatenation given the block-based design
- command-line tool + implementations in Go and Java

architecture

SIVA FILE BLOCK SCHEMA



usage

APPENDING FILES

```
# pack into siva file
$ siva pack example.siva qux

# append into siva file
$ siva pack --append example.siva
bar

# list siva file contents
$ siva list example.siva
Sep 20 13:04     4 B qux -rw-r--r--
Sep 20 13:07     4 B bar -rw-r--r--
```

resources

YOUR NEXT STEPS

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Apache Spark

- ➔ For batch processing, SparkSQL

Engine

- ➔ Library, \w custom DataSource implementation GitDataSource
- ➔ Read repositories from Siva archives in HDFS, exposes though DataFrame
- ➔ API for accessing refs/commits/files/blobs
- ➔ Talks to external services though gRPC for parsing/lexing, and other analysis

motivation

UNIFIED SCALABLE PIPELINE

- easy-to-use pipeline for git repository analysis
- integrated with standard tools for large scale data analysis
- avoid custom code in operations across millions of repos

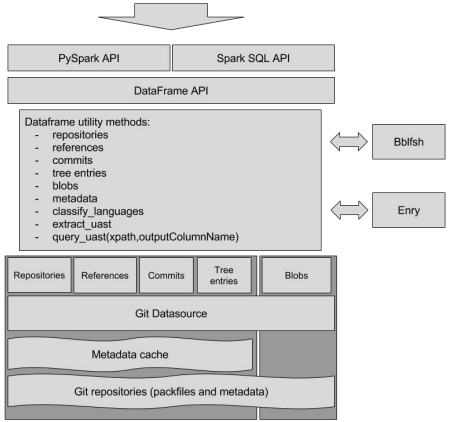
architecture

PREPARATION

- listing and retrieval of git repositories
- Apache Spark datasource on top of git repositories
- iterators over any git object, references
- code exploration and querying using XPath expressions
- language identification and source code parsing
- feature extraction for machine learning at scale

architecture

APACHE SPARK DATAFRAME



- extends Apache SparkSQL
- git repositories stored as siva files or standard repositories in HDFS
- metadata caching for faster lookups over all the dataset.
- fetches repositories in batches and on demand
- available APIs for Spark and PySpark
- can run either locally or in a distributed cluster

usage sample

```
EngineAPI(spark, 'siva',
          '/path/to/siva-files')
.repositories
.references
.head_ref
.files
.classify_languages()
.extract_uasts()
.query_uast('//*[@roleImport and
@roleDeclaration]',
            'imports')
.filter("lang = 'java'")
.select('imports',
        'path',
        'repository_id')
.write
.parquet("hdfs://...")
```

resources

YOUR NEXT STEPS

- https://github.com/src-d/engine
- Early example jupyter notebook: https://github.com/src-d/spark-api/blob/master/examples/notebooks/Example.ipynb

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Enry

- ➔ Programming language identification
- ➔ Re-write of github/linguist in Golang, ~370 langs

Project Babelfish

- ➔ Distributed parser infrastructure for source code analysis
- ➔ Unified interface though gRPC to native parsers in containers: src -> uAST

Talk in Source Code Analysis devRoom
Room: UD2.119, Sunday, 12:40
https://fosdem.org/2018/schedule/event/code_babelfish_a_universal_code_parser_for_source_code_analysis/

motivation

LANG DETECTION AT SCALE

- need to detect programming languages of every file in a git repository
- initially used github/linguist, but needed more performance for large scale applications
- keep compatibility with the original *linguist* project

architecture

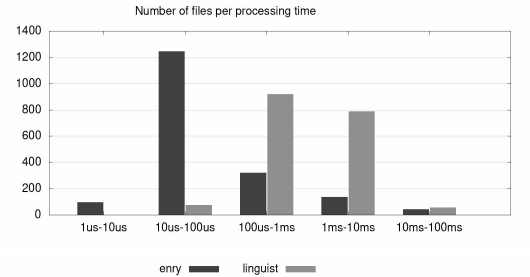
COMPATIBLE AND FLEXIBLE

- *linguist* as source of information on language detection
- ignores binary and vendored files
- command line tool mimics the original *linguist* one
- can be used in Go (native library) or Java (shared library)

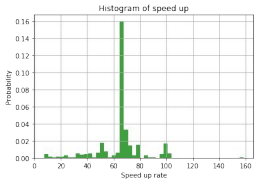
benchmarks

GO FASTER

- src-d/enry is at least 4x faster than *linguist*
- 5x (larger repos) to 20x faster (smaller repos)



- additional info on benchmarking *enry*



- *enry* speed improvement over *linguist* when applied to linguist/samples folder file samples

usage

```
$ enry /path/to/src-d/go-git
98.28%   Go
0.69%    Shell
0.34%    Makefile
0.34%    Markdown
0.34%    Text
```

usable in Go as a native library, in Java as shared library and as a CLI tool.

resources

YOUR NEXT STEPS

- https://github.com/src-d/enry
- enry: detecting languages
- benchmark methodology and results

babelfish A SELF-HOSTED SERVER FOR UNIVERSAL SOURCE CODE PARSING

motivation

UNIVERSAL CODE ANALYSIS

- was born as a solution for massive code analysis
- parsing single files in any programming language
- analyze all source code from all repositories in the world
- analyze many languages using a shared structure/format

use cases

POWERFUL OPPORTUNITIES

- AST-based diff'ing. Understanding changes made to code with finer-grained granularity.
- extract features for Machine Learning on Source Code.
- statistics of language features
- detecting similar coding patterns across languages

architecture

CONTAINER-BASED

- language drivers as the main building blocks
- parsing service via one driver per language
- language drivers can be written in any language and are packaged as standard Docker containers
- containers are executed by the babelfish server in a specific runtime built on-top of libcontainer.

architecture

UNIVERSAL AST

- UAST is a universal (normalized and annotated) form of Abstract Syntax Tree (AST)
- language-independent annotations (roles) such as *Expression*, *Statement*, *Operator*, *Arithmetic*, etc.
- can be easily ported to many languages using gogo/protobuf

usage

TRY BABELFISH ONLINE

- or run babelfish server & dashboard locally:

```
$ docker run --privileged -d -p \
  9432:9432 --name bblfsh \
  bblfsh/server

$ docker run -p 8080:80 --link \
  bblfsh bblfsh/dashboard \
  --bblfsh-addr bblfsh:9432
```

resources

YOUR NEXT STEPS

- https://github.com/bblfsh
- Babelfish documentation
- announcing Babelfish
- Babelfish presentation
- join the Babelfish community

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Further directions

INFRASTRUCTURE

➔ Persistent storage in k8s on bare-metal cluster

COLLECTION

➔ Explore SEDA architecture, to dynamically saturate throughput

STORAGE

➔ Better splittable Git object storage format (\w delta-encoding, etc)

PROCESSING

➔ Distributed Indexes to speed up common Apache Spark queries

ANALYSIS

➔ AST-diff, cross-language abstractions on top of ASTs

thank you.

source{d}