CS 696 Functional Programming and Design
Fall Semester, 2015
Doc 2 Clojure Introduction
Aug 28, 2015

Clojure

Developed by Rich Hickey

Started 2007

Variant of Lisp

Functional programming language

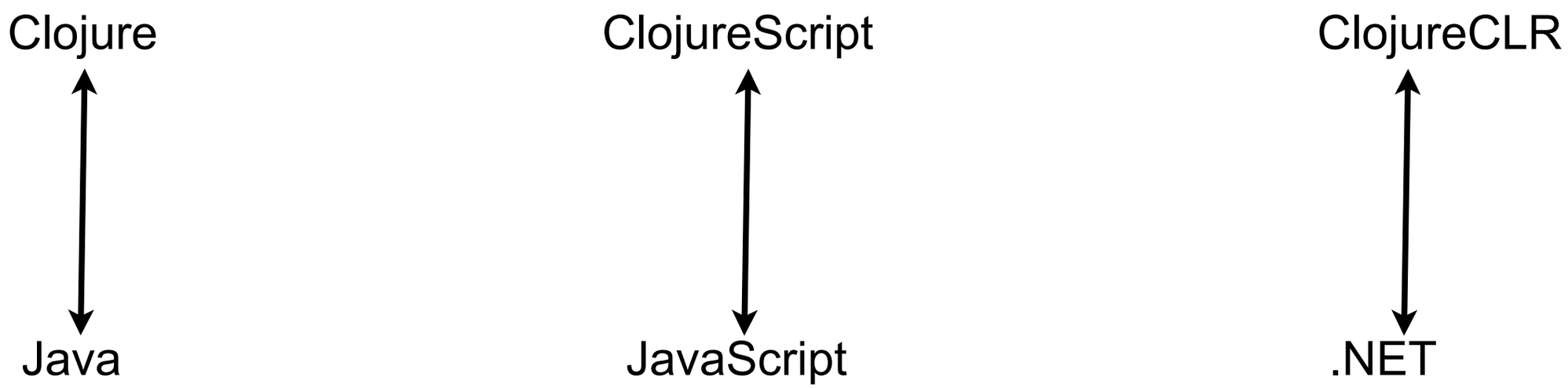
Dynamic typing

Interactive development - REPL

Tight Java Integration

Active development community

Variants



Base language the same

Few changes due differences between Java/Javascript/.NET

Development Environment

Light Table
- Clojure/Web IDE
- http://lighttable.com/

IntelliJ
- Cursive plugin
- https://cursiveclojure.com

Eclipse
- Counterclockwise plugin
- https://code.google.com/p/counterclockwise/

Command Line

Leiningen

Night Code

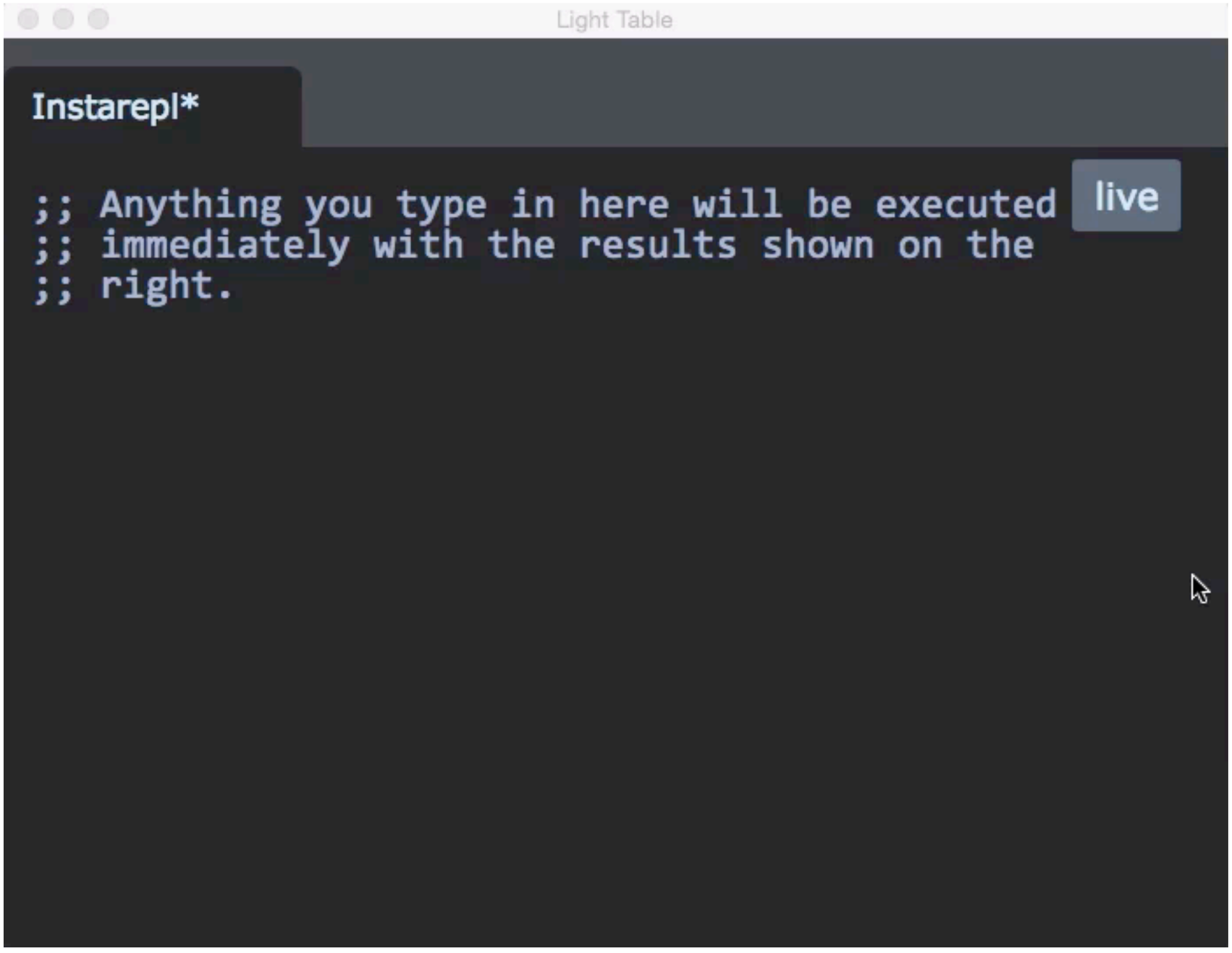
Emacs
- CIDER

Vim
- Fireplace

Light Table

http://www.lighttable.com

Recommended IDE to start learning Clojure



Lots of Irritatiing Superfluous Parenthesis-LISP

Actually not more that Java's

But only () and they build up

```
(+ 5 (- 2 (/ 4 (* 2 (inc (read-string "123"))))))
```

Use editor that is parenthesis aware

Useful forms

- let
- ->

Resources

Clojure Home Page

http://clojure.org

Clojure Cookbook

Safari Books On-line
http://proquest.safaribooksonline.com.libproxy.sdsu.edu/

Elements of Clojure Code

symbols
keywords
literals
lists
vectors
maps
sets

functions
macros
special forms (functions)

REPL

Read-Eval-Print Loop
Light Table - front end to Clojure REPL

Executable code (program) in repl

"hi there"

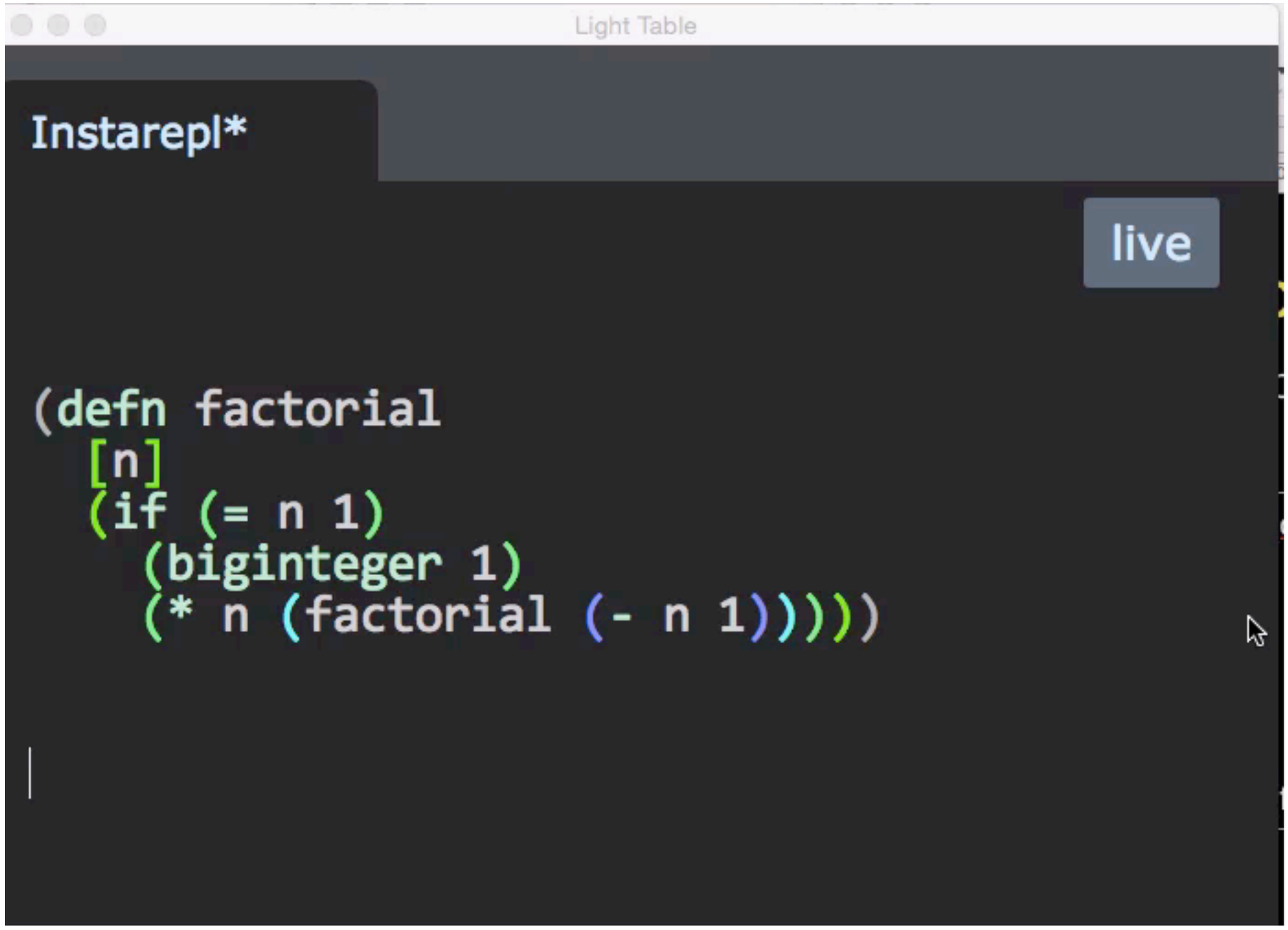
42

[1 2 3]

(+1 2)

Clojure Programs

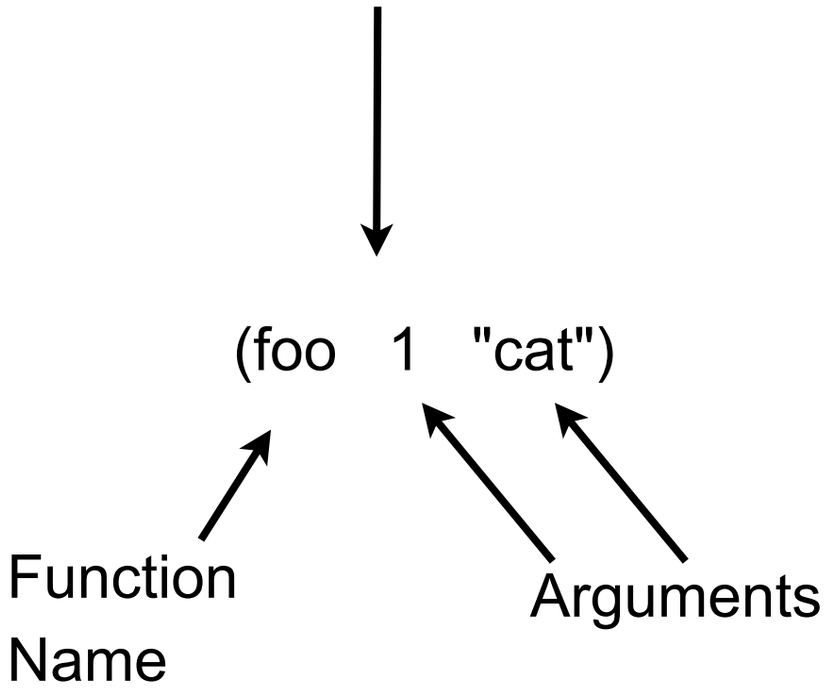
Chain of functions calling functions



Clojure Function Calls

foo(1, "cat")

C function call



Clojure function call

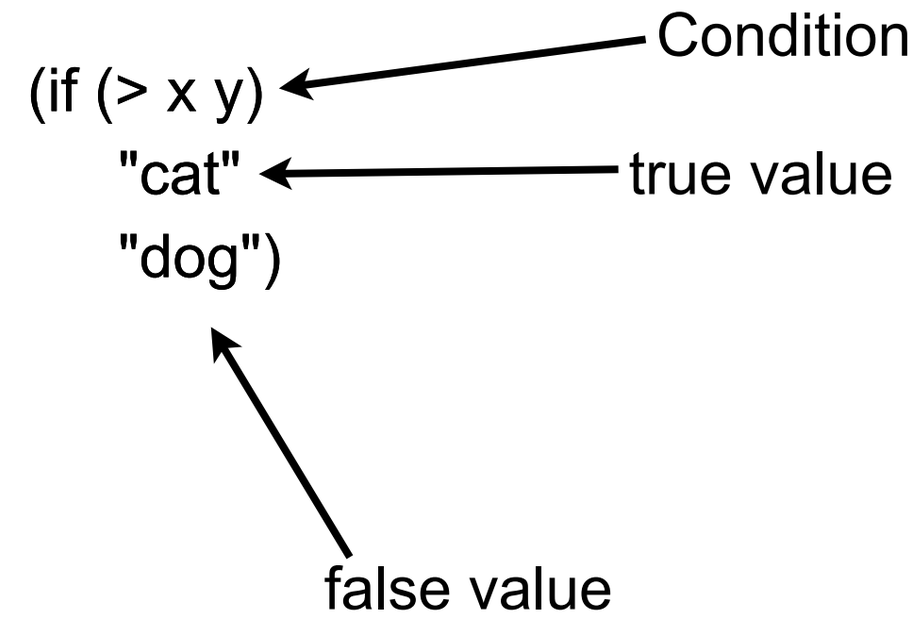
Some Basic Operations

Function	Result
(+ 1 2)	3
(+ 1 2 4 6)	13
(= "cat" "dog")	[redacted]
(= 1 1)	true
(= 1 1 2)	false
(even? 8)	true
(/ 10 2)	5
(/ 10 2 3)	5/3
(bit-shift-left 4 1)	8

Operators

No built-in operators

Just functions



Assignment

No built-in operators

Just functions

```
(def a 10)

(def b  (+ a 12))

(def a 20)
```

Called a binding which is sort of like assignment

No Precedence

a - b * c + d

(- a (+ (* b c) d))

Clojure expressions read inside out

Will see several ways to change this

Recursion
Higher Order Functions
The Functional Way

Vectors

Expandable, indexed list

Fast insert at end

Expensive insert in front

Fast indexed lookup

[4 "cat" \c]

[4, "cat", \c]

[ ]

Vectors

(vector 8 4 2)	[8 4 2]
(nth [:a :b :c] 2)	:c
(first [1 2 3])	1
(second [1 2 3])	2
(third [1 2 3])	Error
(last [1 2 3])	3
(rest [1 2 3])	(2 3)

Compute the Sum

```
public float sum(ArrayList<float> list) {
      float sum = 0;
      for (int k = 0; k < list.length; k++)
            sum = sum + list.get(k);
      return sum;
}
```

Does not work in Functional World

No “for” statement

No side effects

Recursion replaces Iteration

```
(defn sum-1
  [list]
  (if (empty? list)
    0
    (+ (first list) (sum-1 (rest list)))))
```

(sum-1 [1 2 3]) 6

(sum-1 (range 9900)) Stack over flow

(range 9900) [1 2 3 4 5 ... 9898 9899]

Second Try

```
(defn sum-2
  [partial-sum list]
  (if (empty? list)
    partial-sum
    (sum-2 (+ partial-sum (first list))
           (rest list))))
```

(sum-2 0 [1 2 3])	6
(sum-2 0 (range 9900))	Stack over flow

Recursive verses Iterative Process

Recursive Process

(sum-1 [1 2 3])

(+ 1 (sum-1 [2 3]))

(+ 1 (+ 2 (sum-1 [3])))

(+ 1 (+ 2 (+ 3 (sum-1 []))))

(+ 1 (+ 2 (+ 3 0)))

(+ 1 (+ 2 3))

(+ 1 5)

6

Iterative Process

(sum-2 0 [1 2 3])

(sum-2 1 [2 3])

(sum-2 3 [3])

(sum-2 6 (sum-2 [])

6

Tail Recursion Optimization

In a recursive function implementing a iterative process

The compiler can optimize the recursion into iteration

But JVM does not support tail recursion optimization

recur

```
(defn sum-3
  [accumulator list]
  (if (empty? list)
    accumulator
    (recur (+ accumulator (first list))
           (rest list))))
```

Replace the recursive call with recur

recur will call the function

But Clojure will convert to iteration

```
(sum-3 0 [1 2 3])                6

(sum-3 0 (range 9900))           49000050

(sum-3 0 (range 100000))         4999950000
```

One Name, Multiple Implementations

```
(defn sum-4
  ([list]
   (sum-4 0 list))
  ([accumulator list]
   (if (empty? list)
    accumulator
    (recur (+ accumulator (first list))
           (rest list)))))
```

```
(sum-4  [1 2 3])                  6

(sum-4  0 [1 2 3])                6

(sum-4 (range 100000))            4999950000

(sum-4 0 (range 100000))          4999950000
```

Major Points

Recursion replaces “for” loops

Accumulators can be used to convert recursive process into iterative process

Tail recursion optimization (recur) can convert iterative process to iterative code

But this is not the way to implement sum

reduce

```
(reduce + [1 2 3 4 5])
```

What versus How

What

```
(reduce + [1 2 3 4 5])
```

How

```
public float sum(ArrayList<float> list) {
    float sum = 0;
    for (int k = 0; k < list.length; k++)
        sum = sum + list.get(k);
    return sum;
}
```

Less typing

Fewer details

Less cognitive load

More general solution

Code can be optimized

Higher Order Functions

Function that acts on functions

```
(reduce + [1 2 3 4 5])
```

Timing tests

Code	Time
(sum-3 0 (range 100000))	54450.6 msecs
(sum-4 0 (range 100000))	26.1 msecs
(reduce + (range 100000))	6.5 msecs

(def data (range 1000000))

Code	Time
(sum-4 data)	~55 msecs
(reduce + data)	~22.5 msecs

The Functional Way

Raw data

vectors
maps (hash table)
sequences

Rich set of powerful functions on data

map
map-indexed
filter
reduce
remove
keep
zipper
drop-while
take-while
partition
interpose
split-at
etc.

Immediate Goals

Recursion

Master use of built-in functions

Get comfortable with higher-order functions.

Clojure API

http://clojure.org/cheatsheet

Clojure

Search

Download
Google Group
Videos
Contrib Libraries

Clojure 1.3-1.6 Cheat Sheet (v13)

Download PDF version, Download other versions with tooltips

Documentation

clojure.repl/	doc find-doc apropos source pst javadoc (foo.bar/ is namespace for later syms)

Primitives

Numbers

Literals	Long: 7, hex 0xff, oct 017, base 2 2r1011, base 36 36rCRAZY BigInt: 7N Ratio: -22/7 Double: 2.78 -1.2e-5 BigDecimal: 4.2M
Arithmetic	+ - * / quot rem mod inc dec max min
Compare	= == not= < > <= >= compare
Bitwise	bit-{and, or, xor, not, flip, set, shift-right, shift-left, and-not, clear, test} (1.6) unsigned-bit-shift-right
Cast	byte short int long float double bigdec bigint num rationalize

Transients (clojure.org/transients)

Create	transient persistent!
Change	conj! pop! assoc! dissoc! disj! Note: always use return value for later changes, never original!

Misc

Compare	= == identical? not= not compare clojure.data/diff
Test	true? false? instance? nil? (1.6) some?

Sequences

Creating a Lazy Seq

From collection	seq vals keys rseq subseq rsubseq
From producer fn	lazy-seq repeatedly iterate

4Clojure

http://www.4clojure.com