Provenance for Interactive Visualizations

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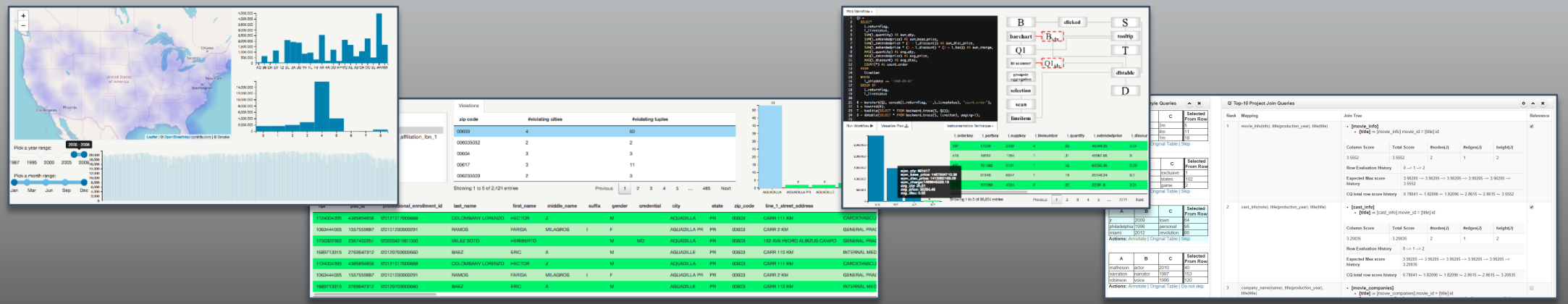

Provenance Primer

Fine-Grained Provenance

(Connections between input and output tuples)

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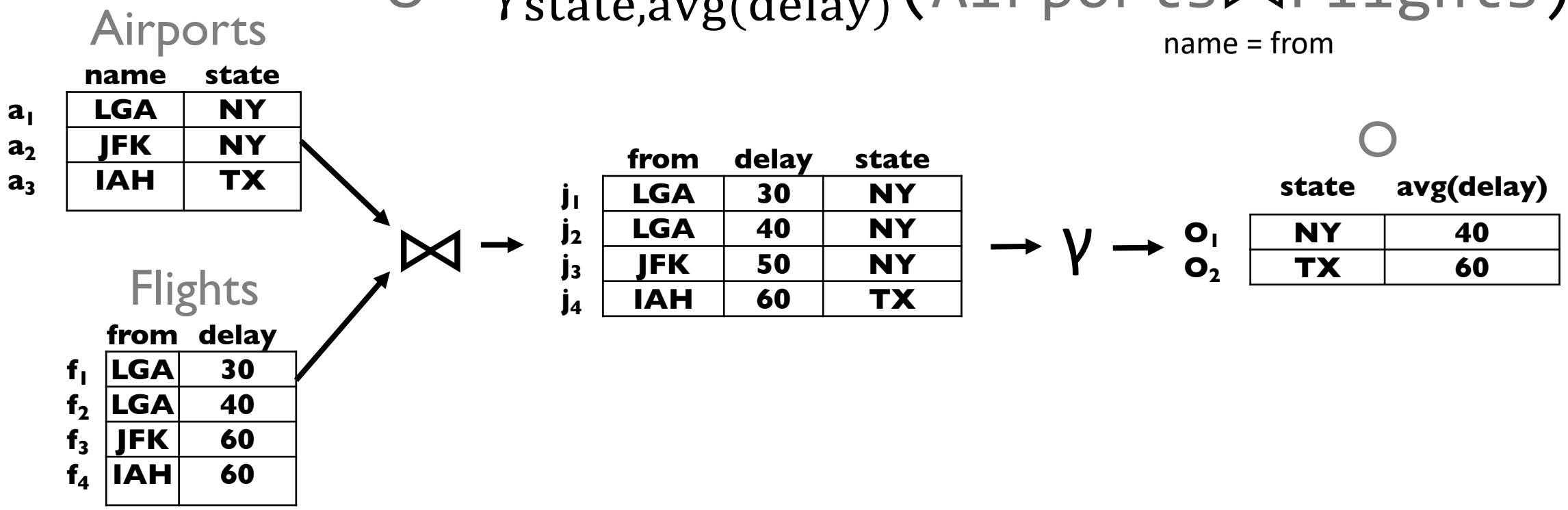
$$O = \gamma_{state,avg(delay)}(Airports \bowtie Flights)$$

name = from



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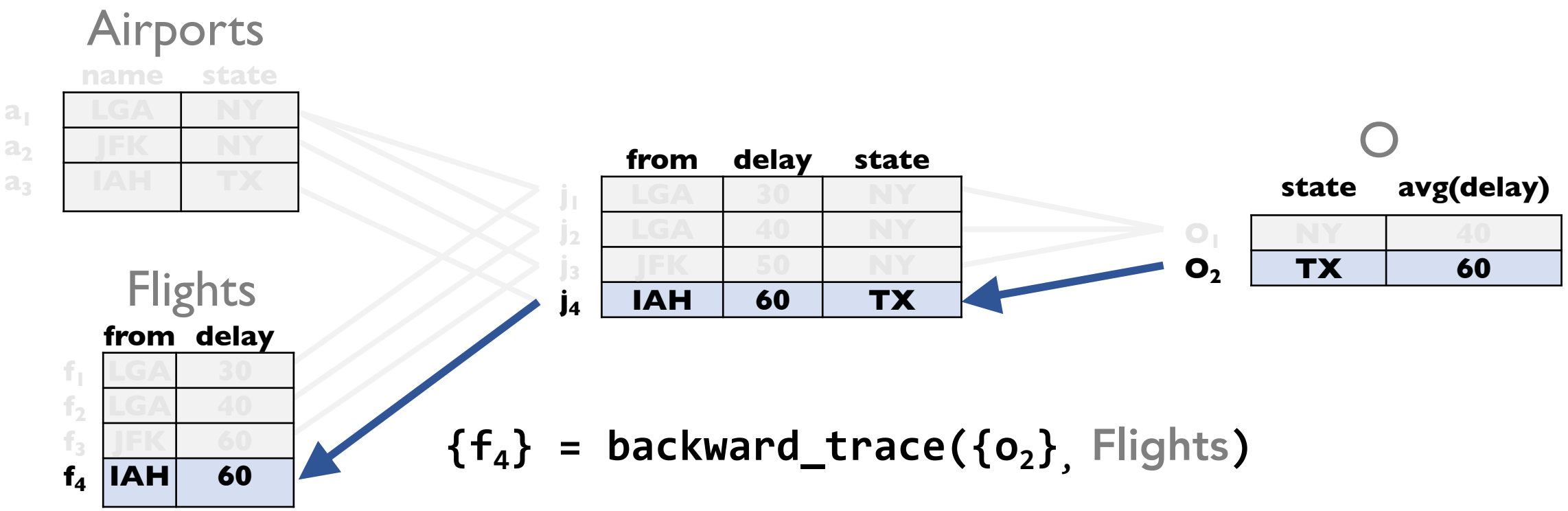

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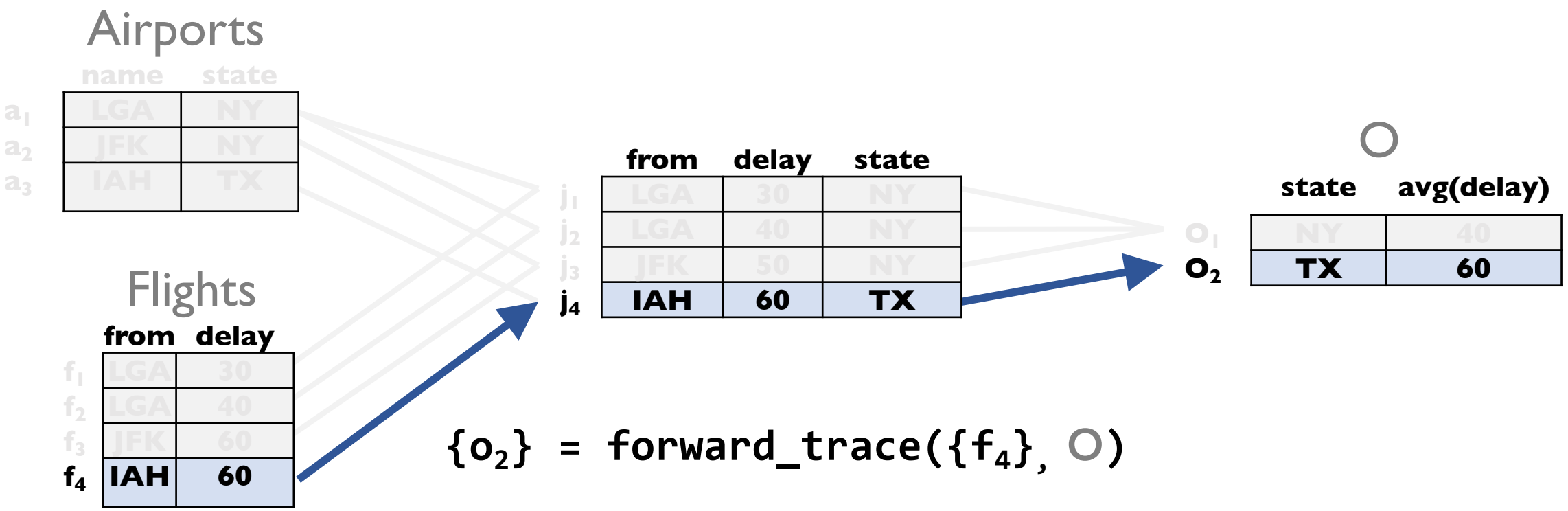

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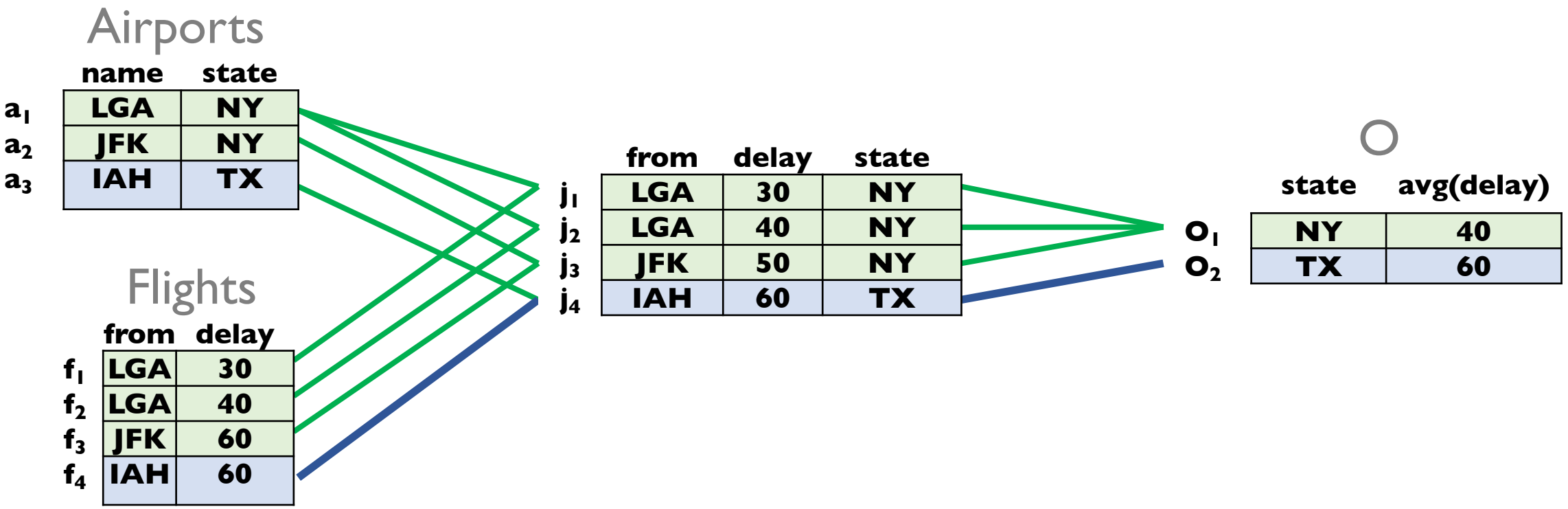


Provenance Primer

Fine-Grained Provenance

(Connections between input and output tuples)

- Navigation of the input-output connections
  - {records} = backward_trace(…)
  - {records} = forward_trace(…)
- Provenance consuming queries
  - SQL(backward_trace(…))
  - SQL(forward_trace(…))

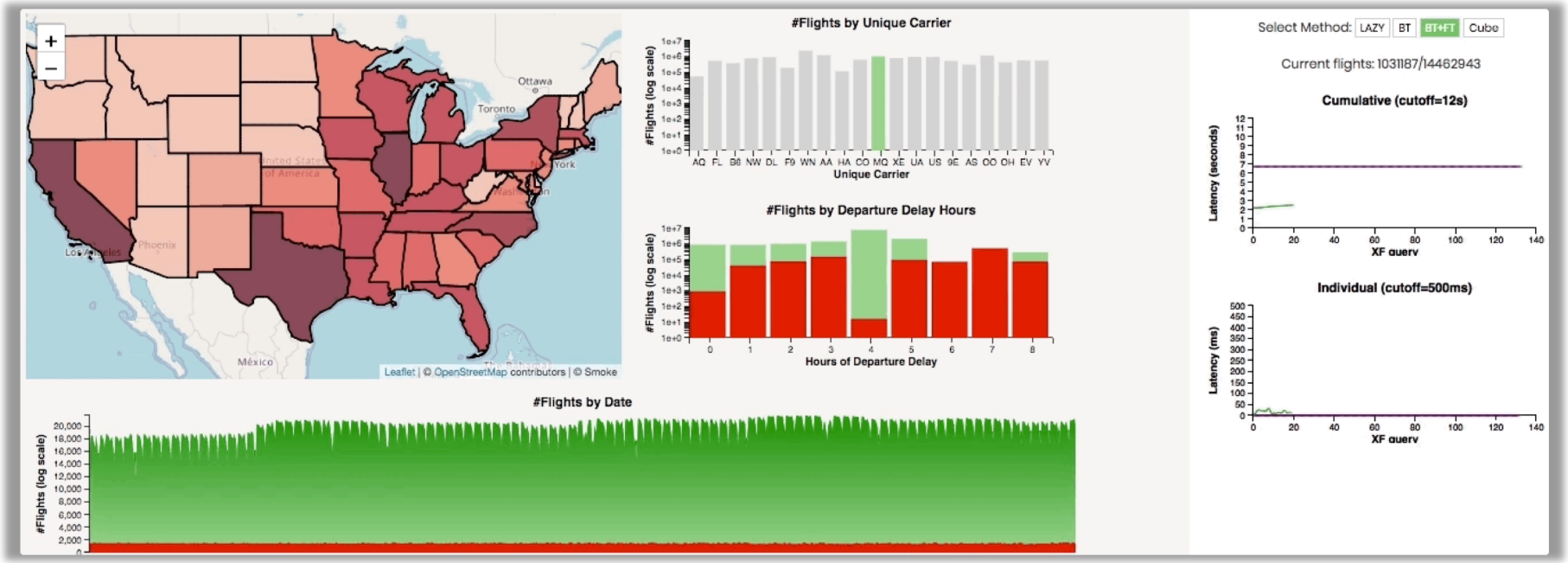
Goal of this talk

How to use fine-grained provenance
to express core interactive application functionality

Why though?

- ❑ **(Expressivity)** Logic over provenance is expressed declaratively
- ❑ **(Performance)** Provenance management systems are becoming ***fast***

See [Smoke, VLDB18] or pass by our demo on Wednesday/Thursday



Connections

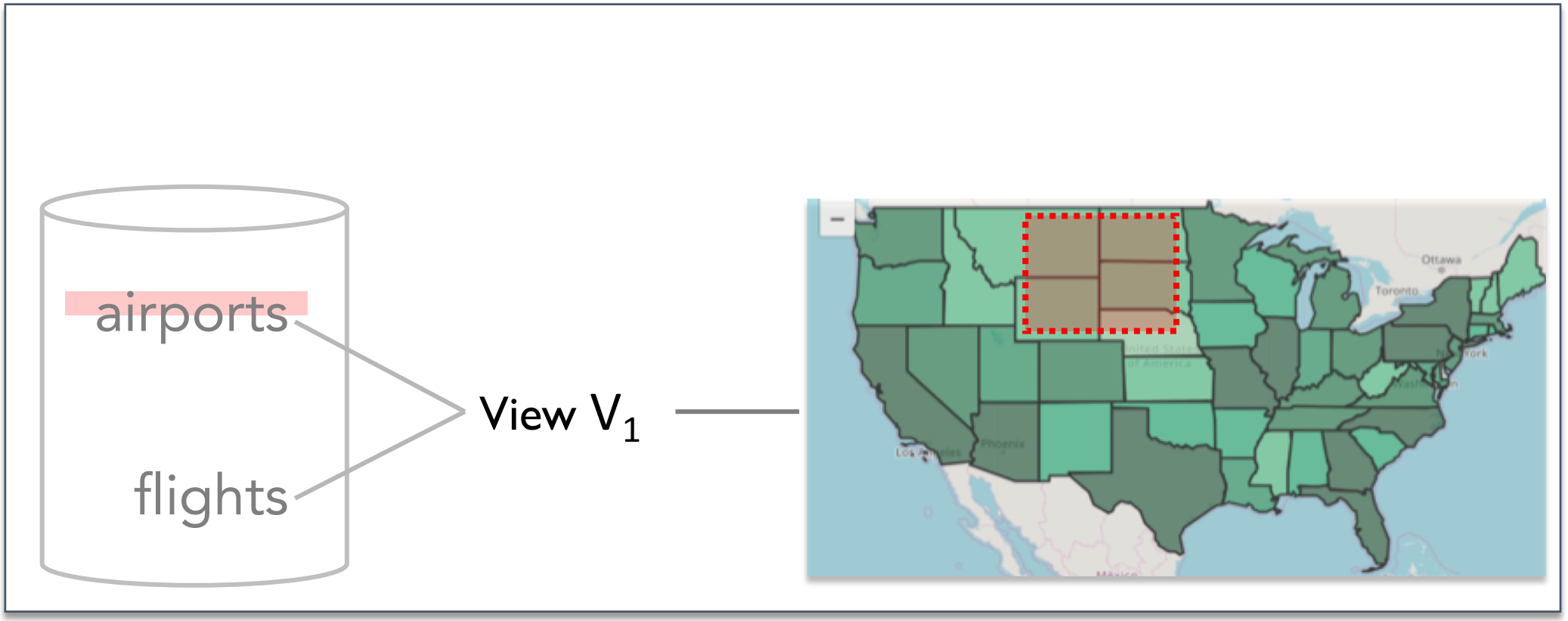
Core interaction logic with provenance

- Selections
- Logic over selections
- Multi-view linking

Interactive Selections

Goal: Get subset of inputs that correspond to selected visual outputs

Example: Find the airports that operate at the selected states



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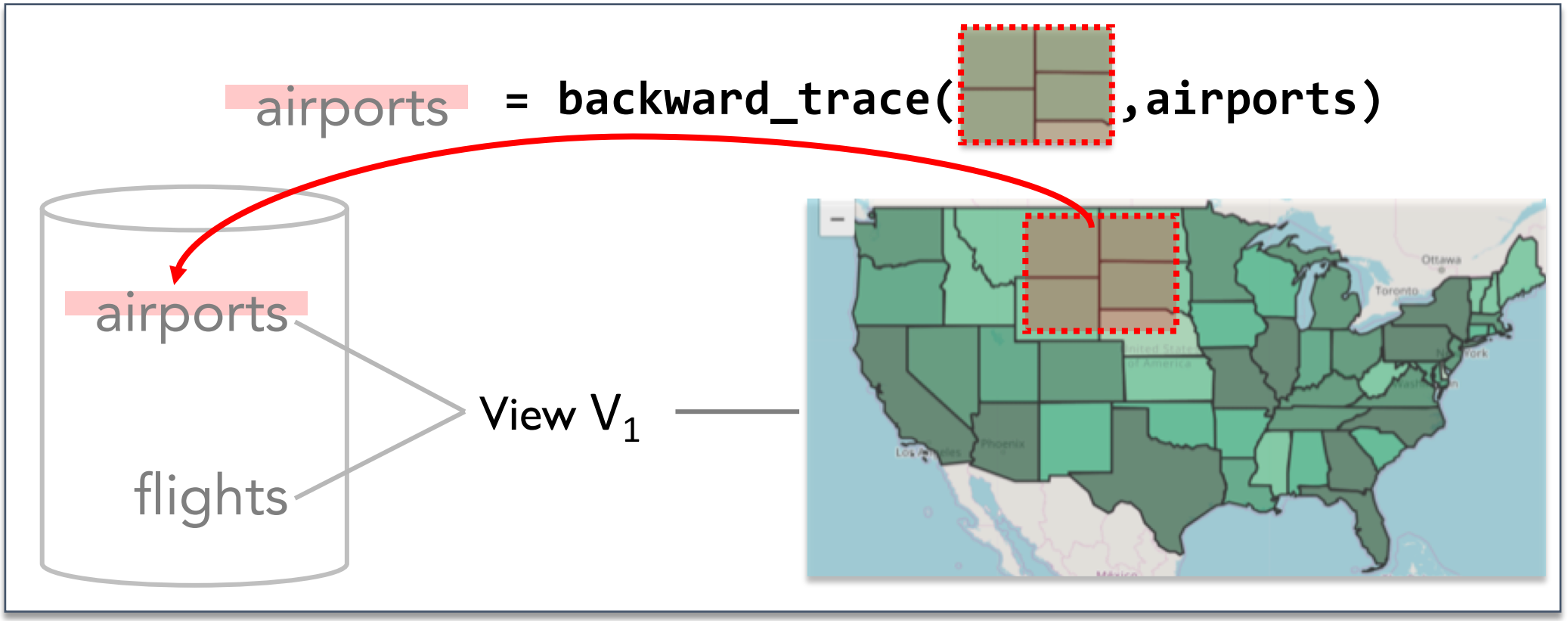
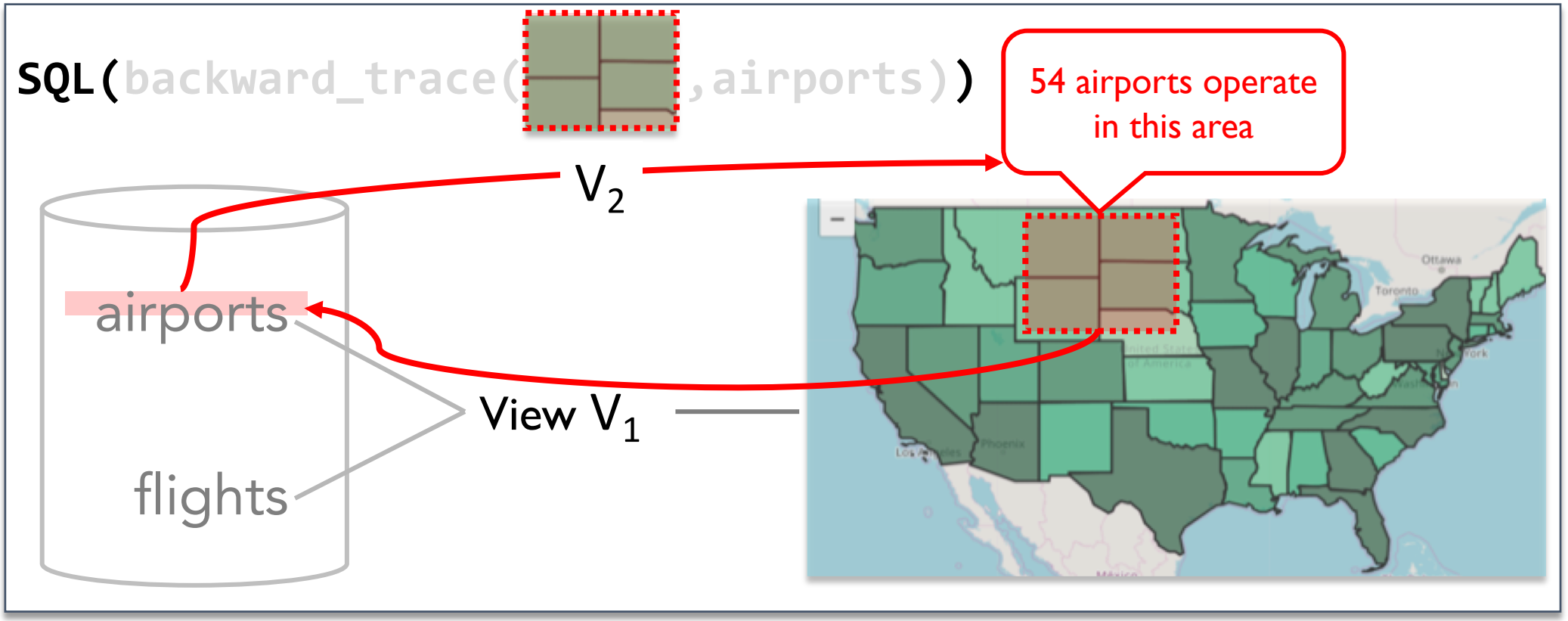


Logic over Selections

Goal: Express application logic over the selected inputs

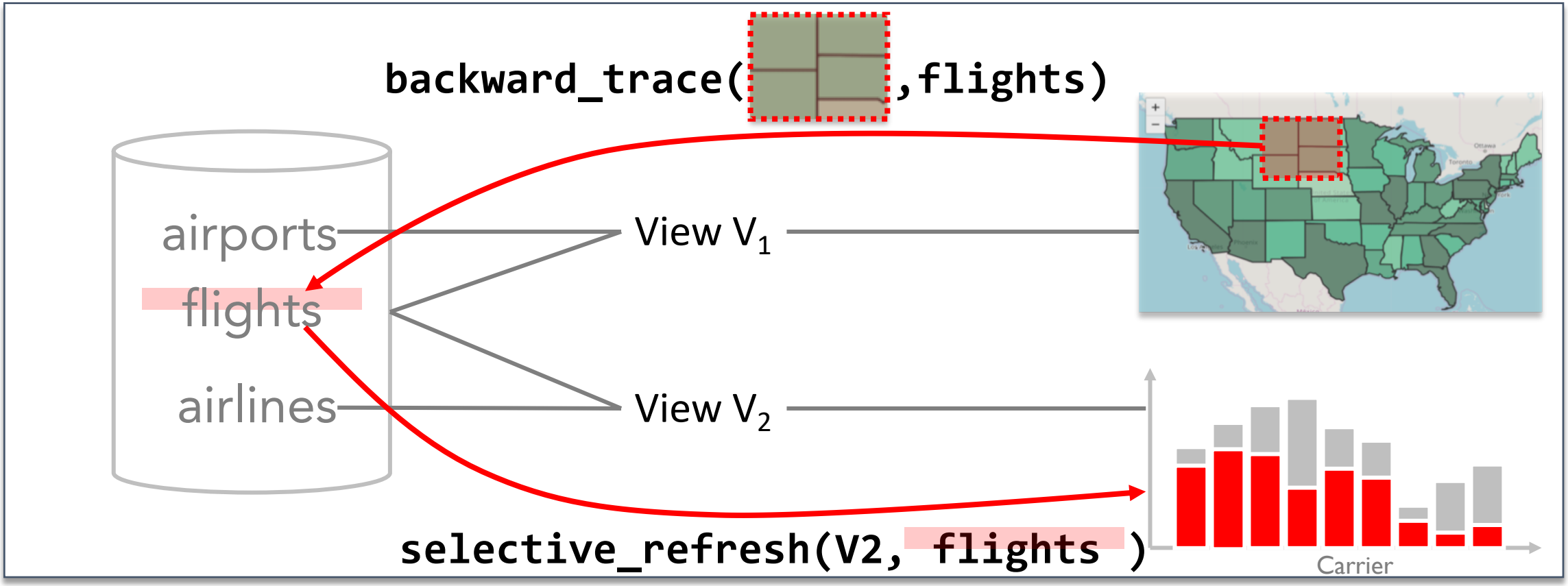
Example: Find the #airports that operate at the selected states



Multi-View linking

Goal: Look at the relationships between different views

Example: Show the distribution of #flights per carrier only for selected states



Provenance for Interactive Visualizations

Interactive Selections
- Item selection
- **Group selection**
- Range selection
- Generalized selections

} `backward_trace(…)`

Logic over Selections
- **Tooltips**
- Details-On-Demand
- Semantic Zooming

} `SQL(backward_trace(…))`

Multi-View Linking
- Linked Brushing
- **Crossfilter**

} `selective_refresh(backward_trace(…))`

What next?

Traditionally provenance systems have been at the core of several applications

Data Integration	Debugging	Network Diagnostics	Resource Scheduling	Auditing	…

Interactive Visualizations	Interactive Data Profiling	Multi-Application Linking	Interactive Query Specification	What-if Provisioning	
Query Explanations	Why-not Analytics	Iterative Analytics	Viz Workflow Debugging	Interactive Data Cleaning	…
Interaction Debugging	ML Interpretability	Visualization Deconstruction and Restyling	Interaction By Example	Application Design Search	
Collaborative Communication	Action Recovery	Sense-Making	Meta-Analysis	Replication and Reproducibility	

What next?

Traditionally provenance systems have been at the core of several applications

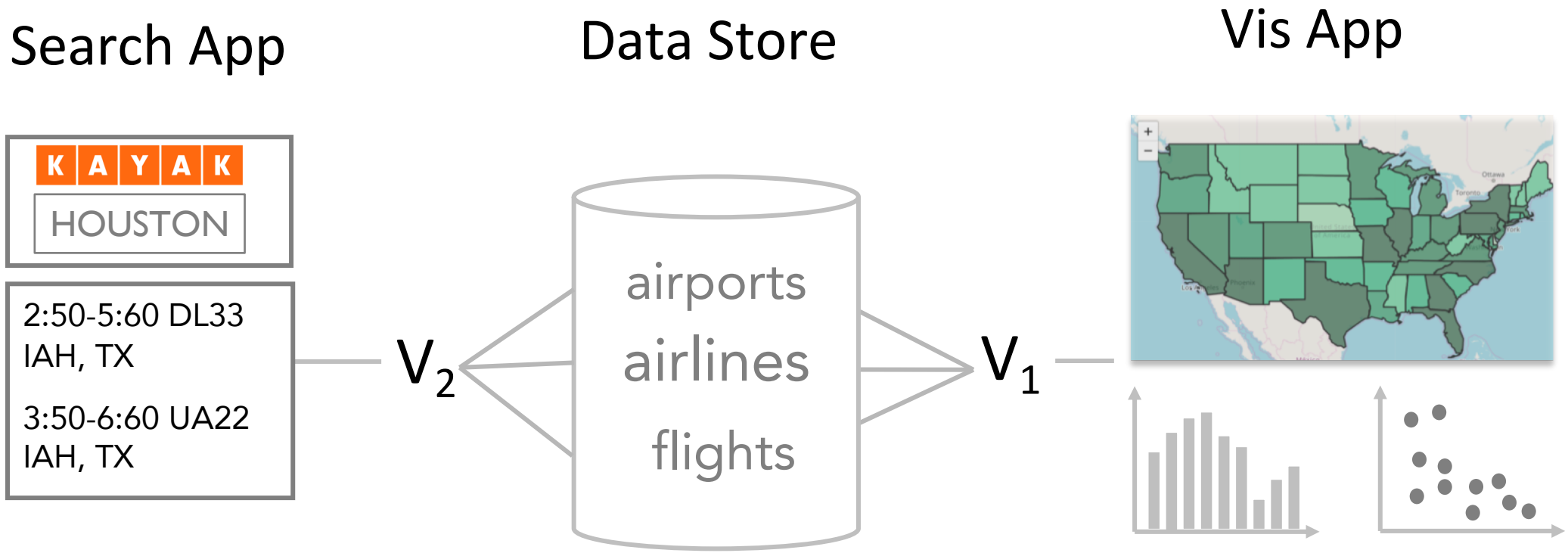
- Data Integration
- Debugging
- Network Diagnostics
- Resource Scheduling
- Auditing
- …

(Fast) Provenance management systems can make a difference on several other domains

- Interactive Visualizations
- Interactive Data Profiling
- Multi-Application Linking
- Interactive Query Specification
- What-if Provisioning
- Query Explanations
- Why-not Analytics
- Iterative Analytics
- Viz Workflow Debugging
- Interactive Data Cleaning
- Interaction Debugging
- ML Interpretability
- Visualization Deconstruction and Restyling
- Interaction By Example
- Application Design Search
- …
- Collaborative Communication
- Action Recovery
- Sense-Making
- Meta-Analysis
- Replication and Reproducibility

Multi-Application Linking

- Many applications are built over the same database (esp. in enterprises)
- Extend multi-view linking to multi-application linking
- Powerful for: connecting data across apps, reuse app logic



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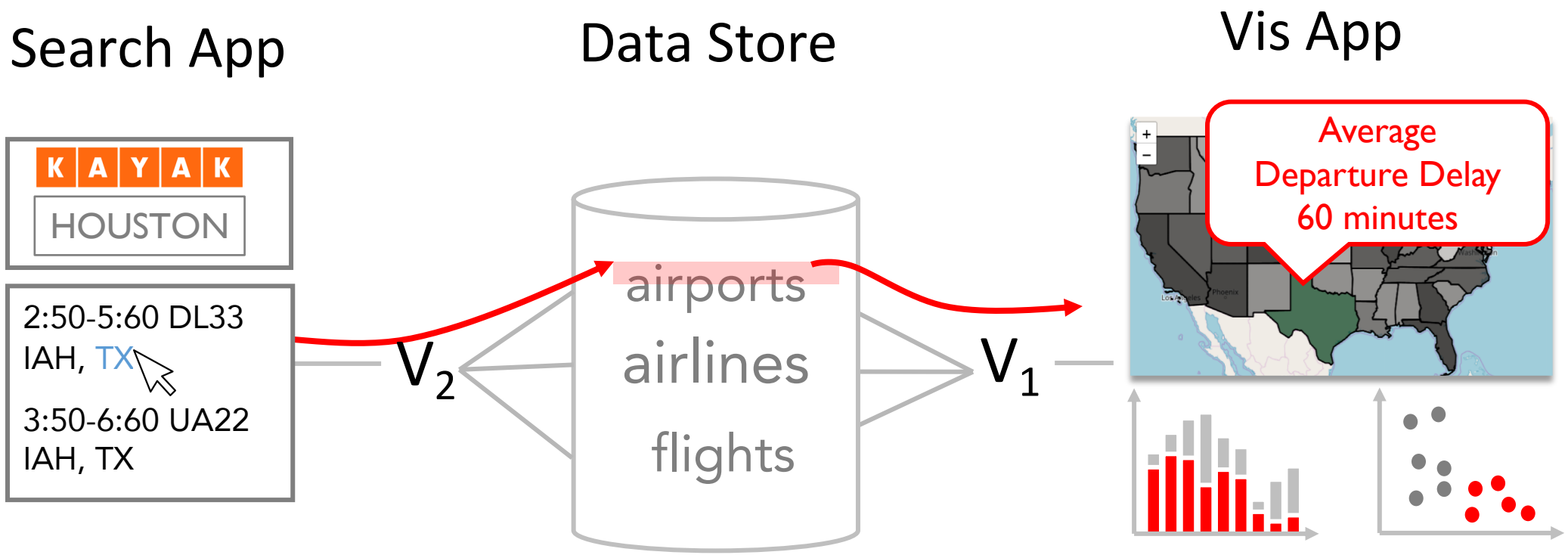
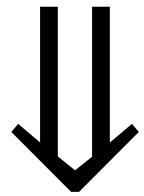


Takeaway

Interaction Logic as Provenance



Declarative wins &
Holistic optimization

Thank You
//Q