Open Source Platforms for Search

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What am I?

- not an academic (anymore)
- not a commercial software developer (anymore)
- open-source guy
  - developer
  - architect
  - manager
  - evangelist (but not a zealot)

What Distinguishes Open Source?

model	research	commerce	open source
license	*various*	*various*	OSI-approved
artifacts	publications	products patents	code
payment	university	private	*various*
motivator	peer	money	*various*
community	academic	closed	open

Lucene pre-history: Xerox PARC

- Text Database (TDB) 1988-1993
  - in Common Lisp
  - B-Tree based (with optimizations)
  - phrase & ranked searching
  - vectors & clustering
  - research prototype, led to several publications
- Lessons
  - seek per <term,doc> pair too slow
  - wanted real users

Lucene pre-History: Apple ATG

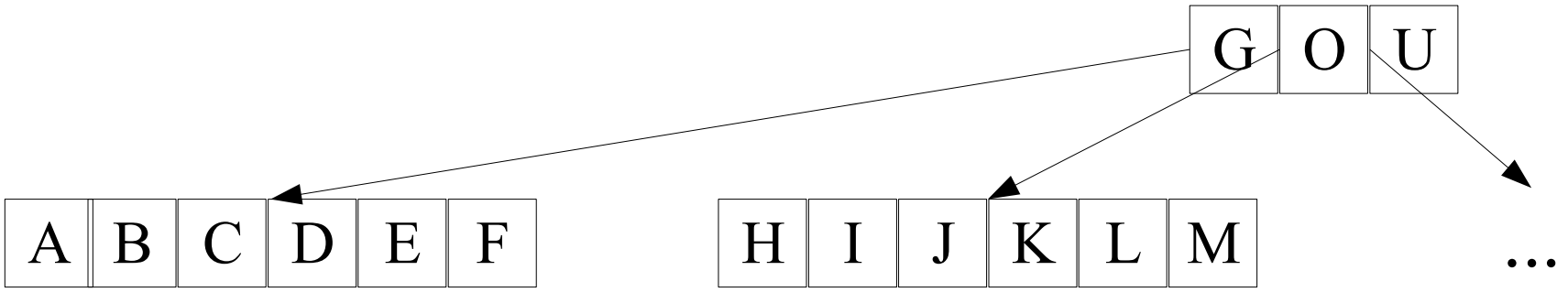
- V-Twin, 1993-1996
  - in C++
  - B-tree based, with optimizations
    - slow to update large collections except by merging indexes
  - no proximity: ranked search only
  - used in Sherlock (1998), Spotlight (2004) etc.
- Lessons:
  - batching seeks still too slow
    - B-trees fragment; index merging required
  - developers don't like subclassing

Lucene pre-History: Excite

- Architext (1996-1998)
  - C++, originally written by Graham Spencer
  - merge-based indexing (4-stage process)
  - 2-level files (subset of keys in RAM w/ pointers to data)
  - no fields, tf*idf ranking, w/ boolean proximity
  - 250M page indexes, ~1000 searches/second peak
- Lessons
  - merging indexes scales optimally
  - server-side rocks, but C++ fragile
  - code can be lost

Digression: Seek versus Transfer

- B-Tree
  - requires seek per access
  - unless to recent, cached page
  - so can buffer & pre-sort accesses
  - but, w/ fragmentation, must still seek per page



Digression:
Seek versus Transfer

- update by merging
  - merge sort takes log(updates), at transfer rate
  - merging updates is linear in db size, at transfer rate
- if 10MB/s xfer, 10ms seek, 1% update of TB db
  - 100B entries, 10kB pages, 10B entries, 1B pages
  - seek per update requires 1000 days!
  - seek per page requires 100 days!
  - transfer entire db takes 1 day

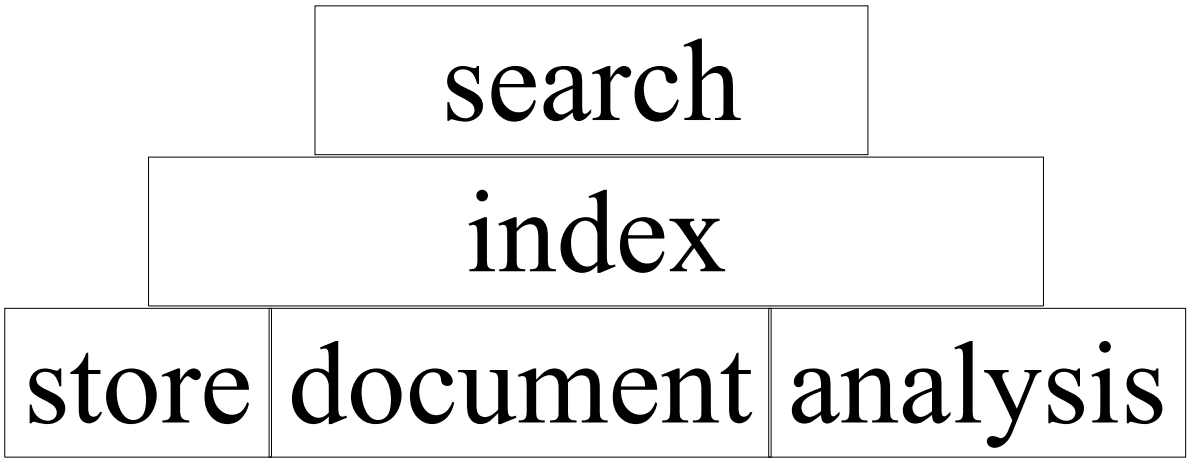
Lucene History

- 1997-98: written in 3 months, part-time
- 1998: Licensed to one client
- 2000: open source on Sourceforge.net
  - GPL at first, then LGPL
- 2001: moved to Apache
- 2005: Apache top-level project

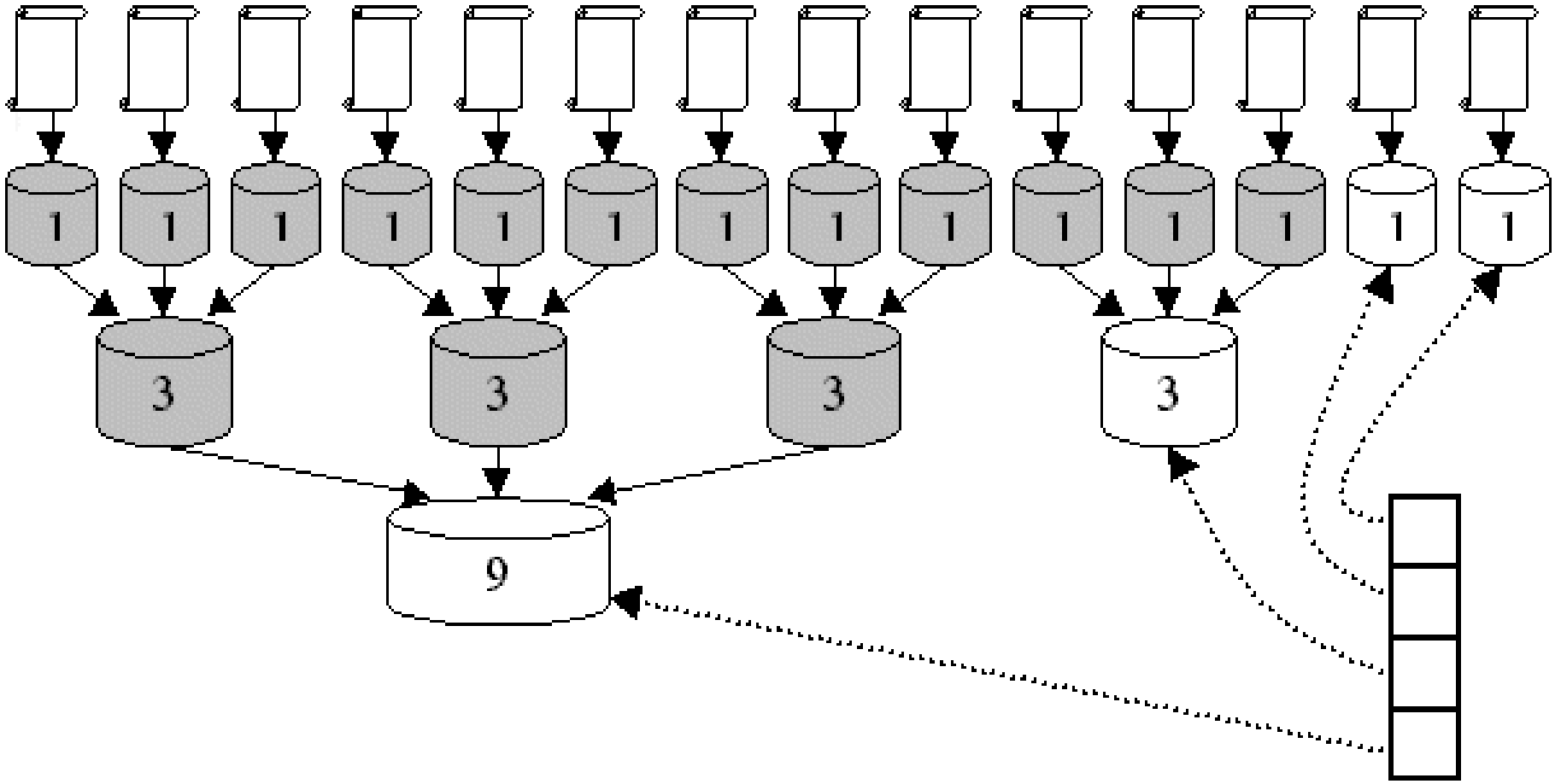
Original Lucene Goals

- in Java
  - new environment, no existing search technology
- simple, well-documented API
  - no user subclassing required
  - no config files – dynamic field typing
- support commonly used features
  - fields, booleans, proximity, tf*idf ranking
- scalable & incremental
  - aimed for ~10M document indexes on single CPU

Lucene Architecture



Lucene Indexing Algorithm



Lucene Indexing Algorithm: notes

- multiway merge: process at transfer rate
- average $b*\log_b(N)/2$ indexes
  - N=1M, b=2 gives just 20 indexes
  - fast to update and not too slow to search
- optimization
  - single-doc indexes kept in RAM, saves system calls
- batch indexing w/ $M=\infty$, merge all at end
  - equivalent to external merge sort, optimal
- segment indexing w/ $M<\infty$

Lucene Search Algorithms

- merge streams of postings, ordered by <doc, pos>
  - can skip ahead in stream
  - collect only top sorting hits
  - space proportional to query size
- lots of operators
  - boolean, phrase, span, range, etc.
- scoring is (modified) tf*idf by default

Lucene Status

- 1.4.3 release widely used
  - wikipedia, eclipse, etc. (anyone here?)
  - translated to C, C++, C#, Python, Perl & Ruby
- 2.0 release recently completed
  - api cleanups
  - lots of new features, bug fixes & optimizations
- users don't subclass
  - but developers do, to extend
- if I'd tried to sell it
  - it would have created less commerce

Rapid Adoption Facilitators

- abstract external interfaces
  - anywhere i/o is performed, language processed, etc.
  - provide default implementations that most folks use
- concrete internal implementations
  - keeps things finite & tractable
  - can easily make private internals public & abstract later
- minimal
- always complete, useful, & working
  - users become developers

Lucene Future

- no central planning
  - Andrew Morton: “Whatever people send me.”
- wish list
  - extensible index format
  - easy federation
  - web service
- what would you add?

Nutch

- web search application
  - crawler
  - link graph
    - link analysis
    - anchor text
  - document format detection & parsing
  - language, charset detection & processing
  - extensible crawling, parsing, indexing & search

Nutch Documents

field	*stored*	*indexed*	*analyzed*
`url`	Yes	Yes	Yes
`anchor`	No	Yes	Yes
`content`	No	Yes	Yes
`site`	Yes	Yes	No
`lang`	Yes	Yes	No
...			

Nutch Queries

- By default:
  - require all query terms
  - search url, anchors and content
  - reward for proximity
- E.g., search for “search engine” is expanded to:
  - +(url:search^*x* anchor:search^*y* content:search^*z*)
  - +(url:engine^*x* anchor:engine^*y* content:engine^*z*)
  - url:“search engine”~*p*^*a*
  - anchor:“search engine”~*q*^*b*
  - content:“search engine”~*r*^*c*

Query Parsing

- Certain characters cause implicit phrases:
  - dash, plus, colon, slash, dot, apostrophe and atsign
  - URL & email are thus phrase searches
  - e.g., http://www.nutch.org/ = “http www nutch org”, doug@nutch.org = “doug nutch org”, etc.
- Stop words indexed, but normally ignored
  - unless in phrase or required.
  - can use N-grams if in phrase
- Plugins can extend for new fields

Nutch Search Performance Tricks

- index N-grams for very common words
  - “the” in content, “www” in url, etc.
  - convert phrase queries (implicit or explicit) to N-grams
  - stop word search still permitted, but very rare
- convert common binary terms to bit-vectors
  - lang:en, content-type:pdf, etc.
- sort indexes by page score
  - stop searching when N=~1000 matches found
- distributed search
  - partition by document

Nutch Scalability Goals

- Scale to entire web
  - pages on millions of different servers
  - billions of pages
  - complete crawl takes weeks
  - very noisy
- Support high traffic
  - thousands of searches per second
- State-of-the-art search quality

Scalability

- To meet scalability goals:
  - multiple simultaneous fetches
    (~100 pages/second / CPU, ~10M / day)
  - parallel, distributed db update
    (100M pages @ 100 pages/second / CPU)
  - distributed search
    (2-20M pages, 1-40 searches/second / CPU)

Initial Scalability

- Initial implementation was scalable...
  - parallel processes on multiple machines
  - some serial bottlenecks, but w/ plans to resolve
  - 100M web pages demonstrated

... but not to billions of pages

- scales better than other open source options
- but large installations are operationally onerous
  - manually monitoring multiple machines is painful
  - data-interchange and space-allocation difficult
- with single operator
  - hard to use more than a handful of machines
  - effectively limited to ~100M pages

Hadoop

- new project, spun out of Nutch
- platform for distributed computing
- foundation for all Nutch operations

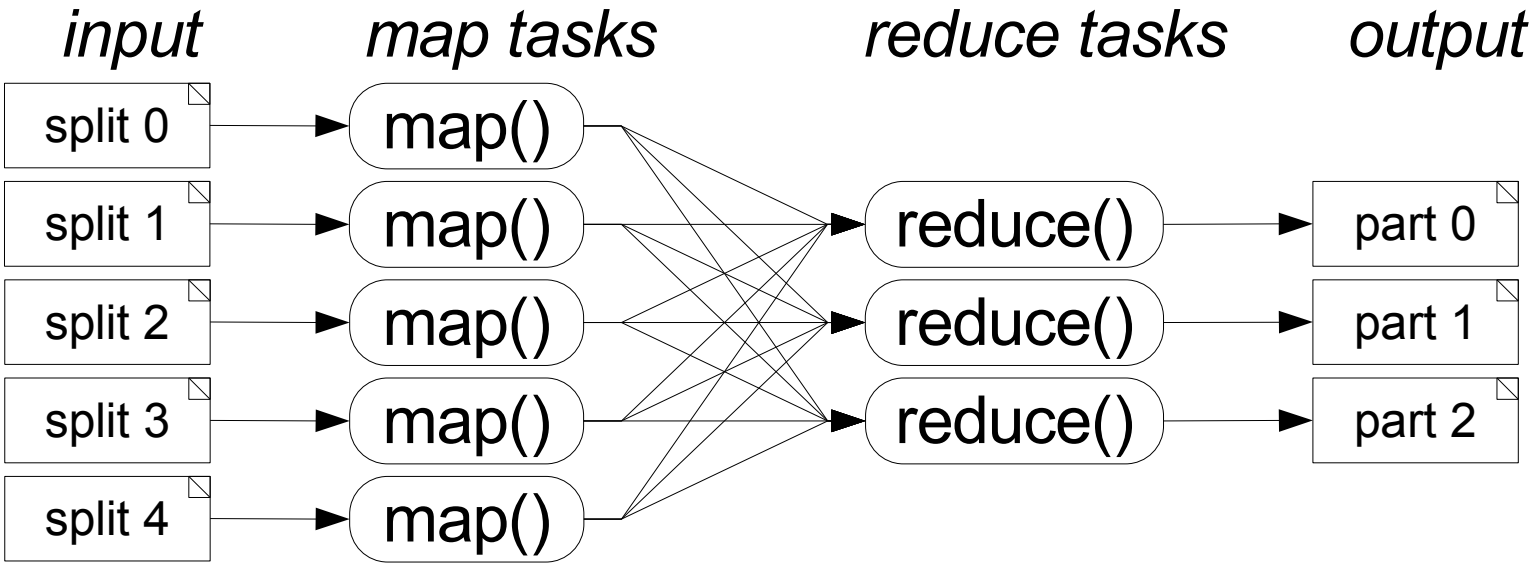
Hadoop's DFS

- modelled after Google's GFS
- single *namenode*
  - maps name → <blockId>*
  - maps blockId → <host:port>$^{replication\_level}$
- many *datanodes*, one per disk generally
  - map blockId → <byte>*
  - poll namenode for replication, deletion, etc. requests
- client code talks to both

MapReduce

- Platform for reliable, scalable computing.
- All data is sequences of <key,value> pairs.
- Programmer specifies two primary methods:
  - map(k, v) → <k', v'>*
  - reduce(k', <v'>*) → <k', v'>*
  - also partition(), compare(), & others
- All v' with same k' are reduced together, in order.
  - bonus: built-in support for sort/merge!

MapReduce job processing



Hadoop Status

- Very active development
- Currently tested on up to 600 nodes
- Latest sort benchmark
  - 300 node cluster
  - 3TB of random data in DFS
  - sorted in under 3 hours
  - output to DFS
- Still lots of room for improvement

Nutch on Hadoop

- Nutch's major algorithms converted in 2 weeks.
- Before:
  - several were undistributed scalabilty bottlenecks
  - distributable algorithms were complex to manage
  - collections larger than 100M pages impractical
- After:
  - all are scalable, distributed, easy to operate
  - code is substantially smaller & simpler
  - should permit multi-billion page collections

Nutch Status

- used in production
  - intranet: Oregon State University
  - vertical: Creative Commons
  - larger-scale vertical: Internet Archive
  - lots of others (you?)
- scaling well
  - 200M pages indexed on 35 boxes
  - 50M pages crawled & indexed in 24 hours on 20 boxes

Nutch Future

- not centrally planned!
- wish list
  - web-based config
  - better incremental updates
  - shingle-based dedup
  - spam detection
- what would you add?

Apache is Community

- technology is only the artifact
- open source license doesn't make a community
- without community
  - technology stagnates
  - is not used
- with community
  - technology evolves
  - meets needs of community
  - survives

Thanks!

http://lucene.apache.org/