# Elasticsearch

## Securing a search engine while maintaining usability

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# Elasticsearch in 10 seconds

- Search Engine (FTS, Analytics, Geo), real-time
- Distributed, scalable, highly available, resilient
- Interface: HTTP & JSON
- Centrepiece of the Elastic Stack (Kibana, Logstash, Beats, APM, ML, Swiftype)
- Uneducated guess: Tens of thousands of clusters worldwide, hundreds of thousands of instances

# Agenda

- Security: Feature or non-functional requirement?
- Security Manager
- Production Mode vs. Development Mode
- Plugins
- Scripting language: Painless

# Security

## Feature or non-functional requirement?

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# Security as a non-functional requirement

- Software has to be secure! O RLY?
- Defensive programming
- Do not persist specific data (PCI DSS)
- Not exploitable (pro tip: not gonna happen)
- No unintended resource access (directory trave
- Least privilege principle
- Reduced impact surface (DoS)

Security

## Dishwasher has directory traversal bug

Thanks a Miele-on for making everything dangerous, Internet of Things firmware slackers

By Richard Chirgwin 26 Mar 2017 at 23:08 192 SHARE ▼

Don't say you weren't warned: Miele went full Internet-of-Things with a network-connected dishwasher, gave it a web server, and now finds itself on the wrong end of a security bug report – *and* it's accused of ignoring the warning.

The utterly predictable vulnerability advisory on the Full Disclosure mailing list details CVE-2017-7240 – aka "Miele Professional PG 8528 - Web Server Directory Traversal." This is the builtin web server that's used to remotely control the glassware-cleaning machine from a browser.

https://www.theregister.co.uk/2017/03/26/miele_joins_internetofst_hall_of_shame/

# Security as a feature

- Authentication
- Authorization (LDAP, users, PKI)
- TLS transport encryption
- Audit logging
- SSO/SAML/Kerberos

# Security or resiliency?

- Integrity checks
- Preventing OOMEs
- Prevent deep pagination
- Do not expose credentials in cluster state/REST APISs
- Stop writing data before running out of disk space
- Unable to call `System.exit`

„[T]HERE ARE KNOWN KNOWNS; THERE ARE THINGS WE KNOW WE KNOW. WE ALSO KNOW THERE ARE KNOWN UNKNOWNS; THAT IS TO SAY WE KNOW THERE ARE SOME THINGS WE DO NOT KNOW. BUT THERE ARE ALSO UNKNOWN UNKNOWNS – THERE ARE THINGS WE DO NOT KNOW WE DON'T KNOW.“

Donald Rumsfeld, ~~former secretary of defense~~, IT Security Expert

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# Security Manager

**Have you ever called `System.setSecurityManager()`?**

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# Introduction

- Sandbox your java application
- Prevent certain calls by your application
- Policy file grants permissions
  - `FilePermission` (read, write)
  - `SocketPermission` (connect, listen, accept)
  - `URLPermission`, `PropertyPermission`, ...

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# DEMO

# OHAI JLS

### 17.5.3. Subsequent Modification of `final` Fields

In some cases, such as deserialization, the system will need to change the `final` fields of an object after construction. `final` fields can be changed via reflection and other implementation-dependent means. The only pattern in which this has reasonable semantics is one in which an object is constructed and then the `final` fields of the object are updated. The object should not be made visible to other threads, nor should the `final` fields be read, until all updates to the `final` fields of the object are complete. Freezes of a `final` field occur both at the end of the constructor in which the `final` field is set, and immediately after each modification of a `final` field via reflection or other special mechanism.

https://docs.oracle.com/javase/specs/jls/se11/html/jls-17.html#jls-17.5.3

# Drawbacks

- Hardcoded policies before startup
- DNS lookups are cached forever by default
- Forces you to think about dependencies!
- Many libraries are not even tested with the security manager, unknown code paths may be executed
- No OOM protection! No stack overflow protection!
- Granularity
- No protection against java agents

# Production mode vs Development mode

**Annoying you now instead of devastating you later**

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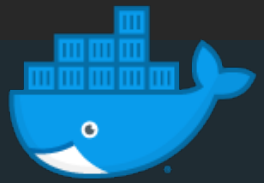
# Is your dev setup equivalent to production?

- Development environments are rarely setup like production ones
- How to ensure certain preconditions in production but not for development?
- What is a good indicator?

# Mode check

```
/**
 * Tests if the checks should be enforced.
 *
 * @param boundTransportAddress the node network bindings
 * @param discoveryType the discovery type
 * @return {@code true} if the checks should be enforced
 */
static boolean enforceLimits(final BoundTransportAddress boundTransportAddress, final String discoveryType) {
    final Predicate<TransportAddress> isLoopbackAddress = t -> t.address().getAddress().isLoopbackAddress();
    final boolean bound =
            !(Arrays.stream(boundTransportAddress.boundAddresses()).allMatch(isLoopbackAddress) &&
            isLoopbackAddress.test(boundTransportAddress.publishAddress()));
    return bound && !"single-node".equals(discoveryType);
}
```



# Bootstrap checks

```
// the list of checks to execute
static List<BootstrapCheck> checks() {
    final List<BootstrapCheck> checks = new ArrayList<>();
    checks.add(new HeapSizeCheck());
    final FileDescriptorCheck fileDescriptorCheck
        = Constants.MAC_OS_X ? new OsXFileDescriptorCheck()
    checks.add(fileDescriptorCheck);
    checks.add(new MlockallCheck());
    if (Constants.LINUX) {
        checks.add(new MaxNumberOfThreadsCheck());
    }
    if (Constants.LINUX || Constants.MAC_OS_X) {
        checks.add(new MaxSizeVirtualMemoryCheck());
    }
    if (Constants.LINUX || Constants.MAC_OS_X) {
        checks.add(new MaxFileSizeCheck());
    }
    checks.add(new ClientJvmCheck());
    checks.add(new UseSerialGCCheck());
    checks.add(new SystemCallFilterCheck());
    checks.add(new OnErrorCheck());
    checks.add(new OnOutOfMemoryErrorCheck());
    checks.add(new EarlyAccessCheck());
    checks.add(new G1GCCheck());
    checks.add(new AllPermissionCheck());
    return Collections.unmodifiableList(checks);
}
```

# Reducing impact

## Bad things have less bad results

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# Reducing impact

- Least privilege principle
- Do not run as root
- No chance of forking a process
- Do not expose sensitive settings
- Security Manager

# Do not run as root

```
/** Returns true if user is root, false if not, or if we don't know */
static boolean definitelyRunningAsRoot() {
    if (Constants.WINDOWS) {
        return false; // don't know
    }
    try {
        return JNACLibrary.geteuid() == 0;
    } catch (UnsatisfiedLinkError e) {
        // this will have already been logged by Kernel32Library, no need to repeat it
        return false;
    }
}
```

```
// check if the user is running as root, and bail
if (Natives.definitelyRunningAsRoot()) {
    throw new RuntimeException("can not run elasticsearch as root");
}
```

# Seccomp - prevent process forks

- Security manager could fail
- Elasticsearch should still not be able to fork processes
- One way transition to tell the operating system to deny `execve`, `fork`, `vfork`, `execveat` system calls
- Works on Linux, Windows, Solaris, BSD, osx

# Mark sensitive settings

```java
/**
 * Username for basic auth.
 */
public static final Setting.AffixSetting<String> AUTH_USERNAME_SETTING =
        Setting.affixKeySetting( prefix: "xpack.monitoring.exporters.", suffix: "auth.username",
                (key) -> Setting.simpleString(key, Property.Dynamic, Property.NodeScope, Property.Filtered));
/**
 * Password for basic auth.
 */
public static final Setting.AffixSetting<String> AUTH_PASSWORD_SETTING =
        Setting.affixKeySetting( prefix: "xpack.monitoring.exporters.", suffix: "auth.password",
                (key) -> Setting.simpleString(key, Property.Dynamic, Property.NodeScope, Property.Filtered));
```

```java
private static final Setting.AffixSetting<SecureString> SETTING_URL_SECURE =
        Setting.affixKeySetting( prefix: "xpack.notification.slack.account.", suffix: "secure_url",
            (key) -> SecureSetting.secureString(key, fallback: null));
```

# Register all your settings

```
stacks/7.1.1/elasticsearch-7.1.1 bin/elasticsearch -Ecluster.namr=my-cluster
```

```
[2019-06-21T10:42:56,943][WARN ][o.e.b.ElasticsearchUncaughtExceptionHandler] [rhincodon] uncaught exception in thread [main]
org.elasticsearch.bootstrap.StartupException: java.lang.IllegalArgumentException: unknown setting [cluster.namr] did you mean [cluster.name]?
        at org.elasticsearch.bootstrap.Elasticsearch.init(Elasticsearch.java:163) ~[elasticsearch-7.1.1.jar:7.1.1]
        at org.elasticsearch.bootstrap.Elasticsearch.execute(Elasticsearch.java:150) ~[elasticsearch-7.1.1.jar:7.1.1]
        at org.elasticsearch.cli.EnvironmentAwareCommand.execute(EnvironmentAwareCommand.java:86) ~[elasticsearch-7.1.1.jar:7.1.1]
```

```
unknown setting [cluster.namr] did you mean [cluster.name]?
```

# Security Manager in Elasticsearch

- Initialization required before starting security manager
- Elasticsearch needs to read its configuration file first to find out about the file paths
- Native code needs to be executed first
- Solution: Start with empty security manager, bootstrap, apply secure security manager

# Security Manager in Elasticsearch

- Special security manager is used
- Does not set `exitVM` permissions, only a few special classes are allowed to call
- Thread & ThreadGroup security is enforced
- Also **`SpecialPermission`** was added, a special marker permission to prevent elevation by scripts

# Security Manager in Elasticsearch

- `ESPolicy` allows for loading from files plus dynamic configuration (from the ES configuration file)
- Bootstrap check for `java.security.AllPermission`

# Plugins

... remaining secure

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# Plugins in 60 seconds

- plugins are just zip files
- each plugin can have its own jars/dependencies
- each plugin is loaded with its own classloader
- each plugin can have its own security permissions
- ES core loads a bunch of code as modules (plugins that ship with Elasticsearch)

# Sample permissions

```
grant {
  // needed to do crazy reflection
  permission java.lang.RuntimePermission "accessDeclaredMembers";
};
```

# Sample permissions

```
grant {
  // needed to generate runtime classes
  permission java.lang.RuntimePermission "createClassLoader";

  // expression runtime
  permission org.elasticsearch.script.ClassPermission "java.lang.String";
  permission org.elasticsearch.script.ClassPermission "org.apache.lucene.expressions.Expression";
  permission org.elasticsearch.script.ClassPermission "org.apache.lucene.search.DoubleValues";
  // available functions
  permission org.elasticsearch.script.ClassPermission "java.lang.Math";
  permission org.elasticsearch.script.ClassPermission "org.apache.lucene.util.MathUtil";
  permission org.elasticsearch.script.ClassPermission "org.apache.lucene.util.SloppyMath";
};
```

# Sample permissions

```
grant codeBase "${codebase.netty-common}" {
   // for reading the system-wide configuration for the backlog of established sockets
   permission java.io.FilePermission "/proc/sys/net/core/somaxconn", "read";

   // netty makes and accepts socket connections
   permission java.net.SocketPermission "*", "accept,connect";
};

grant codeBase "${codebase.netty-transport}" {
   // Netty NioEventLoop wants to change this, because of https://bugs.openjdk.java.net/browse/JDK-6427854
   // the bug says it only happened rarely, and that its fixed, but apparently it still happens rarely!
   permission java.util.PropertyPermission "sun.nio.ch.bugLevel", "write";
};
```

# Introducing Painless

## A scripting language for Elasticsearch

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# Scripting: Why and how?

- Expression evaluation without needing to write java extensions for Elasticsearch

- Node ingest script processor
- Search queries (dynamic requests & fields)
- Aggregations (dynamic buckets)
- Templating (Mustache)

# Scripting in Elasticsearch

- MVEL
- Groovy
- Expressions
- Painless

# Painless - a secure scripting language

- Hard to take an existing programming language and make it secure, but remain fast
- Sandboxing
- Whitelisting over blacklisting, per method
- Opt-in to regular expressions
- Prevent endless loops
- Detect self references to prevent stack overflows

# Summary

**Security is hard - let's go shopping!**

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# Summary

- Not using the Security Manager - what's your excuse?
- Scripting is important, is your implementation secure?
- Use operating system features!
- If you allow for plugins, remain secure!
- If you remove features, have alternatives!

# Thanks for listening!

## Questions?

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# Resources

- https://github.com/elastic/elasticsearch/
- https://www.elastic.co/blog/bootstrap_checks_annoying_instead_of_devastating
- https://www.elastic.co/blog/scripting
- https://www.elastic.co/blog/scripting-security
- https://docs.oracle.com/javase/9/security/toc.htm
- https://docs.oracle.com/javase/9/security/permissions-java-development-kit.htm

# Bonus

## deep pagination vs search_after

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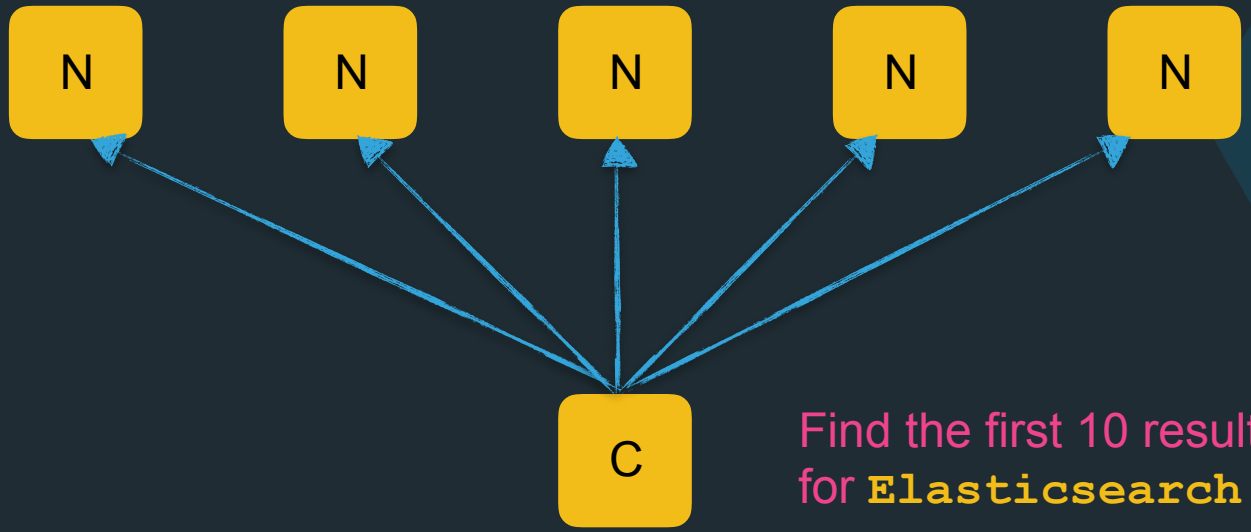
# Pagination: Request


Find the first 10 results for `Elasticsearch`

# Pagination: Request

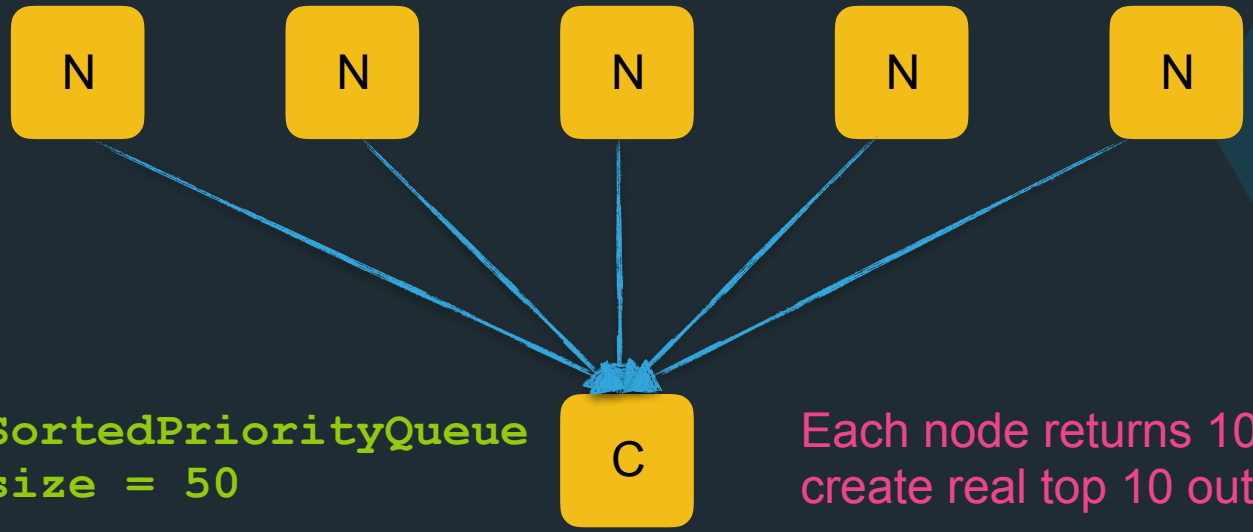

Find the first 10 results for `Elasticsearch`

# Pagination: Request




Find the first 10 results for `Elasticsearch`

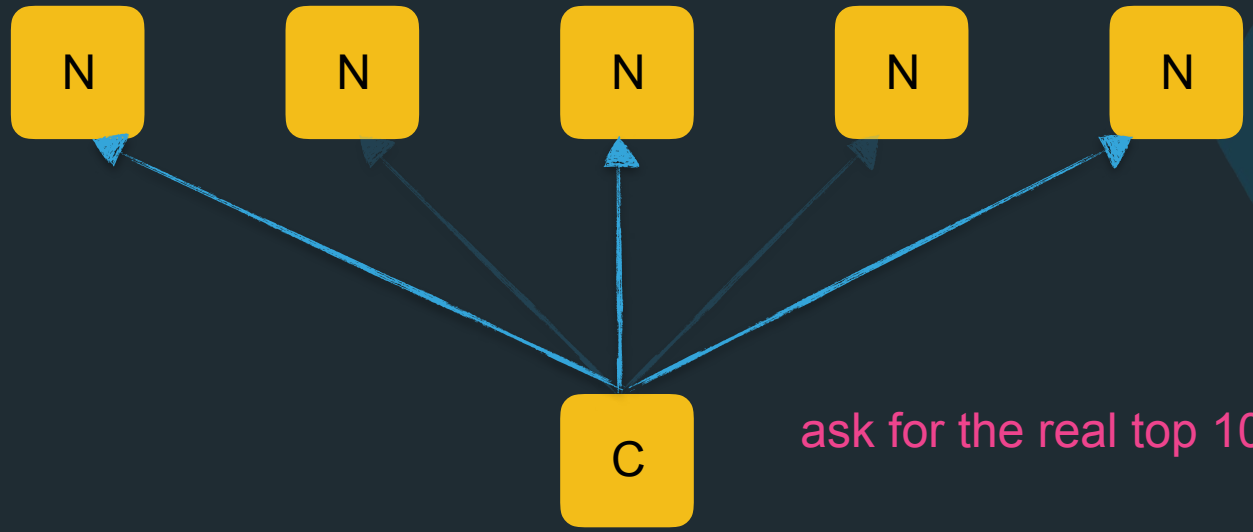
# Pagination: Query Phase



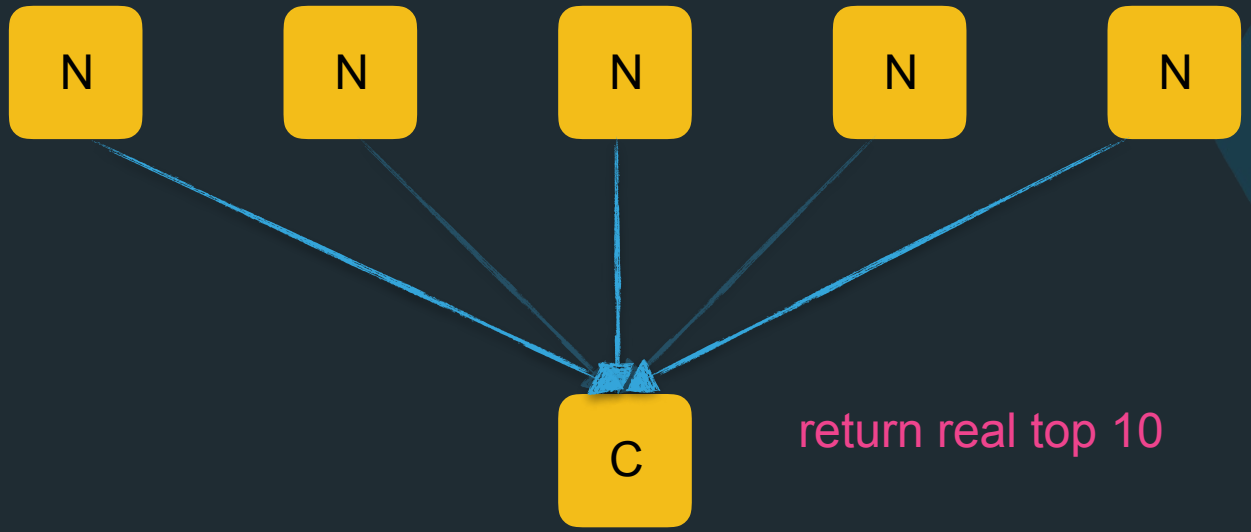

`SortedPriorityQueue`
`size = 50`

Each node returns 10 results,
create real top 10 out of 50

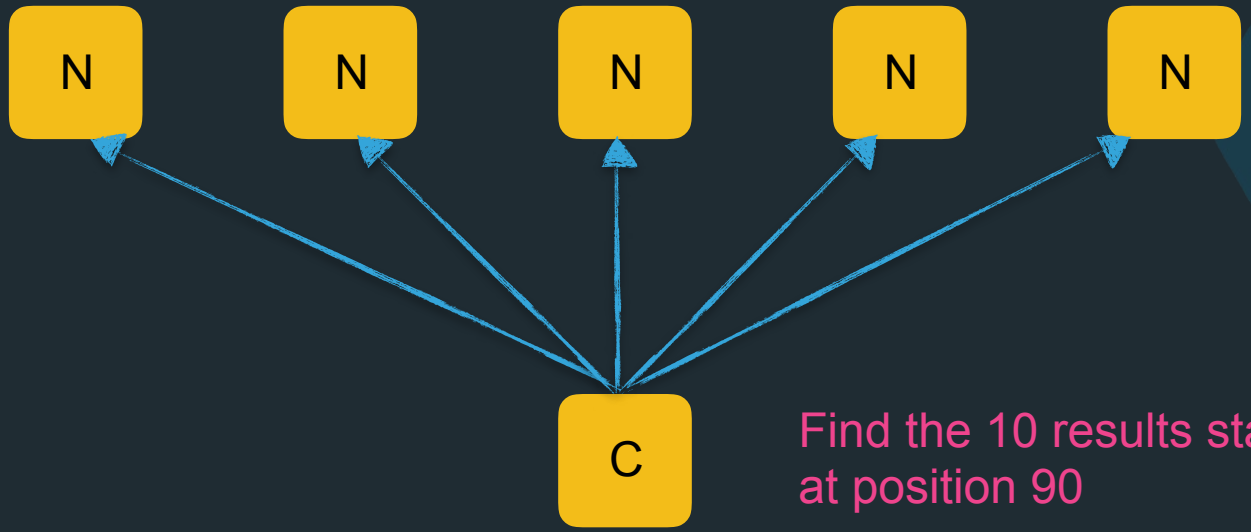
# Pagination: Fetch phase



# Pagination: Query Phase

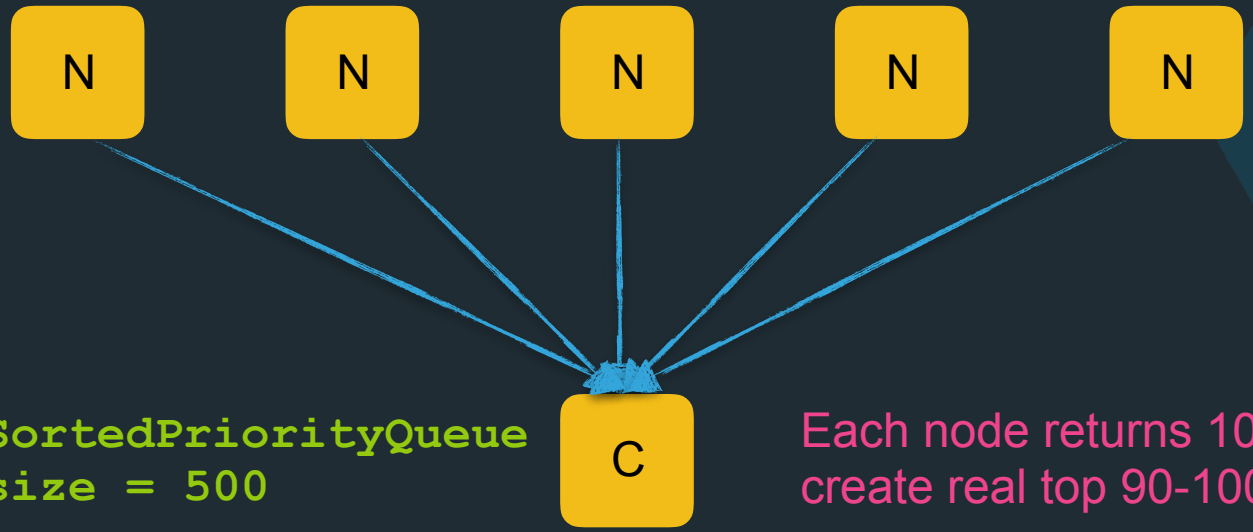


# Pagination: Query




Find the 10 results starting at position 90

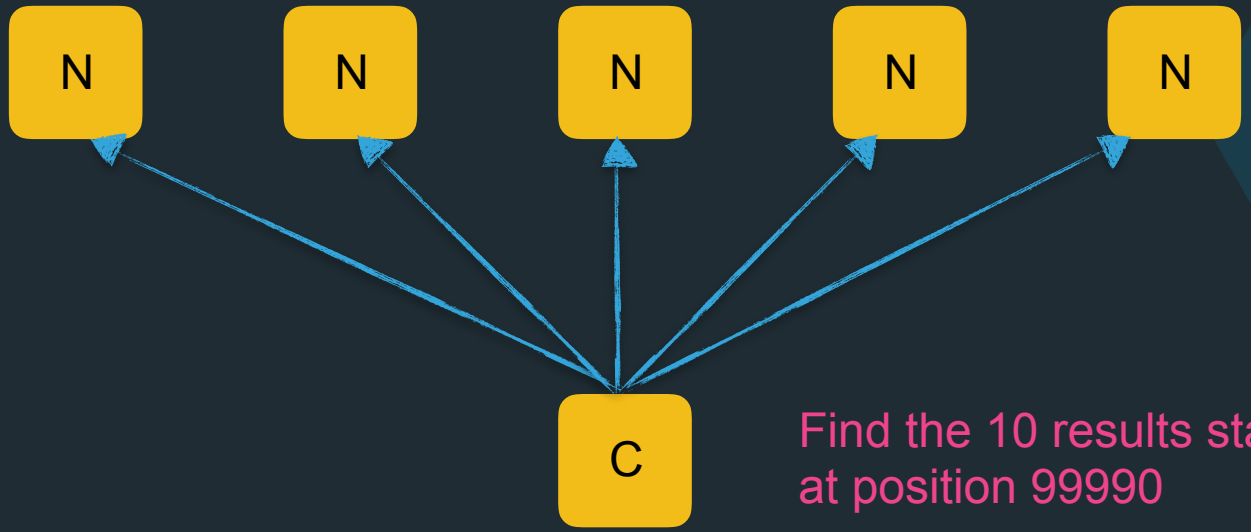
# Pagination: Query Phase




`SortedPriorityQueue`
`size = 500`

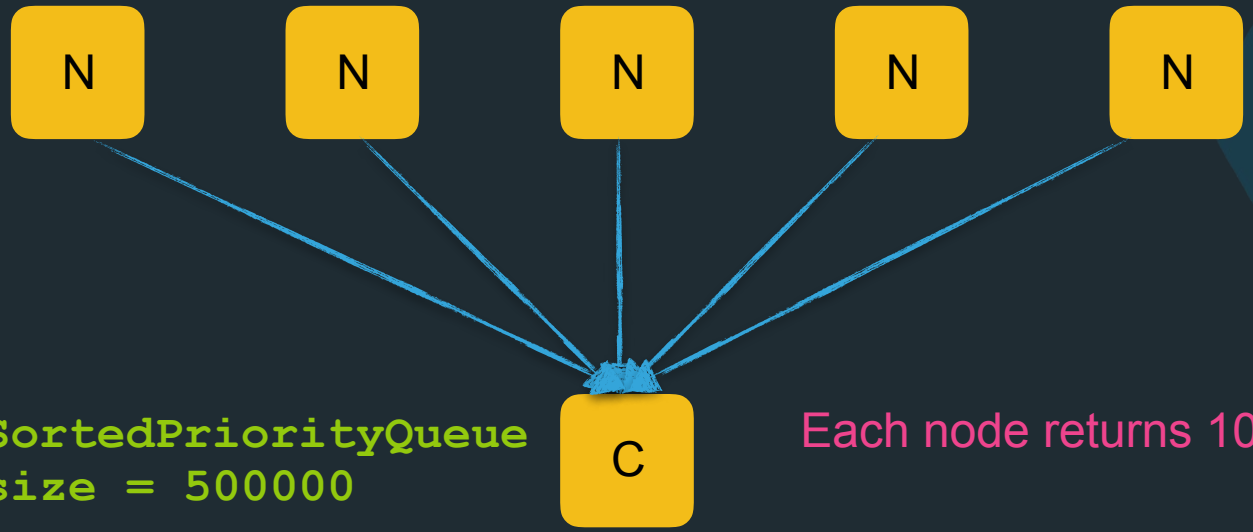
Each node returns 100 results,
create real top 90-100 out of 500

# Pagination: Query




Find the 10 results starting at position 99990

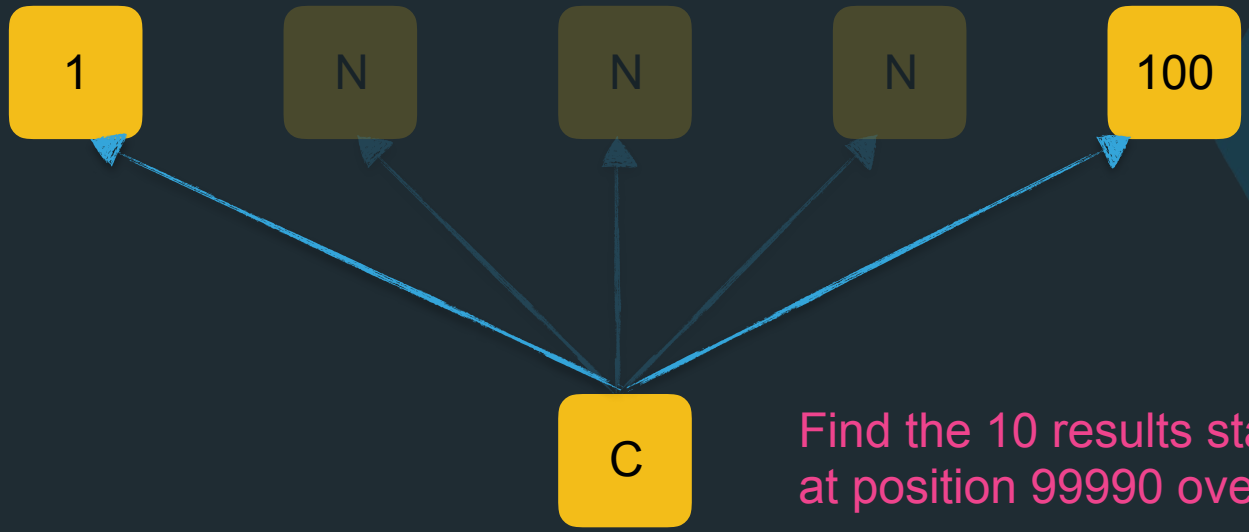
# Pagination: Query Phase




```
SortedPriorityQueue
size = 500000
```

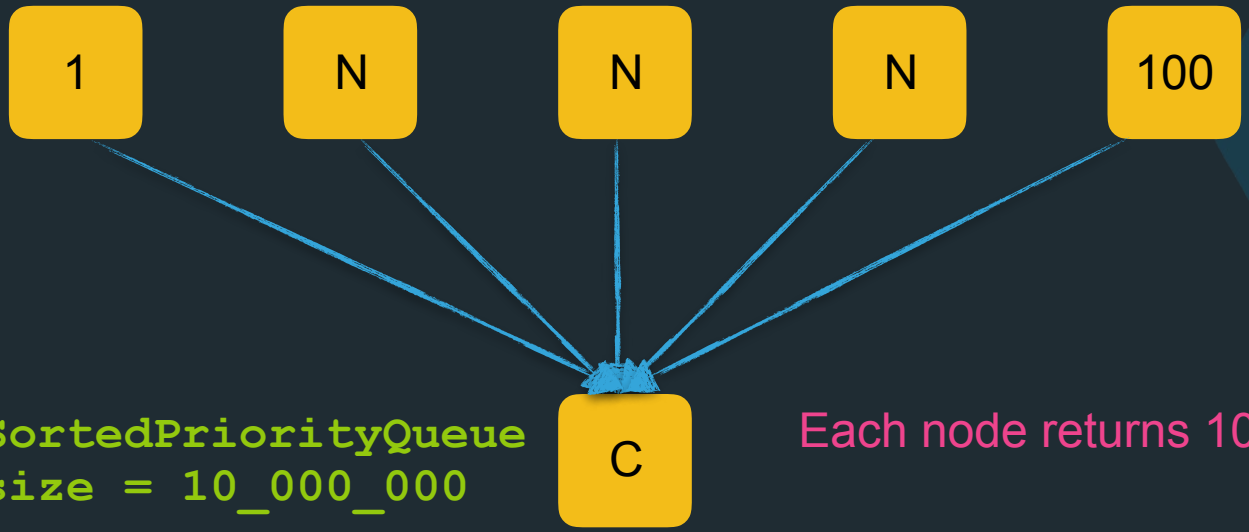
Each node returns 100k results

# Pagination: Query




Find the 10 results starting
at position 99990 over 100 nodes

# Pagination: Query



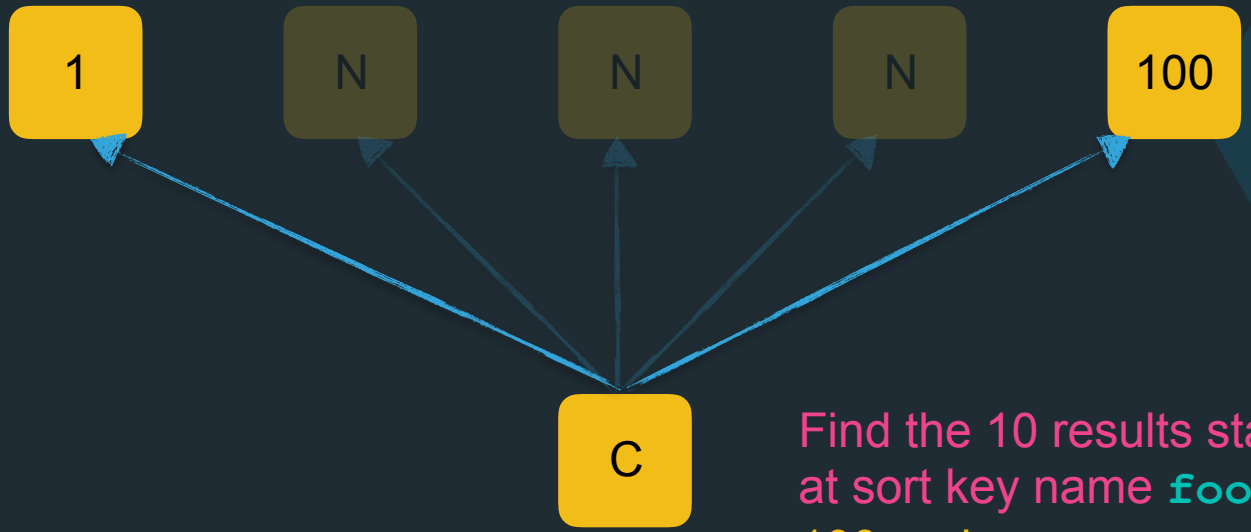

```
SortedPriorityQueue
size = 10_000_000
```

Each node returns 100k results

# Solution: search_after

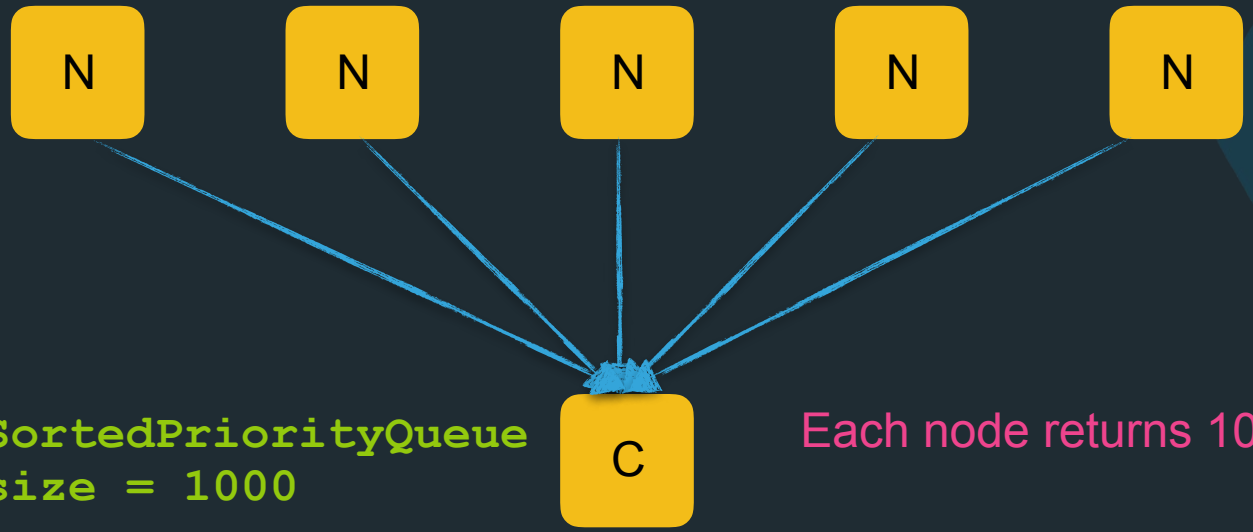
- Do not use numerical positions
- Use keys where you stopped in the inverted index
- Let the client tell you what the last key was
- Just specify the last sort value from the last document returned as a starting point

# Pagination: search_after




Find the 10 results starting at sort key name `foo` over 100 nodes

# Pagination: search_after




`SortedPriorityQueue`
`size = 1000`

Each node returns 10 results

# Bonus

## replacing delete by query

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# delete_by_query removal/replace

- `delete_by_query` API was not safe
- API endpoint was removed
- extensive documentation was added what to do instead
- infrastructure for long running background tasks was added
- `delete_by_query` was reintroduced using above infra and doing the exact same thing as in the documentation
- data > convenience!

# Thanks for listening!

## Questions?

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