Relational Lenses as Libraries

Rudi Horn – Haskell Symposium 2020

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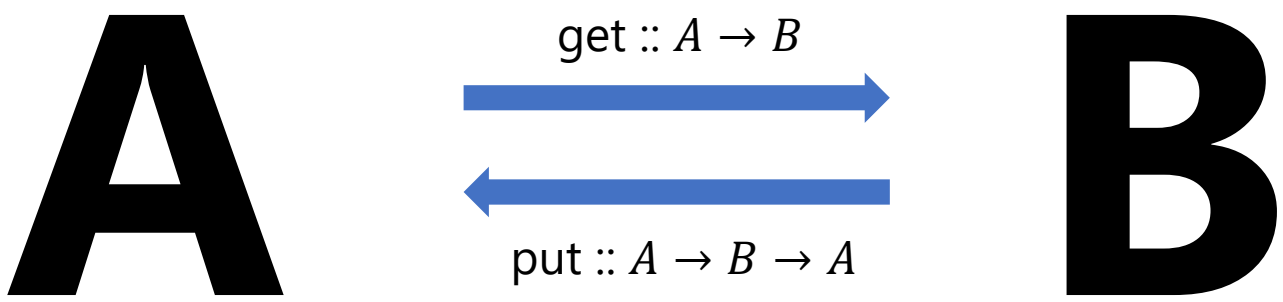
Lenses

A form of **bidirectional transformations** [1, 2]

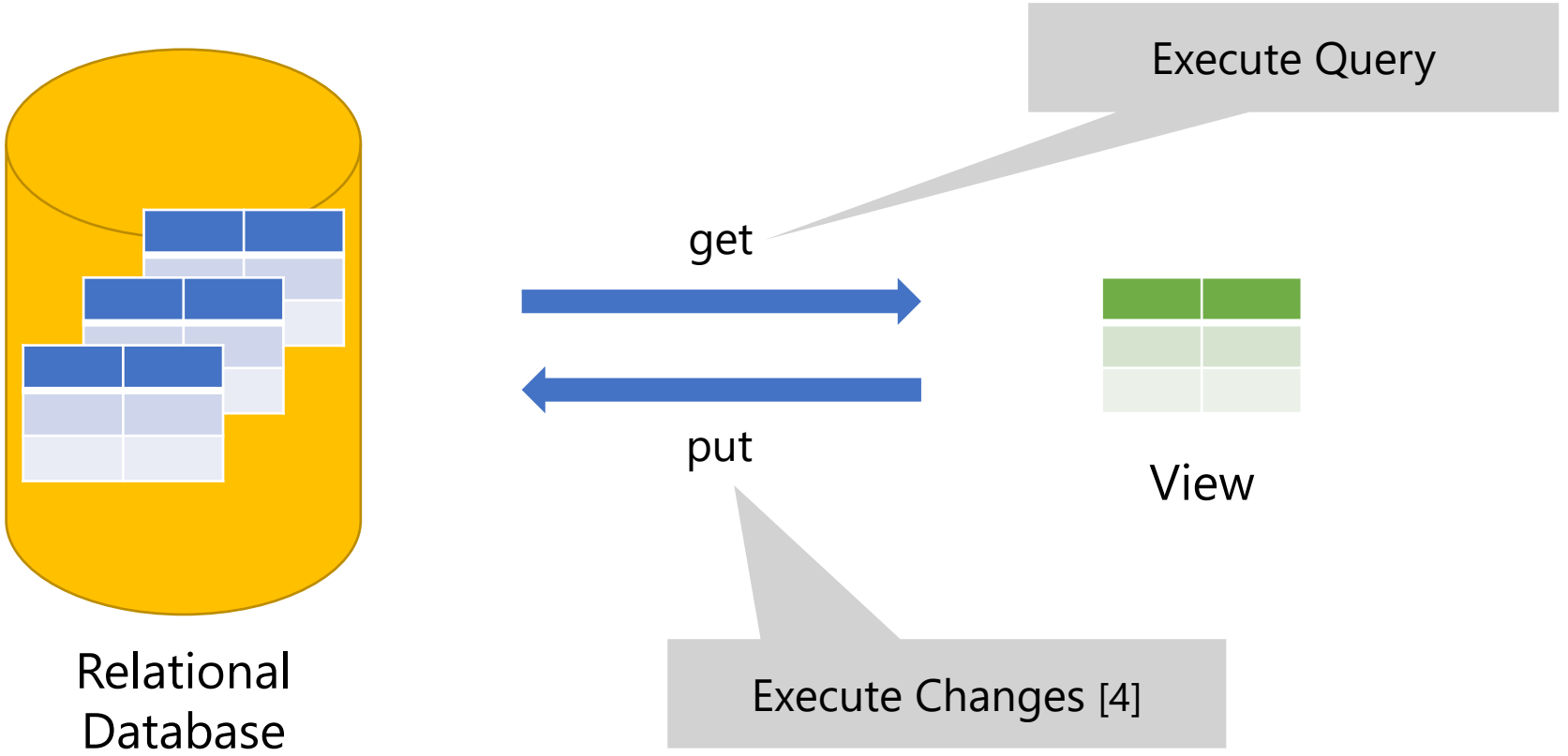


Example: Point { x :: Double; y :: Double }

get_x :: Point → Double
put_x :: Point → Double → Point

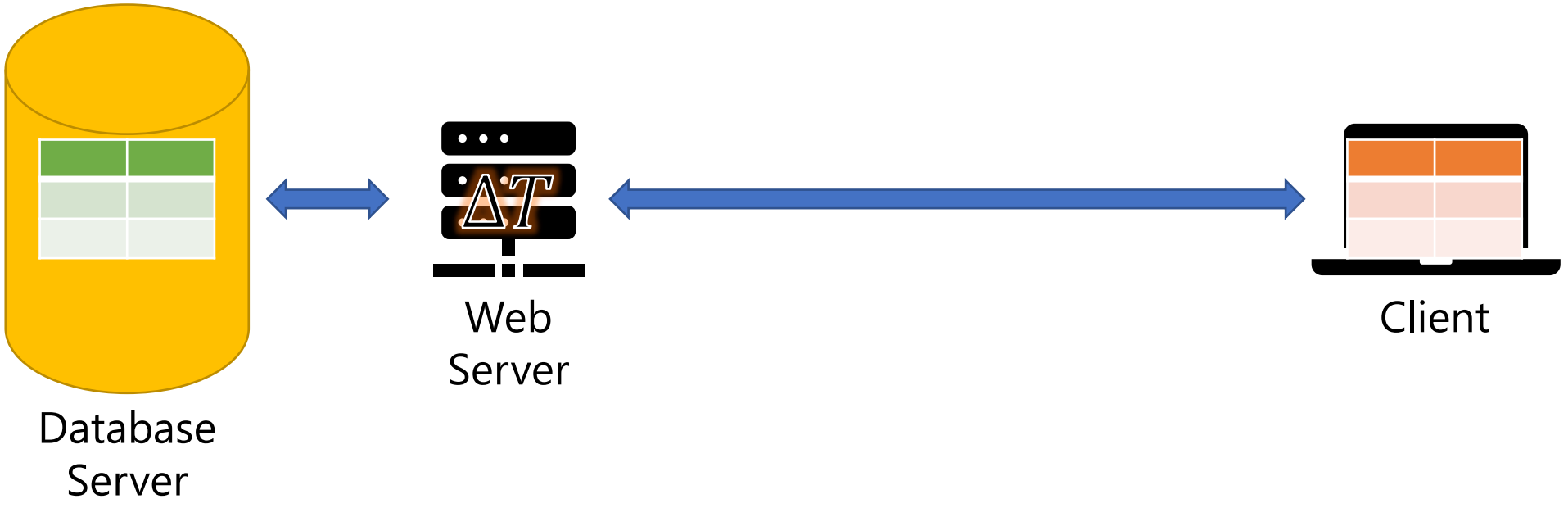
[1] Foster et al. "Combinators for bidirectional tree transformations: A linguistic approach to the view-update problem."
[2] Bohannon, Aaron, et al. "Boomerang: resourceful lenses for string data."

Relational Lenses [3]



[3] Bohannon, Pierce, and Vaughan. "Relational lenses: a language for updatable views."
[4] Horn, Perera, and Cheney. "Incremental relational lenses."

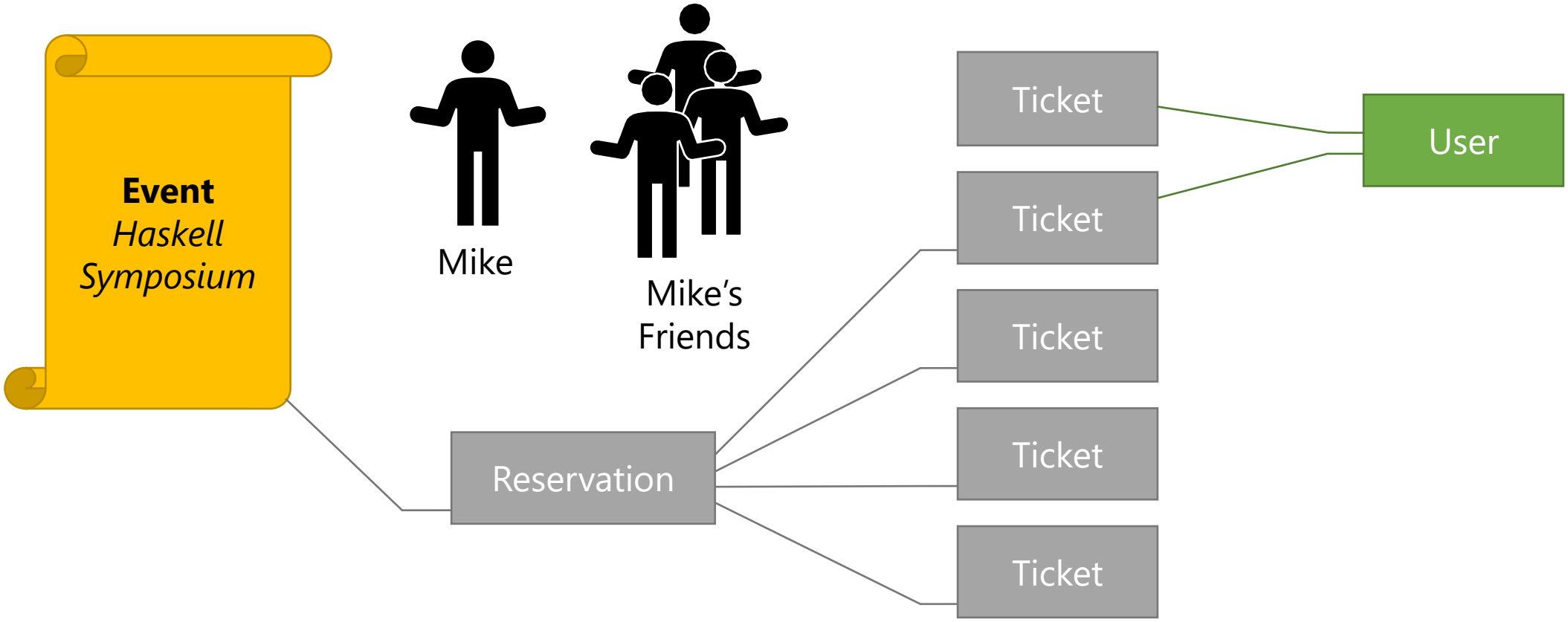
Relational Lenses



Typical Model-View-Controller workflow

Relational Lenses by Example

Lets build an event ticketing system!



Relational Lenses by Example

Lets build an event ticketing system!

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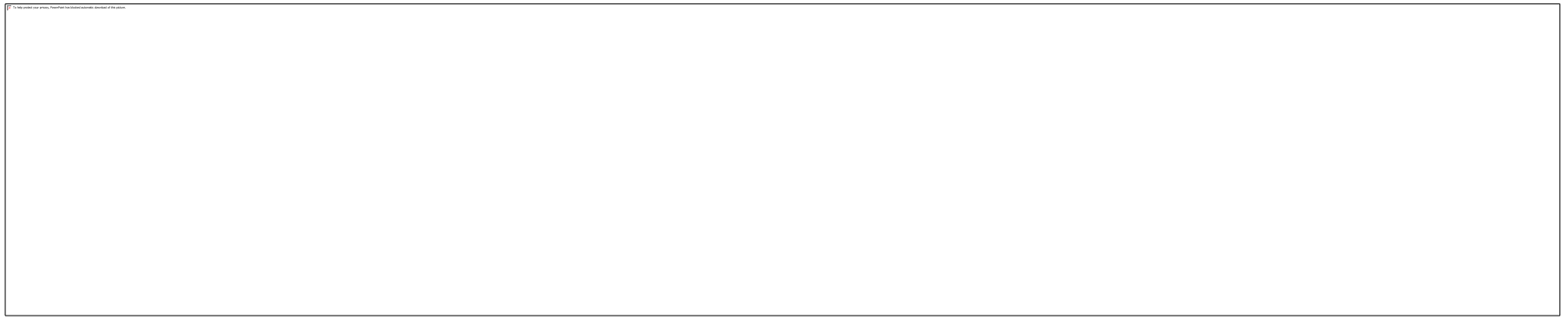


events

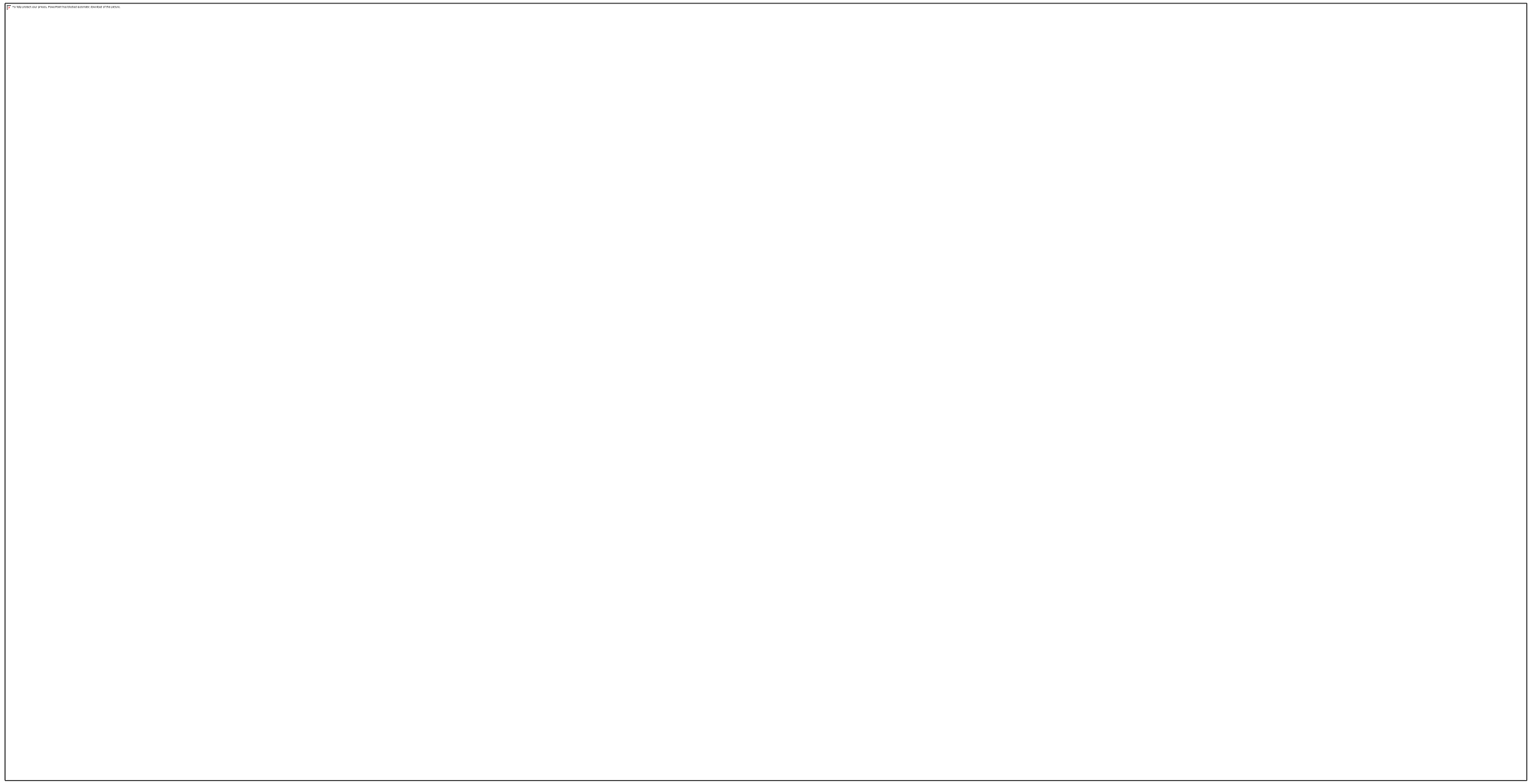
Relational Lenses by Example

events

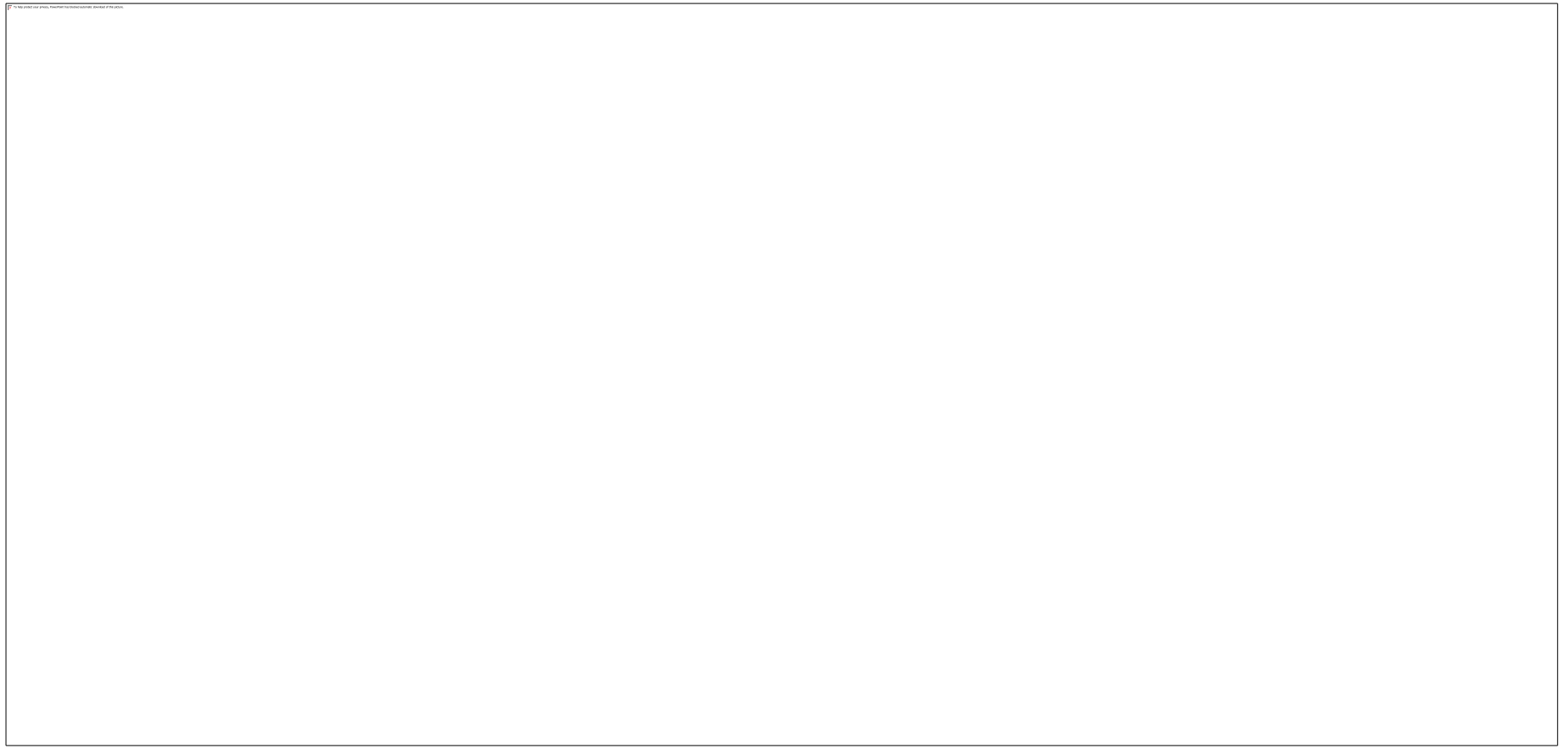
Relational Lenses by Example

reservations

Relational Lenses by Example



Relational Lenses by Example



Relational Lenses by Example

Correctness of Relational Lenses

Should be **well-behaved**

For bidirectional transformations:

- $get\big(put(a, b)\big) = b$
- $put\big(a, get(a)\big) = a$

Correctness of Relational Lenses

Linearity of Tables

Functional Dependencies
$\mathbf{X} \rightarrow \boldsymbol{Y}$

Correctness

Restrictions on Predicates

Consistency

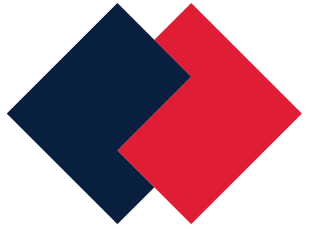
[3] Bohannon, Pierce, and Vaughan. "Relational lenses: a language for updatable views."
[5] Horn, Fowler, and Cheney. “Language-Integrated Updatable Views"

Existing Relational Lenses

Implemented in **Links**

- Extended compiler to support Relational Lenses
  - Implements **Incremental** Relational Lenses [4]
  - Demonstrates **language integration** in functional setting [5]
- Difficult to maintain
- Compatibility with other language features (e.g. continuation serialisation)

https://links-lang.org



Links

[4] Horn, Perera, and Cheney. "Incremental relational lenses."
[5] Horn, Fowler, and Cheney. “Language-Integrated Updatable Views"

Lenses as Library

Better approach: Implement feature as a **Library**

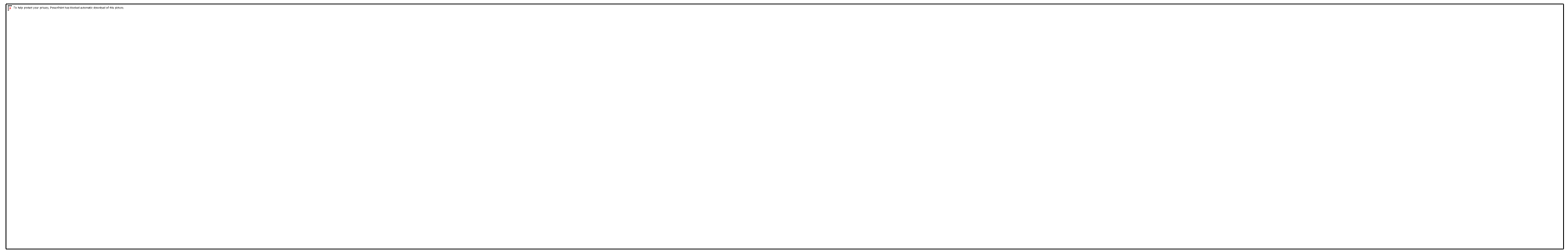
- How to verify correctness statically?
- Implement with reusable language features
- Cleaner abstractions for intended feature

➢Haskell type system sufficient for Relational Lenses

Type-level computation

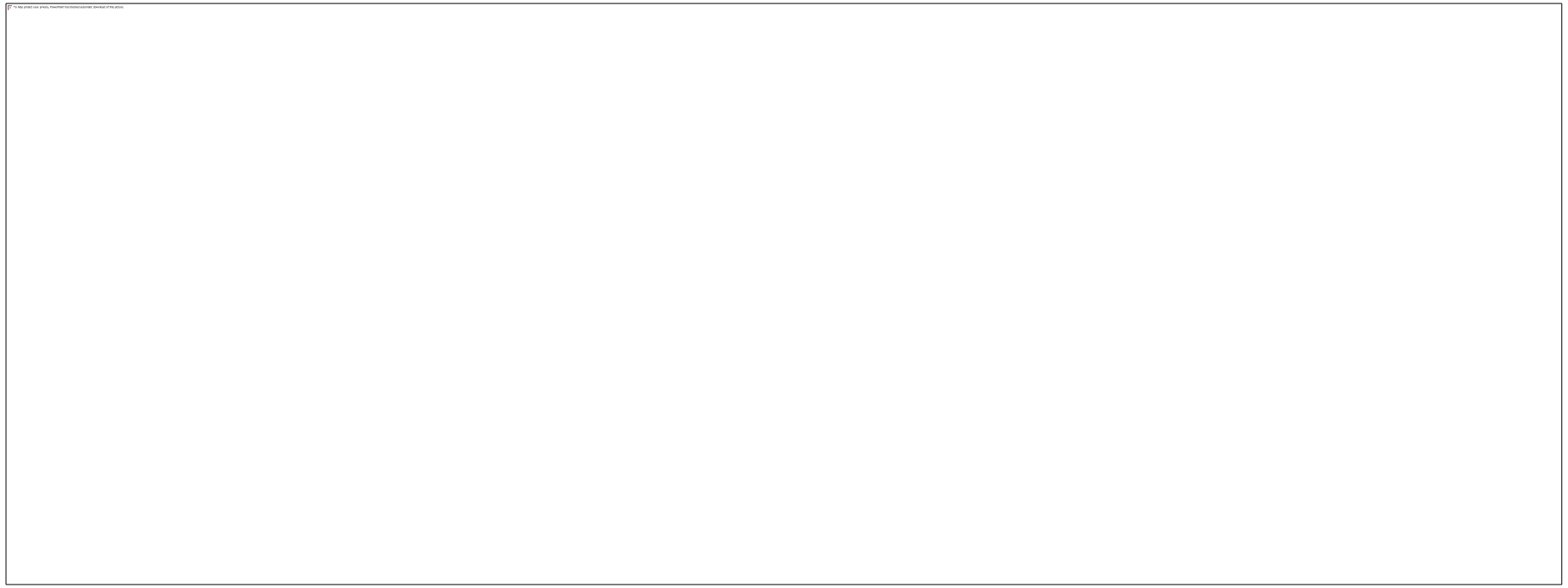
Type Level Programming

Type Literals



Type Families

Type Classes



Constraints

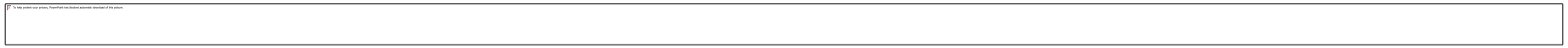
Equality Constraint
$\tau_1 \sim \tau_2$

Equality Constraint
`Recoverable a String`

Lens Building Blocks

Tables

User tries to construct lens:



uses same table twice!

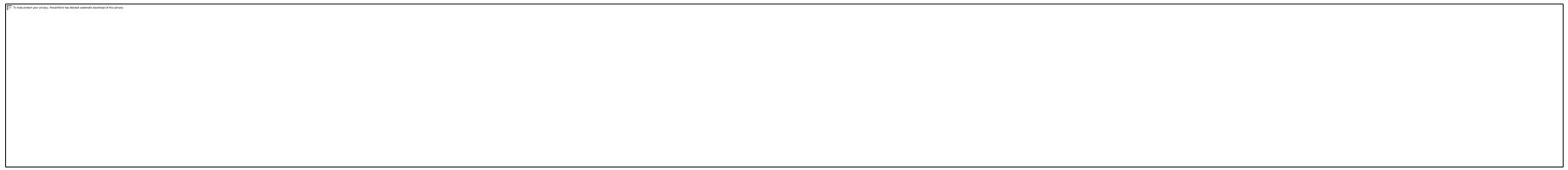
Need a constraint:

```
TablesDisjoint t1 t2 => ...
```

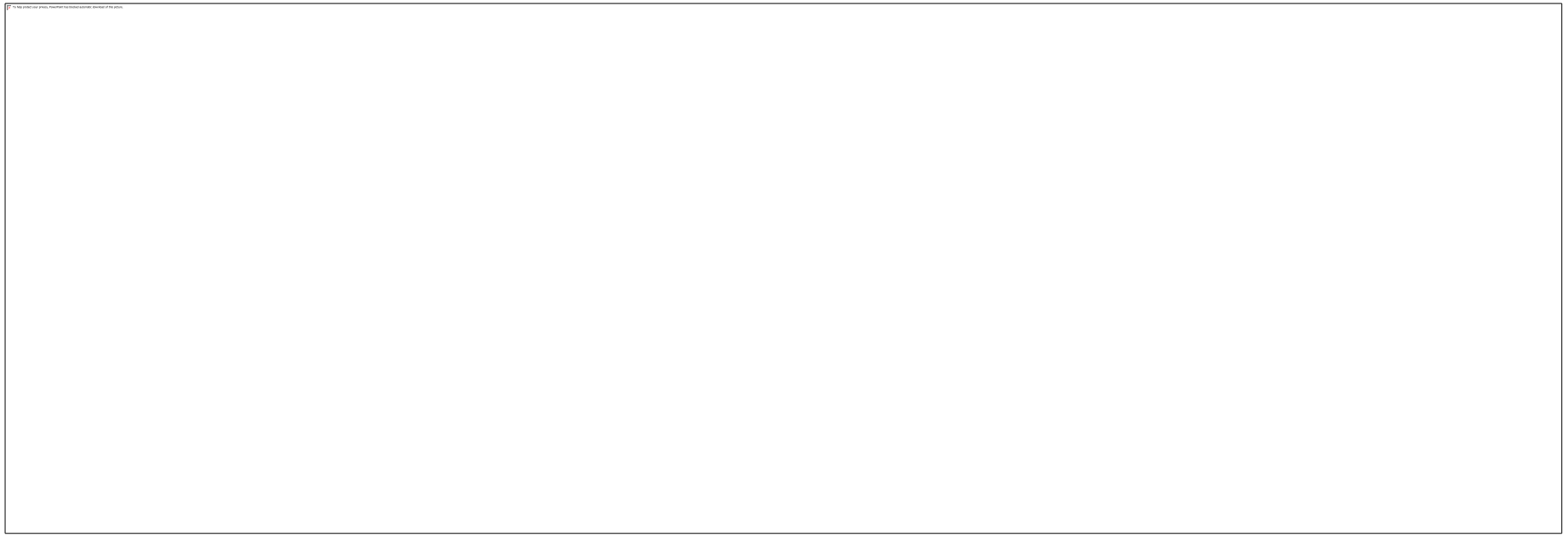
Tables

Record Types

Relational Lenses require representation for records / views

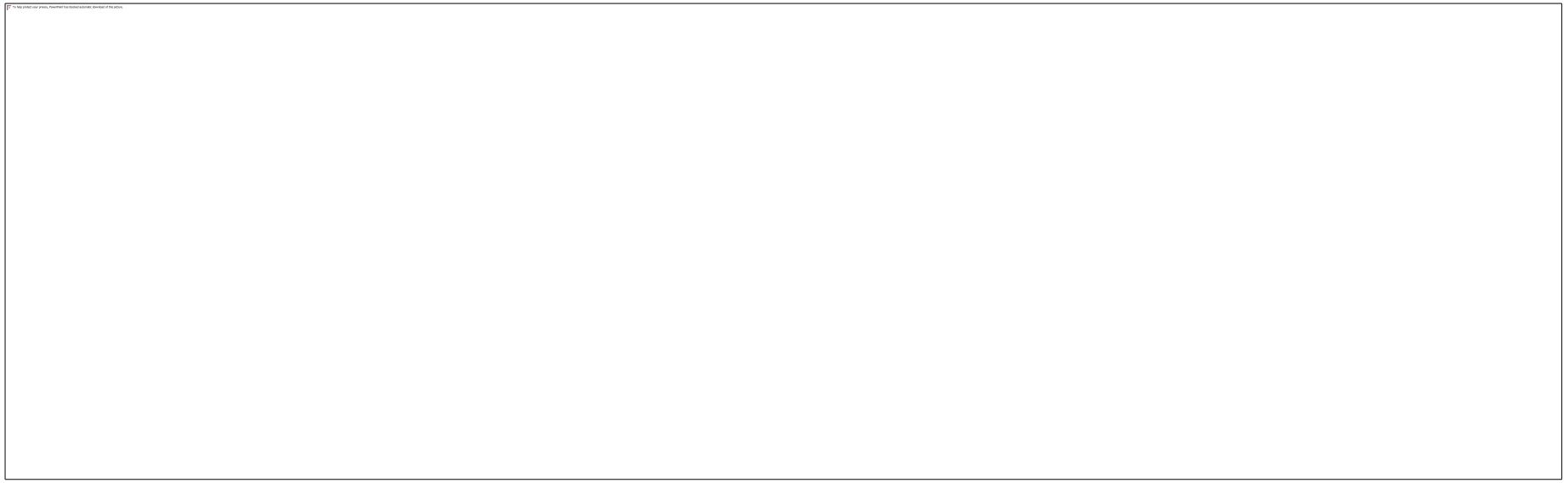


Record Types



Record Projection

Record Set

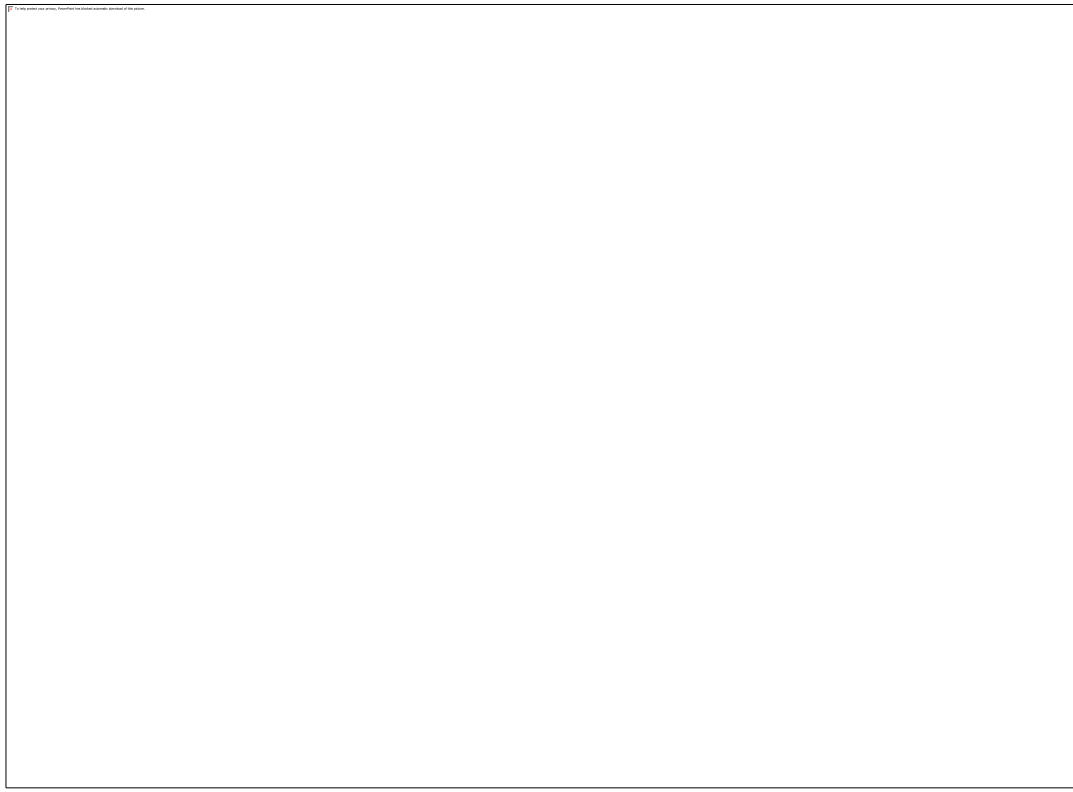


Functional Dependencies

Example: $email \rightarrow title, name$

Tree form:

Forrest with disjoint nodes



Functional Dependencies

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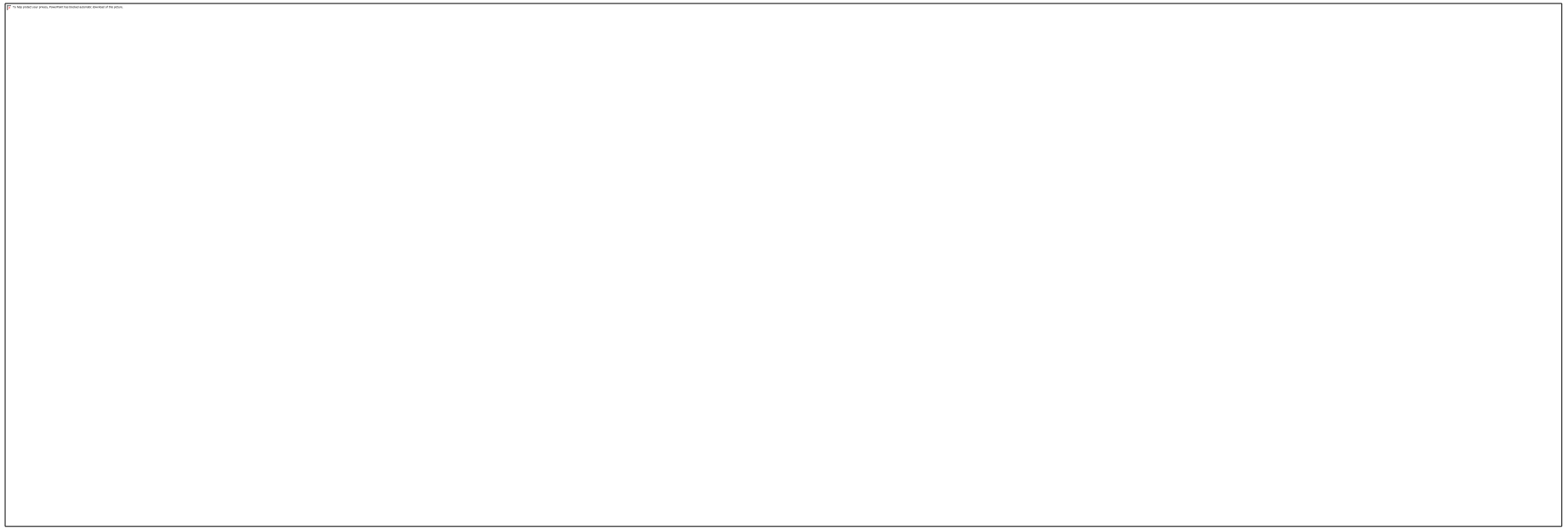
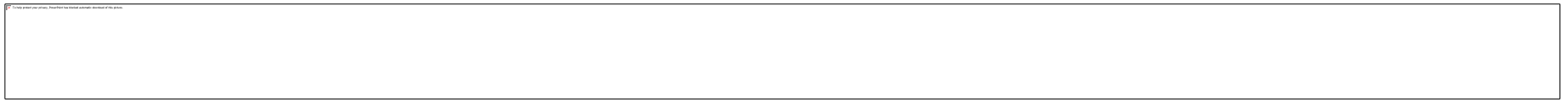


Predicates

Domain Specific Language (**DSL**) for predicates

- Predicate information retained in type
- Statically typable

Example for `test = 5`:



Predicates

Static predicates

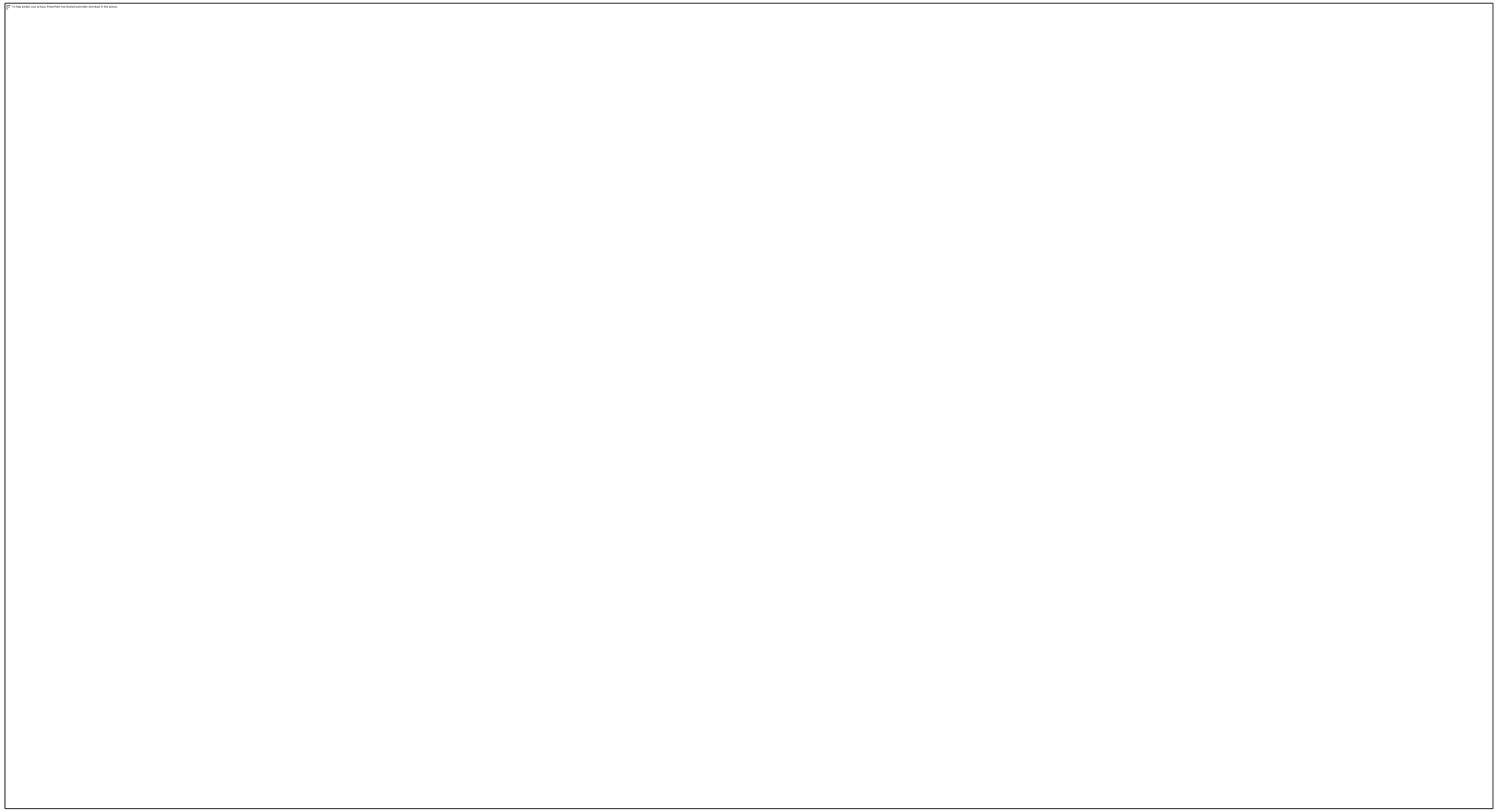
- not always flexible enough,
- however not always necessary!

Lens Constructors

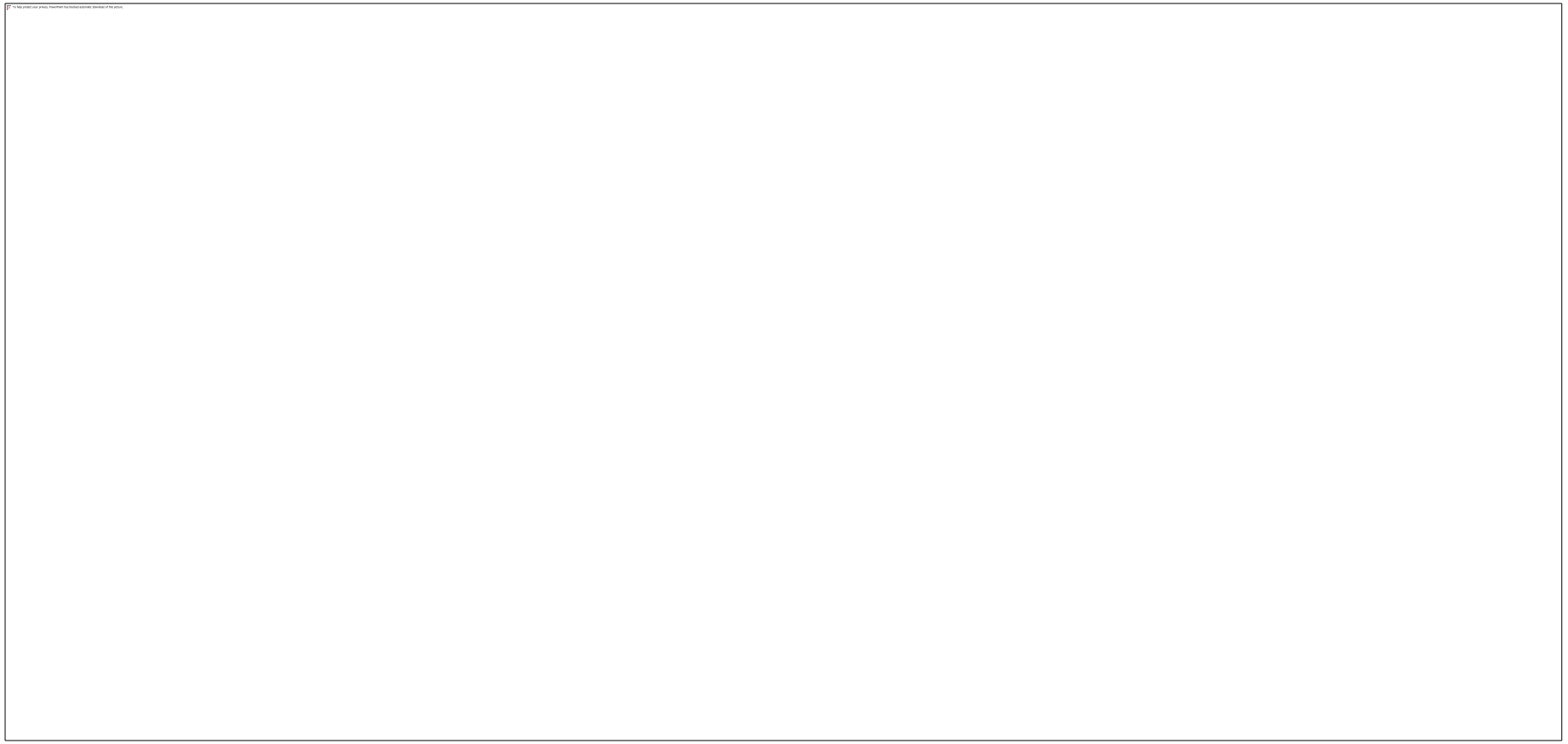
Lens Sorts

Refinement type for lenses

Table Primitive Lens



Select / Filter Lens



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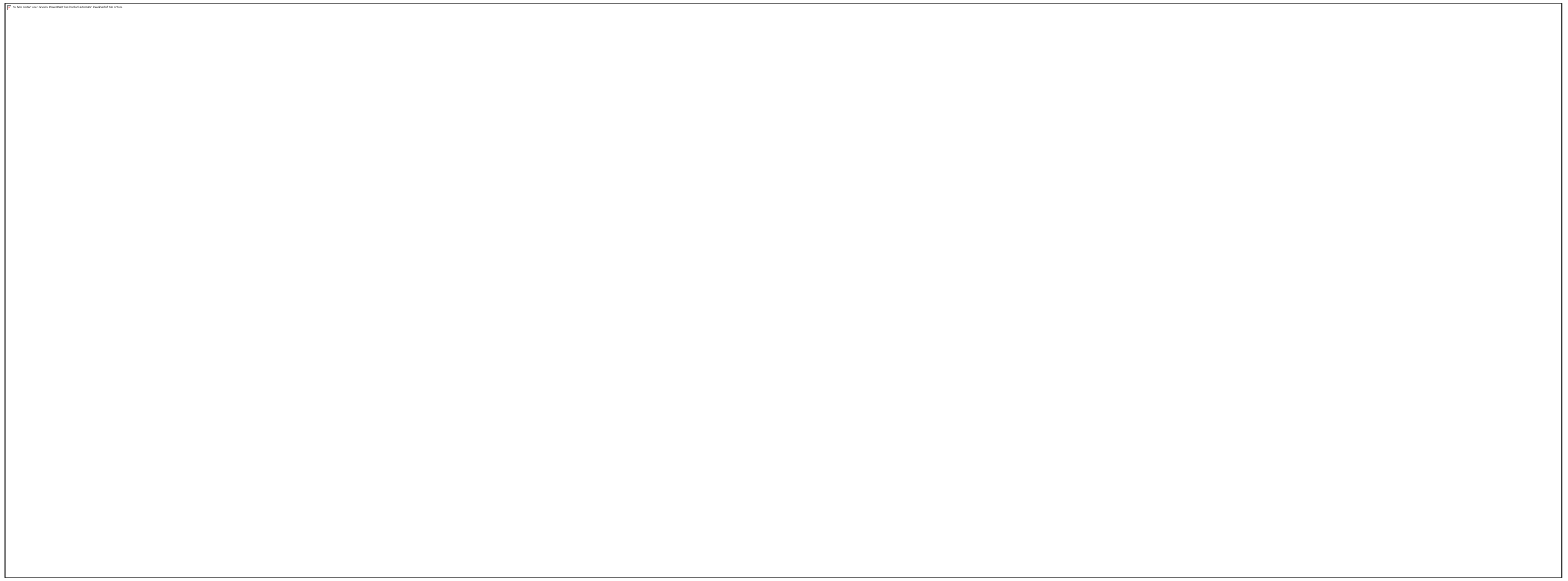
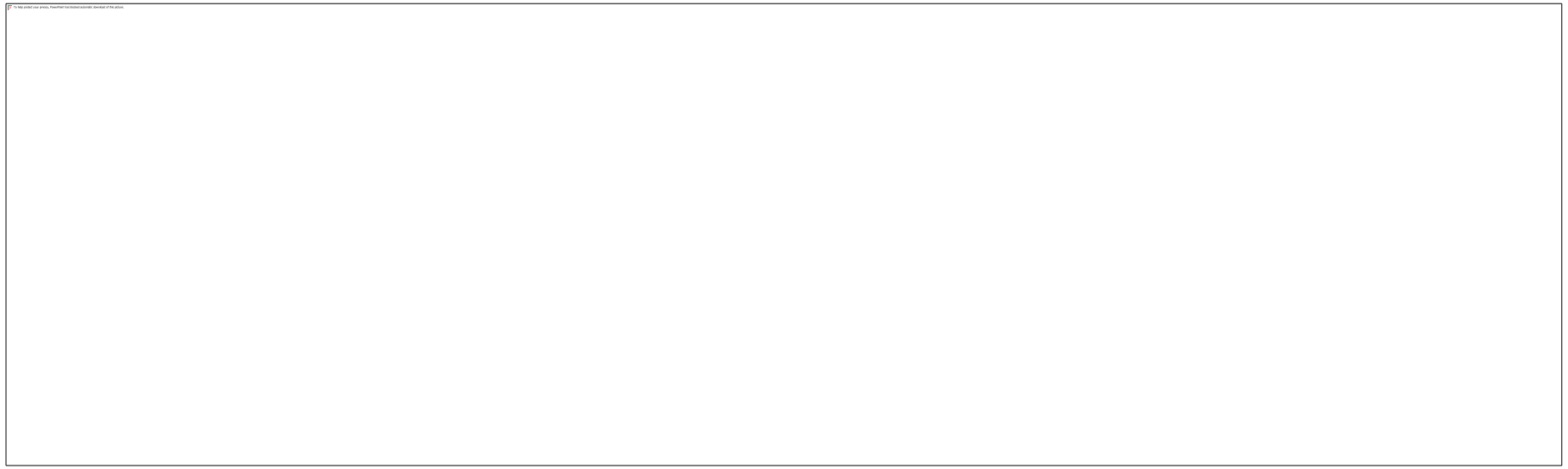


Further Lenses

Drop / Join lenses also supported:



Conclusion

Type-level Computation

No extensions to Haskell necessary!

Lots of similar work on row types:

- https://hackage.haskell.org/package/CTRex-0.6
- https://hackage.haskell.org/package/row-types

Also type level sets:
https://hackage.haskell.org/package/type-level-sets-0.8.0.0

Future Work

Better error handling:

Haskell supports: `TypeError msg`

Lots of large / messy constraints

- Tend to be unavoidable without fully dependent types
- Better abstractions?

Other database server support (shouldn’t be too difficult)

Serial column / auto incrementing column support

Results

- Haskell Lens Library
- Supports Incremental Relational Lens Semantics [4]
- Roughly ~3k of code
- Easy to use view-update for relational databases

[4] Horn, Rudi, Roly Perera, and James Cheney. "Incremental relational lenses."

Questions?