Functional Reactive Programming on iOS

Problem

Apps contain multiple layers of state, state propagation is error prone

Becomes complicated quickly e.g. UITableViewController...

Model
State of properties

Controller
State of user interaction

View
State of subviews

$$\begin{tikzcd} & \text{Controller} \arrow[dr, bend left] & \\ \text{Model} \arrow[ur, bend left] & & \text{View} \end{tikzcd}$$

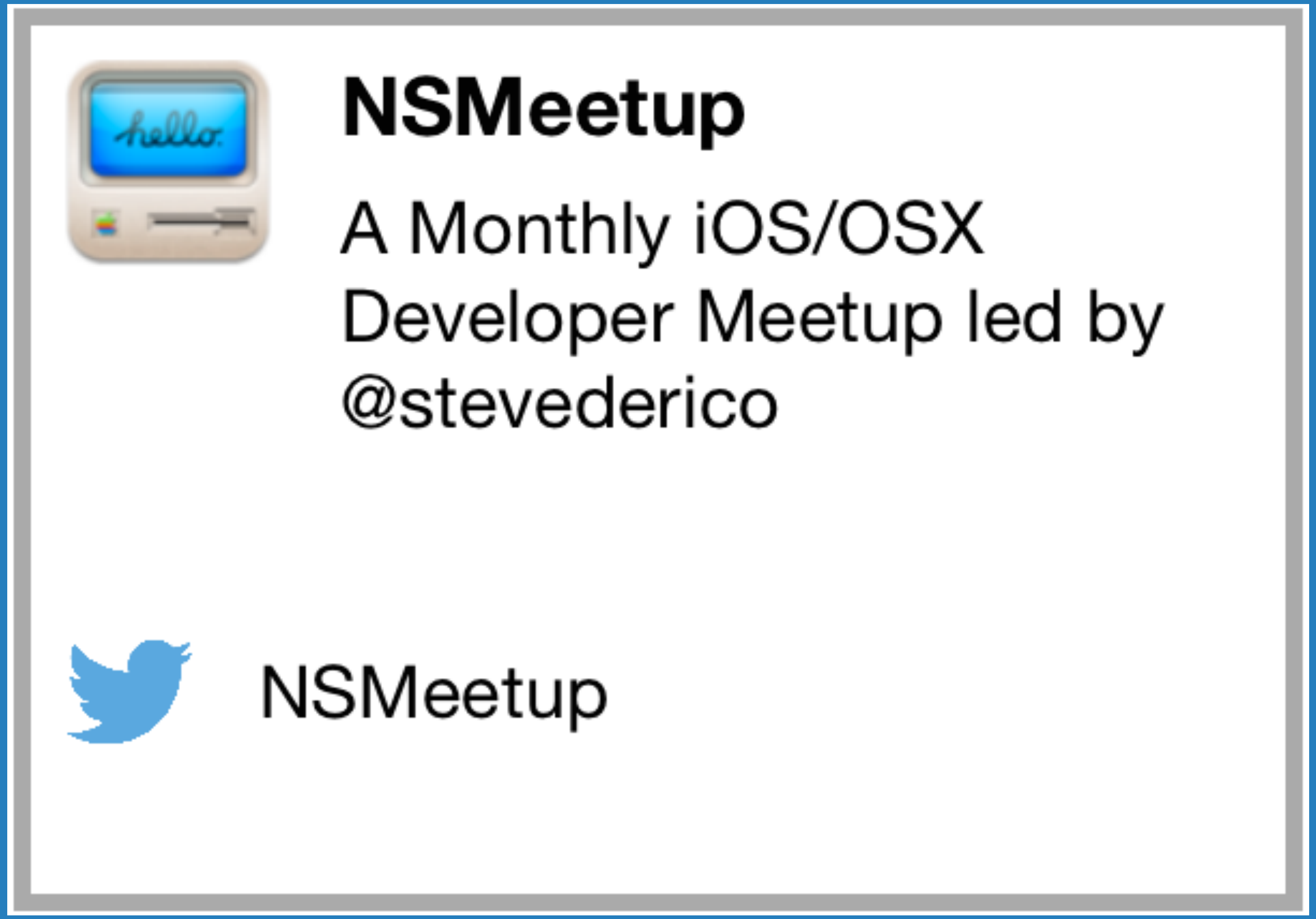
Controller
Fetches a model

Model

View
Renders the current state of model

With an immutable model this approach is simple

Model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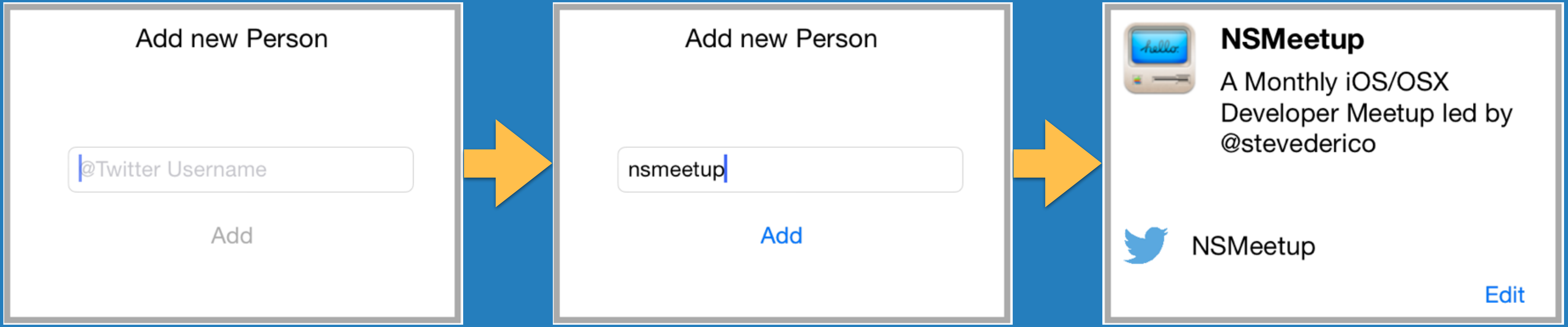
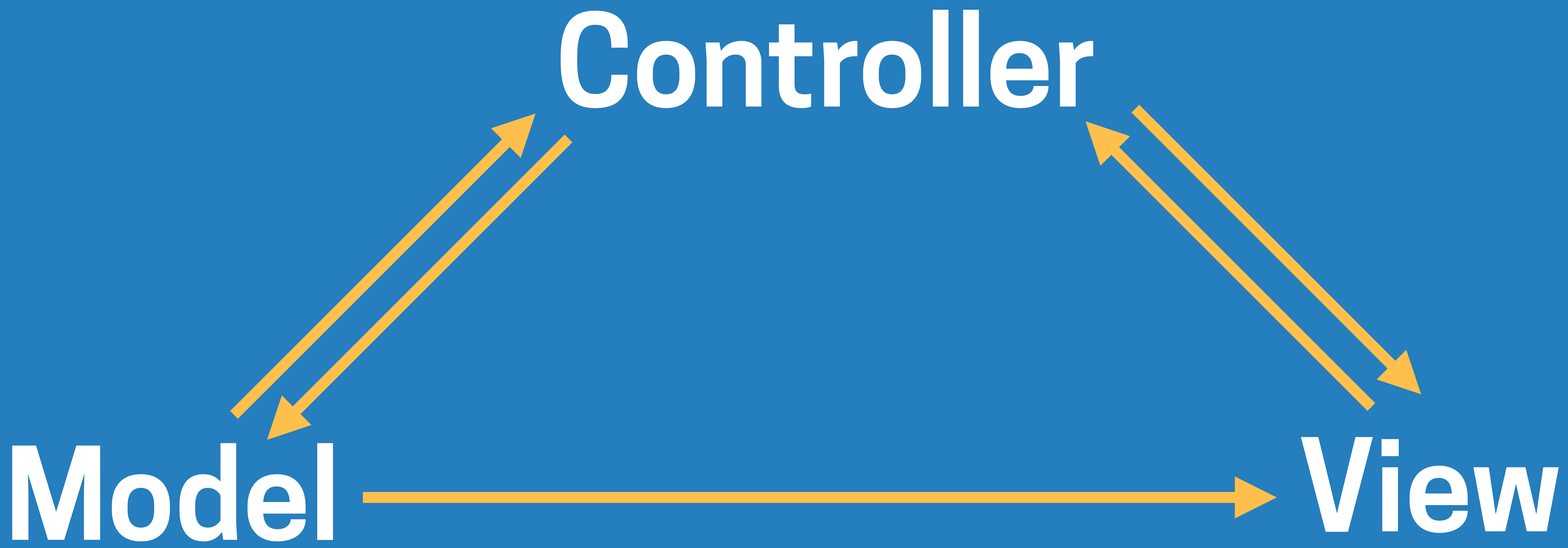
While in reality…

User interaction and network requests drive state changes

User Input changes UI State

Network request changes model state and UI state





State changes propagate in many directions

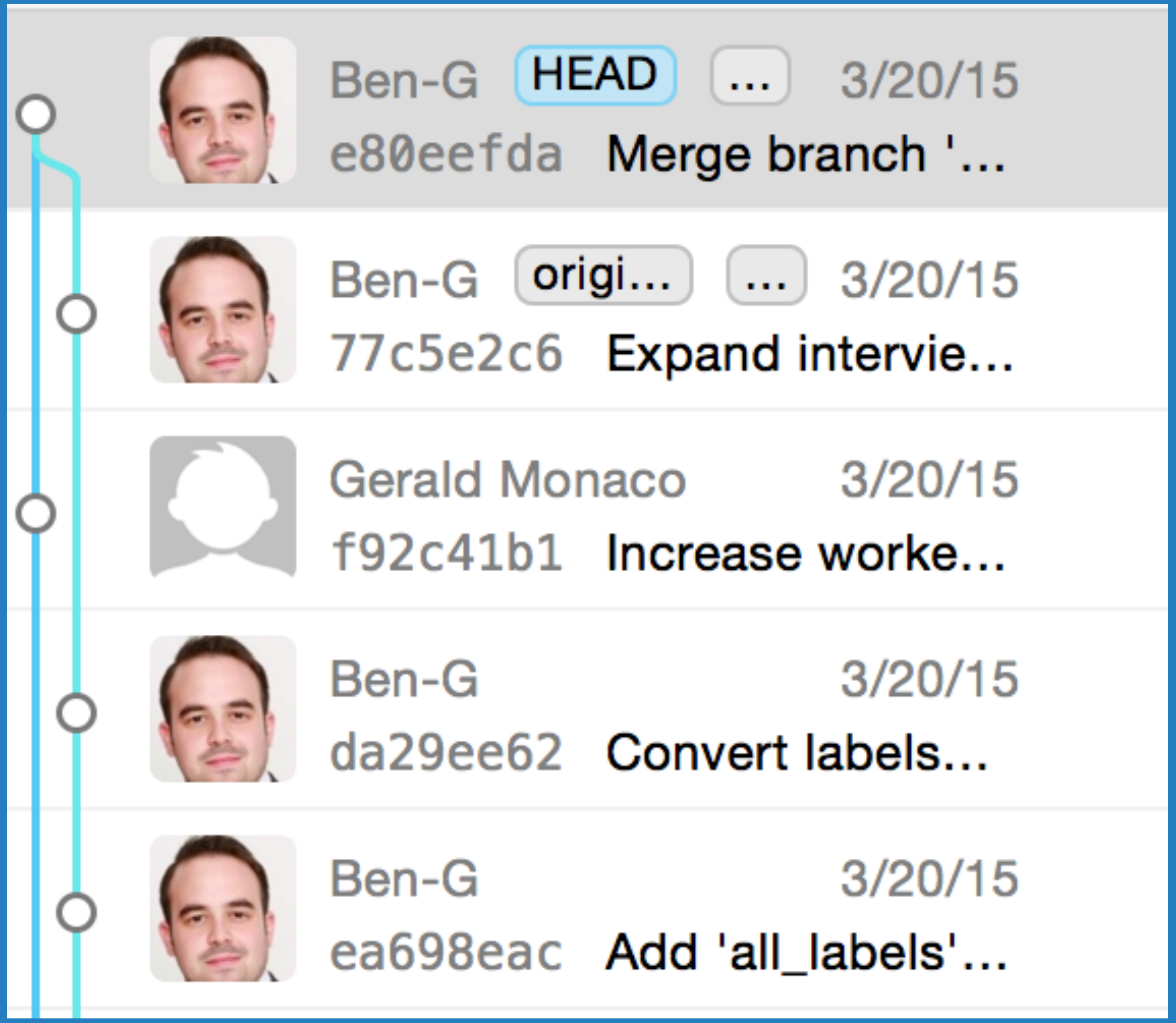
We don’t have the tools to declare the relationship between model and view

State propagation is handled manually

State propagation tools

- Callbacks
- Delegate methods
- KVO / Property overriding

Manual state management is error prone



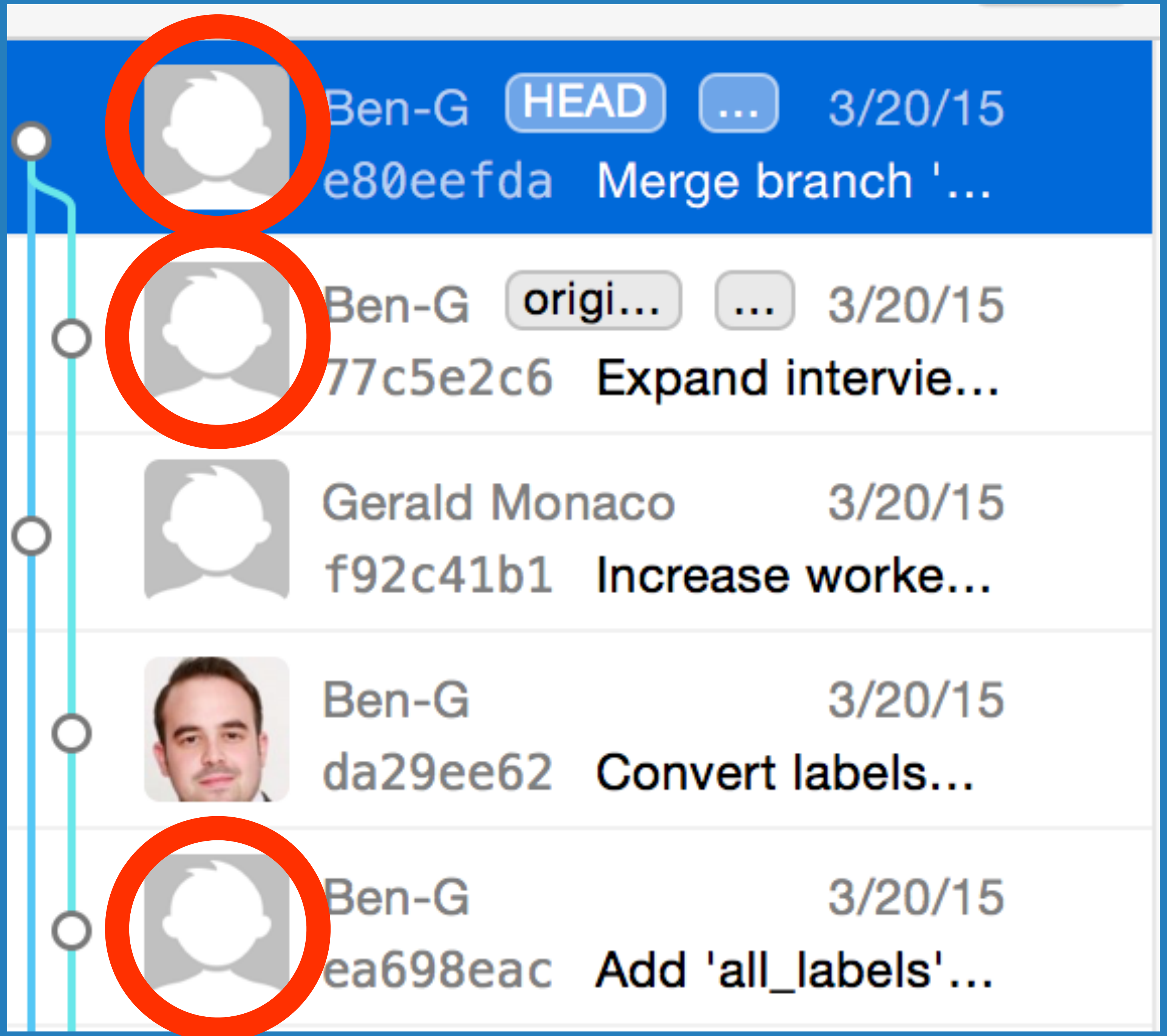
Ben-G HEAD ... 3/20/15
e80eefda Merge branch '...

Ben-G origi... ... 3/20/15
77c5e2c6 Expand intervie...

Gerald Monaco 3/20/15
f92c41b1 Increase worke...

Ben-G 3/20/15
da29ee62 Convert labels...

Ben-G 3/20/15
ea698eac Add 'all_labels'...



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ea698eac Add 'all_labels'...

FRP allows us to declare relationships instead of implementing them manually

What is functional reactive programming?

Imperative vs. Declarative

Imperative

A	B	C
20	10	?

0. Perform the following steps whenever A or B changes
1. Add 50 to value of A
2. Subtract 10 from value of B
3. Add the results from 1.) and 2.)
4. Write result from previous step into C

Declarative

A	B	C
20	10	?

$$C = (A+50) + (B-10)$$

How can we use FRP to propagate state changes **declaratively**?

- Callbacks
- Delegate methods
- KVO / Property overriding

} Signals

Reactive

$\swarrow$

Signals model values over time

[1]

Signals can be transformed using higher order functions

$\nwarrow$

Functional

Example?
Printing mouse position in Elm

A functional reactive language
for interactive applications

[2]

Immutable variable

Transform

Signal

```
main = map asText Mouse.position
```

Higher-Order Function

FRP in a nutshell!

[3]

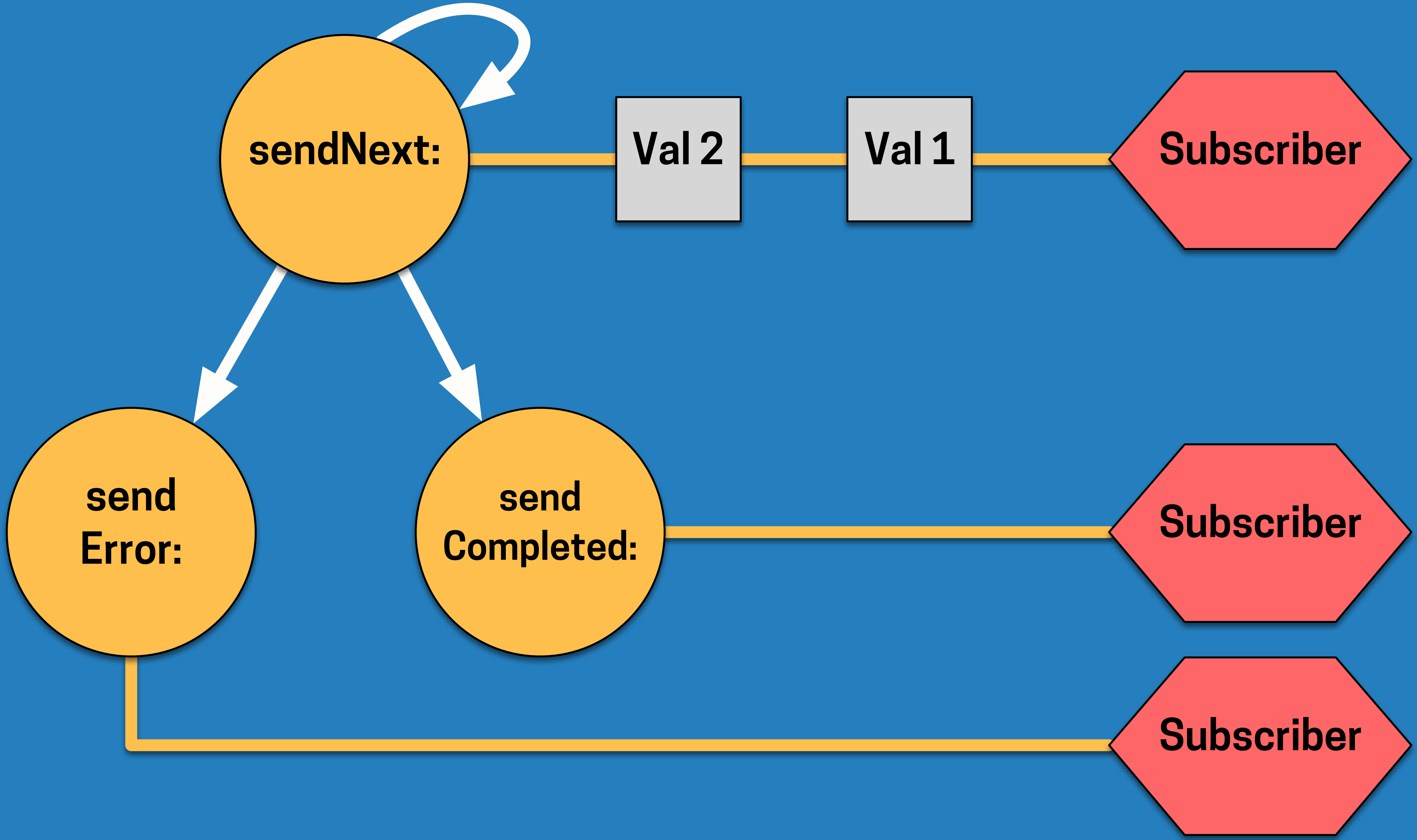
We can assign the current value and all future values to a variable

➔ Binding

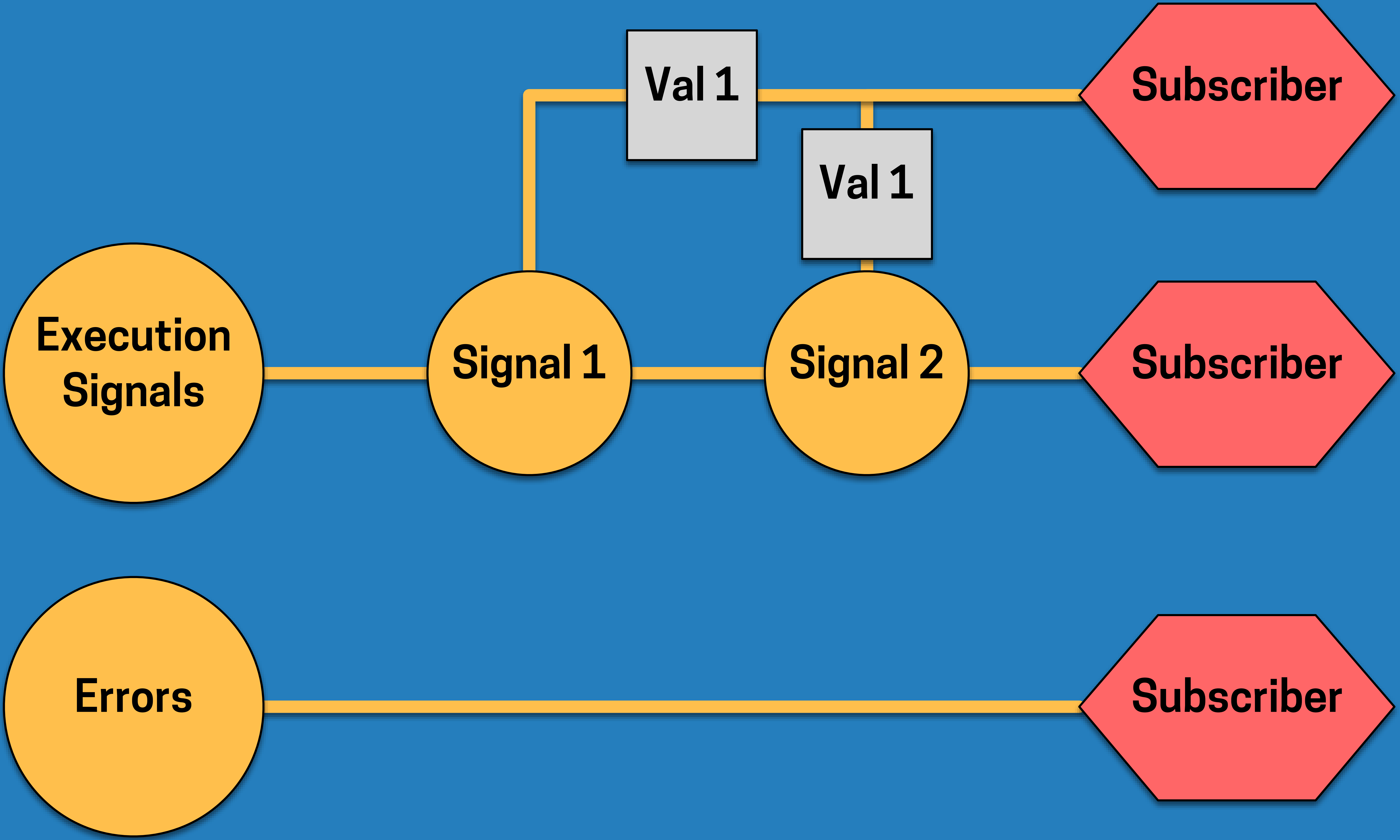
Bindings are one way of subscribing to a Signal

Intro to Reactive Cocoa 2.x

RACSignal


sendNext:
Val 2
Val 1
Subscriber
send Error:
send Completed:
Subscriber
Subscriber

RACCommand


Val 1
Subscriber
Val 1
Execution Signals
Signal 1
Signal 2
Subscriber
Errors
Subscriber

```
- (void)awakeFromNib {
  RAC(self, avatarImageView.image) =
    RACObserve(self, model.avatar);

  RAC(self, nameLabel.text) =
    RACObserve(self, model.name);

  // more binding code
}
```

View updates whenever model or model properties change

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```
RAC(target, keypath) = …
```

Assigns a signal to an object property

```
RACObserve(self, model.name);
```

Creates a signal from KVO changes

$$\text{Model} \longrightarrow \text{View} \quad ✓$$

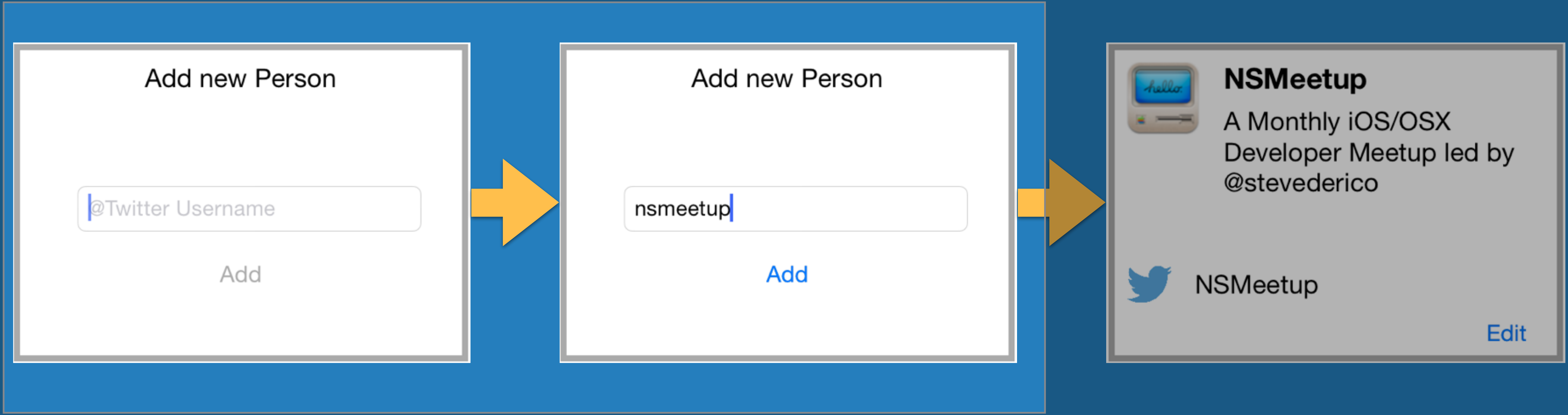
Model $\rightleftarrows$ View ?

Model ↔ ViewModel ↔ View

Model: Stores model state, provides business logic

ViewModel: Stores View state, communicates with model

View: Bindings


Add new Person

@Twitter Username

Add

Add new Person

nsmeetup

Add

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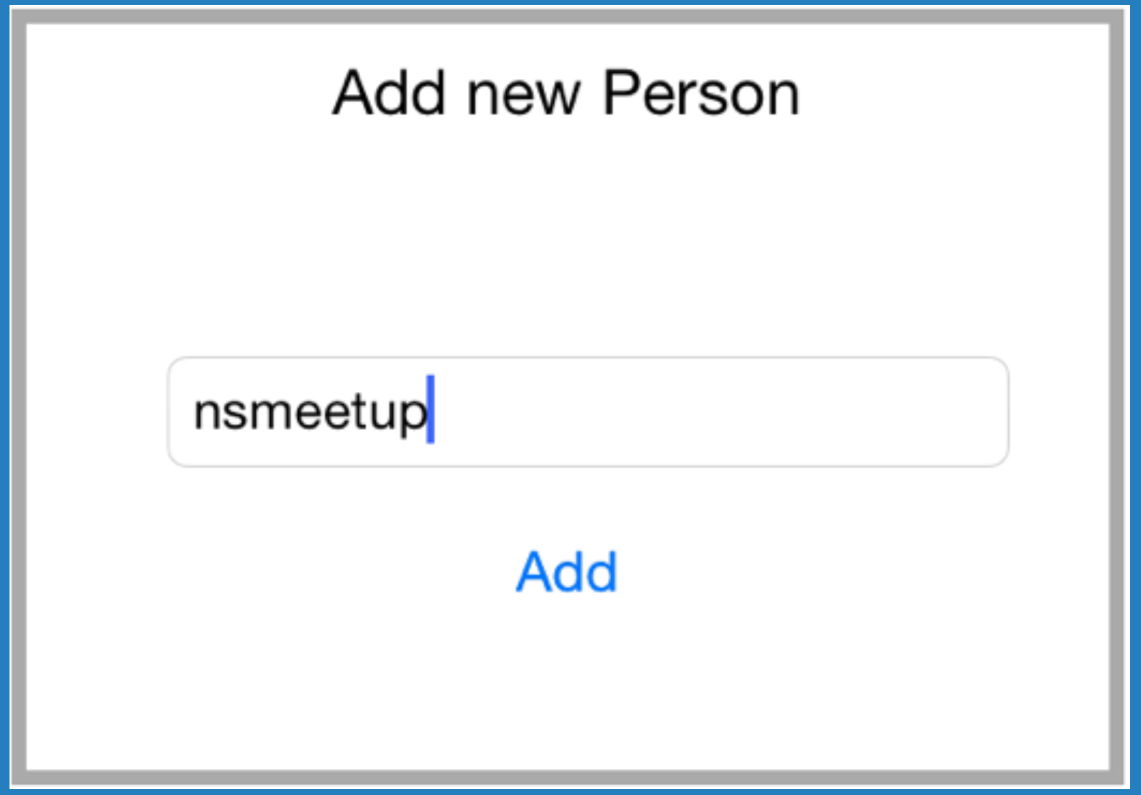
Edit

PersonAddingViewModel → PersonAddingView*

$$\begin{tikzcd}
\text{usernameSearchText} \arrow[r, leftrightarrow] & \text{usernameTextfield.text} \\
\text{addButtonEnabledSignal} \arrow[r] & \text{addButton.enabled} \\
\text{addButtonCommand} \arrow[r] & \text{addButton.rac\_command}
\end{tikzcd}$$

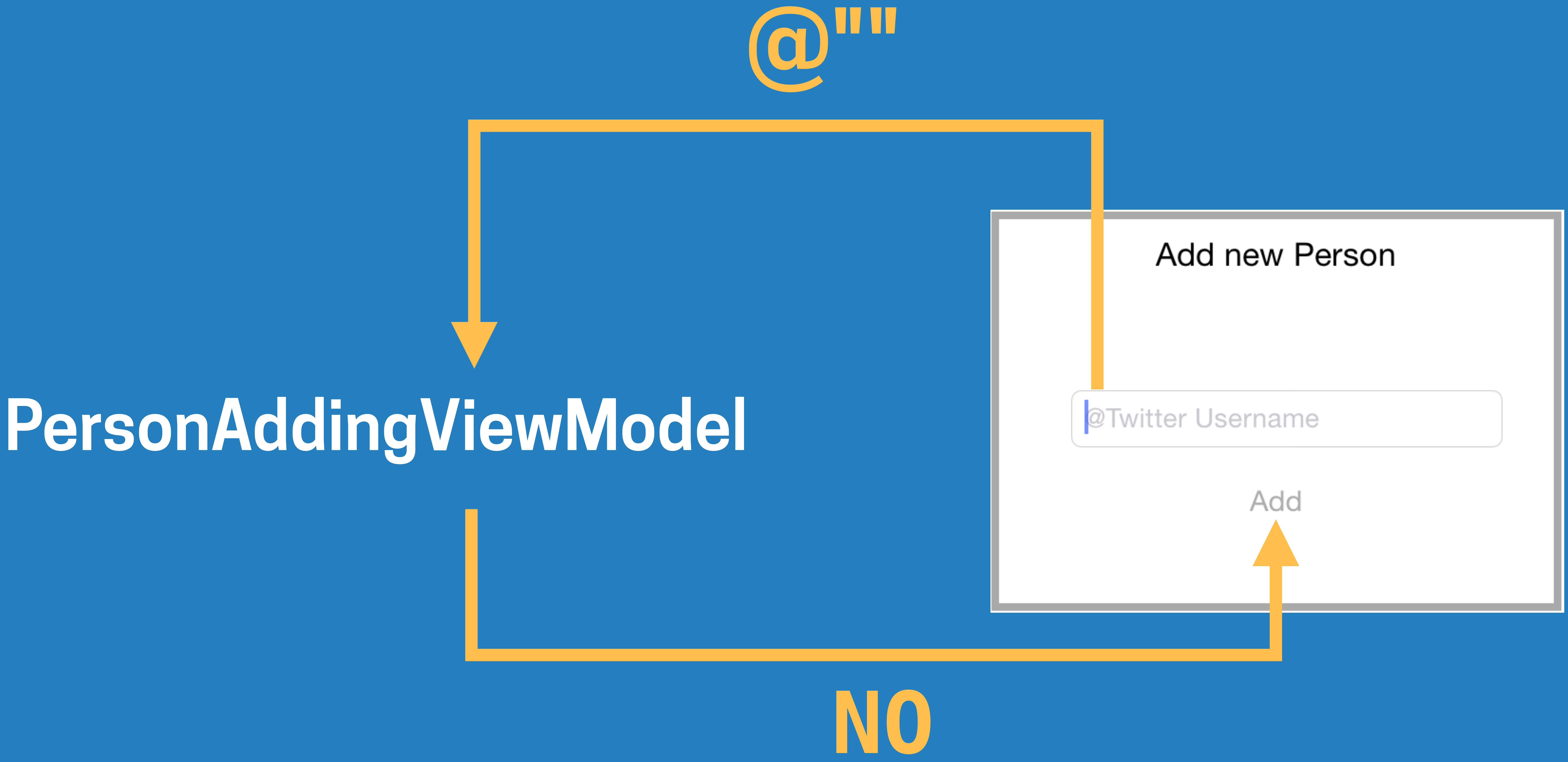
(performs network request)

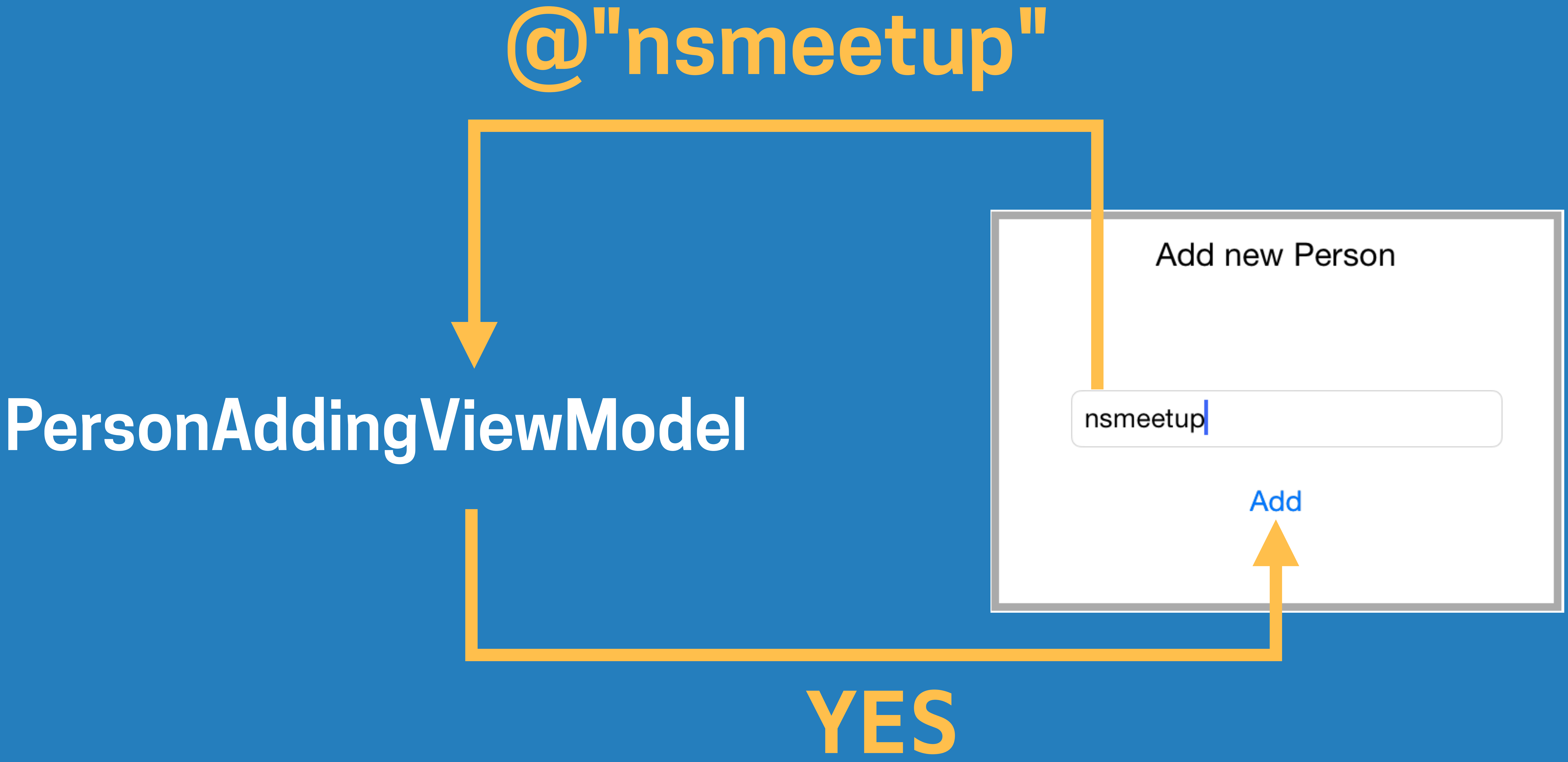


*some variables have been renamed for brevity

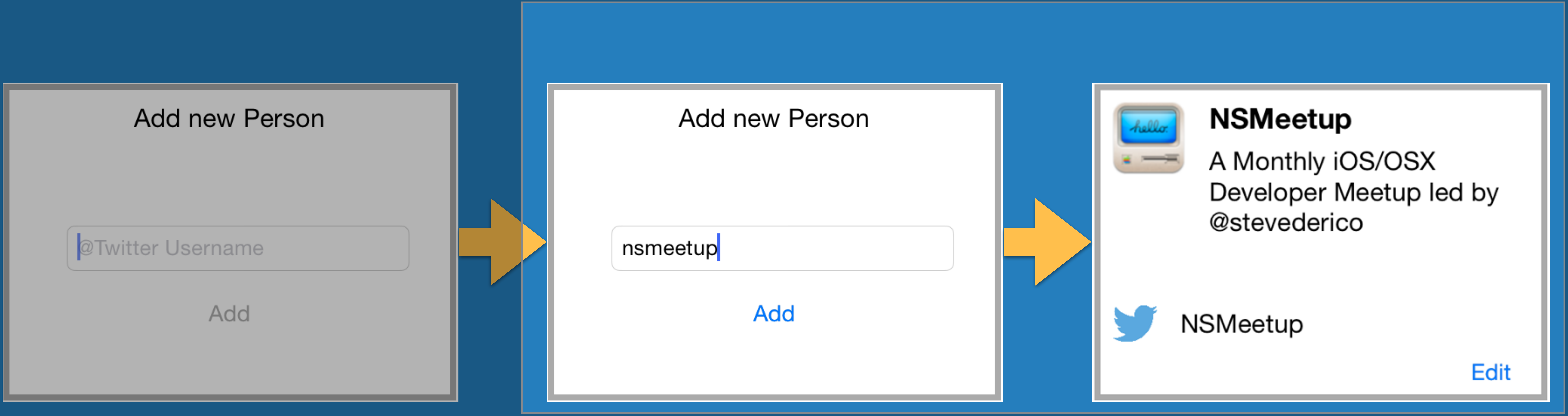
```
@interface PersonAddingViewModel : NSObject

// generates a signal when the ‘add’ button is pressed
@property (strong) RACCommand *addTwitterButtonCommand;
// is bound to the text field in the UI
@property (strong) NSString *usernameSearchText;
// a signal that determines wether ‘add’ button is enabled
@property (strong) RACSignal *addButtonEnabledSignal;

// less relevant interface declarations…

@end
```

```
self.addButtonEnabledSignal = [RACObserve(self, usernameSearchText)
                                map:^id(NSString *searchText) {
  if (!searchText || [searchText  isEqualToString:@""]) {
    return @(NO);
  } else {
    return @(YES);
  }
}];
```


@""
PersonAddingViewModel
Add new Person
@Twitter Username
Add
NO


@"nsmeetup"
PersonAddingViewModel
Add new Person
nsmeetup
Add
YES

Networking with Reactive Cocoa 2.x


Add new Person

@Twitter Username

Add

Add new Person

nsmeetup

Add

NSMeetup

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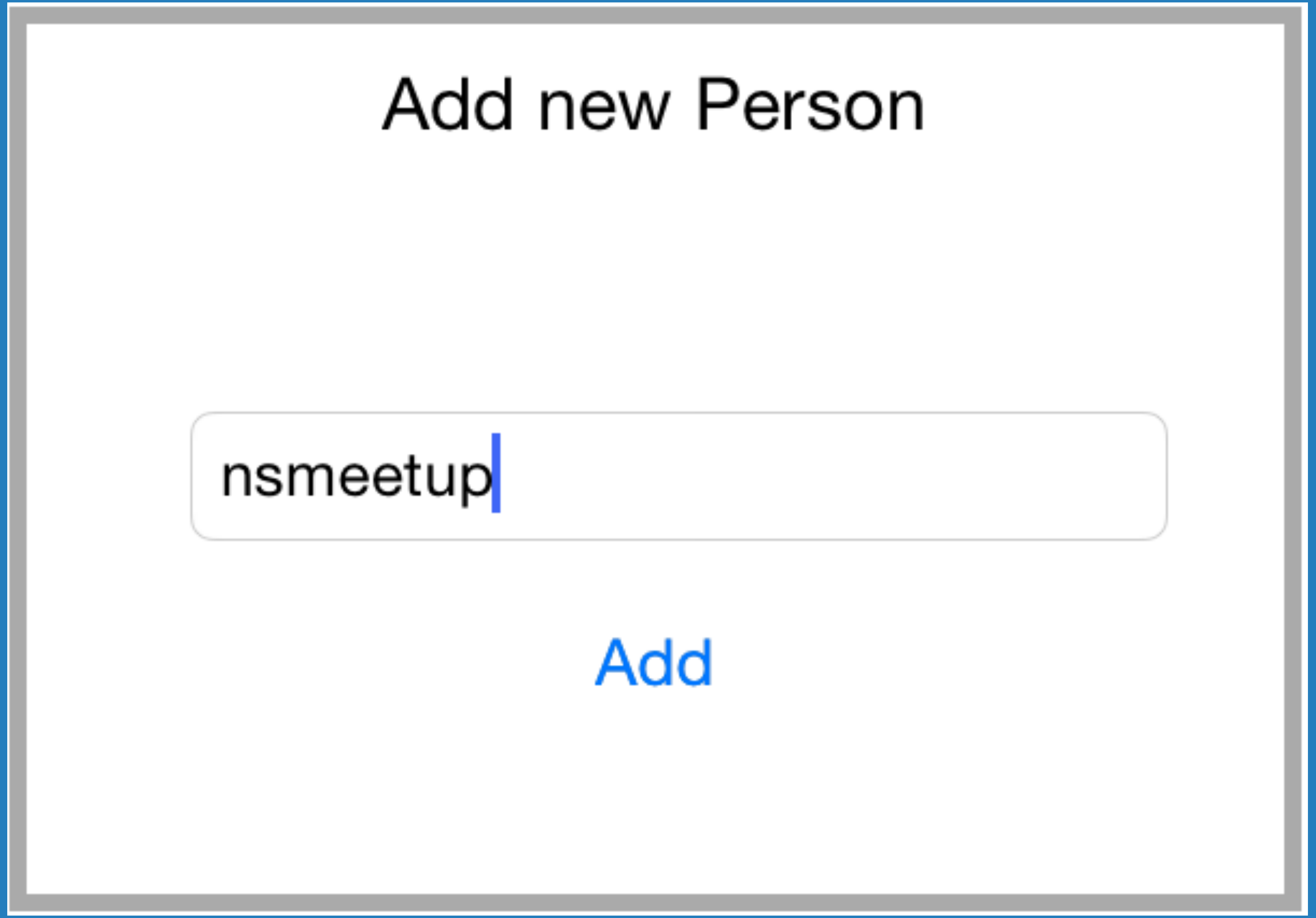
Edit

PersonContainerView

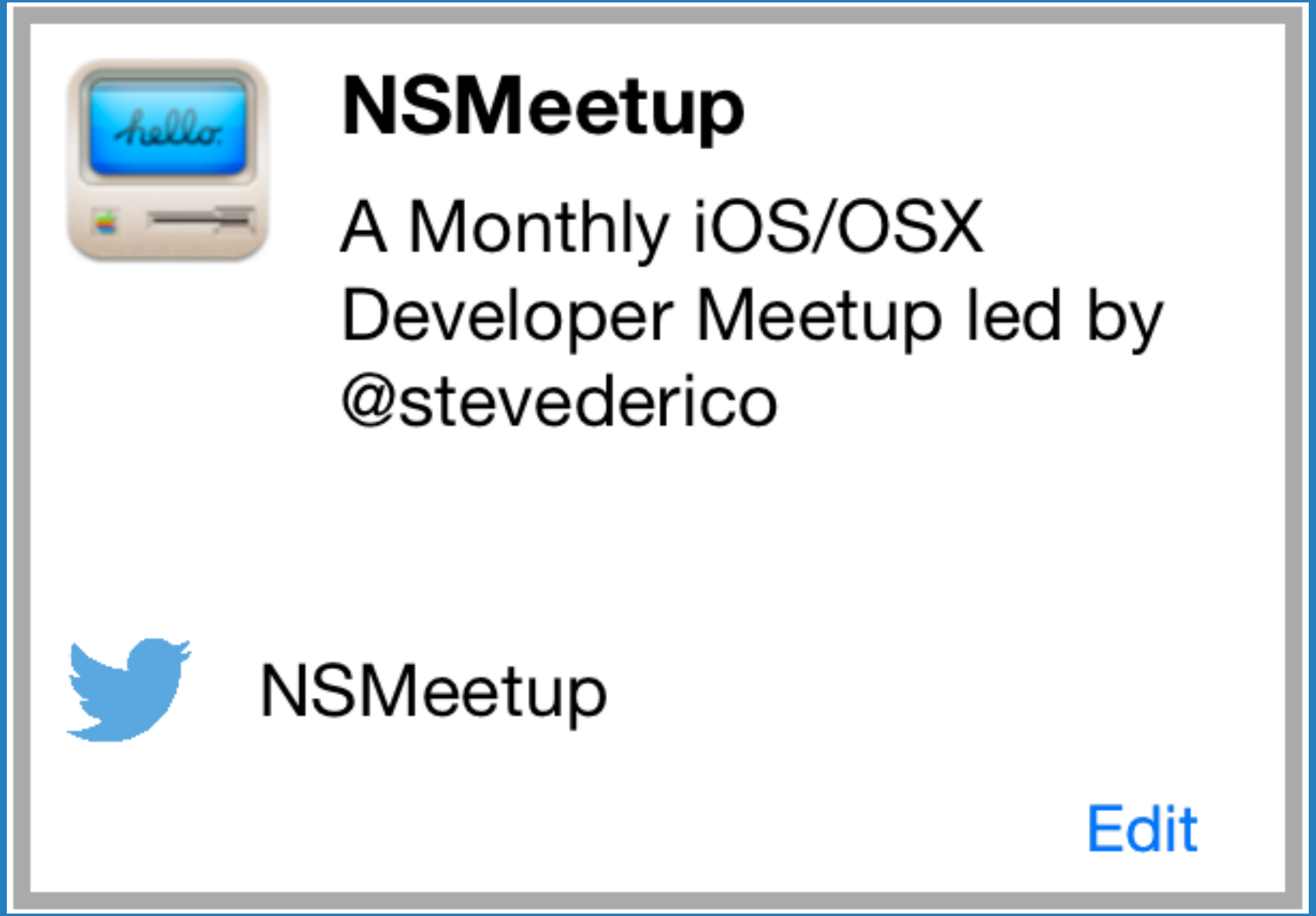
PersonAddingView

PersonDetailView


Add new Person

nsmeetup

Add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Edit

PersonAddingViewModel

Kicking off the network request

```
self.addTwitterButtonCommand = [[RACCommand alloc]
  initWithEnabled:self.addButtonEnabledSignal
    signalBlock:^RACSignal *(id input) {
      RACSignal *signal = [self.twitterClient
        infoForUsername:self.usernameSearchText];

      return signal;
    }
];
```

PersonContainerViewModel

Changing the UIState upon completed request

```
// subscribe to twitter network request
RACSignal *twitterFetchSignal = [RACObserve(self, personAddingViewModel)
  flattenMap:^RACStream *(id value) {
    return [self.personAddingViewModel.
      addTwitterButtonCommand.executionSignals concat];
}];

RACSignal *UIStateSignal = [[twitterFetchSignal map:^id(id value) {
  return @(PersonCollectionReusableViewStateDetails);
}] startWith:@(PersonCollectionReusableViewStateAddingTwitter)];

RAC(self, UIState) = UIStateSignal;
```

PersonContainerViewModel

Updating the model upon completed request

```
RAC(self.person, avatar) = [twitterFetchSignal reduceEach:
  ^id(UIImage *avatar, NSDictionary *userInfo){
    return avatar;
}];

RAC(self.person, twitterUsername) = [twitterFetchSignal reduceEach:
  ^id(UIImage *avatar, NSDictionary *userInfo) {
    return userInfo[@"twitterHandle"];
}];

RAC(self.person, name) = [twitterFetchSignal reduceEach:
  ^id(UIImage *avatar, NSDictionary *userInfo){
    return userInfo[@"name"];
}];
```

Twitter network request

```
- (RACSignal *)infoForUsername:(NSString *)username {
    RACScheduler *bgScheduler = [RACScheduler
      schedulerWithPriority:RACSchedulerPriorityBackground];

    return [[[[self _login]
      deliverOn:bgScheduler]
      flattenMap:^RACStream *(STTwitterAPI *client) {
        return [self client:client fetchUserInfo:username];
    }] flattenMap:^RACStream *(NSDictionary *userInfo) {
    …
```

Twitter network request

```
  flattenMap:^RACStream *(STTwitterAPI *client) {
    return [self client:client fetchUserInfo:username];
  }] flattenMap:^RACStream *(NSDictionary *userInfo) {
    NSDictionary *userDetails =
         @{@"name": userInfo[@"name"],
         @"description": userInfo[@"description"],
         @"twitterHandle": userInfo[@"screen_name"]};

    NSString *downloadURL = [userInfo[@"profile_image_url_https"];

    return [[self imageFromURLString:downloadURL]
                combineLatestWith:[RACSignal return:userDetails]];
  }];
}
```

RACSignal can be used like a promise

Wrapping network requests into a RACSignal

```
- (RACSignal *)client:(STTwitterAPI *)client fetchUserInfo:(NSString
*)username {
  return [RACSignal createSignal:
    ^RACDisposable *(id<RACSubscriber> subscriber) {

     [client getUserInformationFor:username successBlock:^(NSDictionary
 *user) {
      [subscriber sendNext:user];
      [subscriber sendCompleted];
    } errorBlock:^(NSError *error) {
      [subscriber sendError:error];
    }];

    return nil;
  }];
};
```

$$\text{Model} \leftrightarrow \text{ViewModel} \leftrightarrow \text{View} \quad ✓$$

Testing with Reactive Cocoa 2.x

Testing UI without UIKit

```
it(@"calls the Twitter API when add button is tapped", ^{
  id twitterClient = [TwitterClient new];
  id twitterMock = OCMPartialMock(twitterClient);
  OCMStub([twitterMock infoForUsername:@“username"])
     .andReturn([RACSignal return:@(YES)]);

  viewModel = [[PersonAddingViewModel alloc]
    initWithTwitterClient:twitterMock];
  viewModel.usernameSearchText = @"username";
  [viewModel.addTwitterButtonCommand execute:nil];

  OCMVerify([twitterMock infoForUsername:@"username"]);
});
```

Drawbacks

- New Programming Model
- Debugging
- (Performance)

Summary

- RAC provides tools for writing simpler declarative code
- Signals are unified way of handling different types of future values
- State propagation can be handled through bindings

- **MVVM** plays nicely with bindings, reduces controller complexity
- **MVVM** make it easier to write tests
- RAC introduces vastly different programming model that can be harder to debug

Resources

- [1] http://stackoverflow.com/questions/1028250/what-is-functional-reactive-programming
- [2] http://elm-lang.org/
- [3] http://elm-lang.org/edit/examples/Reactive/Position.elm