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Async JavaScript at Netflix

Jafar Husain
@jhusain

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Talk Back

- Use the Facebook widget in the bottom panel to share this presentation with friends and colleagues
- Use Twitter widget to Tweet your favorite quotes from today's presentation with hashtag #ACMWebinarAsyncJS
- Submit questions and comments via Twitter to @acmeducation – we're reading them!

Who is Jafar?

- Cross-Team Technical Lead for the Netflix UIs
- Created the async data platform for Netflix UI’s
- Member of TC39
- 13 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.

[illegible]

2014

The Netflix App is Asynchronous

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

Async Problems

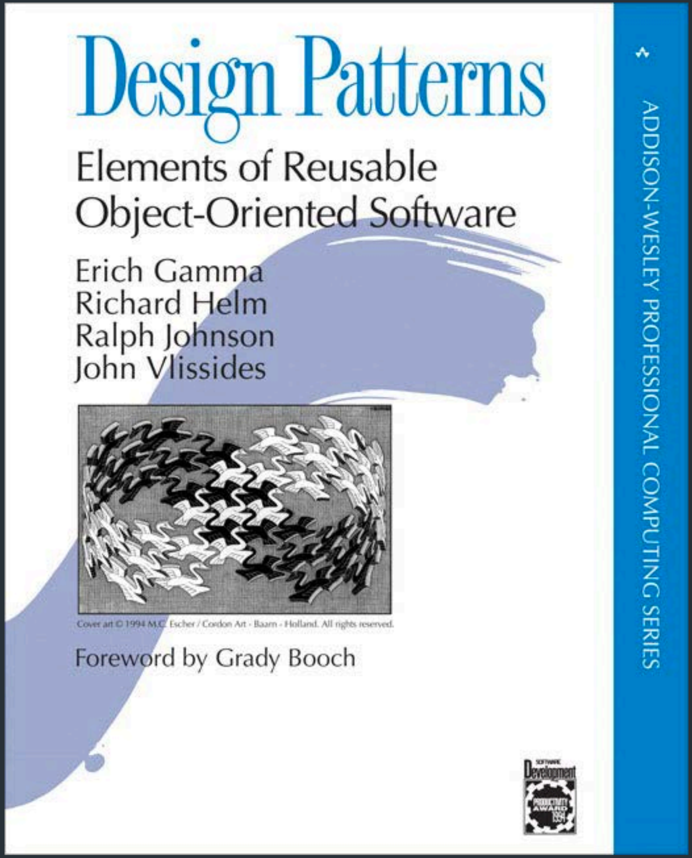
- Memory Leaks
- Race Conditions
- Callback Hell
- Complex state machines
- Error Handling

Async is Hard

```
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();
    });
});
```

1994

ACE VENTURA
PET DETECTIVE
Sports Illustrated
Why me? Why? Why?
Skater Nancy Kerrigan is brutally attacked at Olympic trials
SUPER METROID
SUPER NINTENDO
I WILL NOT
MEANING
KEANU REEVES
SPEED
GREEN DAY
dookie
Tom Hanks is Forrest Gump
July 6
CLERKS
A very funny look at the over-the-counter culture.
NIRVANA
UNPLUGGED IN NEW YORK
weezer
STANLEY CUP CHAMPIONS
AMERICA Online



Design Patterns

Elements of Reusable Object-Oriented Software

Erich Gamma
Richard Helm
Ralph Johnson
John Vlissides

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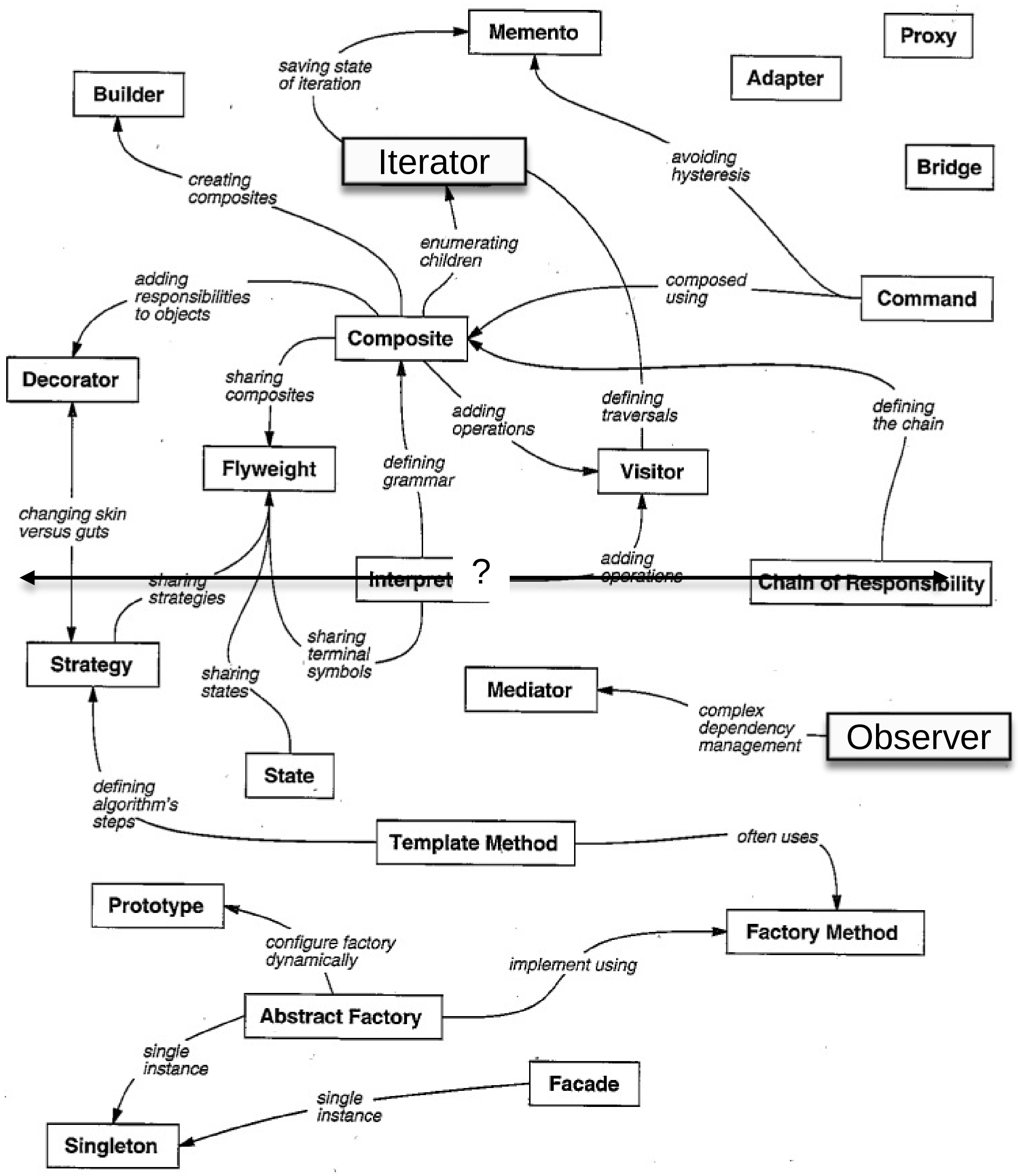
Foreword by Grady Booch

ADDISON-WESLEY PROFESSIONAL COMPUTING SERIES



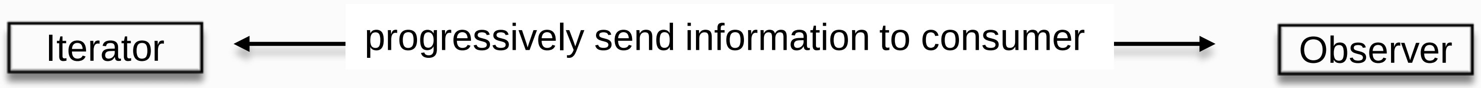
Design Pattern Relationships

Iterator

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

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 }
> { clientX: 476, clientY: 760 }
```


Iterator
progressively send information to consumer
Observer

IN OBSERVER PATTERN
PRODUCER ITERATE YOU

“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.

Now for a brief JavaScript 6 tutorial…

Functions

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

JS5
6

Fin.

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

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]
> 
```

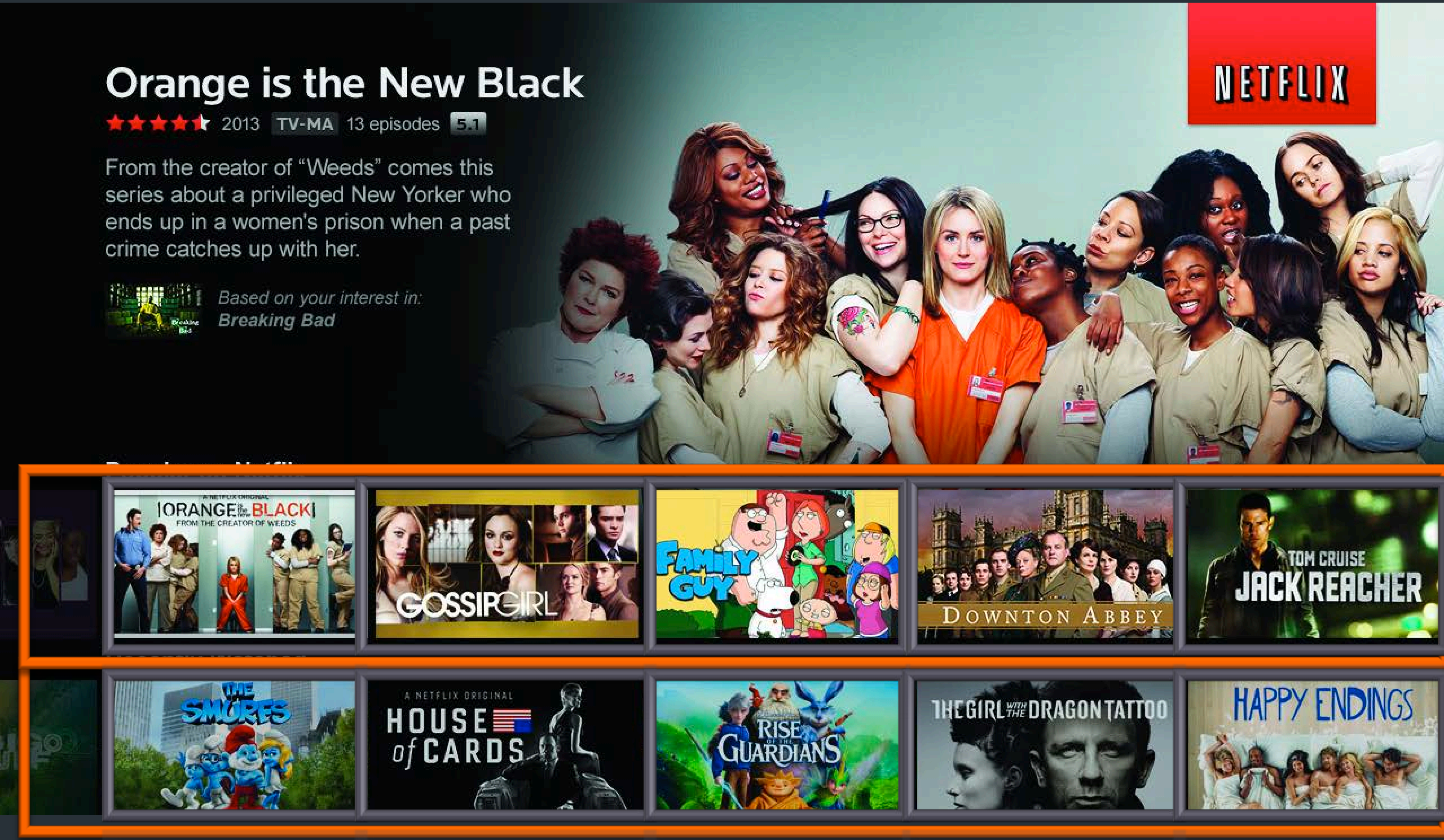
concatAll

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

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));
```

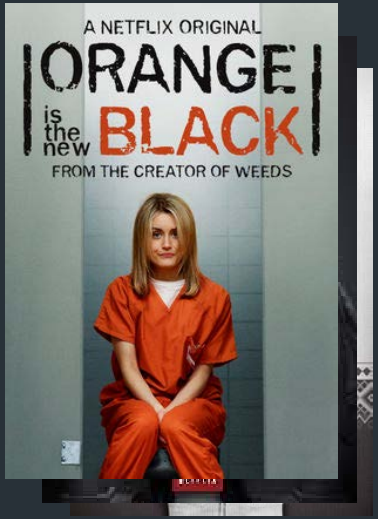
What if I told you…

…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);
```

Introducing Observable

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

Reactive Extensions

- Observable Type + Array Functions (and more)
- Open Source
- Ported to…
  - C
  - C#/VB.Net
  - Javascript
  - Java (Netflix)

Observables can model…

- Events
- Animations
- Async IO

Events to Observables

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

Event Subscription

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

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

Observable.forEach

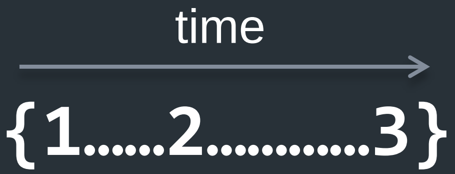
```
// “subscribe”
var subscription =
   mouseMoves.forEach(console.log);

// “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();
```

optional

Observable Literal



ForEach

time $\longrightarrow$

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

Map

$$\xrightarrow{\text{time}}$$

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

> 2

> 🟧

> 🟧

> 🟧
```

Filter

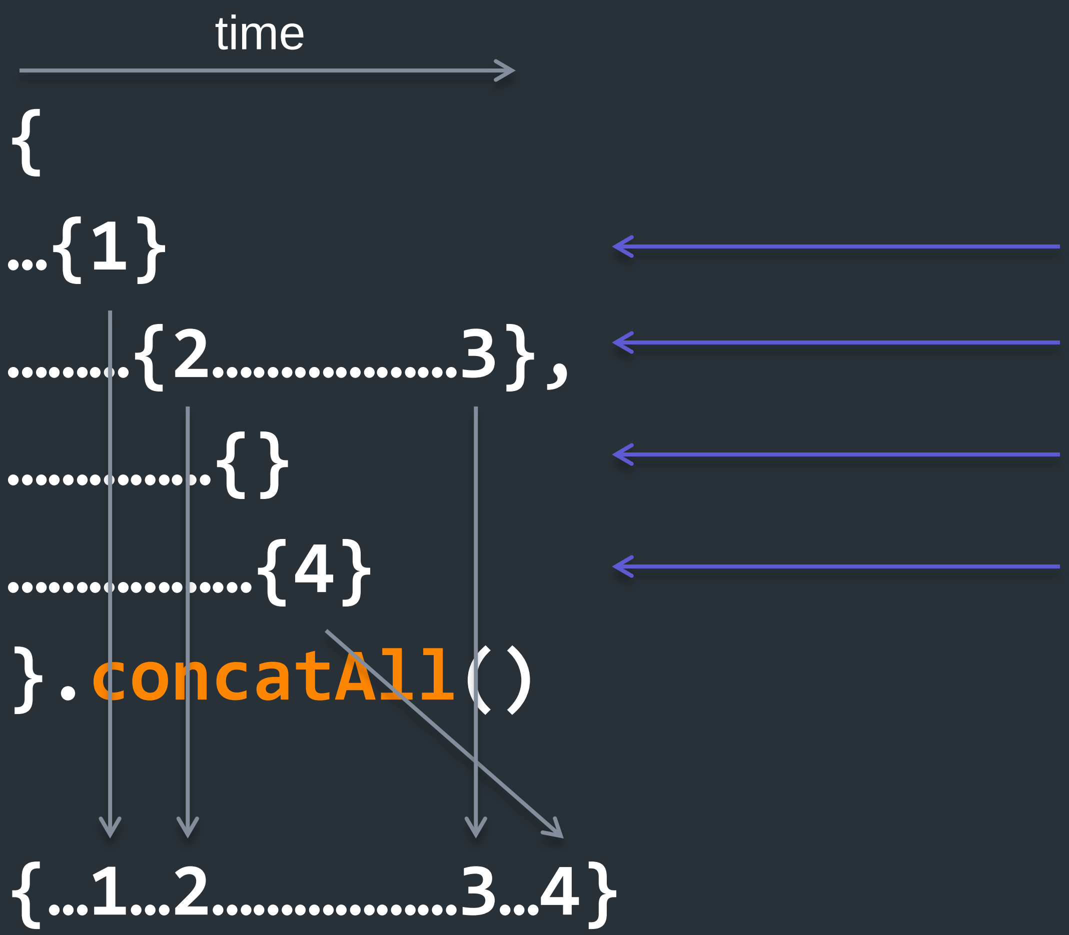
$\xrightarrow{\text{time}}$

```
> {1......2............3}.filter(x => x + 1) ▇

> ▇

> ▇

> ▇
```

concatAll

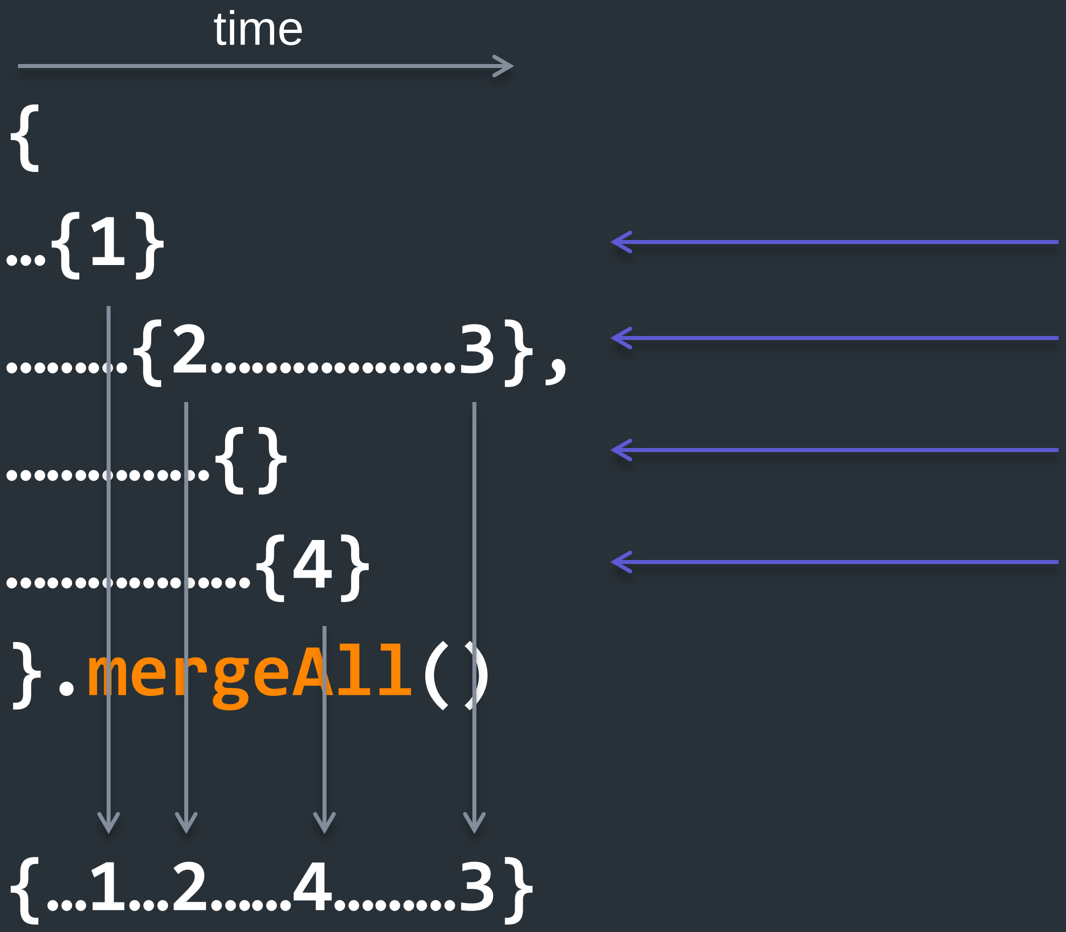
```
[
 [1]
 [2, 3],
 [],
 [4]
].concatAll()

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

concatAll



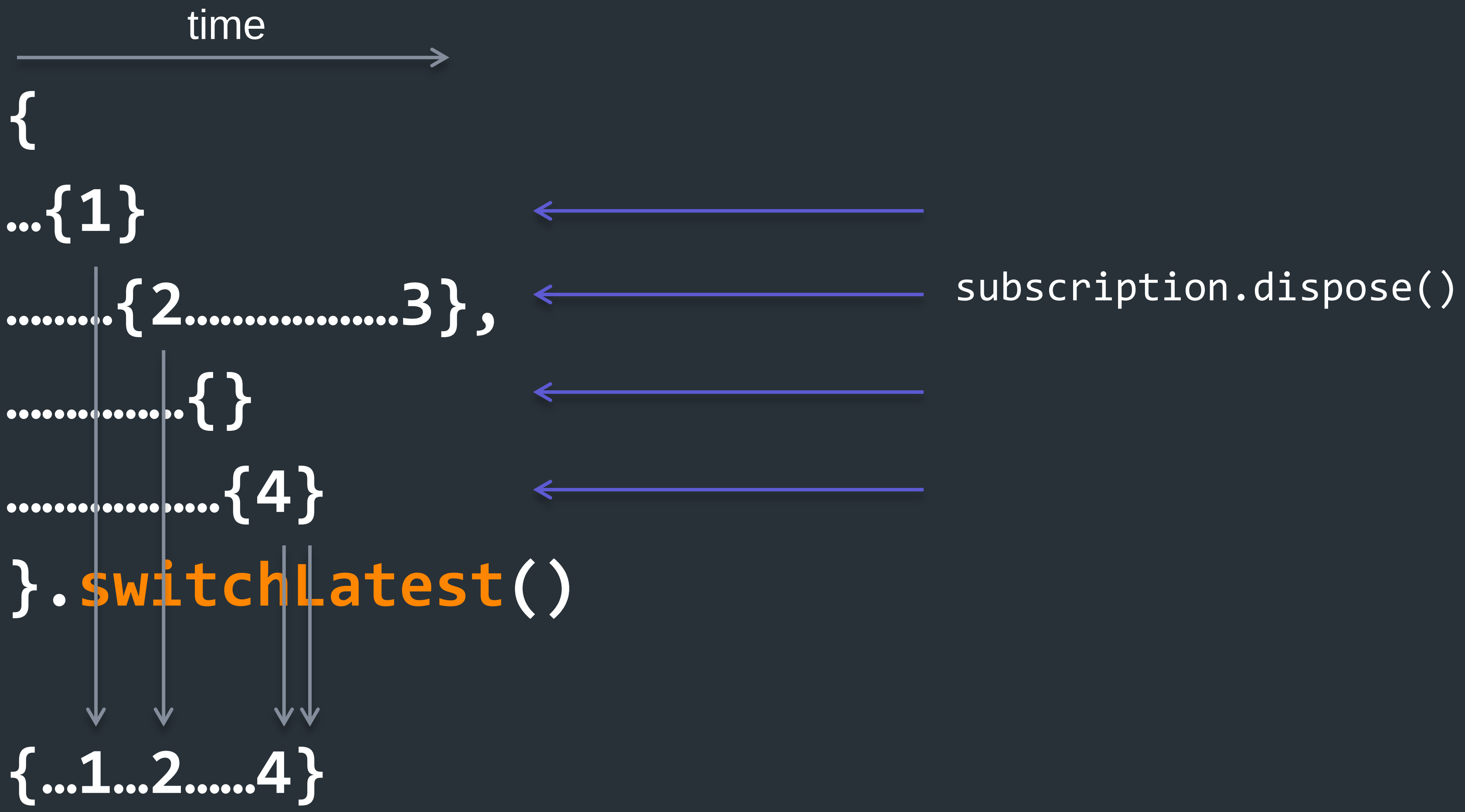
```
{
…{1}
………{2………………3},
…………….{}
……………….{4}
}.concatAll()

{…1…2………………3…4}
```

mergeAll



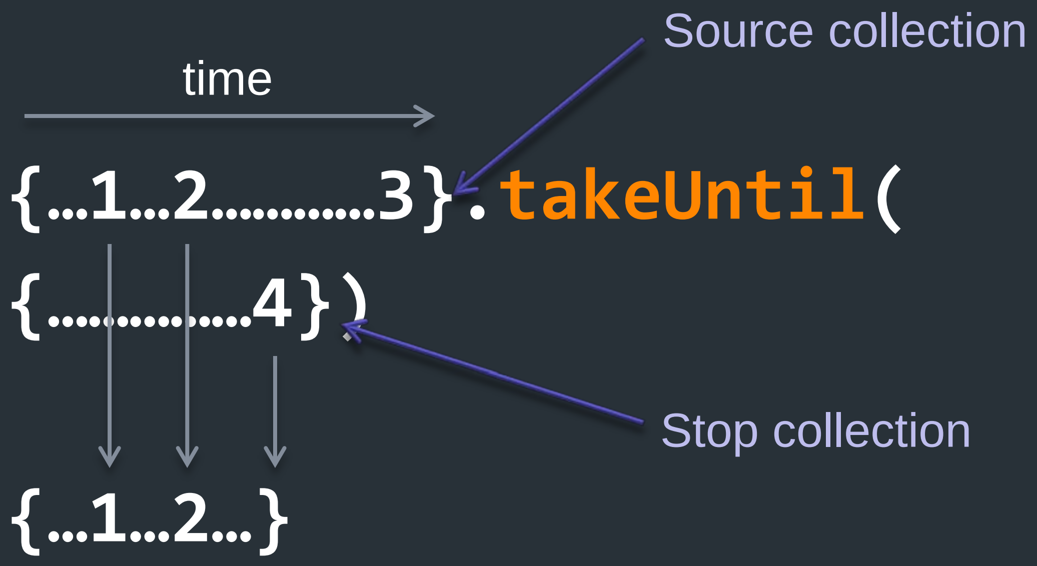
```
{
…{1}
………{2………………3},
…………{}
……………{4}
}.mergeAll()

{…1…2……4………3}
```

switchLatest



```
{
…{1}
………{2……………….3},
…………..{}
……………..{4}
}.switchLatest()

{…1…2……4}
```

TakeUntil



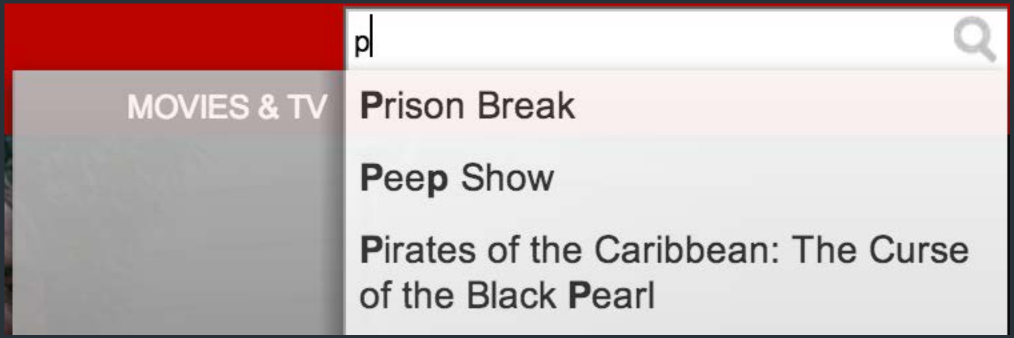
Don’t unsubscribe from Events.

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.”));
```

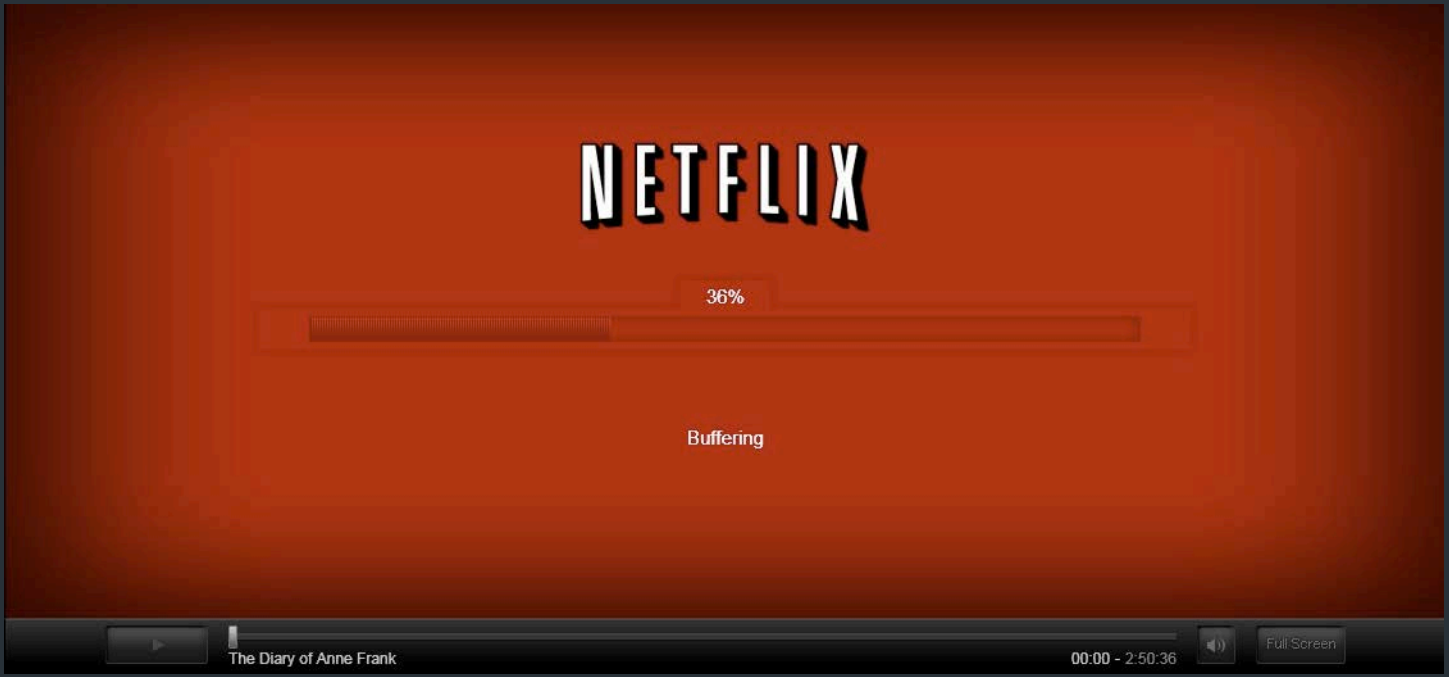
Netflix Search

```
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

ACM: The Learning Continues…

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