

Monad Education Supported by Visualizations

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Contents

- Monads are difficult for students
- What can help?
- What did we try?
- How did it work?



Monads are difficult...

Yet Another Monad Tutorial in 15 Minutes

Monads are like burritos!

Now I finally understand monads

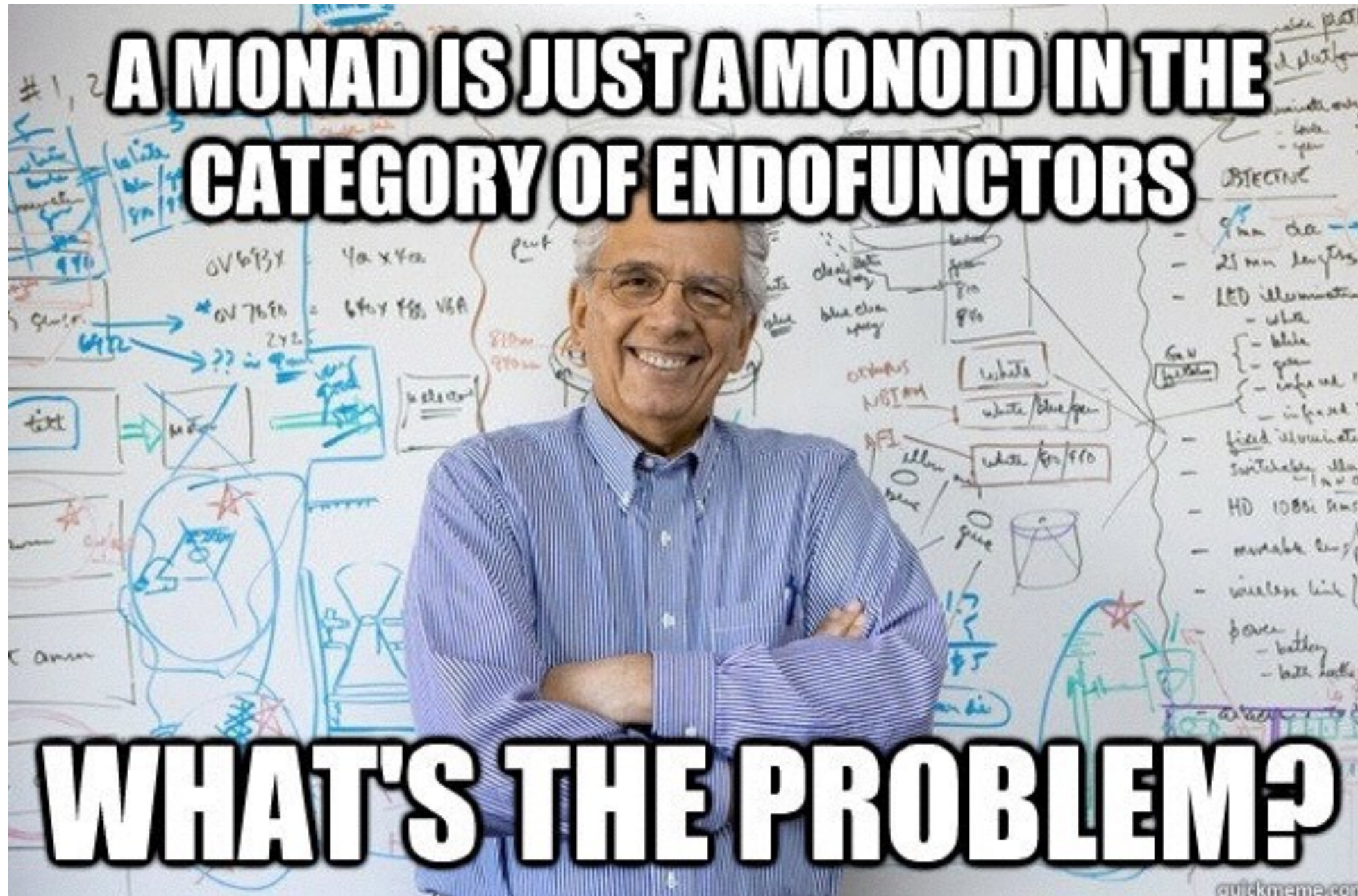
Monads are like unions!

Is it just the scary name?

Monads in pictures

Monads demystified

...or not?



<http://s2.quickmeme.com/img/44/44b0bd758f8ee5c81362923f0d5c8e017c9ddf623925e60c29a4c015b89fbb45.jpg>

Approach

What do these have in common?

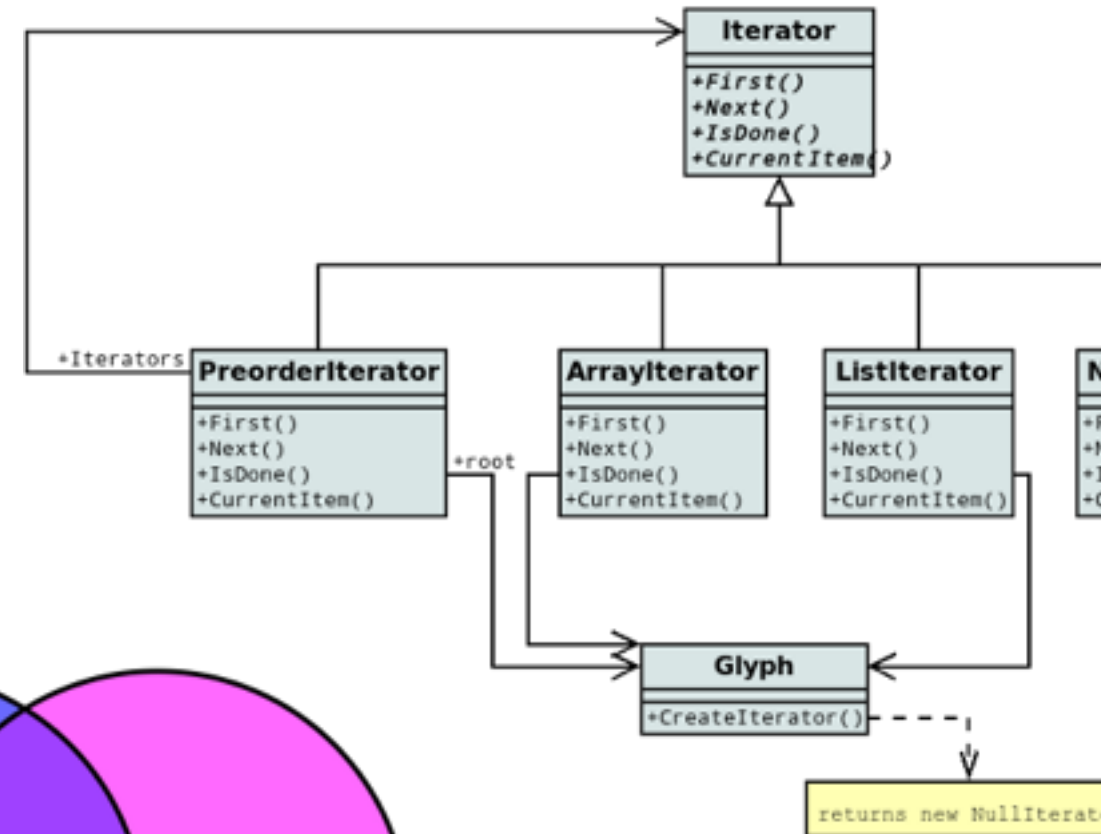
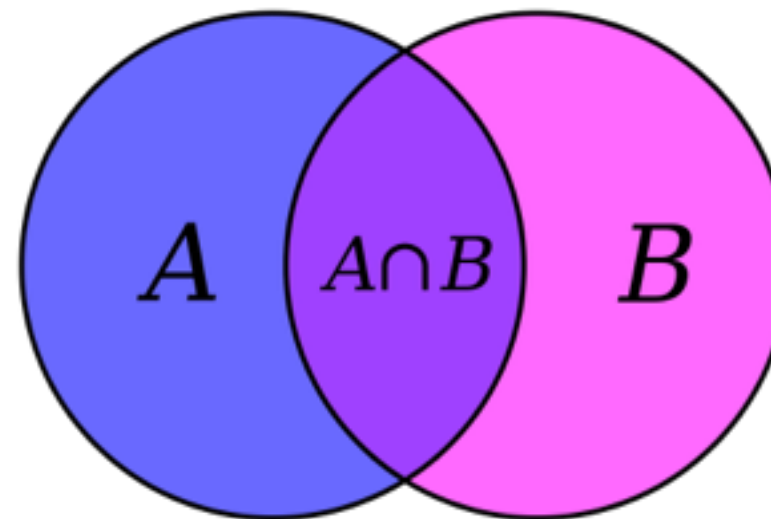
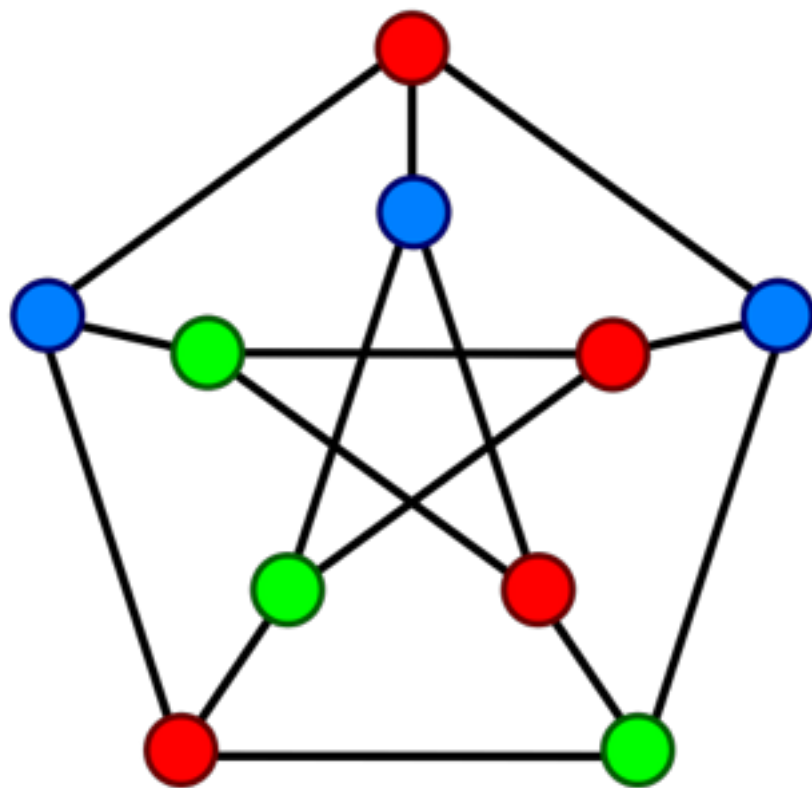
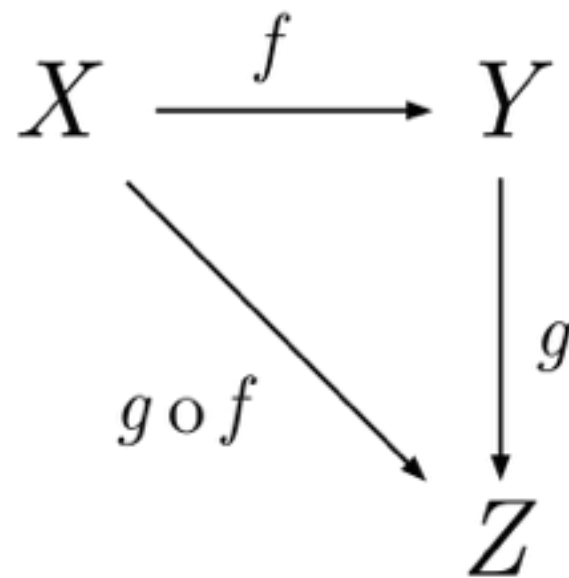
Category Theory

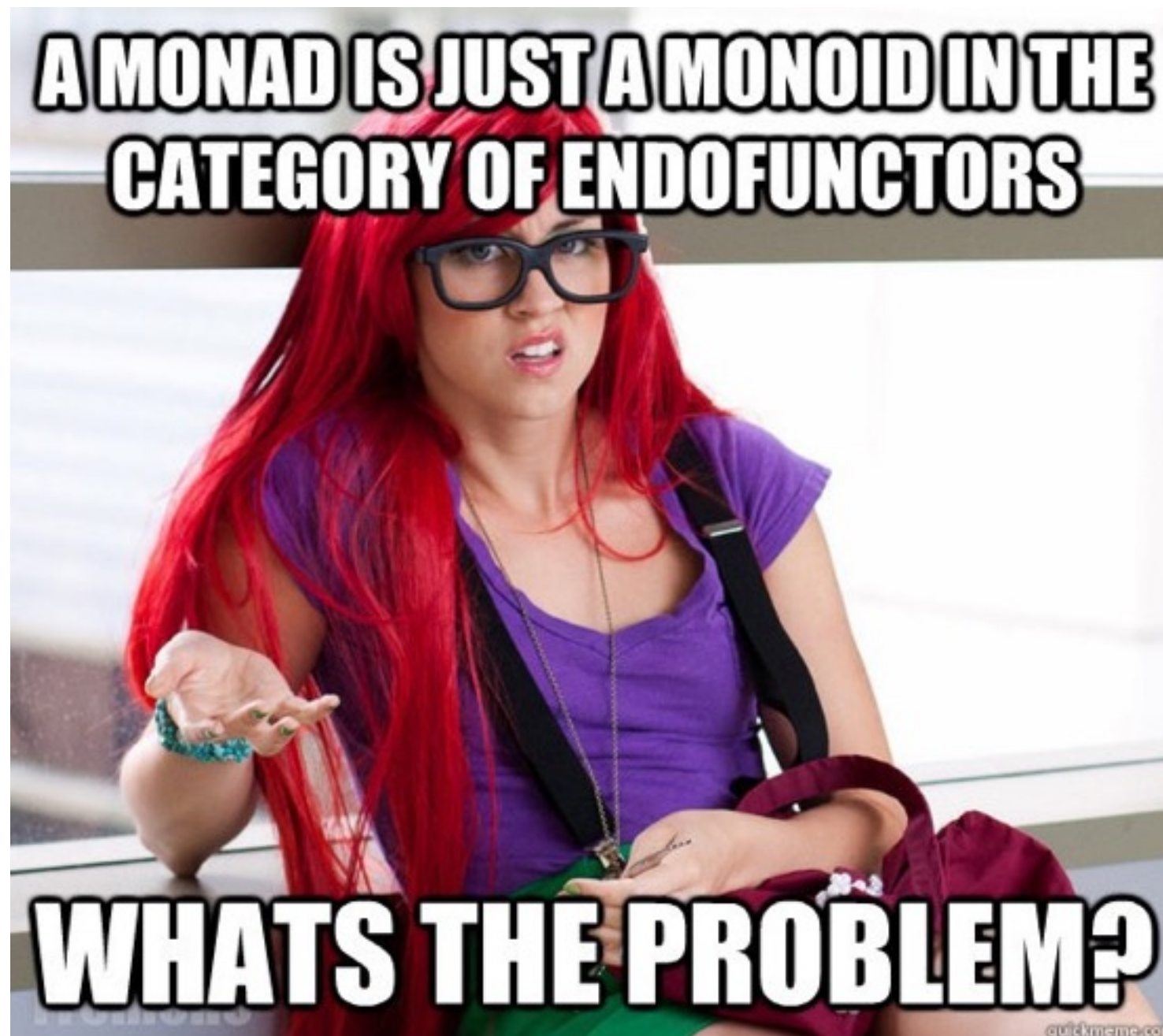
Object Orientation

Graph Theory

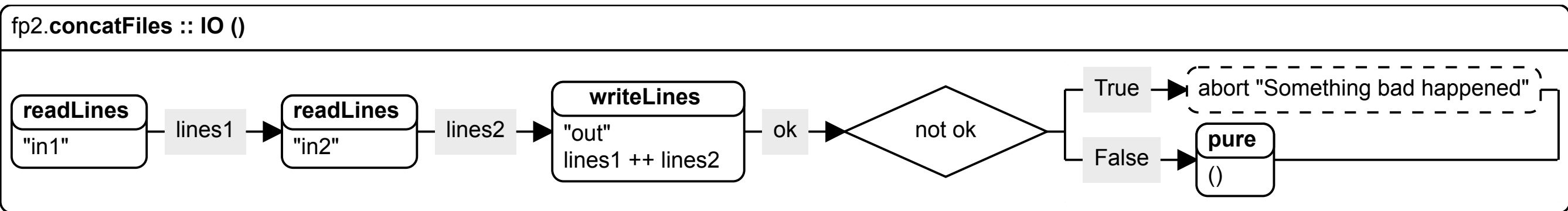
Set Theory

Visualizations!





<http://s2.quickmeme.com/img/c9/c94711e0f933eb488e0cb0baa9d3eff1888a27ead4fd6089fd37d8f7d8f45a97.jpg>



*“I’ve read the code just once
and referred to the picture afterwards.”*

– 2nd year bachelor in CS

Background



Tonic

long ago

How to show program structure to stakeholders?
(navy, coastguard, tax authorities, ...)

2014

Visualize task flow **generated by compiler**

2015

Generalize to **arbitrary monads**
(Maybe, Either, List, Parser, IO, ...)

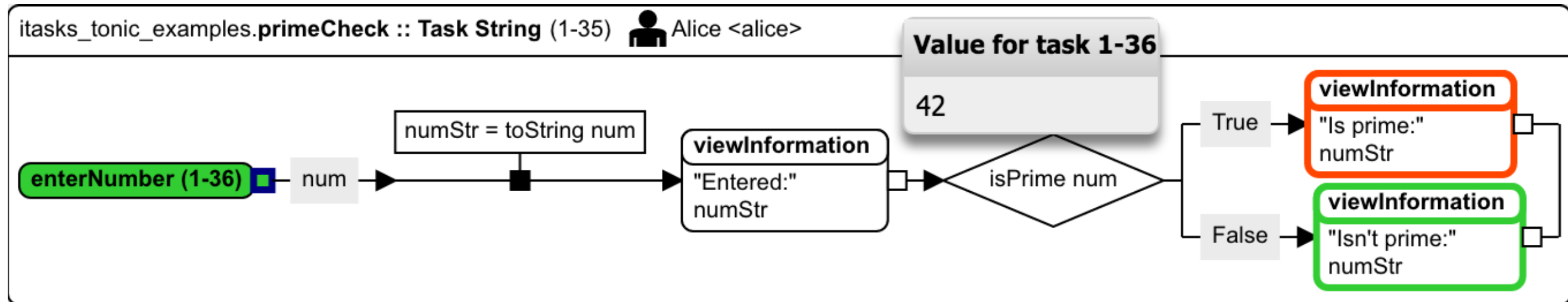
2016

Use for students



<http://assets.absolutdrinks.com/drinks/320x440/gin->

Dynamic information!





http://65.media.tumblr.com/9fb62f2fad63912e96eae8ab462dc2e5/tumblr_n4xk6ogNb81taxo62o1_400.jpg

Example

```
englishToFrench :: String -> Maybe String
englishToFrench en =
  case lookup en en_nl of
    Nothing -> Nothing
    Just nl -> case lookup nl nl_fr of
      Nothing -> Nothing
      Just fr -> Just (nl +++ ": " +++ fr)
```

```
en_nl  :: Map
nl_fr  :: Map
lookup :: String Map -> Maybe String
```

Example

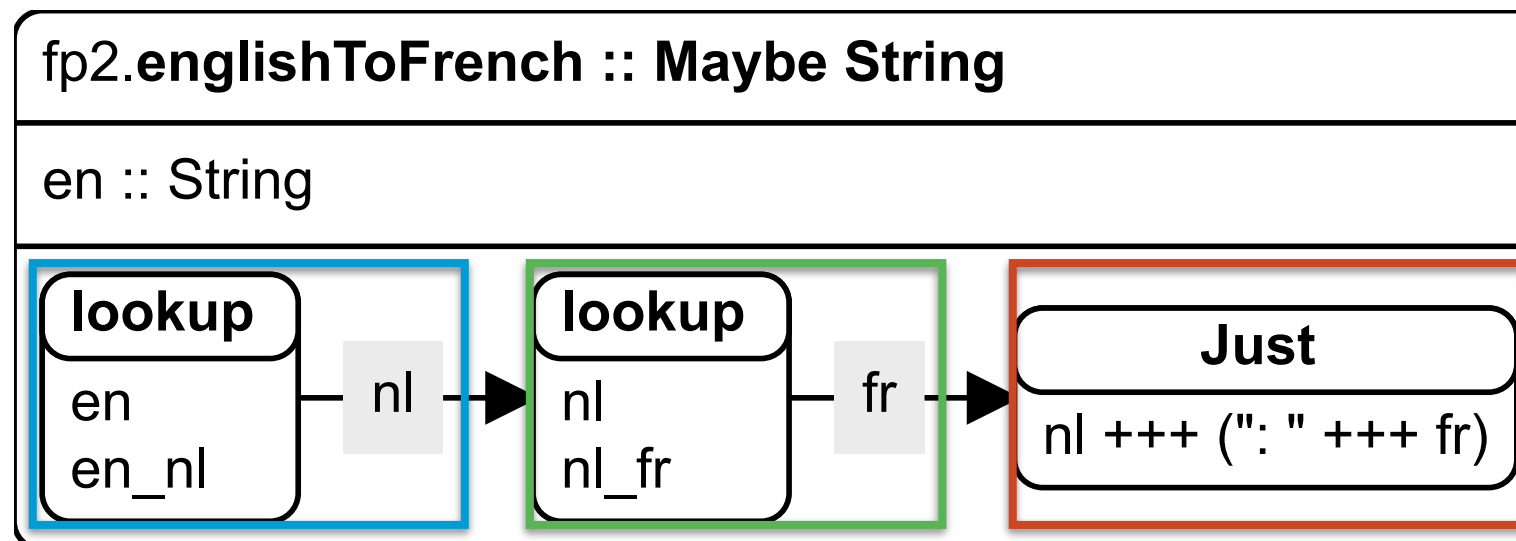
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```
en_nl :: Map
nl_fr :: Map
lookup :: String Map -> Maybe String
```

⇒ Case matching on Maybe all the time 😞

Example

```
englishToFrench :: String -> Maybe String
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```



Example

```
englishToFrench :: String -> Maybe String  
englishToFrench en =
```

```
  case lookup en en_nl of
```

```
    Nothing -> Nothing
```

```
    Just nl -> case lookup nl nl_fr of
```

```
      Nothing -> Nothing
```

```
      Just fr -> Just (nl +++ ": " +++ fr)
```

Before

```
englishToFrench en =
```

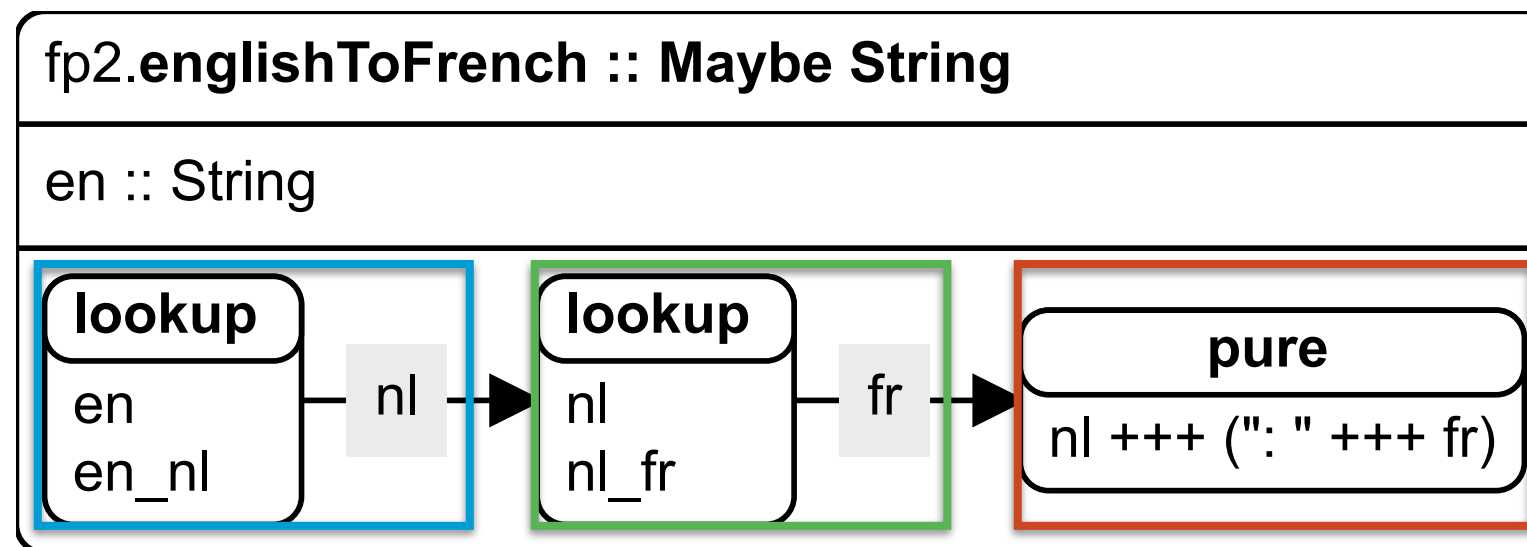
```
  lookup en en_nl >>= \nl ->
```

```
  lookup nl nl_fr >>= \fr ->
```

```
  pure (nl +++ ": " +++ fr)
```

After

Example



```
englishToFrench en =  
  lookup en en_nl >>= \nl ->  
  lookup nl nl_fr >>= \fr ->  
  pure (nl +++ ": " +++ fr)
```

Case Study



*Do visualizations of
monadic programs **help** students
learning the concept of monad,
if so, **how** and
what do they **think** about them?*

Context

- Functional Programming course in Clean or Haskell
- 2nd year bachelor
- 50 students
- 6 groups of pairs/triples closely monitored

<http://i.imgur.com/FLf5J6f.jpg?1>



Schedule

Monday	Give lecture
Tuesday	Test assignments on test group
Wednesday	Record during practical work
Thursday	Skim recordings
Friday & Monday	Perform stimulated recall interviews & Send out survey

Collected data

- Screencasts
- Recordings (audio & video)
- Interviews (audio)
- Survey
- Assignment results
- Exam results (to do)



⇒ We don't want to compare groups,
we'd like to open the “black box” of students mind.

<http://www.asiaonline.net/images/>

Quotes

“I would not draw the pictures myself.”

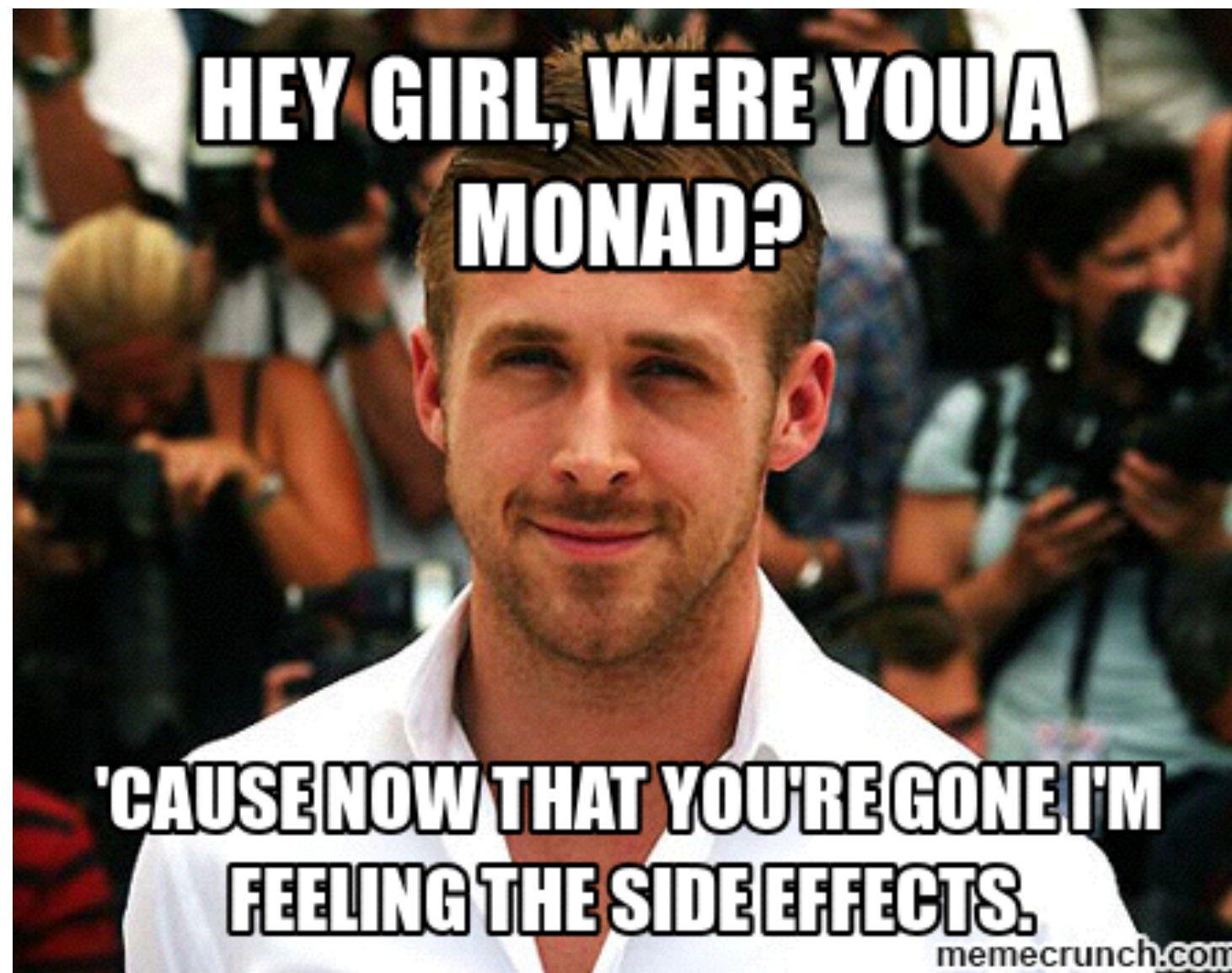
*“The pictures are easy to understand
and do not get into the way.”*

*“In general I’m very visually orientated,
but I didn’t use the pictures.”*

*“The picture showed me
the sequence of the code”*

“I think about types, not pictures.”

*“Now that I take a better look,
the answer is in the picture.”*



http://66.media.tumblr.com/814f75aadd13c0b23059fa906aa5d226/tumblr_n4tmku4dP01taxo62o1_500.png

Future



Future



<http://www.donnybrook-balingup.wa.gov.au/files/2014/09/Apple-FunPark-July-2008.jpg>

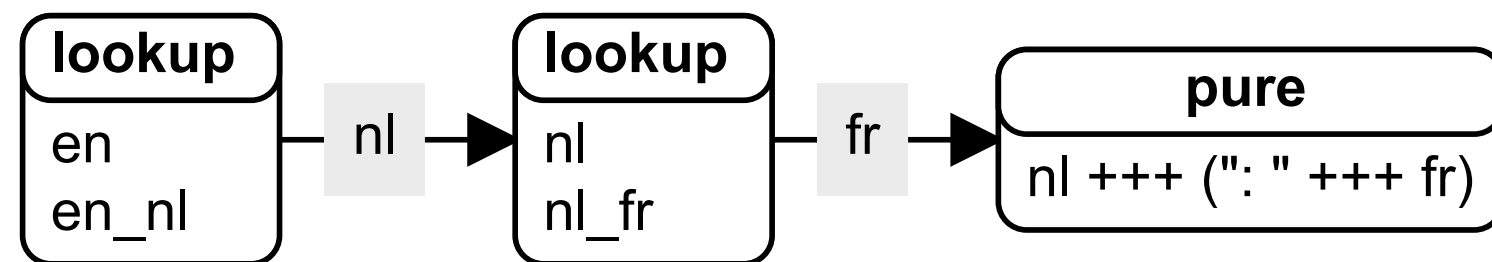
*What do students **encounter** when
learning monads,
how do they **fix** it and
how can visualizations **help**?*

And what about stakeholders?



fp2.englishToFrench :: Maybe String

en :: String



<https://i.warosu.org/data/g/img/0487/27/1435509117580.png>

Extra



What's the problem?

- What makes monads difficult to learn?
- ...and to teach?
- When do students get stuck?
- What do they find difficult?

