INF4820: Algorithms for Artificial Intelligence and Natural Language Processing

Common Lisp Core

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Agenda

Previously

- Common Lisp essentials
- S-expressions (= atoms or lists of s-expressions)
- Recursion
- Quote
- List processing
- Identity vs. Equality

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- Common Lisp essentials
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- Recursion
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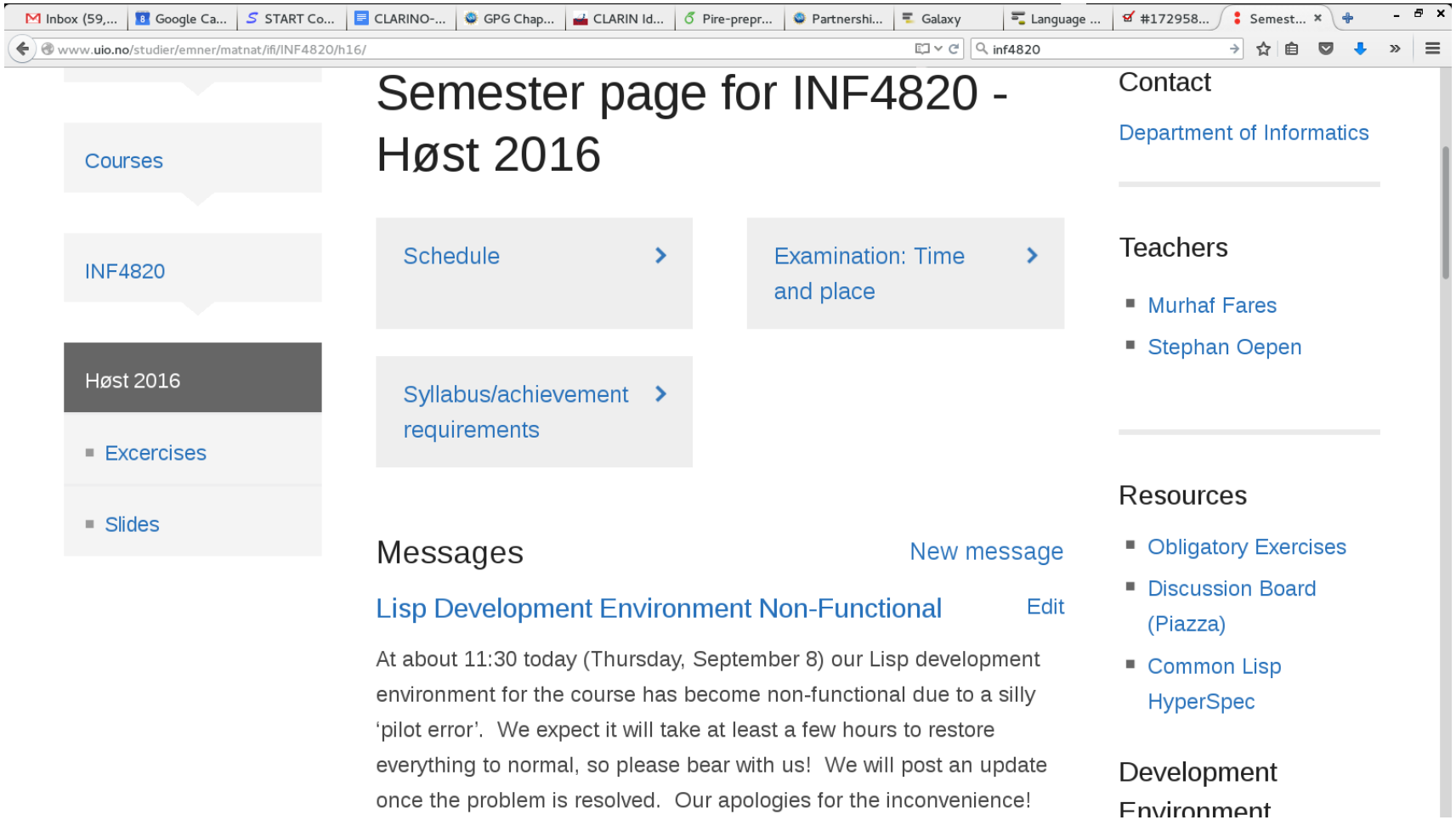
- List processing
- Identity vs. Equality

Today

- More Common Lisp
- Higher-order functions
- Argument lists
- Iteration: (the mighty) `loop`
- Additional data structures

Did You Check the Course Page Today?



http://www.uio.no/studier/emner/matnat/ifi/INF4820/h16/

Rewind: A Note on Symbol Semantics

- Symbols can have values as functions and variables at the same time.
- `#'` (*sharp-quote*) gives us the function object bound to a symbol.

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- #' and `funcall` (as well as `apply`) are useful when passing around functions as arguments.

Higher-Order Functions

- Functions that accept functions as arguments or return values.
- Functions in Lisp are first-class objects.
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- Functions, recursion, conditionals, predicates, lists for code and data.

Anonymous Functions

- We can also pass function arguments without first binding them to a name, using lambda expressions: `(lambda (`*`parameters`*`) `*`body`*`)`
- A function definition without the `defun` and *symbol* part.

```
? (filter foo
          #'(lambda (x)
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- Or, when constructing functions as return values.

Returning Functions

- We have seen how to create anonymous functions using `lambda` and pass them as arguments.
- So we can combine that with a function that itself returns another function (which we then bind to a variable).

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? (filter foo (make-range-test 10 30))

→ (11 22)
```

Parameter Lists: Variable Arities and Naming

Optional Parameters

```
? (defun foo (x &optional y (z 42))
    (list x y z))

? (foo 1) → (1 nil 42)

? (foo 1 2 3) → (1 2 3)
```

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Rest Parameters

```
? (defun avg (x &rest rest)
    (let ((numbers (cons x rest)))
      (/ (apply #'+ numbers)
         (length numbers))))

? (avg 3) → 3

? (avg 1 2 3 4 5 6 7) → 4
```

Recap: Equality for One and All

- `eq` tests object identity; it is not useful for numbers or characters.
- `eql` is like `eq`, but well-defined on numbers and characters.
- `equal` tests structural equivalence
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? (equalp "FOO" "foo") → t
```

- Also many type-specialized tests like `=`, `string=`, etc.

Some Live Programming

From the 2013 Final Exam

Write two versions of a function `swap`*; one based on recursion and one based on iteration. The function should take three parameters—*`x`*,* `y` *and* `list`*— where the goal is to replace every element matching* `x` *with* `y` *in the list* `list`*. Here is an example of the expected behavior:*

```
? (swap "foo" "bar" '("zap" "foo" "foo" "zap" "foo"))
→ ("zap" "bar" "bar" "zap" "bar")
```

Try to avoid using destructive operations if you can. [7 points]

A Brief Detour: Macros

- Elevator Pitch: programs that generate programs.
- Macros provide a way for our code to manipulate itself (before it is passed to the compiler).
- Can implement transformations that extend the syntax of the language.
- Allows us to control (or even prevent) the evaluation of arguments.
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- Allows us to control (or even prevent) the evaluation of arguments.
- We have already encountered some built-in Common Lisp macros: `and`, `or`, `if`, `cond`, `defun`, `setf`, etc.
- Although macro writing is out of the scope of this course, we will look at perhaps the best example of how macros can redefine the syntax of the language—for good or for worse, depending on who you ask:
  - `loop`

Iteration

- While recursion is a powerful control structure,
- sometimes *iteration* comes more natural.
- `dolist` and `dotimes` are fine for simple iteration.

```
(let ((result nil))
  (dolist (x '(0 1 2 3 4 5))
    (when (evenp x)
      (push x result)))
  (reverse result))
→ (0 2 4)
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→ *(0 2 4)*

```
(let ((result nil))
  (dotimes (x 6)
    (when (evenp x)
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Iteration

- While recursion is a powerful control structure,
- sometimes *iteration* comes more natural.
- `dolist` and `dotimes` are fine for simple iteration.
- But (the mighty) `loop` is much more general and versatile.

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(let ((result nil))
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  (reverse result))
```

→ *(0 2 4)*

```
(loop
    for x below 6
    when (evenp x)
    collect x)
```

→ *(0 2 4)*

Iteration with `loop`

```
(loop
    for i from 10 to 50 by 10
    collect i)

→ (10 20 30 40 50)
```

- Illustrates the power of syntax extension through macros;
- `loop` is basically a mini-language for iteration.

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- Reduced uniformity: different syntax based on special keywords.
- Paul Graham on `loop`: “one of the worst flaws in Common Lisp”.

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- Reduced uniformity: different syntax based on special keywords.
- Paul Graham on `loop`: “one of the worst flaws in Common Lisp”.
- But non-Lispy as it may be, `loop` is extremely general and powerful!

loop: A Few More Examples

```
? (loop
      for i below 10
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→ 25
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```
? (loop for x across "foo" collect x)

→ (#\f #\o #\o)
```

```
? (loop
      with foo = '(a b c d)
      for i in foo
      for j from 0
      until (eq i 'c)
      do (format t "~a: ~a ~%" j i))

↝
0: A
1: B
```

loop: Even More Examples

```
? (loop
      for i below 10
      if (evenp i)
      collect i into evens
      else
      collect i into odds
      finally (return (list evens odds)))

→ ((0 2 4 6 8) (1 3 5 7 9))
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→ ((0 2 4 6 8) (1 3 5 7 9))
```

```
? (loop
      for value being each hash-value of *dictionary*
      using (hash-key key)
      do (format t "~&~a -> ~a" key value))
```

`loop`: The Swiss Army Knife of Iteration

- Iteration over lists or vectors: `for` *symbol* { `in` | `on` | `across` } *list*

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- Accumulation: { `collect` | `append` | `sum` | `minimize` | `count` | ... } *sexp*

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- Accumulation: { `collect` | `append` | `sum` | `minimize` | `count` | ... } *sexp*
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- Iteration over lists or vectors: `for` *symbol* { `in` | `on` | `across` } *list*
- Counting through ranges:
  `for` *symbol* [`from` *number*] { `to` | `downto` } *number* [`by` *number*]
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- Note: without at least one accumulator, `loop` will only return `nil`.