Top Ten Things to Learn from Clojure that will make you a better developer in any language

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Why Clojure?

- Small
- Powerful
- Elegant
- Functional
- Extensible
- Concurrency
- Interoperable

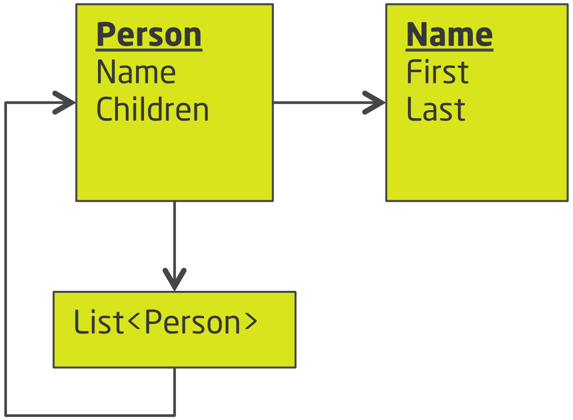
Reducing Complexity of the Implementation Domain

Problem	Simplification
Spaghetti code	Structured programming, OO
Memory management	Garbage collection
Side-effects	**Pure functions**
Sharing data	Message passing, value semantics **Immutable data**
Concurrency / locks	**Software Transactional Memory** Message based concurrency Offline lock patterns, …
Composability	**Common abstractions**, higher-order functions
Limitations of implementation language	**Macros** DSLs, Design patterns

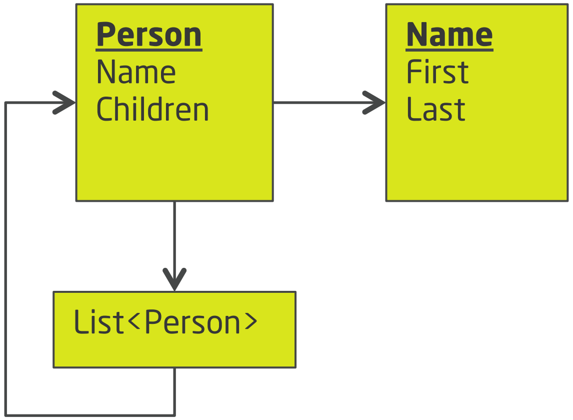
MUTABLE STATE IS THE NEW SPAGHETTI CODE

Mutable state: What is wrong with this code?

```
public class Name {
          public String First { get; set; }
          public String Last { get; set; }
}

public class Person {
          public Person(Name name, List<Person> children)
          {
              this.Name = name;
              this.Children =  children;
          }
          public Name Name { get; set; }
          public List<Person> Children { get; }
}
```



Mutable state:
What’s wrong with this code?

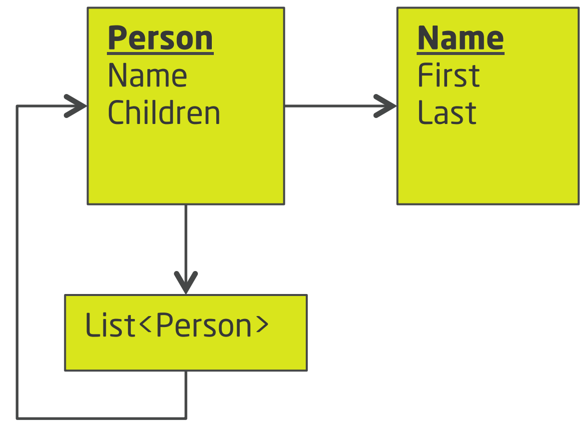


What is the state after this?

```
var noChildren = new List<Person>();
var alpha = new Person(new Name(“Alpha”, “Sister”), noChildren);
var beta  = new Person(new Name(“Beta”, “Sister”), noChildren);

alpha.Name.Last = “Omega”;
alpha.Children.Add(new Person(new Name(“Gamma”, “Sisterdaughter”)));
DoSomethingTo(alpha, beta);
```

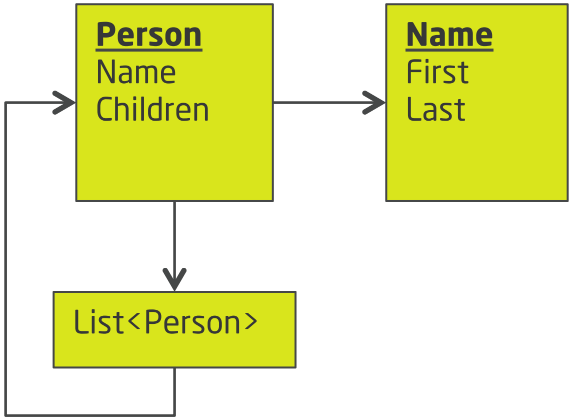
Mutable state:
What is wrong with this code?

```
public class Name {
    public String First { get; set; }
    public String Last { get; set; }
}

public class Person {
    public Person(Name name, List<Person> children)
    {
        this.name = name.DeepClone();
        this.children =  DeepClone(children);
    }
    public Name Name { get; set; }
    public IEnumerable<Person> Children { get { return DeepClone(children); }}
    public Name UpdateName(String f, String l) { this.Name = new Name(f,l); }
    public AddChild(Person p) { this.children.Add(p.DeepClone()); }
}
```



Mutable state

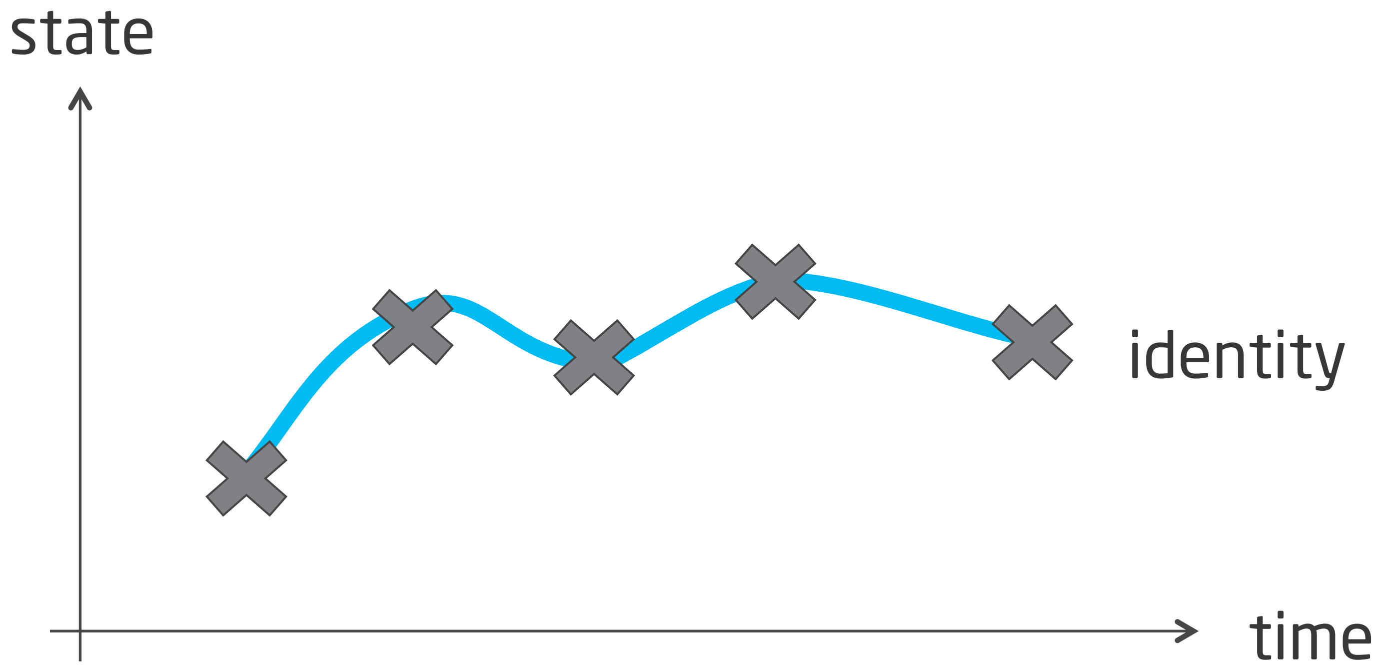
- **Encapsulation** is hard
  - clone in, clone out
- **Ownership** is hard
  - “Entities” and “Value Objects”
- **Reasoning** about state is hard
- **Concurrency** is even worse



Maybe it’s time to stop

IMMUTABILITY

Philosophy of State and Identity



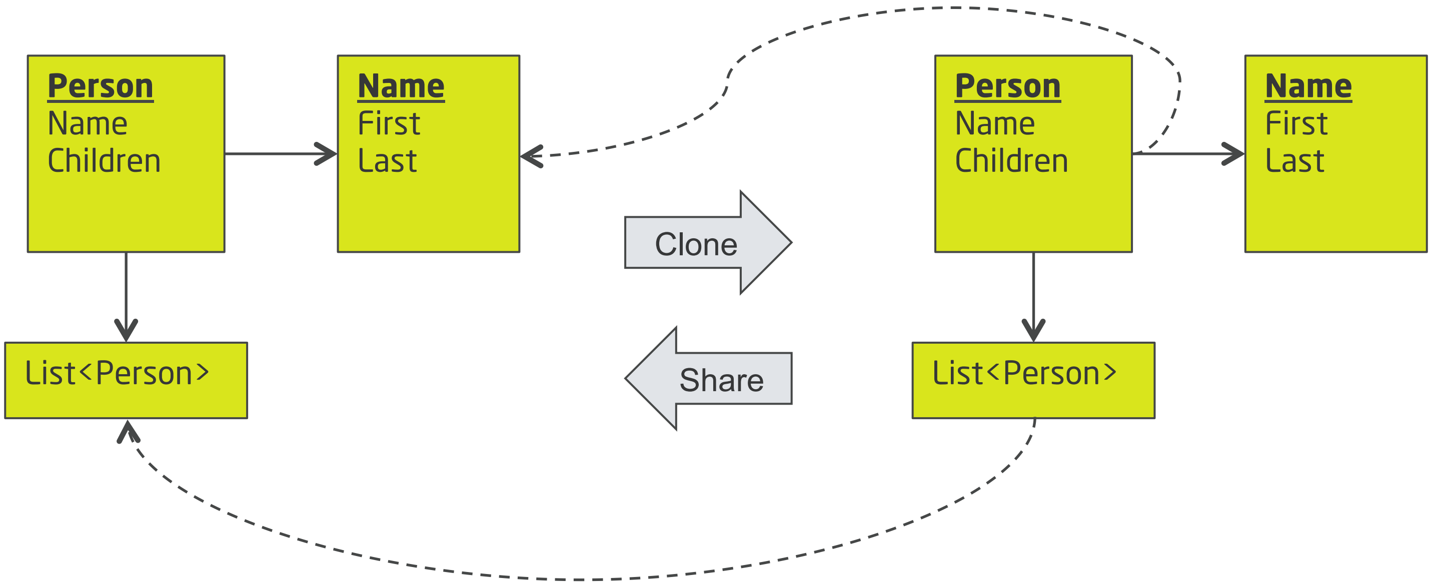
Advantages of Immutability

- Check invariants at construction only
- Reasoning about code is much simpler
- Thread safe
- Iteration safe
- No locks required

Disadvantages of Immutability

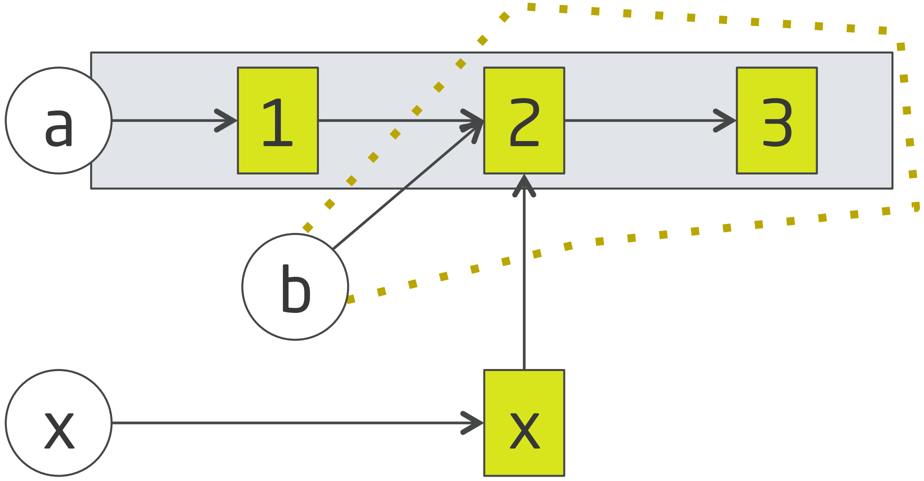
- We need a way do it efficiently
  - Memory
  - Performance
- We need a mutation mechanism

Structural Sharing



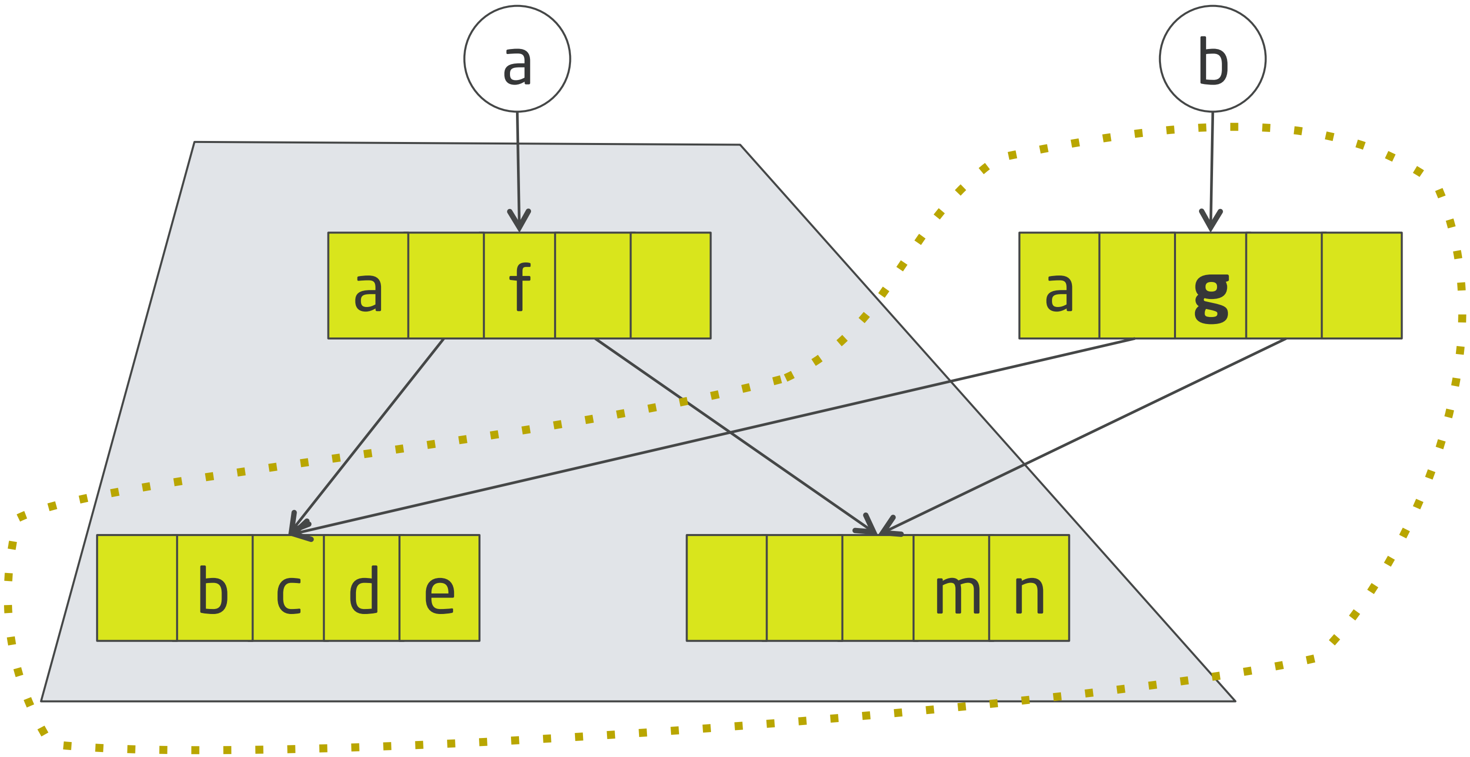
Persistent Collections for performance

```
(def a (list 1 2 3))
=> (1 2 3)

(def b (rest a))
=> (2 3)

(def x (conj b "x"))
=> ("x" 2 3)
```



- Immutable
- Structural Sharing
- Copy-on-write semantics

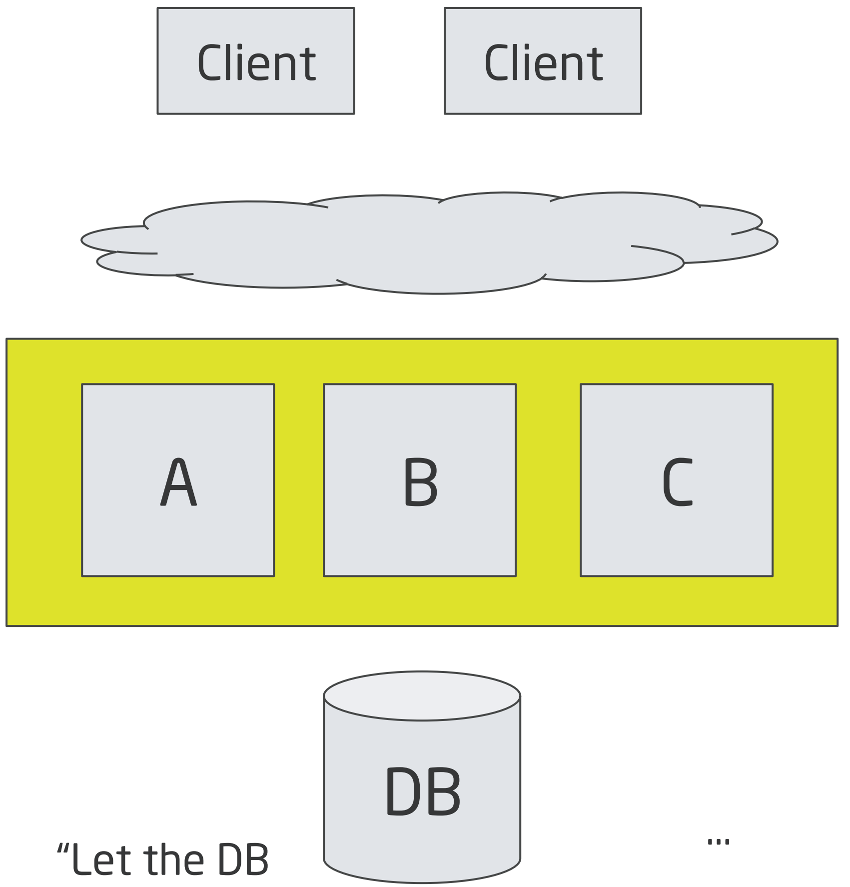
Persistent Collections implemented with hash tries



Extremely simplified diagram!
For full details see: Fast and Space Efficient Trie Searches, Bagwell [2000]

CONCURRENCY WITH SOFTWARE TRANSACTIONAL MEMORY

Concurrency Strategies



In process

Threads
Locks

Offline lock
patterns

“Let the DB
handle it”

Inter process

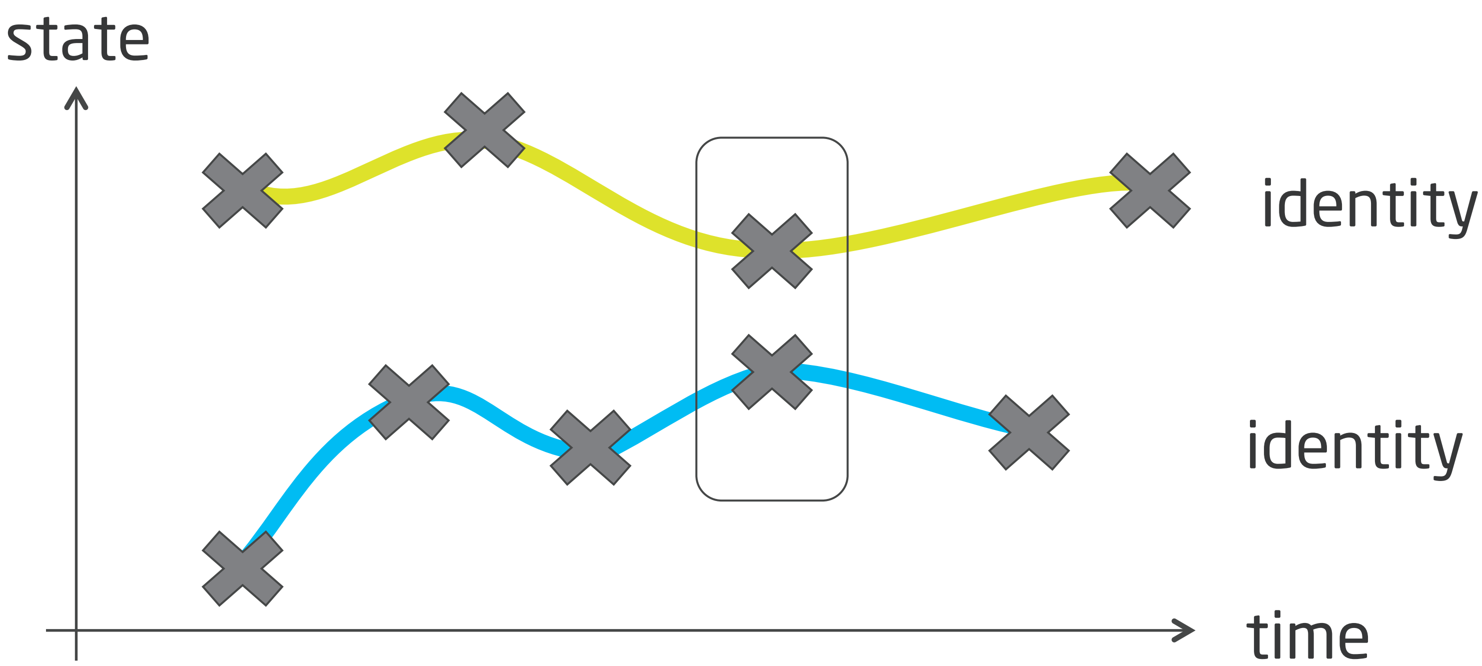
Scheduler

Actor model

Message
passing

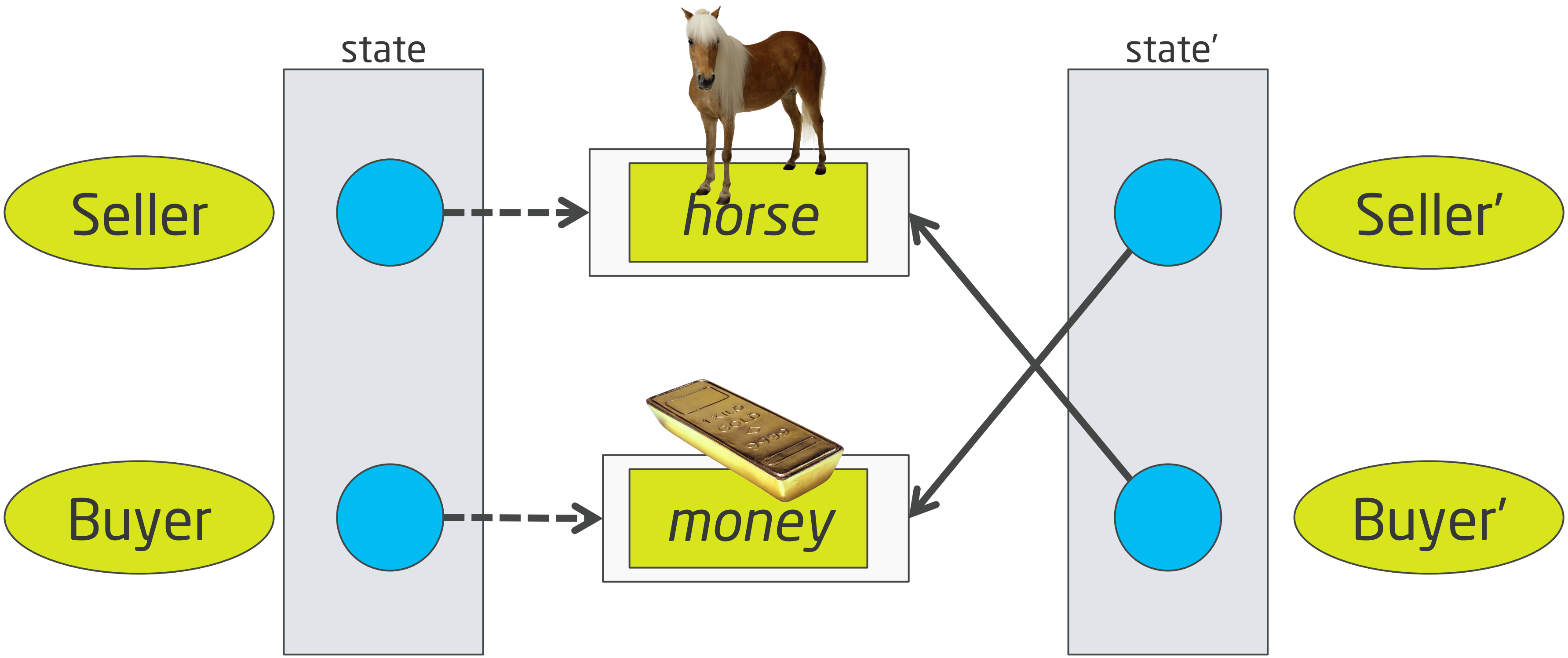
...

Clojure Concurrency



- **Indirect** references to immutable data structures
- Concurrency semantics for references
    - Automatic/enforced
    - No locks

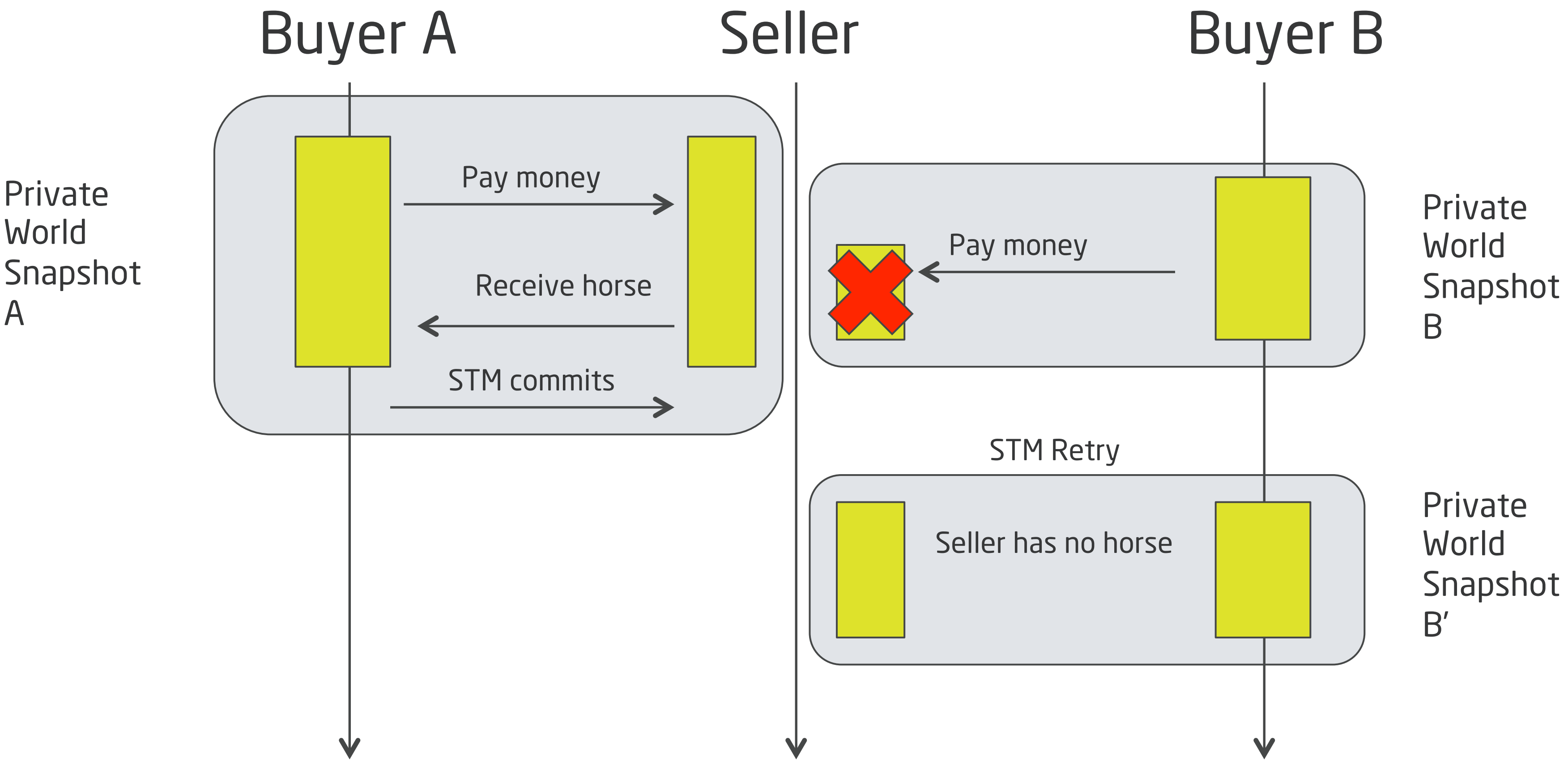
Software Transactional Memory



Multi-Version
Concurrency Control

Atomic
Consistent
Isolated
~~Durable~~

Software Transactional Memory Conflict Resolution



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STM Example

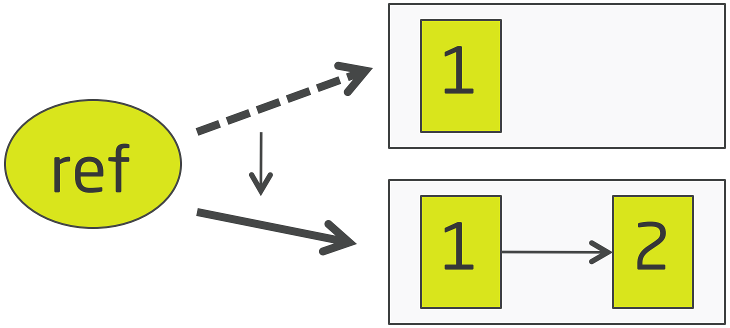
```clojure
(defn post [account amount msg]
  (conj account {:amount amount, :msg msg}))

(defn transfer [from to amount msg]
  (dosync
   (alter from post (- amount) msg)
   (alter to post amount msg)))


(defn balance [account]
  (reduce + 0 (map :amount account)))


(deftest transfer-tests
  (testing "Transfer between accounts"
    (let [a (ref [])
          b (ref [])]
      (transfer a b 10 "message")
      (is (= [{:amount -10, :msg "message"}] @a))
      (is (= [{:amount 10, :msg "message"}] @b)))))
```

:amount	:msg
1000	Initial balance
-170	Train fare
-40	Coffee



file: stm.clj

Concurrency Summary

Immutable data → Lock-free, multi-version concurrency

Indirect References → Simplify transactions → STM

Pure Functions → Enable retry / reordering

Simpler Concurrency Semantics

IT'S ALL ABOUT ABSTRACTIONS

Classes are Islands

```
// C#
class Conference {
  string Name { get; }
  int Year { get; }
}
```

Methods available:

```
ToString
GetHashCode
Equals
GetType
```

```clojure
(defrecord Conference [name year])

(def ndc (Conference. "NDC" 2011))
(def cc (Conference. "Clojure Conj" 2011))
(def confs [ndc cc])

;; Records works with common functions
(filter #(= 2011 (:year %)) confs)
(assoc ndc :rating :great)

;; Their fields have map semantics
(:year ndc)

;; A record is also a map of its properties
(seq ndc)
(doseq [[prop value] ndc]
  (println prop "->" value))
```

file: islands.clj

HOW WOULD YOU DO OBJECT DIFF AND PATCH IN C#?

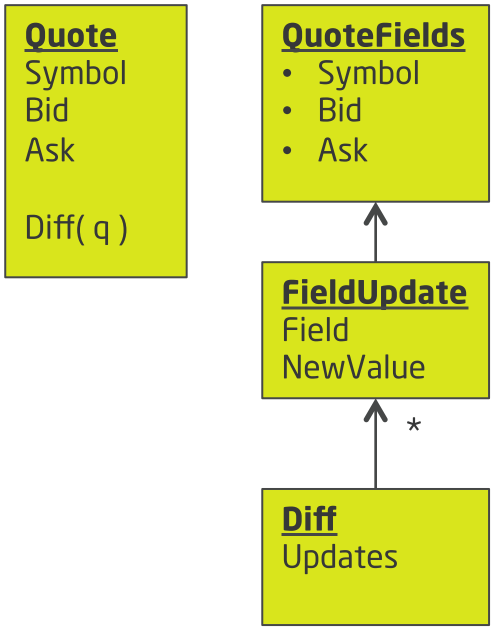
Common Abstractions: diff

```
Diff CalculateDiff(Quoute prev) {
  var result = new Diff();
  if (!(this.Bid.Equals(prev.Bid)))
    result.AddFieldUpdate(QuoteField.Bid, this.Bid));
  // repeat for the other fields …
  return result
}

previous = Quote(EURUSD, Bid:=1.40, Ask:=1.41)
latest   = Quote(EURUSD, Bid:=1.45, Ask:=1.46)

diff = latest.ChangesSince(previous)

⇒  Diff with Updates:
        (Field QuoteField.Bid, NewValue 1.405)
        (Field QuoteField.Ask, NewValue 1.415)
```



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Common Abstractions: diff

```
(defn diff [old new]
  (let [changed (filter (fn [k]
                          (not= (get old k) (get new k)))
                        (keys new))]
    (select-keys new changed)))

(defn patch [old df]
  (merge old df))

(diff {:bid 1.45, :ask 1.46, :symbol :eurusd}
      {:bid 1.44, :ask 1.47, :symbol :eurusd})
=> {:bid 1.44, :ask 1.47}
```

file: diffpatch.clj

Code to Common Abstractions

Core Abstractions

- Higher-order, first-class fn
- Collections
- Seq
- Records

Data Structures

{ :key value }	map
[a b c]	vector
(1 2 3)	list
#{ :a :b :c }	set

Higher-order functions

```
(map fn coll)
(filter pred coll)
(remove pred coll)
(sort-by fn coll)
(group-by fn coll)
```

```
// Linq
from x in coll select f(x);

// Pre-Linq
var result = new List...
foreach (var x in coll) {
  result.Add( f(x) );
}

// Extension methods,
// lambda expressions
coll.ConvertAll( x => f(x) );
```

map

Produces a new sequence of the same length by applying a function to each member

```
(map f [1 2 3])
⇒((f 1) (f 2) (f 3))
```

SELECT f(x) FROM xs

reduce

Reduce a sequence to a single element by combining the elements one by one

```
(reduce + [1 2 3])
⟹ 6
```

```
(reduce + [1 2 3])
is      (+ (+ 1 2) 3)
is      (+ 3 3)
⟹ 6
```

SELECT SUM(x) FROM xs

filter / remove

Select the matches or the non-matches from a seq

```
(filter even? [1 2 3 4])
⇒(2 4)

(remove even? [1 2 3 4])
⇒(1 3)
```

SELECT x FROM xs ***WHERE*** *...*

SPECIALIZING THE IMPLEMENTATION LANGUAGE

How would you add an unless keyword to C#?

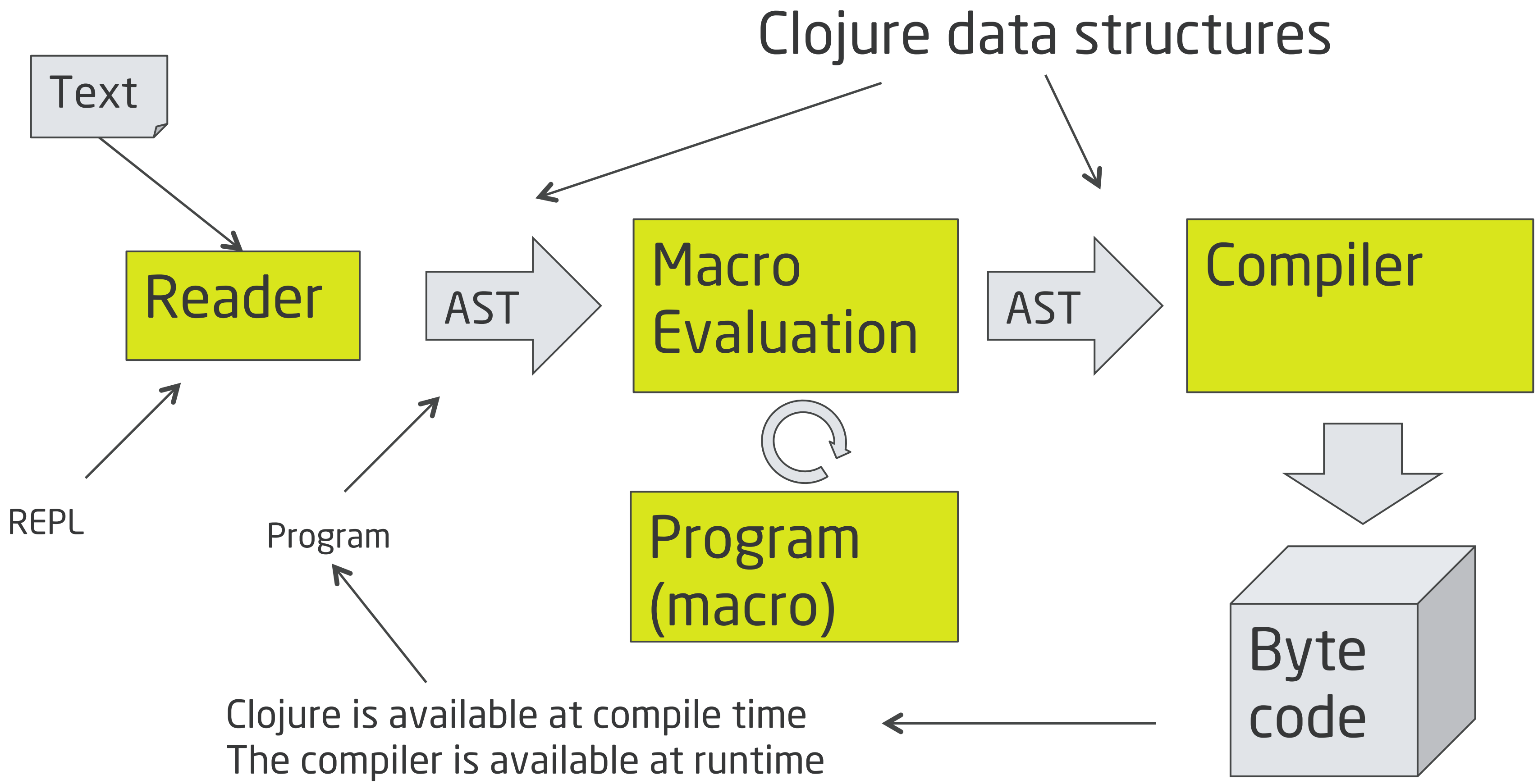
```
public WeakSetPerson(Person p)
{
   this.person = p unless (p == null);
}
```

How would you build Active Record?

```ruby
class Manager < ActiveRecord::Base
  has_one :department
end
```

```ruby
class Module
 def my_attr(symbol)
   class_eval "def #{symbol}; @#{symbol}; end"
   class_eval "def #{symbol}=(value); @#{symbol} = value; end"
 end
end
```

The Clojure Compilation Pipeline



The whole language always available*

- Homoiconic
  - A program is a data structure (AST)
  - ”Code is data is code”
- A **macro** is a function that transforms the program data at compile-time
- Functions are data structures, too.
- Clojure at compile-time, Clojure at runtime.

** Paul Graham, What Made Lisp Different, 2002*

Adding "unless" to Clojure

```
(defmacro unless
  [test & body]
  (list 'if test nil (cons 'do body)))


(macroexpand-1 '(unless (neg? x)
                        (println "x is non-neg")))

;; expands to
(if (neg? x) nil (do (println "x is non-neg")))
```

* Actually, this is the Clojure when-not macro

BETTER POLYMORPHISM

Open/Closed Legacy Code

MenuItem
:name
:type
:price

LegacyMenuItemClass

```
(defmulti menu-item? class )
```

```
(defmethod menu-item? MenuItem [x] true)
(defmethod menu-item? LegacyMenuItemClass [x] true)
(defmethod menu-item? :default [x] false)
```

file: multimethods.clj

Beyond Static Dispatch

MenuItem
:name
:type
:price

```
(defmulti description :type )
```

```
(defmethod description :drink [x]
      (str "Drink a wonderful " (:name x)))
(defmethod description :food [x]
      (str "Savour a tasty " (:name x)))
```

file: multimethods.clj

CONCLUSIONS

Reducing Complexity of the Implementation Domain

Problem	Simplification
Spaghetti code	Structured programming, OO
Memory management	Garbage collection
Side-effects	**Pure functions**
Sharing data	Message passing, value semantics **Immutable data**
Concurrency / locks	**Software Transactional Memory** Message based concurrency Offline lock patterns, ...
Composability	**Common abstractions**, higher-order functions
Limitations of implementation language	**Macros** DSLs, Design patterns

Top 10 Things…

1. Default to immutability
2. Write pure functions
3. Use structural sharing
4. Minimize the scope of mutation
5. You don’t need locks
6. Use common abstractions for composability
7. Dependency inversion principle goes far
8. Code is Data
9. Not everything is an object
10. Polymorphism can go much further

Where to go from here

IDEs

- Emacs SLIME
- Clojurebox (Emacs)
- Eclipse "Counter clockwise"
- NetBeans "Enclojure"
- Intelli/J "La Clojure"
- Visual Studio "vsClojure"

Tools

- Cake (build, test +)
- Leiningen (ditto)
- Midje (testing)

- www.clojure.org

Thank you

Download the slides and examples here:

https://github.com/mjul/top-10-clojure-ndc-2011

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EXTRA SLIDES

Ideas for Experiments in Interop

- Use the Clojure data structures in you C# or Java project
- Use Clojure with macros for code generation
- … at compile-time
- … or include the DLL/jar with your runtime

What made Lisp different?

- Conditionals
- A Function Type
- Recursion
- A New Concept of Variables
- Garbage-collection
- Programs composed of expressions
- A symbol type
- A notation for code
- The whole language always available

-- Paul Graham, 2001 *http://www.paulgraham.com/diff.html*

PECHA KUCHA

Destructuring

```
;; project-to-screen returns vector [x y]
(let [[x y] (project-to-screen spaceship)]
        (move-to sprite x y))

(defn good-buy? [{:keys [price value]}]
        (< price value))

(good-buy? {:price 0, :value 100, :name
"Clojure"})
```

List comprehensions

```
(def squares (for [x (range)] (* x x))
(def pairs (for [x (range), y (range)] [x y]))

(take 10 squares)
(take 5 pairs)
```

Most list functions are lazy

Pre- and Post Conditions

```
(defn raise [salary percent]
  {:post [#(<= salary %)]}
  (* salary (+ 1 (/ percent 100))))

(defn regulated-raise [salary percent]
  {:pre [(< 0 percent 5)]}
  (raise salary percent))
```

The SOLID Principles

- Single Responsibility Principle
  - “Single cause for change”
- Open-Closed Principle
  - “Open for extension, closed for modification”
- Liskov Substitution Principle
  - “subtypes should be substitutable”
- Interface Specialisation Principle
  - “Have many client specific interfaces”
- Dependency Inversion Principle
  - “Depend on abstractions, not concretion”

SOLID: Single Responsibility

SOLID: Open/Closed Principle

MenuItem
:name
:type
:price

LegacyMenuItemClass

```
(defmulti menu-item? class )
```

```
(defmethod menu-item? MenuItem [x] true)
(defmethod menu-item? LegacyMenuItemClass [x] true)
(defmethod menu-item? :default [x] false)
```

SOLID: Really Open for Extension

```clojure
(defrecord Conference [name year])

(def ndc (Conference. "NDC" 2011))
(def ratings [ 5 5 4 5])

(def ext
(assoc ndc :rating (average ratings)))

;; still a Conference
;; with extra :rating key

(sort-by :rating rated-confs)
```

```
class Conference { Name Year }
class RatedConf { Conf Rating }

var ext = new RatedConf( ndc,
 Average(ratings) );

// New type needed
```

Sorting by rating requires knowledge of RatedConf type

Liskov Substition

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SOLID: Interface Segregation

```
(deftype EnemyType [x y])

(defprotocol ClientProtocol
  (foo [this])
  (bar [this]))

(extend-type EnemyType
  ClientProtocol
  (foo [this]
    (str "EnemyType foo, x=" (.x this)))
  (bar [this]
    (str "EnemyType bar, y=" (.y this))))
```

SOLID: Dependency Inversion

Core Abstractions

- Higher-order, first-class fn
- Collections
- Seq
- Records

Data Structures

{ :key value }	map
[a b c]	vector
(1 2 3)	list
#{ :a :b :c }	set