Resilience mit Hystrix

Eine Einführung

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@ufried

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It’s all about production!

Production

Availability

Resilience

Fault Tolerance

re•sil•ience (rɪˈzɪl yəns) also **re•sil′ien•cy**, n.

1. the power or ability to return to the original form, position, etc., after being bent, compressed, or stretched; elasticity.
2. ability to recover readily from illness, depression, adversity, or the like; buoyancy.

http://www.thefreedictionary.com/resilience

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What is Hystrix?

In a distributed environment, failure of any given service is inevitable. Hystrix is a library designed to control the interactions between these distributed services providing greater latency and fault tolerance. Hystrix does this by isolating points of access between the services, stopping cascading failures across them, and providing fallback options, all of which improve the system's overall resiliency.

Hystrix evolved out of resilience engineering work that the Netflix API team began in 2011. Over the course of 2012, Hystrix continued to evolve and mature, eventually leading to adoption

Implemented patterns

- Timeout
- Circuit breaker
- Load shedder

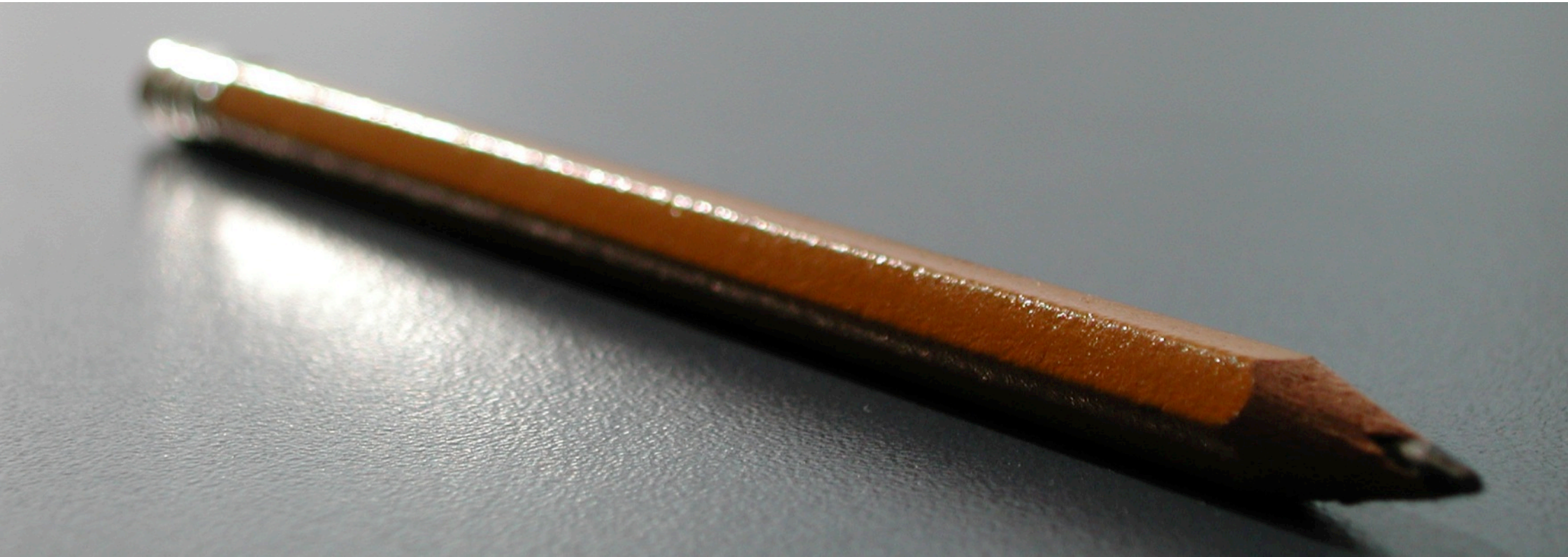
Supported patterns

- Bulkheads
  (a.k.a. Failure Units)
- Fail fast
- Fail silently
- Graceful degradation of service
- Failover
- Escalation
- Retry
- …

That's been enough theory

Give us some code – now!

Basics



Hello, world!

```
public class HelloCommand extends HystrixCommand<String> {
    private static final String COMMAND_GROUP = "default";
    private final String name;

    public HelloCommand(String name) {
        super(HystrixCommandGroupKey.Factory.asKey(COMMAND_GROUP));
        this.name = name;
    }

    @Override
    protected String run() throws Exception {
        return "Hello, " + name;
    }
}
```

```
@Test
public void shouldGreetWorld() {
    String result = new HelloCommand("World").execute();
    assertEquals("Hello, World", result);
}
```

Synchronous execution

```
@Test
public void shouldExecuteSynchronously() {
    String s = new HelloCommand("Bob").execute();
    assertEquals("Hello, Bob", s);
}
```

Asynchronous execution

```
@Test
public void shouldExecuteAsynchronously() {
    Future<String> f = new HelloCommand("Alice").queue();

    String s = null;
    try {
        s = f.get();
    } catch (InterruptedException | ExecutionException e) {
        // Handle Future.get() exceptions here
    }

    assertEquals("Hello, Alice", s);
}
```

Reactive execution (simple)

```
@Test
public void shouldExecuteReactiveSimple() {
    Observable<String> observable =
        new HelloCommand("Alice").observe();
    String s = observable.toBlockingObservable().single();

    assertEquals("Hello, Alice", s);
}
```

Reactive execution (full)

```
public class CommandHelloObserver implements Observer<String> {
    // Needed for communication between observer and test case
    private final AtomicReference<String> aRef;
    private final Semaphore semaphore;

    public CommandHelloObserver(AtomicReference<String> aRef,
                                Semaphore semaphore) {
        this.aRef = aRef;
        this.semaphore = semaphore;
    }

    @Override
    public void onCompleted() { // Not needed here }

    @Override
    public void onError(Throwable e) { // Not needed here }

    @Override
    public void onNext(String s) {
        aRef.set(s);
        semaphore.release();
    }
}
```

```
@Test
public void shouldExecuteReactiveFull() {
    // Needed for communication between observer and test case
    AtomicReference<String> aRef = new AtomicReference<>();
    Semaphore semaphore = new Semaphore(0);

    Observable<String> observable = new HelloCommand("Bob").observe();
    Observer<String> observer =
        new CommandHelloObserver(aRef, semaphore);
    observable.subscribe(observer);

    // Wait until observer received a result
    try {
        semaphore.acquire();
    } catch (InterruptedException e) {
        // Handle exceptions here
    }

    String s = aRef.get();
    assertEquals("Hello, Bob", s);
}
```

Fallback

```
public class FallbackCommand extends HystrixCommand<String> {
    private static final String COMMAND_GROUP = "default";

    public FallbackCommand() {
        super(HystrixCommandGroupKey.Factory.asKey(COMMAND_GROUP));
    }

    @Override
    protected String run() throws Exception {
        throw new RuntimeException("I will always fail");
    }

    @Override
    protected String getFallback() {
        return "Powered by fallback";
    }
}
```

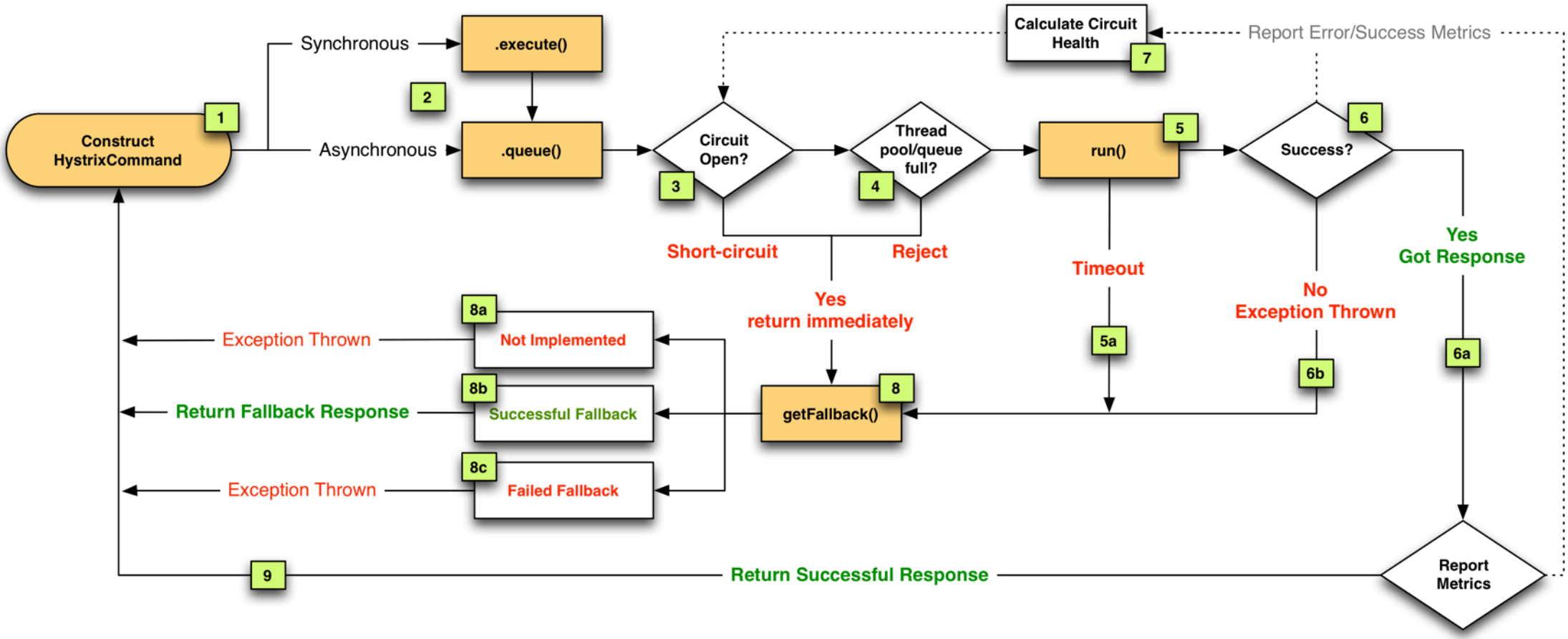
```
@Test
public void shouldGetFallbackResponse() {
    String s = new FallbackCommand().execute();
    assertEquals("Powered by fallback", s);
}
```

Error propagation

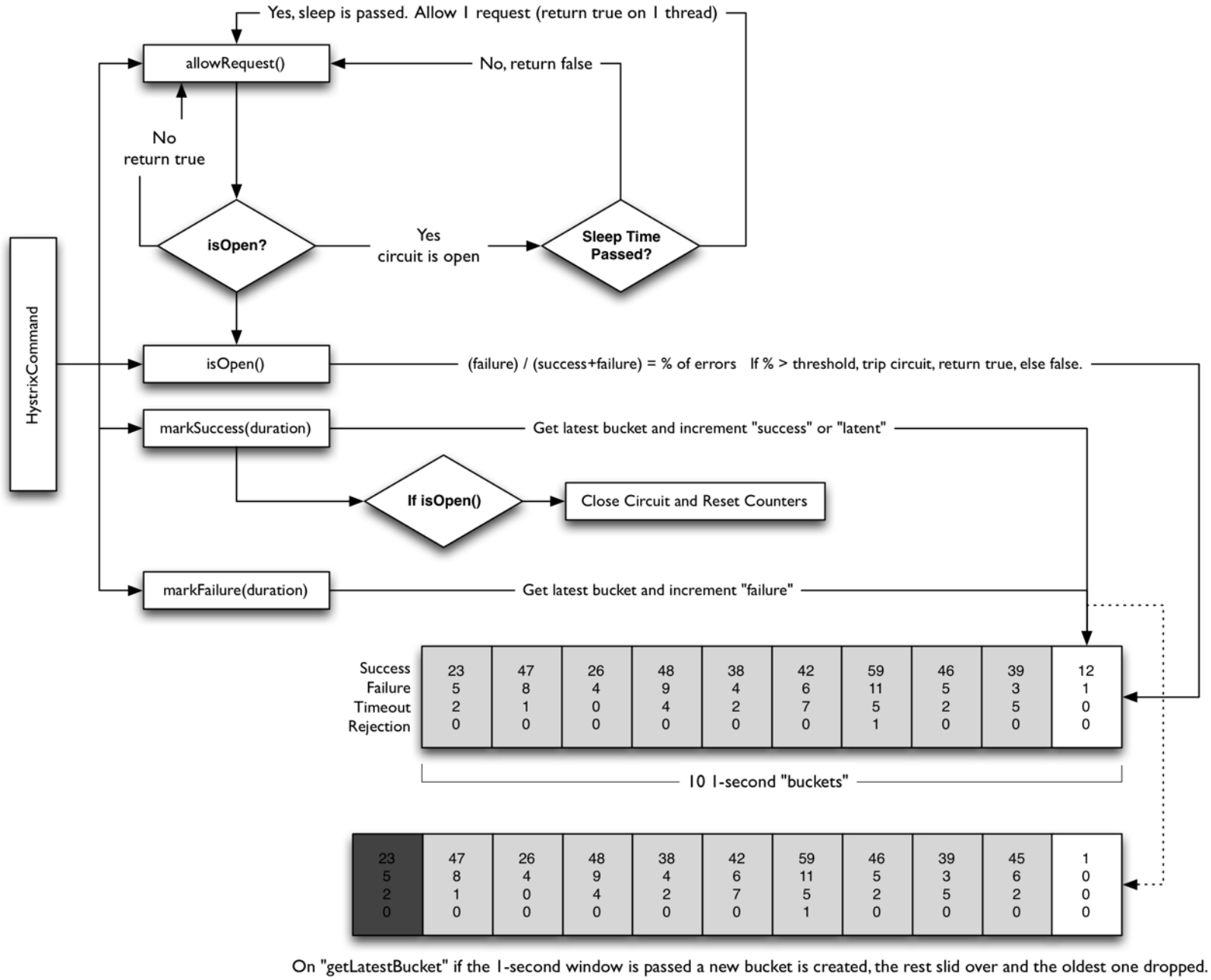
```
public class ErrorPropagationCommand extends HystrixCommand<String> {
    private static final String COMMAND_GROUP = "default";

    protected ErrorPropagationCommand() {
        super(HystrixCommandGroupKey.Factory.asKey(COMMAND_GROUP));
    }

    @Override
    protected String run() throws Exception {
        throw new HystrixBadRequestException("I fail differently",
                new RuntimeException("I will always fail"));
    }

    @Override
    protected String getFallback() {
        return "Powered by fallback";
    }
}
```

```
@Test
public void shouldGetFallbackResponse() {
    String s = null;
    try {
        s = new ErrorPropagationCommand().execute();
        fail();  // Just to make sure
    } catch (HystrixBadRequestException e) {
        assertEquals("I will fail differently", e.getMessage());
        assertEquals("I will always fail", e.getCause().getMessage());
    }
    assertNull(s);  // Fallback is not triggered
}
```

How it works



Source: https://github.com/Netflix/Hystrix/wiki/How-it-Works



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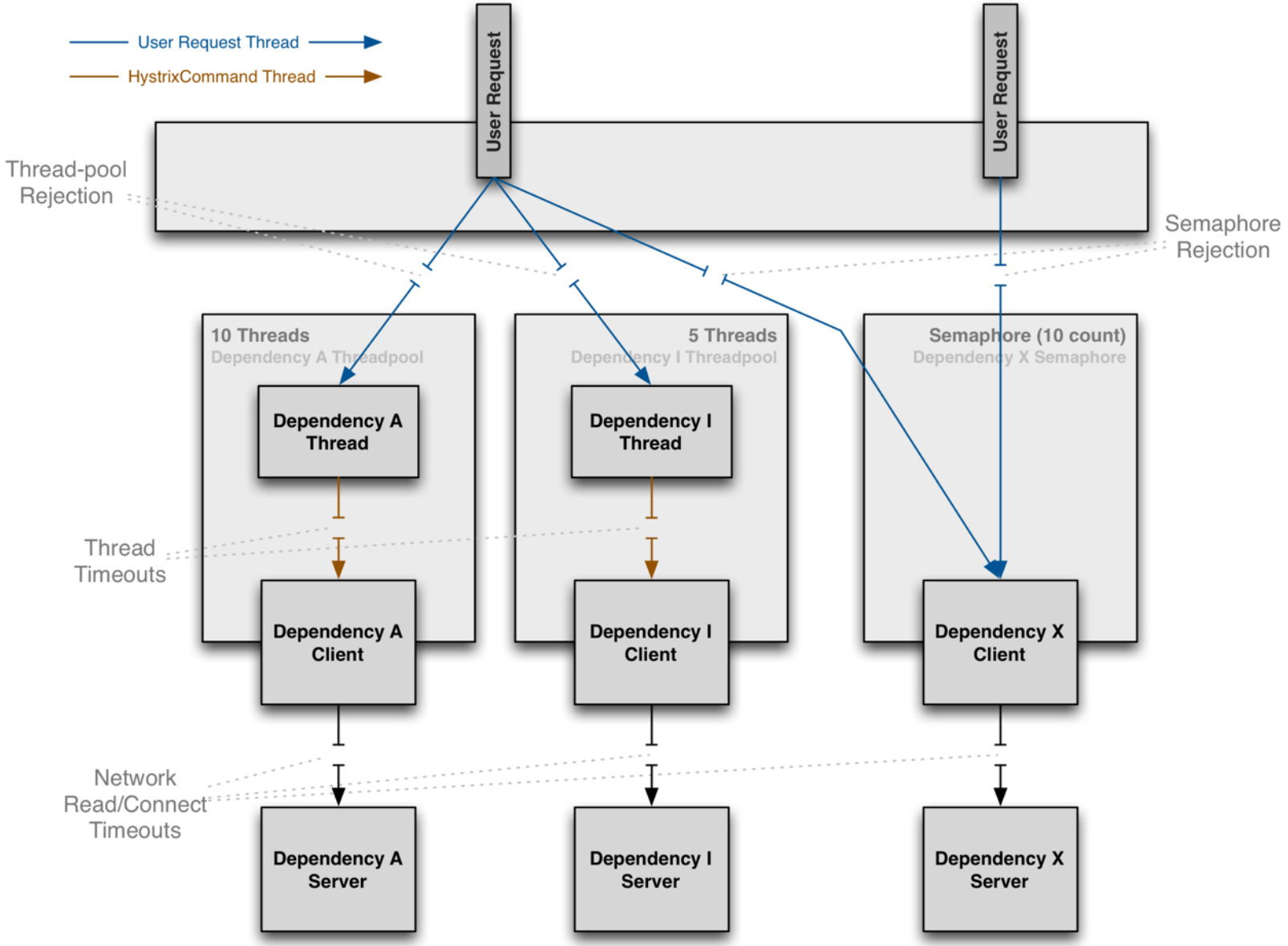


Source: https://github.com/Netflix/Hystrix/wiki/How-it-Works

Configuration

Configuration

- Based on Archaius by Netflix

  which extends the Apache Commons Configuration Library

- Four levels of precedence
  1. Global default from code
  2. Dynamic global default property
  3. Instance default from code
  4. Dynamic instance property

Provides many configuration & tuning options

Configuration – Some examples

- hystrix.command.*.execution.isolation.strategy

  Either "THREAD" or "SEMAPHORE" (Default: THREAD)

- hystrix.command.*.execution.isolation.thread.timeoutInMilliseconds

  Time to wait for the run() method to complete (Default: 1000)

- h.c.*.execution.isolation.semaphore.maxConcurrentRequests

  Maximum number of concurrent requests when using semaphores (Default: 10)

- hystrix.command.*.circuitBreaker.errorThresholdPercentage

  Error percentage at which the breaker trips open (Default: 50)

- hystrix.command.*.circuitBreaker.sleepWindowInMilliseconds

  Time to wait before attempting to reset the breaker after tripping (Default: 5000)

* must be either "default" or the command key name

Configuration – More examples

- hystrix.threadpool.*.coreSize

  Maximum number of concurrent requests when using thread pools (Default: 10)

- hystrix.threadpool.*.maxQueueSize

  Maximum LinkedBlockingQueue size - -1 for using SynchronousQueue (Default: -1)

- hystrix.threadpool.default.queueSizeRejectionThreshold

  Queue size rejection threshold (Default: 5)

… and many more

* must be either “default” or the thread pool key name

Patterns

Timeout

```
public class LatentResource {
    private final long latency;

    public LatentResource(long latency) {
        this.latency = ((latency < 0L) ? 0L : latency);
    }

    public String getData() {
        addLatency();  // This is the important part
        return "Some value”;
    }

    private void addLatency() {
        try {
            Thread.sleep(latency);
        } catch (InterruptedException e) {
            // We do not care about this here
        }
    }
}
```

```
public class TimeoutCommand extends HystrixCommand<String> {
    private static final String COMMAND_GROUP = "default";
    private final LatentResource resource;

    public TimeoutCommand(int timeout, LatentResource resource) {
        super(Setter.withGroupKey(
              HystrixCommandGroupKey.Factory.asKey(COMMAND_GROUP))
              .andCommandPropertiesDefaults(
              HystrixCommandProperties.Setter()
              .withExecutionIsolationThreadTimeoutInMilliseconds(
              timeout)));
        this.resource = resource;
    }

    @Override
    protected String run() throws Exception {
        return resource.getData();
    }

    @Override
    protected String getFallback() {
        return "Resource timed out";
    }
}
```

```
@Test
public void shouldGetNormalResponse() {
    LatentResource resource = new LatentResource(50L);
    TimeoutCommand command = new TimeoutCommand(100, resource);
    String s = command.execute();

    assertEquals("Some value", s);
}

@Test
public void shouldGetFallbackResponse() {
    LatentResource resource = new LatentResource(150L);
    TimeoutCommand command = new TimeoutCommand(100, resource);
    String s = command.execute();

    assertEquals("Resource timed out", s);
}
```

Circuit breaker

```
public class CircuitBreakerCommand extends HystrixCommand<String> {
    private static final String COMMAND_GROUP = "default";

    public CircuitBreakerCommand(String name, boolean open) {
        super(Setter.withGroupKey(
        HystrixCommandGroupKey.Factory.asKey(COMMAND_GROUP))
        .andCommandKey(HystrixCommandKey.Factory.asKey(name))
        .andCommandPropertiesDefaults(
        HystrixCommandProperties.Setter()
        .withCircuitBreakerForceOpen(open)));
    }

    @Override
    protected String run() throws Exception {
        return("Some result");
    }

    @Override
    protected String getFallback() {
        return "Fallback response";
    }
}
```

```
@Test
public void shouldExecuteWithCircuitBreakerClosed() {
    CircuitBreakerCommand command = new
        CircuitBreakerCommand("ClosedBreaker", false);

    String s = command.execute();
    assertEquals("Some result", s);

    HystrixCircuitBreaker breaker =
        HystrixCircuitBreaker.Factory
            .getInstance(command.getCommandKey());

    assertTrue(breaker.allowRequest());
}
```

```
@Test
public void shouldExecuteWithCircuitBreakerOpen() {
    CircuitBreakerCommand command = new
        CircuitBreakerCommand("OpenBreaker", true);

    String s = command.execute();
    assertEquals("Fallback response", s);

    HystrixCircuitBreaker breaker =
        HystrixCircuitBreaker.Factory
            .getInstance(command.getCommandKey());

    assertFalse(breaker.allowRequest());
}
```

Load shedder (Thread pool)

```
public class LatentCommand extends HystrixCommand<String> {
    private static final String COMMAND_GROUP = "default";

    private final LatentResource resource;

    public LatentCommand(LatentResource resource) {
        super(HystrixCommandGroupKey.Factory.asKey(COMMAND_GROUP));
        this.resource = resource;
    }

    @Override
    protected String run() throws Exception {
        return resource.getData();
    }

    @Override
    protected String getFallback() {
        return "Fallback triggered";
    }
}
```

```
@Test
public void shouldShedLoad() {
    List<Future<String>> l = new LinkedList<>();
    LatentResource resource = new LatentResource(500L); // Make latent

    // Use up all available threads
    for (int i = 0; i < 10; i++)
        l.add(new LatentCommand(resource).queue());

    // Call will be rejected as thread pool is exhausted
    String s = new LatentCommand(resource).execute();
    assertEquals("Fallback triggered", s);

    // All other calls succeed
    for (Future<String> f : l)
        assertEquals("Some value", get(f)); // wrapper for f.get()
}
```

Load shedder (Semaphore)

```
public class SemaphoreCommand extends HystrixCommand<String> {
    private static final String COMMAND_GROUP = "default";
    private final LatentResource resource;

    public SemaphoreCommand(LatentResource resource) {
        super(Setter.withGroupKey(
            HystrixCommandGroupKey.Factory.asKey(COMMAND_GROUP))
            .andCommandPropertiesDefaults(
            HystrixCommandProperties.Setter()
            .withExecutionIsolationStrategy(HystrixCommandProperties
                .ExecutionIsolationStrategy.SEMAPHORE)));
        this.resource = resource;
    }

    @Override
    protected String run() throws Exception {
        return resource.getData();
    }

    @Override
    protected String getFallback() {
        return "Fallback triggered";
    }
}
```

```
private class SemaphoreCommandInvocation implements
              java.util.concurrent.Callable<String> {
    private final LatentResource resource;

    public SemaphoreCommandInvocation(LatentResource resource) {
        this.resource = resource;
    }

    @Override
    public String call() throws Exception {
        return new SemaphoreCommand(resource).execute();
    }
}
```

```
@Test
public void shouldShedLoad() {
    List<Future<String>> l = new LinkedList<>();
    LatentResource resource = new LatentResource(500L); // Make latent

    ExecutorService e = Executors.newFixedThreadPool(10);

    // Use up all available semaphores
    for (int i = 0; i < 10; i++)
        l.add(e.submit(new SemaphoreCommandInvocation(resource)));

    // Wait a moment to make sure all commands are started
    pause(250L); // Wrapper around Thread.sleep()

    // Call will be rejected as all semaphores are in use
    String s = new SemaphoreCommand(resource).execute();
    assertEquals("Fallback triggered", s);

    // All other calls succeed
    for (Future<String> f : l)
        assertEquals("Some value", get(f));
}
```

Fail fast

```
public class FailFastCommand extends HystrixCommand<String> {
    private static final String COMMAND_GROUP = "default";

    private final boolean preCondition;

    public FailFastCommand(boolean preCondition) {
        super(HystrixCommandGroupKey.Factory.asKey(COMMAND_GROUP));
        this.preCondition = preCondition;
    }

    @Override
    protected String run() throws Exception {
        if (!preCondition)
            throw new RuntimeException(("Fail fast"));
        return "Some value";
    }
}
```

```
@Test
public void shouldSucceed() {
    FailFastCommand command = new FailFastCommand(true);
    String s = command.execute();

    assertEquals("Some value", s);
}

@Test
public void shouldFailFast() {
    FailFastCommand command = new FailFastCommand(false);
    try {
        String s = command.execute();
        fail("Did not fail fast");
    } catch (Exception e) {
        assertEquals(HystrixRuntimeException.class, e.getClass());
        assertEquals("Fail fast", e.getCause().getMessage());
    }
}
```

Fail silent

```
public class FailSilentCommand extends HystrixCommand<String> {
    private static final String COMMAND_GROUP = "default";

    private final boolean preCondition;

    public FailSilentCommand(boolean preCondition) {
        super(HystrixCommandGroupKey.Factory.asKey(COMMAND_GROUP));
        this.preCondition = preCondition;
    }

    @Override
    protected String run() throws Exception {
        if (!preCondition)
            throw new RuntimeException(("Fail fast"));
        return "Some value";
    }

    @Override
    protected String getFallback() {
        return null;  // Turn into silent failure
    }
}
```

```
@Test
public void shouldSucceed() {
    FailSilentCommand command = new FailSilentCommand(true);
    String s = command.execute();

    assertEquals("Some value", s);
}

@Test
public void shouldFailSilent() {
    FailSilentCommand command = new FailSilentCommand(false);
    String s = "Test value";
    try {
        s = command.execute();
    } catch (Exception e) {
        fail("Did not fail silent");
    }
    assertNull(s);
}
```

Static fallback

```
public class StaticFallbackCommand extends HystrixCommand<String> {
    private static final String COMMAND_GROUP = "default";

    private final boolean preCondition;

    public StaticFallbackCommand(boolean preCondition) {
        super(HystrixCommandGroupKey.Factory.asKey(COMMAND_GROUP));
        this.preCondition = preCondition;
    }

    @Override
    protected String run() throws Exception {
        if (!preCondition)
            throw new RuntimeException(("Fail fast"));
        return "Some value";
    }

    @Override
    protected String getFallback() {
        return "Some static fallback value";  // Static fallback
    }
}
```

```
@Test
public void shouldSucceed() {
    StaticFallbackCommand command = new StaticFallbackCommand(true);
    String s = command.execute();

    assertEquals("Some value", s);
}

@Test
public void shouldProvideStaticFallback() {
    StaticFallbackCommand command = new StaticFallbackCommand(false);
    String s = null;
    try {
        s = command.execute();
    } catch (Exception e) {
        fail("Did not fail silent");
    }
    assertEquals("Some static fallback value", s);
}
```

Cache fallback

```
public class CacheClient {
    private final Map<String, String> map;

    public CacheClient() {
        map = new ConcurrentHashMap<>();
    }

    public void add(String key, String value) {
        map.put(key, value);
    }

    public String get(String key) {
        return map.get(key);
    }
}
```

```
public class CacheCommand extends HystrixCommand<String> {
    private static final String COMMAND_GROUP = "primary";
    private final CacheClient cache;
    private final boolean failPrimary;
    private final String req;

    public CacheCommand(CacheClient cache, boolean failPrimary,
            String request) {
        super(HystrixCommandGroupKey.Factory.asKey(COMMAND_GROUP));
        this.cache = cache;
        this.failPrimary = failPrimary;
        this.req = request;
    }

    @Override
    protected String run() throws Exception {
        if (failPrimary)
            throw new RuntimeException("Failure of primary");
        String s = req + "-o";
        cache.add(req, s);
        return(s);
    }
…
```

```
…
    @Override
    protected String getFallback() {
        return "Cached: " + new FBCommand(cache, req).execute();
    }

    private static class FBCommand extends HystrixCommand<String> {
        private static final String COMMAND_GROUP = "fallback";
        private final CacheClient cache;
        private final String request;

        public FBCommand(CacheClient cache, String request) {
            super(HystrixCommandGroupKey.Factory.asKey(COMMAND_GROUP));
            this.cache = cache;
            this.request = request;
        }

        @Override
        protected String run() throws Exception {
            return cache.get(request);
        }
    }
}
```

```
@Test
public void shouldExecuteWithoutCache() {
    CacheClient cache = new CacheClient();
    String s = new CacheCommand(cache, false, "ping”).execute();
    assertEquals("ping-o", s);
}

@Test
public void shouldRetrieveValueFromCache() {
    CacheClient cache = new CacheClient();
    new CacheCommand(cache, false, "ping").execute();
    String s = new CacheCommand(cache, true, "ping”).execute();
    assertEquals("Cached: ping-o", s);
}

@Test
public void shouldNotRetrieveAnyValue() {
    CacheClient cache = new CacheClient();
    String s = new CacheCommand(cache, true, "ping”).execute();
    assertEquals("Cached: null", s);
}
```

… and so on

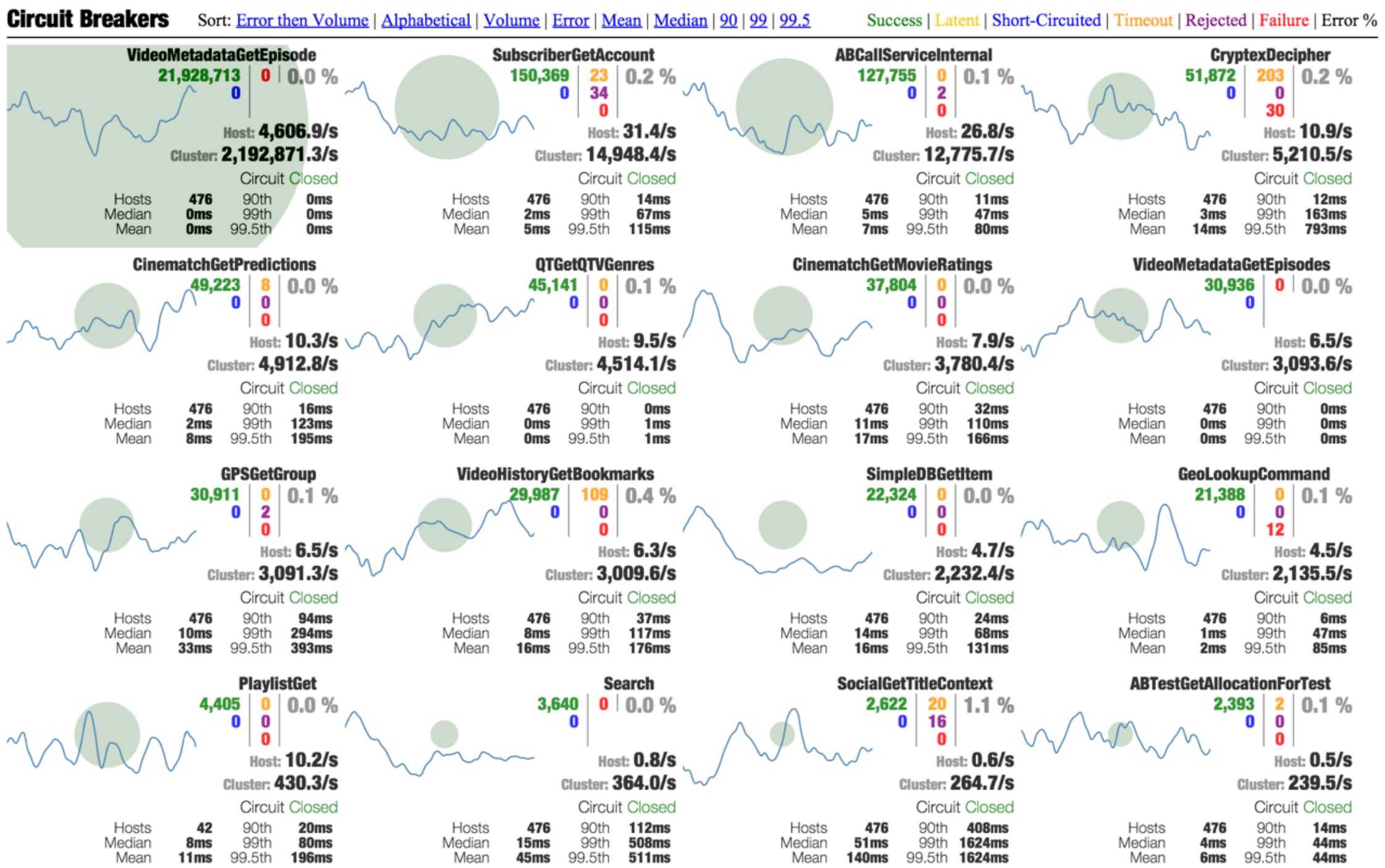
Advanced features

Advanced Features

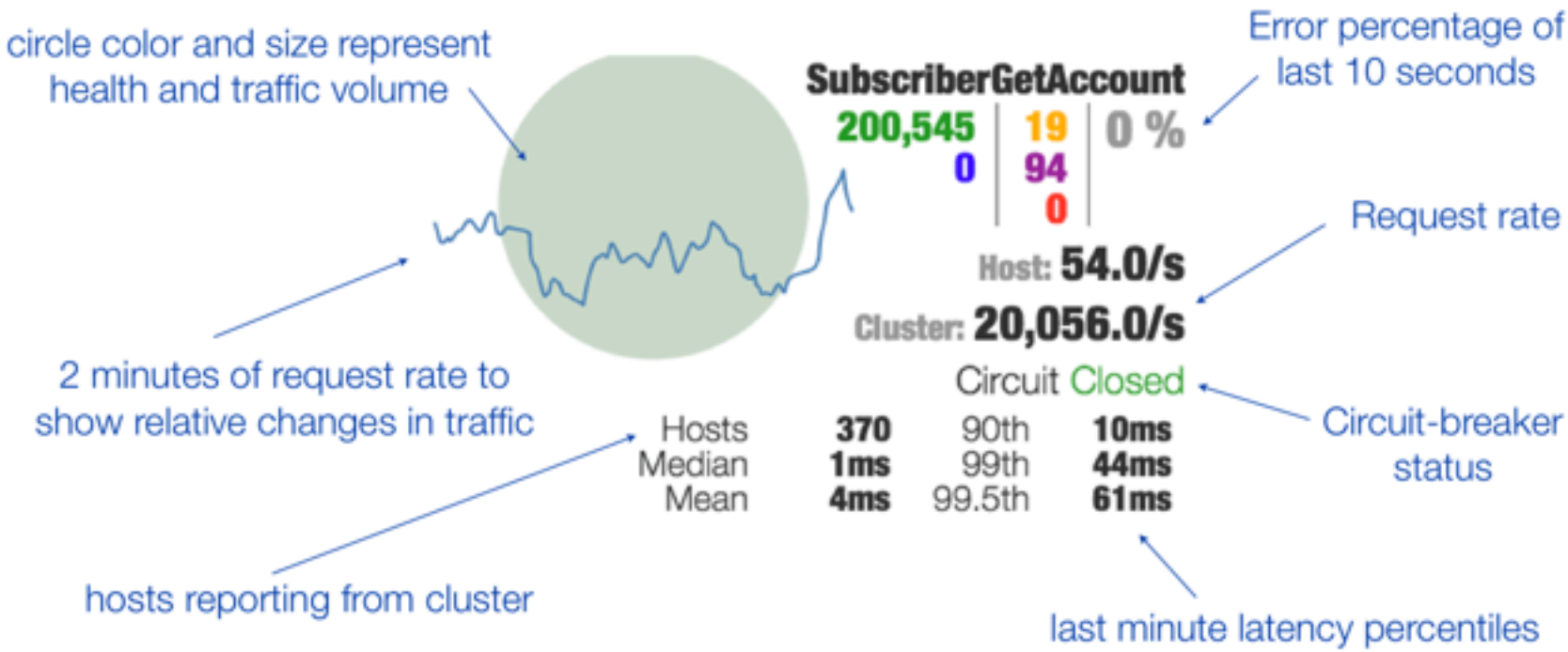
- Request Caching
- Request Collapsing
- Plugins

  Event Notifier, Metrics Publisher, Properties Strategy, Concurrency Strategy, Command Execution Hook
- Contributions

  Metrics Event Stream, Metrics Publisher, Java Annotations, Clojure Bindings, …
- Dashboard



Source: https://github.com/Netflix/Hystrix/wiki/Dashboard



Source: https://github.com/Netflix/Hystrix/wiki/Dashboard

Further reading

1. Hystrix Wiki,
   https://github.com/Netflix/Hystrix/wiki

2. Michael T. Nygard, Release It!,
   Pragmatic Bookshelf, 2007

3. Robert S. Hanmer,
   Patterns for Fault Tolerant Software,
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4. Andrew Tanenbaum, Marten van Steen,
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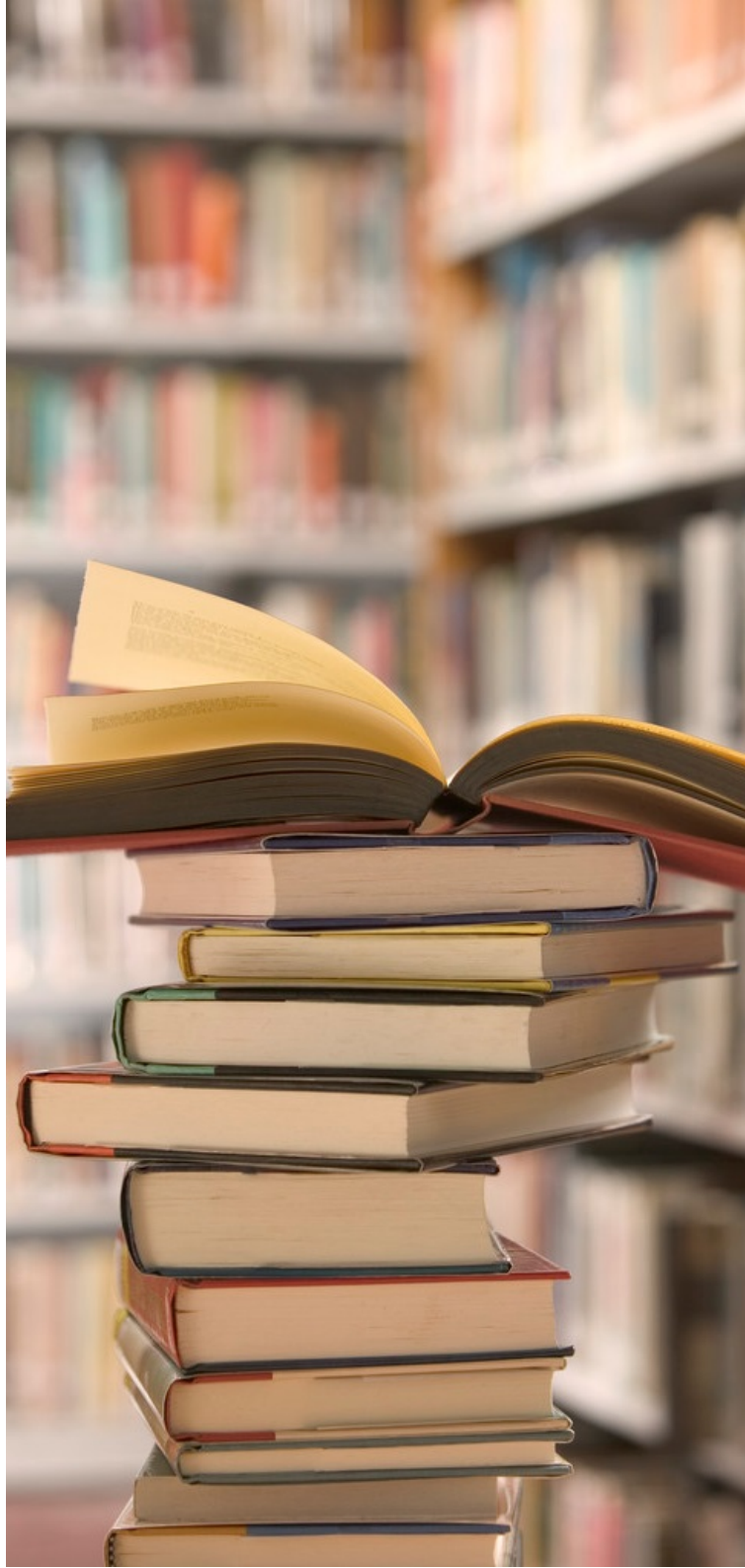
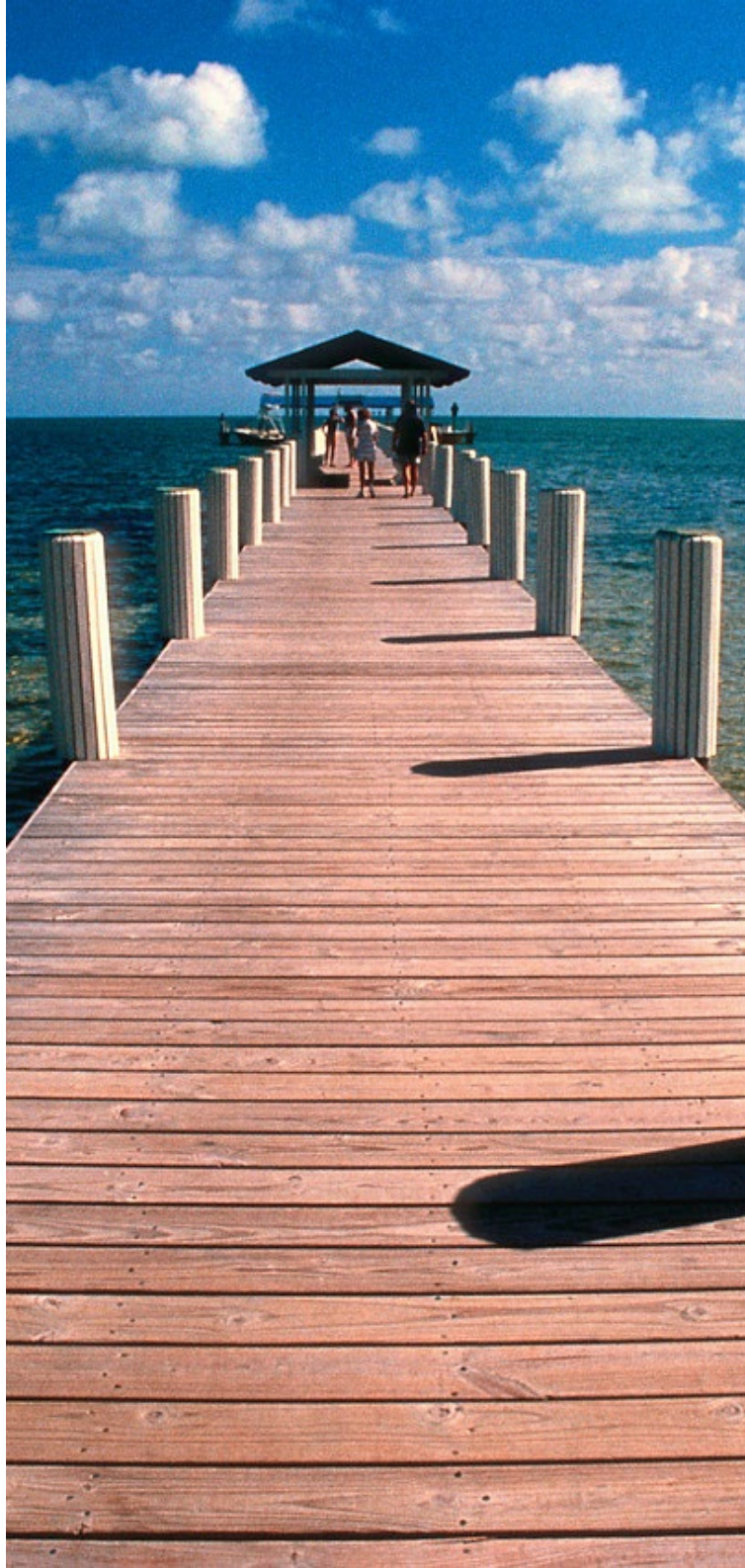
   Prentice Hall, 2nd Edition, 2006



Wrap-up

- Resilient software design becomes a must
- Hystrix is a resilience library
  - Provides isolation and latency control
  - Easy to start with
  - Yet some learning curve
  - Many fault-tolerance patterns implementable
  - Many configuration options
  - Customizable
  - Operations proven

Become a resilient software developer!



It’s all about production!

@ufried

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