

# Web Crawling with Apache Nutch

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## About Me

computational linguist

software developer at Exorbyte (Konstanz, Germany)

search and data matching

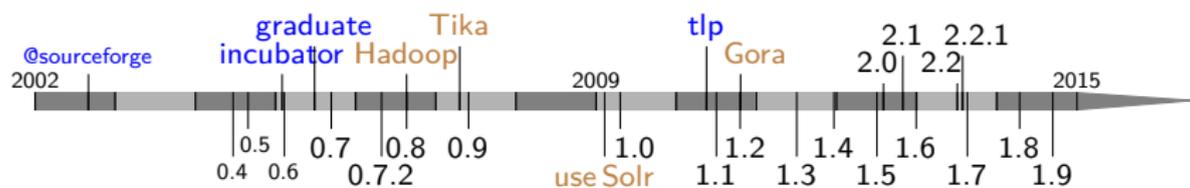
prepare data for indexing, cleansing noisy data,  
web crawling

Nutch user since 2008

2012 Nutch committer and PMC

# Nutch History

- 2002 started by Doug Cutting and Mike Caffarella  
open source web-scale crawler and search engine
- 2004/05 MapReduce and distributed file system in Nutch
- 2005 Apache incubator, sub-project of Lucene
- 2006 Hadoop split from Nutch, Nutch based on Hadoop
- 2007 use Tika for MimeType detection, Tika Parser 2010
- 2008 start NutchBase, ..., 2012 released 2.0 based on Gora 0.2
- 2009 use Solr for indexing
- 2010 Nutch top-level project
- 2012/13 ElasticSearch indexer (2.x), pluggable indexing back-ends (1.x)



# What is Nutch now?

“an extensible and scalable web crawler based on Hadoop”

- ▶ runs on top of  *hadoop*
  - ▶ scalable: billions of pages possible
  - ▶ some overhead (if scale is not a requirement)
  - ▶ not ideal for low latency
- ▶ customizable / extensible plugin architecture
  - ▶ pluggable protocols (document access)
  - ▶ URL filters + normalizers
  - ▶ parsing: document formats + meta data extraction
  - ▶ indexing back-ends
- ▶ mostly used to feed a search index ...
- ▶ ...but also data mining

# Nutch Community

- ▶ mature Apache project
- ▶ 6 active committers
  - ▶ maintain two branches (1.x and 2.x)
- ▶ “friends” — (Apache) projects Nutch delegates work to
  - ▶ Hadoop: scalability, job execution, data serialization (1.x)
  - ▶ Tika: detecting and parsing multiple document formats
  - ▶ Solr, Elasticsearch: make crawled content searchable
  - ▶ Gora (and HBase, Cassandra, ...): data storage (2.x)
  - ▶ crawler-commons: robots.txt parsing
- ▶ steady user base, majority of users
  - ▶ uses 1.x
  - ▶ runs small scale crawls (< 1M pages)
  - ▶ uses Solr for indexing and search

# Crawler Workflow

0. initialize CrawlDb, **inject** seed URLs

repeat generate-fetch-update cycle  $n$  times:

1. **generate** fetch list: select URLs from CrawlDb for fetching

2. **fetch** URLs from fetch list

3. **parse** documents: extract content, metadata and links

4. **update** CrawlDb status, score and signature, add new URLs

inlined or at the end of one crawler run (once for multiple cycles):

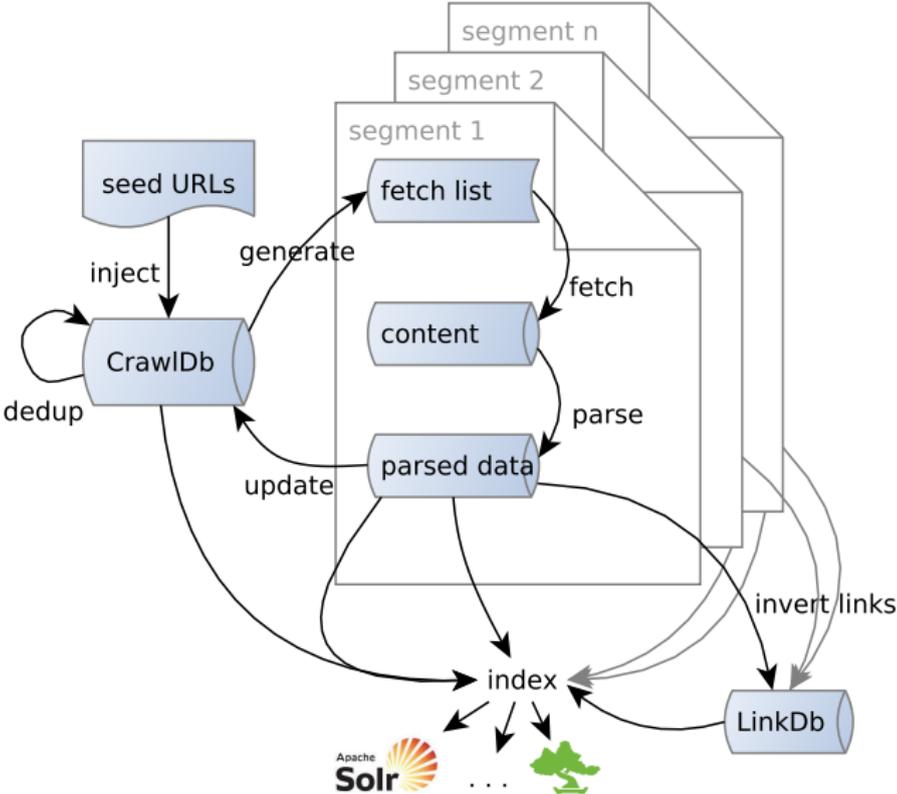
5. **invert links**: map anchor texts to documents the links point to

6. (calculate **link rank** on **web graph**, update CrawlDb scores)

7. **deduplicate** documents by signature

8. **index** document content, meta data, and anchor texts

# Crawler Workflow



# Workflow Execution

- ▶ every step is implemented as one (or more) MapReduce job
- ▶ shell script to run the workflow (**bin/crawl**)
- ▶ **bin/nutch** to run individual tools
  - ▶ inject, generate, fetch, parse, updatedb, invertlinks, index, ...
  - ▶ many analysis and debugging tools
- ▶ local mode
  - ▶ works out-of-the-box (bin package)
  - ▶ useful for testing and debugging
- ▶ (pseudo-)distributed mode
  - ▶ parallelization, monitor crawls with MapReduce web UI
  - ▶ recompile and deploy job file with configuration changes

# Features of selected Tools

## Fetcher

- ▶ multi-threaded, high throughput
- ▶ but always be polite
- ▶ respect robots rules (robots.txt and robots directives)
- ▶ limit load on crawled servers,  
guaranteed delays between access to same host, IP, or domain

## WebGraph

- ▶ iterative link analysis
- ▶ on the level of documents, sites, or domains

... most other tools

- ▶ are either quite trivial
- ▶ and/or rely heavily on plugins

# Extensible via Plugins

## Plugins basics

- ▶ each Plugin implements one (or more) extension points
- ▶ plugins are activated on demand (property `plugin.includes`)
- ▶ multiple active plugins per ext. point
  - ▶ “chained”: sequentially applied (filters and normalizers)
  - ▶ automatically selected (protocols and parser)

## Extension points and available plugins

- ▶ URL filter
  - ▶ include/exclude URLs from crawling
  - ▶ plugins: regex, prefix, suffix, domain
- ▶ URL normalizer
  - ▶ canonicalize URL
  - ▶ regex, domain, querystring

## Plugins (continued)

- ▶ protocols
  - ▶ http, https, ftp, file
  - ▶ protocol plugins take care for robots.txt rules
- ▶ parser
  - ▶ need to parse various document types
  - ▶ now mostly delegated to Tika (plugin parse-tika)
  - ▶ legacy: parse-html, feed, zip
- ▶ parse filter
  - ▶ extract additional meta data
  - ▶ change extracted plain text
  - ▶ plugins: headings, metatags
- ▶ indexing filter
  - ▶ add/fill indexed fields
  - ▶ url, title, content, anchor, boost, digest, type, host, ...
  - ▶ often in combination with parse filter to extract field content
  - ▶ plugins: basic, more, anchor, metadata, ...

## Plugins (continued)

- ▶ index writer
  - ▶ connect to indexing back-ends
  - ▶ send/write additions / updates / deletions
  - ▶ plugins: Solr, ElasticSearch
- ▶ scoring filter
  - ▶ pass score to outlinks (in 1.x: quite a few hops)
  - ▶ change scores in CrawlDb via inlinks
  - ▶ can do magic: limit crawl by depth, focused crawling, ...
  - ▶ OPIC (On-line Page Importance Computation, [1])
    - ▶ online: good strategy to crawl relevant content first
    - ▶ scores also ok for ranking
    - ▶ but seeds (and docs “close” to them) are favored
    - ▶ scores get out of control for long-running continuous crawls
  - ▶ LinkRank
    - ▶ link rank calculation done separately on WebGraph
    - ▶ scores are fed back to CrawlDb

Complete list of plugins:

<http://nutch.apache.org/apidocs/apidocs-1.9/>

# Pluggable classes

## Extensible interfaces (pluggable class implementations)

- ▶ fetch schedule
  - ▶ decide whether to add URL to fetch list
  - ▶ set next fetch time and re-fetch intervals
  - ▶ default implementation: fixed re-fetch interval
  - ▶ available: interval adaptive to document change frequency
- ▶ signature calculation
  - ▶ used for deduplication and not-modified detection
  - ▶ MD5 sum of binary document or plain text
  - ▶ TextProfile based on filtered word frequency list

# Data Structures and Storage in Nutch 1.x

All data is stored as map  $\langle \text{url}, \text{someobject} \rangle$  in Hadoop map or sequence files

Data structures (directories) and stored values:

- ▶ CrawlDb: all information of URL/document to run and schedule crawling
  - ▶ current status (injected, linked, fetched, gone, ...)
  - ▶ score, next fetch time, last modified time
  - ▶ signature (for deduplication)
  - ▶ meta data (container for arbitrary data)
- ▶ LinkDb: incoming links (URLs and anchor texts)
- ▶ WebGraph: map files to hold outlinks, inlinks, node scores

## Data Structures (1.x): Segments

Segments store all data related to fetch and parse of a single batch of URLs (one generate-fetch-update cycle)

`crawl_generate`: list of URLs to be fetched

with politeness requirements (host-level blocking):

- ▶ all URLs of one host (or IP) must be in one partition to implement host-level blocking in one single JVM
- ▶ inside one partition URLs are shuffled: URLs of one host are spread over whole partition to minimize blocking during fetch

`crawl_fetch`: status from fetch (e.g., success, failed, robots denied)

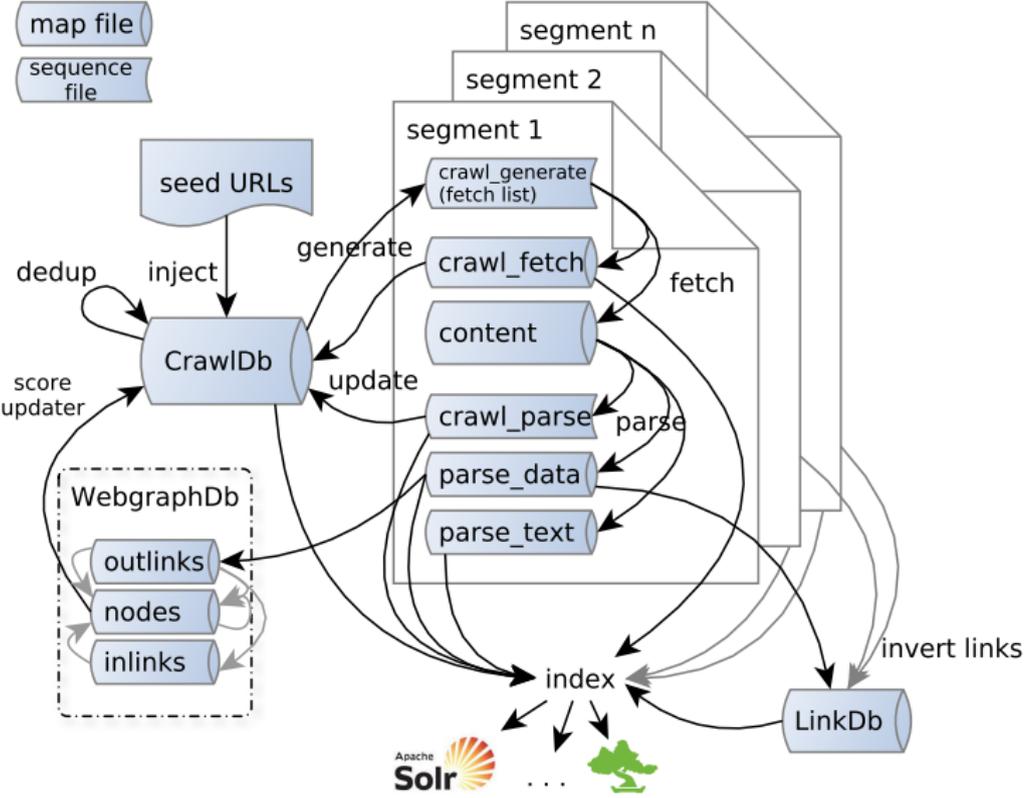
`content`: fetched binary content and meta data (HTTP header)

`parse_data`: extracted meta data, outlinks and anchor texts

`parse_text`: plain-text content

`crawl_parse`: outlinks, scores, signatures, meta data,  
used to update CrawlDb

# Storage and Data Flow in Nutch 1.x



## Storage in Nutch 2.x

### One big table (WebTable)

- ▶ all information about one URL/document in a single row: status, metadata, binary content, extracted plain-text, inlink anchors, ...
- ▶ inspired by BigTable paper [3]
- ▶ ...and rise of NoSQL data stores

### Apache Gora used for storage layer abstraction



- ▶ OTD (object-to-datastore) for NoSQL data stores
- ▶ HBase, Cassandra, DynamoDb, Avro, Accumulo, ...
- ▶ data serialization with Avro
- ▶ back-end specific object-datastore mappings

# Benefits of Nutch 2.x

## Benefits

- ▶ less steps in crawler workflow
- ▶ simplify Nutch code base
- ▶ easy to access data from other applications
  - ▶ access storage directly
  - ▶ or via Gora and schema
- ▶ plugins and MapReduce processing shared with 1.x

## Performance and Efficiency 2.x?

Objective: should be more performant (in terms of latency)

- ▶ no need to rewrite whole CrawlDb for each smaller update
- ▶ adaptable to more instant workflows (cf. [5])

...however

- ▶ benchmark by Julien Nioche [4] shows that Nutch 2.x is slower than 1.x by a factor of  $\geq 2.5$
- ▶ not a problem of HBase and Cassandra but due to Gora layer
- ▶ will hopefully be improved with Nutch 2.3 and recent Gora version which supports filtered scans
- ▶ still fast at scale

## ...and Drawbacks?

### Drawbacks

- ▶ need to install and maintain datastore
- ▶ higher hardware requirements

### Impact on Nutch as software project

- ▶ 2.x planned as replacement, however
  - ▶ still not as stable as 1.x
  - ▶ 1.x has more users
- ▶ need to maintain two branches
- ▶ keep in sync, transfer patches



## Common Crawl moves to Nutch (2013)

<http://blog.commoncrawl.org/2014/02/common-crawl-move-to-nutch/>

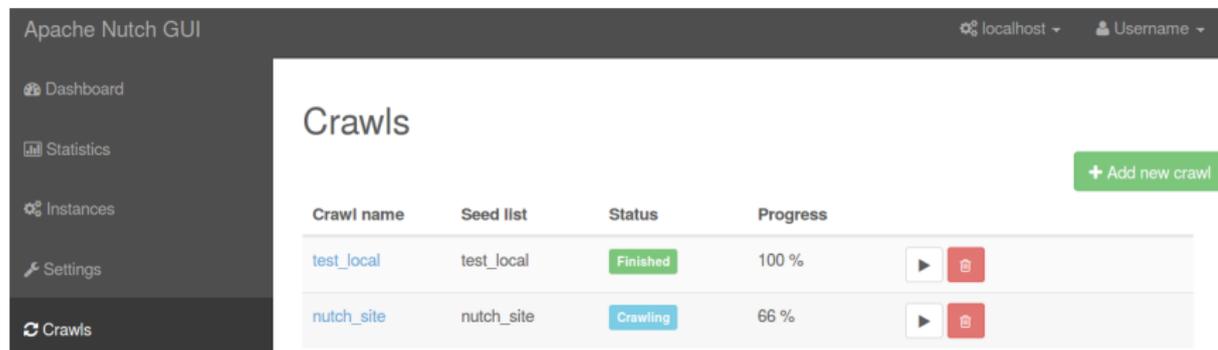
- ▶ public data on Amazon S3
- ▶ billions of web pages

## Generic deduplication (1.x)

- ▶ based on CrawlDb only
- ▶ no need to pull document signatures and scores from index
- ▶ no special implementations for indexing back-ends (Solr, etc.)

Nutch participated in GSoC 2014 ...

# Nutch Web App



The screenshot shows the Apache Nutch GUI interface. On the left is a dark sidebar with navigation links: Dashboard, Statistics, Instances, Settings, and Crawls. The main content area is titled 'Crawls' and features a table with columns for Crawl name, Seed list, Status, and Progress. There are two rows of data: 'test\_local' (Finished, 100%) and 'nutch\_site' (Crawling, 66%). Each row has play and delete icons. A green '+ Add new crawl' button is in the top right. The top header shows 'localhost' and 'Username'.

Crawl name	Seed list	Status	Progress	
<a href="#">test_local</a>	test_local	Finished	100 %	 
<a href="#">nutch_site</a>	nutch_site	Crawling	66 %	 

GSoC 2014 (Fjodor Vershinin):

“Create a Wicket-based Web Application for Nutch”

- ▶ Nutch Server and REST API
- ▶ Web App client to run and schedule crawls
- ▶ only Nutch 2.x (for now)
- ▶ needs completion: change configuration, analytics (logs), ...

# What's coming next?

Nutch 1.x is still alive!

...but we hope to release 2.3 soon

- ▶ with performance improvements from recent Gora release

Fix bugs, improve usability

- ▶ our bottleneck: review patches, get them committed
- ▶ try hard to keep 1.x and 2.x in sync

Pending new features

- ▶ sitemap protocol
- ▶ canonical links

## What's coming next? (mid- and long-term)

Move to Hadoop 2.x and new MapReduce API

... complete Rest API and Web App

... port it “back” to 1.x

... use graph library (Giraph) for link rank computation

... switch from batch processing to streaming

- ▶ Storm / Spark / ?
- ▶ parts of the workflow

## Thanks and acknowledgments ...

... to Julien Nioche, Lewis John McGibbney, Andrzej Białeczki, Chris Mattmann, Doug Cutting, Mike Cafarella – for inspirations and material from previous Nutch presentations

... and to all Nutch committers for review and comments on early versions of these slides.

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Questions?