What are we tracking?
How category theory puts thinking on rails

David I. Spivak

NIST
Compositional Structures in Systems Engineering and Design Workshop
2022 November 3

Outline

Why am I here?

In 2007, I read *The Moment of Complexity* by Mark C. Taylor

- It explained that the world was getting increasingly complex.
- More would be different: Anomalies would become the norm.
- It presaged fake news, deep fake videos, difficulty knowing what's true.

Why am I here?

In 2007, I read *The Moment of Complexity* by Mark C. Taylor

- It explained that the world was getting increasingly complex.
- More would be different: Anomalies would become the norm.
- It presaged fake news, deep fake videos, difficulty knowing what's true.

I wanted to do something, to help the world coordinate.

- Each person and organization structures its experience of the world.
- My neuron pattern and yours are more different than our fingerprints.
- And these are quite different than the database schemas found in orgs.
- Yet we are able to communicate! How??
- For the world to solve big problems, we must communicate better.

Why am I here?

In 2007, I read *The Moment of Complexity* by Mark C. Taylor

- It explained that the world was getting increasingly complex.
- More would be different: Anomalies would become the norm.
- It presaged fake news, deep fake videos, difficulty knowing what's true.

I wanted to do something, to help the world coordinate.

- Each person and organization structures its experience of the world.
- My neuron pattern and yours are more different than our fingerprints.
- And these are quite different than the database schemas found in orgs.
- Yet we are able to communicate! How??
- For the world to solve big problems, we must communicate better.

I'm here to help improve coordination between ACTs and SMEs.

- ACT mathematizes world systems and relationships between them.
- Our work cashes out in improved abilities of subject-matter experts.
- This tutorial is about how I think we can improve the interaction.

Tracking values

Our values are what we care about.

- A company may value its profits and/or making a quality product.
- A person may value their comfort or child's well-being.
- We might value peace, harmony, justice, good music, fancy cars.

Tracking values

Our values are what we care about.

- A company may value its profits and/or making a quality product.
- A person may value their comfort or child's well-being.
- We might value peace, harmony, justice, good music, fancy cars.

But the word value also means something like observable datum.

- This company is valued at \$5B. This product breaks after $\sim$2 years.
- The temperature is 70°. My child just got straight A's.
- There is too much war, the rate of fraud in elections is small.
- What "value" do you put into a certain field in the database?

Tracking values

Our values are what we care about.

- A company may value its profits and/or making a quality product.
- A person may value their comfort or child's well-being.
- We might value peace, harmony, justice, good music, fancy cars.

But the word value also means something like observable datum.

- This company is valued at \$5B. This product breaks after $\sim$2 years.
- The temperature is 70°. My child just got straight A's.
- There is too much war, the rate of fraud in elections is small.
- What "value" do you put into a certain field in the database?

We pursue our values by tracking certain observables.

- If you care about something, you keep track of relevant observables.
- If profits slip or the room temp. drops, we need to figure out why.
- We produce narratives, accounts, for why things are the way they are.
- These let us focus our energy on what we can and should change.

Accounting systems

We solve big problems together by coordinating our activity.

- When my efforts and yours conflict, it causes friction and loss.
- When we coordinate, we stop stepping on each others' toes.
- To work collectively, our activities must align, like a golfer's body.
- The parent explains to the child, the SME explains to the programmer.
- We give accounts. We explain our activity in terms of the collective.

Accounting systems

We solve big problems together by coordinating our activity.

- When my efforts and yours conflict, it causes friction and loss.
- When we coordinate, we stop stepping on each others' toes.
- To work collectively, our activities must align, like a golfer's body.
- The parent explains to the child, the SME explains to the programmer.
- We give accounts. We explain our activity in terms of the collective.

As the collective matures, its internal accounts become more systematic.

- There is friction every time I misinterpret your account of something.
- Or if your account hides key variables, externalities that I must handle.
- We get more systematic, so that we can regulate each other.
- These language games become regular and "grammatical".

Accounting systems

We solve big problems together by coordinating our activity.

- When my efforts and yours conflict, it causes friction and loss.
- When we coordinate, we stop stepping on each others' toes.
- To work collectively, our activities must align, like a golfer's body.
- The parent explains to the child, the SME explains to the programmer.
- We give accounts. We explain our activity in terms of the collective.

As the collective matures, its internal accounts become more systematic.

- There is friction every time I misinterpret your account of something.
- Or if your account hides key variables, externalities that I must handle.
- We get more systematic, so that we can regulate each other.
- These language games become regular and "grammatical".

If the system sufficiently crystalizes, it becomes a mathematical field.

Mathematical fields as accounting systems

I think of mathematical fields as crystalized accounting systems.

- Arithmetic accounts for the flow of quantities, as in finance.
- Hilbert spaces account for the states of elementary particles, as in QM.
- Probability distributions account for likelihoods, as in game theory.
- Each is crystalized: hardened and coherent. Think laws of arithmetic.

Mathematical fields as accounting systems

I think of mathematical fields as crystalized accounting systems.

- Arithmetic accounts for the flow of quantities, as in finance.
- Hilbert spaces account for the states of elementary particles, as in QM.
- Probability distributions account for likelihoods, as in game theory.
- Each is crystalized: hardened and coherent. Think laws of arithmetic.

We obtain a conceptual overlay: the phenomena are abstracted as types.

- In finance, we have the type dollar (\$) and the type quantity (#).
- We can add and multiply #'s by #'s: 5 boxes $\times$ 20 widgets $=$ 100.
- We can add \$'s, and we can multiply \$'s by #'s: 100 * \$3 $=$ \$300.
- But we cannot multiply \$'s by \$'s. Consider it: \$5 * \$3?

Mathematical fields as accounting systems

I think of mathematical fields as crystalized accounting systems.

- Arithmetic accounts for the flow of quantities, as in finance.
- Hilbert spaces account for the states of elementary particles, as in QM.
- Probability distributions account for likelihoods, as in game theory.
- Each is crystalized: hardened and coherent. Think laws of arithmetic.

We obtain a conceptual overlay: the phenomena are abstracted as types.

- In finance, we have the type dollar (\$) and the type quantity (#).
- We can add and multiply #'s by #'s: 5 boxes $\times$ 20 widgets $=$ 100.
- We can add \$'s, and we can multiply \$'s by #'s: 100 * \$3 $=$ \$300.
- But we cannot multiply \$'s by \$'s. Consider it: \$5 * \$3?

Math is a high-fidelity language for systematically tracking our values.

- The language articulates the relevant type-differences ...
- ... and provide operations that correspond with their interactions.
- The rules let us regulate each other: check each others' work.
- The regularity lets the collective share accounts w/o interpretive loss.

Where are we in the story?

- Every person, company, etc. has values it's tracking.
- It is also a collective, and hence its parts must coordinate.
- This is done by internally sharing accounts of "what's happening".
- To reduce internal loss, the accounts become systematic and regular.
- If they crystalize, the resulting system becomes a kind of math.

Where are we in the story?

- Every person, company, etc. has values it's tracking.
- It is also a collective, and hence its parts must coordinate.
- This is done by internally sharing accounts of "what's happening".
- To reduce internal loss, the accounts become systematic and regular.
- If they crystalize, the resulting system becomes a kind of math.

Questions, comments, examples, or concerns?

Where are we in the story?

- Every person, company, etc. has values it's tracking.
- It is also a collective, and hence its parts must coordinate.
- This is done by internally sharing accounts of "what's happening".
- To reduce internal loss, the accounts become systematic and regular.
- If they crystalize, the resulting system becomes a kind of math.

Questions, comments, examples, or concerns? Consider:

- Do you care about yourself, society, your company achieving its goals?
- Do you think this involves coordination of different parts?
- Do you think accountability is important for coordination?
- Do you ever wish the accounts were more systematic and regular?
- Are any of your systems crystalized into something like math?

How Applied Category Theory fits in

Category theory is a kind of math; what sort of phenomena is it tracking?

- It tracks a meta-level phenomenon.
- Namely, that different systems are somehow able to work together.
- To tackle big problems, we need to coordinate between entire systems.
- The finance, engineering, and safety departments must coordinate,...
- ...even though they track their values in entirely different systems.

How Applied Category Theory fits in

Category theory is a kind of math; what sort of phenomena is it tracking?

- It tracks a meta-level phenomenon.
- Namely, that different systems are somehow able to work together.
- To tackle big problems, we need to coordinate between entire systems.
- The finance, engineering, and safety departments must coordinate,...
- ...even though they track their values in entirely different systems.

Category theory has crystalized what it means to connect different systems.

- Each crystalized accounting sys. is captured as a structured category.
  - It tracks the types and relations as "objects" and "morphisms".
  - It tracks operations as monoidal structures, closures, limits, etc.
- Each translation between two systems is captured as a functor.
  - Every translation involves some preservation and some loss.
  - We've worked hard to crystalize the types, relations, operations.
  - So we consider the extent to which our functors preserve these.
  - A functor can be "faithful", "monoidal", "limit-preserving", etc.

How Applied Category Theory fits in

Category theory is a kind of math; what sort of phenomena is it tracking?

- It tracks a meta-level phenomenon.
- Namely, that different systems are somehow able to work together.
- To tackle big problems, we need to coordinate between entire systems.
- The finance, engineering, and safety departments must coordinate,...
- ...even though they track their values in entirely different systems.

Category theory has crystalized what it means to connect different systems.

- Each crystalized accounting sys. is captured as a structured category.
  - It tracks the types and relations as "objects" and "morphisms".
  - It tracks operations as monoidal structures, closures, limits, etc.
- Each translation between two systems is captured as a functor.
  - Every translation involves some preservation and some loss.
  - We've worked hard to crystalize the types, relations, operations.
  - So we consider the extent to which our functors preserve these.
  - A functor can be "faithful", "monoidal", "limit-preserving", etc.

CT lets you create & relate *custom accounting systems* for tracking values.

Plan

The plan for the rest of the tutorial is:

- Consider three different accounting systems as categories.
- Consider some principles for interaction between ACTs and SMEs.
- Consider what you get when you use CT.
- Conclude with a summary.

Outline

How an ACT-SME dialogue might start

ACT: “What sorts of thing are you tracking?”

How an ACT-SME dialogue might start

ACT: "What sorts of thing are you tracking?"
SME: "I'm tracking how money flows through our organization."

How an ACT-SME dialogue might start

ACT: "What sorts of thing are you tracking?"
SME: "I'm tracking how money flows through our organization."
ACT: "What kind of thing is money? What are the rules?"

How an ACT-SME dialogue might start

ACT: "What sorts of thing are you tracking?"
SME: "I'm tracking how money flows through our organization."
ACT: "What kind of thing is money? What are the rules?"
SME: "Huh? You know what money is as well as I do."

How an ACT-SME dialogue might start

ACT: "What sorts of thing are you tracking?"
SME: "I'm tracking how money flows through our organization."
ACT: "What kind of thing is money? What are the rules?"
SME: "Huh? You know what money is as well as I do."
ACT: "Sorry, yeah, but let's think about it together. It's a number?"

How an ACT-SME dialogue might start

ACT: "What sorts of thing are you tracking?"
SME: "I'm tracking how money flows through our organization."
ACT: "What kind of thing is money? What are the rules?"
SME: "Huh? You know what money is as well as I do."
ACT: "Sorry, yeah, but let's think about it together. It's a number?"
SME: "Yes...."

How an ACT-SME dialogue might start

ACT: "What sorts of thing are you tracking?"
SME: "I'm tracking how money flows through our organization."
ACT: "What kind of thing is money? What are the rules?"
SME: "Huh? You know what money is as well as I do."
ACT: "Sorry, yeah, but let's think about it together. It's a number?"
SME: "Yes...."
ACT: "Right... and you can add these numbers right?"

How an ACT-SME dialogue might start

ACT: "What sorts of thing are you tracking?"
SME: "I'm tracking how money flows through our organization."
ACT: "What kind of thing is money? What are the rules?"
SME: "Huh? You know what money is as well as I do."
ACT: "Sorry, yeah, but let's think about it together. It's a number?"
SME: "Yes...."
ACT: "Right... and you can add these numbers right?"
SME: "Of course.. you can add any two numbers.."

How an ACT-SME dialogue might start

ACT: "What sorts of thing are you tracking?"
SME: "I'm tracking how money flows through our organization."
ACT: "What kind of thing is money? What are the rules?"
SME: "Huh? You know what money is as well as I do."
ACT: "Sorry, yeah, but let's think about it together. It's a number?"
SME: "Yes...."
ACT: "Right... and you can add these numbers right?"
SME: "Of course.. you can add any two numbers.."
ACT: "I mean it's meaningful to add dollar figures together."

How an ACT-SME dialogue might start

ACT: "What sorts of thing are you tracking?"
SME: "I'm tracking how money flows through our organization."
ACT: "What kind of thing is money? What are the rules?"
SME: "Huh? You know what money is as well as I do."
ACT: "Sorry, yeah, but let's think about it together. It's a number?"
SME: "Yes...."
ACT: "Right... and you can add these numbers right?"
SME: "Of course.. you can add any two numbers.."
ACT: "I mean it's meaningful to add dollar figures together."
SME: "I'm sorry, I'm not understanding. You can always add numbers."

How an ACT-SME dialogue might start

ACT: "What sorts of thing are you tracking?"
SME: "I'm tracking how money flows through our organization."
ACT: "What kind of thing is money? What are the rules?"
SME: "Huh? You know what money is as well as I do."
ACT: "Sorry, yeah, but let's think about it together. It's a number?"
SME: "Yes...."
ACT: "Right... and you can add these numbers right?"
SME: "Of course.. you can add any two numbers.."
ACT: "I mean it's meaningful to add dollar figures together."
SME: "I'm sorry, I'm not understanding. You can always add numbers."
ACT: "Ok, I know what I mean now. You can't multiply two dollars, right?"

How an ACT-SME dialogue might start

ACT: "What sorts of thing are you tracking?"
SME: "I'm tracking how money flows through our organization."
ACT: "What kind of thing is money? What are the rules?"
SME: "Huh? You know what money is as well as I do."
ACT: "Sorry, yeah, but let's think about it together. It's a number?"
SME: "Yes...."
ACT: "Right... and you can add these numbers right?"
SME: "Of course.. you can add any two numbers.."
ACT: "I mean it's meaningful to add dollar figures together."
SME: "I'm sorry, I'm not understanding. You can always add numbers."
ACT: "Ok, I know what I mean now. You can't multiply two dollars, right?"
SME: "What do you mean?"

How an ACT-SME dialogue might start

ACT: "What sorts of thing are you tracking?"
SME: "I'm tracking how money flows through our organization."
ACT: "What kind of thing is money? What are the rules?"
SME: "Huh? You know what money is as well as I do."
ACT: "Sorry, yeah, but let's think about it together. It's a number?"
SME: "Yes...."
ACT: "Right... and you can add these numbers right?"
SME: "Of course.. you can add any two numbers.."
ACT: "I mean it's meaningful to add dollar figures together."
SME: "I'm sorry, I'm not understanding. You can always add numbers."
ACT: "Ok, I know what I mean now. You can't multiply two dollars, right?"
SME: "What do you mean?"
ACT: "Like is there ever a time when you would want \$3$\times$\$5?"

How an ACT-SME dialogue might start

ACT: "What sorts of thing are you tracking?"
SME: "I'm tracking how money flows through our organization."
ACT: "What kind of thing is money? What are the rules?"
SME: "Huh? You know what money is as well as I do."
ACT: "Sorry, yeah, but let's think about it together. It's a number?"
SME: "Yes...."
ACT: "Right... and you can add these numbers right?"
SME: "Of course.. you can add any two numbers.."
ACT: "I mean it's meaningful to add dollar figures together."
SME: "I'm sorry, I'm not understanding. You can always add numbers."
ACT: "Ok, I know what I mean now. You can't multiply two dollars, right?"
SME: "What do you mean?"
ACT: "Like is there ever a time when you would want \$3$\times$\$5?"
SME: "I guess not actually. Hmm, I never thought about that. Weird!"

How an ACT-SME dialogue might start

ACT: "What sorts of thing are you tracking?"
SME: "I'm tracking how money flows through our organization."
ACT: "What kind of thing is money? What are the rules?"
SME: "Huh? You know what money is as well as I do."
ACT: "Sorry, yeah, but let's think about it together. It's a number?"
SME: "Yes...."
ACT: "Right... and you can add these numbers right?"
SME: "Of course.. you can add any two numbers.."
ACT: "I mean it's meaningful to add dollar figures together."
SME: "I'm sorry, I'm not understanding. You can always add numbers."
ACT: "Ok, I know what I mean now. You can't multiply two dollars, right?"
SME: "What do you mean?"
ACT: "Like is there ever a time when you would want \$3$\times$\$5?"
SME: "I guess not actually. Hmm, I never thought about that. Weird!"
ACT: "So you can add dollars but you can't multiply them."

How an ACT-SME dialogue might start

ACT: "What sorts of thing are you tracking?"
SME: "I'm tracking how money flows through our organization."
ACT: "What kind of thing is money? What are the rules?"
SME: "Huh? You know what money is as well as I do."
ACT: "Sorry, yeah, but let's think about it together. It's a number?"
SME: "Yes...."
ACT: "Right... and you can add these numbers right?"
SME: "Of course.. you can add any two numbers.."
ACT: "I mean it's meaningful to add dollar figures together."
SME: "I'm sorry, I'm not understanding. You can always add numbers."
ACT: "Ok, I know what I mean now. You can't multiply two dollars, right?"
SME: "What do you mean?"
ACT: "Like is there ever a time when you would want \$3×\$5?"
SME: "I guess not actually. Hmm, I never thought about that. Weird!"
ACT: "So you can add dollars but you can't multiply them."
SME: "But you can have 3 widgets at \$5 each, so you can kinda multiply.."

How an ACT-SME dialogue might start

ACT: "What sorts of thing are you tracking?"
SME: "I'm tracking how money flows through our organization."
ACT: "What kind of thing is money? What are the rules?"
SME: "Huh? You know what money is as well as I do."
ACT: "Sorry, yeah, but let's think about it together. It's a number?"
SME: "Yes...."
ACT: "Right... and you can add these numbers right?"
SME: "Of course.. you can add any two numbers.."
ACT: "I mean it's meaningful to add dollar figures together."
SME: "I'm sorry, I'm not understanding. You can always add numbers."
ACT: "Ok, I know what I mean now. You can't multiply two dollars, right?"
SME: "What do you mean?"
ACT: "Like is there ever a time when you would want \$3×\$5?"
SME: "I guess not actually. Hmm, I never thought about that. Weird!"
ACT: "So you can add dollars but you can't multiply them."
SME: "But you can have 3 widgets at \$5 each, so you can kinda multiply.."
ACT: "Now you're getting the hang of what I need from you!"

Finding the right abstractions

The most basic thing that the two characters were working out:

- $'s can be added, subtracted, and scaled, but they can't be multiplied.
- This is a classic mathematical object that the ACT person would see.
- Namely, we see that $ form a vector space.

Finding the right abstractions

The most basic thing that the two characters were working out:

- $'s can be added, subtracted, and scaled, but they can't be multiplied.
- This is a classic mathematical object that the ACT person would see.
- Namely, we see that $ form a vector space.

What does finding this abstraction do for anyone?

- It gives the ACT person some purchase on how to interpret accounts.
- It suggests conceptual neighbors. For example other vector spaces.
- It provides a type system that can catch certain errors.
- All this within two minutes of talking.

Finding the right abstractions

The most basic thing that the two characters were working out:

- $'s can be added, subtracted, and scaled, but they can't be multiplied.
- This is a classic mathematical object that the ACT person would see.
- Namely, we see that $ form a vector space.

What does finding this abstraction do for anyone?

- It gives the ACT person some purchase on how to interpret accounts.
- It suggests conceptual neighbors. For example other vector spaces.
- It provides a type system that can catch certain errors.
- All this within two minutes of talking.

Let's explore the idea of conceptual neighbors with more dialogue.

How an ACT-SME dialogue might proceed

SME: This is cool, I never thought about how you can't multiply $'s before.

How an ACT-SME dialogue might proceed

SME: This is cool, I never thought about how you can't multiply \$'s before.
ACT: I have a question. \$'s is kinda "one-dimensional".

How an ACT-SME dialogue might proceed

SME: This is cool, I never thought about how you can't multiply \$'s before.
ACT: I have a question. \$'s is kinda "one-dimensional".
SME: How so?

How an ACT-SME dialogue might proceed

SME: This is cool, I never thought about how you can't multiply \$'s before.
ACT: I have a question. \$'s is kinda "one-dimensional".
SME: How so?
ACT: Well, do you ever have, like, different sorts of dollars?

How an ACT-SME dialogue might proceed

SME: This is cool, I never thought about how you can't multiply \$'s before.
ACT: I have a question. \$'s is kinda "one-dimensional".
SME: How so?
ACT: Well, do you ever have, like, different sorts of dollars?
SME: We don't really deal with other currencies at our company.

How an ACT-SME dialogue might proceed

SME: This is cool, I never thought about how you can't multiply \$'s before.
ACT: I have a question. \$'s is kinda "one-dimensional".
SME: How so?
ACT: Well, do you ever have, like, different sorts of dollars?
SME: We don't really deal with other currencies at our company.
ACT: Ah yes, right, other currencies!

How an ACT-SME dialogue might proceed

SME: This is cool, I never thought about how you can't multiply \$'s before.
ACT: I have a question. \$'s is kinda "one-dimensional".
SME: How so?
ACT: Well, do you ever have, like, different sorts of dollars?
SME: We don't really deal with other currencies at our company.
ACT: Ah yes, right, other currencies!
SME: Yeah, but we don't do that.

How an ACT-SME dialogue might proceed

SME: This is cool, I never thought about how you can't multiply \$'s before.
ACT: I have a question. \$'s is kinda "one-dimensional".
SME: How so?
ACT: Well, do you ever have, like, different sorts of dollars?
SME: We don't really deal with other currencies at our company.
ACT: Ah yes, right, other currencies!
SME: Yeah, but we don't do that.
ACT: Right, but there's a 2-dimensional vector space of \$ and £

How an ACT-SME dialogue might proceed

SME: This is cool, I never thought about how you can't multiply \$'s before.
ACT: I have a question. \$'s is kinda "one-dimensional".
SME: How so?
ACT: Well, do you ever have, like, different sorts of dollars?
SME: We don't really deal with other currencies at our company.
ACT: Ah yes, right, other currencies!
SME: Yeah, but we don't do that.
ACT: Right, but there's a 2-dimensional vector space of \$ and £
SME: First, we don't do that. Second, you could just convert both to \$.

How an ACT-SME dialogue might proceed

SME: This is cool, I never thought about how you can't multiply \$'s before.
ACT: I have a question. \$'s is kinda "one-dimensional".
SME: How so?
ACT: Well, do you ever have, like, different sorts of dollars?
SME: We don't really deal with other currencies at our company.
ACT: Ah yes, right, other currencies!
SME: Yeah, but we don't do that.
ACT: Right, but there's a 2-dimensional vector space of \$ and £
SME: First, we don't do that. Second, you could just convert both to \$.
ACT: Oh, right: That conversion is a linear transformation $V \to \mathbb{R}$!

How an ACT-SME dialogue might proceed

SME: This is cool, I never thought about how you can't multiply \$'s before.
ACT: I have a question. \$'s is kinda "one-dimensional".
SME: How so?
ACT: Well, do you ever have, like, different sorts of dollars?
SME: We don't really deal with other currencies at our company.
ACT: Ah yes, right, other currencies!
SME: Yeah, but we don't do that.
ACT: Right, but there's a 2-dimensional vector space of \$ and £
SME: First, we don't do that. Second, you could just convert both to \$.
ACT: Oh, right: That conversion is a linear transformation $V \to \mathbb{R}$!
SME: I'm not following. Or maybe you're not listening..?

How an ACT-SME dialogue might proceed

SME: This is cool, I never thought about how you can't multiply \$'s before.
ACT: I have a question. \$'s is kinda "one-dimensional".
SME: How so?
ACT: Well, do you ever have, like, different sorts of dollars?
SME: We don't really deal with other currencies at our company.
ACT: Ah yes, right, other currencies!
SME: Yeah, but we don't do that.
ACT: Right, but there's a 2-dimensional vector space of \$ and £
SME: First, we don't do that. Second, you could just convert both to \$.
ACT: Oh, right: That conversion is a linear transformation $V \to \mathbb{R}$!
SME: I'm not following. Or maybe you're not listening..?
ACT: Sorry. I'm listening, but I'm following a trail.

How an ACT-SME dialogue might proceed

SME: This is cool, I never thought about how you can't multiply \$'s before.
ACT: I have a question. \$'s is kinda "one-dimensional".
SME: How so?
ACT: Well, do you ever have, like, different sorts of dollars?
SME: We don't really deal with other currencies at our company.
ACT: Ah yes, right, other currencies!
SME: Yeah, but we don't do that.
ACT: Right, but there's a 2-dimensional vector space of \$ and £
SME: First, we don't do that. Second, you could just convert both to \$.
ACT: Oh, right: That conversion is a linear transformation $V \to \mathbb{R}$!
SME: I'm not following. Or maybe you're not listening..?
ACT: Sorry. I'm listening, but I'm following a trail.
SME: What is it? Vectors?

How an ACT-SME dialogue might proceed

SME: This is cool, I never thought about how you can't multiply \$'s before.
ACT: I have a question. \$'s is kinda "one-dimensional".
SME: How so?
ACT: Well, do you ever have, like, different sorts of dollars?
SME: We don't really deal with other currencies at our company.
ACT: Ah yes, right, other currencies!
SME: Yeah, but we don't do that.
ACT: Right, but there's a 2-dimensional vector space of \$ and £
SME: First, we don't do that. Second, you could just convert both to \$.
ACT: Oh, right: That conversion is a linear transformation $V \to \mathbb{R}$!
SME: I'm not following. Or maybe you're not listening..?
ACT: Sorry. I'm listening, but I'm following a trail.
SME: What is it? Vectors?
ACT: Question: do you ever do accounting for different sorts of widgets?

How an ACT-SME dialogue might proceed

SME: This is cool, I never thought about how you can't multiply \$'s before.
ACT: I have a question. \$'s is kinda "one-dimensional".
SME: How so?
ACT: Well, do you ever have, like, different sorts of dollars?
SME: We don't really deal with other currencies at our company.
ACT: Ah yes, right, other currencies!
SME: Yeah, but we don't do that.
ACT: Right, but there's a 2-dimensional vector space of \$ and £
SME: First, we don't do that. Second, you could just convert both to \$.
ACT: Oh, right: That conversion is a linear transformation $V \to \mathbb{R}$!
SME: I'm not following. Or maybe you're not listening..?
ACT: Sorry. I'm listening, but I'm following a trail.
SME: What is it? Vectors?
ACT: Question: do you ever do accounting for different sorts of widgets?
SME: All the time. We sell 11 types of widgets.

How an ACT-SME dialogue might proceed

SME: This is cool, I never thought about how you can't multiply \$'s before.
ACT: I have a question. \$'s is kinda "one-dimensional".
SME: How so?
ACT: Well, do you ever have, like, different sorts of dollars?
SME: We don't really deal with other currencies at our company.
ACT: Ah yes, right, other currencies!
SME: Yeah, but we don't do that.
ACT: Right, but there's a 2-dimensional vector space of \$ and £
SME: First, we don't do that. Second, you could just convert both to \$.
ACT: Oh, right: That conversion is a linear transformation $V \to \mathbb{R}$!
SME: I'm not following. Or maybe you're not listening..?
ACT: Sorry. I'm listening, but I'm following a trail.
SME: What is it? Vectors?
ACT: Question: do you ever do accounting for different sorts of widgets?
SME: All the time. We sell 11 types of widgets.
ACT: I bet they form a vector space too. This is starting to come together.

How an ACT-SME dialogue might proceed

SME: This is cool, I never thought about how you can't multiply \$'s before.
ACT: I have a question. \$'s is kinda "one-dimensional".
SME: How so?
ACT: Well, do you ever have, like, different sorts of dollars?
SME: We don't really deal with other currencies at our company.
ACT: Ah yes, right, other currencies!
SME: Yeah, but we don't do that.
ACT: Right, but there's a 2-dimensional vector space of \$ and £
SME: First, we don't do that. Second, you could just convert both to \$.
ACT: Oh, right: That conversion is a linear transformation $V \to \mathbb{R}$!
SME: I'm not following. Or maybe you're not listening..?
ACT: Sorry. I'm listening, but I'm following a trail.
SME: What is it? Vectors?
ACT: Question: do you ever do accounting for different sorts of widgets?
SME: All the time. We sell 11 types of widgets.
ACT: I bet they form a vector space too. This is starting to come together.
SME: Cool, because this is exactly what I wanted to tell you about next.

Summarizing and concluding this example

What happened here?

- The ACT was looking for the right mathematical object.
- Having found it, the idea of multiple dimensions suggested itself.
- Multiple currencies was the first idea; it works, but isn't relevant.
- Multiple sorts of widgets was the second idea.
- The ACT and SME are now vibing: they agree on what's relevant.
- This can happen even when the ACT doesn't know the subject.

Summarizing and concluding this example

What happened here?

- The ACT was looking for the right mathematical object.
- Having found it, the idea of multiple dimensions suggested itself.
- Multiple currencies was the first idea; it works, but isn't relevant.
- Multiple sorts of widgets was the second idea.
- The ACT and SME are now vibing: they agree on what's relevant.
- This can happen even when the ACT doesn't know the subject.

What happens from here?

- Every collaboration takes its own turns.
- Maybe they invent a souped-up spreadsheet that type checks formulas.
- Maybe the SME explains the *accounting equation*,

$$\text{Assets} = \text{Liabilities} + \text{Equity}$$

- The ACT considers why it's so central to financial accounting today.
- They create a new ACT account of the firm, grounded in this equation.

What is a recipe?

Turn to your neighbor. Consider together: what is a recipe?

What is a recipe?

Turn to your neighbor. Consider together: what is a recipe?

- What is it tracking? What sort of account is it?
- What types (of actions, objects, structures) are involved?
- What operations can you do on these types. (Combine actions?)

Meta: The role of questions and answers

Soon, I will give you my answers to the above questions.

- This will have positive and negative aspects. Why?
- Questions "open" the conversation, answers "close" it.
- When we *jump* to conclusions, we prematurely close.
- Concluding / closing needs to be done in order to act consistently.

Meta: The role of questions and answers

Soon, I will give you my answers to the above questions.

- This will have positive and negative aspects. Why?
- Questions "open" the conversation, answers "close" it.
- When we *jump* to conclusions, we prematurely close.
- Concluding / closing needs to be done in order to act consistently.

The ACT-SME interaction seeks to temporarily reopen closed questions.

- Traditional methods are in use but closed. (e.g. ZFC, UML)
- It can feel either plodding or cleansing to reopen them.
- We use CT to find deeper structures in what we're already doing.

Meta: The role of questions and answers

Soon, I will give you my answers to the above questions.

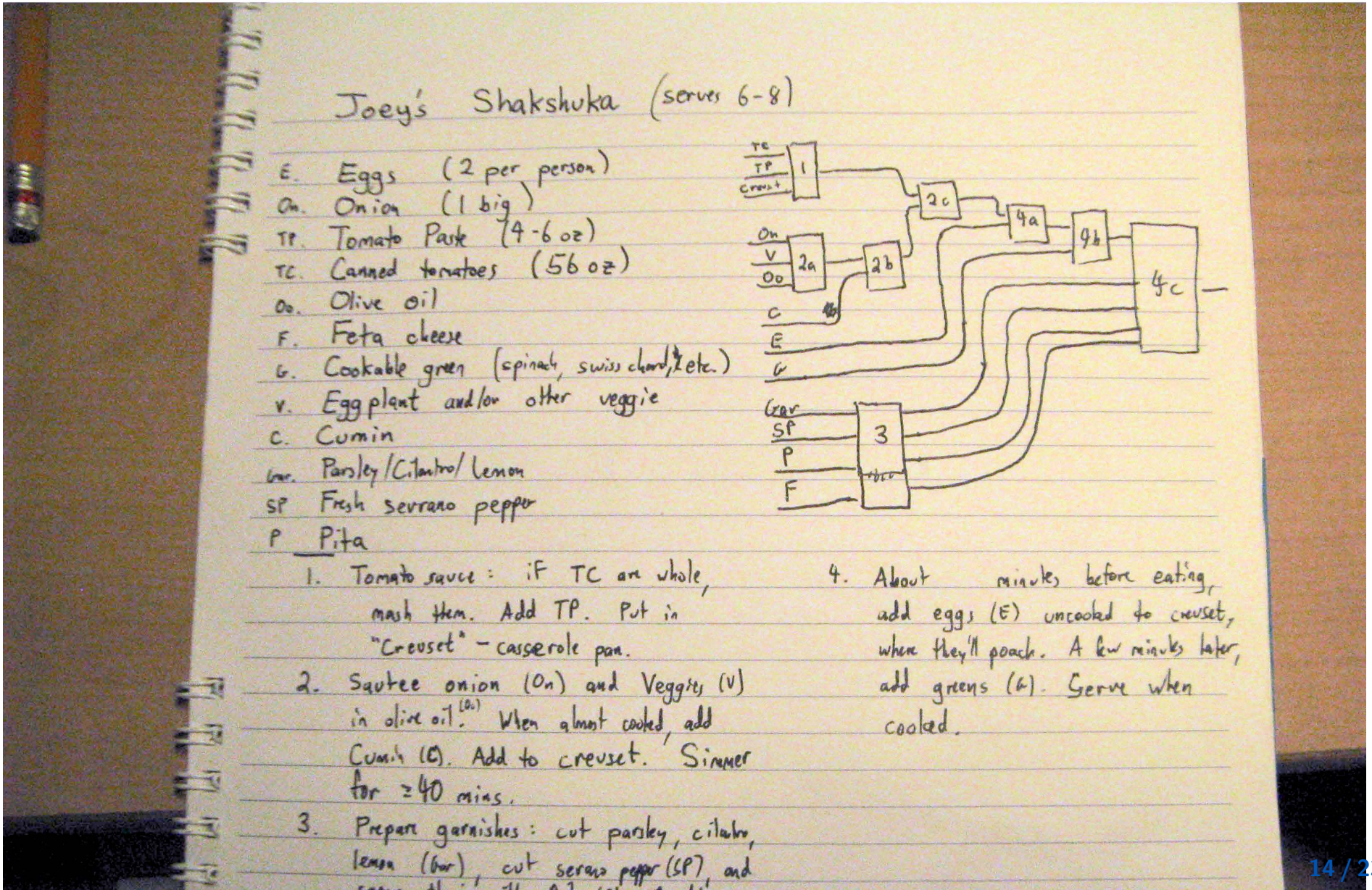
- This will have positive and negative aspects. Why?
- Questions "open" the conversation, answers "close" it.
- When we *jump* to conclusions, we prematurely close.
- Concluding / closing needs to be done in order to act consistently.

The ACT-SME interaction seeks to temporarily reopen closed questions.

- Traditional methods are in use but closed. (e.g. ZFC, UML)
- It can feel either plodding or cleansing to reopen them.
- We use CT to find deeper structures in what we're already doing.

Can we find any structure to recipes?

Joey Hirsch's Shakshuka recipe



Joey's Shakshuka (serves 6-8)

E. Eggs (2 per person)
On. Onion (1 big)
TP. Tomato Paste (4-6 oz)
TC. Canned tomatoes (56 oz)
Oo. Olive oil
F. Feta cheese
G. Cookable green (spinach, swiss chard, kale etc.)
V. Eggplant and/or other veggie
C. Cumin
Gar. Parsley/Cilantro/Lemon
SP Fresh serrano pepper
P Pita

1. Tomato sauce: if TC are whole, mash them. Add TP. Put in "Creuset" - casserole pan.
2. Sautee onion (On) and Veggies (V) in olive oil. (Oo) When almost cooked, add Cumin (C). Add to creuset. Simmer for ≥40 mins.
3. Prepare garnishes: cut parsley, cilantro, lemon (Gar), cut serano pepper (SP) and
4. About minutes before eating, add eggs (E) uncooked to creuset, where they'll poach. A few minutes later, add greens (G). Serve when cooked.

Recipe structure: parallel, series, and nesting

A recipe tracks resources and ways they're combined.

- Each step in the recipe takes many inputs and produces an output.
- Some steps must be done sequentially, others can be done in parallel.
- Each step in the recipe could be seen as a whole recipe.
  - You can zoom into the step and take it apart.
  - To mix the eggs into the flour, get a whisk and stir vigorously.
    - To get a whisk, open the drawer on the left and then....
- Maybe we should say: a recipe is the free operad on some signature.
  - Fix a set of all possible resources; call them *types*.
  - Fix a set of all simple operations, ones that need no explanation.
  - Now form the free (typed) operad on this data.

Recipe structure: parallel, series, and nesting

A recipe tracks resources and ways they're combined.

- Each step in the recipe takes many inputs and produces an output.
- Some steps must be done sequentially, others can be done in parallel.
- Each step in the recipe could be seen as a whole recipe.
  - You can zoom into the step and take it apart.
  - To mix the eggs into the flour, get a whisk and stir vigorously.
    - To get a whisk, open the drawer on the left and then....
- Maybe we should say: a recipe is the free operad on some signature.
  - Fix a set of all possible resources; call them *types*.
  - Fix a set of all simple operations, ones that need no explanation.
  - Now form the free (typed) operad on this data.

But what if someone objects that a step can produce many outputs.

- A single egg can produce two resources: egg white and egg yolk.
- This viewpoint produces a Petri net: the free monoidal category.
- Either viewpoint works; we get a functor from that one to this one.

Recipe structure: parallel, series, and nesting

A recipe tracks resources and ways they're combined.

- Each step in the recipe takes many inputs and produces an output.
- Some steps must be done sequentially, others can be done in parallel.
- Each step in the recipe could be seen as a whole recipe.
  - You can zoom into the step and take it apart.
  - To mix the eggs into the flour, get a whisk and stir vigorously.
    - To get a whisk, open the drawer on the left and then....
- Maybe we should say: a recipe is the free operad on some signature.
  - Fix a set of all possible resources; call them *types*.
  - Fix a set of all simple operations, ones that need no explanation.
  - Now form the free (typed) operad on this data.

But what if someone objects that a step can produce many outputs.

- A single egg can produce two resources: egg white and egg yolk.
- This viewpoint produces a Petri net: the free monoidal category.
- Either viewpoint works; we get a functor from that one to this one.

We're still connected if two developers try out different approaches.

Another ACT-SME dialogue

SME: We need help thinking about cybersecurity.

Another ACT-SME dialogue

SME: We need help thinking about cybersecurity.
ACT: That sounds complicated; what exactly is it?

Another ACT-SME dialogue

SME: We need help thinking about cybersecurity.
ACT: That sounds complicated; what exactly is it?
SME: We need to keep our systems safe from vulnerabilities.

Another ACT-SME dialogue

SME: We need help thinking about cybersecurity.
ACT: That sounds complicated; what exactly is it?
SME: We need to keep our systems safe from vulnerabilities.
ACT: Is that possible? Can you know about all possible vulnerabilities?

Another ACT-SME dialogue

SME: We need help thinking about cybersecurity.
ACT: That sounds complicated; what exactly is it?
SME: We need to keep our systems safe from vulnerabilities.
ACT: Is that possible? Can you know about all possible vulnerabilities?
SME: The zero day vulnerabilities, no, but the known ones, yes.

Another ACT-SME dialogue

SME: We need help thinking about cybersecurity.
ACT: That sounds complicated; what exactly is it?
SME: We need to keep our systems safe from vulnerabilities.
ACT: Is that possible? Can you know about all possible vulnerabilities?
SME: The zero day vulnerabilities, no, but the known ones, yes.
ACT: You have some catalogue of all known vulnerabilities?

Another ACT-SME dialogue

SME: We need help thinking about cybersecurity.
ACT: That sounds complicated; what exactly is it?
SME: We need to keep our systems safe from vulnerabilities.
ACT: Is that possible? Can you know about all possible vulnerabilities?
SME: The zero day vulnerabilities, no, but the known ones, yes.
ACT: You have some catalogue of all known vulnerabilities?
SME: Yes, NIST puts it out. You can query a database of them.

Another ACT-SME dialogue

SME: We need help thinking about cybersecurity.
ACT: That sounds complicated; what exactly is it?
SME: We need to keep our systems safe from vulnerabilities.
ACT: Is that possible? Can you know about all possible vulnerabilities?
SME: The zero day vulnerabilities, no, but the known ones, yes.
ACT: You have some catalogue of all known vulnerabilities?
SME: Yes, NIST puts it out. You can query a database of them.
ACT: So why do you need ACT?

Another ACT-SME dialogue

SME: We need help thinking about cybersecurity.
ACT: That sounds complicated; what exactly is it?
SME: We need to keep our systems safe from vulnerabilities.
ACT: Is that possible? Can you know about all possible vulnerabilities?
SME: The zero day vulnerabilities, no, but the known ones, yes.
ACT: You have some catalogue of all known vulnerabilities?
SME: Yes, NIST puts it out. You can query a database of them.
ACT: So why do you need ACT?
SME: Because every expert suggests a different approach to handling it.

Another ACT-SME dialogue

SME: We need help thinking about cybersecurity.
ACT: That sounds complicated; what exactly is it?
SME: We need to keep our systems safe from vulnerabilities.
ACT: Is that possible? Can you know about all possible vulnerabilities?
SME: The zero day vulnerabilities, no, but the known ones, yes.
ACT: You have some catalogue of all known vulnerabilities?
SME: Yes, NIST puts it out. You can query a database of them.
ACT: So why do you need ACT?
SME: Because every expert suggests a different approach to handling it.
ACT: So what you want is to somehow map out the space of approaches?

Another ACT-SME dialogue

SME: We need help thinking about cybersecurity.
ACT: That sounds complicated; what exactly is it?
SME: We need to keep our systems safe from vulnerabilities.
ACT: Is that possible? Can you know about all possible vulnerabilities?
SME: The zero day vulnerabilities, no, but the known ones, yes.
ACT: You have some catalogue of all known vulnerabilities?
SME: Yes, NIST puts it out. You can query a database of them.
ACT: So why do you need ACT?
SME: Because every expert suggests a different approach to handling it.
ACT: So what you want is to somehow map out the space of approaches?
SME: Exactly. We can't see the forest for the trees.

Another ACT-SME dialogue

SME: We need help thinking about cybersecurity.
ACT: That sounds complicated; what exactly is it?
SME: We need to keep our systems safe from vulnerabilities.
ACT: Is that possible? Can you know about all possible vulnerabilities?
SME: The zero day vulnerabilities, no, but the known ones, yes.
ACT: You have some catalogue of all known vulnerabilities?
SME: Yes, NIST puts it out. You can query a database of them.
ACT: So why do you need ACT?
SME: Because every expert suggests a different approach to handling it.
ACT: So what you want is to somehow map out the space of approaches?
SME: Exactly. We can't see the forest for the trees.
ACT: It's like an unbound atlas: pages of local pictures without binding.

Another ACT-SME dialogue

SME: We need help thinking about cybersecurity.
ACT: That sounds complicated; what exactly is it?
SME: We need to keep our systems safe from vulnerabilities.
ACT: Is that possible? Can you know about all possible vulnerabilities?
SME: The zero day vulnerabilities, no, but the known ones, yes.
ACT: You have some catalogue of all known vulnerabilities?
SME: Yes, NIST puts it out. You can query a database of them.
ACT: So why do you need ACT?
SME: Because every expert suggests a different approach to handling it.
ACT: So what you want is to somehow map out the space of approaches?
SME: Exactly. We can't see the forest for the trees.
ACT: It's like an unbound atlas: pages of local pictures without binding.
SME: Yes, we need to put the pages together somehow and see the globe.

Another ACT-SME dialogue

SME: We need help thinking about cybersecurity.
ACT: That sounds complicated; what exactly is it?
SME: We need to keep our systems safe from vulnerabilities.
ACT: Is that possible? Can you know about all possible vulnerabilities?
SME: The zero day vulnerabilities, no, but the known ones, yes.
ACT: You have some catalogue of all known vulnerabilities?
SME: Yes, NIST puts it out. You can query a database of them.
ACT: So why do you need ACT?
SME: Because every expert suggests a different approach to handling it.
ACT: So what you want is to somehow map out the space of approaches?
SME: Exactly. We can't see the forest for the trees.
ACT: It's like an unbound atlas: pages of local pictures without binding.
SME: Yes, we need to put the pages together somehow and see the globe.
ACT: Yeah, you need the overlaps in order to form the whole "manifold".

Another ACT-SME dialogue

SME: We need help thinking about cybersecurity.
ACT: That sounds complicated; what exactly is it?
SME: We need to keep our systems safe from vulnerabilities.
ACT: Is that possible? Can you know about all possible vulnerabilities?
SME: The zero day vulnerabilities, no, but the known ones, yes.
ACT: You have some catalogue of all known vulnerabilities?
SME: Yes, NIST puts it out. You can query a database of them.
ACT: So why do you need ACT?
SME: Because every expert suggests a different approach to handling it.
ACT: So what you want is to somehow map out the space of approaches?
SME: Exactly. We can't see the forest for the trees.
ACT: It's like an unbound atlas: pages of local pictures without binding.
SME: Yes, we need to put the pages together somehow and see the globe.
ACT: Yeah, you need the overlaps in order to form the whole "manifold".
SME: Why do you call it a manifold?

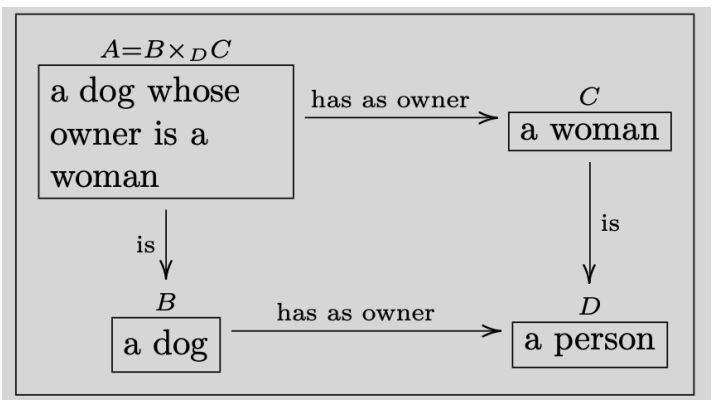
Another ACT-SME dialogue

SME: We need help thinking about cybersecurity.
ACT: That sounds complicated; what exactly is it?
SME: We need to keep our systems safe from vulnerabilities.
ACT: Is that possible? Can you know about all possible vulnerabilities?
SME: The zero day vulnerabilities, no, but the known ones, yes.
ACT: You have some catalogue of all known vulnerabilities?
SME: Yes, NIST puts it out. You can query a database of them.
ACT: So why do you need ACT?
SME: Because every expert suggests a different approach to handling it.
ACT: So what you want is to somehow map out the space of approaches?
SME: Exactly. We can't see the forest for the trees.
ACT: It's like an unbound atlas: pages of local pictures without binding.
SME: Yes, we need to put the pages together somehow and see the globe.
ACT: Yeah, you need the overlaps in order to form the whole "manifold".
SME: Why do you call it a manifold?
ACT: I'll explain later. For now, can you show me a sample "page"?

Ologs and databases

Ologs were my way of bringing SMEs and ACTs together.

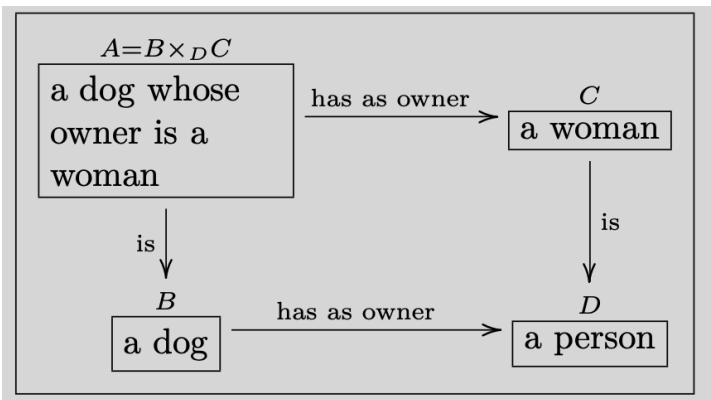
- An olog is a mix between math and natural language.
- The math is just that of categories, or perhaps "sketches".
- Each object is assigned a noun phrase, indicating a set.
- Each arrow is assigned a verb phrase, indicating a function.



Ologs and databases

Ologs were my way of bringing SMEs and ACTs together.

- An olog is a mix between math and natural language.
- The math is just that of categories, or perhaps "sketches".
- Each object is assigned a noun phrase, indicating a set.
- Each arrow is assigned a verb phrase, indicating a function.



Ologs form database schemas. An *instance* fills your olog with data.

- For each box, you record examples. You connect them along arrows.
- E.g. every example of "a woman" is an example of "a person".

How do ologs connect to our use-case?

There may be *way* more appropriate ACT systems for cybersecurity.

- But in our dialogue, the SME needed to weave together perspectives.
- This comes up a lot, not just in cybersecurity.
- Different engineers, safety experts, programmers, finance people...
- ... need to understand each other's lingo and form a working whole.

How do ologs connect to our use-case?

There may be *way* more appropriate ACT systems for cybersecurity.

- But in our dialogue, the SME needed to weave together perspectives.
- This comes up a lot, not just in cybersecurity.
- Different engineers, safety experts, programmers, finance people...
- ... need to understand each other's lingo and form a working whole.

As categories, ologs can be connected by functors.

- This allows you to migrate data between different worldviews.
- For the "atlas of worldviews" idea, use spans of injections.
- You can then put everything together as a *colimit*.
- But you may not want to; you may prefer having "local jurisdictions."
- Allow movement between worldviews without making "urban sprawl."

How do ologs connect to our use-case?

There may be *way* more appropriate ACT systems for cybersecurity.

- But in our dialogue, the SME needed to weave together perspectives.
- This comes up a lot, not just in cybersecurity.
- Different engineers, safety experts, programmers, finance people...
- ... need to understand each other's lingo and form a working whole.

As categories, ologs can be connected by functors.

- This allows you to migrate data between different worldviews.
- For the "atlas of worldviews" idea, use spans of injections.
- You can then put everything together as a *colimit*.
- But you may not want to; you may prefer having "local jurisdictions."
- Allow movement between worldviews without making "urban sprawl."

Often, the ACT comes to understand deeper aspects by making an olog.

- The discipline of creating ologs with SMEs can lead to clarifications.
- This can lead to a crystalizing insight into "the real thing".

Outline

Best practices for the interaction

Again, this is all my perspective. Take everything with a grain of salt.

- Work in person for a few full days, as often as possible.
- Work at a board, drawing pictures, making marks, pointing.
- Make every step obvious. Don't let the other lead without following.
- Interrupt when you don't understand.
- Regularize notation; notation can be a great guide; make use of it!
  - If X and P are the same type of thing, use X, X' or X_1, X_2.
  - Serge Lang: "The notation must be functorial with respect to the ideas!"
- Move back and forth between abstraction and concrete example.
- If something's difficult to explain, slow down; don't try to skip over it.

Best practices for the ACT

Applied category theorists:

- Do not impress them; help them see.
  - It's easy to move a little too fast, to jump to the next thing.
  - Make sure they're really following. Match their speed.
- Make your abstractions relevant.
  - Abstractions should feel right in terms of their prime example.
  - Oversimplifying at first is ok; a firm foundation can be built upon.
  - If you have to twist things, it probably won't work.

Best practices for the ACT

Applied category theorists:

- Do not impress them; help them see.
  - It's easy to move a little too fast, to jump to the next thing.
  - Make sure they're really following. Match their speed.
- Make your abstractions relevant.
  - Abstractions should feel right in terms of their prime example.
  - Oversimplifying at first is ok; a firm foundation can be built upon.
  - If you have to twist things, it probably won't work.
- Don't hide difficulties under the rug.
  - Explain everything. If they think it's hard, do more examples.
  - Don't say "oh, this is easy" but never show them.
  - Their confidence comes from being able to do it themselves.
  - This leads to them being able to explain it and spread it.

Best practices for the ACT

Applied category theorists:

- Do not impress them; help them see.
  - It's easy to move a little too fast, to jump to the next thing.
  - Make sure they're really following. Match their speed.
- Make your abstractions relevant.
  - Abstractions should feel right in terms of their prime example.
  - Oversimplifying at first is ok; a firm foundation can be built upon.
  - If you have to twist things, it probably won't work.
- Don't hide difficulties under the rug.
  - Explain everything. If they think it's hard, do more examples.
  - Don't say "oh, this is easy" but never show them.
  - Their confidence comes from being able to do it themselves.
  - This leads to them being able to explain it and spread it.

I felt sheepish when I introduced ologs.

- They are not even math, they are not complex, they are not fancy.
- But they worked for what I wanted. They make sense to people...
- ...and they connect to real math in a relevant way.

Best practices for the SME

Subject matter experts:

- Do not flood them with complexity.
- Clarify the very most basic things first.
  - The ACT may not know very basic things.
  - They may not be willing or able to follow "simple" calculations.

Best practices for the SME

Subject matter experts:

- Do not flood them with complexity.
- Clarify the very most basic things first.
  - The ACT may not know very basic things.
  - They may not be willing or able to follow "simple" calculations.
- Be patient if things feel too slow or simple at first.
  - I remember watching a building being built from my dorm room.
  - The bulldozers spent literally six months moving dirt around.
  - Then a 10-story building went up in like a month.
  - Getting the foundation right is the hardest part.

Best practices for the SME

Subject matter experts:

- Do not flood them with complexity.
- Clarify the very most basic things first.
  - The ACT may not know very basic things.
  - They may not be willing or able to follow "simple" calculations.
- Be patient if things feel too slow or simple at first.
  - I remember watching a building being built from my dorm room.
  - The bulldozers spent literally six months moving dirt around.
  - Then a 10-story building went up in like a month.
  - Getting the foundation right is the hardest part.
- Do not be scared of the math. Ask for explanations.
  - Draw your own pictures and ask if they look right.
  - Explain your understanding of the math, and be ready to learn.

Best practices for the SME

Subject matter experts:

- Do not flood them with complexity.
- Clarify the very most basic things first.
  - The ACT may not know very basic things.
  - They may not be willing or able to follow "simple" calculations.
- Be patient if things feel too slow or simple at first.
  - I remember watching a building being built from my dorm room.
  - The bulldozers spent literally six months moving dirt around.
  - Then a 10-story building went up in like a month.
  - Getting the foundation right is the hardest part.
- Do not be scared of the math. Ask for explanations.
  - Draw your own pictures and ask if they look right.
  - Explain your understanding of the math, and be ready to learn.
- Expect clarity and interoperability, not magic.
  - CT is like information plumbing. It's not grand, but...
  - ...plumbing has saved more lives than doctors.

What is the value proposition of ACT?

To some degree this is an open question. Here are some thoughts.

- For computer implementation:
  - ACT is generally quite good at seeing the "corner cases".
  - The math gives a complete spec. No technical debt.
  - You are done as soon as you implement XYZ monoidal category.
  - No feature bloat because it's a crystal, not a bunch of stuff.

What is the value proposition of ACT?

To some degree this is an open question. Here are some thoughts.

- For computer implementation:
  - ACT is generally quite good at seeing the "corner cases".
  - The math gives a complete spec. No technical debt.
  - You are done as soon as you implement XYZ monoidal category.
  - No feature bloat because it's a crystal, not a bunch of stuff.
- Conceptual clarity:
  - You see more deeply and clearly when concepts are streamlined.
  - You can see conceptual neighbors: turn the knobs.
  - Anecdote from Amgen: when ML came to companies.
    - The hype said that the ML would solve everything.
    - To start, the data scientists needed to organize the data.
    - This clarif'n process helped immensely; the ML itself didn't.

What is the value proposition of ACT?

To some degree this is an open question. Here are some thoughts.

- For computer implementation:
  - ACT is generally quite good at seeing the "corner cases".
  - The math gives a complete spec. No technical debt.
  - You are done as soon as you implement XYZ monoidal category.
  - No feature bloat because it's a crystal, not a bunch of stuff.
- Conceptual clarity:
  - You see more deeply and clearly when concepts are streamlined.
  - You can see conceptual neighbors: turn the knobs.
  - Anecdote from Amgen: when ML came to companies.
    - The hype said that the ML would solve everything.
    - To start, the data scientists needed to organize the data.
    - This clarif'n process helped immensely; the ML itself didn't.
- Information hygiene: get the plumbing right to reduce disease.
- Compositionality: everything works really well together.

Outline

Summary

Applied category theory is growing quite fast now.

- As complexity increases, everyone sees a need to organize it.
- ACT is naturally anti-hype because it is not magical. It's plumbing.

Summary

Applied category theory is growing quite fast now.

- As complexity increases, everyone sees a need to organize it.
- ACT is naturally anti-hype because it is not magical. It's plumbing.

ACT allows us to create custom accounting systems for tracking values.

- Making accounts systematic allows us to regulate each other.
- It puts thinking on rails.
- As the system crystallizes, we can automate it.

Summary

Applied category theory is growing quite fast now.

- As complexity increases, everyone sees a need to organize it.
- ACT is naturally anti-hype because it is not magical. It's plumbing.

ACT allows us to create custom accounting systems for tracking values.

- Making accounts systematic allows us to regulate each other.
- It puts thinking on rails.
- As the system crystallizes, we can automate it.

Soon there will be a tooling ecosystem; we need to build it!

- These tools will help everyone. A rising sea that lifts all boats.
- In 1880 AT&T created a nationwide long-distance network.
- This was a huge investment! But it paid off.

Summary

Applied category theory is growing quite fast now.

- As complexity increases, everyone sees a need to organize it.
- ACT is naturally anti-hype because it is not magical. It's plumbing.

ACT allows us to create custom accounting systems for tracking values.

- Making accounts systematic allows us to regulate each other.
- It puts thinking on rails.
- As the system crystallizes, we can automate it.

Soon there will be a tooling ecosystem; we need to build it!

- These tools will help everyone. A rising sea that lifts all boats.
- In 1880 AT&T created a nationwide long-distance network.
- This was a huge investment! But it paid off.

We're ready for the first big step in laying down information infrastructure.

- Everything is in place: the right problems, people, and institutions.
- It's now just a matter of investing resources in it.

Thanks! Comments and questions welcome...