Moo in practice - App::Math::Tutor

Jens Rehsack

Niederrhein Perl Mongers

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Motivation

Moo and App::Math::Tutor

- real world examples over far-fetched conceptuals
- MooX::Cmd, MooX::Options and MooX::ConfigFromFile provide way more features and flexibility than either
  - App::Cmd with Getopt::Long::Descriptive
  - MooseX::App::Cmd along with corresponding MooseX wrappers around related stuff
- 2nd generation of modern OO in Perl5

App::Math::Tutor

- Allow parents help their children improving their mathematical skills
- Add support for exercise types as children require
- provide extensible design to allow easy augment of exercise
- **Goal:** Improve to Web-Service, eg. by mapping MooX::Cmd to URI path and MooX::Options to GET parameters

Audience

Audience

- Developers who want to create or improve Perl5 software
- Developers who want to learn how to develop modern OO with Perl5
- Developers who are interested in developing mathematical exercises

Prerequisites of the Audience

Following knowledge is expected:

- General knowledge about object oriented programming or concepts like
  - classes
  - objects
  - polymorphism, inheritance and/or roles
  - methods, class functions
  - attributes, properties
- slightly above basic Perl experience
- ever heard of Smalltalk and its OO-concept is a strong bonus

Classes in Moo

- classes can be instantiated
- one can inherit from classes
- one can aggregate classes
- distinguish naming conflicts is up to developer

```
{
    package Natural;

    use Moo;

    sub _stringify { ... };
}
{
    package Roman;

    use Moo;
    extends "Natural";

    sub _stringify { ... };
}
my $natnum = Natural->new( value => 42 ); say $natnum->_stringify(); # 42
my $romnum = Roman->new( value => 42 ); say $romnum->_stringify(); # XLII
```

Roles in Moo

- roles describe a dedicated behavior (e.g. `printable`)
- roles can be composed into classes
- one can't inherit from roles - only consume
- roles cannot exist stand-alone
- roles are consumed once
- naming conflicts cause compile time error

```
{   package Printable;

    use Moo::Role; # now it's a role - no 'is a' relationship anymore

    sub print { my $self = shift; say $self->_stringify }
}
{    package Natural;

    use Moo; # class
    with "Printable"; # consumes a role

    sub _stringify { ... };
}
my $natnum = Natural->new( value => 42 ); $natnum->print; # 42
my $romnum = Roman->new( value => 42 ); $romnum->print; # XLII
```

Attributes in Moo

```
package VulFrac;

use Moo;

has numerator => ( is => "ro", required => 1 );
has denominator => ( is => "ro", required => 1 );

1;
```

- use "has" keyword to define a attribute
- attributes "numerator" and "denominator"
- attributes are immutable and required

Attribute options - Selection I

is **mandatory** behavior description

- **ro** defines the attribute is read-only
- **rw** defined the attribute is read/writable
- **lazy** defines the attribute is read-only with a lazy initialization, implies `builder => 1`

required when set to a true value, attribute must be passed on instantiation

init_arg Takes the name of the key to look for at instantiation time of the object. A common use of this is to make an underscored attribute have a non-underscored initialization name. undef means that passing the value in on instantiation is ignored.

isa defines a subroutine (`coderef`) which is called to validate values to set

coerce defines a subroutine (`coderef`) which forces attribute values

default subroutine (`coderef`) which is called to initialize an attribute

Attribute options - Selection II

Following options can benefit from *attribute shortcuts*: the value of 1 instead of a method name means to generate a `coderef` which calls the method `_${option_name}_${attr_name}`

builder
: takes a method name (`string`) which is called to initialize an attribute (calls `_build_${attr_name}` on *attribute shortcut*)

trigger
: takes a subroutine (`coderef`) which is called anytime the attribute is set (calls `_trigger_${attr_name}` on *attribute shortcut*)

clearer
: takes a method name (`string`) which will clear the attribute (provides `clear_${attr_name}` on *attribute shortcut*)

predicate
: takes a method name (`string`) which will return true if an attribute has a value (provides `has_${attr_name}` on *attribute shortcut*)

Methods in Moo I

```
package VulFrac;

use Moo;
use overload '""'    => "_stringify",
             '0+'    => "_numify",
             'bool'  => sub { 1 },
             '<=>'   => "_num_compare";

has numerator => ( is => "ro", required => 1 );
has denominator => ( is => "ro", required => 1,
  isa => sub { $_[0] != 0 or die "Not != 0" };

sub _stringify { my $self = shift;
  return sprintf("\\frac{%s}{%s}",
  $self->numerator, $self->denominator); }

sub _numify { $_[0]->numerator / $_[0]->denominator; }
...
```

Methods in Moo II

```
package Rationale;

use Moo;

extends "VulFrac";

has digits => ( is => "ro", required => 1 );

sub _stringify {
  my $digits = $_[0]->digits;
  sprintf("%.${digits}g", $_[0]->_numify); }
```

- nothing like `MooseX::Declare` - pure Perl5 keywords are enough for plain methods

Method Modifiers

Method modifiers are a convenient feature from the CLOS (Common Lisp Object System) world:

before `before method(s) => sub { ...}`
before is called before the method it is modifying. Its return value is totally ignored.

after `after method(s) => sub { ...}`
after is called after the method it is modifying. Its return value is totally ignored.

around `around method(s) => sub { ...}`
around is called instead of the method it is modifying. The method you're overriding is passed as `coderef` in the first argument.

- No support for `super`, `override`, `inner` or `augment`

In doubt `MooX::Override` provides `override` and `super` while `MooX::Augment` provides `augment` and `inner`

Method Modifiers - Advantages

- supersedes `$self->SUPER::foo(@_)` syntax
- cleaner interface than `SUPER`
- allows multiple modifiers in single namespace
- also possible from within roles and not restricted to inheritance
- ensures that inherited methods invocation happens right (mostly - remember around)
- no need to change packages

Methods Modifiers - around avoid calling $orig

```
package App::Math::Tutor::Role::Roman;

use Moo::Role;

with "App::Math::Tutor::Role::Natural";

{ package RomanNum;
  use Moo;
  extends "NatNum"; # derives overloading!
  sub _stringify { ... } }

around "_guess_natural_number" => sub {
    my $orig    = shift;
    my $max_val = $_[0]->format;
    my $value   = int( rand( $max_val - 1 ) ) + 1;
    return RomanNum->new( value => $value );
};
```

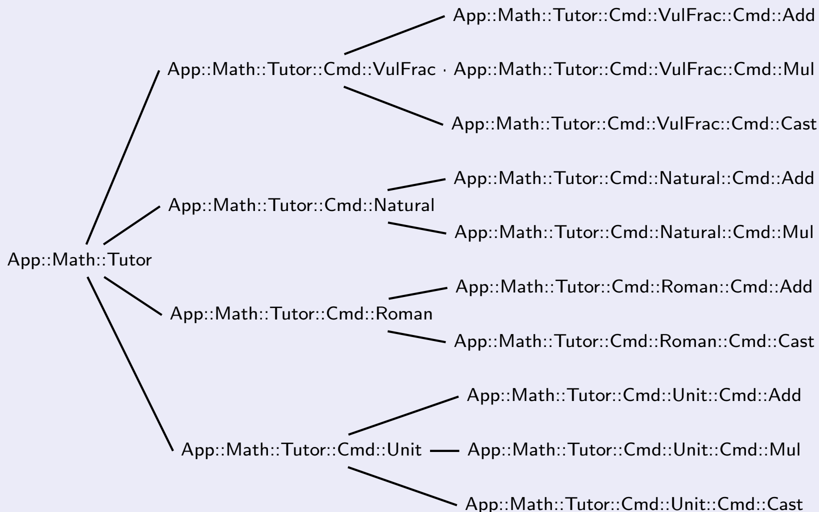
- captures control
- receives responsibility
- runtime of modified method completely eliminated

Methods Modifiers - around modifying $orig return value

```
package App::Math::Tutor::Role::Roman;

use Moo::Role;

with "App::Math::Tutor::Role::Natural";

{ package RomanNum;
  use Moo;
  extends "NatNum"; # derives overloading!
  sub _stringify { ... } }

around "_guess_natural_number" => sub {
    my $orig = shift;
    my $num  = $orig->(@_);
    return RomanNum->new( value => $num->value );
};
```

- modifies only required part
- leaves most responsibility in modified method
- runtime of modified method added to this method's runtime

Frontend (dictated by MooX::Cmd)



Exercise Groups

App::Math::Tutor::Cmd::VulFrac Exercises in vulgar fraction calculation

App::Math::Tutor::Cmd::Natural Exercises in calculations using natural numbers

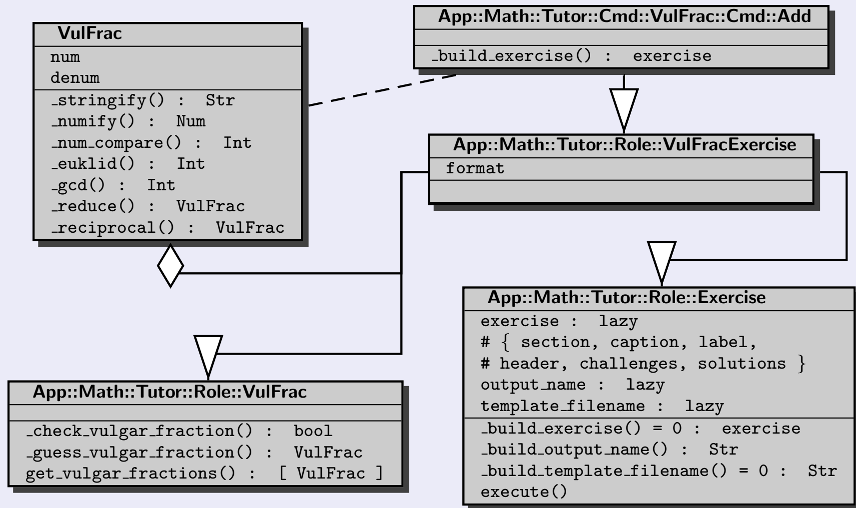
App::Math::Tutor::Cmd::Roman Exercises in calculations using natural numbers, but show them using roman number encoding (exercises and solutions)

App::Math::Tutor::Cmd::Unit Exercises in calculations using units (times, currency, ...)

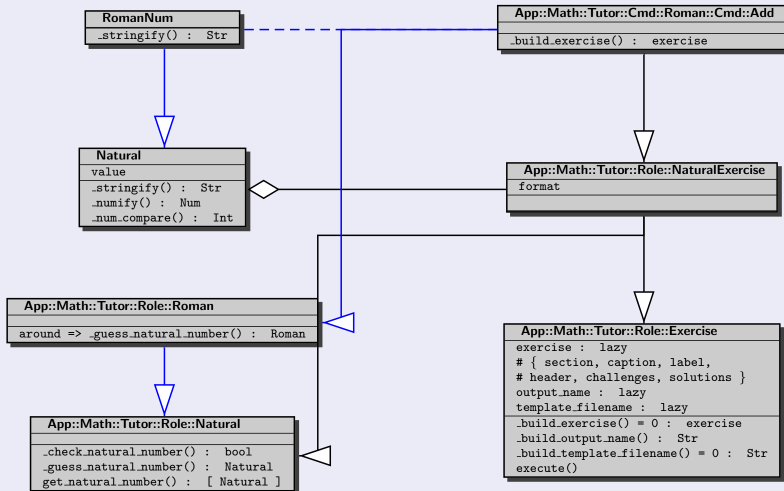
App::Math::Tutor::Cmd::Power Exercises in calculations of power mathematics

App::Math::Tutor::Cmd::Polynom Exercises for polynomial mathematics (Zero of a function, Vertex, ...)

Typical Exercise design



Derived Exercise design



Improving design

- introduce factories
- add lazy factory attribute (allowes overriding factory to use by `around`'ing builder)
- separate `number` classes (type system, but **no** `MooseX::Types`)
- approval for reasonable exercise value should be part of factory
- approval for valid number should be `coerced` (`trigger?`)

Design history

- I started with just vulgar fraction exercises
- Design covered exactly those needs

Design future

- Modern Perl-OO allowes easy refactoring to apply above improvements

MooX in general

Some Moo extensions for getting a picture - the list is neither complete nor is it intended to be

MooX Distributions

- **MooX::Log::Any** logging role building a very lightweight wrapper to Log::Any
- **MooX::Validate** minimalist Data Validation for Moo
- **MooX::Types::MooseLike** Moose like types for Moo
- **MooX::Override** adds "override method => sub ..." support to Moo
- **MooX::Augment** adds "augment method => sub ..." support to Moo
- **MooX::late** easily translate Moose code to Moo
- **MooX::PrivateAttributes** create attribute only usable inside your package
- **MooX::Singleton** turn your Moo class into singleton
- **MooX::Aliases** easy aliasing of methods and attributes in Moo

MooX Distributions for CLI

MooX::Cmd

- giving an easy Moo style way to make command organized CLI apps
- support sub-commands with separated options when used together with MooX::Options

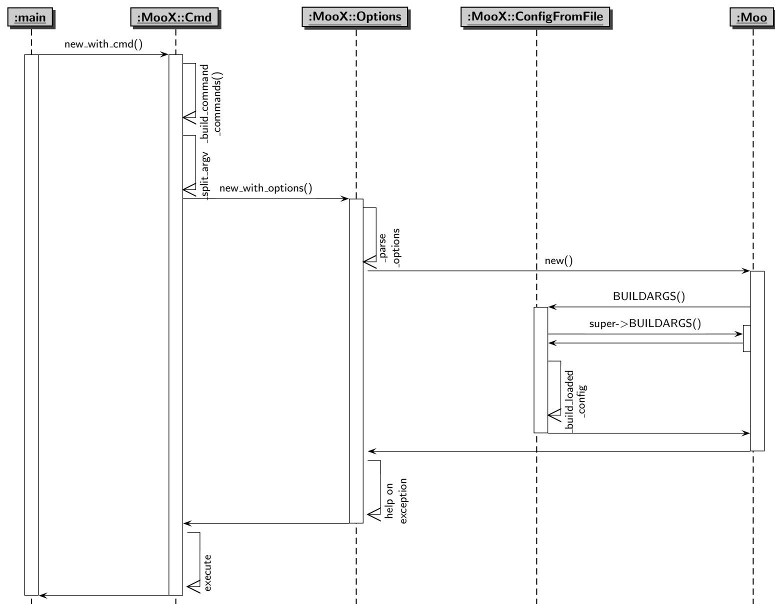
MooX::Options

- explicit Options eXtension for Object Class
- no mess with composed attributes

MooX::ConfigFromFile

- Moo eXtension for initializing objects from config file
- RC files with structures (JSON, INI, YAML, XML, ...)

General CLI Construction Flow



```
package App::Math::Tutor::Role::Exercise;

use strictures; # instead of strict + warnings
use Moo::Role; use MooX::Options;

option quantity => (
                    is       => "ro",
                    doc      => "Specifies number of exercises to generate",
                    long_doc => "Specify number of exercises to generate. "
                      . "In case of several kind of ...",
                    format  => "i",
                    short   => "n",
                    default => sub { 15 },
                  );

has output_name => ( is => "lazy" );
sub _build_output_name {
    join( "", map { $_->command_name || "" } @{ $_[0]->command_chain } );
}
```

- being a role (no "*is a*" relationship) and add CLI options capabilities
- defining an attribute which will be initialized by command line
- support MooX::Option's --man usage feature
- attribute for output file to generate — lazy to allow provide individual name builder

```
has exercises => ( is => "lazy" );
sub execute {
    my $exercises = $_[0]->exercises;
    my $ttcpath = File::Spec->catfile(
       File::ShareDir::dist_dir("App-Math-Tutor"),
       $_[0]->template_filename . ".tt2" );
    my $template = Template->new( { ABSOLUTE => 1 });
    my $rc = $template->process( $ttcpath, {
                                 exercises => $exercises,
                                 output    => { format => 'pdf' },
                              },
                              $_[0]->output_name . '.pdf');

    $rc or croak( $template->error() );
    return 0;
}
```

- attribute containing the exercises definitions, exercises itself and their solutions (depending on template) — lazy implies requires `''_build_exercises''`
- method to satisfy `MooX::Cmd`
- fetch exercises definition implies calling `_build_exercises`
- build full qualified path of template file name residing in app's share directory, instantiate template processor and run it
- force output format "pdf" (`Template::LaTeX` will be instructed by template)

```
package App::Math::Tutor::Role::VulFracExercise;
use strictures; use Moo::Role; use MooX::Options;
with "App::Math::Tutor::Role::Exercise", "App::Math::Tutor::Role::VulFrac";

option format => (
    is       => "ro",
    doc      => "specifies format of numerator/denominator",
    long_doc => "Allow specifying the format of the numerator/denominator ...",
    isa => sub { defined( $_[0] ) and !ref $_[0]
            and $_[0] !~ m,^\d?n+(?:/\d?n+)?$, and die("Invalid format");
    },
    coerce => sub { ...
        my ( $fmta, $fmtb ) = ( $_[0] =~ m,^(\d?n+)(?:/(\d?n+))?$, );
        $fmtb //= $fmta;
        my $starta = "1"; my $startb = "1";
        $fmta =~ s/^(\d)(.*)/$2/ and $starta = $1;
        $fmtb =~ s/^(\d)(.*)/$2/ and $startb = $1;
        [ $starta . "0" x length($fmta), $startb . "0" x length($fmtb) ]
    },
    default => sub { return [ 100, 100 ]; }, format => "s",
                );
```

- be a nice package ^Wrole, intending to provide command line options for instantiation
- compose role behavior using Exercise and VulFrac
- define option coercing option string into array ensuring the array ref as value

```perl
package App::Math::Tutor::Cmd::VulFrac::Cmd::Add;

use strictures;

use Moo;
use MooX::Cmd;
use MooX::Options;

has template_filename => ( is      => "ro",
                           default => "twocols");

with "App::Math::Tutor::Role::VulFracExercise";
```

- `$ mtut vulfrac add`
- we're of course a nice class
- satisfy requirement of Exercise role: provide template_filename – two column template (for addition and substraction)
- compose role `...VulFracExercise`

```
sub _build_exercises {
    my ($self) = @_;

    my (@tasks);
    foreach my $i ( 1 .. $self->amount ) {
        my @line;
        for ( 0 .. 1 ) { # 0: +, 1: -
            my ( $a, $b ) = $self->get_vulgar_fractions(2);
            push @line, [ $a, $b ];
        }
        push @tasks, \@line;
    }

    my $exercises = ...;
    return $exercises;
}
```

- exercise builder has to be provided by individual exercise
- hold tasks of the exercise sheet
- how many tasks per sheet? (remember the option in `...Role::Exercise`)
- a "+" and a "-" exercise per line
- invoke factory per task
- safe each line for processing

```
my $exercises = {
                  section => "Vulgar fraction addition / subtraction",
                  caption => 'Fractions',
                  label   => 'vulgar_fractions_addition',
                  header  => [ [ 'Vulgar Fraction Addition', 'Vulgar Fraction Su
                  challenges => [], solutions  => [],
               };

foreach my $line (@tasks) {
    my ( @solution, @challenge );
    foreach my $i ( 0 .. 1 ) {
        my ( $a, $b, @way ) = @{ $line->[$i] }; my $op = $i ? '-' : '+';
        $op eq '-' and $a < $b and ( $b, $a ) = ( $a, $b );
        push @challenge, sprintf( '$ %s %s %s = $', $a, $op, $b );
        push @way, sprintf( '%s %s %s', $a, $op, $b );
        ...
    }
    push( @{ $exercises->{challenges} }, \@challenge );
    push( @{ $exercises->{solutions} }, \@solution );
}
```

- create exercise structure containing challenges and solutions
- loop over created tasks and exercises per line
- format challenge using operator `'""'` of `VulFrac` objects
- same (but different) opening "way" and remember the little thingies ...

```perl
sub _build_exercises {
    ( $a, $b ) = ( $a->_reduce, $b = $b->_reduce );
    push @way, sprintf( '%s %s %s', $a, $op, $b )
      if ( $a->num != $line->[$i]->[0]->num or $b->num != ... );

    my $gcd = VulFrac->new( num => $a->denum, denum => $b->denum )->_gcd;
    my ( $fa, $fb ) = ( $b->{denum} / $gcd, $a->{denum} / $gcd );
    push @way, sprintf( '\frac{%d \cdot %d}{%d \cdot %d} %s ...',
                        $a->num, $fa, $a->denum, $fa, $op, $b->num, $fb, ... );
    push @way, sprintf( '\frac{%d}{%d} %s \frac{%d}{%d}',
                      $a->num*$fa, $a->denum*$fa, $op, $b->num*$fb, $b->denum*$fb );
    push @way, sprintf( '\frac{%d %s %d}{%d}',
                      $a->num * $fa, $op, $b->num * $fb, $a->denum * $fa );
    my $s = VulFrac->new( denum => $a->denum * $fa,
                 num => $i ? $a->num * $fa - $b->num * $fb : ...s/-/+/);
    push @way, "" . $s; my $c = $s->_reduce; $c->num != $s->num and push @way, '
    $c->num > $c->denum and $c->denum > 1 and push @way, $c->_stringify(1);

    push( @solution, '$ ' . join( " = ", @way ) . ' $' );
}
```

- try to reduce operands and add them to opening when successful
- World of Handcraft: show calculation method by determine geatest common divisor of operands denominator, format subsequent steps to reach the solution
- remark possible reducing, mixed fraction, cord it and go ahead

Vulgar Fraction Addition	Vulgar Fraction Subtraction
$\frac{99}{67} + \frac{43}{84} =$	$\frac{45}{41} - \frac{32}{48} =$
$\frac{19}{7} + \frac{16}{54} =$	$\frac{51}{47} - \frac{49}{65} =$
$\frac{38}{82} + \frac{38}{99} =$	$\frac{56}{33} - \frac{30}{32} =$
$\frac{96}{80} + \frac{46}{39} =$	$\frac{49}{79} - \frac{29}{82} =$
$\frac{72}{68} + \frac{46}{99} =$	$\frac{42}{49} - \frac{38}{59} =$

Vulgar Fraction Addition

$$\frac{99}{67}+\frac{43}{84}=\frac{99\cdot 84}{67\cdot 84}+\frac{43\cdot 67}{84\cdot 67}=\frac{8316}{5628}+\frac{2881}{5628}=\frac{8316+2881}{5628}=\frac{11197}{5628}=1\frac{5569}{5628}$$

$$\frac{19}{7}+\frac{16}{54}=\frac{19}{7}+\frac{8}{27}=\frac{19\cdot 27}{7\cdot 27}+\frac{8\cdot 7}{27\cdot 7}=\frac{513}{189}+\frac{56}{189}=\frac{513+56}{189}=\frac{569}{189}=3\frac{2}{189}$$

$$\frac{38}{82}+\frac{38}{99}=\frac{19}{41}+\frac{38}{99}=\frac{19\cdot 99}{41\cdot 99}+\frac{38\cdot 41}{99\cdot 41}=\frac{1881}{4059}+\frac{1558}{4059}=\frac{1881+1558}{4059}=\frac{3439}{4059}$$

$$\frac{96}{80}+\frac{46}{39}=\frac{6}{5}+\frac{46}{39}=\frac{6\cdot 39}{5\cdot 39}+\frac{46\cdot 5}{39\cdot 5}=\frac{234}{195}+\frac{230}{195}=\frac{234+230}{195}=\frac{464}{195}=2\frac{74}{195}$$

$$\frac{72}{68}+\frac{46}{99}=\frac{18}{17}+\frac{46}{99}=\frac{18\cdot 99}{17\cdot 99}+\frac{46\cdot 17}{99\cdot 17}=\frac{1782}{1683}+\frac{782}{1683}=\frac{1782+782}{1683}=\frac{2564}{1683}=1\frac{881}{1683}$$

Vulgar Fraction Subtraction

$$\frac{45}{41}-\frac{32}{48}=\frac{45}{41}-\frac{2}{3}=\frac{45\cdot 3}{41\cdot 3}-\frac{2\cdot 41}{3\cdot 41}=\frac{135}{123}-\frac{82}{123}=\frac{135-82}{123}=\frac{53}{123}$$

$$\frac{51}{47}-\frac{49}{65}=\frac{51}{47}-\frac{49}{65}=\frac{51\cdot 65}{47\cdot 65}-\frac{49\cdot 47}{65\cdot 47}=\frac{3315}{3055}-\frac{2303}{3055}=\frac{3315-2303}{3055}=\frac{1012}{3055}$$

$$\frac{56}{33}-\frac{30}{32}=\frac{56}{33}-\frac{15}{16}=\frac{56\cdot 16}{33\cdot 16}-\frac{15\cdot 33}{16\cdot 33}=\frac{896}{528}-\frac{495}{528}=\frac{896-495}{528}=\frac{401}{528}$$

$$\frac{49}{79}-\frac{29}{82}=\frac{49\cdot 82}{79\cdot 82}-\frac{29\cdot 79}{82\cdot 79}=\frac{4018}{6478}-\frac{2291}{6478}=\frac{4018-2291}{6478}=\frac{1727}{6478}$$

$$\frac{42}{49}-\frac{38}{59}=\frac{6}{7}-\frac{38}{59}=\frac{6\cdot 59}{7\cdot 59}-\frac{38\cdot 7}{59\cdot 7}=\frac{354}{413}-\frac{266}{413}=\frac{354-266}{413}=\frac{88}{413}$$

Conclusion

- lazy attributes allow designing a multi-stage initialization phase
- benefit of common runtime (faster load) when using
  - DBIx::Class
  - Web::Simple (Jedi)
- improve design by
  - using roles for behavioral design (avoid duck typing)
  - using explicit patterns for clear separation of concerns
  - express intensions clearer for method overloading by using *method modifiers*

Resources

Software

https://metacpan.org/pod/Moo/

https://github.com/moose/Moo

https://metacpan.org/search?q=MooX

https://metacpan.org/pod/MooX::Cmd

https://metacpan.org/pod/MooX::Options

https://metacpan.org/pod/MooX::ConfigFromFile

https://github.com/rehsack/App-Math-Tutor

IRC

irc://irc.perl.org/#moose

irc://irc.perl.org/#web-simple

Thank You For Contributing

Graham "haarg" Knop Found a lot of spelling errors and first suggestions

Vincent "celogeek" Bachelier Suggested some real examples

Fedor Babkin UML diagram improvements

Curtis "Ovid" Poe Final review and figured out missing fundamentals

Thank You For Listening

Questions?

Jens Rehsack <rehsack@cpan.org>