CS 596 Functional Programming and Design
Fall Semester, 2015
Doc 25 Sample Code, Monads
Dec 8, 2015

Beginner Clojure Code

Masters Exam Website

Implemented by four undergraduate students from Brazil

No Clojure experience

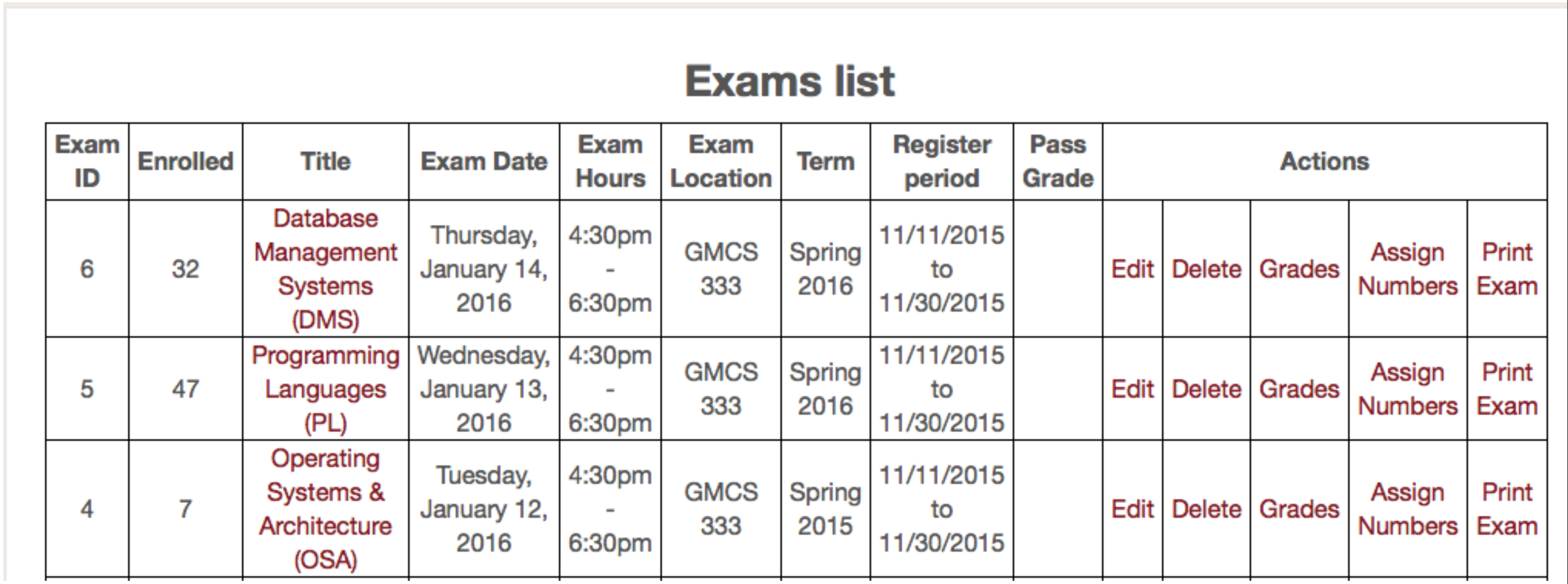
No Functional Programming experience

Only one had any web programming experience

Long Sequences of composed functions

Used recursion rather than higher order functions
- map/reduce/filter
- Towards the end started using higher order functions

Issue: Displaying Dates



Exams list

Exam ID	Enrolled	Title	Exam Date	Exam Hours	Exam Location	Term	Register period	Pass Grade	Actions				
6	32	Database Management Systems (DMS)	Thursday, January 14, 2016	4:30pm - 6:30pm	GMCS 333	Spring 2016	11/11/2015 to 11/30/2015		Edit	Delete	Grades	Assign Numbers	Print Exam
5	47	Programming Languages (PL)	Wednesday, January 13, 2016	4:30pm - 6:30pm	GMCS 333	Spring 2016	11/11/2015 to 11/30/2015		Edit	Delete	Grades	Assign Numbers	Print Exam
4	7	Operating Systems & Architecture (OSA)	Tuesday, January 12, 2016	4:30pm - 6:30pm	GMCS 333	Spring 2015	11/11/2015 to 11/30/2015		Edit	Delete	Grades	Assign Numbers	Print Exam

```
(defn convert-date-to-calendar-format
  "Get a whole vector of maps and convert a date type (yyyy-mm-dd) to
   Calendar type (Day, Month Day, Year)"

  ([vector-of-maps key] (convert-date-to-calendar-format vector-of-maps key []))

  ([vector-of-maps key result]
     (if (empty? vector-of-maps)
         result
         (convert-date-to-calendar-format
                              (rest vector-of-maps)
                              key
                              (conj
                                  result
                                  (assoc (first vector-of-maps)
                                           (keyword key)
                                           (f/unparse calendar-formatter (c/from-sql-date
                                                          ((keyword key) (first vector-of-maps))))))))))
```

All the work is done in last argument of the last argument of the last argument of the recursion

The Actual Work

```
(defn date->string
  "Convert a java.sql.Date object to string Full date format
   ie Thursday, January 14, 2016"
  [sql-date]
  (->> sql-date
        c/from-sql-date
       (f/unparse calendar-formatter)))
```

```
(defn convert-date-to-calendar-format
  "Get a whole vector of maps and convert a date type (yyyy-mm-dd) to
   Calendar type (Day, Month Day, Year)"

  ([vector-of-maps key] (convert-date-to-calendar-format vector-of-maps key []))

  ([vector-of-maps key result]
    (if (empty? vector-of-maps)
        result
        (convert-date-to-calendar-format
                              (rest vector-of-maps)
                              key
                              (conj
                                  result
                                  (assoc (first vector-of-maps)
                                            (keyword key)
                                            (date->string
                                                 ((keyword key)
                                                 (first vector-of-maps))))))))))
```

Using Higher Order Functions

```
(defn date->string
  "Convert a java.sql.Date object to string - Thursday, January 14, 2016"
  [sql-date]
  (->> sql-date
        c/from-sql-date
        (f/unparse calendar-formatter)))

(defn convert-date-to-calendar-format
  "Convert value at key from java.sql.Date to string - Full date format"
  [vector-of-maps key]
  (mapv #(update % key date->string) vector-of-maps))
```

Issue: Entering Student Requests in Database

Students can sign up for 1- 3 exams

```
(defn insert-request!
   "Manipulate request to be sent to database"
   [current-id request-map]
   (when (string? (:exam_id request-map))
     (let [new-exam-id (Integer. (:exam_id request-map))]
         (insert-request-to-db! (assoc request-map :exam_id new-exam-id
                                                   :request_date (l/local-now)
                                                   :student_redid current-id)))))
```

```
(defn insert-exam-request!
  "Add exam request to student in database
   current-id Int student Red Id requesting exam
   request-map {:exam_id IntOrString, _} Id of exam to add"
  [current-id request-map]
  (let [exam-id-int (Integer. (:exam_id request-map))]
    (insert-request-to-db! {:exam_id exam-id-int
                            :request_date (l/local-now)
                             :student_redid current-id})))
```

```
(defn insert-multiple-requests!
  "Insert multiple exam requests"
  [current-id request-map]
  (if (vector? (:exam_id request-map))
    (let [request (core/from-map-of-vector-to-vector-of-maps-request request-map)]
      (loop [req request]
        (when (not-empty req)
          (insert-exam-request! current-id (first req))
          (recur (rest req)))))
    (insert-exam-request! current-id request-map)))
```

```
(defn insert-multiple-requests!
  "Insert multiple exam requests"
  [current-id request-map]
  (if (vector? (:exam_id request-map))
    (let [request (core/from-map-of-vector-to-vector-of-maps-request request-map)]
      (doseq [req request]
          (insert-exam-request! current-id  req)))
    (insert-exam-request! current-id request-map)))
```

```
(defn from-map-of-vector-to-vector-of-maps-request
  "Change the structure from map of vectors to vector of maps"
  [map-of-vectors]
  (vec (for [x (range (count (:exam_id map-of-vectors)))]
         {:exam_id (nth (:exam_id map-of-vectors) x)})))

(defn from-map-of-vector-to-vector-of-maps-request
  "{:exam_id [a b c],_ } -> [{:exam_id a} {:exam_id b} {:exam_id c}]"
  [map-of-vectors]
  (vec (for [x (range (count (:exam_id map-of-vectors)))]
         {:exam_id (nth (:exam_id map-of-vectors) x)})))


(defn from-map-of-vector-to-vector-of-maps-request
  "{:exam_id [a b c],_ } -> [{:exam_id a} {:exam_id b} {:exam_id c}]"
  [map-of-vectors]
  (for [x (:exam_id map-of-vectors)]
         {:exam_id x}))
```

This is only used in one function - insert-multiple-requests!

```
(defn insert-multiple-requests!
  "Insert multiple exam requests"
  [current-id request-map]
  (if (vector? (:exam_id request-map))
    (let [request (core/from-map-of-vector-to-vector-of-maps-request request-map)]
      (loop [req request]
        (when (not-empty req)
          (insert-exam-request! current-id (first req))
          (recur (rest req)))))
    (insert-exam-request! current-id request-map)))
```

```
(defn insert-multiple-requests!
  "Insert multiple exam requests
   request-map {:exam_id IntOrString} or {:exam_id [IntOrStrings]}"
  [current-id request-map]
  (if (vector? (:exam_id request-map))
      (doseq [exam-id (:exam_id request-map)]
          (insert-exam-request! current-id  {:exam_id exam-id}))
    (insert-exam-request! current-id request-map)))
```

Simpler code

Improved function names

More information about arguments

Step in Processing Students Request

Get data from web page

Validate data

- 1-3 exams
- No exams that meet at same time

If errors display them to user

Convert data into format needed by database

Enter data into database

All done as one thing

```
(defn request-exam
  "Requests an exam"
  [request exams]
  (let [current-id {:redid (Integer. (:identity request))}
        registered-exams (student/get-active-registered-exams current-id)
        registered-exams-after-calendar (core/convert-date-to-calendar-format registered-exams :exam_date)
        registered-exams-after-slash (core/convert-dash-to-slash-format registered-exams-after-calendar :register_start :register_end)
        exam (exam/filter-exams-for-registration (exam/get-available-exams current-id))
        exam-after-calendar (core/convert-date-to-calendar-format exam :exam_date)
        exam-after-slash (core/convert-dash-to-slash-format exam-after-calendar :register_start :register_end)]
    (if (too-many-exams (:exam_id exams) registered-exams-after-slash)
      (layout/render "students/exam-request.html" {:exams   exam-after-slash :registered-exams registered-exams-after-slash
                                               :request request :error "You can only register for three exams"})
      (if (exam/verify-conflict-exam-requests exams)
        (layout/render "students/exam-request.html" {:exams   exam-after-slash :registered-exams registered-exams-after-slash
                                                 :request request :error "You cannot register for exams given at the same time"})
        (let [current-id (Integer. (:identity request))]
          (try
            (exam/insert-multiple-requests! current-id exams)
            (response/redirect "/masters/students/request-exam")
            (catch Exception e
              (timbre/error e)
              (response/redirect "/masters/students/request-exam")
              )))))))
```

How to make sure it works

Display web page

Enter data

See what happens

Debugging behind web server using web browser sucks

The structure of the program makes it hard to debug/maintain/extend

Make Independent

Get data from web page

Validate data

Convert data into format needed by database

Enter data into database

You can test at least the last two in
- REPL
- Unit tests

Testing database is work

- Seperate converting data
- From adding to database

The End of Dynamic Languages

By Elben Shira

Nov 22, 2015

http://elbenshira.com/blog/the-end-of-dynamic-languages/

Used Clojure in the past

Working in Scala (work) and Haskell (side project)

Spent a week doing Ruby & Clojure

Uncertainty

What are the arguments to the functions

```
(defn convert-date-to-calendar-format  [vector-of-maps key]
```

AppsFlyer

Mobile Analytics Company

Based in San Francisco

2 Billion events per day

Traffic double in 3 months

Grew from 6 to 50 people past year

Technologies used

- Redis, Kafka, Couchbase, CouchDB, Neo4j
- ElasticSearch, RabbitMQ, Consul, Docker, Mesos
- MongpDB, Riemann, Hadoop, Secor, Cascalog, AWS

AppsFlyer - Python Based

Started code base in Python

After two years python could not handle the traffic

Problems caused by

- String manipulations
- Python memory management

Their options

Rewrite parts in C & wrap in Python

Rewrite in programming language more suitable for data proccessing

  Wanted to try Functional Programming

Scala vs. OCaml vs. Haskell vs. Clojure

Scala
- Functional & Object Oriented
- They wanted pure Functional

OCaml
- Smaller community
- Only one thread runs at a time even on multicore

Haskell
- Monads made us cringe in fear

Clojure
- Runs on JVM
- Access to mutable state if needed
- Now have 10 Clojure engineers

Monads

What are they?

Why do they make engineers cringe in fear?

Monoids & Monads

Monoid

Binary Function Two parameters	Integer +
Parameters and returned value have same type	2 + 1
Identity value	2 + 0
Associatively	(2+3) + 4 = 2 + (3 + 4)

Monoid

Binary Function

Two parameters

Parameters and returned value - same type

Identity value

Associatively

Java String concat

```
“hi”.concat(“ Mom”);

“hi”.concat(“”)

“hi”.concat(“Mom”.concat(“!”))
“hi”.concat(“Mom”).concat(“!”)
```

Monoid

Binary Function
    Two parameters

Parameters and returned value - same type

Identity value

Associatively

Sets union

```
“hi”.concat(“ Mom”);

“hi”.concat(“”)

“hi”.concat(“Mom”.concat(“!”))
“hi”.concat(“Mom”).concat(“!”)
```

Monoid

Associative binary function F: X*X -> X
that has an identity

Haskell

```
class Monoid m where
    mempty :: m
    mappend :: m -> m -> m
    mconcat :: [m] -> m
    mconcat = foldr mappend mempty
```

Monad - Some Motivation

Exceptions

- Interrupt program flow

```
(filter foo [a b c d e f g h])
```

Swift - optionals

```
let possibleNumber = "123"
let convertedNumber = possibleNumber.toInt()

if (convertedNumber)
      println( convertedNumber! )
```

Pyramid Of Doom

```
let b = foo(a)
if b
    let c = bar(b)
    if c
        let d = fooBar(c)
        if d
            let e = barFoo(e)
            if e
                return e!
            return “No e”
        return “No d”
    return “No c”
return “No b”
```

Clojure-like example

```
(-> some-collection
    foo
    bar
    fooBar
    barFoo)
```

What if one of the functions (foo, etc) returns an optional?

All the rest of the functions need handle them

Haskell Monad

Contains a context & four functions

return

- return :: a -> m a
- Takes a value and wraps in a monad

bind

- (>>=) :: m a -> (a -> m b) -> m b
- Take a
  - monad
  - function that requires a regular value and returns a monad
  - Applies the function to the monad

Haskell Monad

Contains a context & four functions

>>

    (>>) :: m a -> m b -> m b
    First argument is ignored

Error

What are Monads used for?

In Haskell all functions are pure

Monad contexts can have side effects

All I/O in Haskell is done in monads

Monads allow you to compose computational steps together

Monads in Clojure

let

for

->

->>

Monads Tutorial For Clojure Programmers

http://onclojure.com/2009/03/05/a-monad-tutorial-for-clojure-programmers-part-1/