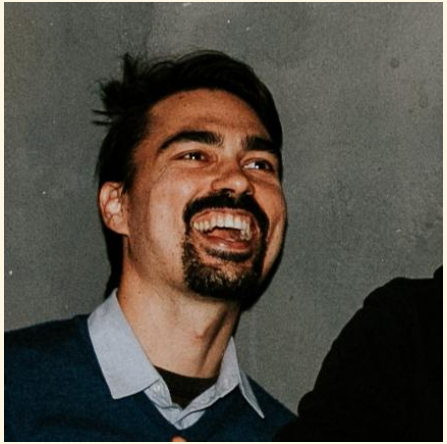
The Elements of a Functional Mindset



Eric Normand

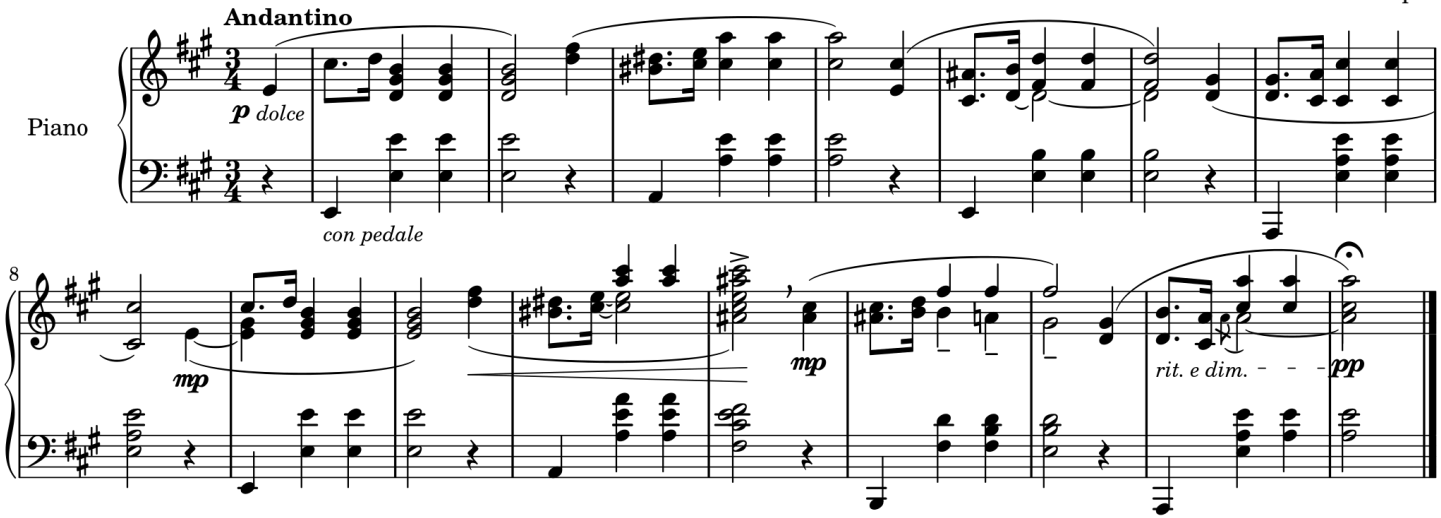
PurelyFunctional.tv

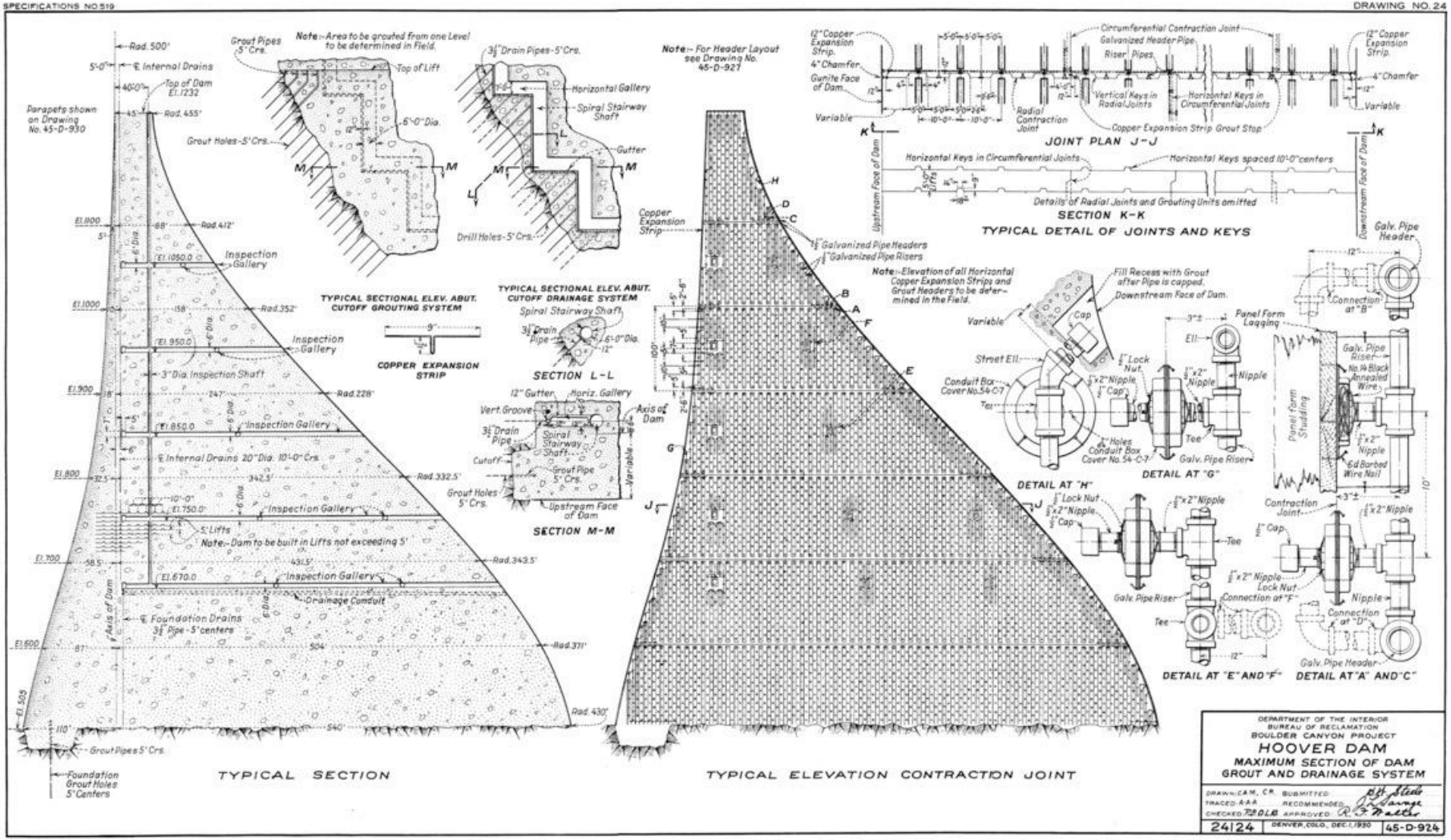
What is uniquely human?

Prelude

Op. 28, No. 7

Frederic Chopin




TYPICAL SECTION
TYPICAL ELEVATION CONTRACTION JOINT
TYPICAL SECTIONAL ELEV. ABUT. CUTOFF GROUTING SYSTEM
TYPICAL SECTIONAL ELEV. ABUT. CUTOFF DRAINAGE SYSTEM
COPPER EXPANSION STRIP
SECTION L-L
SECTION M-M
JOINT PLAN J-J
SECTION K-K
TYPICAL DETAIL OF JOINTS AND KEYS
DETAIL AT "H"
DETAIL AT "G"
DETAIL AT "E" AND "F"
DETAIL AT "A" AND "C"
Note:- Area to be grouted from one Level to be determined in Field.
Note:- For Header Layout see Drawing No. 45-D-927
Note:- Dam to be built in Lifts not exceeding 5'
Note:- Elevation of all Horizontal Copper Expansion Strips and Grout Headers to be determined in the Field.
Parapets shown on Drawing No. 45-D-930
Grout Pipes 5' Crs.
Grout Holes-5' Crs.
Drill Holes-5' Crs.
Inspection Gallery
Drainage Conduit
Foundation Drains 3½" Pipe-5' centers
Foundation Grout Holes 5' Centers
Copper Expansion Strip
Galvanized Pipe Headers
Galvanized Pipe Risers
Upstream Face of Dam
Downstream Face of Dam
Circumferential Contraction Joint
Galvanized Header Pipe
Riser Pipes
Copper Expansion Strip Grout Stop
Vertical Keys in Radial Joints
Horizontal Keys in Circumferential Joints
Radial Contraction Joint
Details of Radial Joints and Grouting Units omitted
Galv. Pipe Header
Galv. Pipe Riser
Panel Form Lagging
Panel Form Studding
Connection at "B"
Connection at "D"
Connection at "F"
Contraction Joint
Fill Recess with Grout after Pipe is capped.
Downstream Face of Dam.
Conduit Box Cover No. 54-C-7
Street Ell
Lock Nut
Nipple
Tee
Cap
Variable
Axis of Dam
Spiral Stairway Shaft
Horizontal Gallery
Gutter
Vert. Groove
Cutoff
Grout Pipe 5' Crs.
Upstream Face of Dam
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
BOULDER CANYON PROJECT
HOOVER DAM
MAXIMUM SECTION OF DAM
GROUT AND DRAINAGE SYSTEM
DRAWN: C.A.M., C.R.
TRACED: A.S.A.
CHECKED: R.D.L.B.
SUBMITTED:
RECOMMENDED:
APPROVED:
24124
DENVER, COLO., DEC. 1, 1930
45-D-924

Edsger Dijkstra

The purpose of abstraction is not to be vague, but to create a new semantic level in which one can be absolutely precise.

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Current average: 754/100 = 7.54

Read average: ???/100 = ???

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Current average: 754/100 = 7.54; 801/101 = 7.93

Read average: 801/100 = 8.01

Problem:
“In-between” state.

Solution:
Make mutation atomic.

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Problem:
Threads will write over each other in global state.

Solution:
Make state local.

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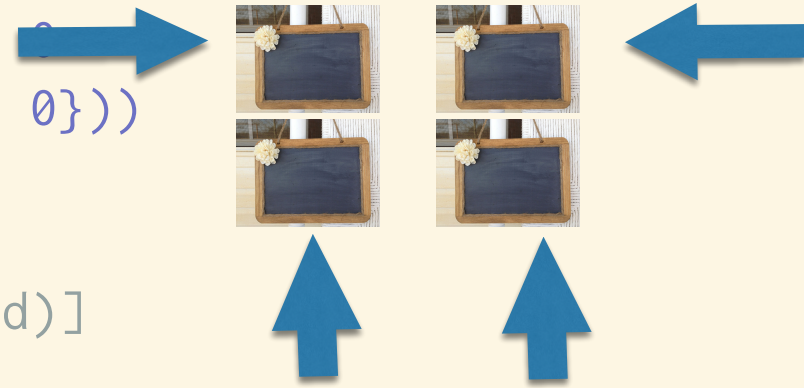

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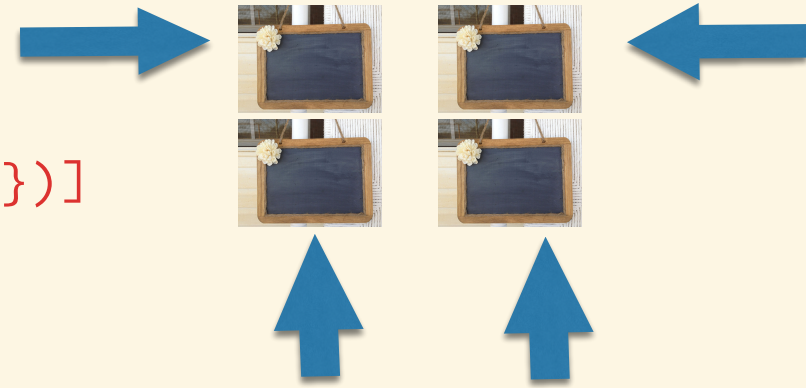

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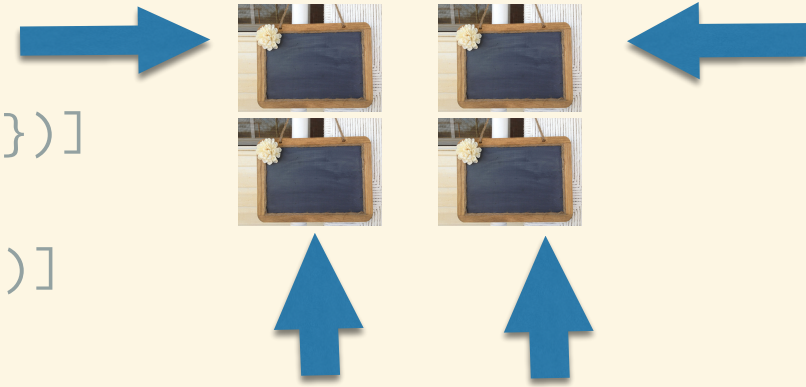

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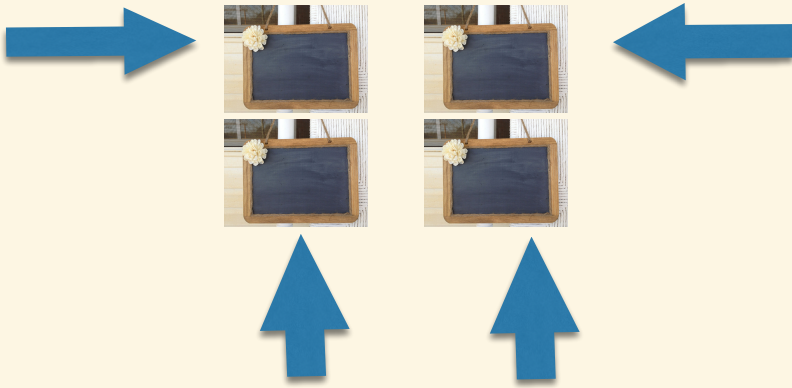

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state:

non-atomic -> atomic
global -> local

more meaningful
more precise
more general

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Problem:
Side effect “buried” in logic.

Solution:
Separate side effect, call it elsewhere,
and pass result as argument.

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side effects:
buried -> separated

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We are calculating the average score, but now we need to find the average age. Can we express that?

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Problem:
Our function depends on internal structure of data.

Solution:
Abstract the structure using a fn argument.

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```
(defn accumulate-average [record-average f records]
  (doseq [record records]
    (swap! record-average
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             {:sum   (+ sum (f record))
              :count (+ count 1)
              :finished false})))
  (swap! record-average assoc :finished true))

(defn calculate-average [{:keys [sum count finished]}]
  [(/ sum count) finished])

(defn average-records [f records]
  (let [record-average (atom {:sum   0
                              :count 0
                              :finished false})]
    (future (accumulate-average record-average f records))
    (fn [] (calculate-average @record-average))))
```

We are calculating the average score, but now we need to find the average age. Can we express that?

```
(defn accumulate-average [record-average f records]
  (doseq [record records]
    (swap! record-average
           (fn [{:keys [sum count]}]
             {:sum   (+ sum (f record))
              :count (+ count 1)
              :finished false})))
  (swap! record-average assoc :finished true))

(defn calculate-average [{:keys [sum count finished]}]
  [(/ sum count) finished])

(defn average-records [f records]
  (let [record-average (atom {:sum   0
                              :count 0
                              :finished false})]
    (future (accumulate-average record-average f records))
    (fn [] (calculate-average @record-average))))
```

We are calculating the average score, but now we need to find the average age. Can we express that?

```
(defn accumulate-average [average f vals]
  (doseq [val vals]
    (swap! average
           (fn [{:keys [sum count]}]
             {:sum   (+ sum (f val))
              :count (+ count 1)
              :finished false})))
  (swap! average assoc :finished true))

(defn calculate-average [{:keys [sum count finished]}]
  [(/ sum count) finished])

(defn average [f vals]
  (let [average (atom {:sum 0
                       :count 0
                       :finished false})]
    (future (accumulate-average average f vals))
    (fn [] (calculate-average @record-average))))
```

Now we need to calculate the sum. Can we express that?

```
(defn accumulate-average [average f vals]
  (doseq [val vals]
    (swap! average
           (fn [{:keys [sum count]}]
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  (let [average (atom {:sum 0
                       :count 0
                       :finished false})]
    (future (accumulate-average average f vals))
    (fn [] (calculate-average @record-average))))
```

Problem:
What we calculate is buried in how we calculate it.

Solution:
Dig out structure into one place.

Now we need to calculate the sum. Can we express that?

```
(defn accumulate-average [average f vals]
  (doseq [val vals]
    (swap! average
           (fn [{:keys [sum count]}]
             {:sum   (+ sum (f val))
              :count (+ count 1)
              :finished false})))
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(defn calculate-average [{:keys [sum count finished]}]
  [(/ sum count) finished])

(defn average [f vals]
  (let [average (atom {:sum 0
                       :count 0
                       :finished false})]
    (future (accumulate-average average f vals))
    (fn [] (calculate-average @record-average))))
```

Now we need to calculate the sum. Can we express that?

```
(defn accumulate-average [accum average f vals]
  (doseq [val vals]
   (accum val))
  (swap! average assoc :finished true))

(defn calculate-average [{:keys [sum count finished]}]
  [(/ sum count) finished])

(defn average [f vals]
  (let [average (atom {:sum 0
                       :count 0
                       :finished false})
        accum (fn [val]
                (swap! average
                  (fn [{:keys [sum count]}]
                    {:sum   (+ sum (f val))
                     :count (+ count 1)
                     :finished false})))]
    (future (accumulate-average accum average f vals))
    (fn [] (calculate-average @record-average))))
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    (future (accumulate-average accum average f vals))
    (fn [] (calculate-average @record-average))))
```

Now we need to calculate the sum. Can we express that?

```
(defn accumulate-average [accum finish average f vals]
  (doseq [val vals]
   (accum val))
  (finish))

(defn calculate-average [{:keys [sum count finished]}]
  [(/ sum count) finished])

(defn average [f vals]
  (let [average (atom {:sum 0
                       :count 0
                       :finished false})
        accum (fn [val]
                (swap! average
                  (fn [{:keys [sum count]}]
                    {:sum   (+ sum (f val))
                     :count (+ count 1)
                     :finished false})))
        finish (fn [] (swap! average assoc :finished true))]
    (future (accumulate-average accum finish average f vals))
    (fn [] (calculate-average @record-average))))
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                (swap! average
                  (fn [{:keys [sum count]}]
                    {:sum   (+ sum (f val))
                     :count (+ count 1)
                     :finished false})))
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    (future (accumulate-average accum finish average f vals))
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                (swap! average
                  (fn [{:keys [sum count]}]
                    {:sum   (+ sum (f val))
                     :count (+ count 1)
                     :finished false})))
        finish (fn [] (swap! average assoc :finished true))]
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```
(defn accumulate [accum finish vals]
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   (accum val))
  (finish))

(defn calculate-average [{:keys [sum count finished]}]
  [(/ sum count) finished])

(defn average [f vals]
  (let [average (atom {:sum 0
                       :count 0
                       :finished false})
        accum (fn [val]
                (swap! average
                  (fn [{:keys [sum count]}]
                    {:sum   (+ sum (f val))
                     :count (+ count 1)
                     :finished false})))
        finish (fn [] (swap! average assoc :finished true))]
    (future (accumulate accum finish vals))
    (fn [] (calculate-average @record-average))))
```

Now we need to calculate the sum. Can we express that?

```
(defn accumulate [accum finish vals]
  (doseq [val vals]
   (accum val))
  (finish))

(defn average [f vals]
  (let [average (atom {:sum 0
                       :count 0
                       :finished false})
        accum (fn [val]
                (swap! average
                  (fn [{:keys [sum count]}]
                    {:sum   (+ sum (f val))
                     :count (+ count 1)
                     :finished false})))
        finish (fn [] (swap! average assoc :finished true))
        current (fn []
                  (let [{:keys [sum count finished]} @average]
                    [(/ sum count) finished]))]
    (future (accumulate accum finish vals))
    current))
```

Now we need to calculate the sum. Can we express that?

```
(defn accumulate [accum finish vals]
  (doseq [val vals]
   (accum val))
  (finish))

(defn average [f vals]
  (let [average (atom {:sum 0
                       :count 0
                       :finished false})
        accum (fn [val]
                (swap! average
                  (fn [{:keys [sum count]}]
                    {:sum   (+ sum (f val))
                     :count (+ count 1)
                     :finished false})))
        finish (fn [] (swap! average assoc :finished true))
        current (fn []
                  (let [{:keys [sum count finished]} @average]
                    [(/ sum count) finished]))]
    (future (accumulate accum finish vals))
    current))
```

Now we need to calculate the sum. Can we express that?

```
(defn accumulate [accum finish vals]
  (doseq [val vals]
   (accum val))
  (finish))
(defn average-accumulator [f]
  (let [average (atom {:sum 0
                       :count 0
                       :finished false})]
    [(fn [val]
       (swap! average
         (fn [{:keys [sum count]}]
           {:sum   (+ sum (f val))
            :count (+ count 1)
            :finished false})))
     (fn [] (swap! average assoc :finished true))
     (fn []
       (let [{:keys [sum count finished]} @average]
         [(/ sum count) finished]))]))
(defn average [f vals]
  (let [[accum finish current] (average-accumulator f)]
    (future (accumulate accum finish vals))
    current))
```

Now we need to calculate the sum. Can we express that?

```
(defn accumulate [accum finish vals]
  (doseq [val vals]
   (accum val))
  (finish))
(defn average-accumulator [f]
  (let [average (atom {:sum 0
                       :count 0
                       :finished false})]
    [(fn [val]
       (swap! average
         (fn [{:keys [sum count]}]
           {:sum   (+ sum (f val))
            :count (+ count 1)
            :finished false})))
     (fn [] (swap! average assoc :finished true))
     (fn []
       (let [{:keys [sum count finished]} @average]
         [(/ sum count) finished]))]))
(defn average [f vals]
  (let [[accum finish current] (average-accumulator f)]
    (future (accumulate accum finish vals))
    current))
```

Now we need to calculate the sum. Can we express that?

```
(defn accumulate [accum finish vals]
  (doseq [val vals]
   (accum val))
  (finish))
(defn average-accumulator []
  (let [average (atom {:sum 0
                       :count 0
                       :finished false})]
    [(fn [val]
       (swap! average
         (fn [{:keys [sum count]}]
           {:sum   (+ sum val)
            :count (+ count 1)
            :finished false})))
     (fn [] (swap! average assoc :finished true))
     (fn []
       (let [{:keys [sum count finished]}
             @average]
        [(/ sum count) finished]))]))
(defn average [f vals]
  (let [[accum finish current] (average-accumulator)]
    (future (accumulate (comp accum f) finish vals))
    current))
```

```
(average :score (fetch-records 10))

(average :age (fetch-records 10))
```

Now we need to calculate the sum. Can we express that?

```
(defn accumulate [accum finish vals]
  (doseq [val vals]
   (accum val))
  (finish))

(defn average-accumulator []
  (let [average (atom {:sum 0
                       :count 0
                       :finished false})]
    [(fn [val]
       (swap! average
         (fn [{:keys [sum count]}]
           {:sum   (+ sum val)
            :count (+ count 1)
            :finished false})))
     (fn [] (swap! average assoc :finished true))
     (fn []
       (let [{:keys [sum count finished]}
             @average]
         [(/ sum count) finished]))]))
(defn average [f vals]
  (let [[accum finish current] (average-accumulator)]
    (future (accumulate (comp accum f) finish vals))
```

Now we need to calculate the sum. Can we express that?

```
(defn accumulate [accum finish vals]
  (doseq [val vals]
   (accum val))
  (finish))

(defn sum-accumulator []
  (let [average (atom {:sum 0
                       :finished false})]
    [(fn [val]
       (swap! average
         (fn [{:keys [sum]}]
           {:sum   (+ sum val)
            :finished false})))
     (fn [] (swap! average assoc :finished true))
     (fn []
       (let [{:keys [sum finished]}
             @average]
         [sum finished]))]))

(defn sum [f vals]
  (let [[accum finish current] (sum-accumulator)]
    (future (accumulate (comp accum f) finish vals))
    current))
```

```
(average :score (fetch-records 10))

(average :age (fetch-records 10))

(sum :score (fetch-records 12))
```

dependencies:
concrete structure -> abstraction
disparate structure -> consolidated

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