Introducing Apache HTrace

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About Me

- I work on the Hadoop Distributed Filesystem and related big data technologies at Cloudera.
- Previously, I worked on the Ceph distributed filesystem

Overview

- Motivations for HTrace
- HTrace Architecture overview
- Using HTrace
- The HTrace community
- Demo
- Q&A

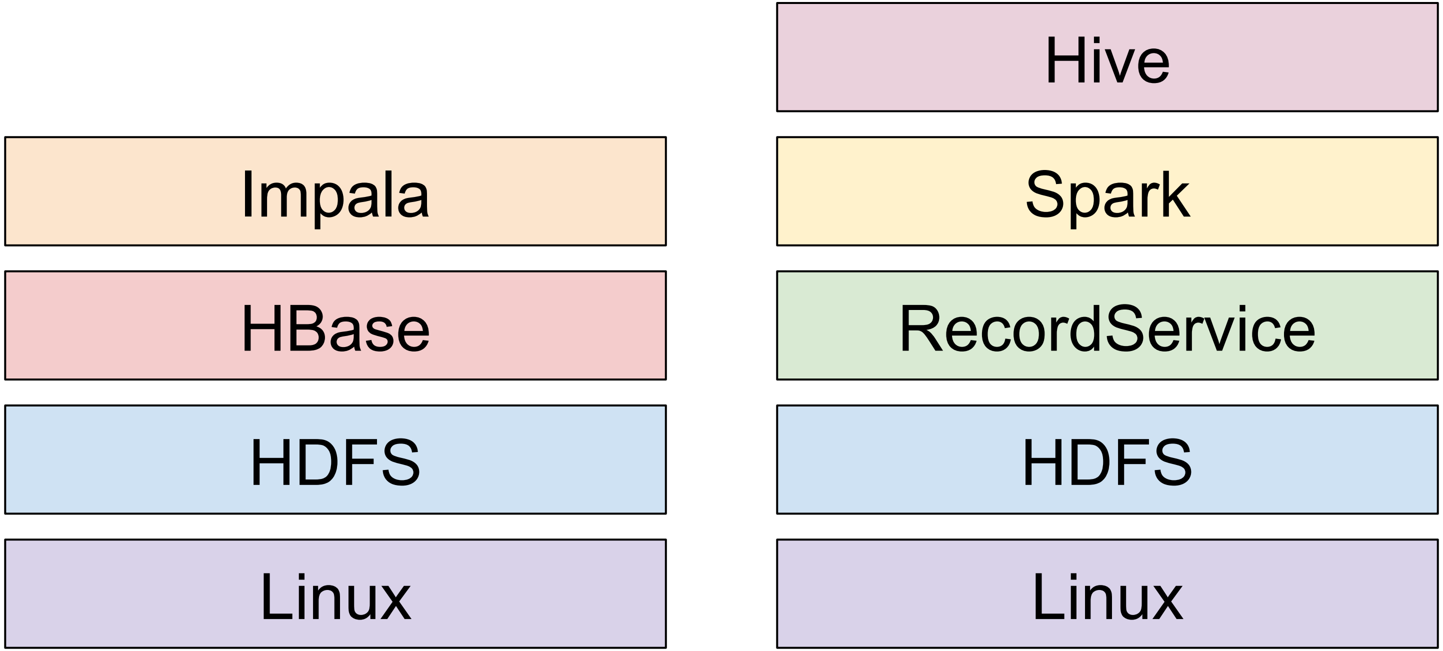
Big Data in 2016

- Volume of data continues to grow: petabytes to exabytes
- New open source projects
  - Apache Spark
  - RecordService
  - Kudu

Big Data Challenges

- Larger clusters (thousands of nodes)
- More disks (density)
- Lower latency targets
- Manageability
- Monitoring
- Heterogeneous clusters
- Complex stacks

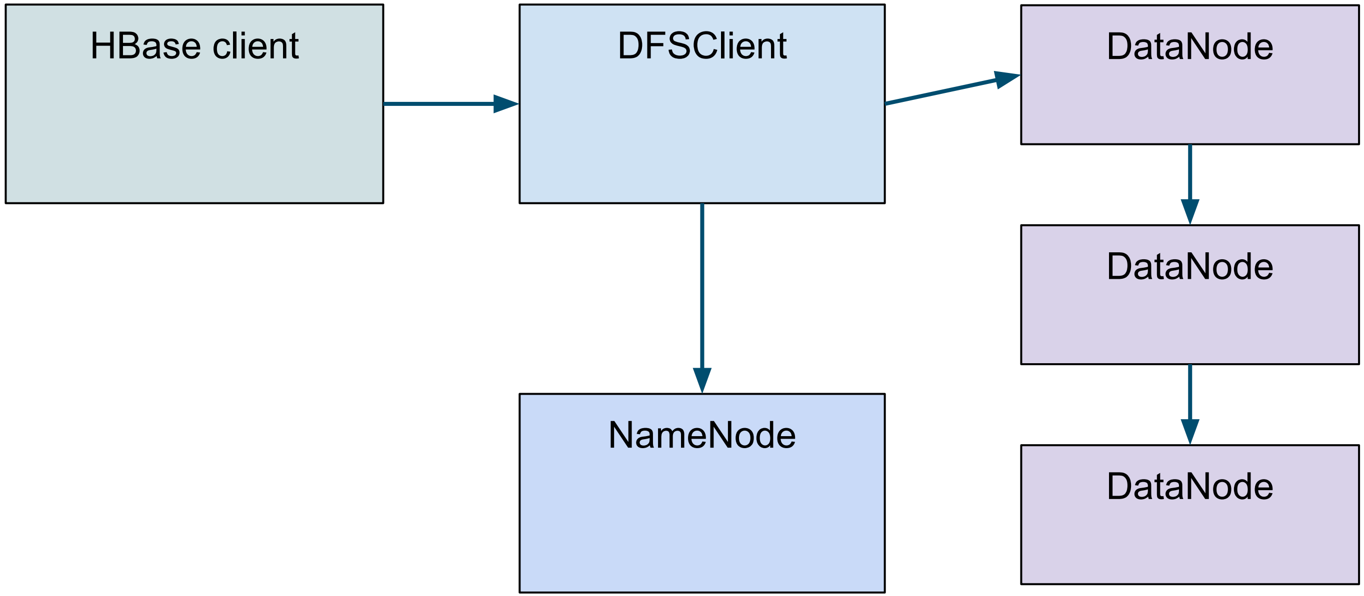
Example Big Data Stacks



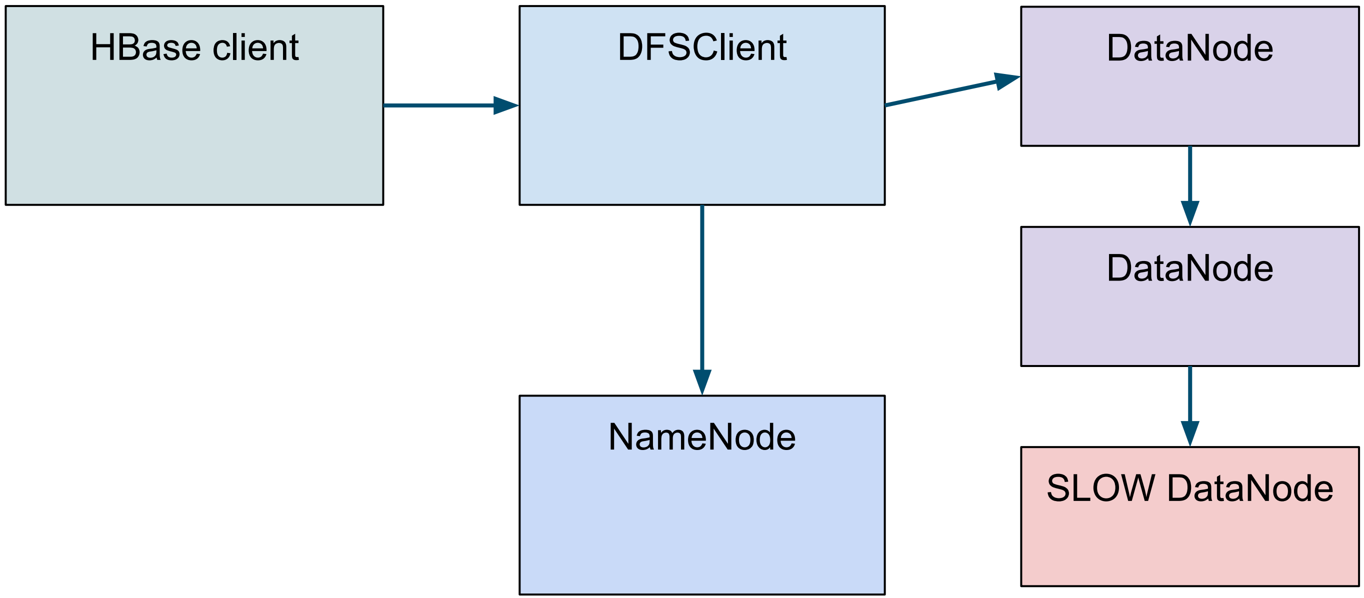
Diagnosing Distributed Systems is Hard

- Many timeouts and fallbacks
- Performance problems often not repeatable
- Difficult to follow requests across project boundaries and network boundaries

Diagnosing Distributed Systems is Hard

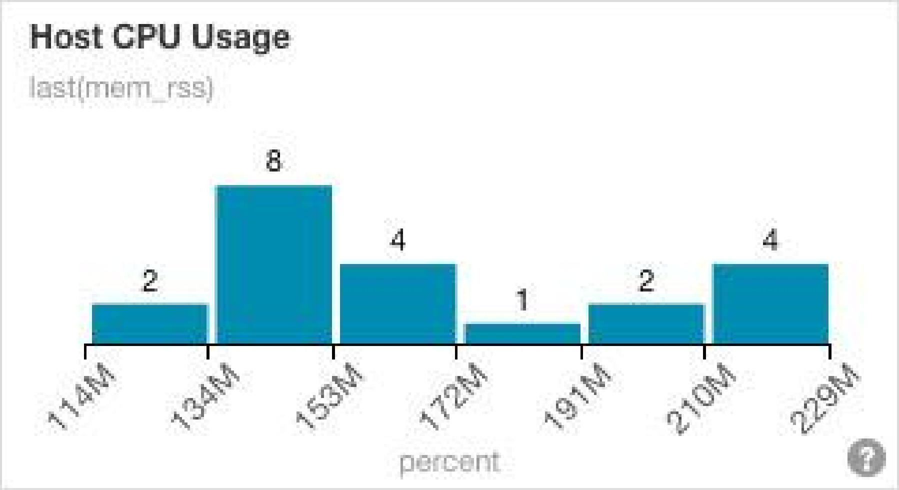


Diagnosing Distributed Systems is Hard



Metrics

- Many different metrics available
  - JMX
  - top
  - vmstat
  - iostat
- Aggregated
- Downsampled over time



Metrics

- Good for getting an overall view of throughput
- Bad for identifying latency problems.
  - Average bandwidth, CPU, disk I/O, etc. numbers often hide significant outliers
- Hard to figure out **why**
  - Disk I/O stats are low… because of I/O errors? Bottlenecks elsewhere? Low load?

Log Files

- Daemons all generate log files
  - HDFS audit log
  - log4j files
  - Client log files
- Usually stored on the nodes that generated them
- Kept for some length of time, then deleted

Log Files

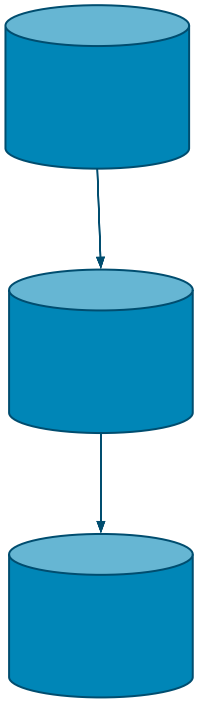
- Good for getting detailed information about a particular operation or point in time
- Bad for getting a holistic view of a single request. Difficult to correlate what is going on on different systems via logs
- Tradeoff between performance and logging
- Split into many different files
  - Per-host, per-project, per-faculty

HTrace’s Approach

- Distributed Tracing
  - Follow specific requests across the entire cluster
  - Follow requests across network **and project** boundaries
  - End-to-end tracing on a sampled subset of requests

End-to-End Tracing

- Multiple cluster nodes
- Multiple projects
  - Follow a request from HBase to HDFS
- Multiple languages (app vs. lib)
  - Java, C, C++ language bindings
- Use available storage and compute stack

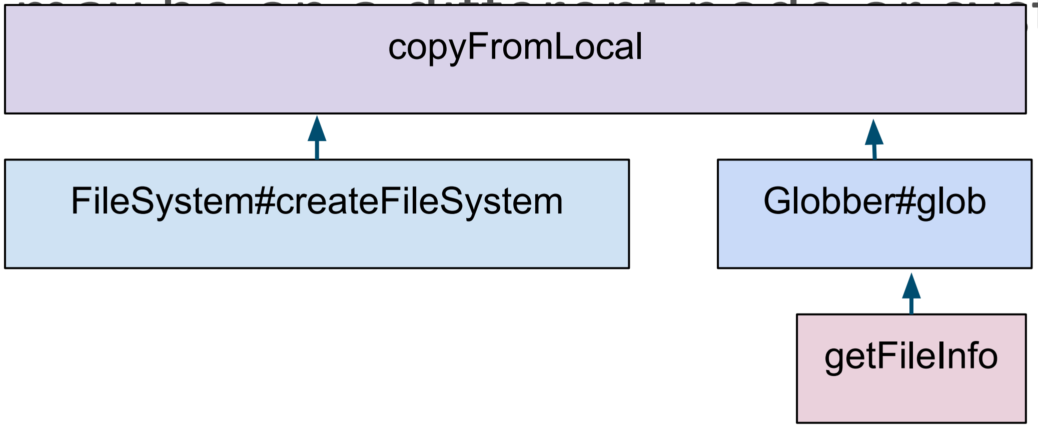


HTrace Goals

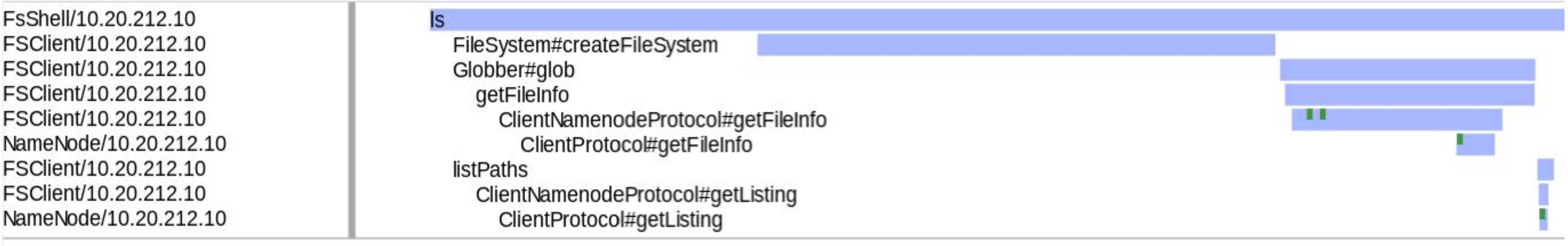
- Support multiple storage and compute backends
  - Not tied to any one RPC, language, framework
- Stable, well-supported client API
- Approximately zero impact when not in use
- Can be used on production clusters
- Integration with upstream big data and Hadoop projects, to allow end-users to enable tracing without writing code.

Trace Spans

- Annotations decompose requests into **trace spans**
- Trace spans can be nested (parent/child relationship)
- Parent may be on a different node or system



Trace Spans



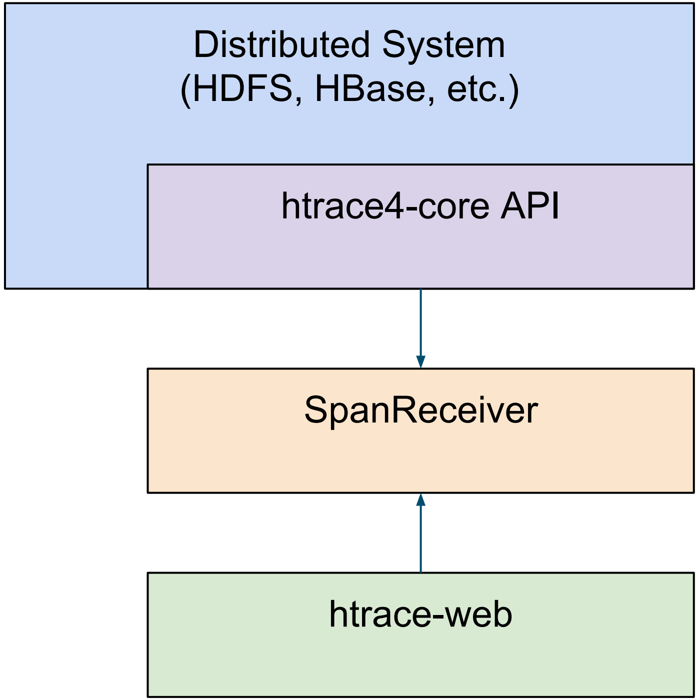
- A trace span represents a length of time
  - Description
  - Start time
  - End time
  - Parents
  - Unique Identifier
  - Process ID and IP address
  - Time Annotations
  - Key/Value Annotations

Sampling

- Tracing all requests generates an enormous amount of data
- It’s usually more useful to do sampling-- to trace only < 1% of requests
- Sampling rate and sampler is configurable
- Sampling is currently done at the level of the entire request

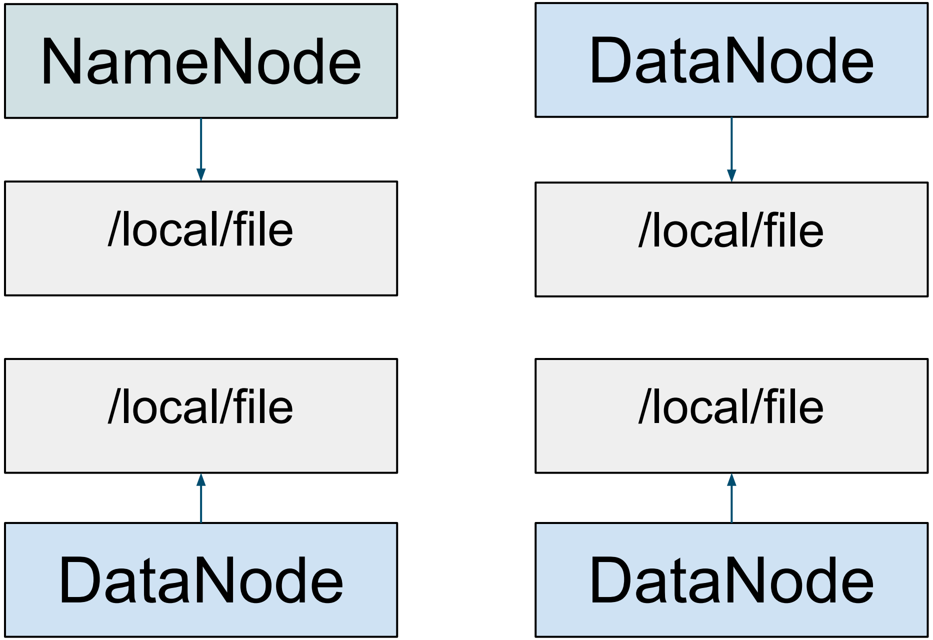
Pluggable Architecture

- htrace4-core is the library for creating spans
- SpanReceivers process spans created by htrace4-core
- htrace-web queries SpanReceiver data



LocalFileSpanReceiver

- Stores spans in files on the local filesystem
- Can post-process files later with MapReduce, Spark, etc.

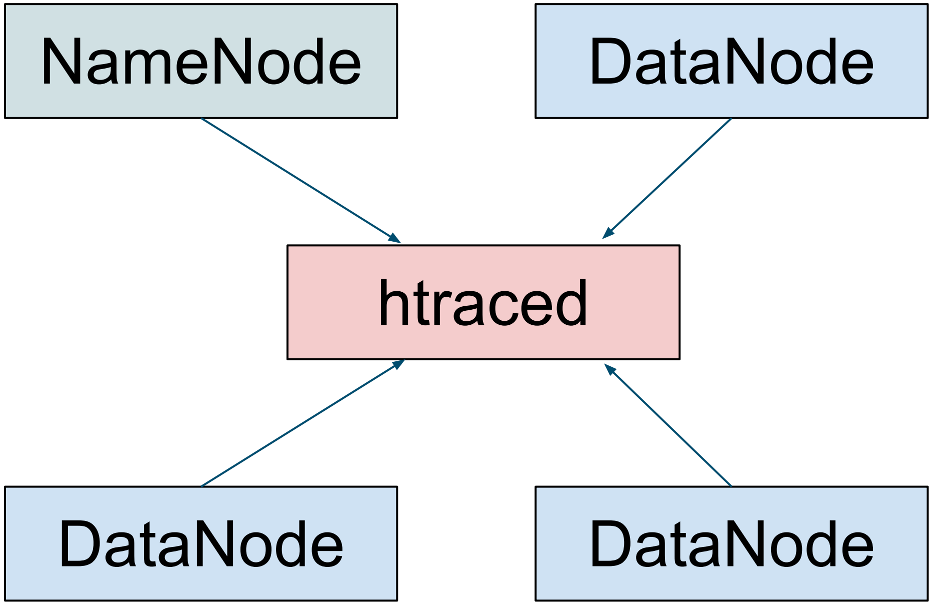


Span JSON


```
{
    "a":"f8e9e09c72e388f3fef51b32115beba5",
    "b":1448220893721,
    "e":1448220893788,
    "d":"ClientNamenodeProtocol#create",
    "p":["f8e9e09c72e388f3dc6778916cf3a5ac"],
    "r":"FSClient/10.20.190.31"
}
```

HTracedSpanReceiver

- Easy-to-use SpanReceiver that stores spans in a central daemon
- Indexing, web ui, aggregation in one place



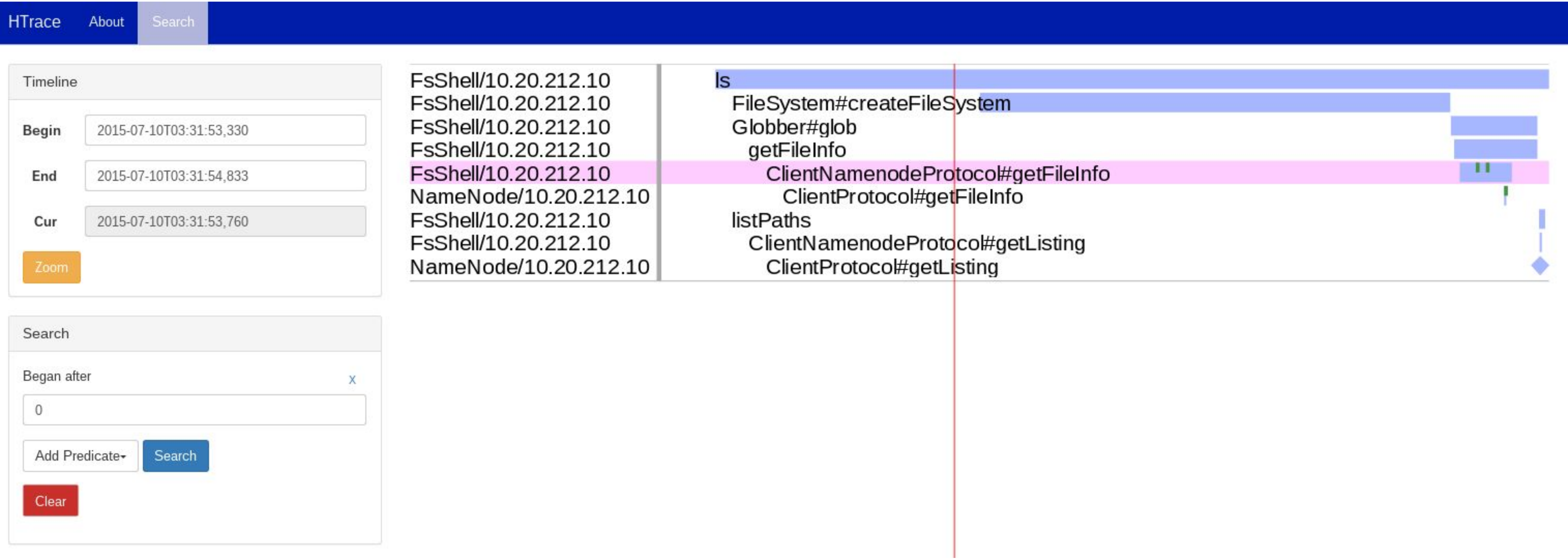
htraced

- Written in Go
- rpc
  - Serializes spans via msgpack
  - Exposes REST + JSON API for webapp and command-line tools
  - Java and C clients
  - Handles overload gracefully

htraced

- storage
  - Optimized for high write throughput
  - Uses multiple leveldb instances to store span data
  - begin time, end time, duration, and span ID are indexed so that range queries are fast
  - leveldb persists data to disk

HTrace Graphical Interface



Using HTrace

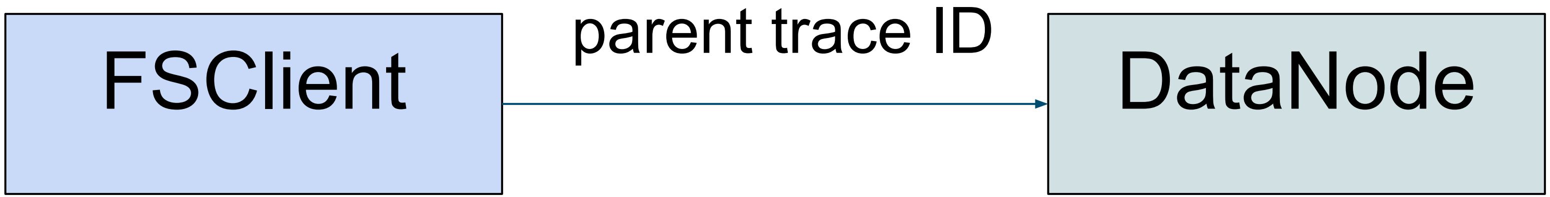
- Adding HTrace support to applications
- Configuring HTrace
- Using the HTrace web interface

Adding HTrace Support to Code

- Link against htrace4-core (java) or libhtrace.so (C/C++)
- Allow HTrace to access the application or library configuration
- Add trace spans to measure important events
- Add annotations to trace spans

Adding HTrace Support to Code

- Some applications and libraries will need to pass parent trace IDs over the network



htrace-core API

- Tracer
  - Creates trace scopes
  - Each tracer has its own sampling configuration
  - Use is thread-safe

```
Tracer tracer = new Tracer.Builder("FsShell").
  conf(TraceUtils.wrapHadoopConf(
    SHELL_HTRACE_PREFIX, getConf())).build();
```

htrace-core API

- TraceScope
  - Manages the trace span for this thread (nests)

```
TraceScope piScope =
  tracer.newScope("calculatePi");
try {
  calculatePi();
} finally {
  piScope.close();
}
```

htrace-core API

- Span
  - The Trace span itself

```
Span piSpan = piScope.getSpan();
if (piSpan != null) {
  piSpan.addKVAnnotation(“piDigits”,
    Integer.toString(numPiDigits));
}
```

htrace-core API Wrapper Classes

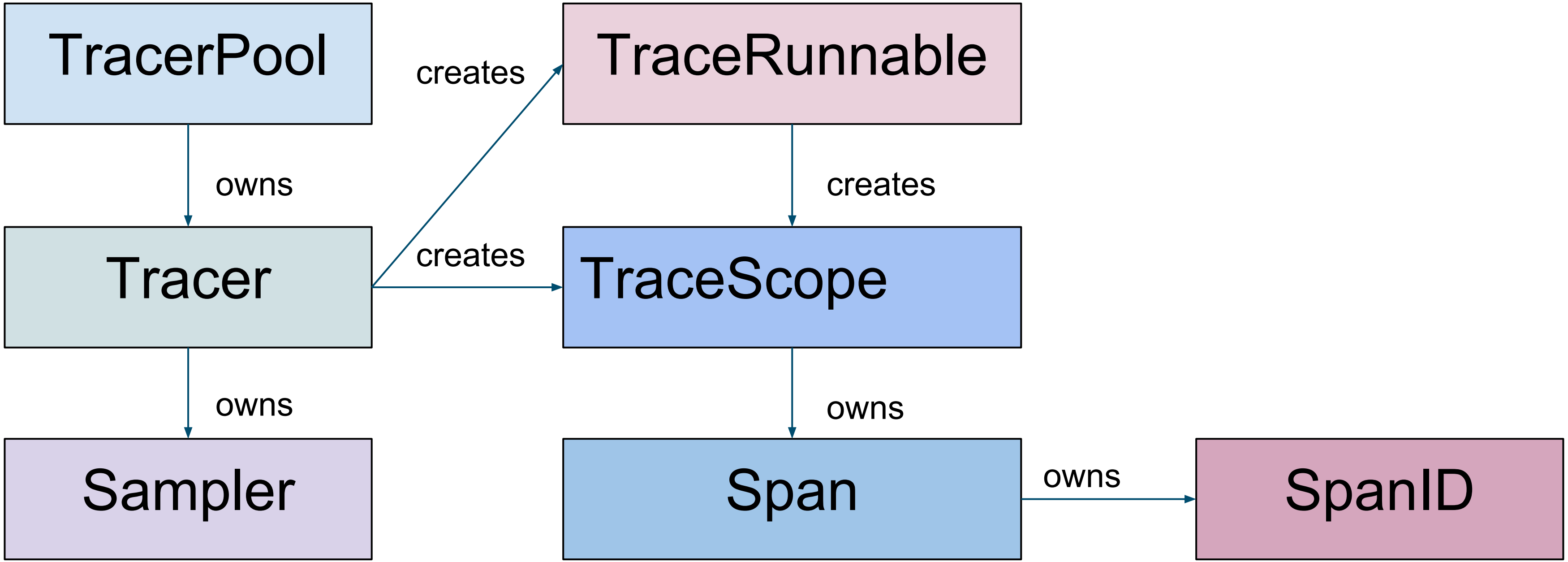
- Wrappers automatically create spans for work items
  - TraceRunnable
  - TracerCallable
  - TraceExecutorService

```
Runnable myRunnable =
  tracer.wrap(myPiRunnable, “calculatePi”);
```

htrace-core API Internal Classes

- Sampler
  - Determines which requests to trace
- TracerID
  - Represents the span ID of a trace
- TracerPool
  - Used to manage a group of Tracers
  - Usually the default TracerPool is fine

htrace-core API Internal Classes



Configuring HTrace

- Determine which SpanReceiver to use
- Set up configuration
- Run htraced or other daemons if needed

Configuring HTrace in Hadoop

- Add htrace-htraced.jar to **CLASSPATH** (or whichever SpanReceiver is being used)
- Set up **hadoop.htrace.span.receiver.classes** and other HTrace configuration keys
- Set up htraced
- More instructions at

HTrace Community

- Vibrant upstream community
  - HTrace is an Apache open source Project
  - Contributors from NTT Data, Cloudera, Hortonworks, Facebook, and others
  - Two releases in the last few months-- 4.0 and 4.0.1

HTrace Community

- Sharing ideas with other big data projects
  - Hadoop
  - HBase
  - OpenTracing
  - XTrace
  - Twitter Zipkin

Recent Work in HTrace

- More effective error checking in the htrace client
- Optimized RPC format for sending spans to htraced
- Better integration with HDFS
- New web GUI for visualizing spans
- Trace spans are now tagged with IP address or hostname
- Span IDs extended to 128 bits to avoid collisions

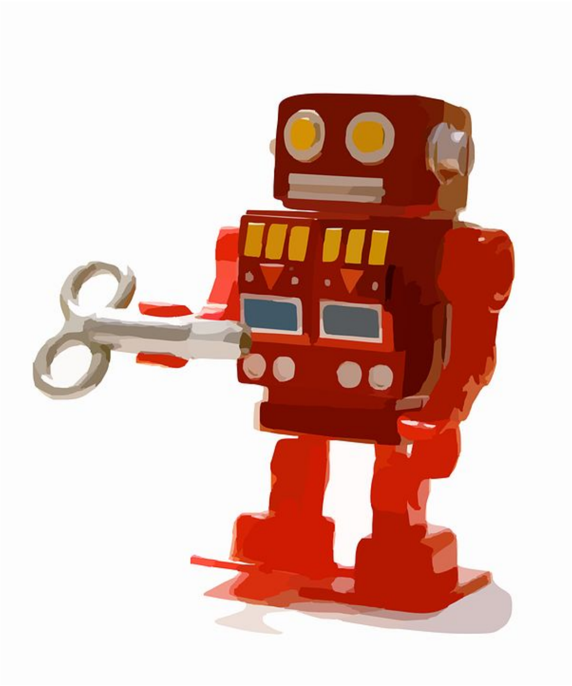
HTrace in Cloudera's Distribution of Hadoop

- Available as a Cloudera Labs "beta" for CDH5.5 and later
- HDFS tracing is supported
- RPMs and debs are available for htraced
- See http://blog.cloudera.com/blog/2015/12/new-in-cloudera-labs-apache-htrace-incubating/

Planned

- Improve the HTrace integration in HBase
- Add more annotations to Hadoop span data to get more insight
- Support more SpanReceivers
- Better integration with cluster management systems
- Improve and test C and C++ support
- Create an aggregate view for spans

HTrace Demo



HTrace Q & A