Reactive Thinking in Java

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Reactive thinking is not new

Reactive thinking is not new

Бди!

Козьма Прутков ©

Reactive thinking is not new

Microsoft Excel - BudgetForecastsXDemoA

File Edit View Insert Format Tools Data Window Help

Verdana 8

	B	C	D	E	F	G	H	I	J	K	L	M	N
2			Happy Valley Farm										
3	Div./Department			Status	1	Enter 1 for completed status.							
4	Cut Flowers												
5	Happy Valley Farm		Start Date	Completed >	Complete								
6			Jun-06										
7	Unit Sales			Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07	Feb-07	Mar-07
8	Products	Direct Unit Cost	Totals	1	2	3	4	5	6	7	8	9	10
9	Flowers-Export	$0.27	169,000	0	5,000	6,500	7,500	10,000	20,000	20,000	20,000	20,000	20,000
10	Flowers-Local	$0.43	93,200	0	200	3,500	5,500	4,000	8,000	12,000	12,000	12,000	12,000
11	Flowers-Eldoret	$0.81	151,540	0	40	1,500	5,000	10,000	15,000	20,000	20,000	20,000	20,000
12	Revenue 4	$0.00	0	0	0	0	0	0	0	0	0	0	0
13	Revenues 5	$0.00	0	0	0	0	0	0	0	0	0	0	0
14	Total Units		413,740	0	5,240	11,500	18,000	24,000	43,000	52,000	52,000	52,000	52,000
15	Sales	Unit Prices											
16	Flowers-Export	$2.25	$380,250	$0	$11,250	$14,625	$16,875	$22,500	$45,000	$45,000	$45,000	$45,000	$45,000
17	Flowers-Local	$2.95	$274,940	$0	$590	$10,325	$16,225	$11,800	$23,600	$35,400	$35,400	$35,400	$35,400
18	Flowers-Eldoret	$3.45	$522,813	$0	$138	$5,175	$17,250	$34,500	$51,750	$69,000	$69,000	$69,000	$69,000
19	Revenue 4	$0.00	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
20	Revenues 5	$0.00	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
21	Total Sales		$1,178,003	$0	$11,978	$30,125	$50,350	$68,800	$120,350	$149,400	$149,400	$149,400	$149,400
22													
23	Direct Cost of Sales		$208,453	$0	$1,468	$4,475	$8,440	$12,520	$20,990	$26,760	$26,760	$26,760	$26,760
24													
25	Gross Margin		$969,550	$0	$10,510	$25,650	$41,910	$56,280	$99,360	$122,640	$122,640	$122,640	$122,640
26	Gross Margin %		82.3%	0.0%	87.7%	85.1%	83.2%	81.8%	82.6%	82.1%	82.1%	82.1%	82.1%
27													
28	Operating Expenses		$558,977	$24,700	$27,363	$31,415	$35,923	$40,036	$51,526	$58,002	$58,002	$58,002	$58,002
29	Operating Profit/Loss		-$753,566	-$24,700	-$16,853	-$5,765	$5,987	$16,244	$47,834	$64,638	$64,638	$64,638	$64,638
30	Management Charges		$60,624	$0	$1	$2	$3	$4	$5	$6	$7	$8	$9
31	Profit/Loss		$410,507	-$24,700	-$16,854	-$5,767	$5,984	$16,240	$47,829	$64,632	$64,631	$64,630	$64,629
32	Operating Margin %		34.85%	0.00%	-140.77%	-19.14%	11.88%	23.61%	39.74%	43.26%	43.26%	43.26%	43.26%
33													
34				Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07	Feb-07	Mar-07
35	Variable Costs Budget	22.29%	Totals										
36	Variable Costs	Variable %	$262,575	$0	$2,663	$6,715	$11,223	$15,336	$26,826	$33,302	$33,302	$33,302	$33,302

License / Welcome / Capacities / Introduction / Excel / Set Up / **Year One** / Years 2-3 / Years 4-10

Ready

The reactive style app

- Message-driven - components communicates via notifications
- Non-imperative - the app logic is coded in async, non-blocking, composable functions
- The data moves through your app's algorithm

www.reactivemanifesto.org

Java concurrency

- Blocking I/O is the problem

- `Future.get()`
  - blocks till all threads are complete

- `CompletableFuture.supplyAsync(task).thenAccept(action)`
  - what if the tasks need to fetch millions of records?

Some open-source Rx libraries

http://reactivex.io

- RxJava
  - RxAndroid, RxJavaFX, RxSwing
- Rx.NET, RxCpp, RxJS, Rx.rb, Rx.py, RxSwift, RxScala, RxPHP

JDK 9 will include reactive streams in java.util.concurrent.Flow

Main RxJava players

- **Observable** - producer of data
- **Observer** - consumer of observable sequences
- **Subscriber** - connects observer with observable
- **Operator** - en-route data transformation
- **Scheduler** - multi-threading support

Java Iterable: a pull

```
beers.forEach(brr -> {
            if ("USA".equals(brr.country)){
                americanBeers.add(brr);
            }
        });
```

Java 8 Stream: a pull

```
beers.stream()
        .skip(1)
        .limit(3)
        .filter(b -> "USA".equals(b.country))
        .map(b -> b.name + ": $" + b.price)
        .forEach(beer -> System.out.println(beer));
```

A fool with a tool is still a fool

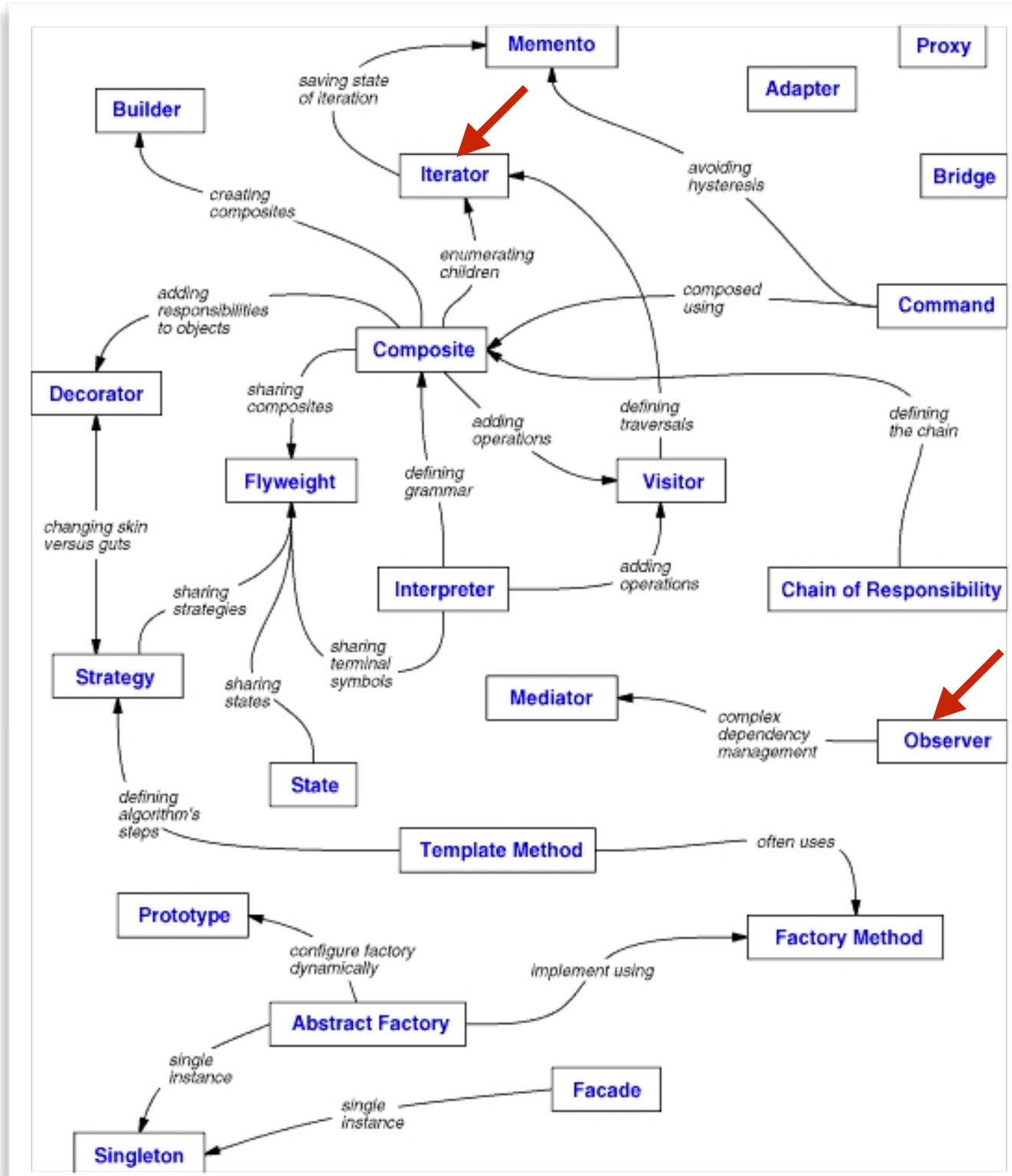
Американская народная мудрость

A fool with a tool is still a fool

Американская народная мудрость

A pull with a tool is still a pull

Observable is an Iterable inside out



Word	Antonym
Iterable	Observable
Iterator	Observer
Pull	Push

Data Flow

Data Source

Data Flow

Observable

Data Source

Data Flow

Observable

Data Source

Data Flow

Observer

Subscriber

Observable

Data Source

Data Flow

Observer

Subscriber

Observable

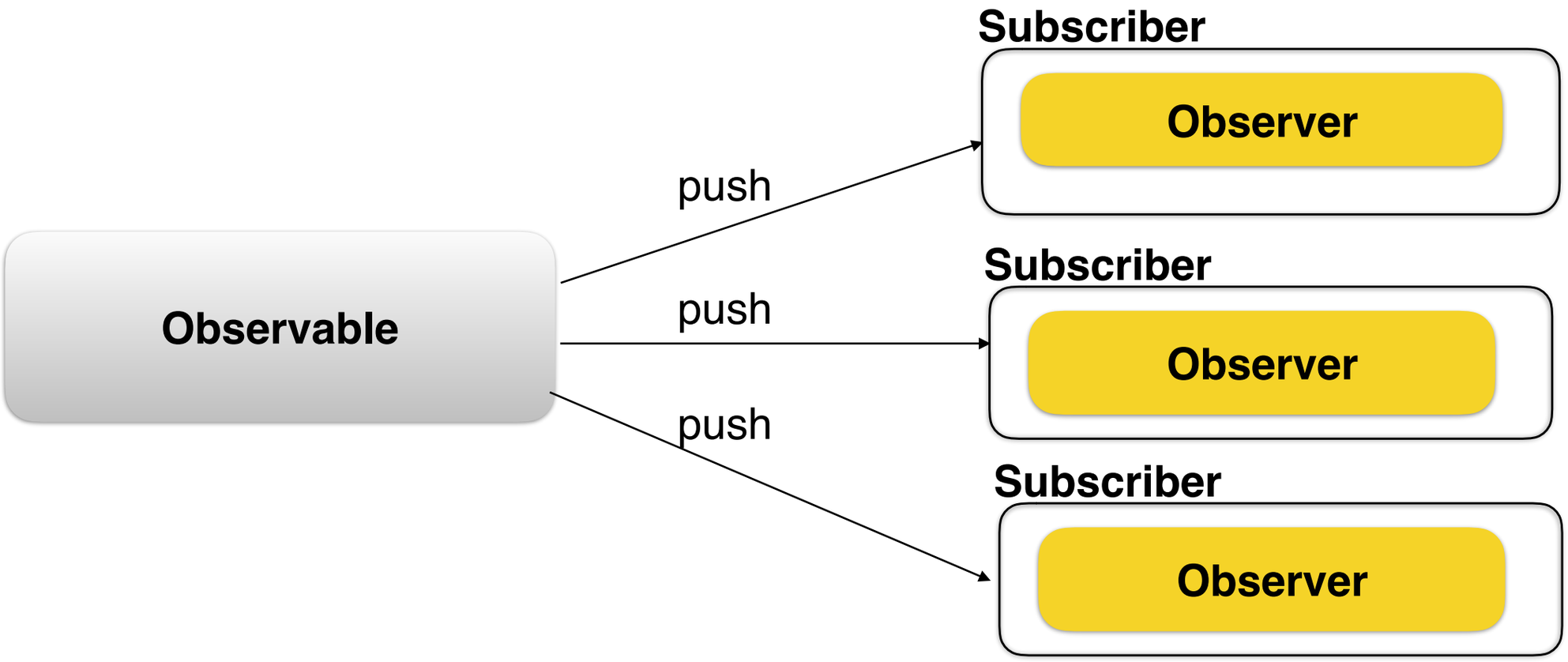
Data Source

onNext()

onError()

onCompleted()

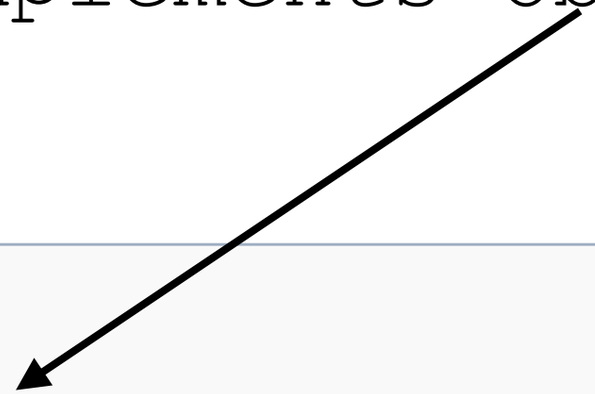
Event-driven push



Subscribe to messages from Observable and handle them by Observer

```
Observable.subscribe(Subscriber)

class Subscriber implements Observer {}
```



Method Summary

Methods

Modifier and Type	Method and Description
void	**onCompleted**() Notifies the Observer that the **Observable** has finished sending push-based notifications.
void	**onError**(java.lang.Throwable e) Notifies the Observer that the **Observable** has experienced an error condition.
void	**onNext**(**T** t) Provides the Observer with a new item to observe.

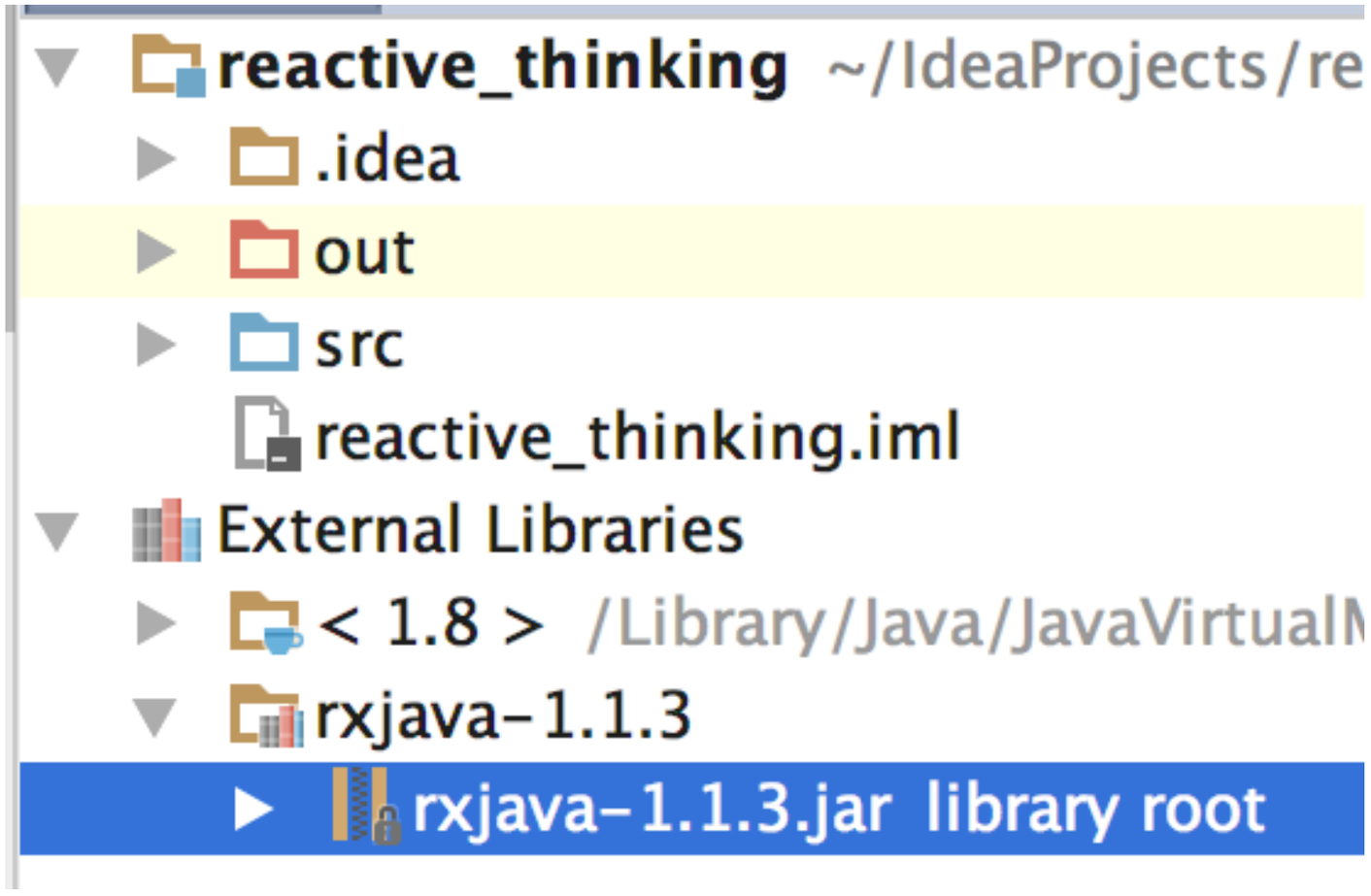
Rx Observable: a push

```
observableBeer
        .skip(1)
        .take(3)
        .filter(b -> "USA".equals(b.country))
        .map(b -> b.name + ": $" + b.price)
        .subscribe(
                beer -> System.out.println(beer),
                err -> System.out.println(err),
                () -> System.out.println("Streaming is complete")
);
```

Demo

HelloObservable

Get rxjava.jar on http://search.maven.org



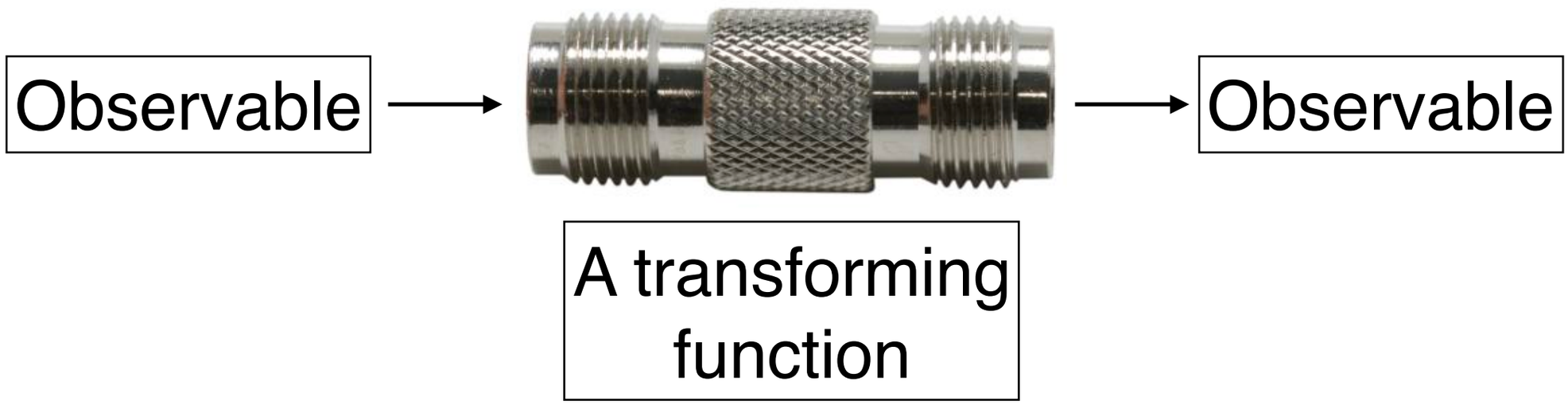
A pure function

- Produces no side effects
- The same input always results in the same output
- Doesn’t modify the input
- Doesn’t rely on the external state

A higher-order function can:

- Take one or more functions as argument(s)
- Return a function

An Operator



An Operator


```
observableBeer
        .filter(b -> "USA".equals(b.country))
```

An Operator

Observable →  → Observable

A transforming function

pure function

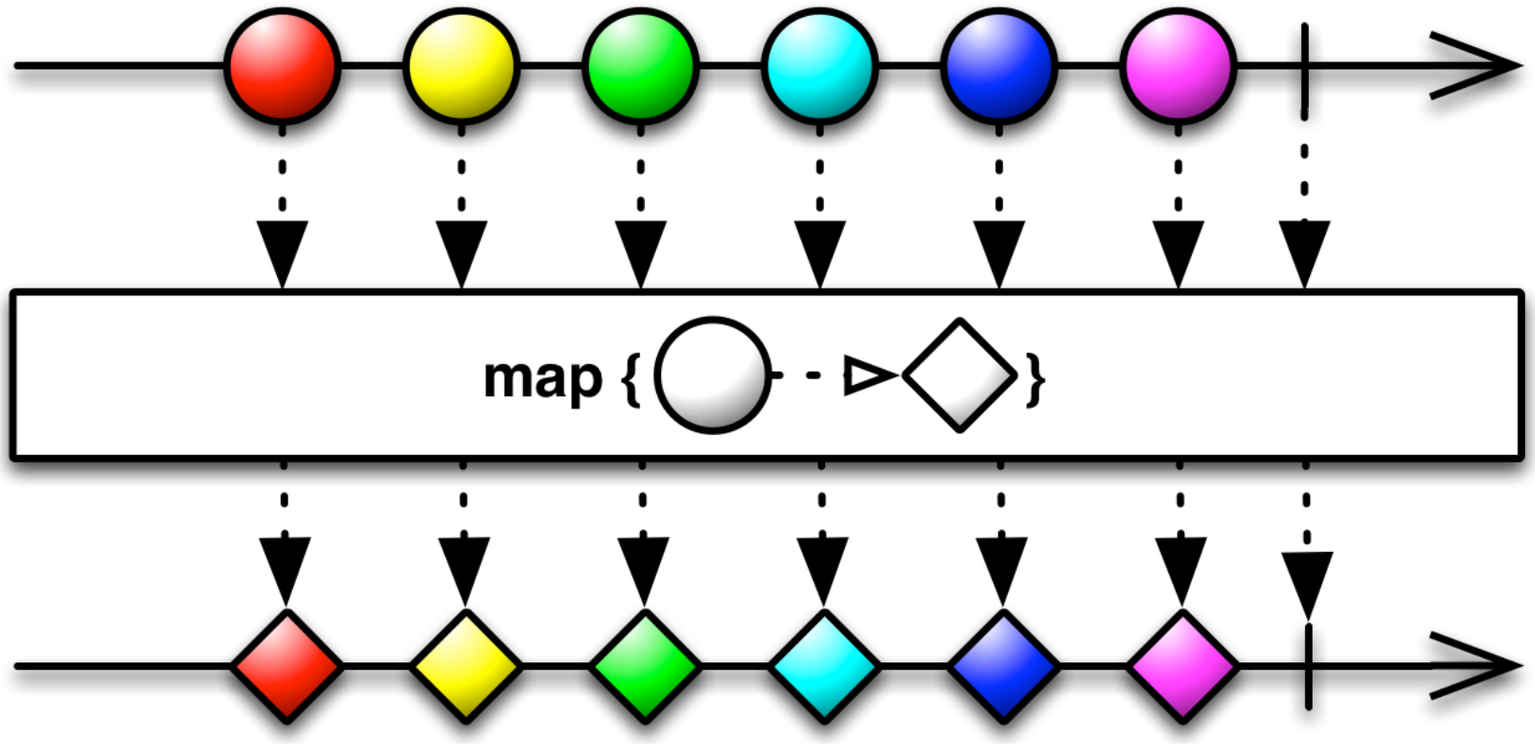
```
observableBeer
        .filter(b -> "USA".equals(b.country))
```

An operator is a higher-order function

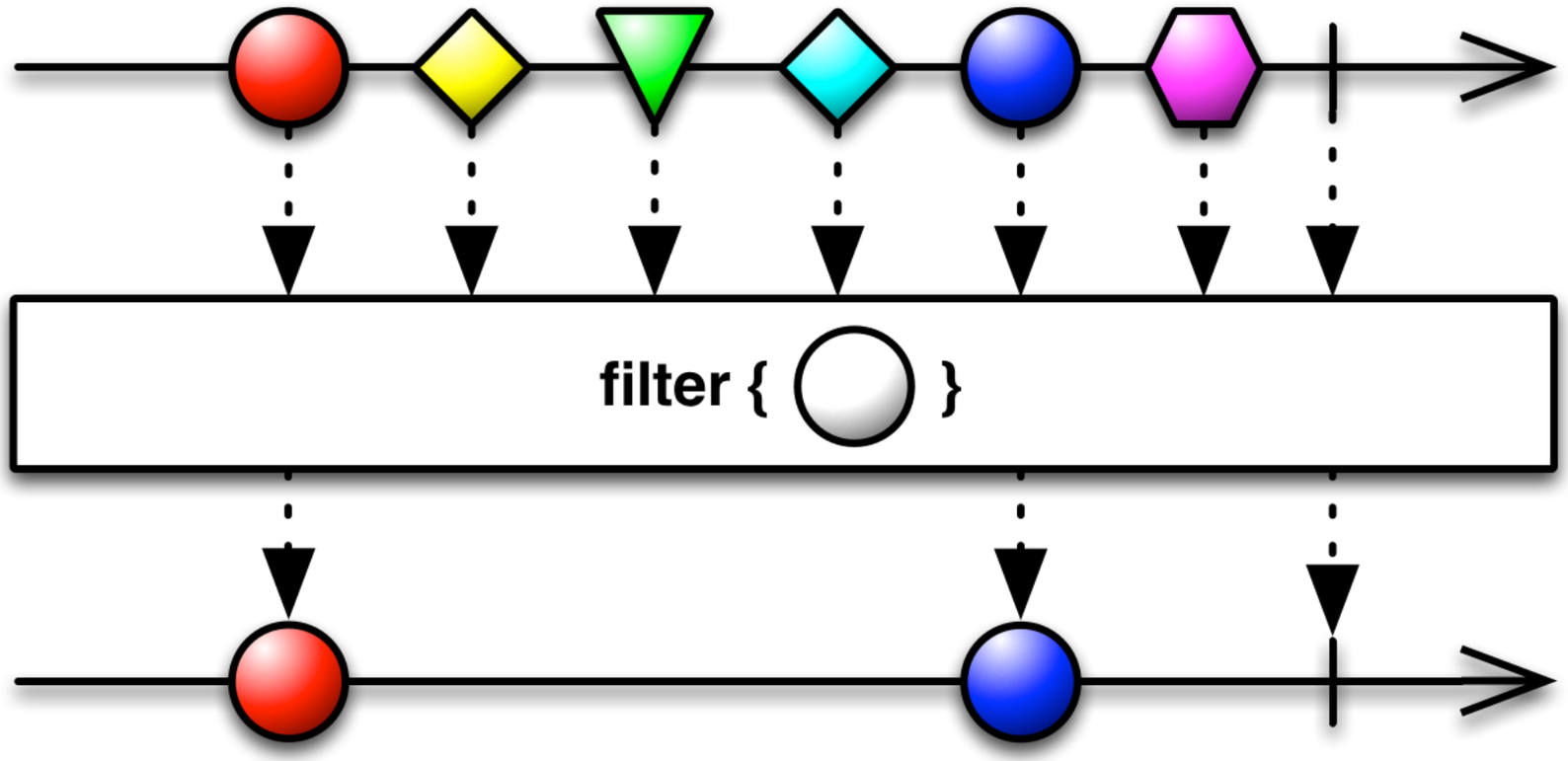
Marble Diagrams

http://rxmarbles.com

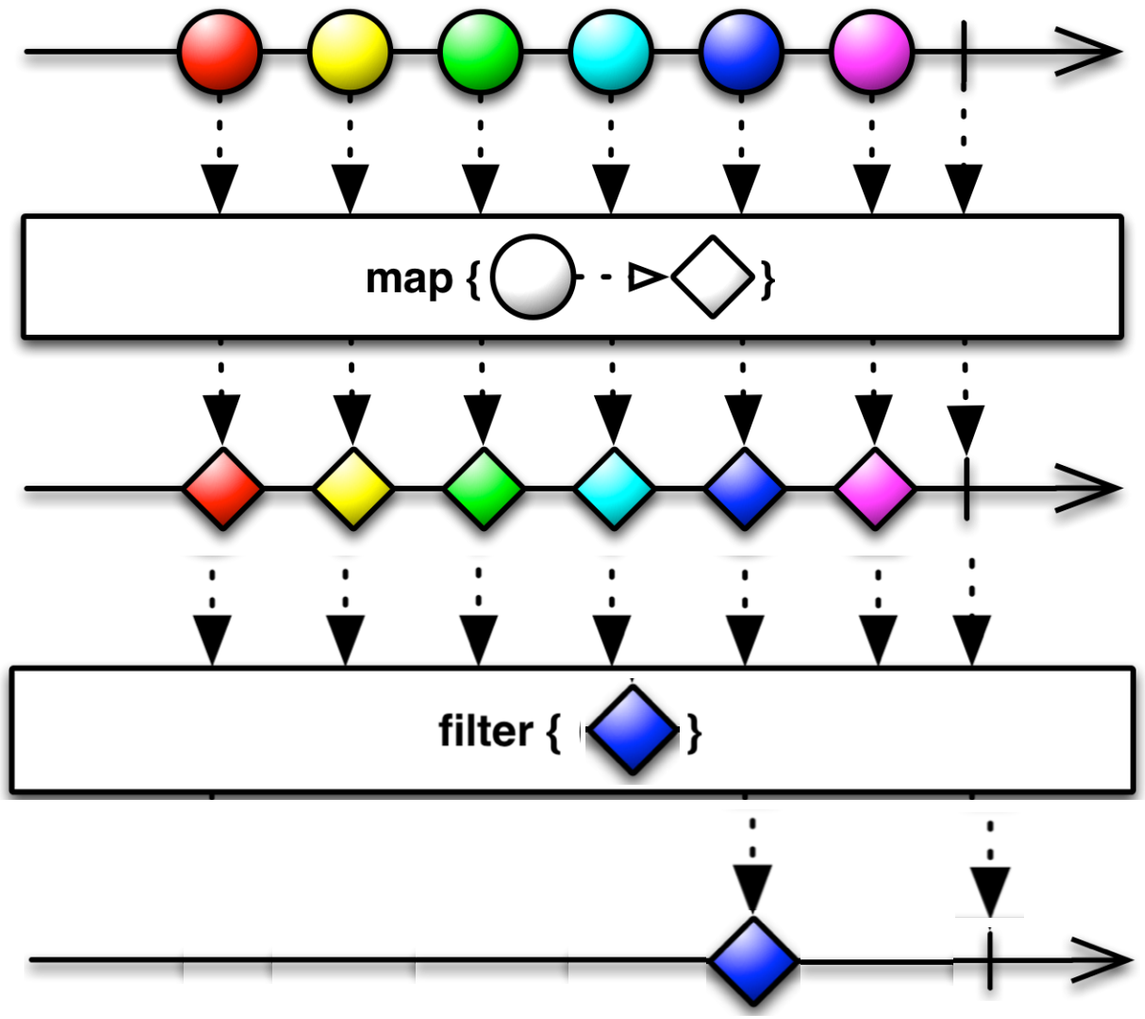
Observable map(function){}



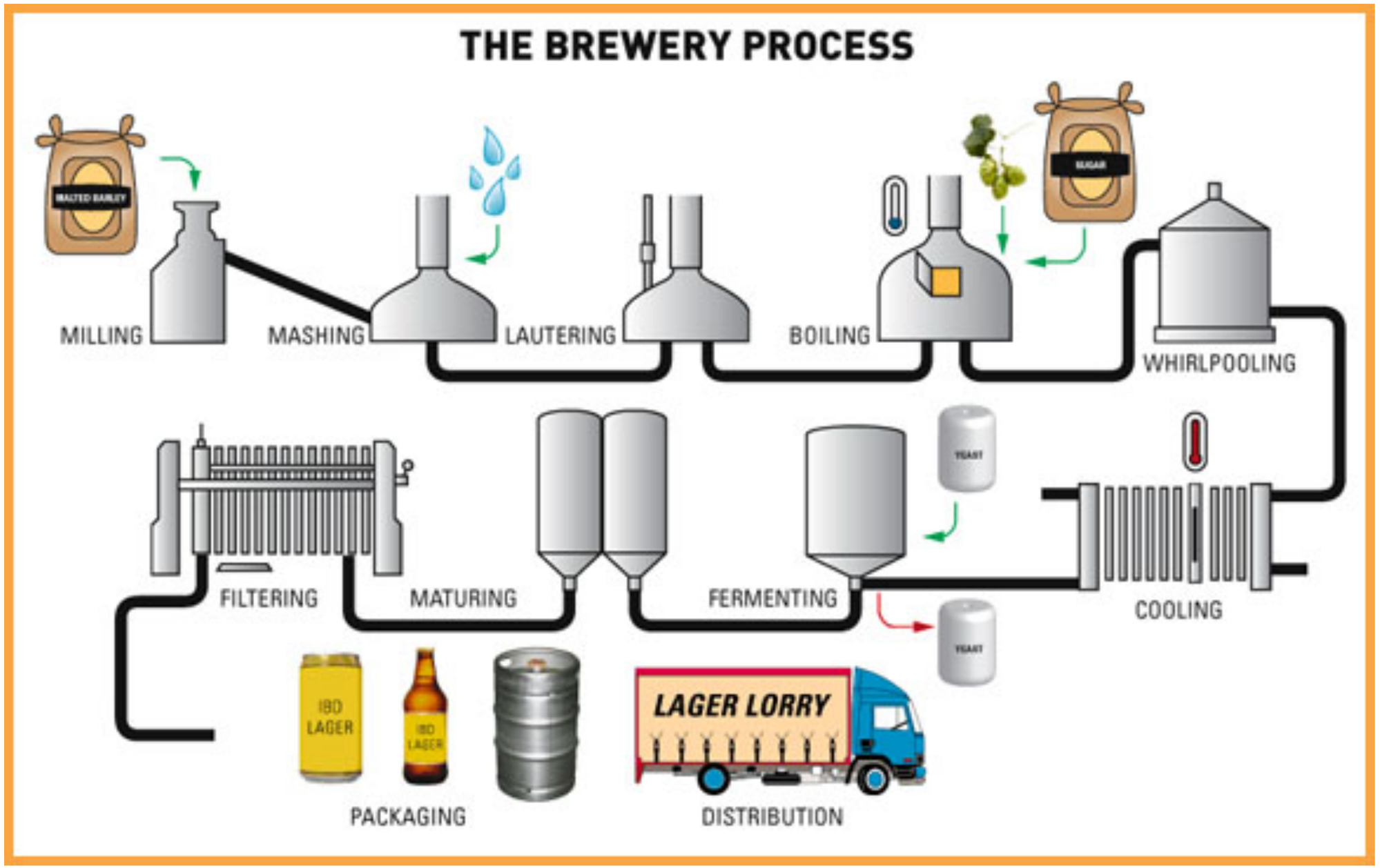
Observable filter(function){}



Operator chaining: map and filter



RX: the data moves across your algorithm



Operator

Operator

Operator

Operator

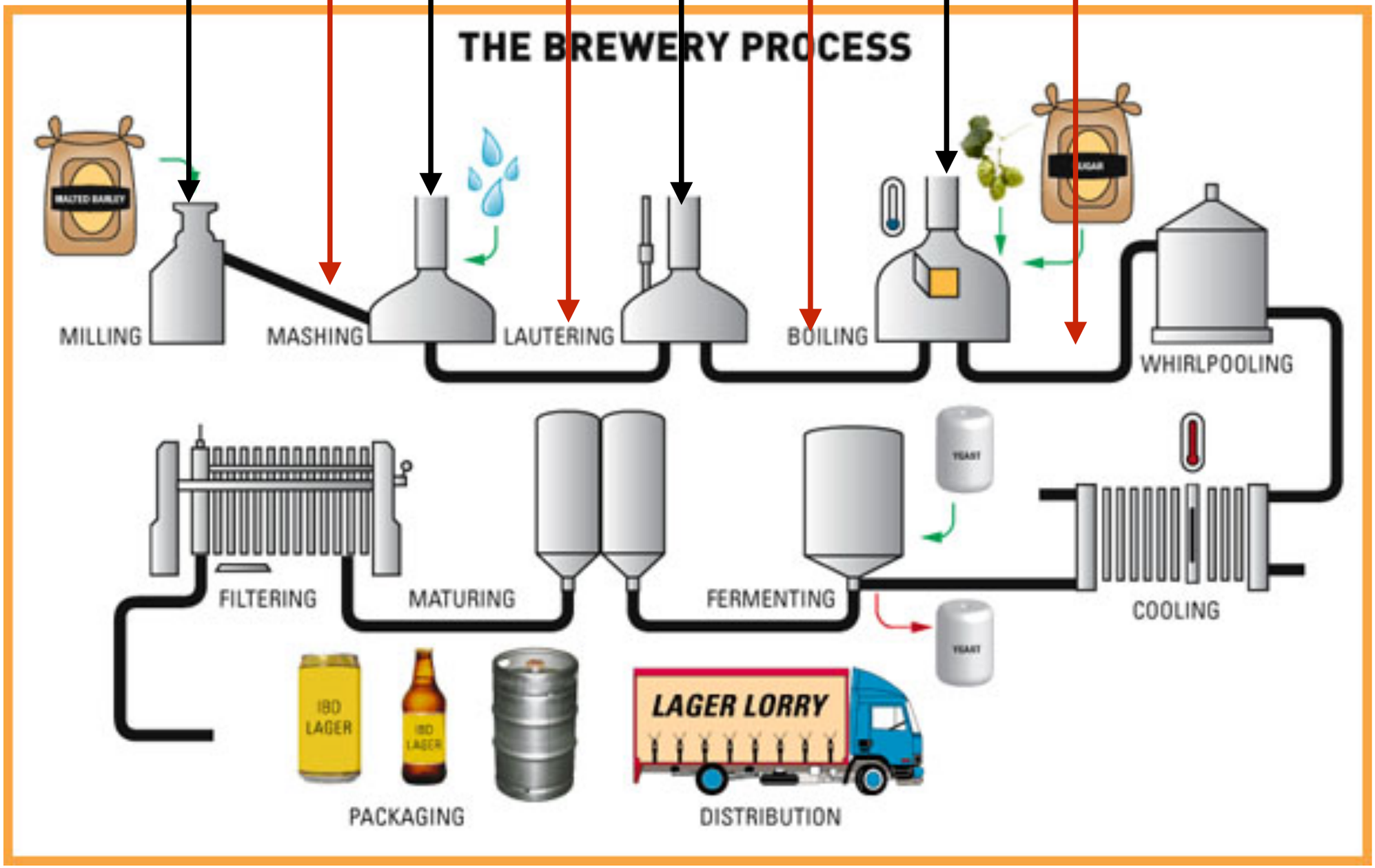
Observable

Observable

Observable

Observable

Observable



Creating an Observable

- Observable.create() - returns Observable that can invoke methods on Observer
- Observable.from() - converts an Iterable or Future into Observable
- Observable.fromCallable() - converts a Callable into Observable
- Observable.empty() - returns empty Observable that invokes onCompleted()
- Observable.range() - returns a sequence of integers in the specified range
- Observable.just() - converts up to 10 items into Observable

Demo

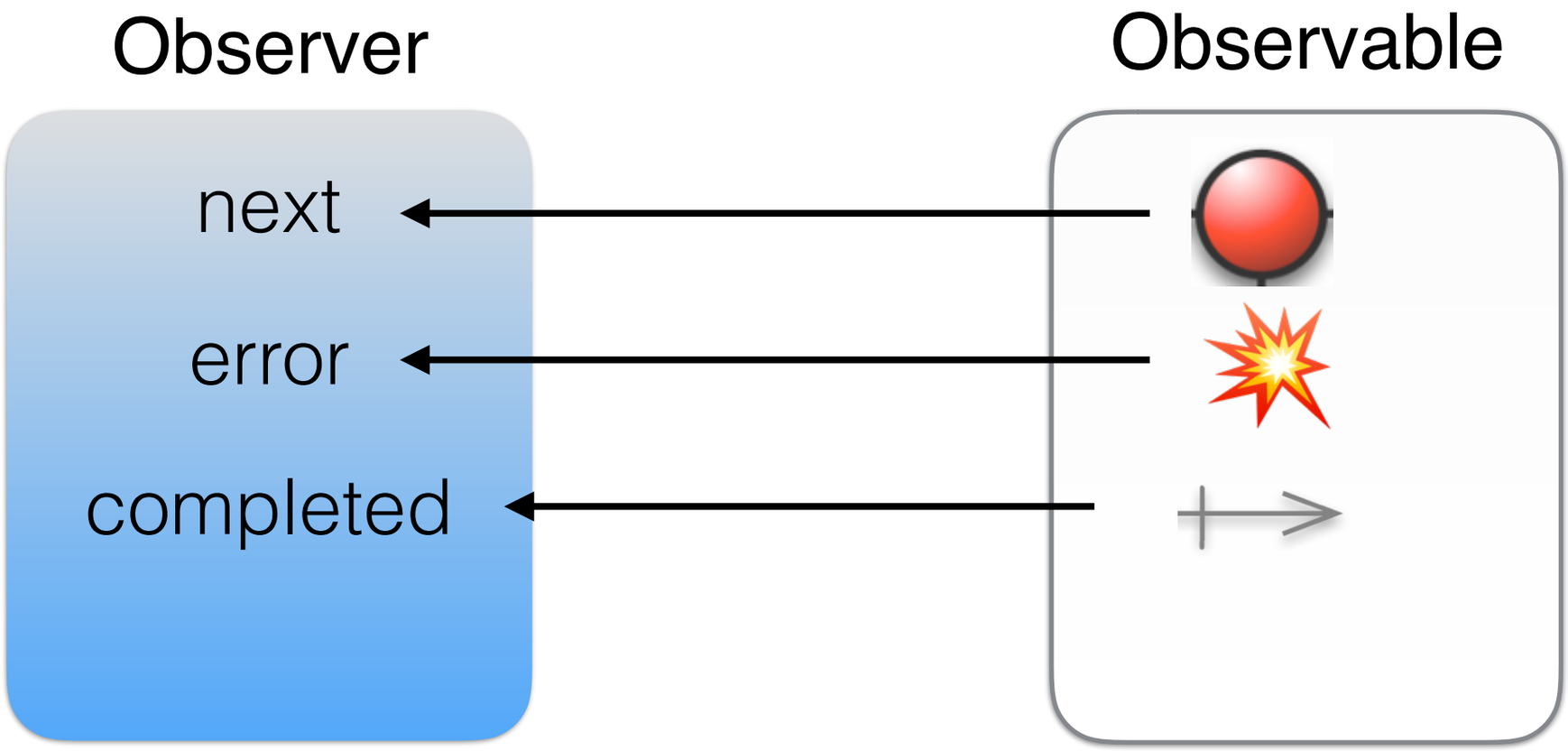
BeerClient

Functions with side effects

Affect environment outside the function.

- doOnNext()
- doOnError()
- doOnCompleted()
- doOnEach()
- doOnSubscribe()

Error Handling



Error-handling operators

- Errors sent using **onError()** kill the subscription

- **retryWhen()** - intercept, anylize the error, resubscribe

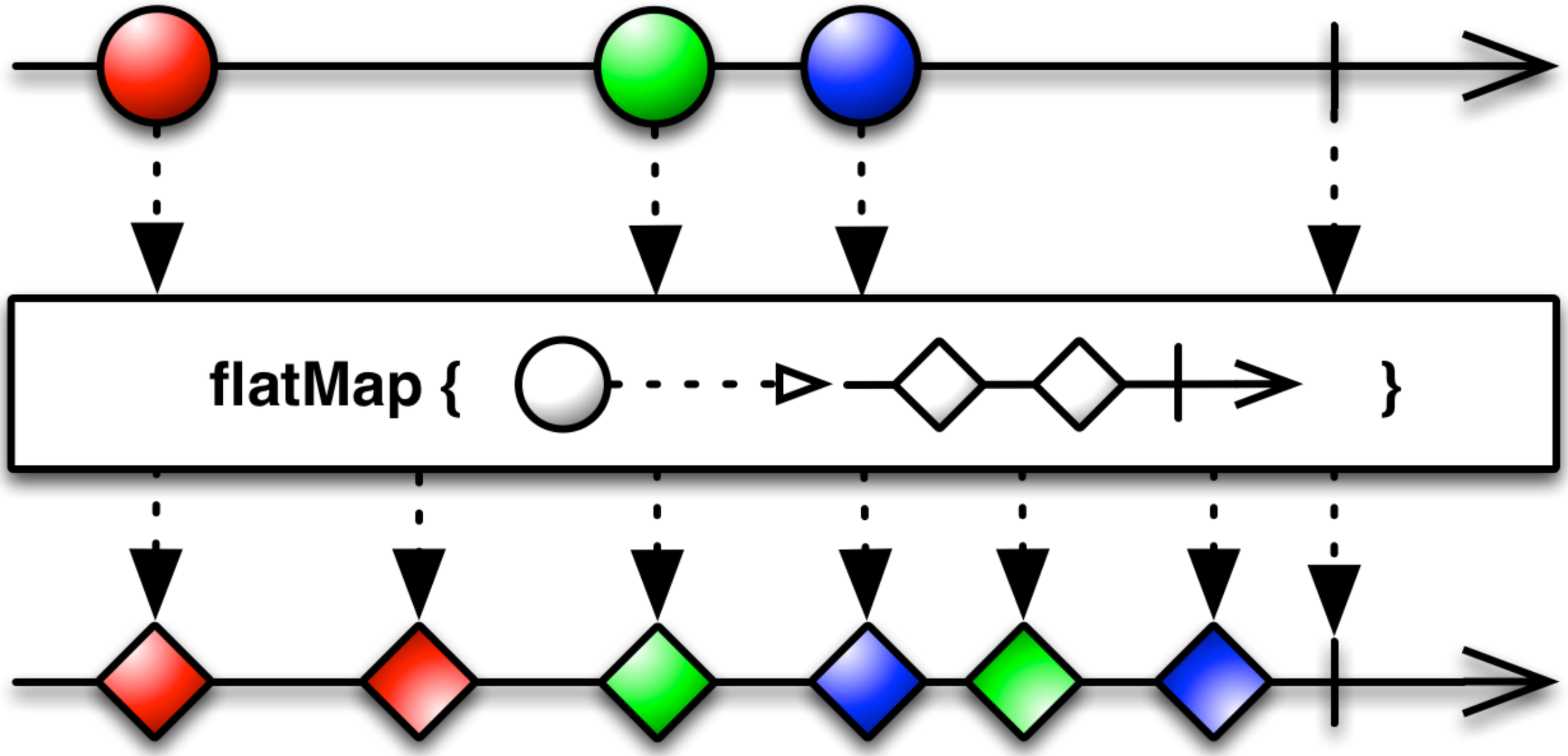
- onErrorResumeNext() - used for failover to another Observable

- onResumeReturn() - returns an app-specific value

Demo

BeerClientWithFailover

The flatMap() operator

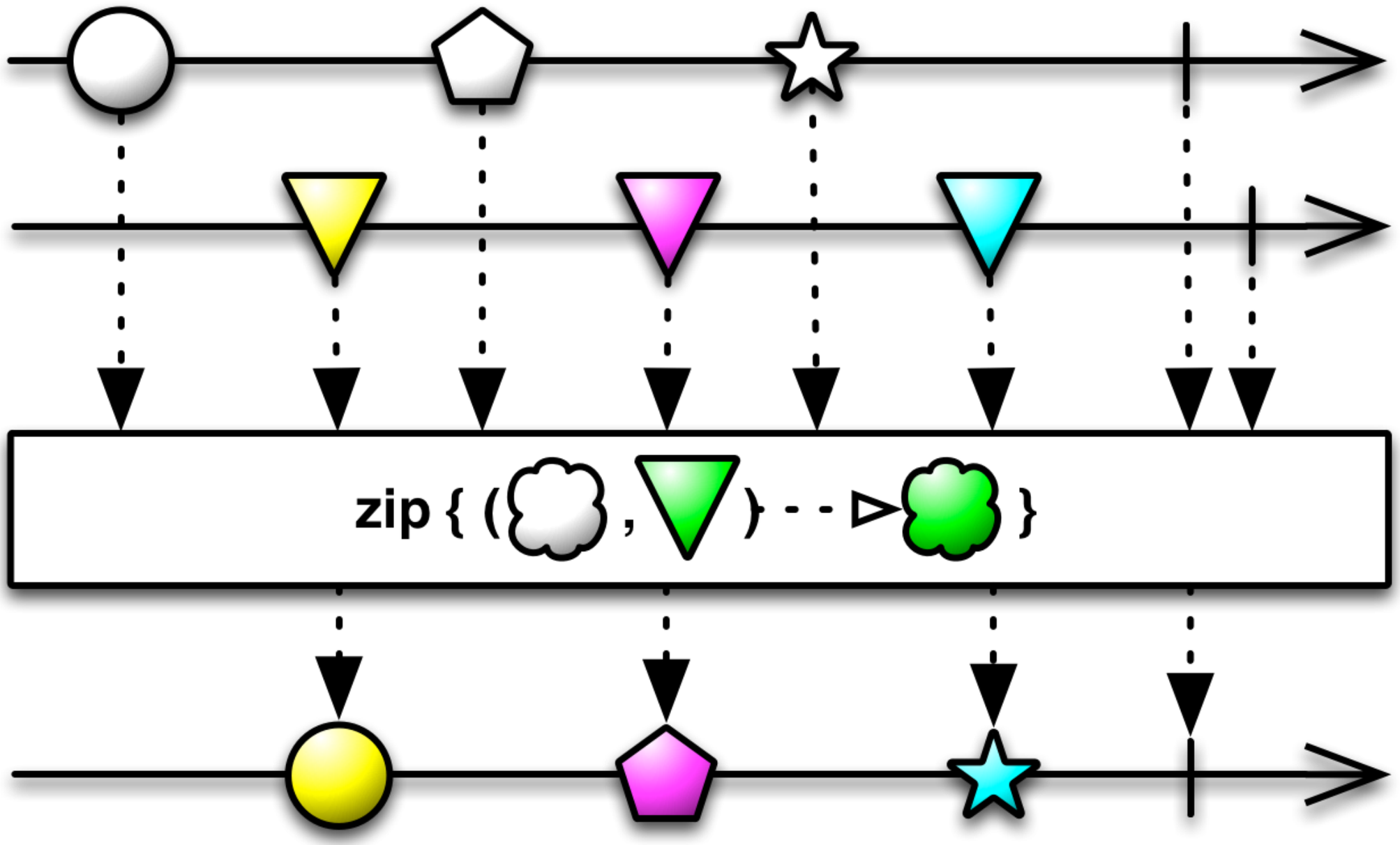


Observable.flatMap()

Demo

composingObservables
ObservableDrinks

The zip() operator



Think Netflix

- take(10) - get a list of lists of videos (the first 10)
- flatmap() - turn them into one list of videos
- map() - for each video make nested calls to get some observable metadata (ratings, reviews, etc.)
- zip() - combine observables into a a video object
- observeOn() - switch to the UI thread and render the videos

Schedulers

Schedulers

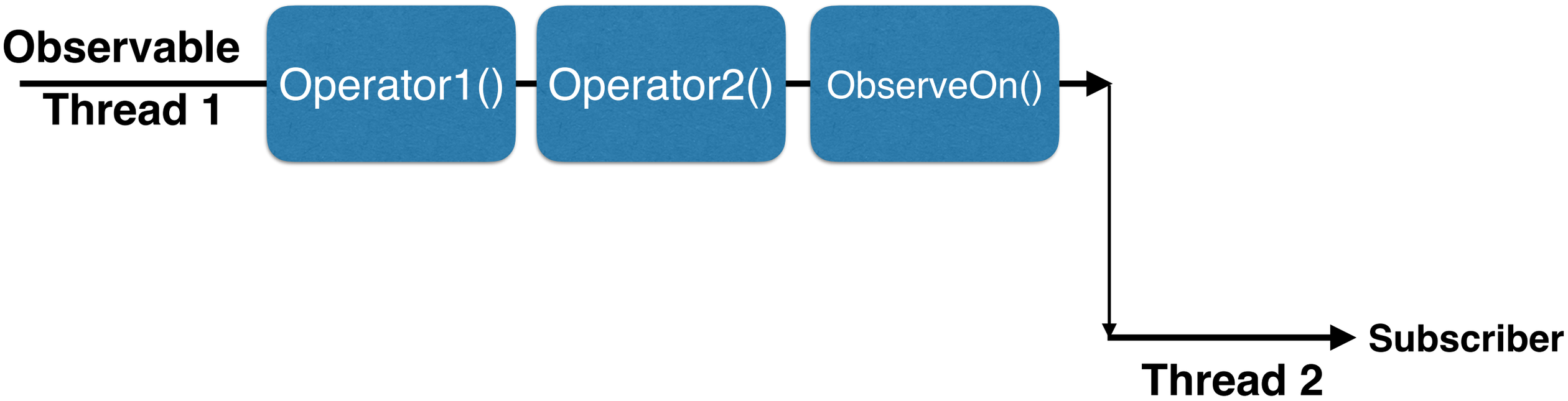
Concurrency with Schedulers

- An observable stream is single-threaded by default
- `subscribeOn(strategy)` - run **Observable** in a separate thread
- `observeOn(strategy)` - run **Observer** in a separate thread

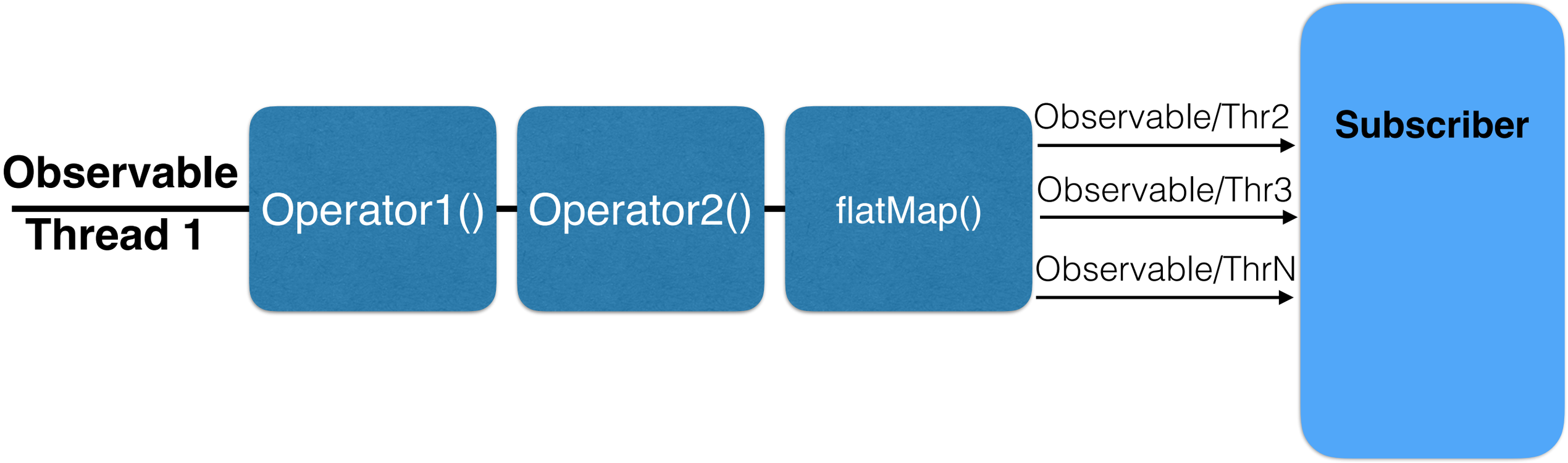
Multi-threading strategies

- Schedulers.computation() - for computations: # of threads <= # of cores
- Schedulers.io() - for long running communications; backed by a thread pool
- Schedulers.newThread() - new thread fo each unit of work
- Schedulers.from(Executor) - a wrapper for Java Executor
- Scedulers.trampoline() - queues the work on the current thread
- AndroidSchedulers.mainThread() - handle data on the main thread (RxAndroid)

Switching threads



Parallel processing



Demo

schedulers/SubscribeOnObserveOn
schedulers/ParallelStreams

Hot and cold observables

- **Cold:** emits items only when someone subscribes to it
- **Hot:** emits items when it's created regardless if there is a subscriber or not

Backpressure

- **Throttling**: sample(), throttleFirst(), debounce()
- **Buffers**: buffer()
- **Window**: window(n)
- **Reactive pull**: Subscriber.request(n)

https://github.com/ReactiveX/RxJava/wiki/Backpressure

Http and Observables

```
class AppComponent {

  products: Array<string> = [];

  constructor(private http: Http) {

    this.http.get('http://localhost:8080/products')
        .map(res => res.json())
        .subscribe(
            data => {
                this.products=data;
            },
            err =>
              console.log("Can't get products. Error code: %s, URL: %s ",
                                                    err.status, err.url),
            () => console.log('Product(s) are retrieved')
        );
  }
}
```

Observer

Http and Observables

```
class AppComponent {

  products: Array<string> = [];

  constructor(private http: Http) {

    this.http.get('http://localhost:8080/products')
        .map(res => res.json())
        .subscribe(
          data => {
            this.products=data;
          },
          err =>
            console.log("Can't get products. Error code: %s, URL: %s ",
                                                    err.status, err.url),
          () => console.log('Product(s) are retrieved')
        );
  }
}
```

Observer

This code is from an Angular 2 app written in TypeScript

The switchMap operator

Observable 1

Observable 2

```
this.searchInput.valueChanges
        .debounceTime(200)
        .switchMap(city => this.getWeather(city))
        .subscribe(
            res => {
              if (res['cod'] === '404') return;
              if (!res.list[0]) {
                 this.temperature ='City is not found';
              } else {
                this.temperature =
                    `Current temperature is  ${res.list[0].main.temp}F, ` +
                    `humidity: ${res.list[0].main.humidity}%`;
              }
            },
            err => console.log(`Can't get weather. Error code: %s, URL: %s`, err.message, err.url),
            () => console.log(`Weather is retrieved`)
        );
}

getWeather(city): Observable<Array> {
  return this.http.get(this.baseWeatherURL + city + this.urlSuffix)
    .map(res => res.json());
}
```

This code is from an Angular 2 app written in TypeScript

Links

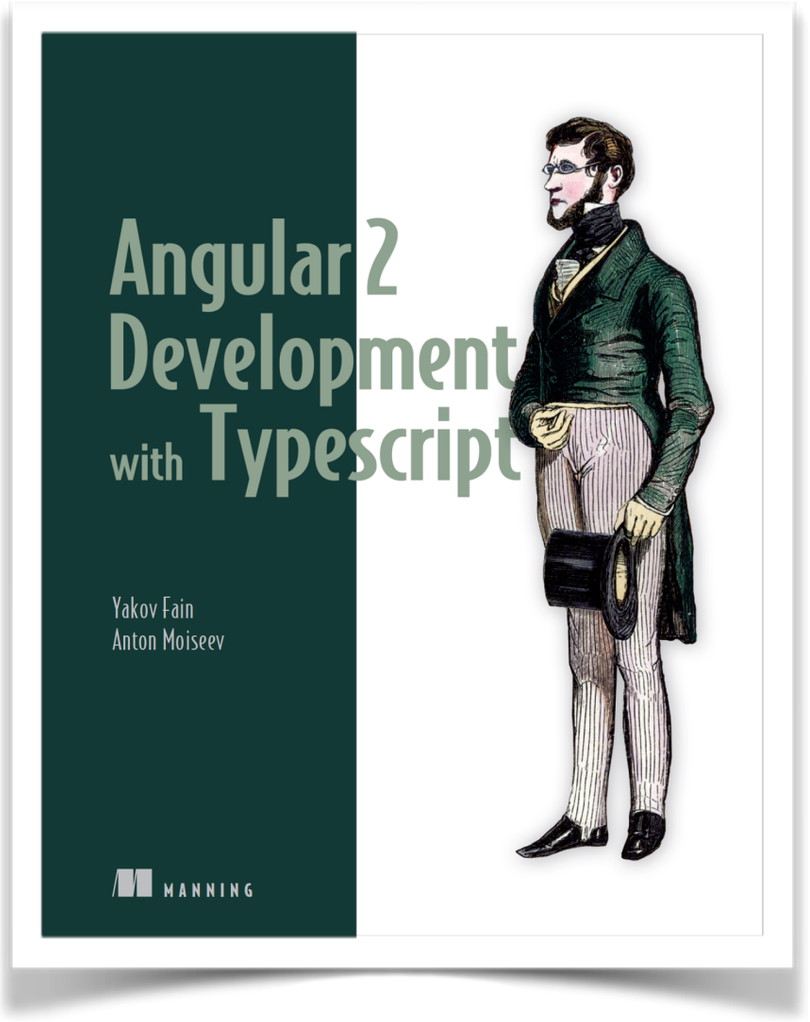
- Code samples and slides:

  https://github.com/yfain/rxjava

- Our company: faratasystems.com

- Blog: yakovfain.com

- Twitter:@yfain



discount code: faindz