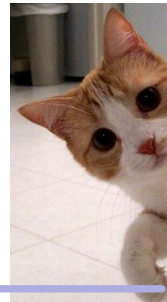
Generalizing Lenses

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

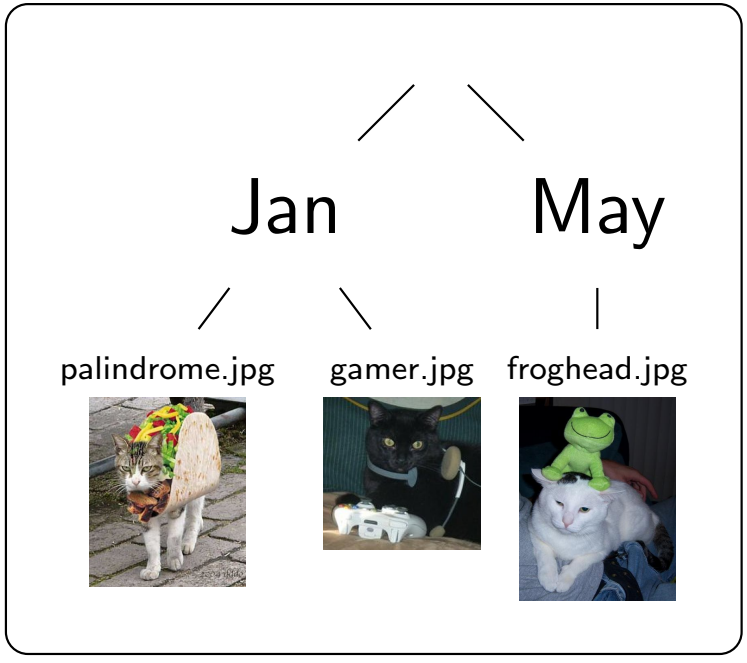
Symmetry

Edits

Multidirectionality

Logistics

Traditional lenses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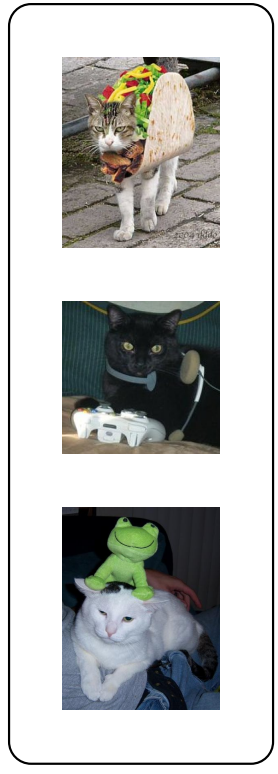

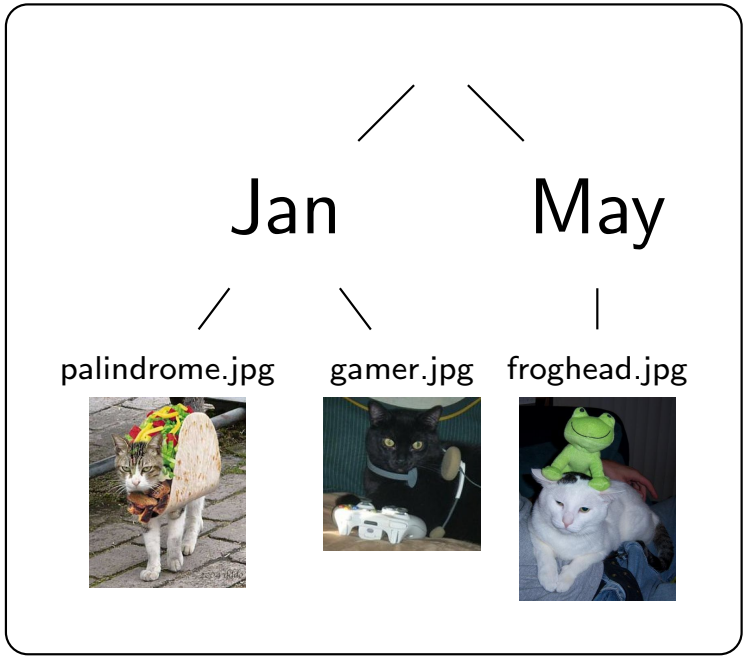
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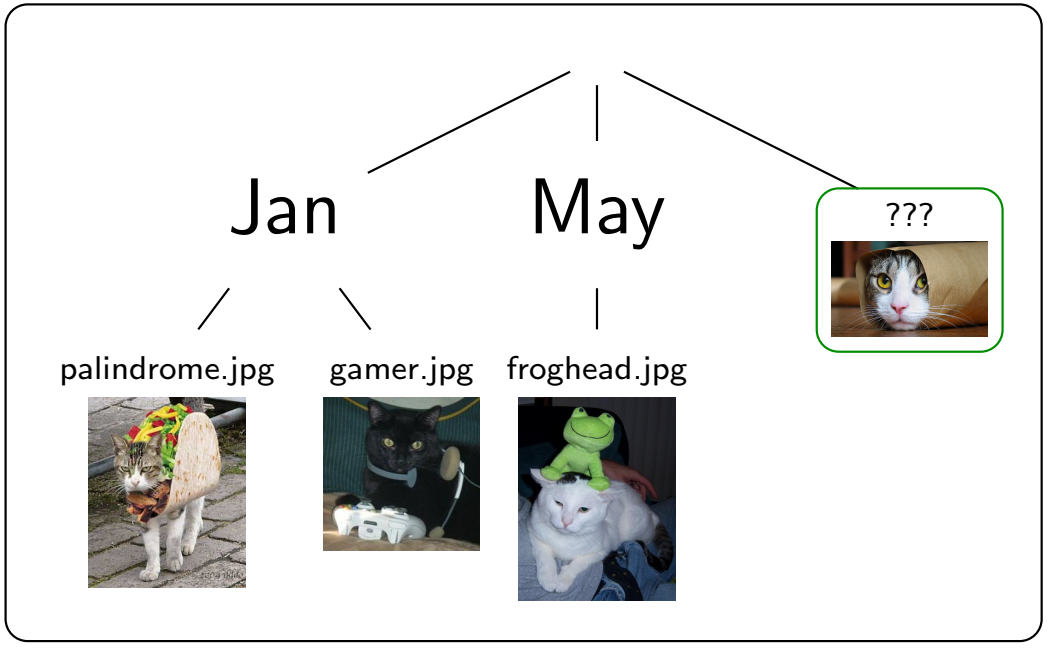
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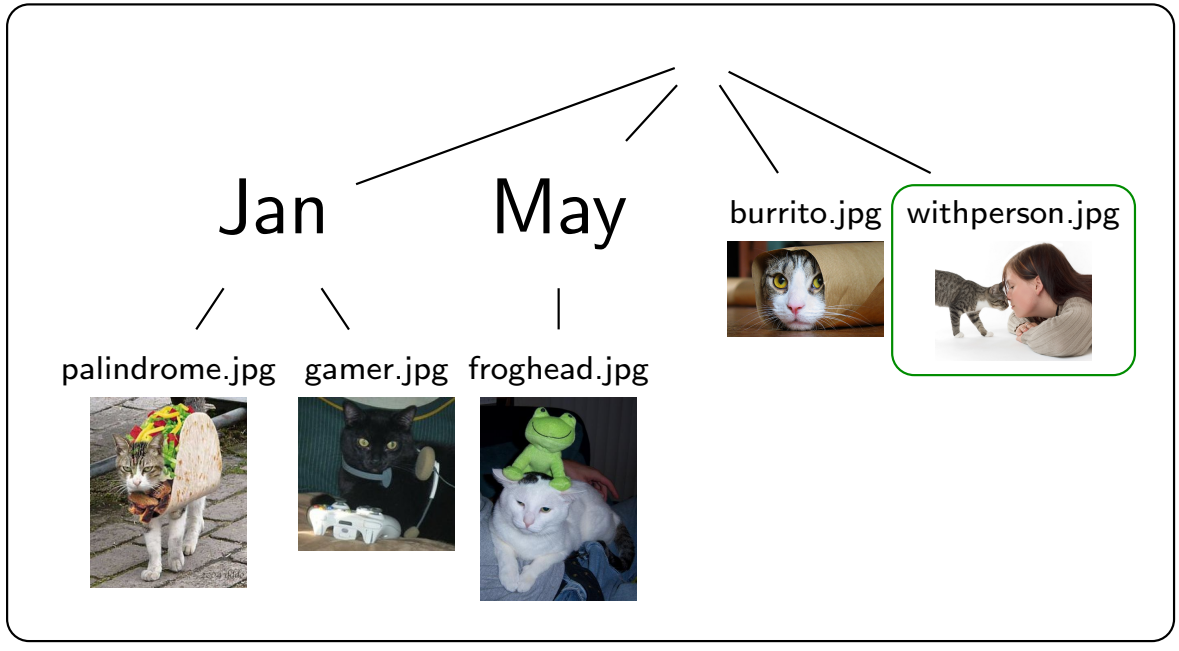
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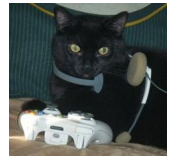

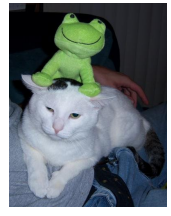

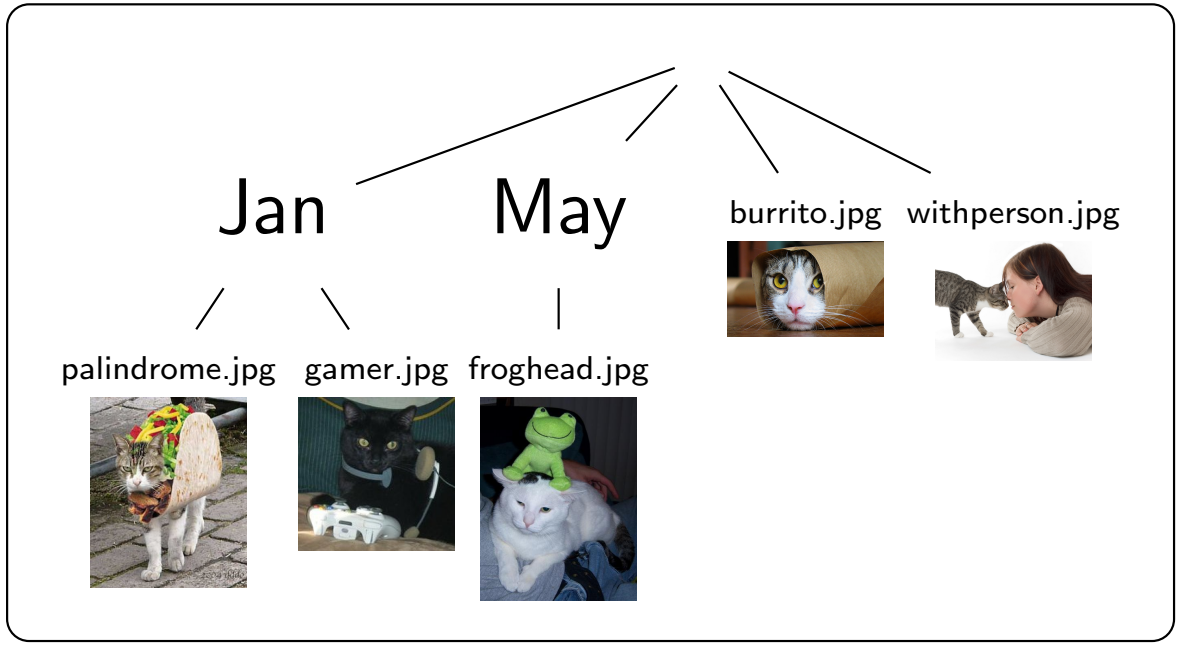
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Abstract model

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

$$get \in X \to Y$$
$$put \in Y \times X \to X$$

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Synchronizing too often doesn't hurt.

$$get(put(y, x)) = y$$
$$put(get(x), x) = x$$

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$$put(get(x), x) = x$$
$$put(y', put(y, x)) = put(y', x)$$

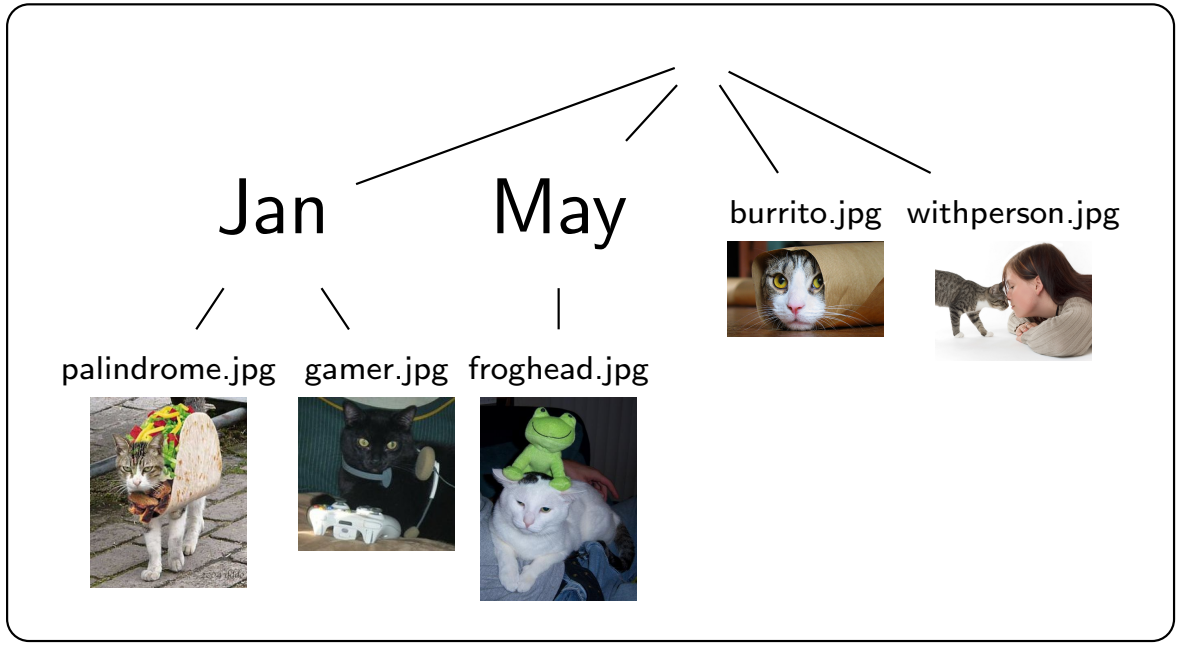
Not synchronizing often enough doesn't hurt.

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)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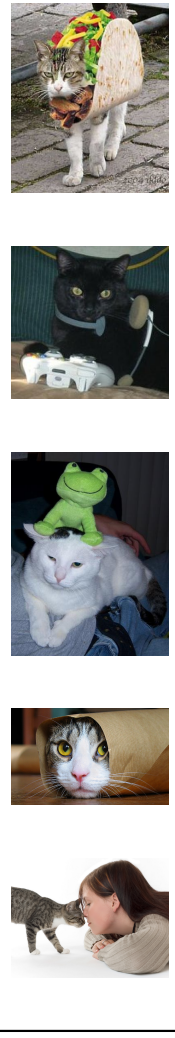

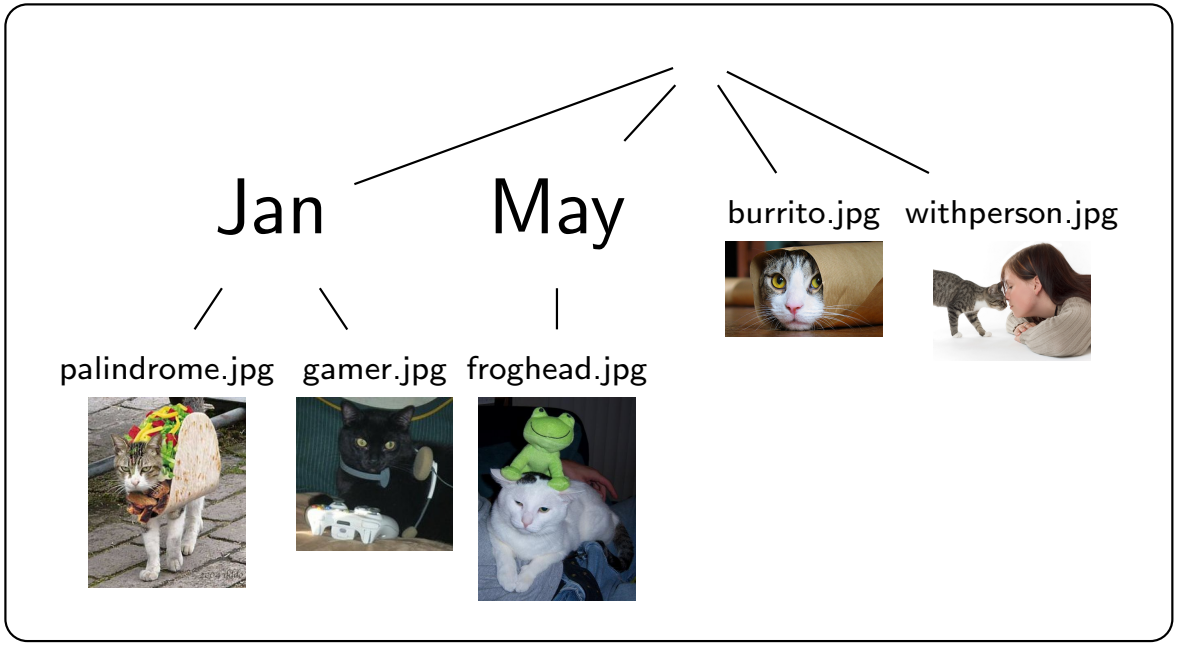

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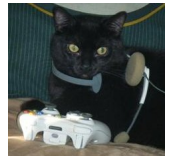
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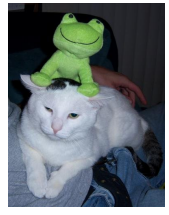
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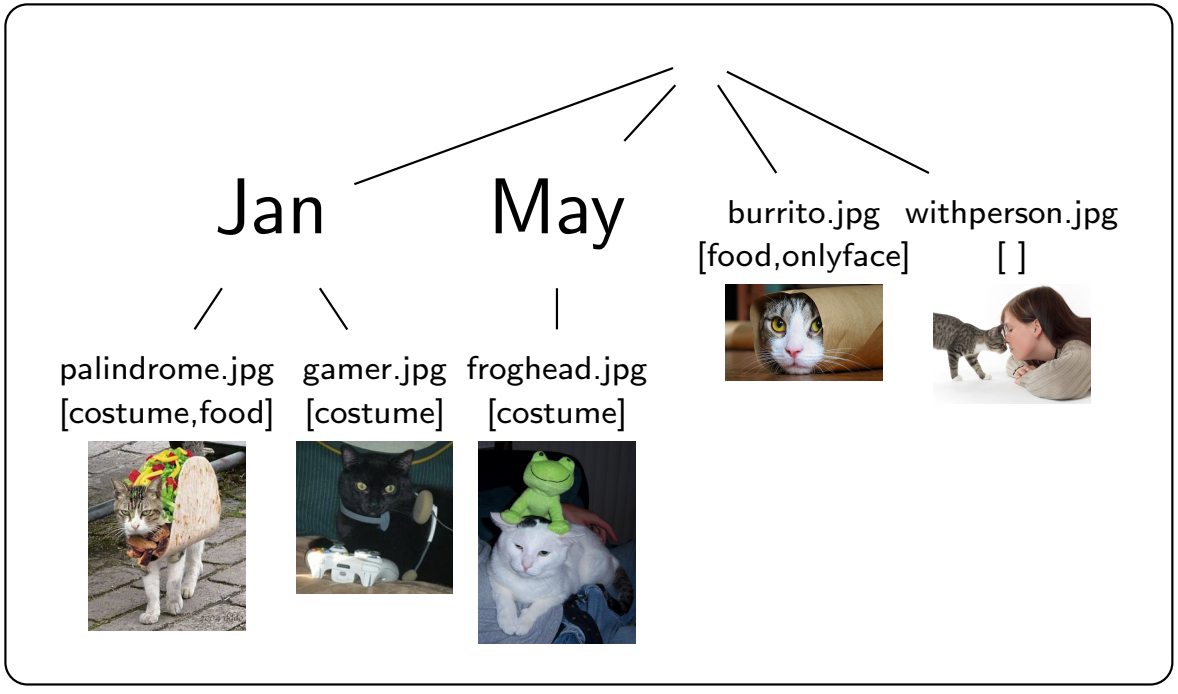
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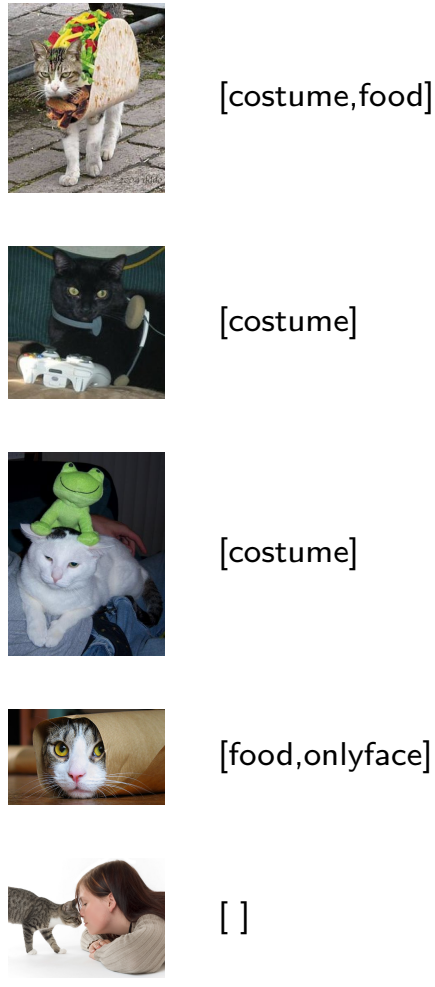
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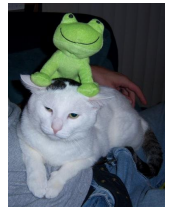

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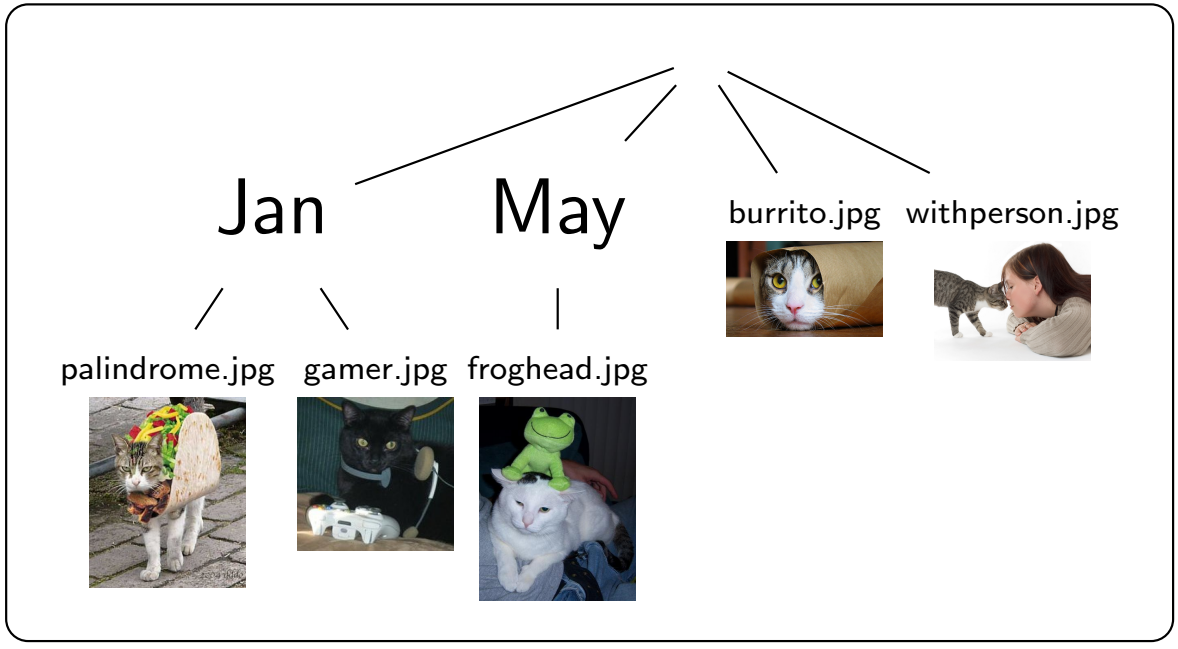

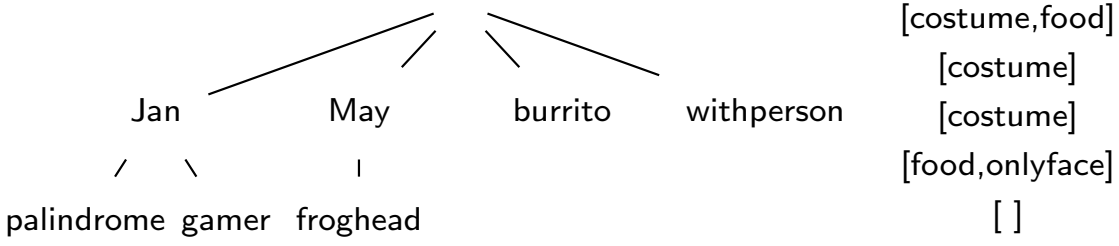

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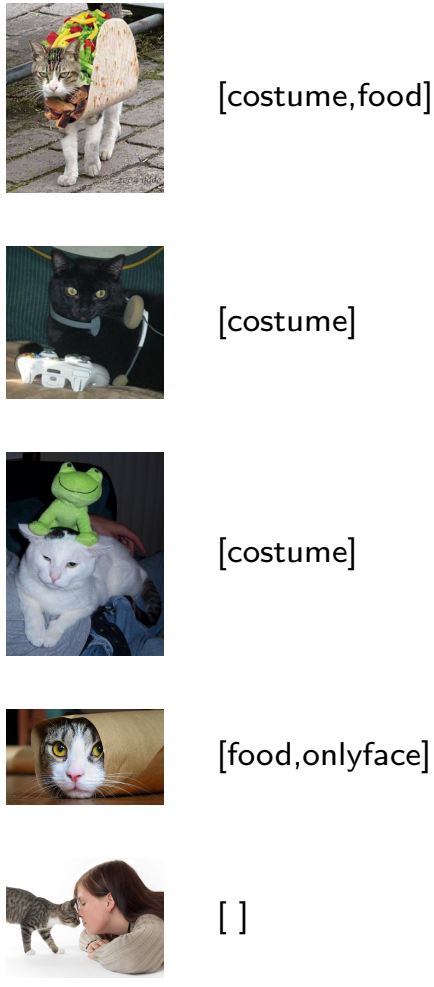

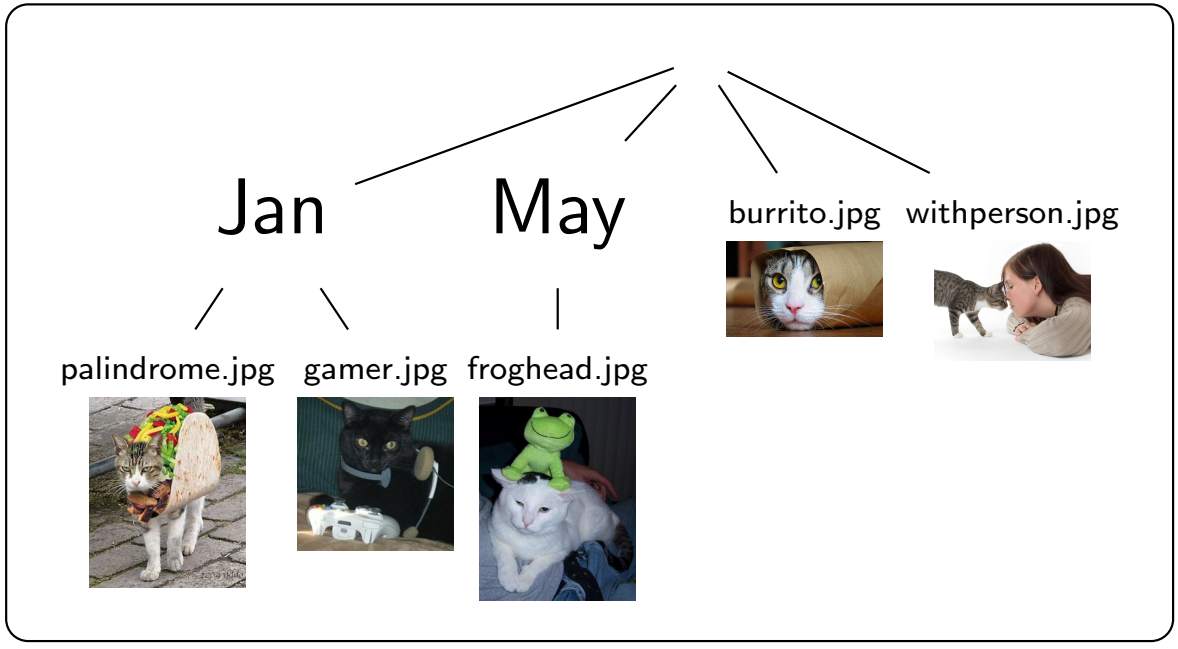

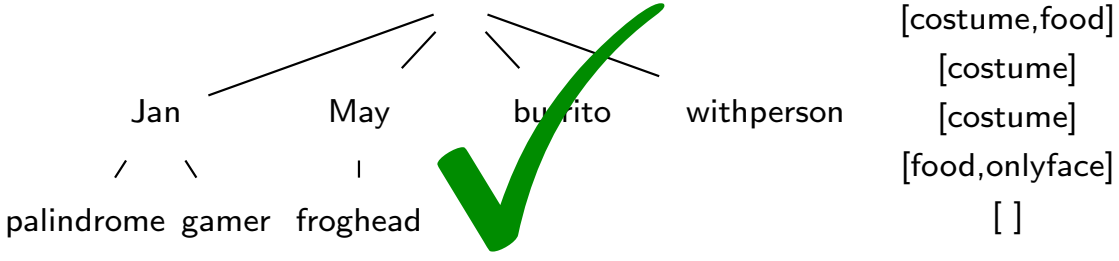

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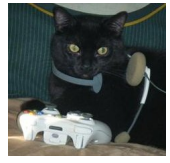

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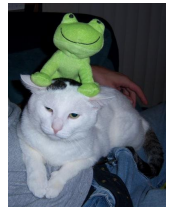

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A lens $\ell \in X \overset{s}{\leftrightarrow} Y$ has a set C and components

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

Twist: equational reasoning

$$\mathsf{A} \overset{a}{\underset{k}{\longleftrightarrow}} \mathsf{B} \overset{a}{\underset{\ell}{\longleftrightarrow}} \mathsf{C} \overset{a}{\underset{m}{\longleftrightarrow}} \mathsf{D}$$

Nice property of asymmetric lenses:

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

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$$\mathsf{A} \overset{a}{\underset{k}{\longleftrightarrow}} \mathsf{B} \overset{a}{\underset{\ell}{\longleftrightarrow}} \mathsf{C} \overset{a}{\underset{m}{\longleftrightarrow}} \mathsf{D}$$

Nice property of asymmetric lenses:

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

Not true for symmetric lenses!

In dissertation

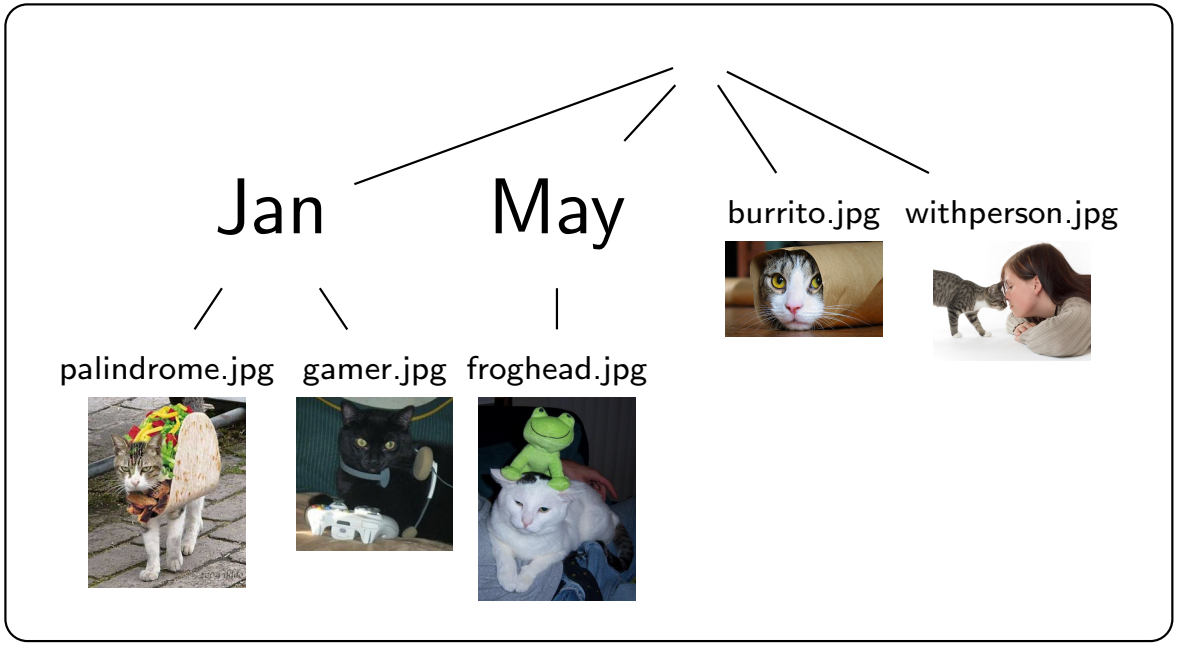
- Observational equivalence
- Point-free programming language
  - Basic (non-recursive) data types
  - Lists, with folds and unfolds
  - Some generalized container operations
- Proof that this generalizes asymmetric lenses

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)



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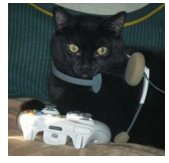
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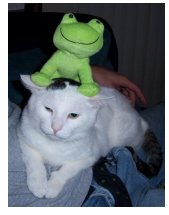
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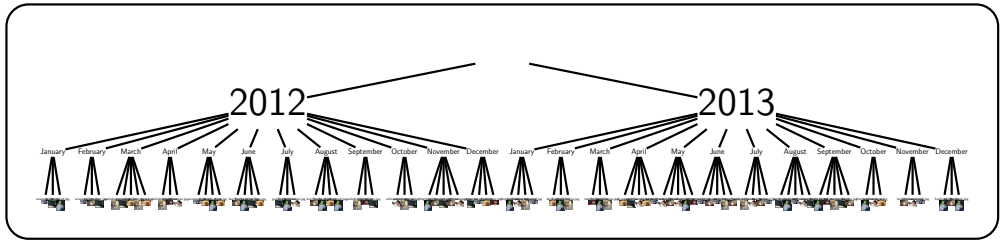
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Abstract model

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

$$dputr \in M \times C \to N \times C$$
$$dputl \in N \times C \to M \times C$$

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$$dputr(\mathbf{1}_M, c) = (\mathbf{1}_N, c)$$

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$$dputr(\mathbf{1}_M, c) = (\mathbf{1}_N, c)$$

Not synchronizing often enough doesn't hurt.

$$\frac{dputr(m, c) = (n, c') \quad dputr(m', c') = (n', c'')}{dputr(mm', c) = (nn', c'')}$$

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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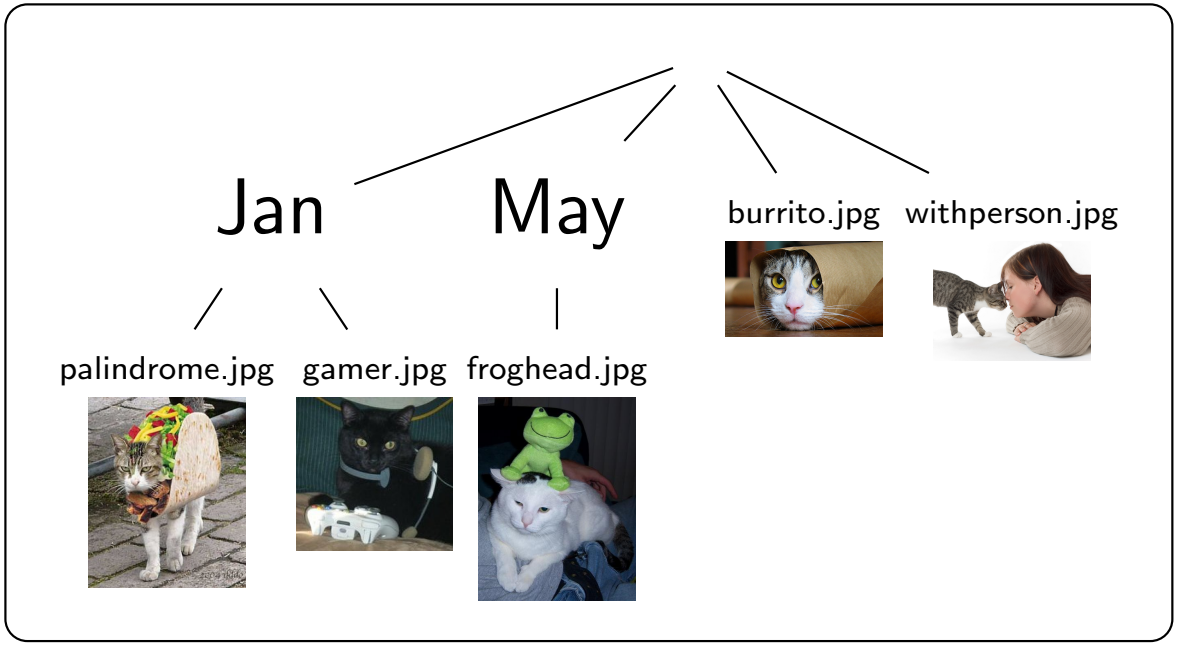
- Intentional information in edits aids alignment
- Smaller complement in many cases!
- Roundtrip laws are monoid homomorphism laws
- Observational equivalence, combinator language, generalizes symmetric lenses

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)



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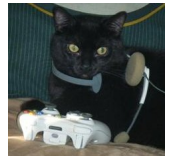
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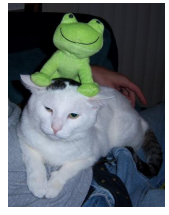
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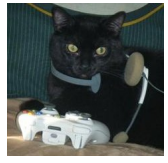

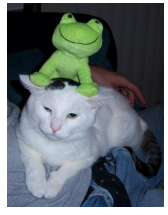

costume

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

Straw-man abstract model

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

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

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

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

Inputs are really inputs and consistency is restored.

$$put(S, f)|_S = f|_S$$
$$put(S, f) \in K$$

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$$put(S, f) \in K$$
$$put(\emptyset, f) = f$$

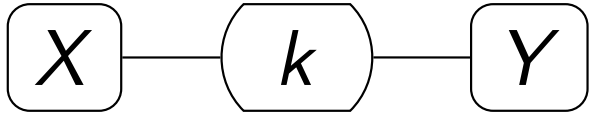
Synchronizing too often doesn't hurt.

Unsolvable updates

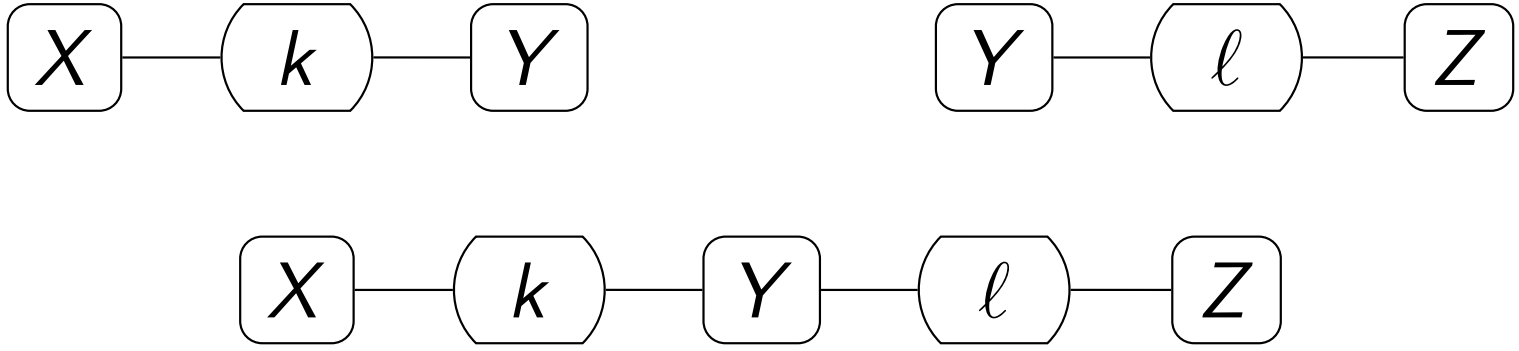
	Students	Equipment	Total
2012	70000	9000	79000
2013	70000	4000	74000
Total	0	0	1

Track sets of names that are always solvable.

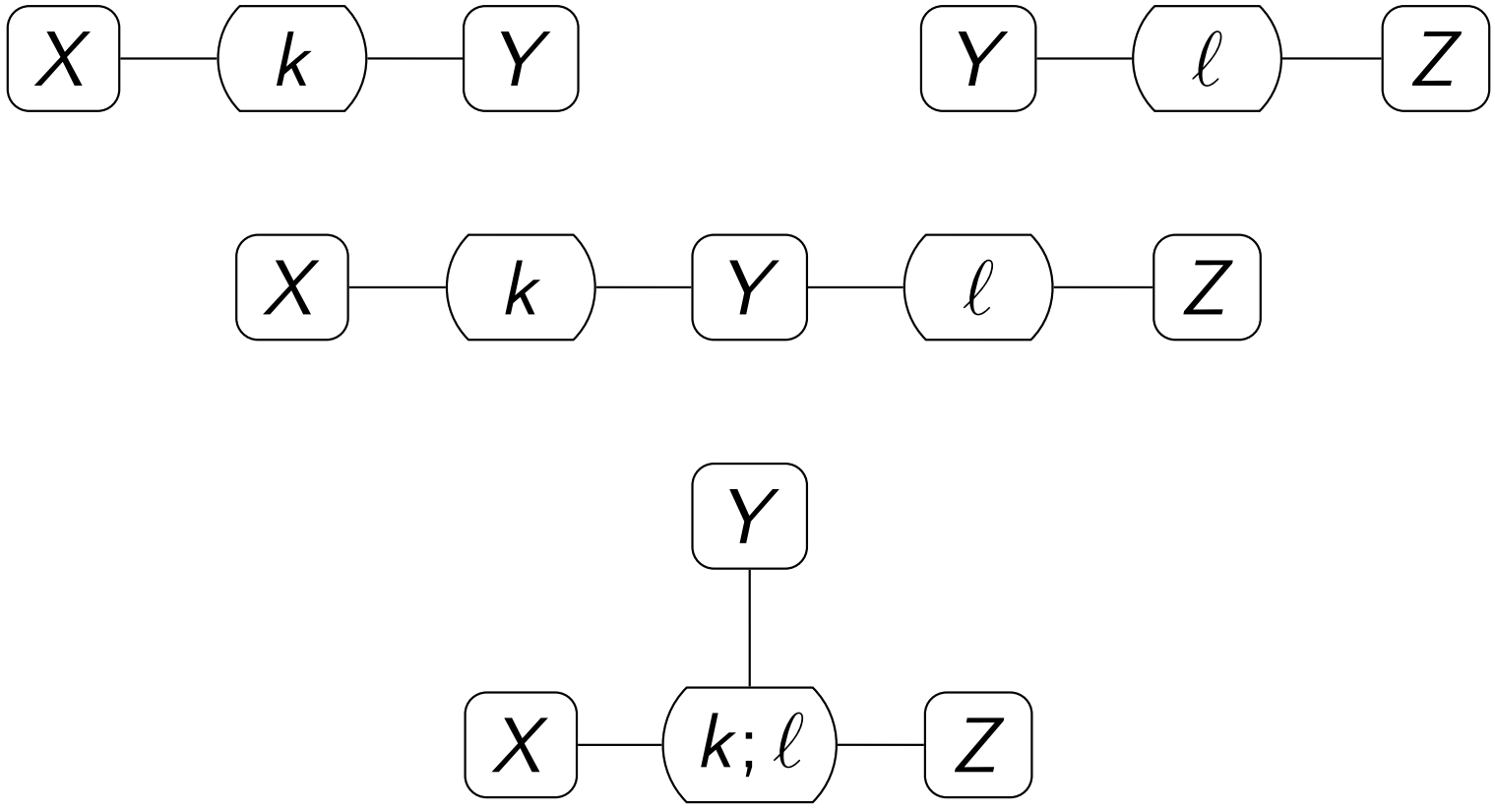
Composition intuition



Composition intuition

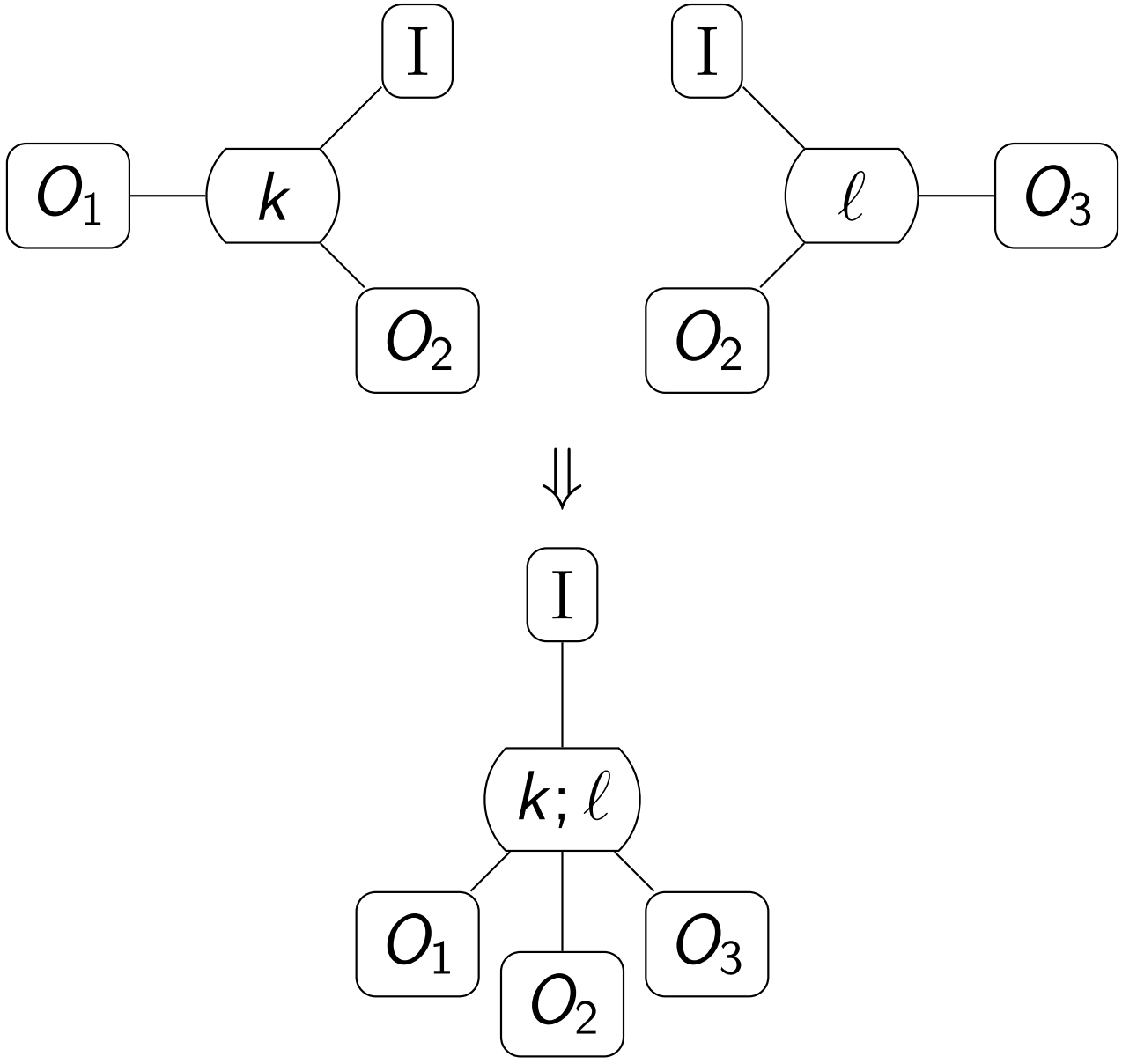


Composition intuition

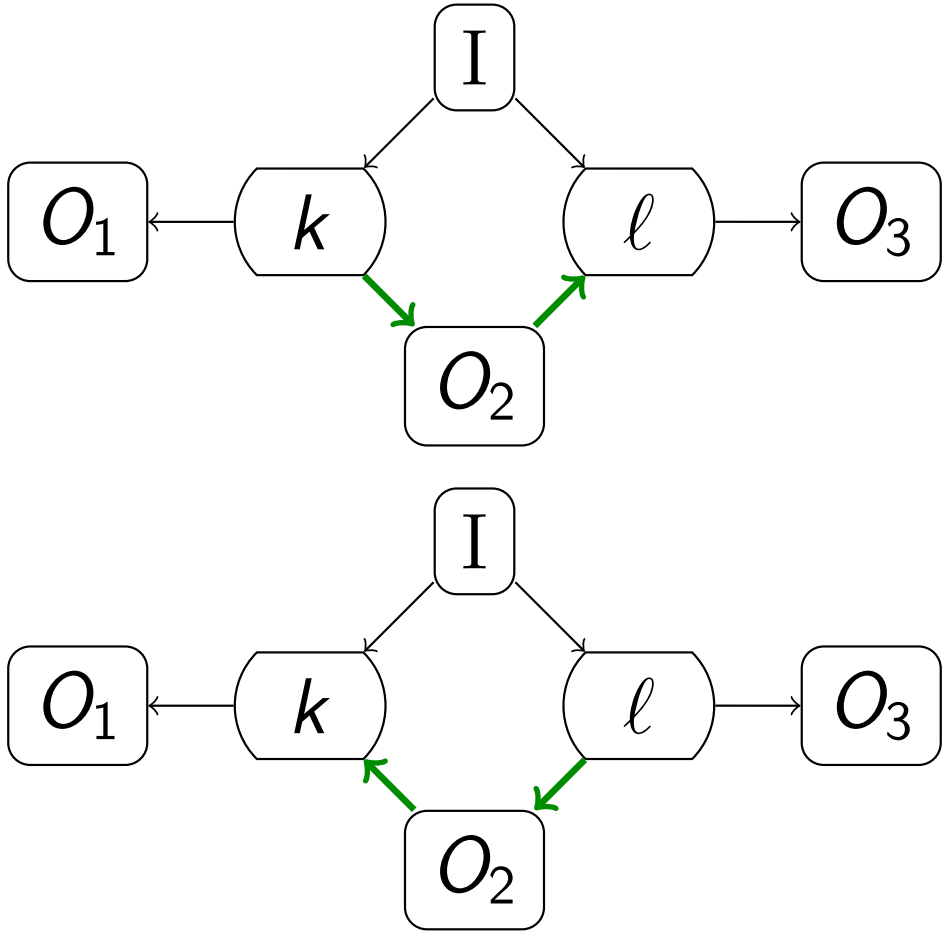


Safe updates: $\{X\}$ or $\{Z\}$.

Ambiguous updates



Two plans



Observational equivalence is no help.

Remaining questions

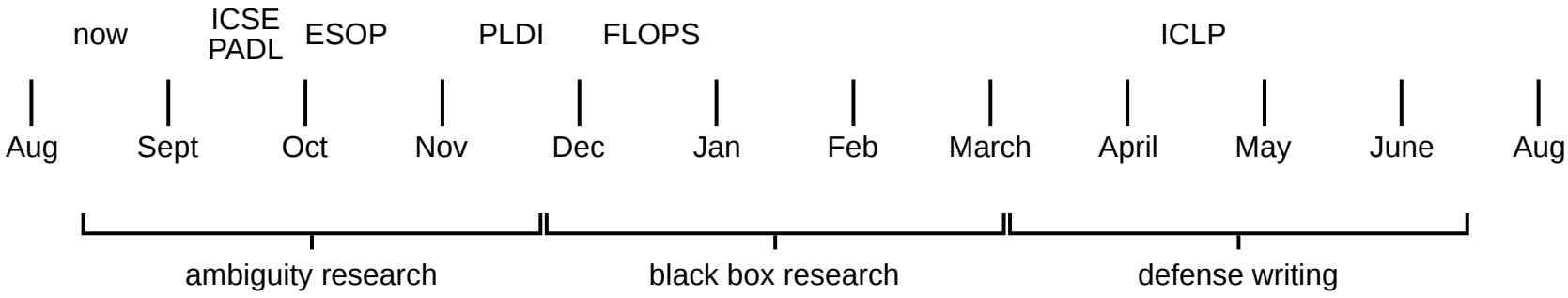
- Complete strategies for disambiguation?
- Behavioral specifications for disambiguation?
- How can we extend the static update check?
- What dynamic update checks are possible?

Related work: bidirectional spreadsheets

- Tiresias: The Database Oracle for How-To Queries
  (Meliou and Suciu; 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, Haveraaen, 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
  (Hyvőnen; AIAWS 1991)

Logistics

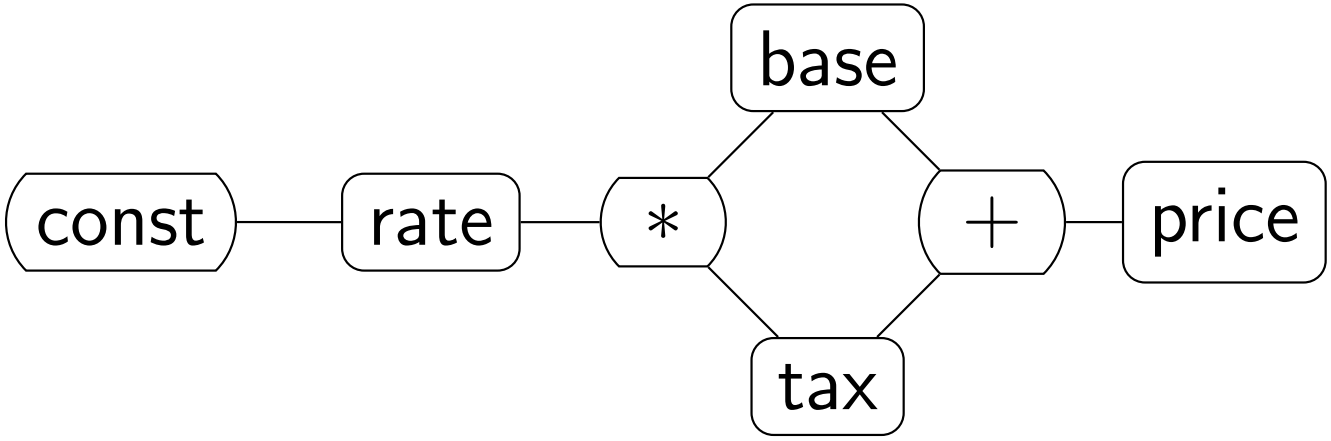
Timeline



- 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?

$$price = base + tax$$
$$tax = 0.08 * base$$



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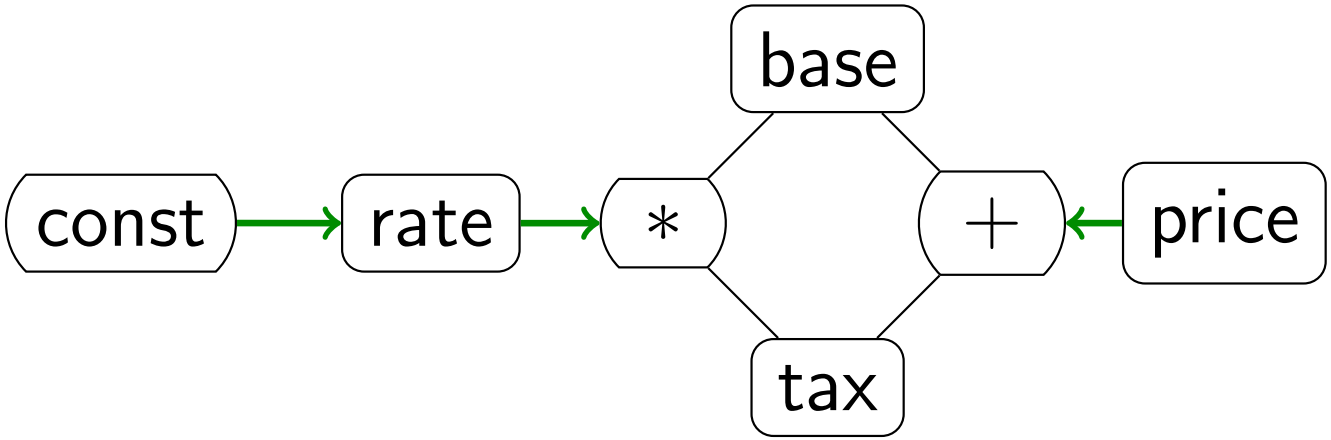

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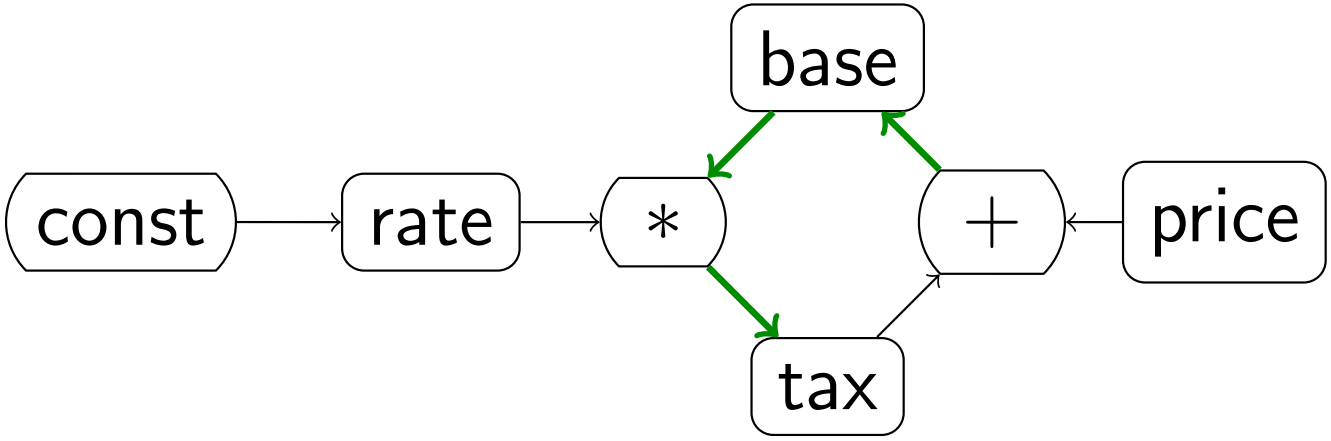

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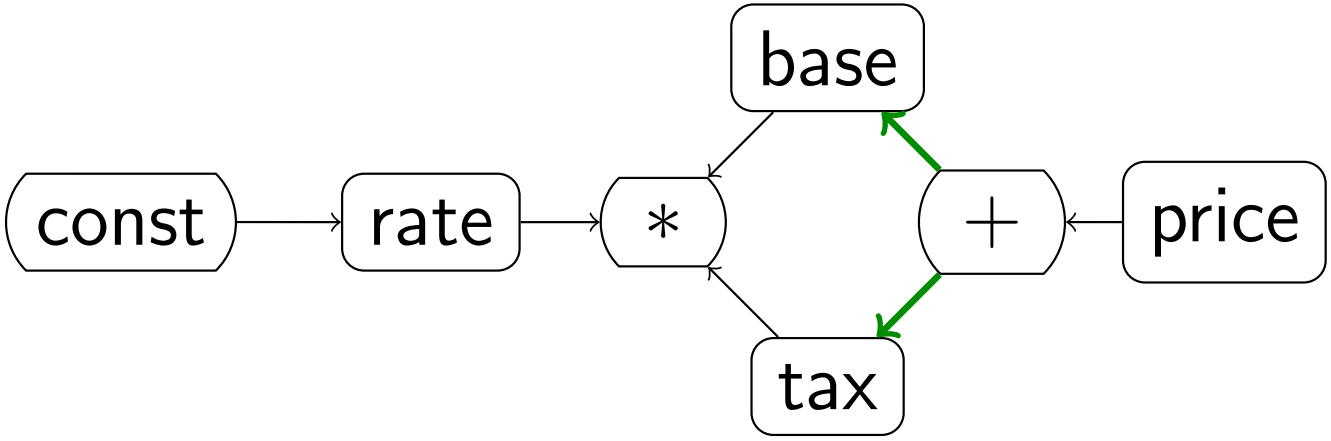
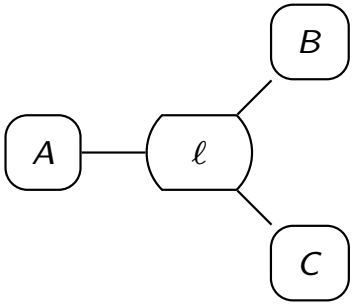
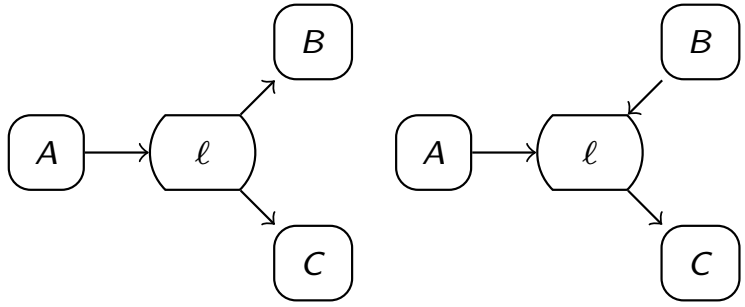


How to progress



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)