Async Coding in Java

Why asynchronous calls make sense in a microservices context and a comparison of frameworks that help you do it

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Spotify®

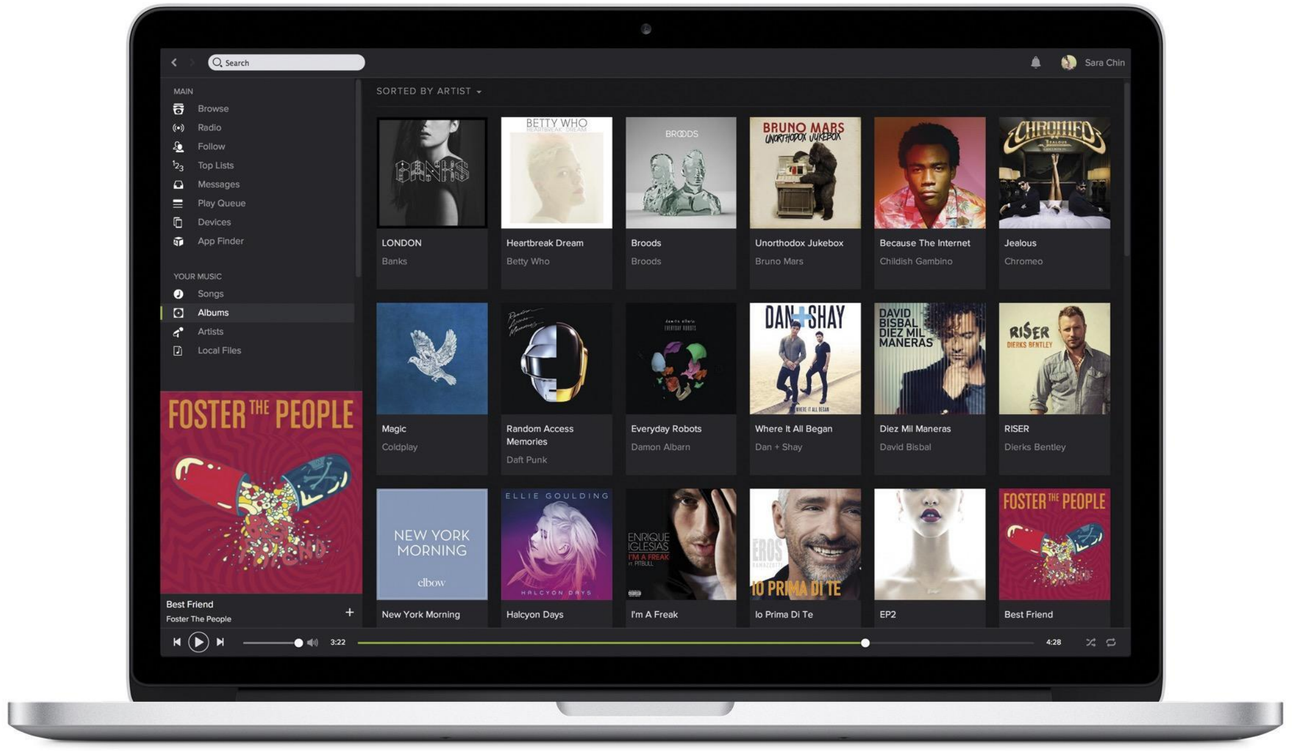
What is Spotify?

Music

Spotify brings you the right music for every moment – on your computer, your mobile, your tablet, your home entertainment system and more.

Numbers

- ❏ > 60M active users (last 30 days)
- ❏ > 1.5B playlists
- ❏ > 30M songs
- ❏ Available in 58 countries



Microservices, Async and Me

My background

- Currently building infrastructure at Spotify:
  - service discovery
  - routing infrastructure
  - service development framework
- About 6 years of microservices (4 Shopzilla, 2 Spotify)
- Similar sizes: 3-5 datacenters, a few thousand servers, more than 100 services

Async code

- Shopzilla sites: page rendering, ~10-40 service calls/page
- Shopzilla inventory: high-performance VoltDB calls
- Spotify view aggregation services, ~5-10 service calls/request

Topics covered

Why write asynchronous code?

Why not write asynchronous code?

I’m going to do it, how?

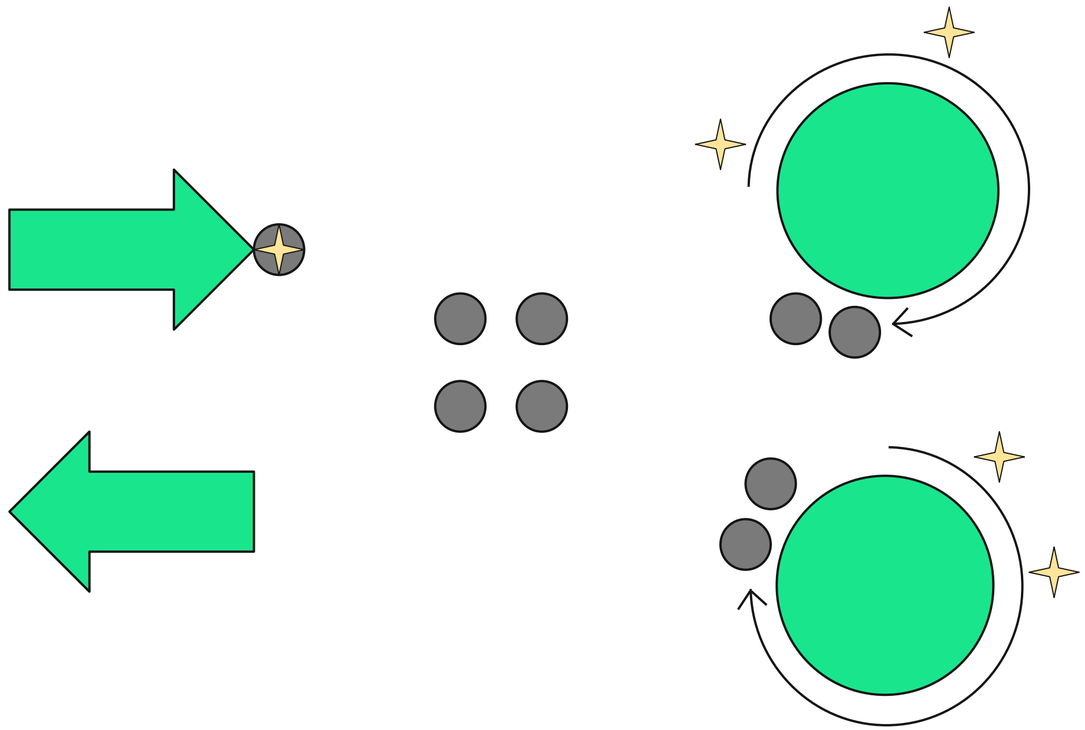
- ❏ Code examples
- ❏ Frameworks

Why Asynchronous?

Performance

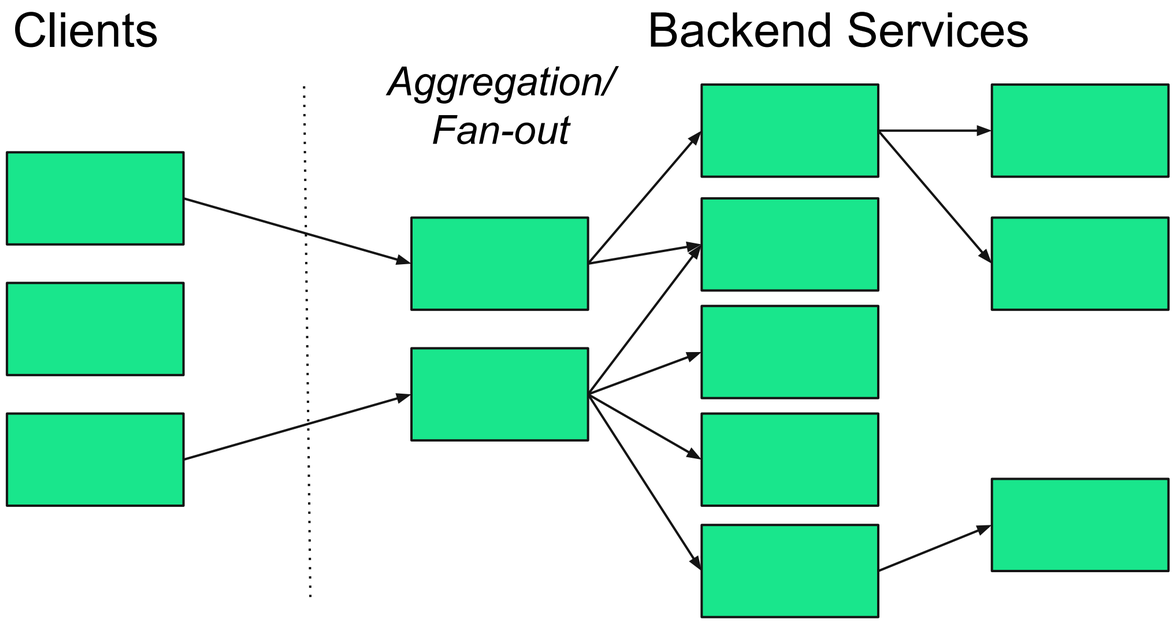
- ❏ Synchronous => throughput limited by thread/worker count
- ❏ Synchronous => resources used for the wrong things
- ❏ Asynchronous => latency improvements through parallelism
- ❏ Async means ‘less active waiting’

(A)synchronicity in a Restaurant



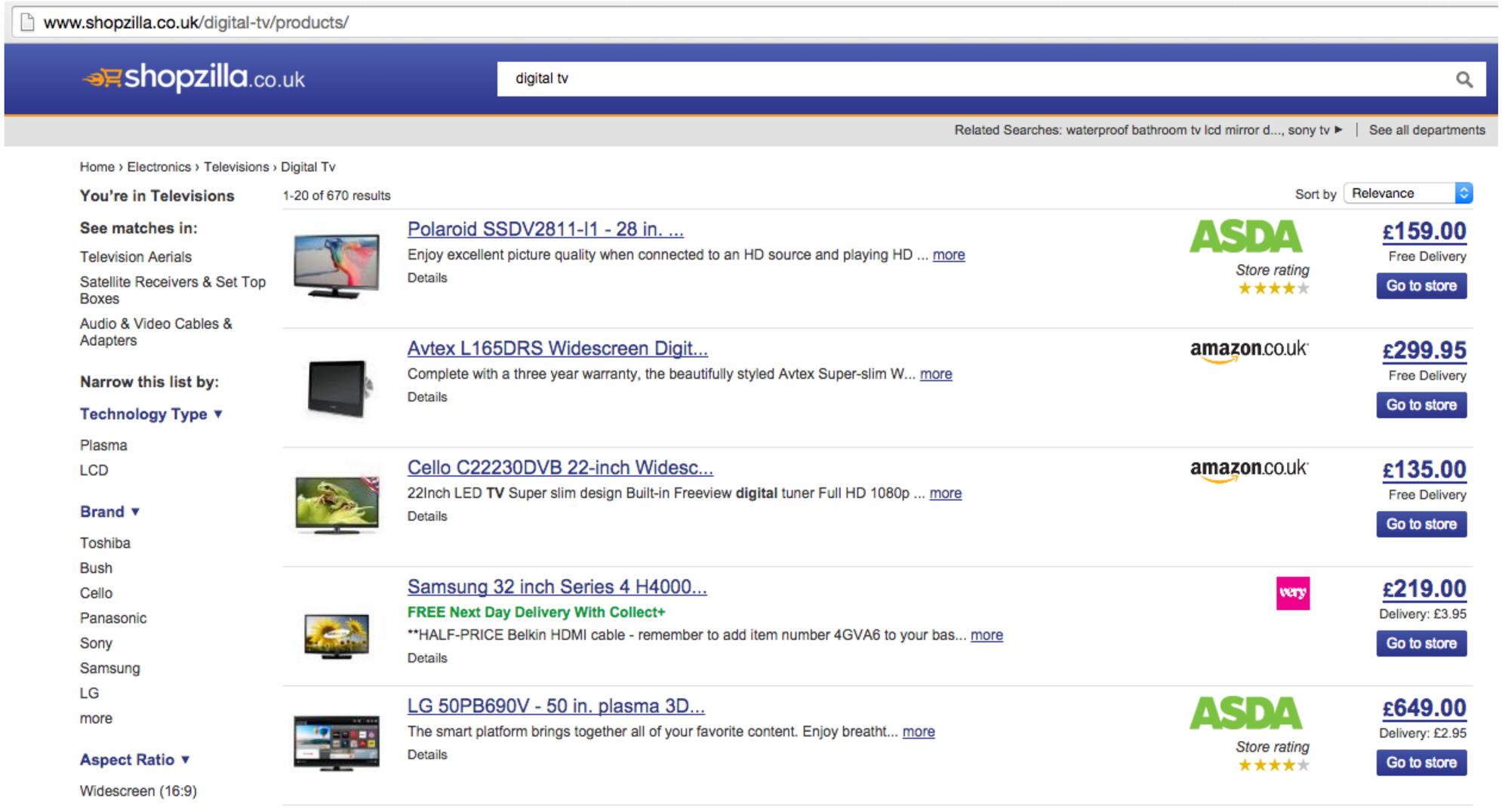
Async and Microservices

Typical microservices architecture:



Difference monolithic => microservices is latency; what used to be a method call is a remote call across the network

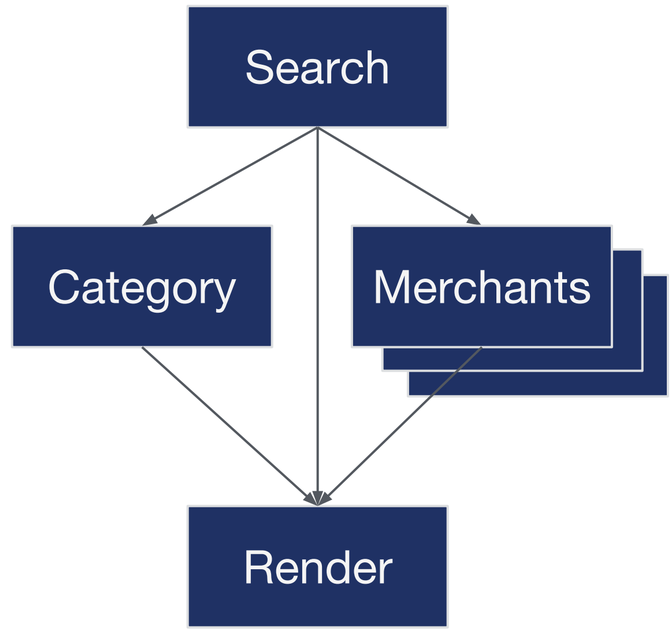
Async at Shopzilla



Async at Shopzilla

Shopzilla Async Framework

- ❏ Latency to start of render critical for revenue
- ❏ Framework put futures into a map, get actual results out
- ❏ Problems:
  - ❏ get = null - why?
  - ❏ get => block, mistakes delayed start of render
  - ❏ lack of visibility - what gets put into the map? Is it used?



Created PageFlow

- ❏ explicitly specifying call graph as data structure
- ❏ clunky syntax, tightly tied to Shopzilla infrastructure
- ❏ ‘accidentally’ moved concurrency into framework, great

Shopzilla Inventory

- ❏ Read/write logic for VoltDB databases
- ❏ In-memory, transactional, high-performance DB
- ❏ 100k+ writes/sec => async needed for performance
- ❏ Futures.transform() makes a sequence nested and harder to read

Created library for chaining invocations

- ❏ Simpler, less tied to infrastructure than PageFlow
- ❏ Just a chain, no fan-out/fan-in

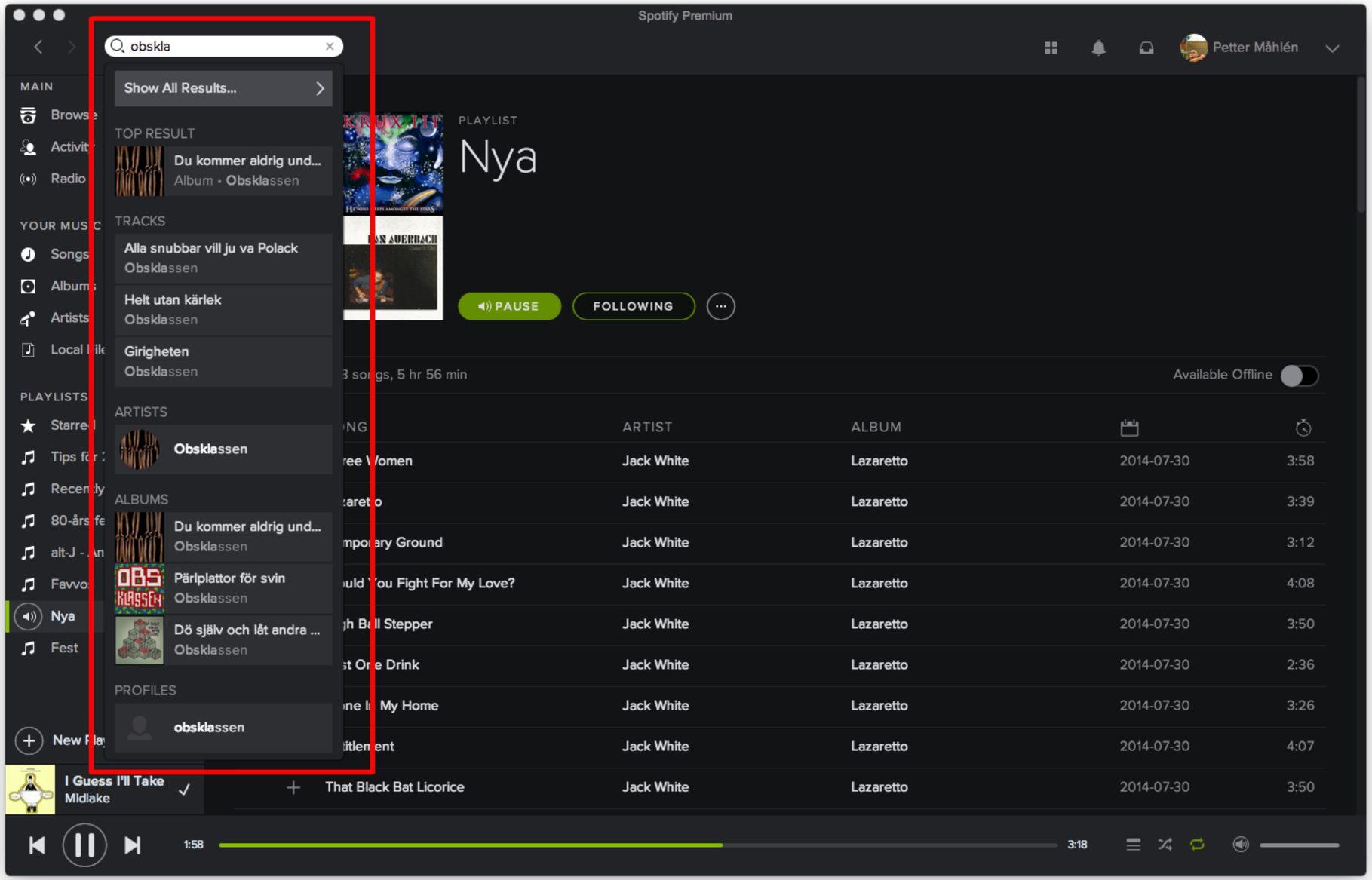
Async at Spotify

Thinner Clients

- Move logic from clients to backend
  - Easier, faster deployment
  - More mobile-friendly
- “View aggregation services”
  - Many downstream service invocations, more complex graphs
  - Use of ListenableFutures makes code complex

Created Trickle with Rouzbeh Delavari

- Open source (https://github.com/spotify/trickle/)
- Explicit graph like PageFlow
- Generic like the VoltDB library


Spotify Premium
obskla
Show All Results...
TOP RESULT
Du kommer aldrig und...
Album • Obsklassen
TRACKS
Alla snubbar vill ju va Polack
Obsklassen
Helt utan kärlek
Obsklassen
Girigheten
Obsklassen
ARTISTS
Obsklassen
ALBUMS
Du kommer aldrig und...
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Pärlplattor för svin
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Dö själv och låt andra ...
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YOUR MUSIC
Songs
Albums
Artists
Local Files
PLAYLISTS
Starred
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Favvos
Nya
Fest
New Play
I Guess I'll Take
Midlake
Petter Måhlén
PLAYLIST
Nya
PAUSE
FOLLOWING
3 songs, 5 hr 56 min
Available Offline
ARTIST
ALBUM
Jack White
Lazaretto
2014-07-30
3:58
3:39
3:12
4:08
3:50
2:36
3:26
4:07
3:50
That Black Bat Licorice
1:58
3:18

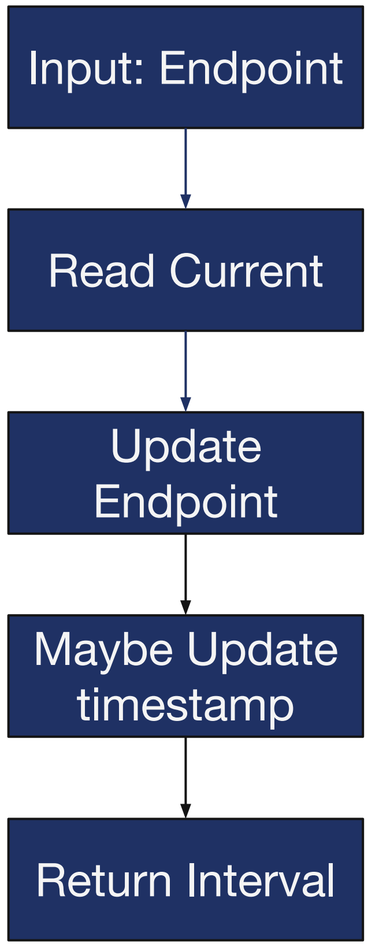
Why not asynchronous?

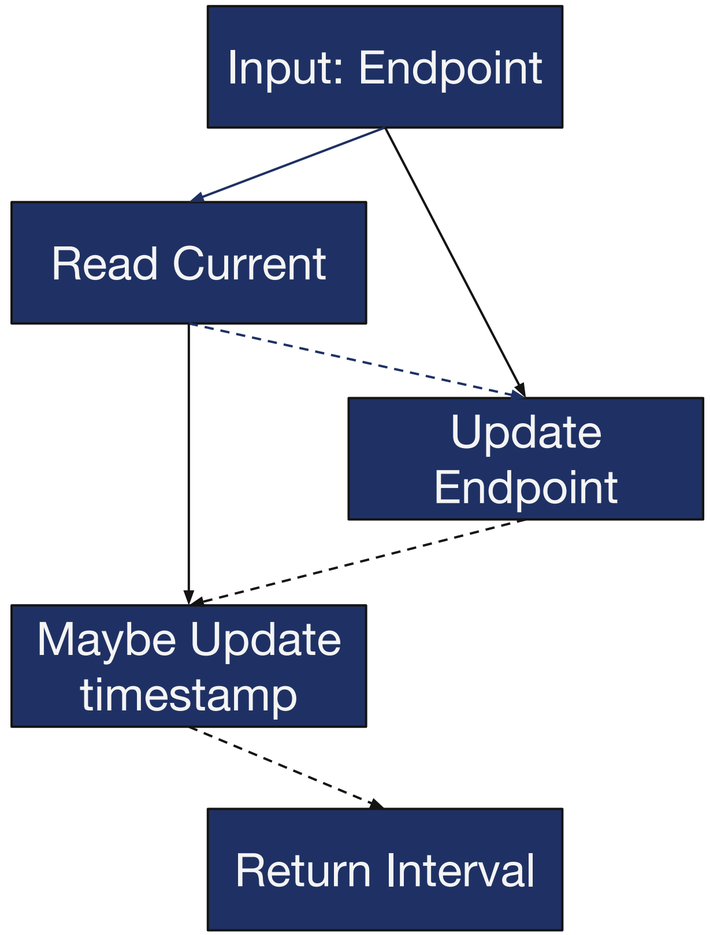
Because it’s harder to write, read, test and reason about

- ❏ Business logic obscured by concurrency management overhead
- ❏ Concurrency primitives can be invasive. What if somebody by accident does a get() instead of a transform?
- ❏ Typesafe fan-in hard (Futures.allAsList(), FuncN, BiConsumer/BiFunction, etc.)
- ❏ Testing - flakiness, exception handling, more execution paths
- ❏ Understanding errors/call stacks

- ❏ (Graceful degradation in case of errors)

Code Examples!





Subjective Comparison:
ListenableFutures

https://code.google.com/p/guava-libraries/wiki/ListenableFutureExplained

Pros

- ❏ low-level: not much magic
- ❏ (mostly) familiar concepts
- ❏ nice and small API
- ❏ good interoperability with other frameworks since futures are so common

Cons

- ❏ verbose
- ❏ concurrency management obscures business logic
- ❏ low-level: concurrency is in your face, easier to make mistakes
- ❏ fan-in is messy

Subjective Comparison:

RxJava

Rx = Reactive Extensions

http://reactivex.io/

Pros

- ❏ feature-rich, especially for streams of data
- ❏ separates concurrency from business logic
- ❏ easy to combine results, do fallbacks, etc.
- ❏ clean code

Cons

- ❏ unfamiliar concepts/high learning threshold
- ❏ large and clumsy API (cf #methods on Observable interface)
- ❏ “everything is a collection”

Subjective Comparison:
Trickle

https://github.com/spotify/trickle/

Pros

- ❏ separates concurrency from business logic
- ❏ nice error handling + reporting support
- ❏ developer-friendly API
- ❏ good interoperability with regular Futures/other frameworks

Cons

- ❏ weird to do graph wiring in data
- ❏ not in widespread use

Many subjective comparisons

Result of engineers at Spotify coding up a pretty small async graph

Technology	Get going	Focus on core	Cleanness
ListenableFutures	4.0	3.6	2.7
RxJava	2.8	3.7	3.1
Trickle	3.9	3.8	4.4

Let’s get more data: try it yourself at https://github.com/pettermahlen/async-shootout and fill in the form!

Choices, choices

There's more:

- ❏ Akka
  - ❏ actors
  - ❏ cool, but sort of all-or-nothing - greenfield only?
- ❏ CompletionStage in Java 8
  - ❏ allows chaining of asynchronous calls
  - ❏ fan-in is harder than Rx or Trickle
- ❏ Disruptor
  - ❏ Not just super-high-performance; allows constructing call graphs
  - ❏ also all-or-nothing, at least within single service

Picking your Framework

Consider:

- ❏ your migration path, if any
- ❏ how to integrate with third-party tools
- ❏ the learning curve
- ❏ the expected level of concurrency expertise of devs

… and above all, make sure you need it!

Questions?

Spotify®

```java
public class SynchronousHeartbeat {
  private final SynchronousStore store;
  private final long heartbeatIntervalMillis;

  public SynchronousHeartbeat(SynchronousStore store, long heartbeatIntervalMillis) {
    this.store = store;
    this.heartbeatIntervalMillis = heartbeatIntervalMillis;
  }

  public long heartbeat(final Endpoint endpoint) {
    // fetch what we currently know about the endpoint
    RegistryEntry previous = store.get(endpoint);

    // no matter what, flag it as known to be UP right now
    store.put(createEntry(endpoint, UP));

    // if it wasn't known to be up before, that's a change to the current state of things,
    // which means we need to update the last change timestamp.
    if (!isPresent(previous) || !isUp(previous)) {
      store.updateLastChangeTimestamp();
    }

    // let the caller know when he's next expected to be in touch
    return heartbeatIntervalMillis;
  }
}
```

```
public class ListenableFutureHeartbeat {
  private final Store store;
  private final long heartbeatIntervalMillis;

  public ListenableFutureHeartbeat(Store store, long heartbeatIntervalMillis) {
    this.store = store;
    this.heartbeatIntervalMillis = heartbeatIntervalMillis;
  }

  public ListenableFuture<Long> heartbeat(final Endpoint endpoint) {
    ListenableFuture<RegistryEntry> previousFuture = store.get(endpoint);

    return Futures.transform(
            previousFuture,
            (AsyncFunction<RegistryEntry, Long>) previous -> {
              final ListenableFuture<Boolean> upFuture = store.put(createEntry(endpoint, UP));

              ListenableFuture<Void> serialNumberFuture =
                      Futures.transform(upFuture,
                                        (AsyncFunction<Boolean, Void>) IGNORED -> {
                                          if (!isPresent(previous) || !isUp(previous)) {
                                            return store.updateLastChangeTimestamp();
                                          }
                                          return Futures.immediateFuture(null);
                                        });

              return Futures.transform(serialNumberFuture,
                                       (AsyncFunction<Void, Long>) IGNORED ->
                                               Futures.immediateFuture(heartbeatIntervalMillis));
            });
  }
}

// NOTE:
// - noise level
// - 'pretend' transforms
// - ignoring inputs to handle chaining
```

```scala
class ScalaHeartbeat(store: ScalaStore, heartbeatIntervalMillis: Long) {

  def createEntry(endpoint: Endpoint, state: State): RegistryEntry = ???
  def isPresent(entry: RegistryEntry): Boolean = ???
  def isUp(entry: RegistryEntry): Boolean = ???


  def heartbeat(endpoint: Endpoint): Future[Long] = {
    for {
      previous <- store.get(endpoint)
      _ <- store.put(createEntry(endpoint, UP))
      _ <- if (!isPresent(previous) || !isUp(previous))
        store.updateLastChangeTimestamp()
      else
        Future.successful(())
    } yield heartbeatIntervalMillis
  }
}

trait ScalaStore {
  def get(endpoint: Endpoint):Future[RegistryEntry] = ???
  def put(entry: RegistryEntry): Future[Boolean] = ???
  def updateLastChangeTimestamp():Future[Void] = ???
}
```

```java
public class RxHeartbeat {
  private final ObservableStore store;
  private final long heartbeatIntervalMillis;

  public RxHeartbeat(ObservableStore store, long heartbeatIntervalMillis) {
    this.store = store;
    this.heartbeatIntervalMillis = heartbeatIntervalMillis;
  }

  public Observable<Long> heartbeat(Endpoint endpoint) {
    Observable<RegistryEntry> previous = store.get(endpoint);
    Observable<Boolean> up = previous.flatMap(IGNORED -> store.put(createEntry(endpoint, UP)));

    return previous
            .zipWith(up, (RegistryEntry previousEntry, Boolean IGNORED) -> {
              if (!isPresent(previousEntry) || !isUp(previousEntry)) {
                return store.updateLastChangeTimestamp();
              }
              return null;
            })
            .map(IGNORED -> heartbeatIntervalMillis);
  }
}

// NOTE:
// - rx = reactive extensions
// - reduced noise level
// - 'functional' method names
// - ignoring inputs to handle chaining
// - method count on Observable => discoverability
```

```java
public class TrickleHeartbeat {
  private final Input<Endpoint> endpointInput;
  private final Graph<Long> heartbeatGraph;

  public TrickleHeartbeat(Store store, long heartbeatIntervalMillis) {
    endpointInput = Input.named("endpoint");

    Graph<RegistryEntry> previous = call(store::get).with(endpointInput);
    Graph<Boolean> up = call((Endpoint endpoint) -> store.put(createEntry(endpoint, UP)))
            .with(endpointInput)
            .after(previous);
    Graph<Void> timestamp = call(
            (RegistryEntry previousEntry) -> {
              if (!isPresent(previousEntry) || !isUp(previousEntry)) {
                return store.updateLastChangeTimestamp();
              }
              return immediateFuture(null);
            })
            .with(previous)
            .after(up);

    heartbeatGraph = call(() -> immediateFuture(heartbeatIntervalMillis)).after(timestamp);
  }

  public ListenableFuture<Long> heartbeat(final Endpoint endpoint) {
    return heartbeatGraph.bind(endpointInput, endpoint).run();
  }
}

// NOTE:
// - noisier than Rx
// - what's with all the 'Graph':s?
// - optional names
// - IDE help building graphs
```

Calling an asynchronous method

- exceptions
- timing

Testing tips

Some code

```
public ListenableFuture<Gherkin> serve() {
  ListenableFuture<Integer> count = counter.count();
  return Futures.transform(count, new Function<>() {
     public Gherkin apply(Integer count) {
       if (count == 0) {
         froobishes.delete();
       }
       return new Gherkin(count);
     }
  });
}
```

A Test

```
public void shouldDeleteFroobishesWhenCountIsZero()
    throws Exception {

  when(counter.count()).thenReturn(intFuture(0));
  service.serve().get(); // <--- terminate the future

  verify(froobishes).delete();
}
```