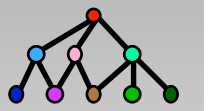
Tuning for Performance



- ***Outline of talk:***
  - ***Classifier Performance***
  - ***Recognizer Performance***
  - ***Performance Tips***
  - ***CLOS Instances and the Backchainer***

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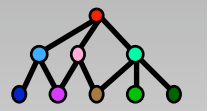
Performance
Where does the time go?



- *In some systems, slow performance is due to poorly-tuned code.*
- *In Loom, slow performance can result from the enormous amount of inferencing that occurs under the hood.*

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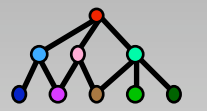
Classifier Performance

- Classifier Phases
  - (1) normalization (compute closure of ~100 inference rules)
  - (2) classification (compute subsumption links — very fast)
  - (3) completion (normalize constraints)
  - (4) sealing (compile access functions)



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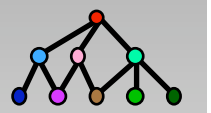
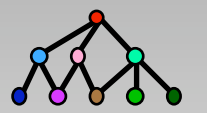
Classifier Performance



- **Classifier Phases**
  - (1) normalization
  - (2) classification
  - (3) completion
  - (4) sealing

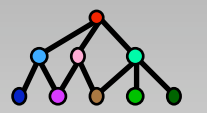
- **Bulk of time is spent in phases (1) and (3), normalizing features:**
  - (i) start with local features (:at-most, :at-least, :all, ...);
  - (ii) inherit features from parent concepts;
  - (iii) compute larger set of features (deductive closure);
  - (iv) keep only the most specific features;
  - (v) classify the remaining features.

Speeding Up Normalization



- *Each constraint in Loom represents a rule of inference (not just a type check).*
- *The overhead of normalization depends on the number of features per concept (it's estimated to be quadratic in the number of features).*
- *So, a simple way to speed up an application is to specify fewer constraints :-).*

Speeding Up Normalization (cont.)



- *Loom permits you to lobotomize the classifier*
  - *"(power-level :medium)" causes Loom to ignore a few of the most expensive normalization rules.*
  - *"(power-level :low)" causes Loom to make a single pass over the normalization rules (rather than computing their closure).*

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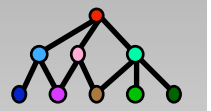
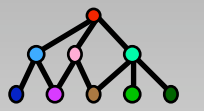
Load-Time vs. Run-Time Classification



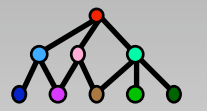
- ***Most applications perform the bulk of classification at load time; for them, speed of classification may not be critical.***
  - ***Normally, run-time production of new system-generated descriptions will quiesce (no more "." s and "+"s);***

Recognizer Performance



- An explicit call by an application (e.g., (tellm)) triggers reclassification of updated instances .
- Recognition strategy:
  - For each instance on the queue
    - (1) normalize asserted and inherited features;
    - (2) classify the instance;
    - (3) install dependency bombs (TMS monitors);
    - (4) test for incoherence;
    - (5) propagate forward constraints.
- Steps 1-5 are applied to each instance at least two times (once each in strict and default mode).

Classifying Instances



During the recognition process, each feature in a concept definition represents a miniature query.

Examples:

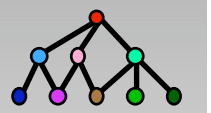
`(:at-least k R)`
Retrieve fillers of the role R;
Succeed if the number of fillers is at least k.

`(:at-most k R)`
If role R is closed, retrieve fillers of the role R;
Succeed if the number of fillers is at most k.

`(:all R A)`
If role R is closed, retrieve fillers of the role R;
Succeed if each of the fillers satisfies the concept A.

The bulk of recognition time consists of computing feature satisfaction *and* truth maintaining the results.

Testing for Closed Roles



- ***Probing features such as*** **(:all R A)** ***or*** **(:at-most k R)** ***usually entails proving that the role R is closed.***
- ***This test is fast if***
  - ***R has the :closed-world property, or***
  - ***R is :single-valued and a role filler exists.***
- ***Tip : Always specify the :single-valued and :closed-world properties on relations whenever they are valid for your application domain.***

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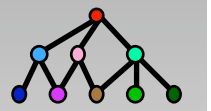
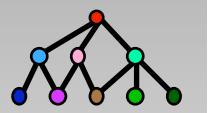
Subtlety in the semantics of role closure:



```
(defconcept A
   :implies (:at-least 1 R))
(defrelation R
  :characteristics (:closed-world))
(tell (Thing Joe)
      (A Fred))
```

- *The role "`(R of Joe)`" is closed, but the role "`(R of Fred)`" is not closed.*

Domain and Range Constraints



- *Tip : Always specify domain and range constraints for a relation (unless they are inherited from a parent relation).*

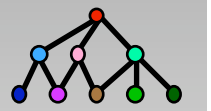
```
(defrelation R :domain A :range B)
(tellm (R Fred Joe))
```

➔ *Loom infers that Fred satisfies A and that Joe satisfies B.*

```
(defconcept A :implies (:exactly 1 R))
(defrelation R :domain A)
```

➔ *Loom infers that R is :single-valued.*

Performance Warnings



- *A ``no generator found'' performance warning indicates that a query will exhibit abysmal performance.*
  - *Slower (sometimes) :*

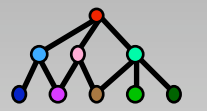
```
(retrieve (?x ?y) (R ?x ?y))
```

  - *Faster (sometimes) :*

```
(retrieve (?x ?y)
    (and (A ?x) (R ?x ?y)))
```

  - *If no domain is specified for R, the slower query will scan the entire kb to generate bindings for ?x.*

Performance Tips:



- *Tip : Always rephrase definitions or queries to eliminate performance warnings.*
- *Tip : Never wrap an eval around an ask or retrieve unless you are single, childless, and have no desire to graduate, e.g.,*
  - *(eval `(retrieve (?y) (and (R ,foo ?y) (A ?y)))*
- *Tip: To programmatically compose a query on the fly, use "query" or bind variables:*
  - *(query '(?y) `(and (R ,foo ?y) (A ?y)))*
  - *(let ((?x foo))*
    (retrieve (?y) (and (R ?x ?y) (A ?y))))

Better!

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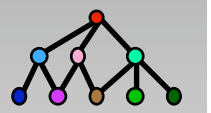
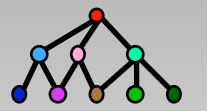
:perfect relations



- *Marking a concept or relation :perfect tells Loom that facts about it cannot change.*
  - *Tip : Use of the :perfect properties reduces match overhead.*
  - *Tip : Computed relations are prime candidates for the :perfect attribute .*

```
(defrelation <>
   :domain Number :range Number
   :characteristics (:symmetric :perfect)
   :predicate /= )
```

How to Get No Recognition



- *The overhead of instance classification (recognition) is eliminated if you specify as a creation policy* `:clos-instance` *or* `:lite-instance`.
- *Deduction over CLOS instances and LITE instances is backward chained, with no caching.*
- *However (there is always a catch) inference without instance classification is strictly weaker than inference with it.*

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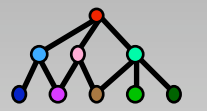
Deduction with CLOS and LITE Instances



- *With creation policy set to* `:clos-instance` *or* `:lite-instance` *inference is performed using backward chaining.*

- *The backchainer recognizes rules of the form*

  `(implies A B)` *and*

  `(implies <description> B)`

but ignores rules of the form

`(implies A <descriptions>)`

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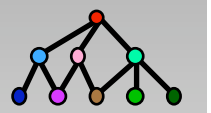
Backward chaining and type restrictions



- *The design decision not to chain backwards across value restrictions was a judgment call.*

```
(defconcept A
    :implies (:all R B))
(tell (A Fred) (R Fred Joe))
(ask (B Joe))  -->  ???
```

- *The recognizer will prove that Joe satisfies B; the backchainer won't.*

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