

Generalizing Lenses

Daniel Wagner

August 19, 2013



Thesis Proposal

There are many fundamentally bidirectional settings that call for generalizations of traditional lenses where a language is possible and helpful.

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Overview

Traditional lenses

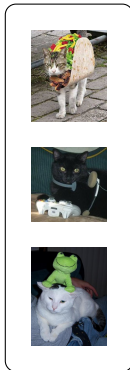
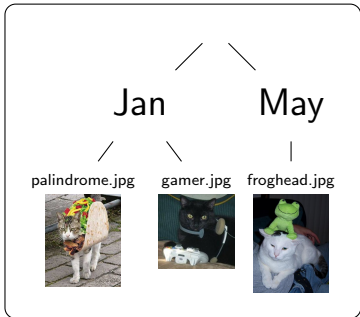
Symmetry

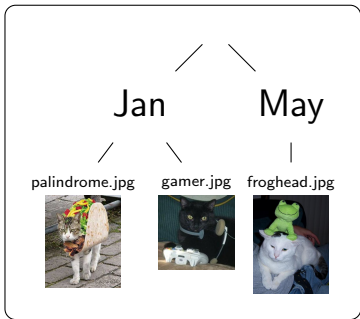
Edits

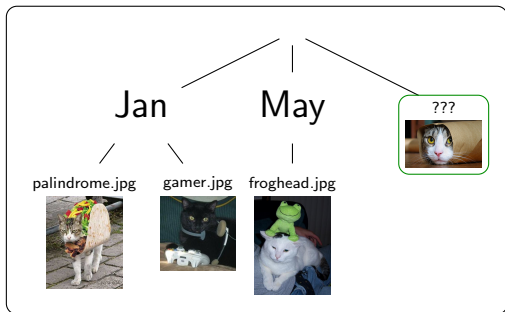
Multidirectionality

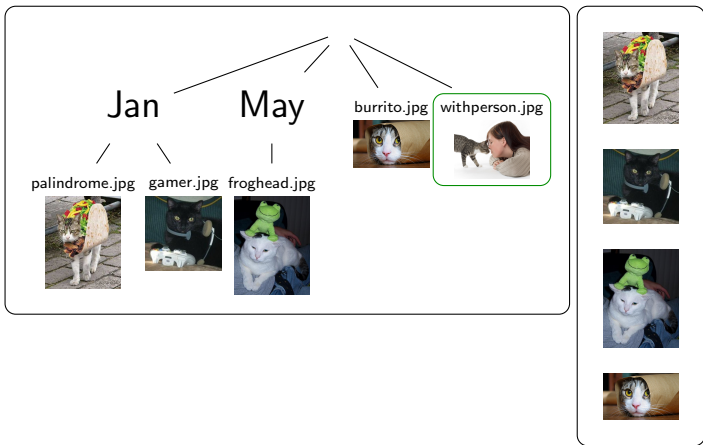
Logistics

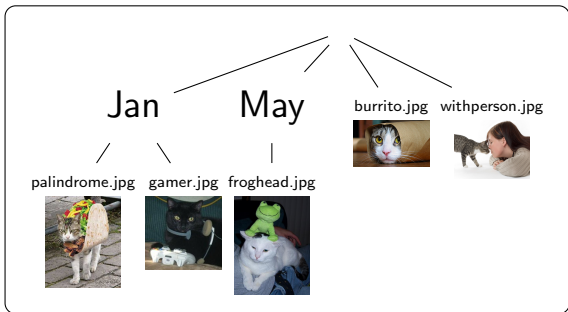
Traditional lenses











Abstract model

A lens $\ell \in X \overset{a}{\leftrightarrow} Y$ has components

$$\textit{get} \in X \rightarrow Y$$

$$\textit{put} \in Y \times X \rightarrow X$$

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Synchronizing too often doesn't hurt.

$$\text{get}(\text{put}(y, x)) = y$$

$$\text{put}(\text{get}(x), x) = x$$

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$$\text{put}(y', \text{put}(y, x)) = \text{put}(y', x)$$

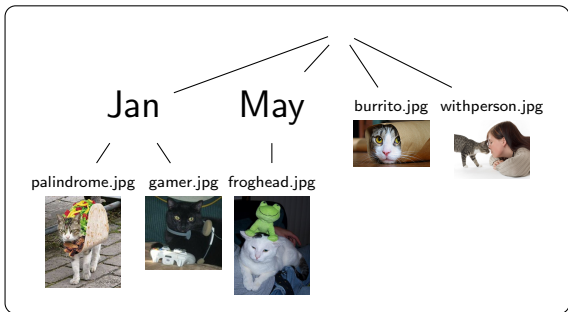
Not synchronizing often enough doesn't hurt.

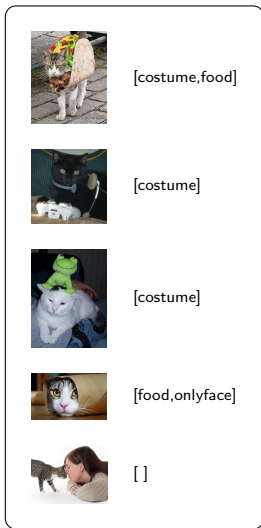
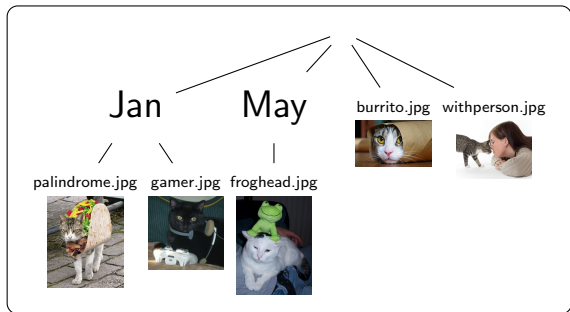
Related work: asymmetric lenses

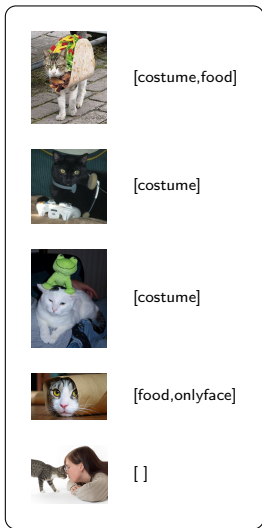
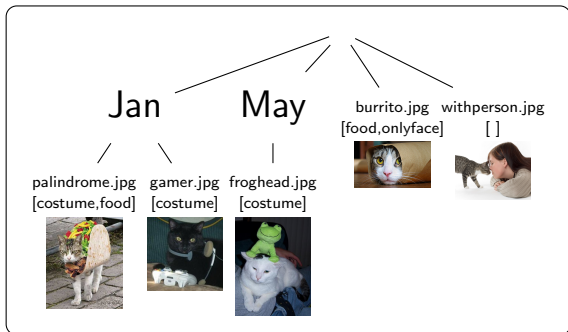
- ▶ Combinators for Bidirectional Tree Transformations
(Foster, Greenwald, Moore, Pierce, Schmitt; POPL 2005)
 - ▶ Relational Lenses: A Language For Updateable Views
(Bohannon, Vaughn, and Pierce; PODS 2006)
 - ▶ Boomerang: Resourceful Lenses for String Data
(Bohannon, Foster, Pierce, Pilkiewicz, and Schmitt; POPL 2008)
 - ▶ Bidirectional Programming Languages
(Foster; thesis 2009)
 - ▶ Bidirectionalizing Graph Transformations
(Hidaka, Hu, Inaba, and Kato; ICFP 2010)
 - ▶ Update Semantics of Relational Views
(Bancilhon and Spyratos; 1981)
-

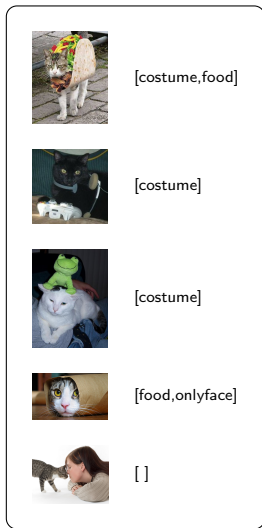
Symmetry

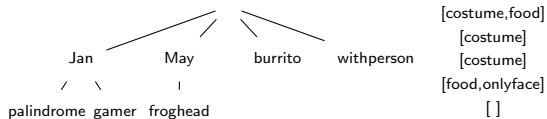
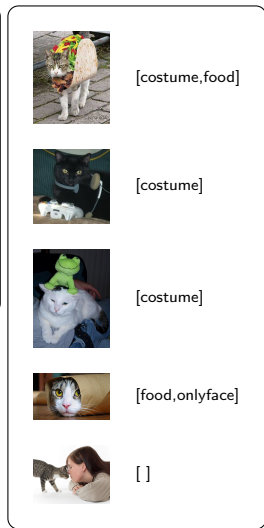
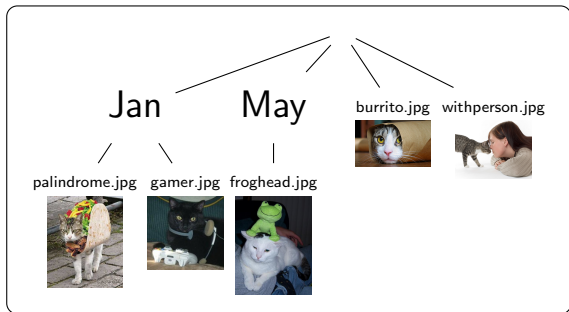
(in collaboration with Martin Hofmann and Benjamin Pierce)

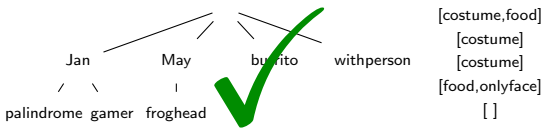
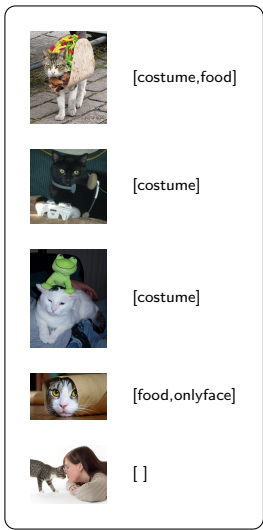
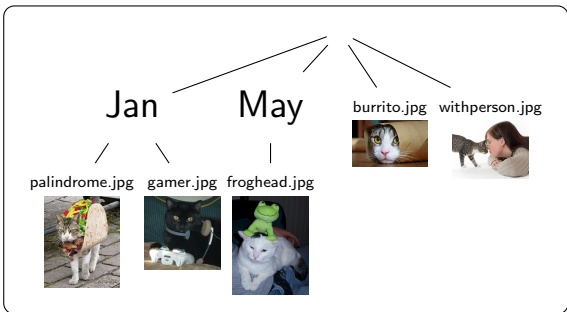












Abstract model

A lens $\ell \in X \overset{S}{\leftrightarrow} Y$ has a set C and components

$$putr \in X \times C \rightarrow Y \times C$$

$$putl \in Y \times C \rightarrow X \times C$$



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$$putr(x, c) = putr(x, c')$$

Twist: equational reasoning

$$A \begin{array}{c} \xleftarrow{a} \\ \xrightarrow{k} \end{array} B \begin{array}{c} \xleftarrow{a} \\ \xrightarrow{\ell} \end{array} C \begin{array}{c} \xleftarrow{a} \\ \xrightarrow{m} \end{array} D$$

Nice property of asymmetric lenses:

$$(k; \ell); m = k; (\ell; m)$$

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Nice property of asymmetric lenses:

$$(k; \ell); m = k; (\ell; m)$$

Not true for symmetric lenses!

In dissertation

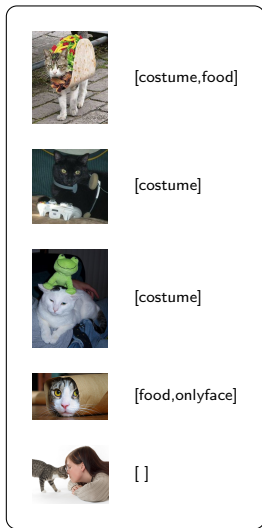
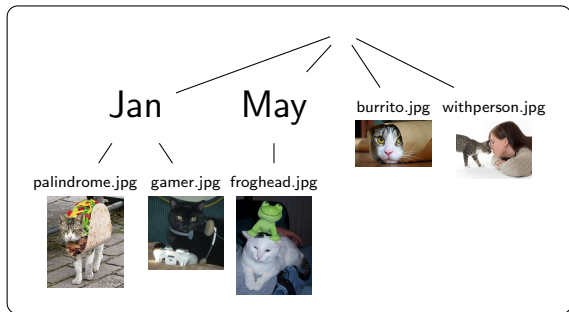
- ▶ Observational equivalence
 - ▶ Point-free programming language
 - ▶ Basic (non-recursive) data types
 - ▶ Lists, with folds and unfolds
 - ▶ Some generalized container operations
 - ▶ Proof that this generalizes asymmetric lenses
-

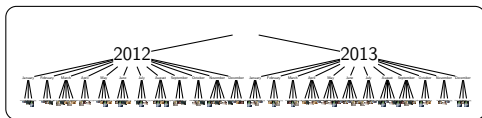
Related work: other symmetric approaches

- ▶ Symmetric Constraint Maintainers
(Meertens; 1998)
 - ▶ Towards an Algebraic Theory of Bidirectional Transformations
(Stevens; ICGT 2008)
 - ▶ Bidirectional Model Transformations in QVT: Semantic Issues and Open Questions
(Stevens; MoDELS 2007)
 - ▶ Algebraic Models for Bidirectional Model Synchronization
(Diskin; MoDELS 2008)
 - ▶ Supporting Parallel Updates with Bidirectional Model Transformations
(Xiong, Song, Hu, and Takeichi; ICMT 2009)
-

Edits

(in collaboration with Martin Hofmann and Benjamin Pierce)





Abstract model

Edit lens $\ell \in (M, X, \cdot) \overset{\delta}{\leftrightarrow} (N, Y, \odot)$ has set C and

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$$dputr(m, c) = (n, c')$$

$$dputr(m', c') = (n', c'')$$

$$dputr(mm', c) = (nn', c'')$$

Notable benefits

- ▶ All changes reported, so synchronizing less often is less controversial
 - ▶ Intentional information in edits aids alignment
 - ▶ Smaller complement in many cases!
 - ▶ Roundtrip laws are monoid homomorphism laws
-

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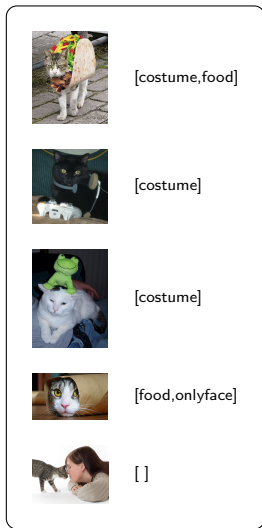
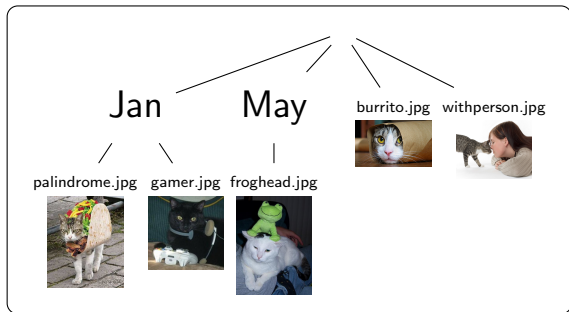
- ▶ All changes reported, so synchronizing less often is less controversial
 - ▶ Intentional information in edits aids alignment
 - ▶ Smaller complement in many cases!
 - ▶ Roundtrip laws are monoid homomorphism laws
 - ▶ Observational equivalence, combinator language, generalizes symmetric lenses
-

Related work: other edit-based approaches

- ▶ Towards an Algebraic Theory of Bidirectional Transformations
(Stevens; ICGT 2008)
 - ▶ Matching Lenses: Alignment and View Update
(Barbosa, Cretin, Foster, Greenberg, and Pierce; ICFP 2010)
 - ▶ From State- to Delta-based Bidirectional Model Transformations
(Diskin, Xiong, Czarnecki; TPMT 2010)
 - ▶ From State- to Delta-based Bidirectional Model Transformations: The Symmetric Case
(Diskin, Xiong, Czarnecki, Ehrig, Hermann, and Orejas; MoDELS 2011)
 - ▶ Delta Lenses over Inductive Types
(Pacheco, Cunha, Hu; ECEASST 2012)
-

Multidirectionality

(in collaboration with Jen Paykin, Benjamin Pierce, Jeff Vaughan, and Geoff Washburn)





[costume,food]



[costume]



[costume]



[food,onlyface]



[]



costume



food



onlyface

	A	B	C	D
1		Students	Equipment	Total
2	2012	70000	9000	79000
3	2013	70000	4000	74000
4	Total	140000	13000	153000

New interaction mode

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2012	70000	9000	79000
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New interaction mode

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Total	140000	26000	166000

... and this happens behind the scenes, too.

Straw-man abstract model

For universe U , lens $\ell \in \mathcal{M}(N)$ has components

$$put \in 2^N \rightarrow U^N \rightarrow U^N$$

$$K \in 2^{U^N}$$

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Inputs are really inputs and consistency is restored.

$$\begin{aligned} \text{put}(S, f)|_S &= f|_S \\ \text{put}(S, f) &\in K \end{aligned}$$

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$$\begin{aligned} \text{put}(S, f)|_S &= f|_S \\ \text{put}(S, f) &\in K \\ \text{put}(\emptyset, f) &= f \end{aligned}$$

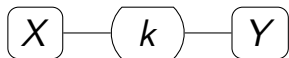
Synchronizing too often doesn't hurt.

Unsolvable updates

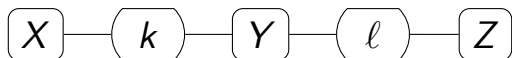
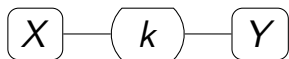
	Students	Equipment	Total
2012	70000	9000	79000
2013	70000	4000	74000
Total	0	0	1

Track sets of names that are always solvable.

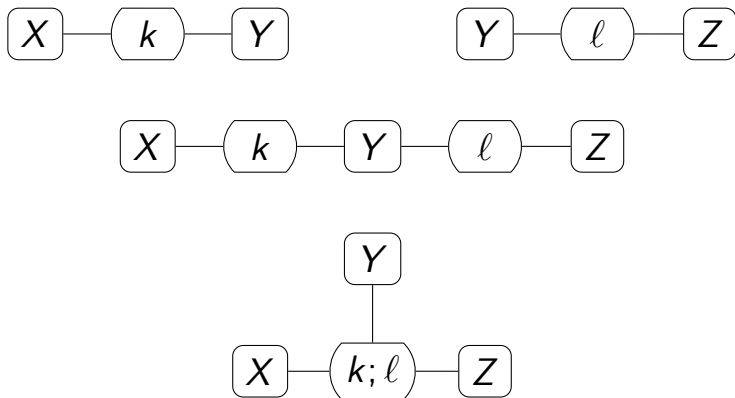
Composition intuition



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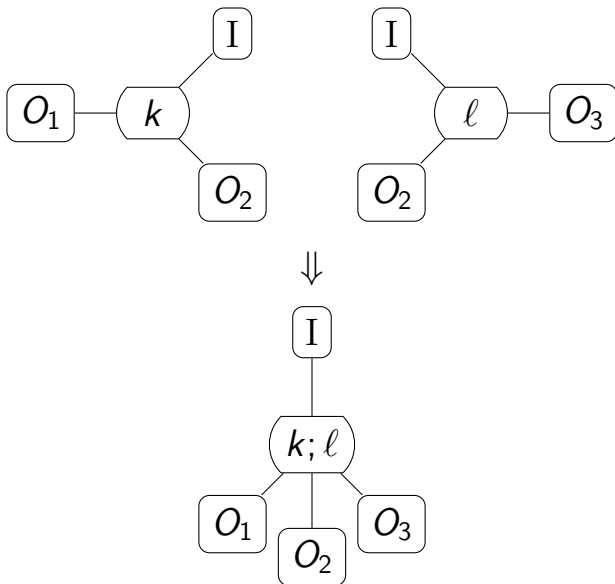


Composition intuition

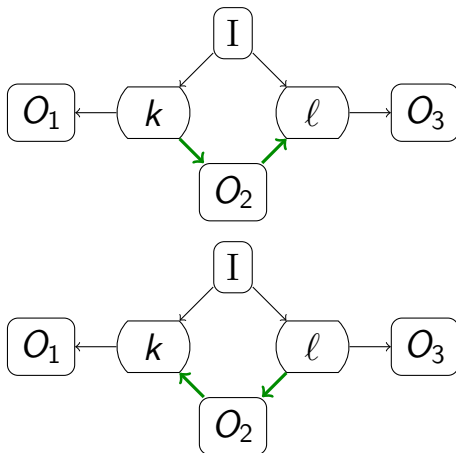


Safe updates: $\{X\}$ or $\{Z\}$.

Ambiguous updates



Two plans



Observational equivalence is no help.

Remaining questions

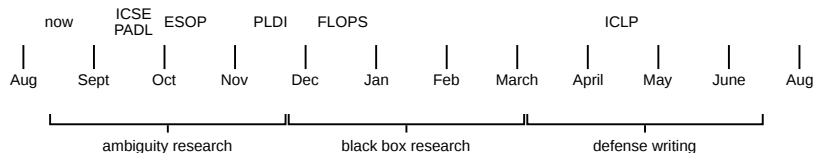
- ▶ Complete strategies for disambiguation?
 - ▶ Behavioral specifications for disambiguation?
 - ▶ How can we extend the static update check?
 - ▶ What dynamic update checks are possible?
-

Related work: bidirectional spreadsheets

- ▶ Tiresias: The Database Oracle for How-To Queries
(Meliou and Suciú; SIGMOD ICMD 2012)
 - ▶ A Spreadsheet Based on Constraints
(Stadelmann; UIST 1993)
 - ▶ SkyBlue: A Multi-way Local Propagation Constraint Solver for User Interface Construction
(Sannella; UIST 1994)
 - ▶ Expressing Multi-way Dataflow Constraint Systems as a Commutative Monoid Makes Many of their Properties Obvious
(Järvi, Haveráaen, Freeman, and Marcus; SIGPLAN WGP 2012)
 - ▶ A Constraint-Based Spreadsheet for Cooperative Production Planning
(Chew and David; KBPPSC 1992)
 - ▶ How to Use the Spreadsheet Manager
(Evans; tech report 1993)
 - ▶ Interval Constraint Spreadsheets for Financial Planning
(Hyvönen; AIAWS 1991)
-

Logistics

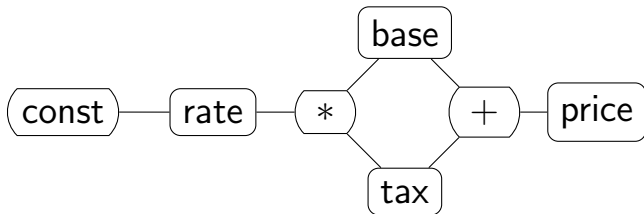
Timeline



- ▶ Nailing ambiguity resolution is lynchpin
 - ▶ Extending static and dynamic checks is polish
 - ▶ Bad case: trade black box time for additional ambiguity time
 - ▶ Worst case: biased composition
-

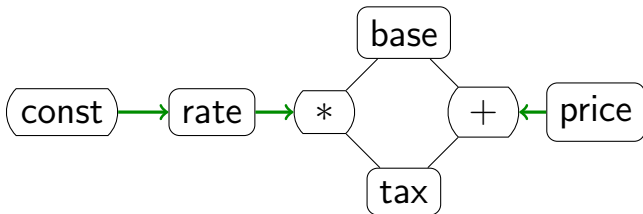
Why black boxes?

$$\text{price} = \text{base} + \text{tax}$$
$$\text{tax} = 0.08 * \text{base}$$



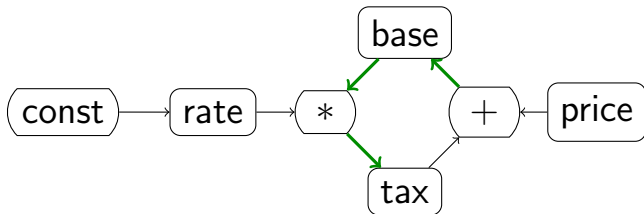
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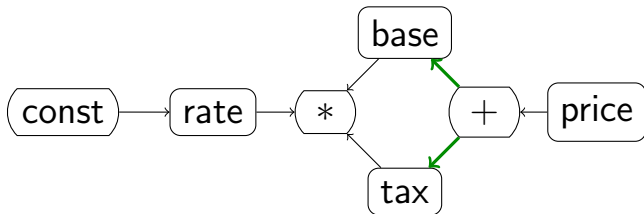
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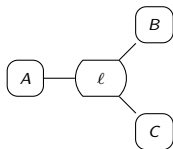


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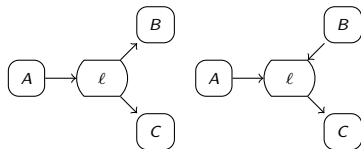
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How to progress



constraint



sample methods

- ▶ When any plan will do: greedy algorithm
- ▶ Assign a cost to each method
- ▶ Specification: min-cost set of methods
- ▶ Implementation: search (efficient when combining costs is monotonic)