$$\begin{aligned} \text{Categories} &= \text{Graphs} + \text{Algebra} && (1) \\ &= \text{The future of} && (2) \\ &\quad \text{semantic representation} \end{aligned}$$

National Institute of
Standards and Technology
U.S. Department of Commerce

Spencer Breiner

$$\text{Categories} = \text{Graphs} + \text{Algebra} \quad (1)$$
$$= \text{The future of} \quad (2)$$
$$\text{semantic representation}$$

Goals Today: Explain (1)

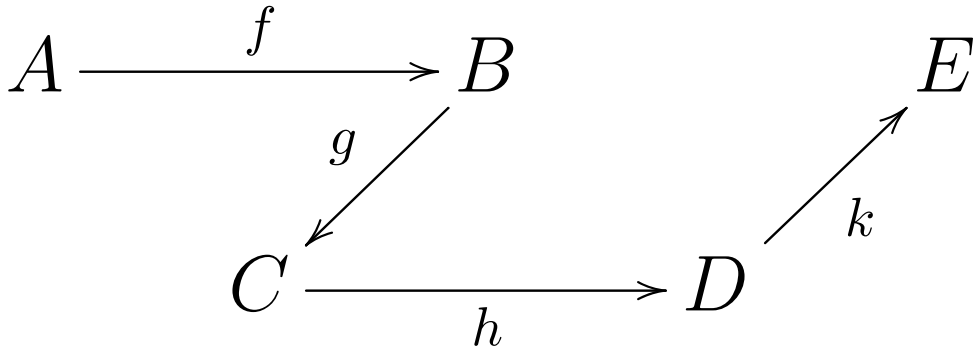
Justify (2)

NIST
National Institute of
Standards and Technology
U.S. Department of Commerce

Spencer Breiner

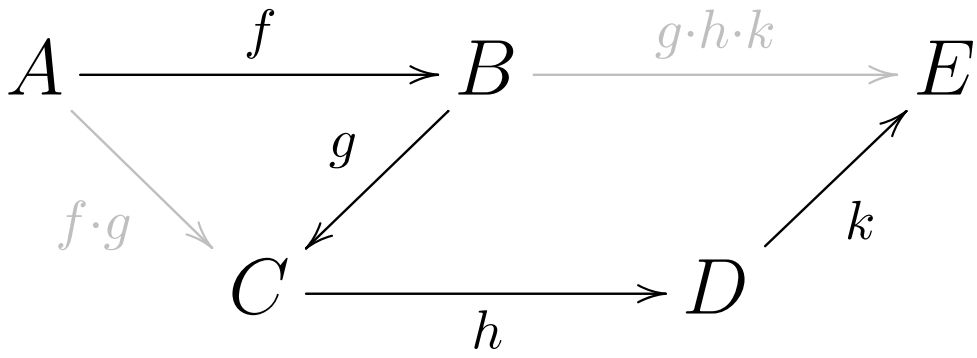
# Composition & Topology

Category = Graph + algebra on edges



# Composition & Topology

Category = Graph + algebra on edges

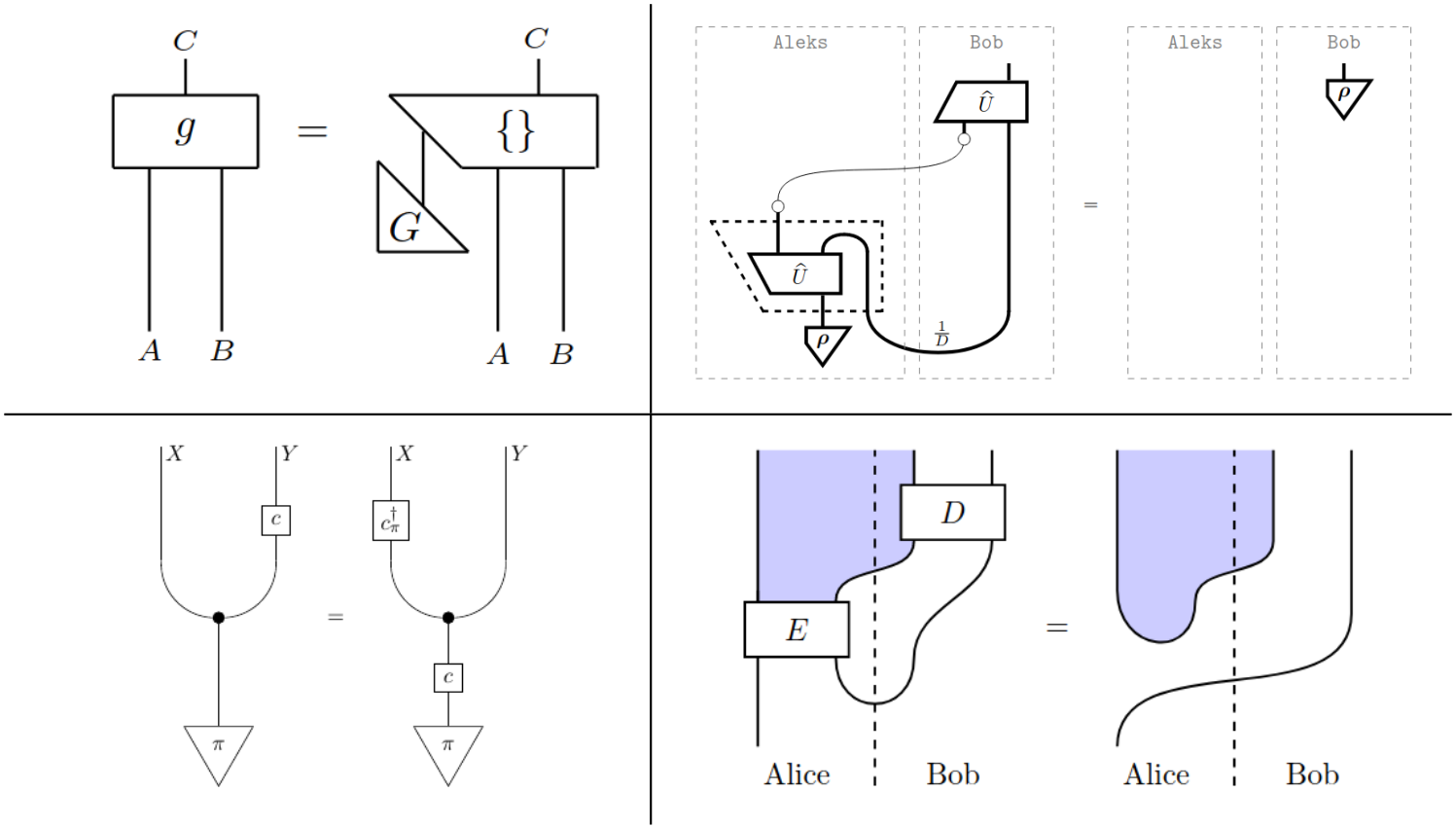



Pithy slogan:

Edges : Graphs :: Paths : Categories

# Composition & Topology

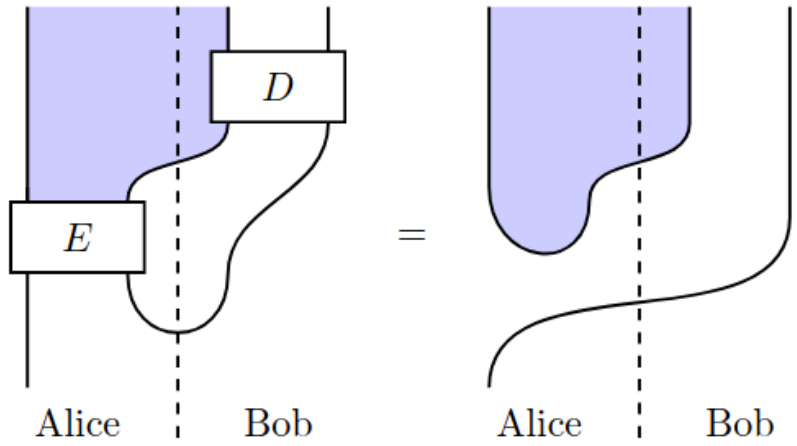
## Monoidal Category += Algebra on nodes




Diagrams cf. [6, 3, 7, 9]

# What's wrong with graphs?

Algebra supports *equational* reasoning




[9]

Graph *relationships* are too restrictive

Homomorphism: Nodes $\mapsto$ Nodes, Edges $\mapsto$ Edges

Functor: Nodes $\mapsto$ Nodes, Edges $\mapsto$ *Paths*

# You're already doing it (without the manual)

Some categories "in the wild"

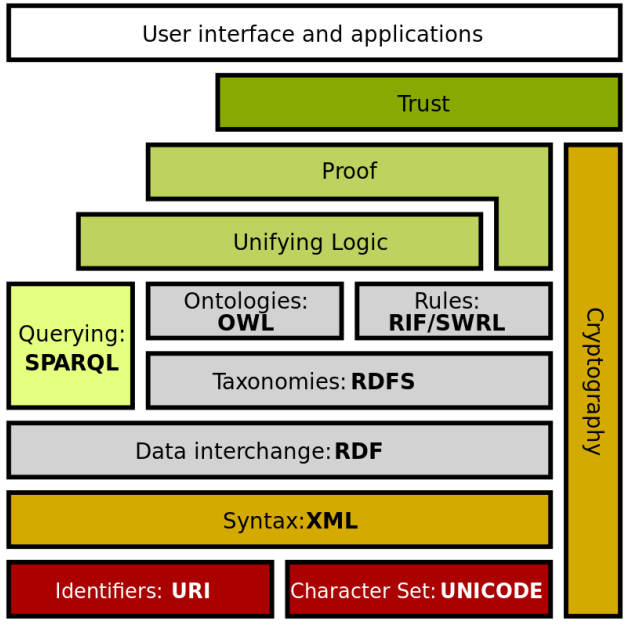
- Computer programs
- Logical proofs
- Bayesian probabilities
- Matrices (tensors)
- Automata & machines

! Graphs

Functorial semantics: A model is a mapping

$$\textbf{Syntax} \xrightarrow{\textbf{Model}} \textbf{Semantics}$$

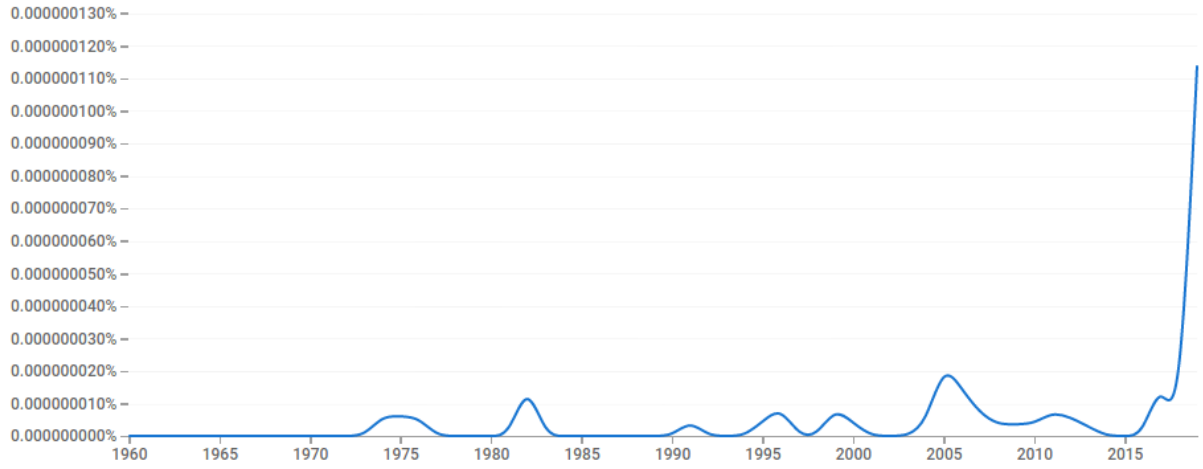
# You're already doing it (without the manual)




"Not yet fully realized: Unifying Logic and Proof layers" [4]

# Your peers (and competitors) are already doing it

Google nGram for "applied category theory":




| | |
|---|---|
| NASA | Temporal logic [8], system architecture [10] |
| DARPA | Systems of systems [1] |
| Siemens | Robot planning [5] |
| More ... | See NIST report [2] |

# Thank you I

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# Thank you II


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