codeq: Making Git Repos Smarter

@stuarthalloway

Where Are We?

Motivation

Schema

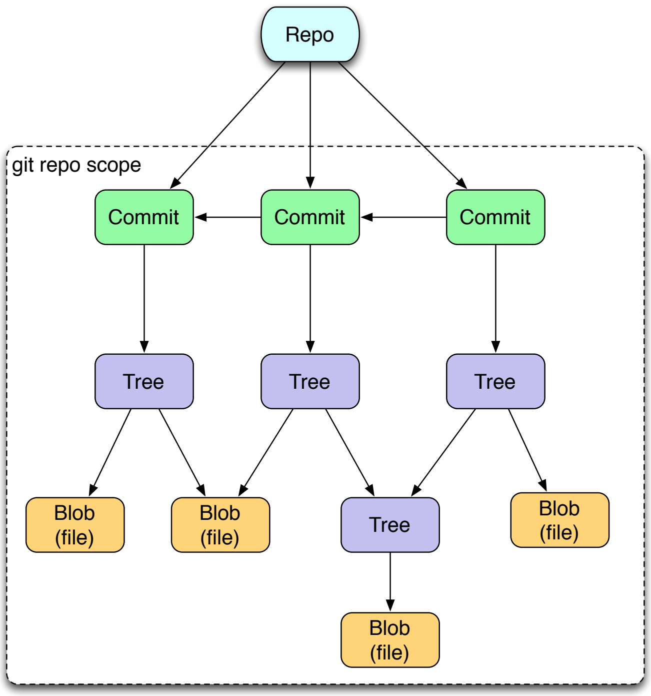
Import

Datalog

Rules

Queries

Git is a Database



Flexible

Immutable Values

Time Aware

Trees

Content Addressing

Opportunity 1: API

How many commits?

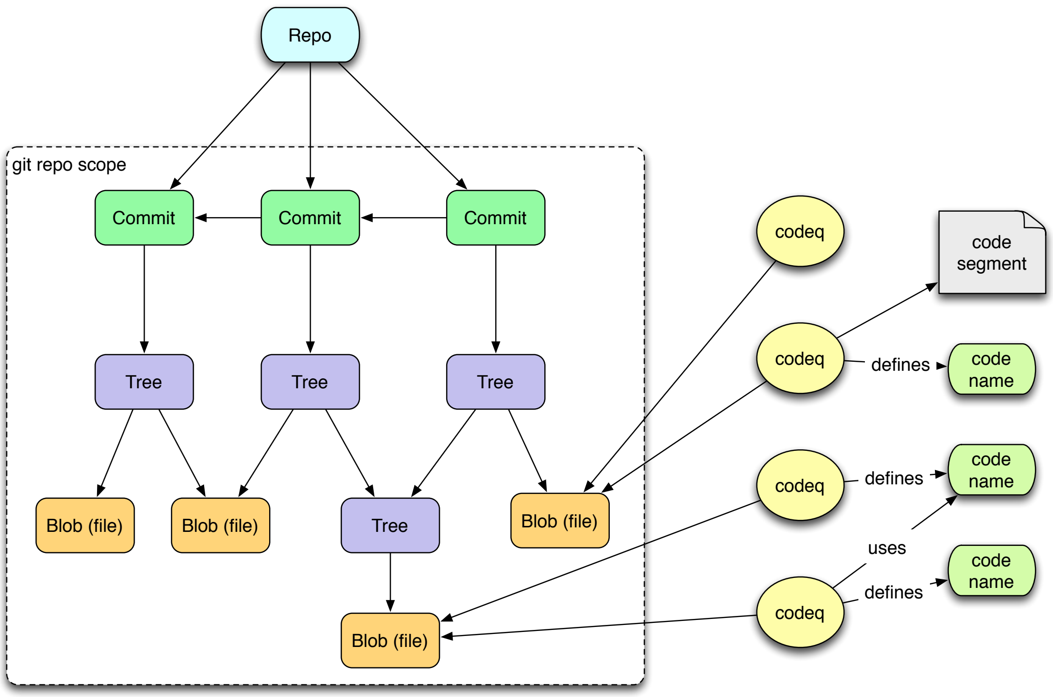
```
>git log -format=oneline | wc -l
1590
```

Opportunity 1: API

How many commits?

```
>SELECT COUNT(*) FROM COMMITS;
1590
```

Opportunity 2: Model



codeq

Foundation Schema

Import Phase (Indexes What Git Knows)

Analysis Phase (Indexes What Tools Know)

Pluggable Analyzers

Datalog Query

Why Datomic?

Power: Datalog Queries

Flexibility: Universal Relation

Immutability: Matches Git Semantics

Extensibility: Add Capabilities Using Java*

Free

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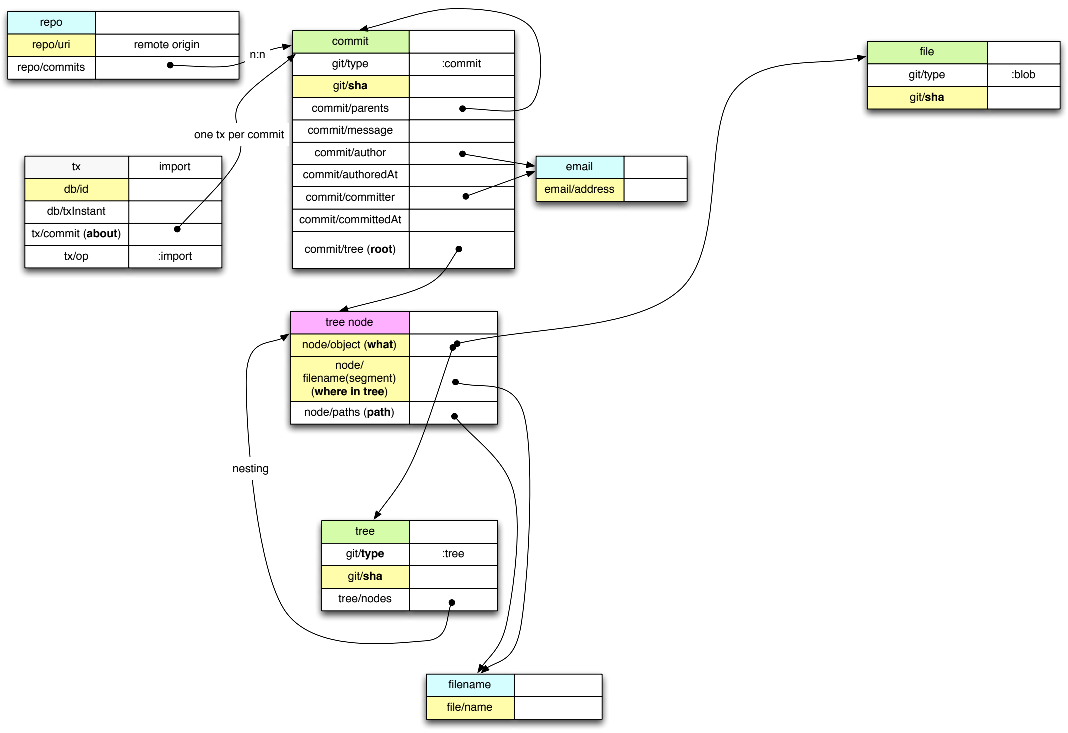
Schema (Import Subset)



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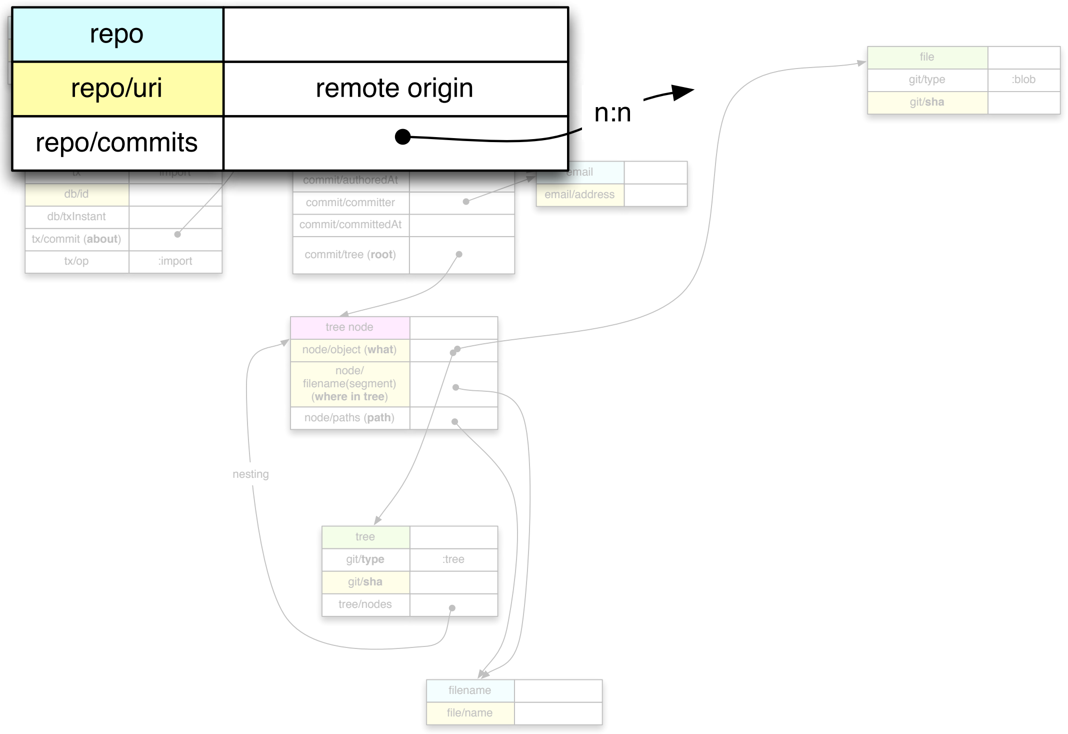

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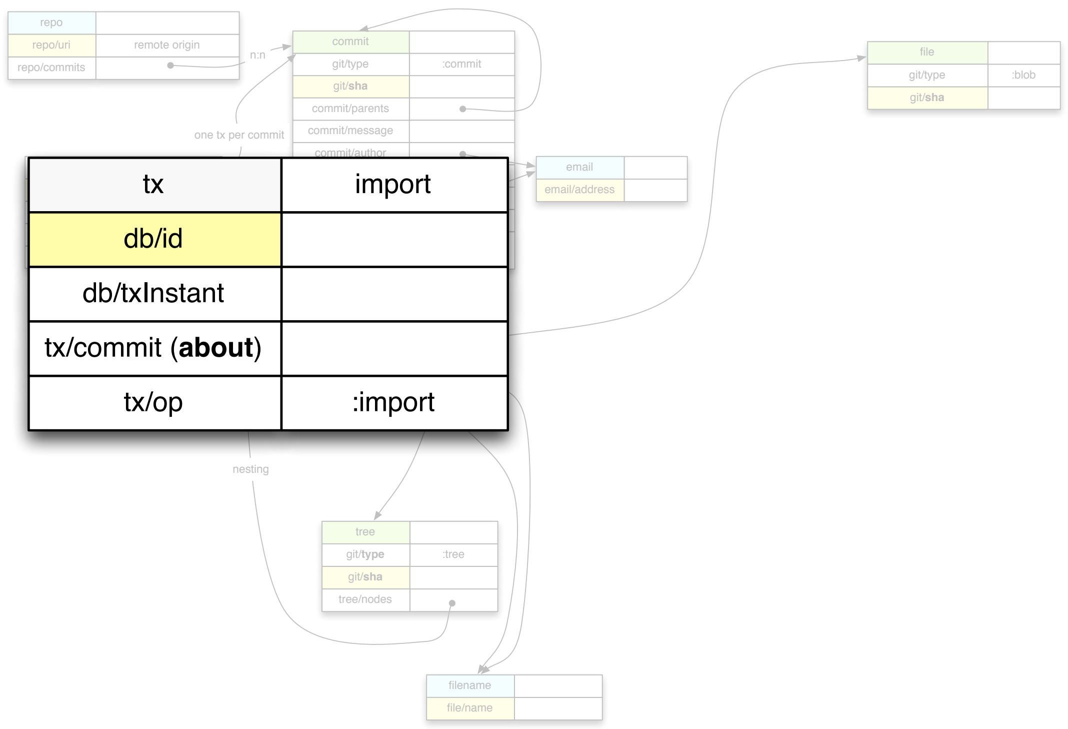

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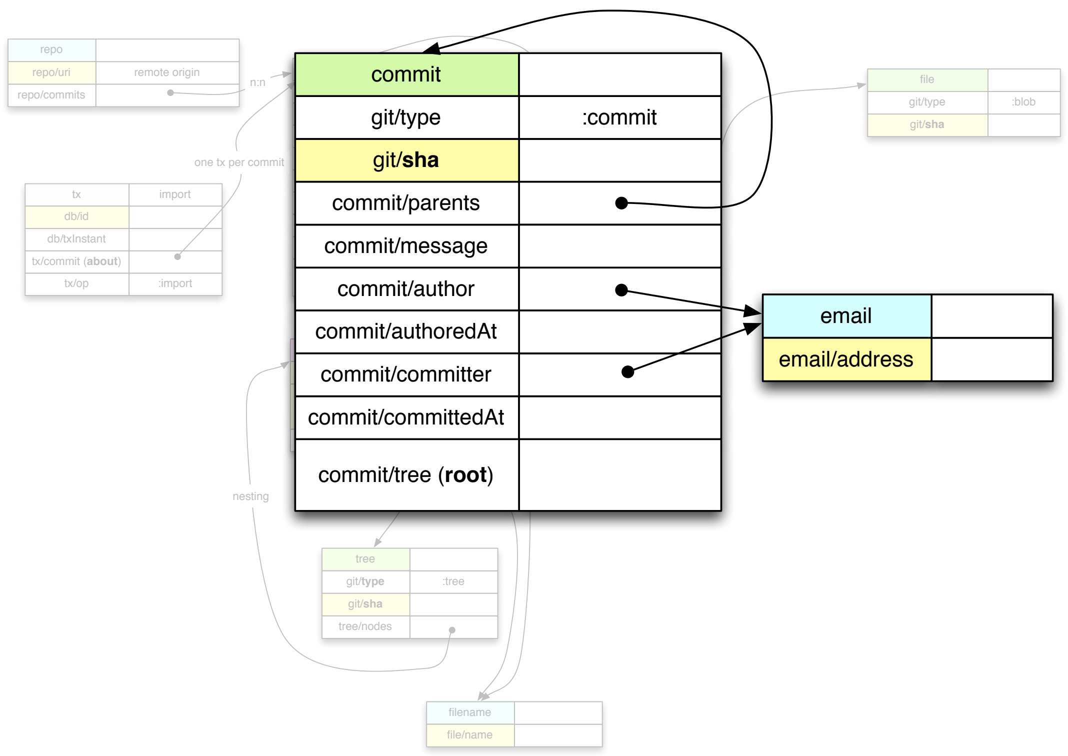

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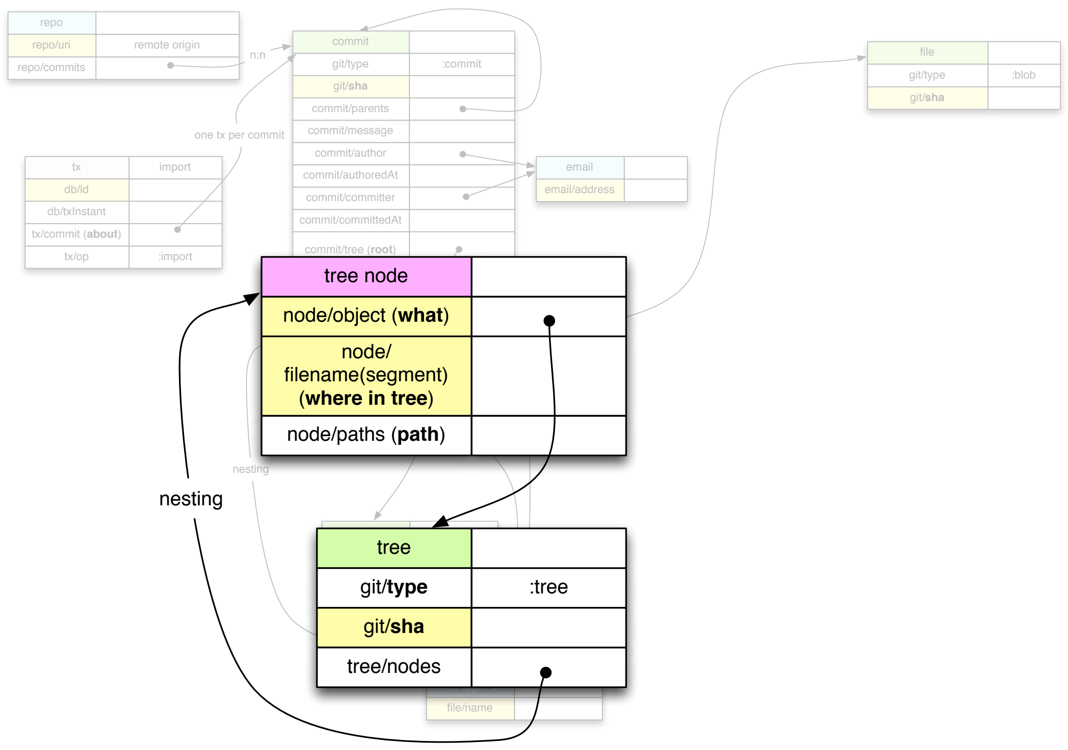

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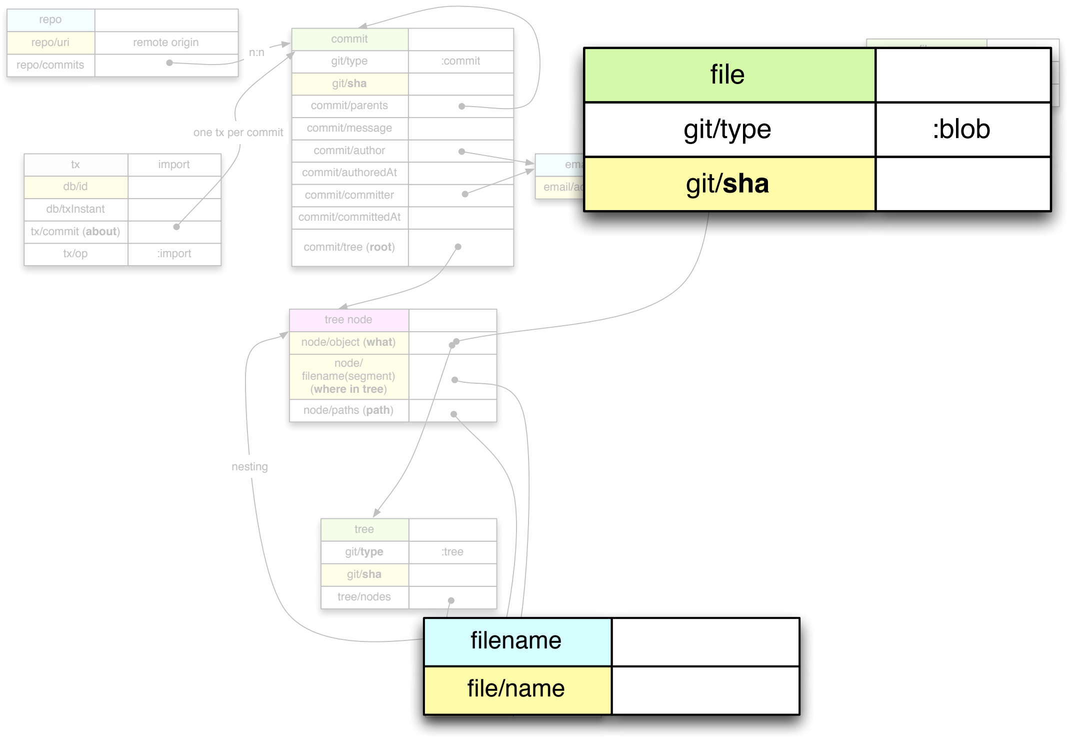

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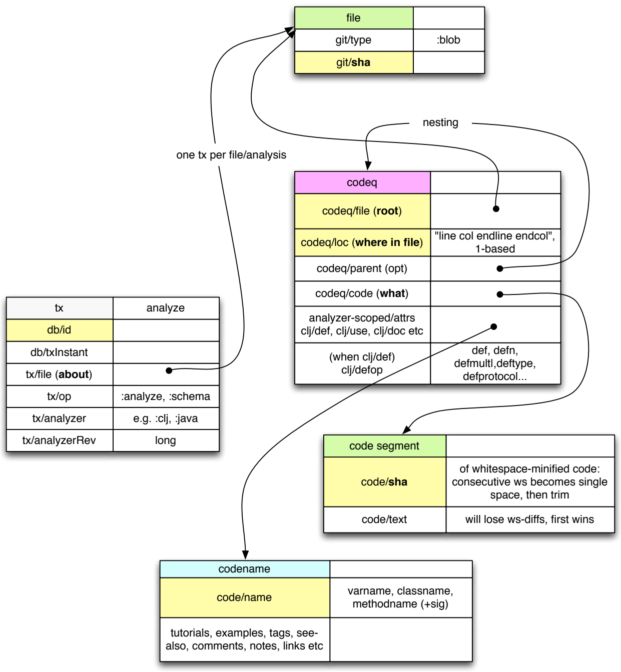
file
git/type
:blob
git/**sha**
nesting
one tx per file/analysis
codeq
codeq/file (**root**)
codeq/loc (**where in file**)
"line col endline endcol", 1-based
codeq/parent (opt)
codeq/code (**what**)
analyzer-scoped/attrs clj/def, clj/use, clj/doc etc
(when clj/def) clj/defop
def, defn, defmultl,deftype, defprotocol...
tx
analyze
db/id
db/txInstant
tx/file (**about**)
tx/op
:analyze, :schema
tx/analyzer
e.g. :clj, :java
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long
code segment
code/**sha**
of whitespace-minified code: consecutive ws becomes single space, then trim
code/text
will lose ws-diffs, first wins
codename
code/name
varname, classname, methodname (+sig)
tutorials, examples, tags, see-also, comments, notes, links etc

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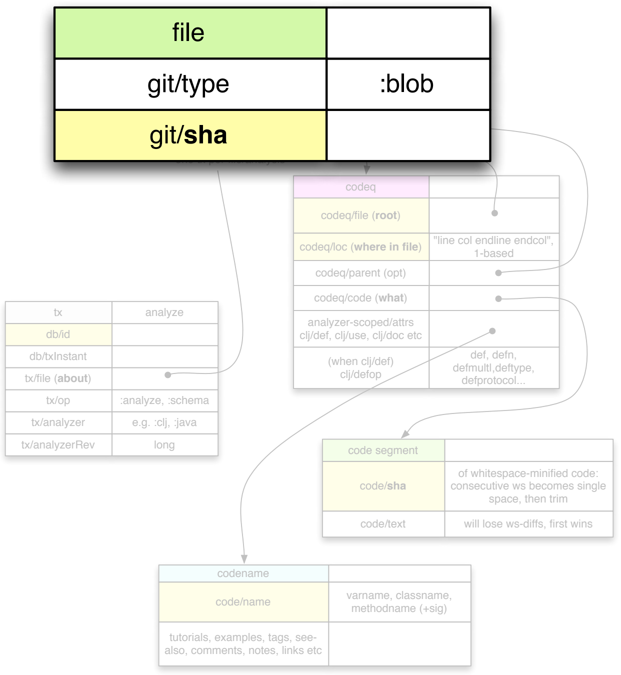
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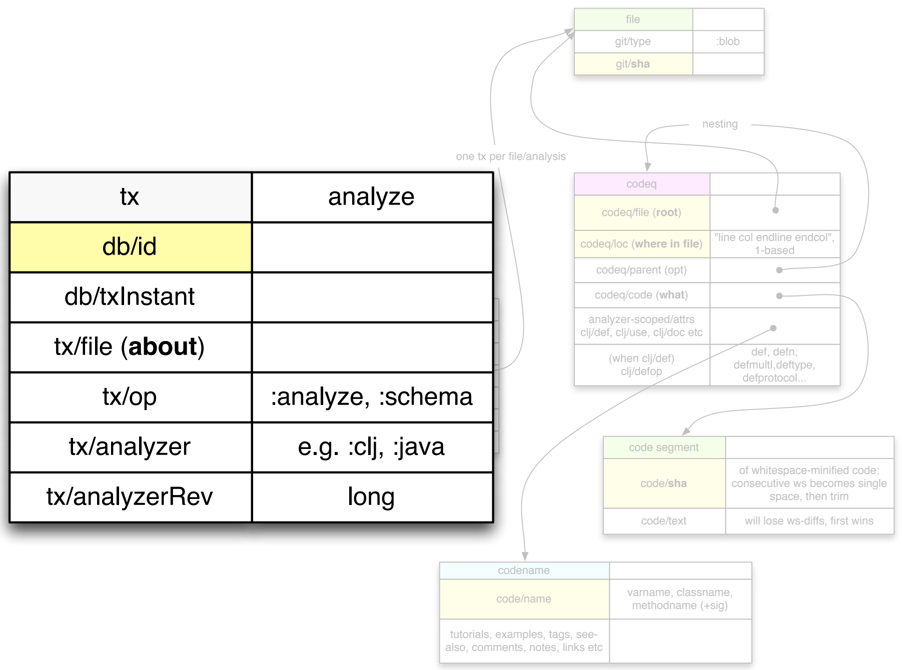
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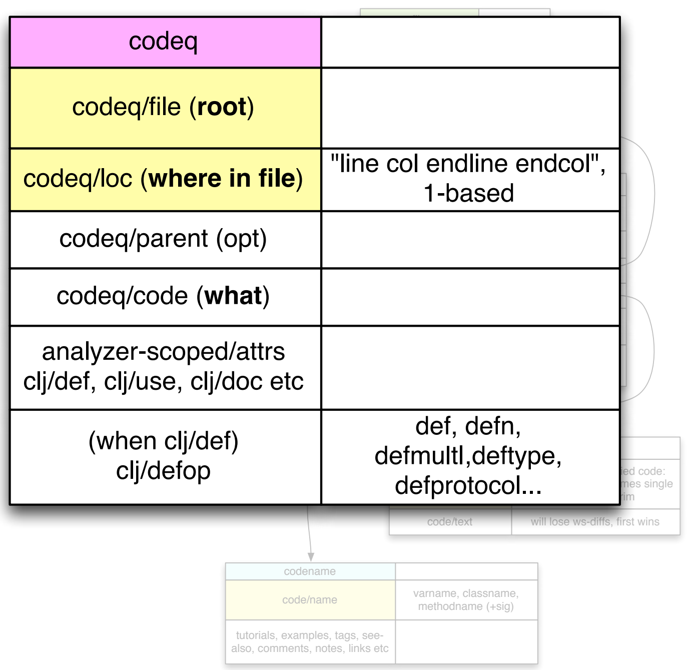
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will lose ws-diffs, first wins

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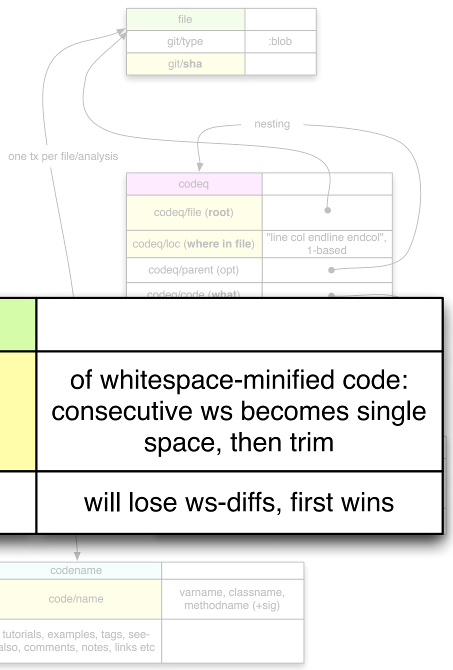
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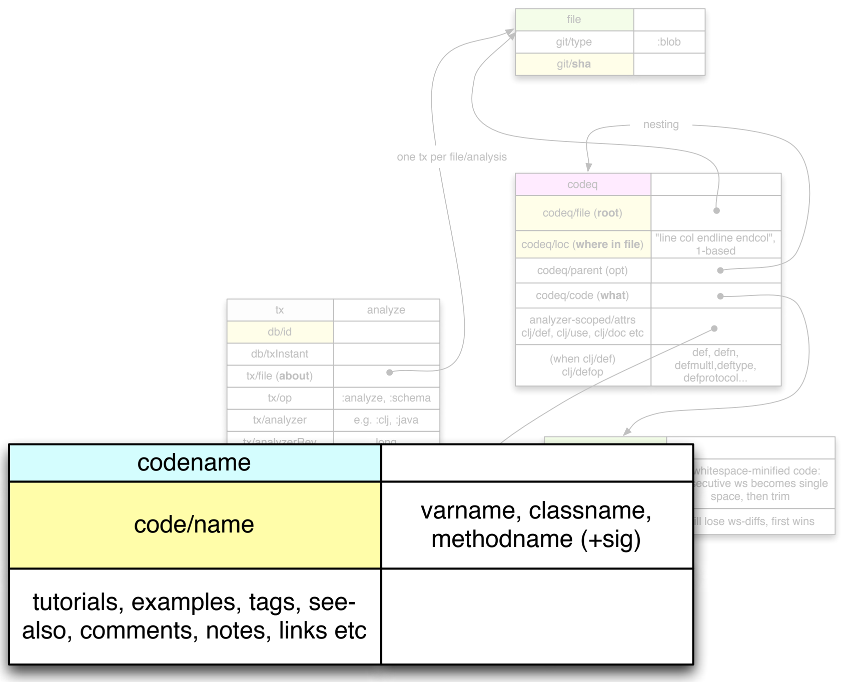

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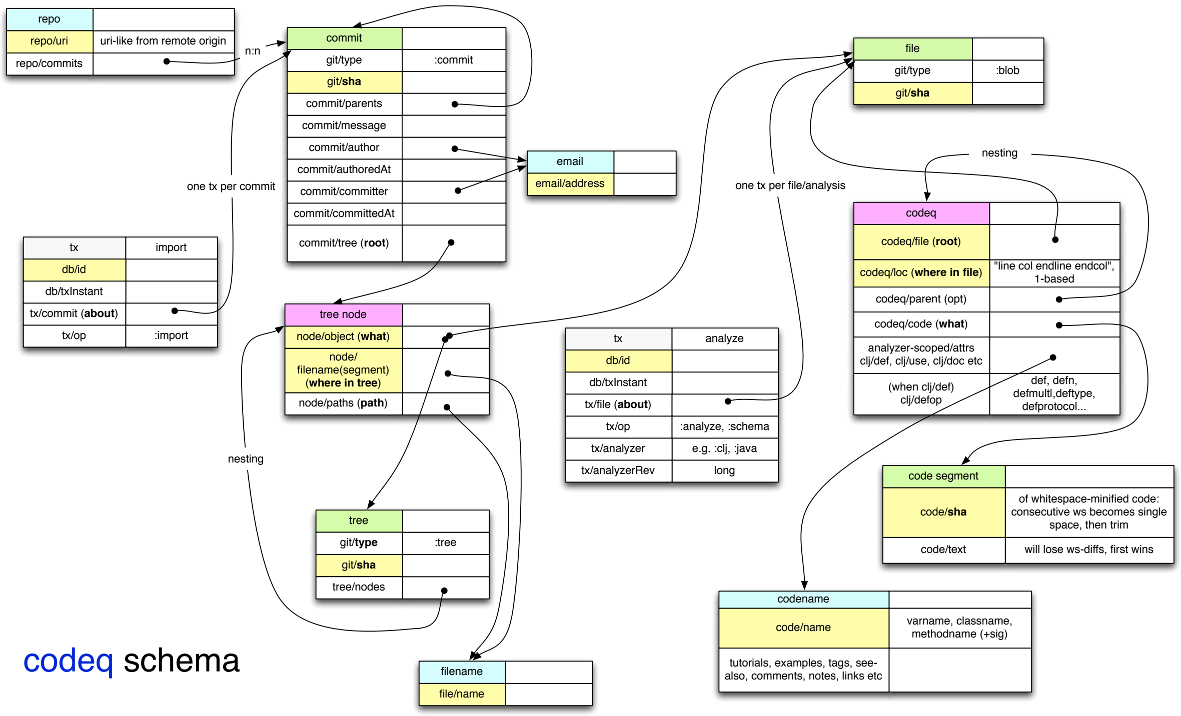

codeq schema

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Queries

java -jar codeq.jar datomic:free://localhost:4334/junit-1

```
Importing repo: git@github.com:junit-team/junit.git as: junit
Adding repo git@github.com:junit-team/junit.git
Importing commit: b6a0693454ac8ded32b3a1ea7c859c5a840169dc
Importing commit: aac9e722a36626e98794748c894cf3db3b24f4eb
 ...
Importing commit: 2a010a89464d9879a740fc611a004a6c15ae6ed1
Import complete!

Analyzing...
Running analyzer: :clj on [.clj]
Running analyzer: :java on [.java]
analyzing file: 17592186045530  - sha:  10b5045c7d23d20775eb20523d615e94277eaa19
analyzing file: 17592186045534  - sha:  dcd205011ab311610cbddf76d6f30bb4b78a23a5
 ...
analyzing file: 17592186085759  - sha:  ea793ff8db6451dfd02d0d89ca73f615bf6ca386
Analysis complete!
```

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query anatomy

query anatomy

```
q([:find ...
   :in ...
   :where ...],
   input1,
   ...
   inputN);
```

query anatomy

constraints

```
q([:find ...
   :in ...
   :where ...],
   input1,
   ...
   inputN);
```

query anatomy

```
q([:find ...
   :in ...
   :where ...],
   input1,
   ...          ←—— inputs
   inputN);
```

query anatomy

```
q([:find ...
   :in ...       ←—— names for
                     inputs
   :where ...],
   input1,
   ...
   inputN);
```

query anatomy

```
q([:find ...
   :in ...
   :where ...],
   input1,
   ...
   inputN);
```

variables to
return

variables

```
?customer
                ?product

       ?orderId

                  ?email
```

constants

```
42                        :email

             “john”

:order/id

              #inst "2012-02-29"
```

keywords

```
42                        :email

             “john”

:order/id

              #inst "2012-02-29"
```

namespaces

```
                                            :email
42

                      “john”

:order/id

                        #inst "2012-02-29"
```

extensible reader

```
                                            :email
42

                      “john”

:order/id

                        #inst "2012-02-29"
```

data patterns

example database

entity	attribute	value
42	:email	jdoe@example.com
43	:email	jane@example.com
42	:orders	107
42	:orders	141

data pattern

Constrains the results returned,
binds variables

```
[?customer :email ?email]
```

data pattern

Constrains the results returned,
binds variables

```
[?customer :email ?email]

     ↑           ↑          ↑

   entity    attribute    value
```

data pattern

Constrains the results returned,
binds variables

constant

```
[?customer :email ?email]
```

data pattern

Constrains the results returned,
binds variables

variable variable

```
[?customer :email ?email]
```

entity	attribute	value
42	:email	jdoe@example.com
43	:email	jane@example.com
42	:orders	107
42	:orders	141

```
[?customer :email ?email]
```

constants anywhere

"Find a particular customer's email"

```
[42 :email ?email]
```

entity	attribute	value
42	:email	jdoe@example.com
43	:email	jane@example.com
42	:orders	107
42	:orders	141

```
[42 :email ?email]
```

variables anywhere

“What attributes does customer 42 have?

```
[42 ?attribute]
```

entity	attribute	value
42	:email	jdoe@example.com
43	:email	jane@example.com
42	:orders	107
42	:orders	141

```
[42 ?attribute]
```

variables anywhere

“What attributes and values does customer 42 have?

```
[42 ?attribute ?value]
```

entity	attribute	value
42	:email	jdoe@example.com
43	:email	jane@example.com
42	:orders	107
42	:orders	141

```
[42 ?attribute ?value]
```

basic usage

:where clause

data pattern

```
[:find ?customer
 :where [?customer :email]]
```

:find clause

variable to return

```
[:find ?customer
 :where [?customer :email]]
```

implicit join

"Find all the customers who have placed orders."

```
[:find ?customer
 :where [?customer :email]
        [?customer :orders]]
```

API

```
import static datomic.Peer.q;


q("[:find ?customer
    :where [?customer :id]
           [?customer :orders]]",
  db);
```

q

```
import static datomic.Peer.q;

q("[:find ?customer
    :where [?customer :id]
           [?customer :orders]]",
   db);
```

query

```
import static datomic.Peer.q;

q("[:find ?customer
    :where [?customer :id]
           [?customer :orders]]",
   db);
```

input(s)

```
import static datomic.Peer.q;


q("[:find ?customer
    :where [?customer :id]
           [?customer :orders]]",
   db);
```

:in clause

Names inputs so you can refer to them elsewhere in the query

```
:in $database ?email
```

parameterized query

"Find a customer by email."

```
q([:find ?customer
   :in $database ?email
   :where [$database ?customer :email ?email]],
   db,
   "jdoe@example.com");
```

first input

"Find a customer by email."

```
q([:find ?customer
   :in $database ?email
   :where [$database ?customer :email ?email]],
   db,
   "jdoe@example.com");
```

second input

“Find a customer by email.”

```
q([:find ?customer
   :in $database ?email
   :where [$database ?customer :email ?email]],
   db,
   "jdoe@example.com");
```

verbose?

“Find a customer by email.”

```
q([:find ?customer
   :in $database ?email
   :where [$database ?customer :email ?email]],
   db,
   "jdoe@example.com");
```

shortest name possible

“Find a customer by email.”

```
q([:find ?customer
   :in $ ?email
   :where [$ ?customer :email ?email]],
   db,
   "jdoe@example.com");
```

elide $ in :where

“Find a customer by email.”

```
q([:find ?customer
   :in $ ?email
   :where [ ?customer :email ?email]],
   db,
   "jdoe@example.com");
```

no need to
specify $

extending query

predicates

Functional constraints that can appear in a :where clause

```
[(< 50 ?price)]
```

adding a predicate

"Find the expensive items"

```
[:find ?item
 :where [?item :item/price ?price]
        [(< 50 ?price)]]
```

functions

Take bound variables as inputs
and bind variables with output

```
[(shipping ?zip ?weight) ?cost]
```

function args

```
[(shipping ?zip ?weight) ?cost]
```

$\uparrow$

bound inputs

function returns

```
[(shipping ?zip ?weight) ?cost]
```

$\uparrow$

bind return values

putting it all together

"Find me the customer/product combinations where the shipping cost dominates the product cost."

```
[:find ?customer ?product
 :where [?customer :shipAddress ?addr]
        [?addr :zip ?zip]
        [?product :product/weight ?weight]
        [?product :product/price ?price]
        [(Shipping/estimate ?zip ?weight) ?shipCost]
        [(<= ?price ?shipCost)]]
```

putting it all together

"Find me the customer/product combinations where the shipping cost dominates the product cost."

navigate from customer to zip

```
[:find ?customer ?product
 :where [?customer :shipAddress ?addr]
        [?addr :zip ?zip]
        [?product :product/weight ?weight]
        [?product :product/price ?price]
        [(Shipping/estimate ?zip ?weight) ?shipCost]
        [(<= ?price ?shipCost)]]
```

putting it all together

"Find me the customer/product combinations where the shipping cost dominates the product cost."

get product facts needed *during query*

```
[:find ?customer ?product
 :where [?customer :shipAddress ?addr]
        [?addr :zip ?zip]
        [?product :product/weight ?weight]
        [?product :product/price ?price]
        [(Shipping/estimate ?zip ?weight) ?shipCost]
        [(<= ?price ?shipCost)]]
```

putting it all together

"Find me the customer/product combinations where the shipping cost dominates the product cost."

call web service to bind shipCost

```
[:find ?customer ?product
 :where [?customer :shipAddress ?addr]
        [?addr :zip ?zip]
        [?product :product/weight ?weight]
        [?product :product/price ?price]
        [(Shipping/estimate ?zip ?weight) ?shipCost]
        [(<= ?price ?shipCost)]]
```

byo functions

Functions can be plain JVM code.

```
public class Shipping {
  public static BigDecimal
  estimate(String zip1, int pounds);
}
```

putting it all together

“Find me the customer/product combinations where the shipping cost dominates the product cost.”

```
[:find ?customer ?product
 :where [?customer :shipAddress ?addr]
        [?addr :zip ?zip]
        [?product :product/weight ?weight]
        [?product :product/price ?price]
        [(Shipping/estimate ?zip ?weight) ?shipCost]
        [(<= ?price ?shipCost)]]
```

constrain price

putting it all together

"Find me the customer/product combinations where the shipping cost dominates the product cost."

return customer, product pairs

```
[:find ?customer ?product
 :where [?customer :shipAddress ?addr]
        [?addr :zip ?zip]
        [?product :product/weight ?weight]
        [?product :product/price ?price]
        [(Shipping/estimate ?zip ?weight) ?shipCost]
        [(<= ?price ?shipCost)]]
```

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rule clause

"Products are related if they have a common category."

```
[(relatedProduct ?p1 ?p2)
 [?p1 :category ?c]
 [?p2 :category ?c]
 [(!= ?p1 ?p2)]]
```

rule head

"Products are related if they have a common category."

this is true...

```
[(relatedProduct ?p1 ?p2)
 [?p1 :category ?c]
 [?p2 :category ?c]
 [(!= ?p1 ?p2)]]
```

rule body

“Products are related if they have a common category.”

```
[(relatedProduct ?p1 ?p2)
 [?p1 :category ?c]
 [?p2 :category ?c]
 [(!= ?p1 ?p2)]]
```

...if all these are true

rule inputs

“Find all products related to expensive chocolate.”

```
q("[:find ?p2
    :in $ %
    :where (expensiveChocolate p1)
           (relatedProduct p1 p2)]",
  db,
  rules)
```

rules are a kind of input

naming rule inputs

“Find all products related to expensive chocolate.”

```
q("[:find ?p2
    :in $ %
    :where (expensiveChocolate p1)
           (relatedProduct p1 p2)]",
  db,
  rules)
```

rule names begin with %

using rule patterns

“Find all products related to expensive chocolate.”

```
q("[:find ?p2
    :in $ %
    :where (expensiveChocolate p1)
           (relatedProduct p1 p2)]",
  db,
  rules)
```

rule patterns can appear in :where clause

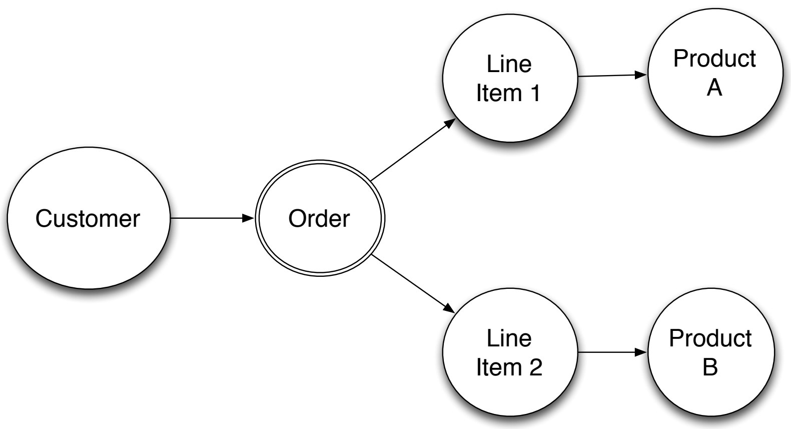
implicit or

"Products are related if they have the same category, or they have appeared in the same order."

```
[[(relatedProduct ?p1 ?p2)
  [?p1 :category ?c]
  [?p2 :category ?c]
  [(!= ?p1 ?p2)]]
 [(relatedProduct ?p1 ?p2)
  [?o :order/item ?item1]
  [?item1 :order/product ?p1]
  [?o :order/item ?item2]
  [?item2 :order/product ?p2]
  [(!= ?p1 ?p2)]]]
```

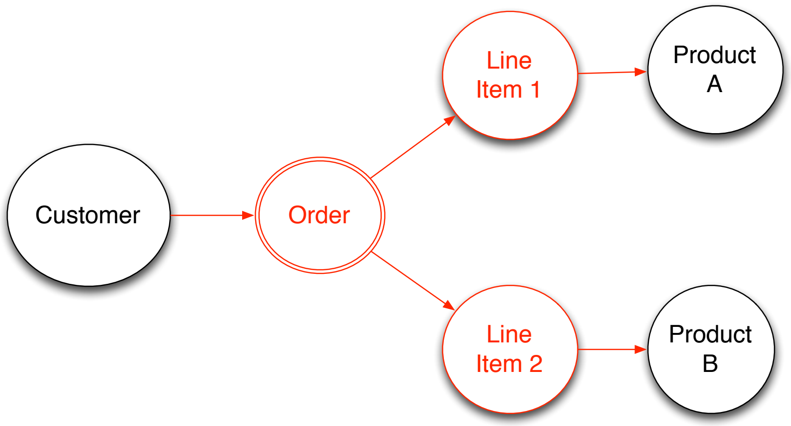
extent

Get "the whole order".



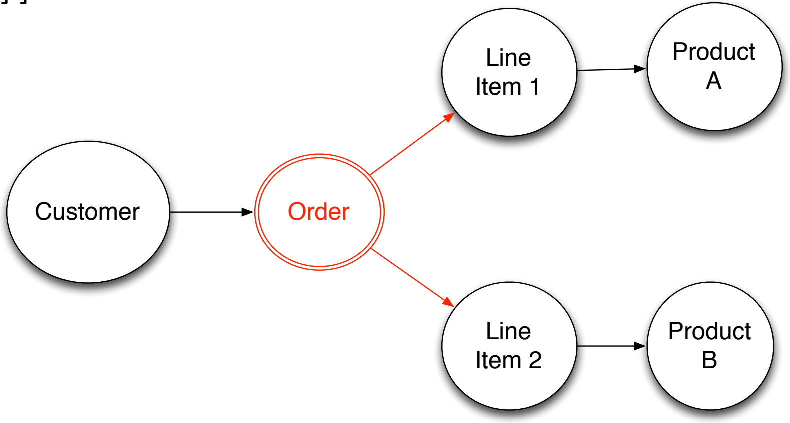
extent

Get "the whole order".



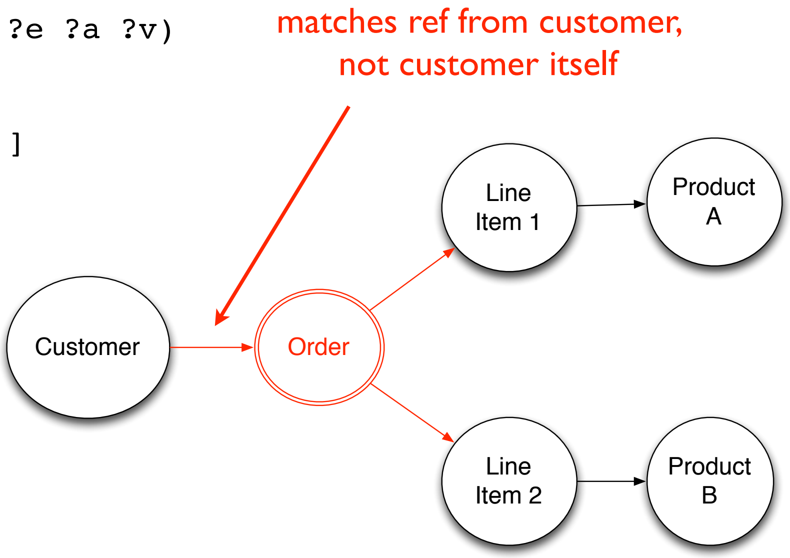
my direct references

```
[(extent ?x ?e ?a ?v)
 (?e ?a ?v)
 (?x ?a ?v)
 [(= ?e ?x)]]
```



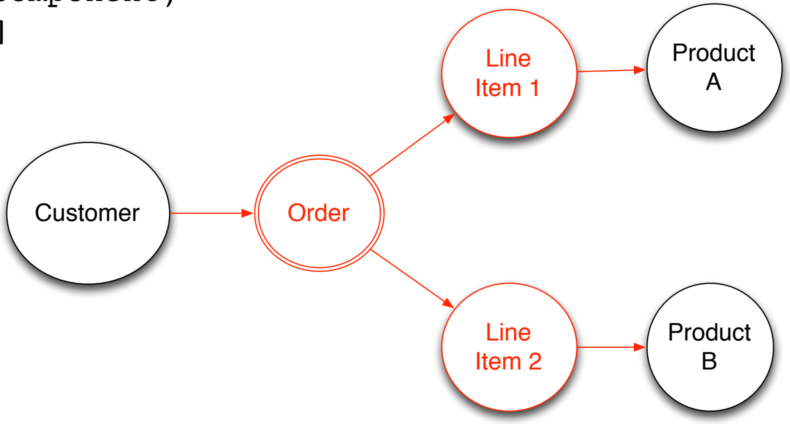
direct references to me

```
[(extent ?x ?e ?a ?v)
 (?e ?a ?v)
 (?e ?a ?x)
 [(= ?v ?x)]]
```



recurse *component* attributes

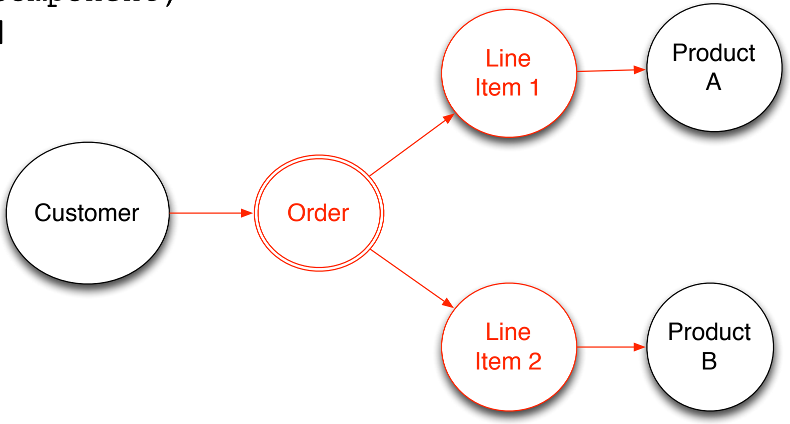
```
[(extent ?x ?e ?a ?v)
 (components ?x ?y)
 (extent ?y ?e ?a ?v)]
[(components ?p ?c)
 (?a :db/isComponent)
 (?p ?a ?c)]
```



recurse *component* attributes

```
[(extent ?x ?e ?a ?v)
 (components ?x ?y)
 (extent ?y ?e ?a ?v)]
[(components ?p ?c)
 (?a :db/isComponent)
 (?p ?a ?c)]
```

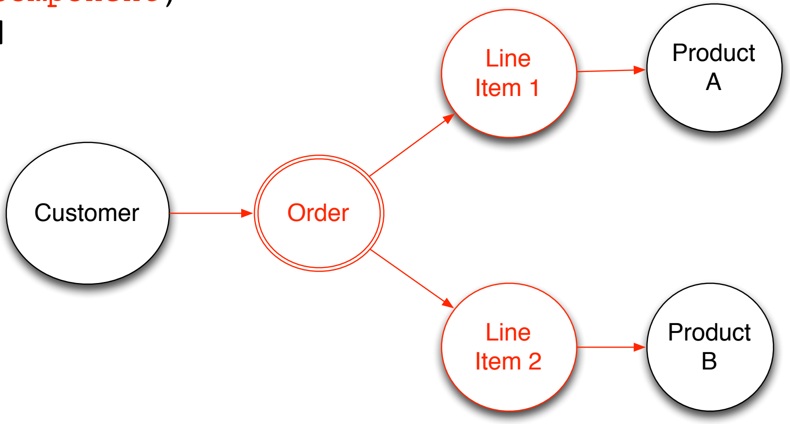
recursive definition



recurse *component* attributes

```
[(extent ?x ?e ?a ?v)
 (components ?x ?y)
 (extent ?y ?e ?a ?v)]
[(components ?p ?c)
 (?a :db/isComponent)
 (?p ?a ?c)]
```

only recurse attributes marked :db/isComponent



Where Are We?

Motivation

Schema

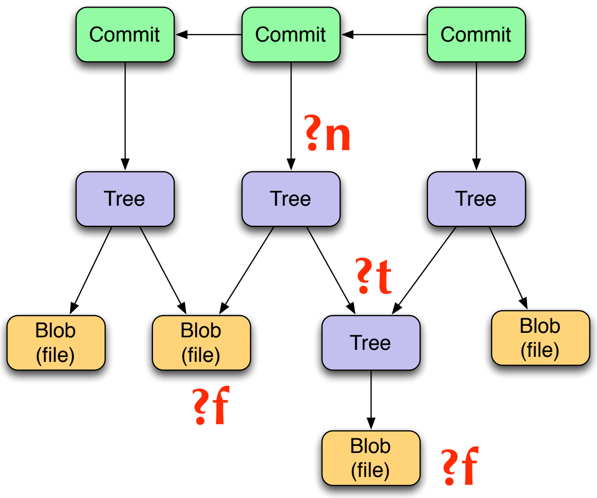
Import

Datalog

Rules

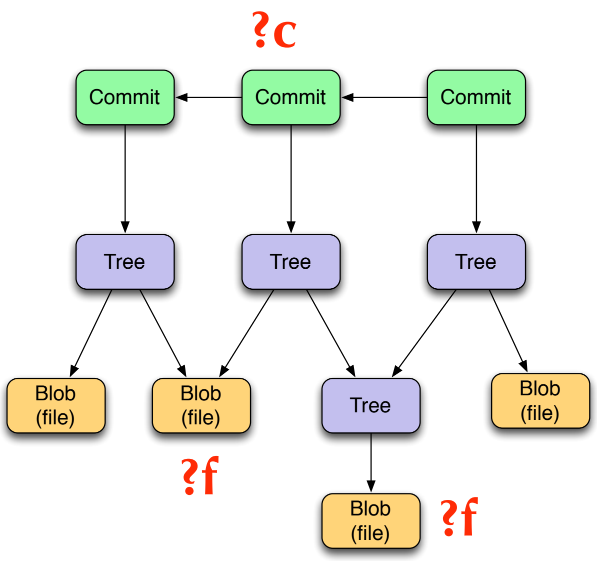
Queries

node-files



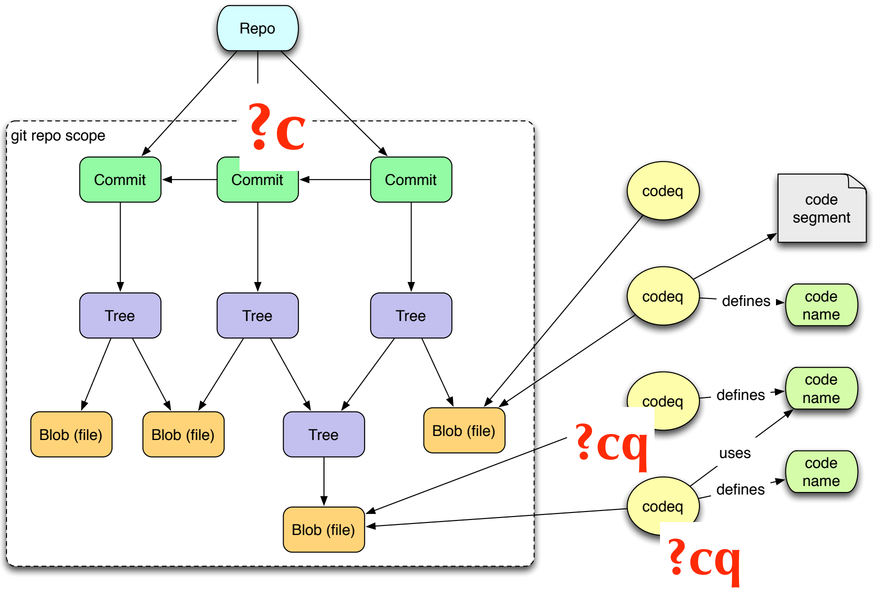
```
[(node-files ?n ?f)
 [?n :node/object ?f] [?f :git/type :blob]]

[(node-files ?n ?f)
[?n :node/object ?t] [?t :git/type :tree] [?t :tree/nodes ?n2] (node-files ?n2 ?f)]
```

commit-files



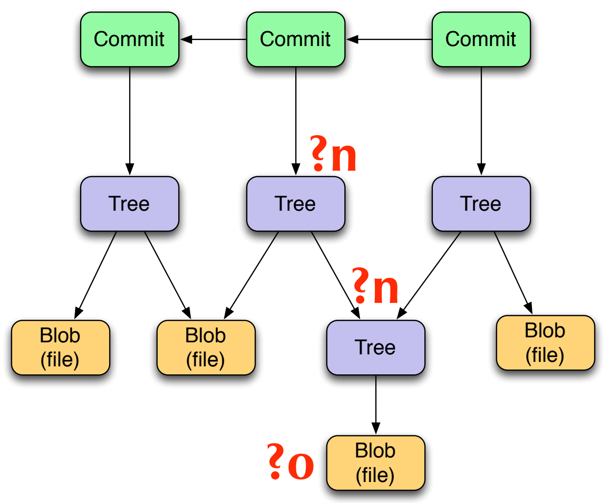
```
[(commit-files ?c ?f)
 [?c :commit/tree ?root] (node-files ?root ?f)]
```

commit-codeqs



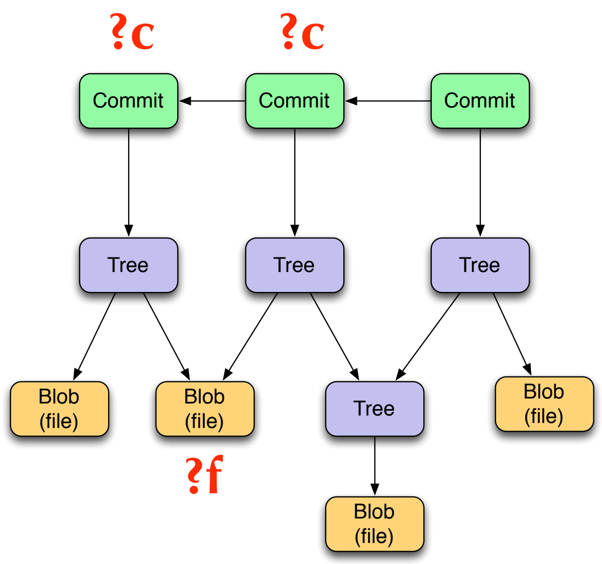
```
[(commit-codeqs ?c ?cq)
 (commit-files ?c ?f) [?cq :codeq/file ?f]]
```

object-nodes



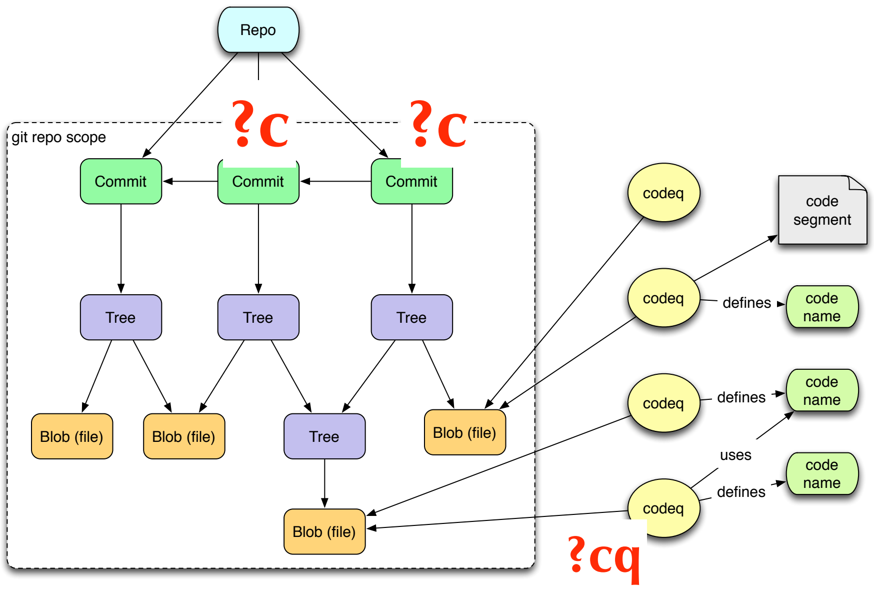
```
[(object-nodes ?o ?n)
 [?n :node/object ?o]]
[(object-nodes ?o ?n)
 [?n2 :node/object ?o] [?t :tree/nodes ?n2] (object-nodes ?t ?n)]
```

file-commits



```
[(file-commits ?f ?c)
 (object-nodes ?f ?n) [?c :commit/tree ?n]]
```

codeq-commits



```
[(codeq-commits ?cq ?c)
 [?cq :codeq/file ?f] (file-commits ?f ?c)]
```

Resources

Codeq
http://blog.datomic.com/2012/10/codeq.html. Introduction to codeq.
https://github.com/Datomic/codeq. codeq repository.
http://www.google-melange.com/gsoc/project/google/gsoc2013/navgeet/7001.
GSOC project.

Datomic
http://edn-format.org. The edn specification.
http://www.datomic.com/. Datomic.
https://github.com/datomic/datomic-groovy-examples. Datomic queries in Groovy.

Stuart Halloway
https://github.com/stuarthalloway/presentations/wiki. Presentations
http://thinkrelevance.com/blog/tags/podcast. The Relevance Podcast.
http://www.linkedin.com/pub/stu-halloway/0/110/543/
https://twitter.com/stuarthalloway