Async JavaScript at Netflix

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Who is Jafar?

- Cross-Team Technical Lead for Netflix UIs
- Architect of Netflix UI Data Platform
- Member of JavaScript standards committee (TC39)
- 16 years in the industry, formerly worked at Microsoft and GE

This is the story of how Netflix solved

BIG async problems

by thinking differently about

Events.


2014

Async Programming was very

HARD

The Netflix App was plagued by

- Race Conditions
- Memory Leaks
- Complex State Machines
- Uncaught Async Errors

Playing a Movie Asynchronously

```
function play(movieId, cancelButton, callback) {
    var movieTicket,
        playError,
        tryFinish = function() {
            if (playError) {
                callback(null, playError);
            }
            else if (movieTicket && player.initialized) {
                callback(null, ticket);
            }
        };
    cancelButton.addEventListener("click", function() { playError = "cancelled"; }
    if (!player.initialized) {
        player.init(function(error) {
            playError = error;
            tryFinish();
        });
    }
    authorizeMovie(function(error, ticket) {
        playError = error;
        movieTicket = ticket;
        tryFinish();
    });
});
```

Today

the majority of Netflix's async code is written with just a few *flexible* functions.

But first a brief

JavaScript 6 tutorial…

Functions

```
function(x) { return x + 1; }
function(x, y) { return x + y; }
```

```
x => x + 1
(x, y) => x + y
```

JS5
6

Fin.

ForEach

```
> [1, 2, 3].forEach(x => console.log(x))
> 1
> 2
> 3
>
```

Map

Map

```
> [1, 2, 3].map(x => x + 1)
> [2, 3, 4]
>
```

Filter

Filter

```
> [1, 2, 3].filter(x => x > 1)
> [2, 3]
>
```

concatAll

concatAll

```
> [ [1], [2, 3], [], [4] ].concatAll()
> [1, 2, 3, 4]
>
```

Map/Filter/ConcatAll

```
> [1, 2, 3].map(x => x + 1)
> [2, 3, 4]

> [1, 2, 3].filter(x => x > 1)
> [2, 3]

> [ [1], [2, 3], [], [4] ].concatAll()
> [1, 2, 3, 4]
>
```

Orange is the New Black

★★★★½ 2013 TV-MA 13 episodes 5.1

From the creator of “Weeds” comes this series about a privileged New Yorker who ends up in a women's prison when a past crime catches up with her.

Based on your interest in:
Breaking Bad

Let’s use map, filter, and concatAll to get a list of your favorite Netflix titles.

Top-rated Movies Collection

```
var getTopRatedFilms = user =>
   user.videoLists.
      map(videoList =>
         videoList.videos.
            filter(video => video.rating === 5.0)).
      concatAll();

getTopRatedFilms(user).
   forEach(film => console.log(film));
```

What if I told you…

…that you could create a drag event…

…with nearly the *same code*?

Top-rated Movies Collection

```
var getTopRatedFilms = user =>
    user.videoLists.
        map(videoList =>
            videoList.videos.
                filter(video => video.rating === 5.0)).
        concatAll();

getTopRatedFilms(user).
    forEach(film => console.log(film));
```

Mouse Drags Collection

```
var getElementDrags  = elmt =>
   elmt.mouseDowns.
      map(mouseDown =>
         document.mouseMoves.
            filter takeUntil(document.mouseUps)).
      concatAll();

getElementDrags(image).
   forEach(pos => image.position = pos);
```

“What’s the difference between an Array…

```
[{x: 23, y: 44}, {x:27, y:55}, {x:27, y:55}]
```

… and an Event?

Events and Arrays are *both*

collections.

So why don’t we program them the same way?


1994
ACE VENTURE
PET DETECTIVE
Sports Illustrated
SUPER METROID
KEANU REEVES
Tom Hanks is Forrest Gump
July 6
CLERKS
A very funny look at the over-the-counter culture.
NIRVANA
UNPLUGGED IN NEW YORK
weezer
AMERICA Online

Design Patterns

Elements of Reusable Object-Oriented Software

Erich Gamma
Richard Helm
Ralph Johnson
John Vlissides

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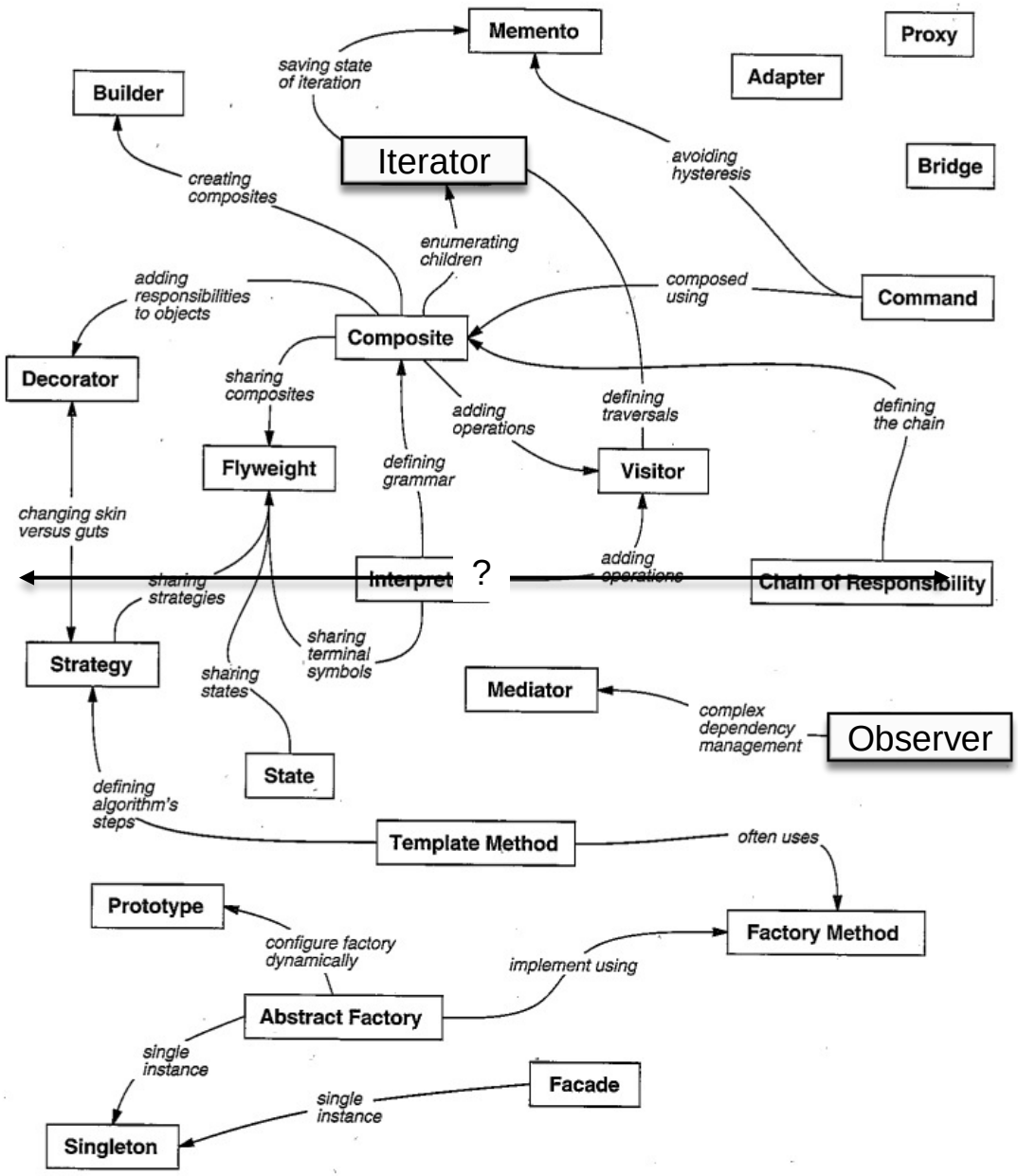
Foreword by Grady Booch

ADDISON-WESLEY PROFESSIONAL COMPUTING SERIES



Design Pattern Relationships

Iterator

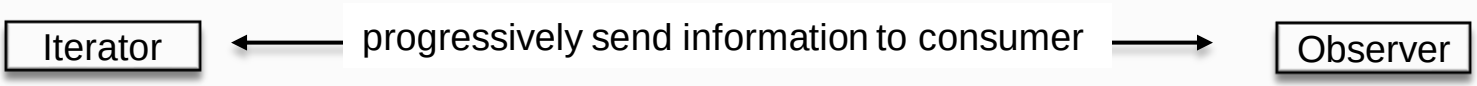
```
> var iterator = [1,2,3].iterator();
> console.log(iterator.next());
> { value: 1, done: false }
> console.log(iterator.next());
> { value: 2, done: false }
> console.log(iterator.next());
> { value: 3, done: false }
> console.log(iterator.next());
> { done: true }
>
```

Map, Filter, and ConcatAll can be implemented using an Iterator.

Observer Pattern

```
> document.addEventListener(
    “mousemove”,
    function next(e) {
     console.log(e);
    });
```

```
> { clientX: 425, clientY: 543 }
> { clientX: 450, clientY: 558 }
> { clientX: 455, clientY: 562 }
> { clientX: 460, clientY: 743 }
> { clientX: 476, clientY: 760 }
> { clientX: 476, clientY: 760 }
> { clientX: 476, clientY: 760 }
```


Iterator
progressively send information to consumer
Observer

The Iterator and Observer Pattern are Symmetrical.


IN OBSERVER PATTERN
PRODUCER ITERATE YOU

The authors of
“Design Patterns”

missed

this symmetry.

As a result, they gave

Iterator and Observer

different semantics.

So Many Push APIs

DOM Events
Websockets
Server-sent Events
Node Streams
Service Workers
jQuery Events
XMLHttpRequest
setInterval

Introducing Observable

```
Observable === Collection + Time
```

Observables can model…

- Events
- Animations
- Async Server Requests

Reactive Extensions

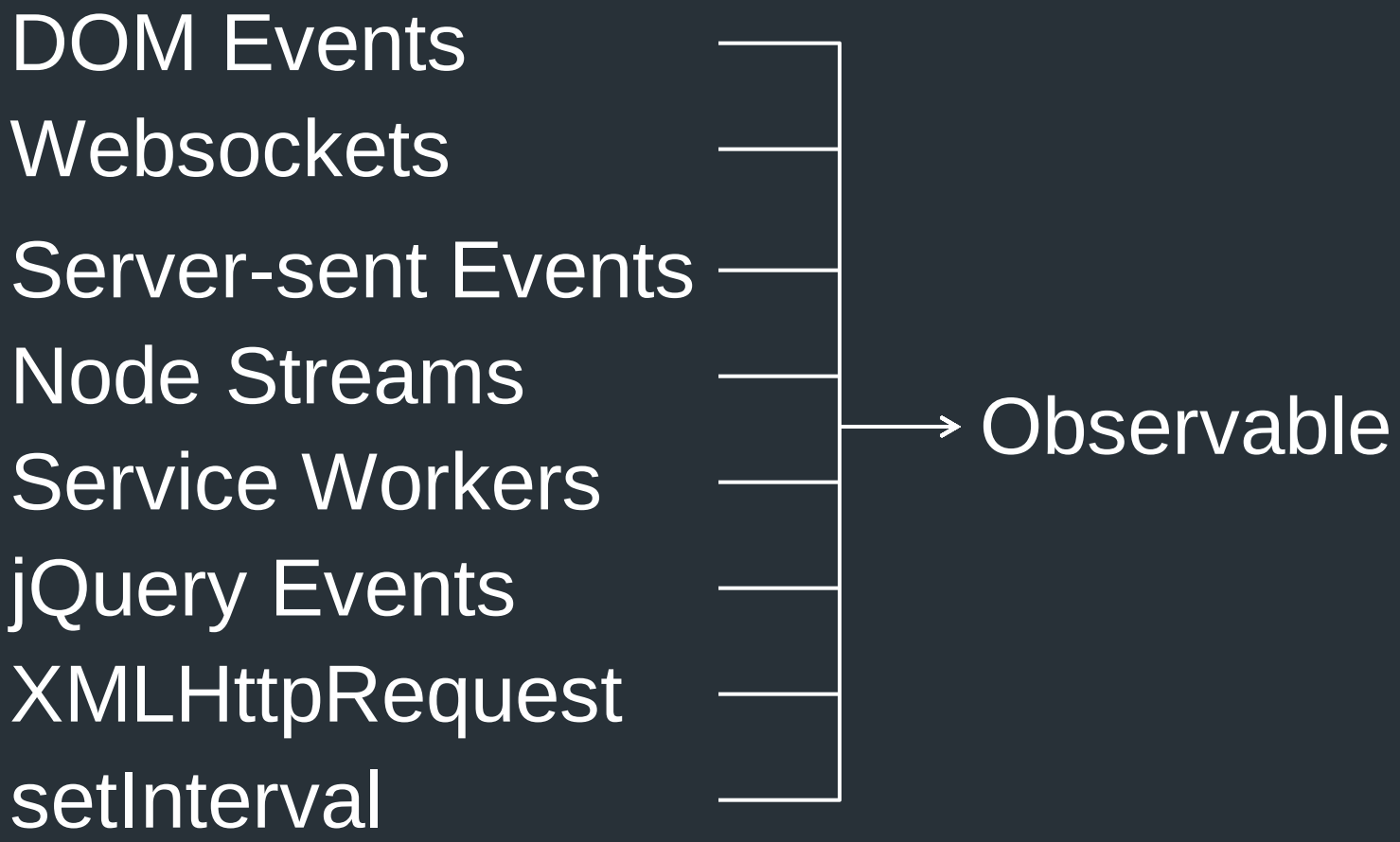
- Events as Streams
- Open Source (Apache2)
- Ported to many languages
  - C
  - .NET
  - JavaScript
  - Java (Netflix)
  - Objective-C

http://reactivex.io

Events to Observables

```
var mouseMoves =
    Observable.
        fromEvent(element, “mousemove”);
```

Adapt Push APIs to Observable



Event Subscription

```
// “subscribe”
var handler = (e) => console.log(e);
document.addEventListener(“mousemoves”, handler);

// “unsubscribe”
document.removeEventListener(“mousemoves”, handler);
```

Observable.forEach

```
// “subscribe”
var subscription =
    mouseMoves.forEach(console.log);

// “unsubscribe”
subscription.dispose();
```

Expanded Observable.forEach

```
// “subscribe”
var subscription =
    mouseMoves.forEach(
        // next data
        event => console.log(event),
        // error
        error => console.error(error),
        // completed
        () => console.log(“done”));

// “unsubscribe”
subscription.dispose();
```

Expanded Observable.forEach

```
// “subscribe”
var subscription =
    mouseMoves.forEach({
        onNext: event => console.log(event),
        // error
        onError: error => console.error(error),
        // completed
        onCompleted: () => console.log(“done”)
    });

// “unsubscribe”
subscription.dispose();
```

Converting Events to Observables

```
Observable.fromEvent = function(dom, eventName) {
    // returning Observable object
    return {
        forEach: function(observer) {
            var handler = (e) => observer.onNext(e);
            dom.addEventListener(eventName, handler);

            // returning Subscription object
            return {
                dispose: function() {
                    dom.removeEventListener(eventName, handler);
                }
            };
        }
    };
}
```

Observable Literal

time

{1.....2.....3}

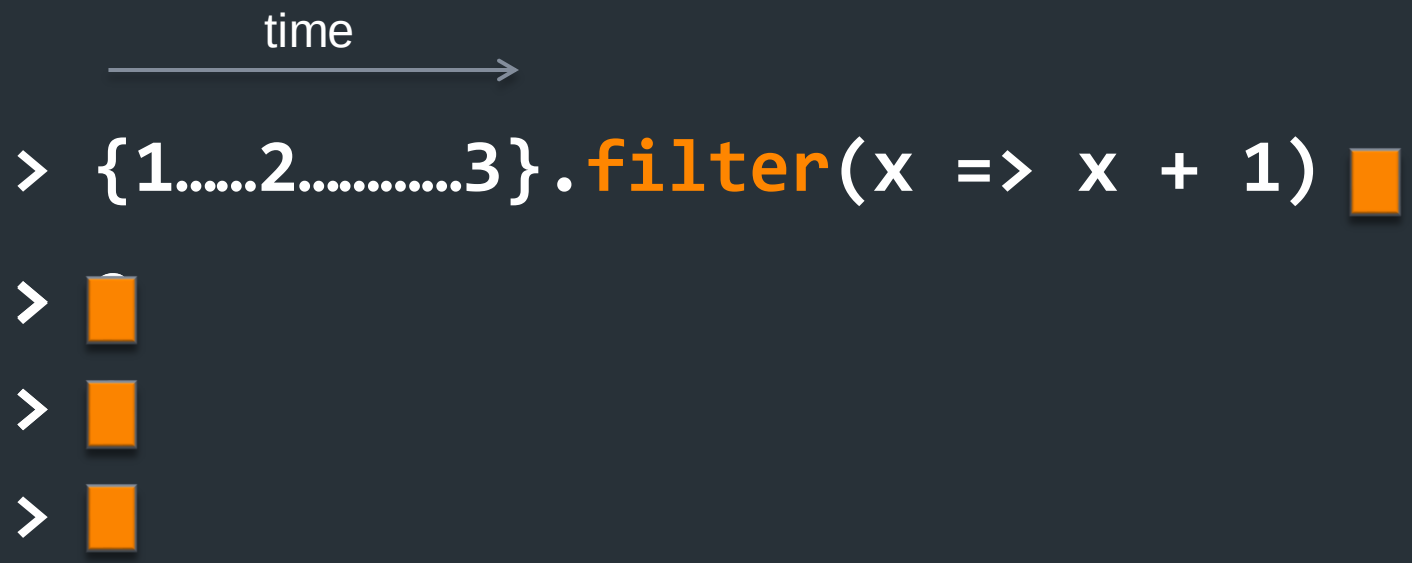
ForEach


```
> {1……2…….....3}.forEach(console.log)
> 1
>
>
>
```

Map


```
> {1……2…….....3}.map(x => x + 1)
> 2
>
>
>
```

Filter

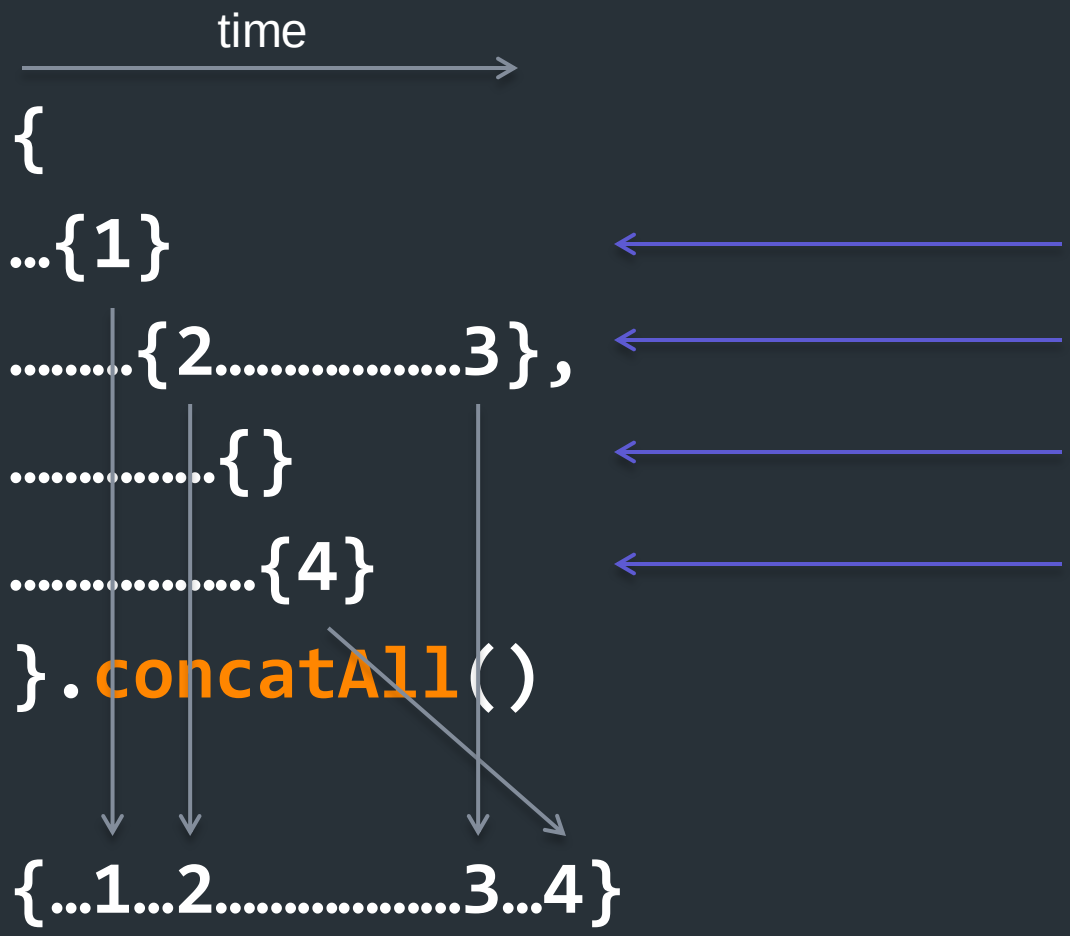


concatAll

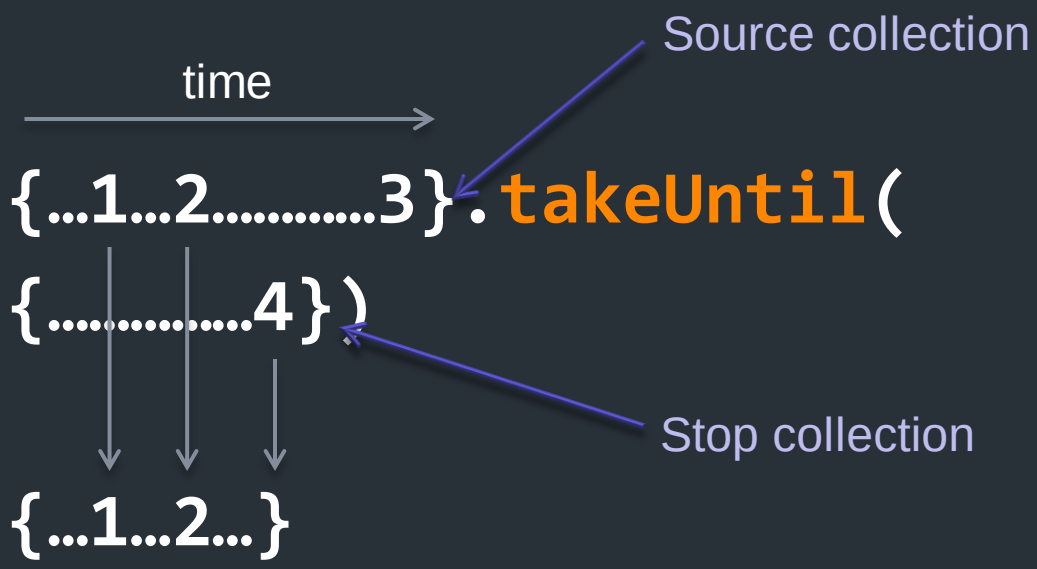
```
[
 [1]
 [2, 3],
 [],
 [4]
].concatAll()

[1, 2, 3, 4]
```

concatAll



TakeUntil

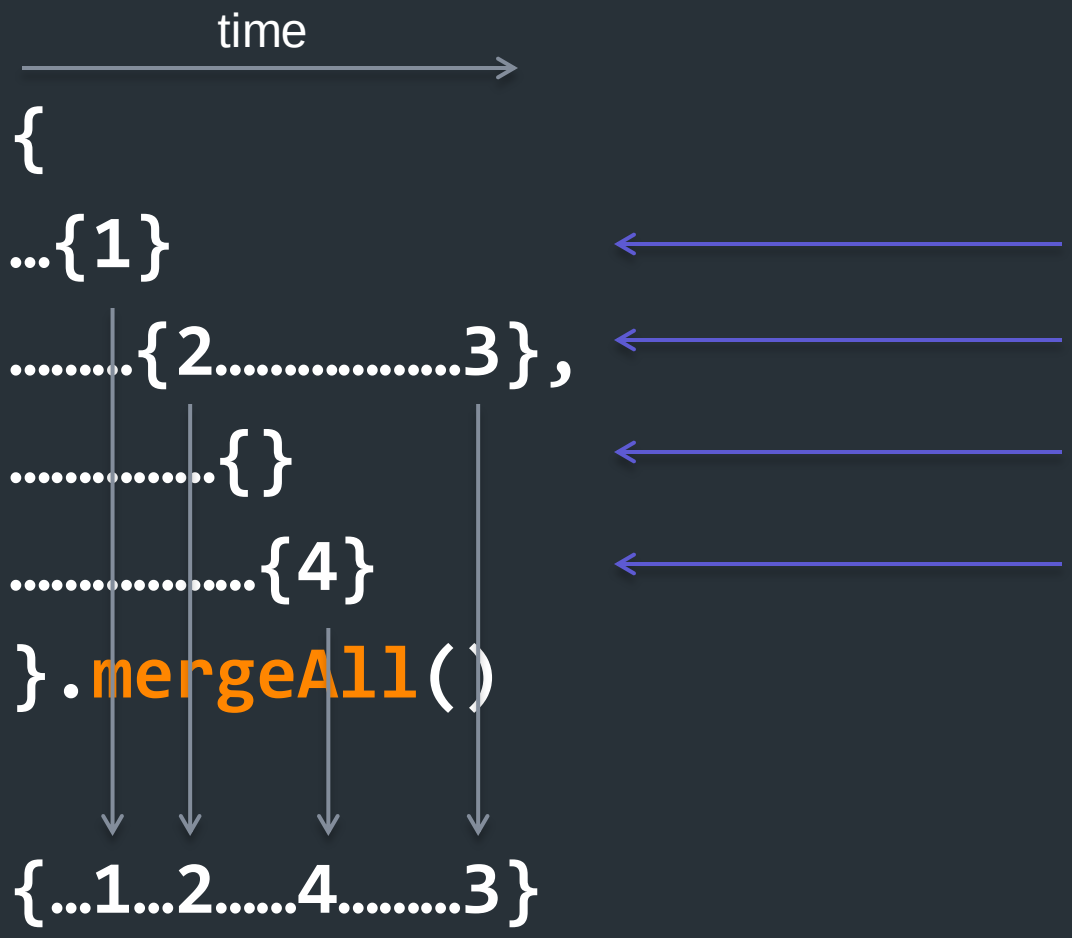


Mouse Drags Collection

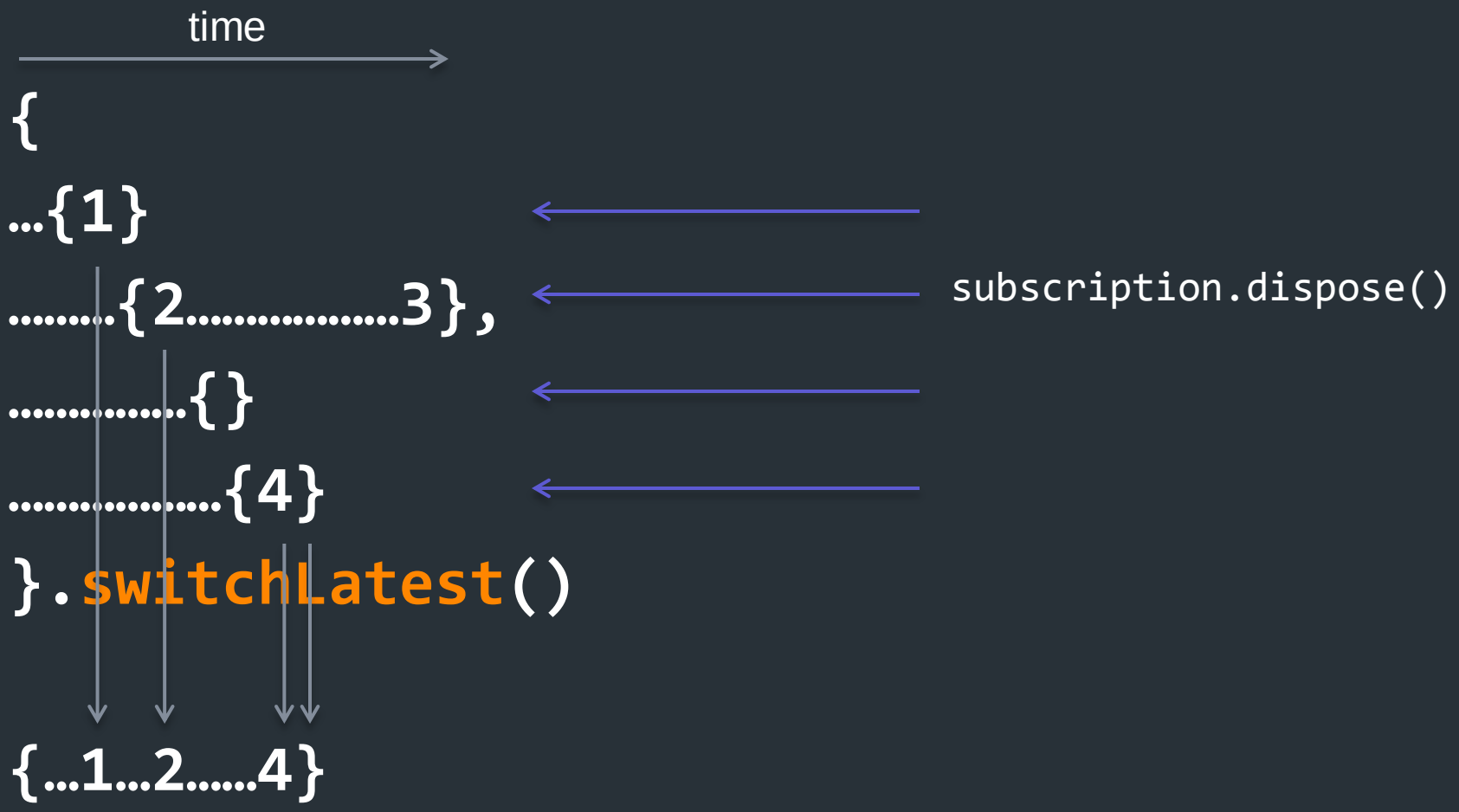
```
var getElementDrags  = elmt =>
   elmt.mouseDowns.
      map(mouseDown =>
         document.mouseMoves.
            takeUntil(document.mouseUps)).
      concatAll();

getElementDrags(image).
   forEach(pos => image.position = pos);
```

mergeAll



switchLatest



Don’t unsubscribe from Events.

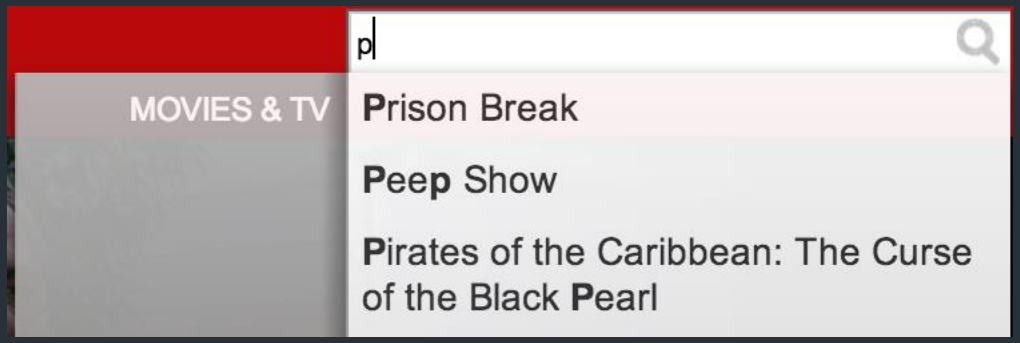
Complete them when another event fires.

Mouse Drags Collection

```
var getElementDrags  = elmt =>
   elmt.mouseDowns.
      map(mouseDown =>
         document.mouseMoves.
            takeUntil(document.mouseUps)).
      concatAll();

getElementDrags(image).
   forEach(pos => image.position = pos);
```

Netflix Search



Netflix Search

```
var searchResultSets =
   keyPresses.
      throttle(250).
      map(key =>
         getJSON(“/searchResults?q=” + input.value).
            retry(3).
            takeUntil(keyPresses)).
      concatAll();

searchResultSets.forEach(
   resultSet => updateSearchResults(resultSet),
   error => showMessage(“the server appears to be down.”));
```

Netflix Search

```
var searchResultSets =
    keyPresses.
        throttle(250).
        map(key =>
            getJSON(“/searchResults?q=” + input.value).
                retry(3).
                takeUntil(keyPresses)).
        concatAll switchLatest();

searchResultSets.forEach(
    resultSet => updateSearchResults(resultSet),
    error => showMessage(“the server appears to be down.”));
```

Netflix Search

```
var searchResultSets =
    keyPresses.
        throttle(250).
        map(key =>
            getJSON(“/searchResults?q=” + input.value).
                retry(3)).
        switchLatest();

searchResultSets.forEach(
    resultSet => updateSearchResults(resultSet),
    error => showMessage(“the server appears to be down.”));
```

Netflix Player

Player Callback Hell

```
function play(movieId, cancelButton, callback) {
    var movieTicket,
        playError,
        tryFinish = function() {
            if (playError) {
                callback(null, playError);
            }
            else if (movieTicket && player.initialized) {
                callback(null, ticket);
            }
        };
    cancelButton.addEventListener(“click”, function() { playError = “cancel”; });
    if (!player.initialized) {
        player.init(function(error) {
            playError = error;
            tryFinish();
        }
    }
    authorizeMovie(movieId, function(error, ticket) {
        playError = error;
        movieTicket = ticket;
        tryFinish();
    });
});
```

Player with Observable

```
var authorizations =
   player.
      init().
      map(() =>
         playAttempts.
            map(movieId =>
               player.authorize(movieId).
                     catch(e => Observable.empty).
                     takeUntil(cancels)).
            concatAll())).
      concatAll();

authorizations.forEach(
   license => player.play(license),
   error => showDialog("Sorry, can't play right now."));
```

Netflix: Observable Everywhere

- App Startup 
- Player 
- Data Access 
- Animations 
- View/Model binding 

Interactive Learning Exercises

http://jhusain.github.io/learnrx/

Observable in JavaScript 7?

```
async function* getStocks() {
   let reader = new AsyncFileReader("stocks.txt");
   try {
      while(!reader.eof) {
         let line = await reader.readLine();
         await yield JSON.parse(line);
      }
   }
   finally {
      reader.close();
   }
}

async function writeStockInfos() {
   let writer = new AsyncFileWriter("stocksAndPrices.txt");
   try {
      for(let name on getStocks()) {
         let price = await getStockPrice(name);
         await writer.writeLine(JSON.stringify({name, price}));
      }
   }
   finally {
      writer.close();
   }
}
```

Resources

- reactivetrader.azurewebsites.net
- https://github.com/Reactive-Extensions/RxJS
- RxJava
- http://jhusain.github.io/learnrx/
- @jhusain

Questions