

# Dialogue

Wei Xu

(many slides from Greg Durrett)

# This Lecture

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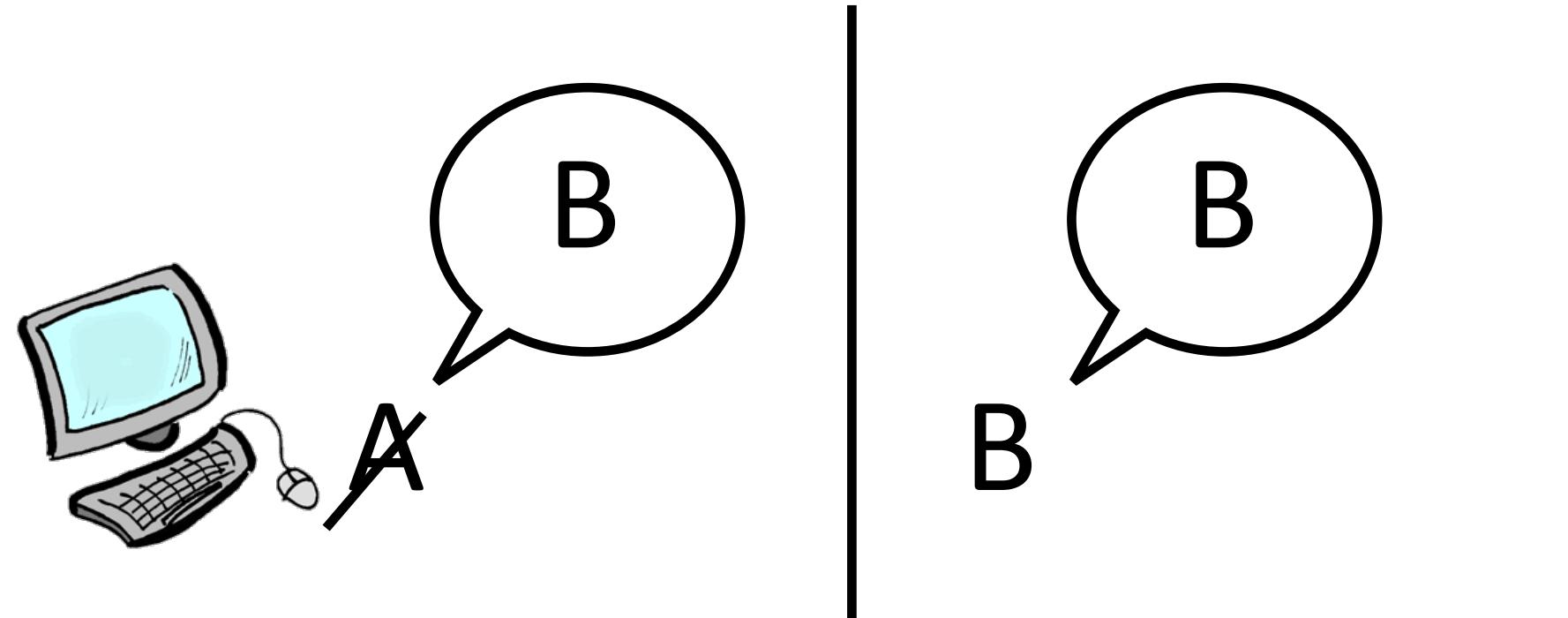
- ▶ Chatbot dialogue systems
- ▶ Task-oriented dialogue
- ▶ Other dialogue applications

# Chatbots

# Turing Test (1950)

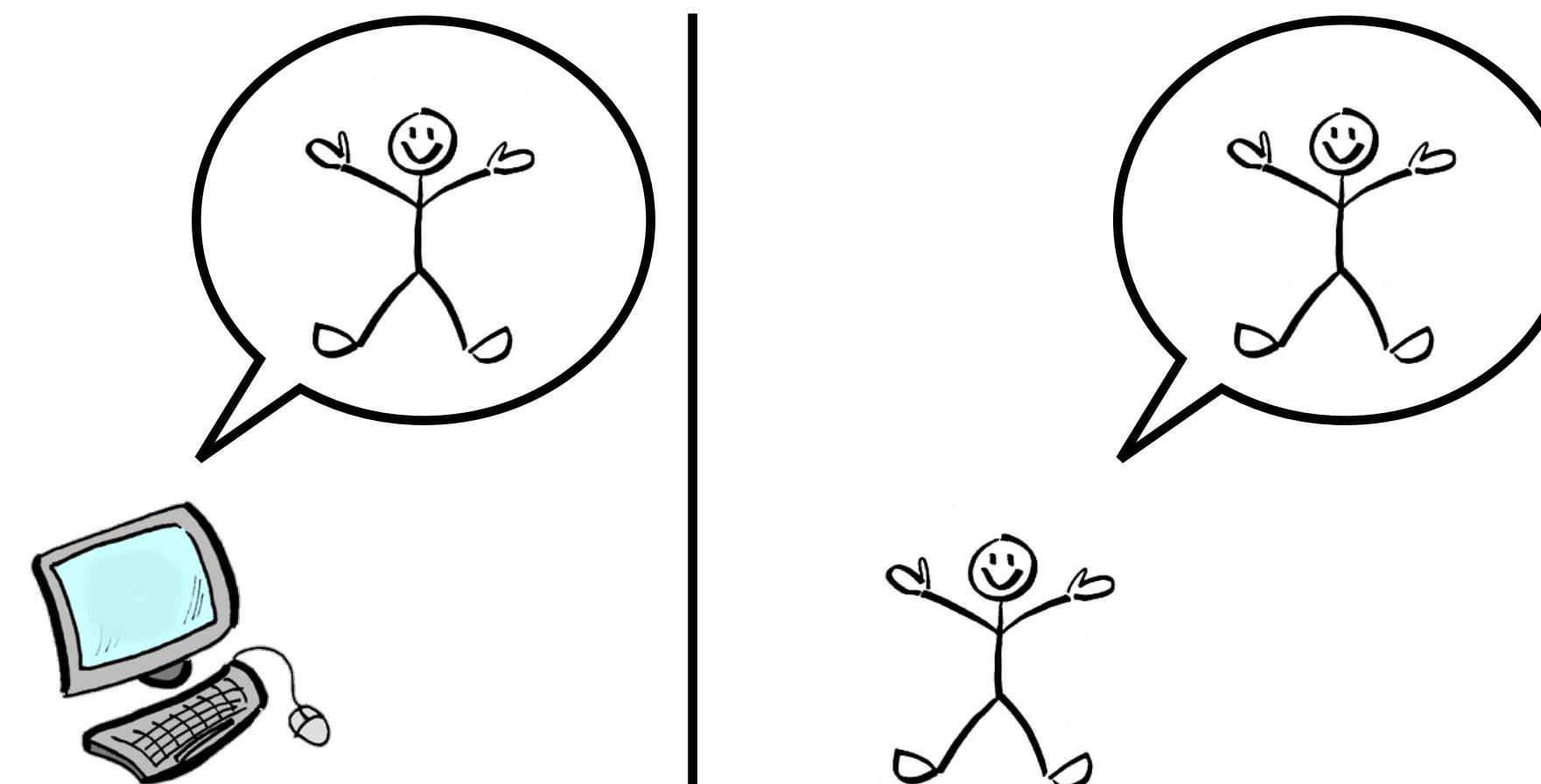
- ▶ Imitation game: A and B are locked in rooms and answer C's questions via typewriter. Both are trying to act like B

Original Interpretation:



C trained judge

Standard Interpretation:



C trained judge

- ▶ The test is **not** “does this computer seem human-like to random people with a web browser?”

# ELIZA

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- ▶ Created 1964-1966 at MIT, heavily scripted
- ▶ DOCTOR script was most successful:  
repeats user's input,  
asks inane questions

You are like my father in some ways.

WHAT RESEMBLANCE DO YOU SEE

You are not very aggressive but I think you don't want me to notice that.

WHAT MAKES YOU THINK I AM NOT VERY AGGRESSIVE

You don't argue with me.

WHY DO YOU THINK I DON'T ARGUE WITH YOU

You are afraid of me.

DOES IT PLEASE YOU TO BELIEVE I AM AFRAID OF YOU

My father is afraid of everybody.

WHAT ELSE COMES TO MIND WHEN YOU THINK OF YOUR FATHER

Bullies.

DOES THAT HAVE ANYTHING TO DO WITH THE FACT THAT YOUR BOYFRIEND MADE YOU COME HERE

# ELIZA

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- ▶ Identify keyword, identify context, apply transformation rule

(.\* ) you (.\* ) me



Why do you think I \\$2 you?

My (.) (.\* )



What else comes to mind when you think of your \\$1?

You don't argue with me.

WHY DO YOU THINK I DON'T ARGUE WITH YOU

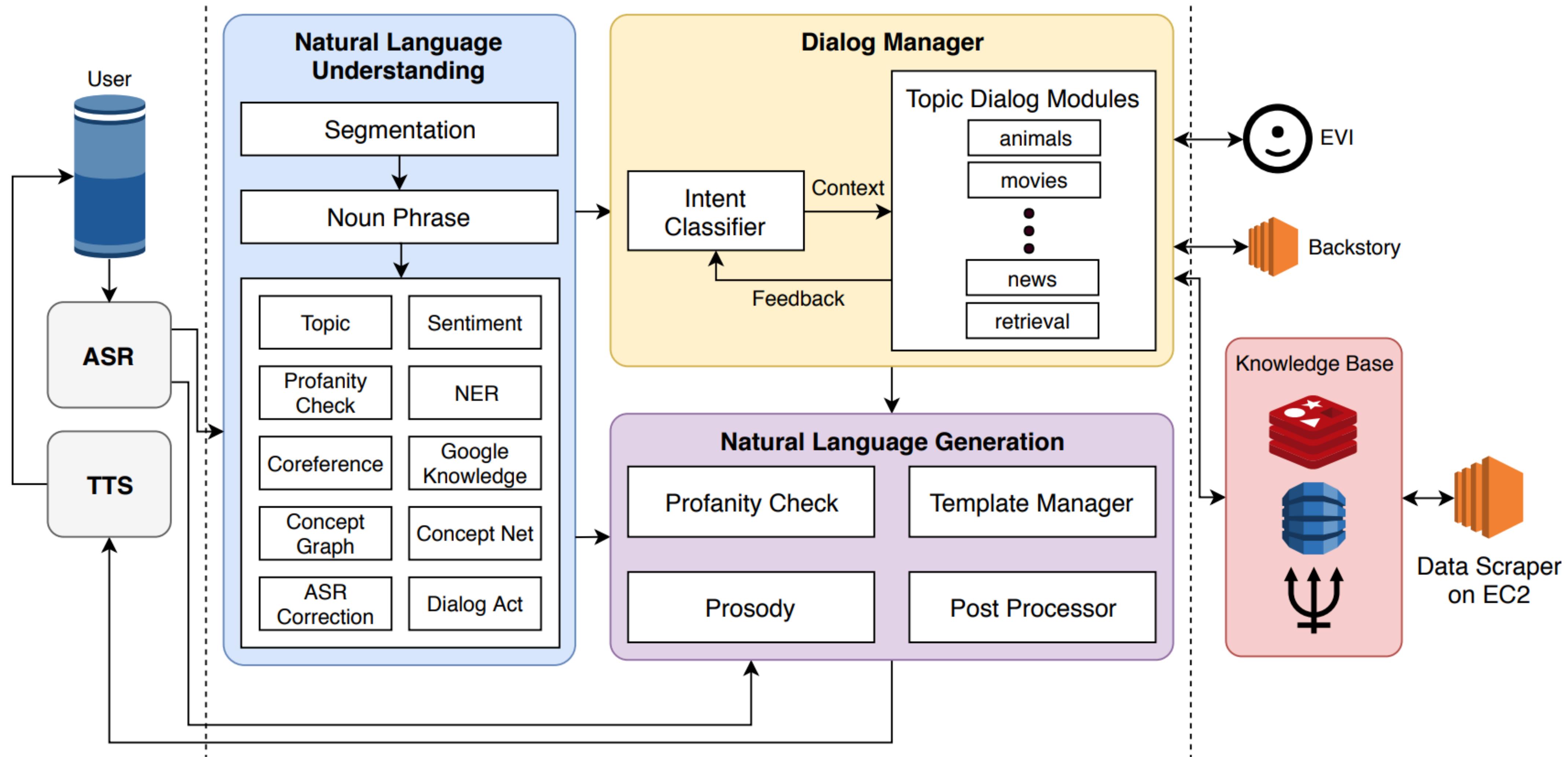
- ▶ Very little need to generate new content, but can only have one type of conversation

# Amazon Alexa Prize

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- ▶ Challenge: create a bot that users interact with on average for 20 minutes (via Alexa, so turns are kind of slow)
- ▶ \$1M prize if you get to 20 minutes. Only \$500k won in 2017-2020 since teams got to ~10 minutes
- ▶ “Alexa, let’s chat” will get you talking to one of these

# Gunrock System (Alexa Prize 2018 winner)



# Gunrock System

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**User\_1:**  
**Gunrock\_1:**

let's chat  
Hi, this is an Alexa Prize Socialbot. It's nice to talk to you again, George. I think last time we were talking about movies. Would you like to talk about it now?

**User\_2:**  
**Gunrock\_2:**

sure [SPL] that would be great  
By the way, I love to discover new movies. I recently watched Crazy Rich Asians because someone told me it was hilarious. What movie would you recommend to me?

**User\_3:**

ha [SPL] it's a tough question [SPL] i don't think i have a good one to recommend [SPL] wait [SPL] i think that *stars born* is good

**Gunrock\_3:**

Yes I remember watching *a star is born*.  
Hmm. If you had to rate this movie from 1 to 10, what would it be?

**User\_4:**  
**Gunrock\_4:**

ten  
A perfect 10! You have to tell me more. What was so exceptional? When I watched it, the music design really stood out to me.

**User\_5:**  
**Gunrock\_5:**

when i watched it the music was amazing [SPL] and bradley cooper was super talented in the movie [SPL] i really like him You've got me wanting to watch the movie again. Ouu, Maybe you will find this interesting. Bradley Cooper claimed that his dream was to be a director before he got into acting and this was his directorial debut ...

# Gunrock System

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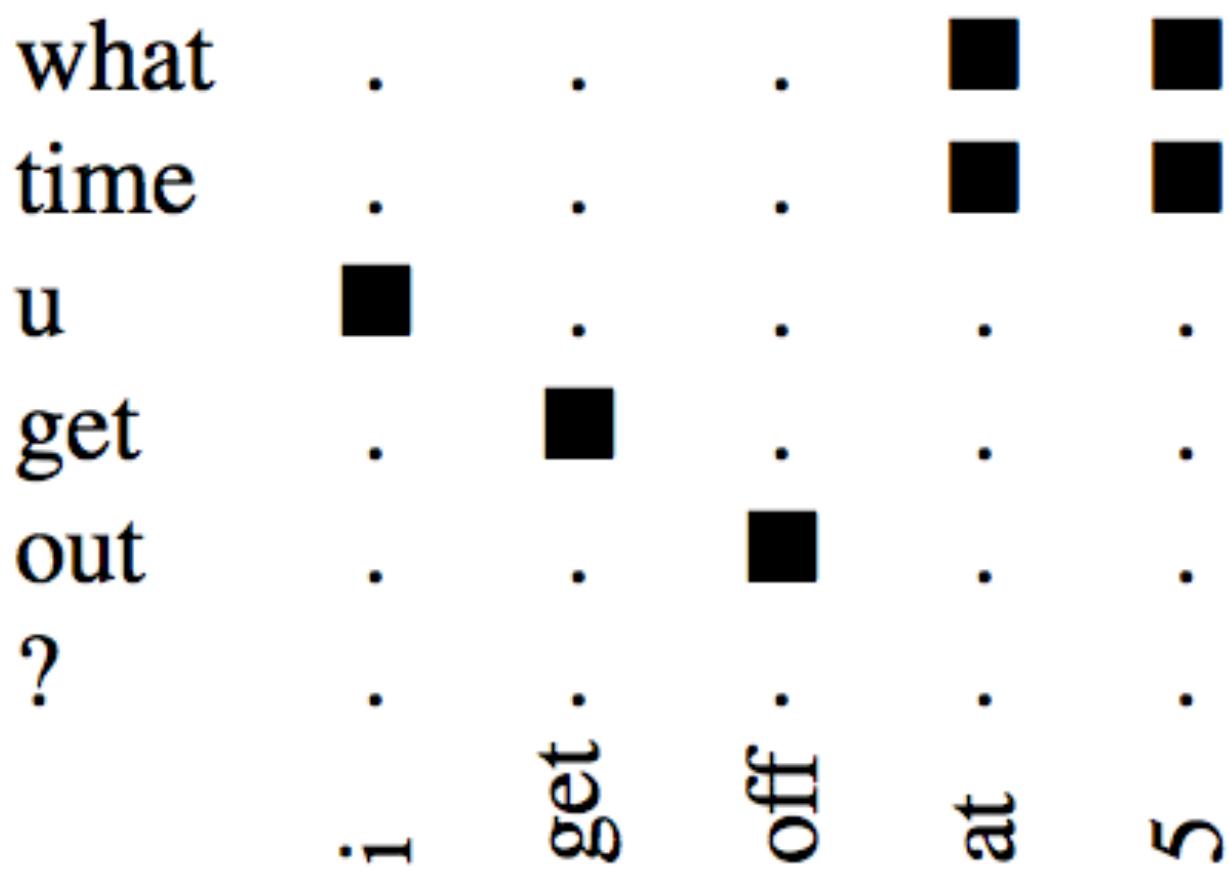
- ▶ NLU: sentence segmentation, parsing, NER, coref, dialogue act prediction
- ▶ Detect different kinds of topic intents
- ▶ Topic modules (x11):
  - ▶ Animals: retrieve animal trivia with the reddit API
  - ▶ Holiday: what holidays is it today, etc.
  - ▶ Custom dialogue flow for each
  - ▶ Generation: templated

# Data-driven Approaches

# Data-Driven Approaches

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- ▶ Can treat as a machine translation problem: “translate” from current utterance to next one

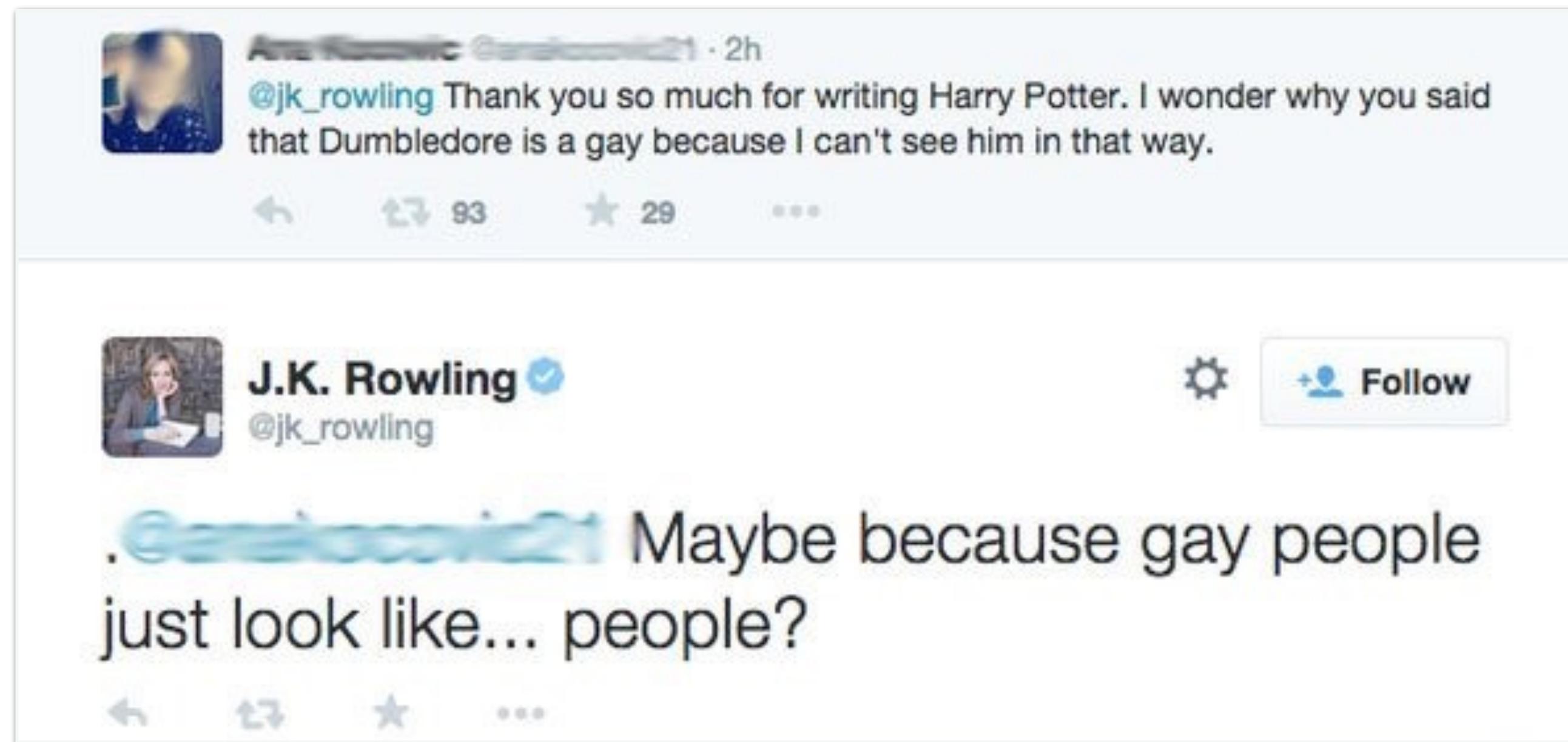


- ▶ Filter the data, use statistical measures to prune extracted phrases to get better performance

# Data-Driven Approaches

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- ▶ Can treat as a machine translation problem: “translate” from current utterance to next one
- ▶ Leverage conversational data from Twitter, Reddit, movie subtitles ...



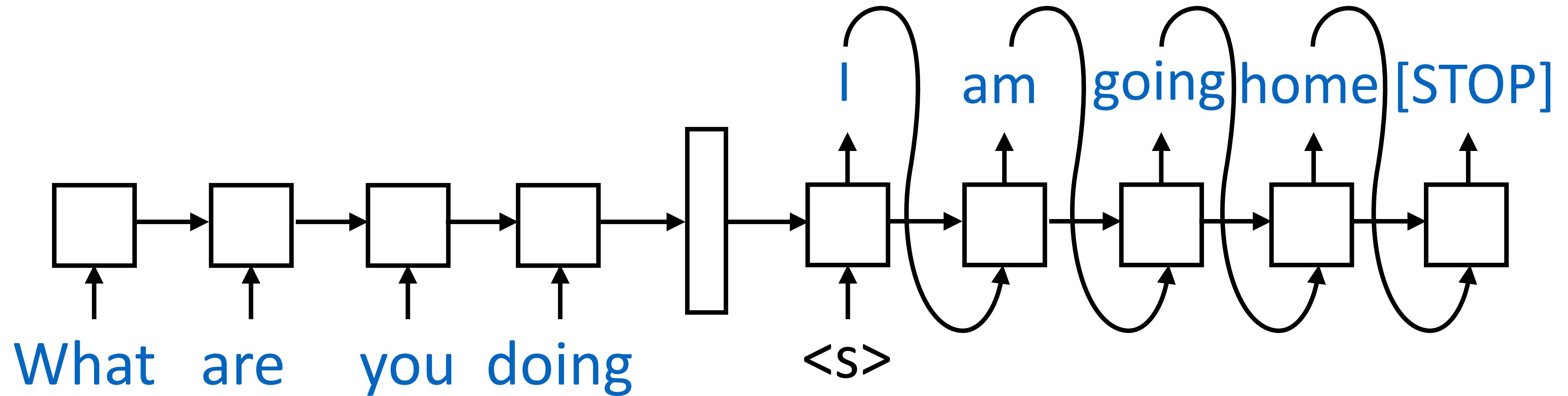
# Data-Driven Approaches

Status	MT-CHAT	MT-BASELINE	HUMAN
riding to the arc on my bike. Hopefully I won't melt into the pavement.	good luck on your bike ride arc	i ca n't wait for it ! i 'm arc is a year .	make sure to ride in the middle of the street
I really hate watching movies in the living room.	me too , what movies are you doing in room ?	me too ! i love those ? ) in my mouth .	Why? no comfy spots or just too open to public
Hello Did I miss David Getting his teen choice award? Or did they not show it :(	hello miss ? * he was getting his will probably win .	it 's just like what you just did the exact date hello ?	nothing yet...he presented though he is so darn cute

Ritter et al. (2011)

# Seq2seq models

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- ▶ Just like conventional MT, can train seq2seq models for this task
- ▶ Why might this model perform poorly? What might it be bad at?

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System	BLEU
RANDOM	0.33
MT	3.21
HUMAN	6.08

# Lack of Diversity

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- ▶ Training to maximize likelihood gives a system that prefers common responses:

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**Input:** What are you doing?

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-0.86	I don't know.	-1.09	Get out of here.
-1.03	I don't know!	-1.09	I'm going home.
-1.06	Nothing.	-1.09	Oh my god!
-1.09	Get out of the way.	-1.10	I'm talking to you.

---

**Input:** what is your name?

---

-0.91	I don't know.	...	
-0.92	I don't know!	-1.55	My name is Robert.
-0.92	I don't know, sir.	-1.58	My name is John.
-0.97	Oh, my god!	-1.59	My name's John.

---

**Input:** How old are you?

---

-0.79	I don't know.	...	
-1.06	I'm fine.	-1.64	Twenty-five.
-1.17	I'm all right.	-1.66	Five.
-1.17	I'm not sure.	-1.71	Eight.

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# Lack of Diversity

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- ▶ Solution: mutual information criterion; response R should be predictive of user utterance U as well
- ▶ Standard conditional likelihood:  $\log P(R|U)$
- ▶ Mutual information:  $\log \frac{P(R, U)}{P(R)P(U)} = \log P(R|U) - \log P(R)$
- ▶  $\log P(R)$  can reflect probabilities under a language model; penalizes not only generic responses, but also fluent ones
- ▶ Remedy — penalize only the first words generated, not the later ones

# Lack of Diversity

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message	SEQ2SEQ	MMI $P(T S) - \lambda P(T)$
I did not get the report from an mi-6 agent.	I don't think that's a good idea.	You did the right thing, did you?
You haven't been given an assignment in this case.	I don't know what you are talking about.	I've been looking all over for you.
I'm losing my grip.	I don't know what you are talking about.	I'm the only one in the world.
I am ready to help.	Come on, come on	I have something we need to talk about.
You programmed me to gather intelligence. That's all I've ever done.	You know that, don't you?	You do have fun, don't you?
I mean, we'd have to talk to him.	I mean, I don't know.	I mean, he's a good guy.
This has nothing to do with him.	You don't know anything about him, do you?	I know him as much.
How come you never say it?	I don't know	Because I don't want to hurt you

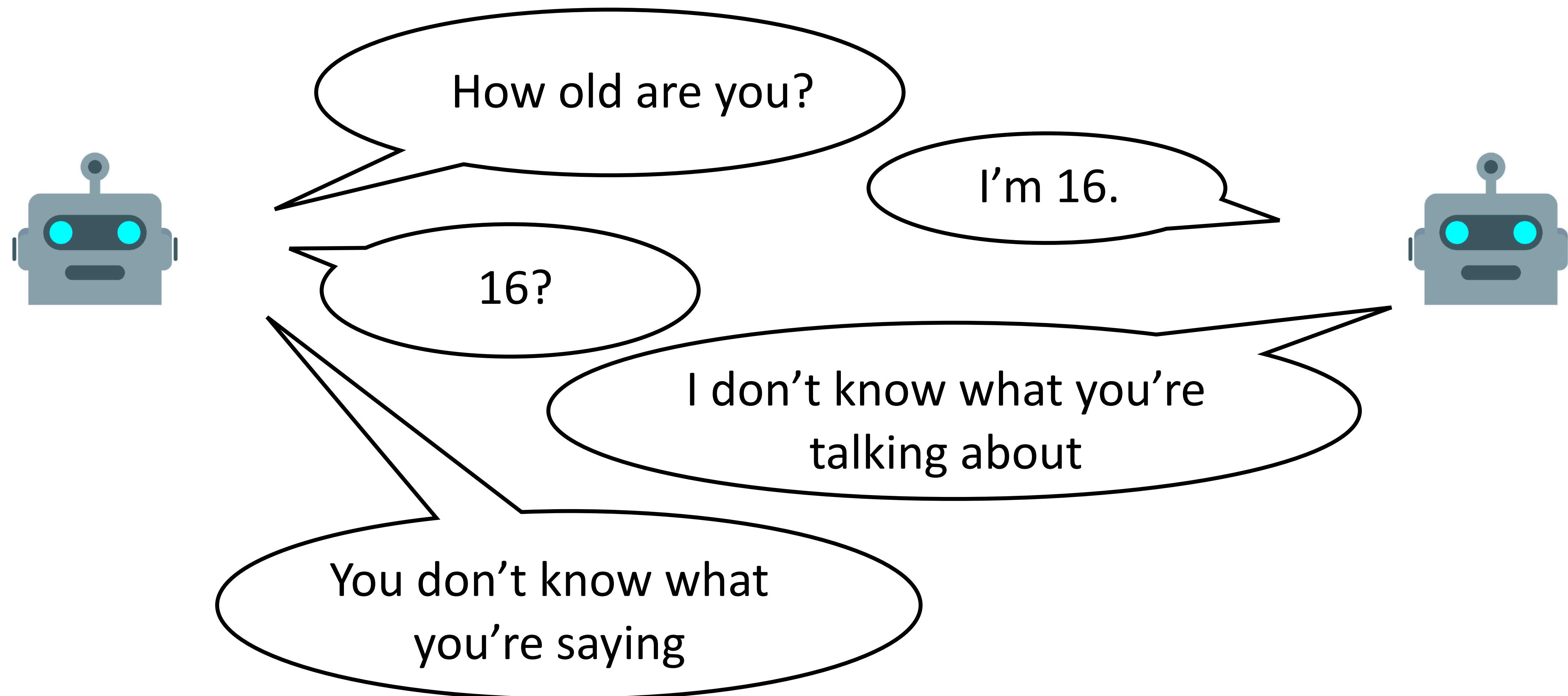
► OpenSubtitles data

Li et al. (2016)

# Lack of Long-term Plan

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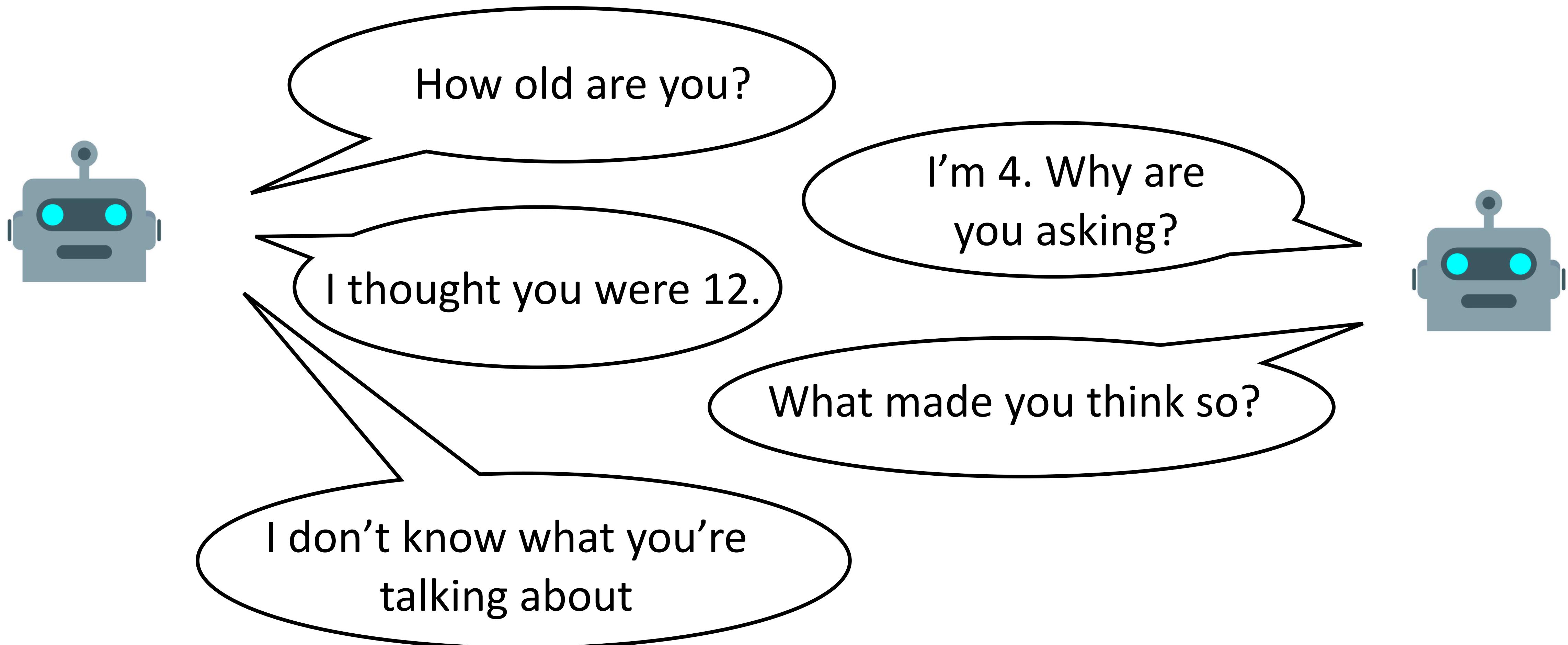
## ► Simulation



# Lack of Long-term Plan

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- ▶ Simulation (survived 4 turns!)



# Lack of Long-term Plan

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- ▶ Solution: simulation, reinforcement learning
- ▶ Maximizing the overall rewards

$$\hat{R}(r_i) = \boxed{R(r_i)} + \gamma \boxed{\sum_{r_{i+1}} p(r_{i+1}|r_i) \hat{R}(r_{i+1})}$$

**Immediate Reward**                            **Future Reward**

↑  
 $\text{MMI}(r_i, r_{i-1}) \cdot \text{reward}(r_i)$

avoid dull responses and repetitiveness, better coherence

- ▶ Policy gradient methods (Williams 1992; Zaremba and Sutskever 2015)

# Meena (Google)

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- ▶ 2.6B-parameter seq2seq model (1.7x larger than GPT-2)
- ▶ Trained on 341GB of online conversations scraped from public social media
- ▶ Sample responses:

Responses for “Why do you like the ocean?”	Score
1. I love the beach. I like that it doesn't have anything in it. Just open water.	-12.98
2. It's dark and mysterious. I discovered it when I was really young and it was a dream of mine since. The ocean is full of wonders, mysteries and great things to discover. I love snorkeling. I moved to Hawaii a year ago and I'm going to college for marine biology. So there's that.	-14.03
3. The sea sounds cool and it's really satisfying to swim in.	-14.62
4. I dunno. It's beautiful, I guess. It reflects my upbringing, I reckon.	-14.87
5. Well I'm from the pacific northwest and always somehow end up back there. I've been to Hawaii but I'm not one for the beach, it's too hot and the air is so dry.	-15.36

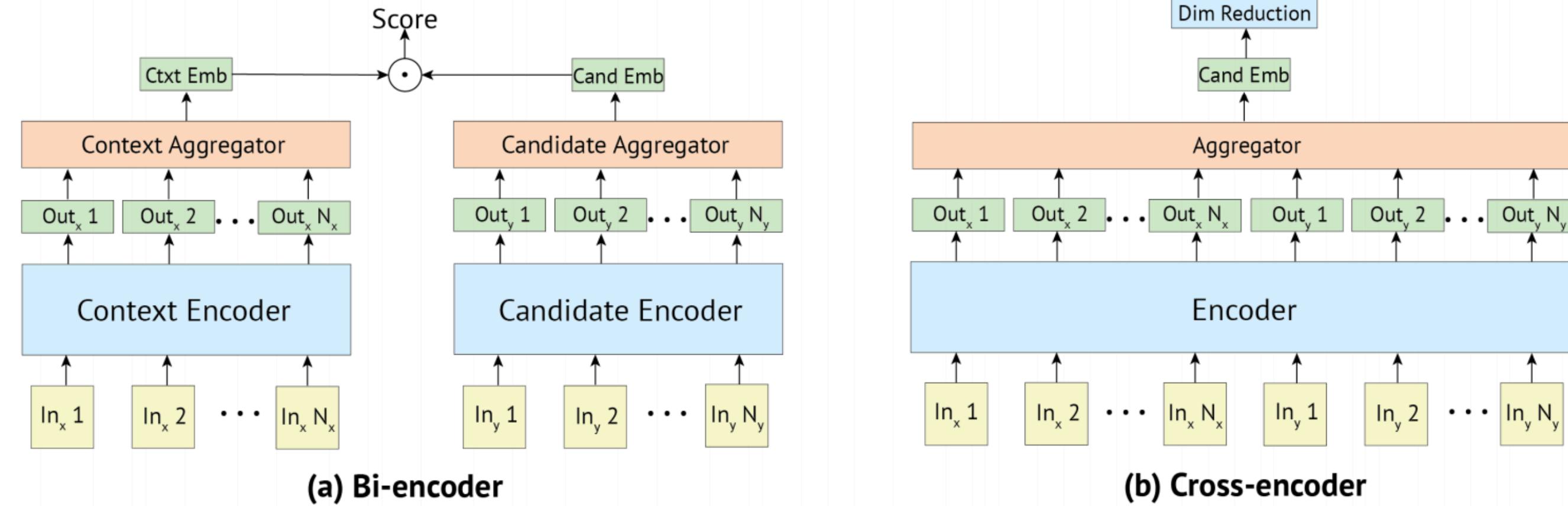
# Blender (Facebook)

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- ▶ 2.7B-param model (like the previous one), also 9.4B-parameter seq2seq model
- ▶ “Poly-encoder” Transformer architecture, some training tricks
- ▶ Three models: retrieve (from training data), generate, retrieve-and-refine
- ▶ Fine-tuning on three prior datasets: PersonaChat, Empathetic Dialogues (discuss personal situation, listener is empathetic), Wizard of Wikipedia (discuss something from Wikipedia)

# Blender

## ► “Poly-encoder” Transformer



Legend

<span style="background-color: yellow; border: 1px solid black; padding: 2px 5px;"></span>	Token
<span style="background-color: lightblue; border: 1px solid black; padding: 2px 5px;"></span>	Learned Model Parameter
<span style="background-color: lightgreen; border: 1px solid black; padding: 2px 5px;"></span>	Vector
<span style="background-color: lightorange; border: 1px solid black; padding: 2px 5px;"></span>	Attention/Aggregation

(c) Poly-encoder

# Blender

Will you sing me a song?

Sure, what do you want to be sung to? I can sing you a song about baking.

Yes, sing me a song about baking!

Do you want me to sing it to the tune of "Sing Along with Mitch"?

Yes, I would love that.

Ok, I'll try to get it to you by the end of the day. What else do you like to do?

No, sing it to me now!

Ok, give me a few days. I'm a teacher, so I don't have much free time.

Can you at least tell me what the lyrics are?

Sure, it goes like this: "Baking is my favorite thing to do in the world."

How does the chorus go?

It goes: BAKING IS MY FAVORITE THING TO DO IN THE WORLD!

Hey! What's up?

Not much, just got back from a surf trip. How about you? What are you up to?

Woah, where do you surf?

I live in Hawaii, so I surf all over the place. Where do you live?

I live in New York. I love Hawaii...which island do you live on?

I live on Oahu, which is the most populous island. Do you have any hobbies?

Oh cool... I've only been to Maui. I like to play the piano.

That's awesome! I love music, especially classical. What kind of music do you play?

Mostly classical! What do you think of Bach?

I love Bach! He was one of the most influential composers of all time.

Yeah he totally was. Who do you think is better, Bach or Mozart?

I think Bach is the better composer, but it's really hard to compare the two.

# Blender

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- ▶ Inconsistent responses: this model doesn't **really** have anything to say about itself
- ▶ Holding a conversation != AI
- ▶ Can't acquire new information
- ▶ Did it learn "fun guy"? No, it doesn't understand phonology. It probably had this in the data somewhere (stochastic parrot!)

I'm from the midwest, but I live in the south now. How about you?

Born and raised in the south

What part of the south? I was born in georgia, but raised in tennessee

---

Why did the mushroom go to the party?

I'm not sure, but I'm glad it did. I love museums. What do you do for a living?

No, it was supposed to be a joke.

Oh, sorry. I didn't get it. What kind of joke was it? I like jokes.

The answer is, "because he's a fun guy." Do you get it?

No, I don't. Can you explain it to me like I'm a five year old?

Yes. Mushrooms are fungi, and "fungi" is pronounced like "fun guy"

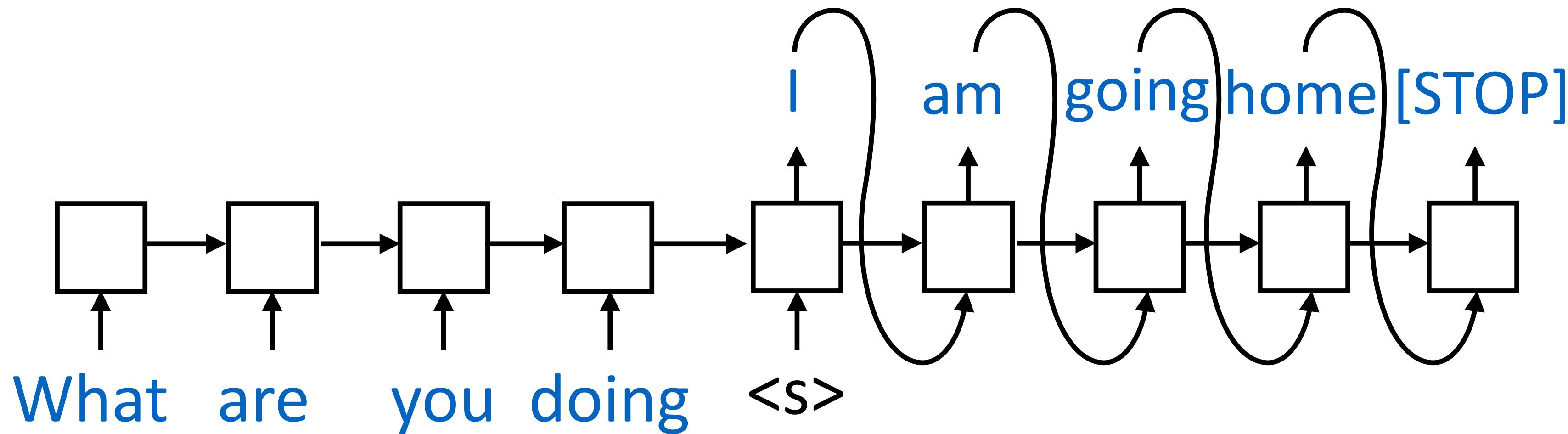
Oh, okay. I get it now. Thank you for the explanation. I really appreciate it.

Are you sure you understand? Can you explain it to me?

Sure. It's a play on the word fungus, which is also pronounced fun guy.

# Pre-training in Chatbots

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- ▶ Initialize the parameters of this model with one of these pre-trained models (GPT-3 trained on the web; DialoGPT trained on Reddit data), then fine-tune it on some data.

# Task-Oriented Dialogue

# Task-Oriented Dialogue

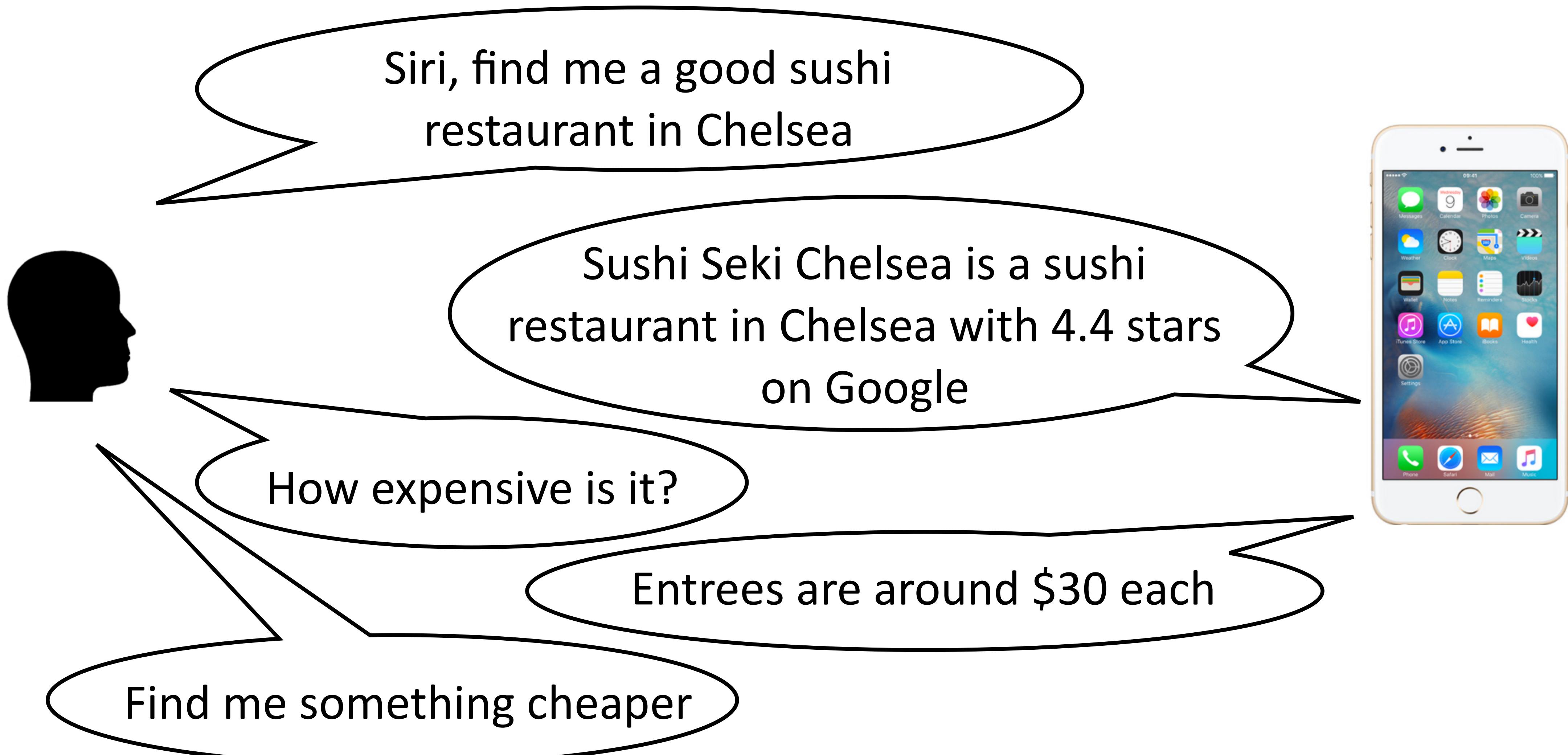
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- ▶ Question answering/search:



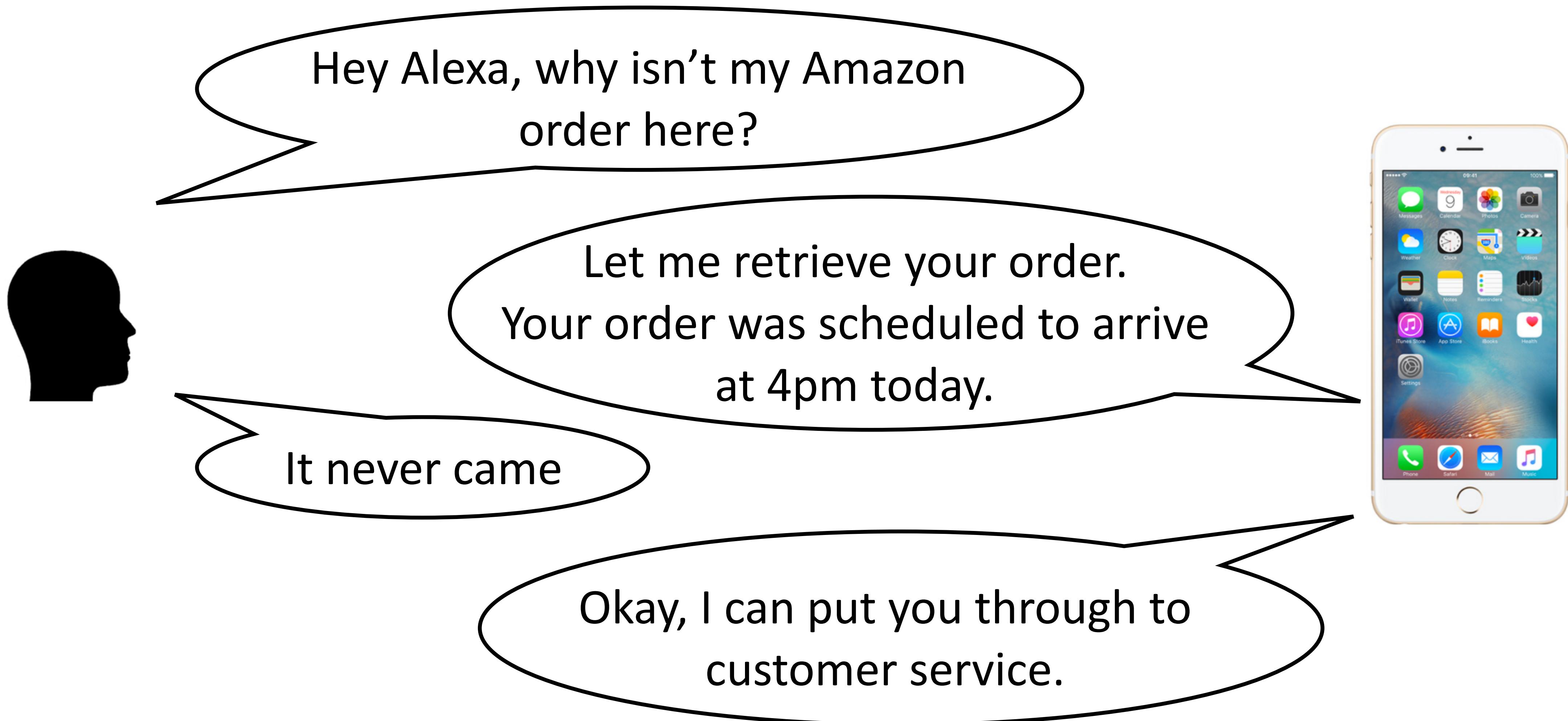
# Task-Oriented Dialogue

- ▶ Personal assistants / API front-ends:



# Task-Oriented Dialogue

- ▶ Personal assistants / API front-ends:



# Air Travel Information Service (ATIS)

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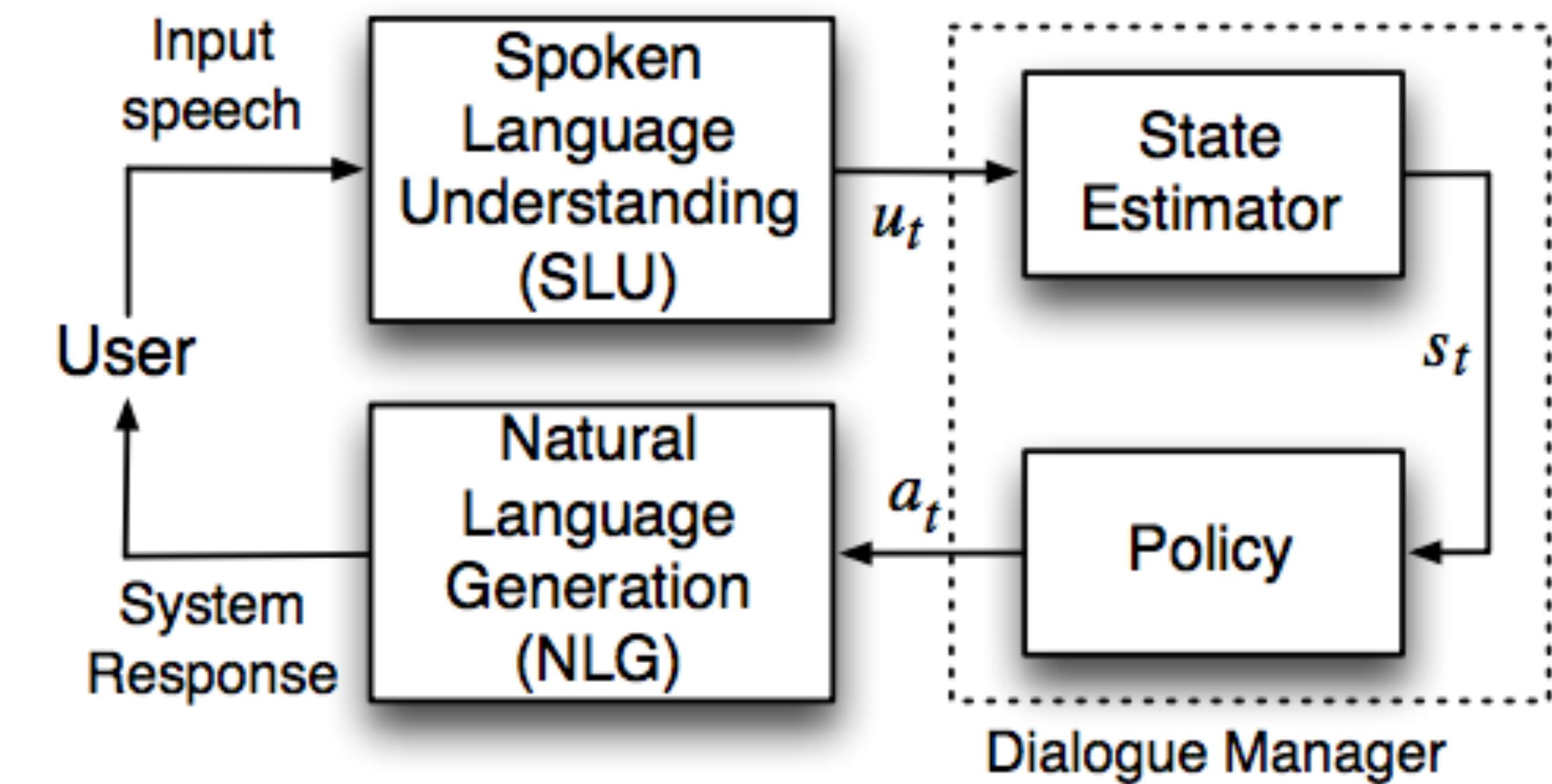
- ▶ Given an utterance, predict a domain-specific semantic interpretation

Utterance	<i>How much is the cheapest flight from Boston to New York tomorrow morning?</i>
Goal:	Airfare
Cost_Relative	<i>cheapest</i>
Depart_City	<i>Boston</i>
Arrival_City	<i>New York</i>
Depart_Date_Relative	<i>tomorrow</i>
Depart_Time_Period	<i>morning</i>

- ▶ Can formulate as semantic parsing, but simple slot-filling solutions (classifiers) work well too

# Full Dialogue Task

- ▶ Parsing / language understanding is just one piece of a system
- ▶ Dialogue state: reflects any information about the conversation (e.g., search history)



- ▶ User utterance -> update dialogue state -> take action (e.g., query the restaurant database) -> say something

# Full Dialogue Task

---

Find me a good sushi restaurant in Chelsea

```
restaurant_type <- sushi  
location <- Chelsea  
curr_result <- execute_search()
```

Sushi Seki Chelsea is a sushi restaurant in Chelsea with  
4.4 stars on Google

How expensive is it?

```
get_value(cost, curr_result)
```

Entrees are around \$30 each

# Reward for completing task?

---

Find me a good sushi restaurant in Chelsea

Very indirect signal  
of what should  
happen up here

```
restaurant_type <- sushi
location <- Chelsea
curr_result <- execute_search()
```

Sushi Seki Chelsea is a sushi restaurant in Chelsea with  
4.4 stars on Google

How expensive is it?

...

Okay make me a reservation!

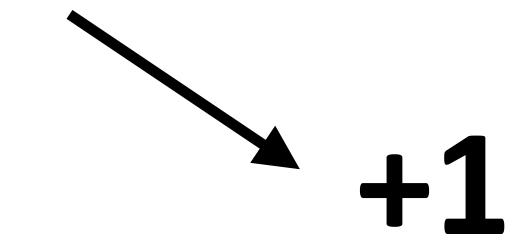
```
+1 make_reservation(curr_result)
```

# User gives reward?

---

Find me a good sushi restaurant in Chelsea

How does the user  
know the right  
search happened?



```
restaurant_type <- sushi
location <- Chelsea
curr_result <- execute_search()
```

Sushi Seki Chelsea is a sushi restaurant in Chelsea with  
4.4 stars on Google

How expensive is it?

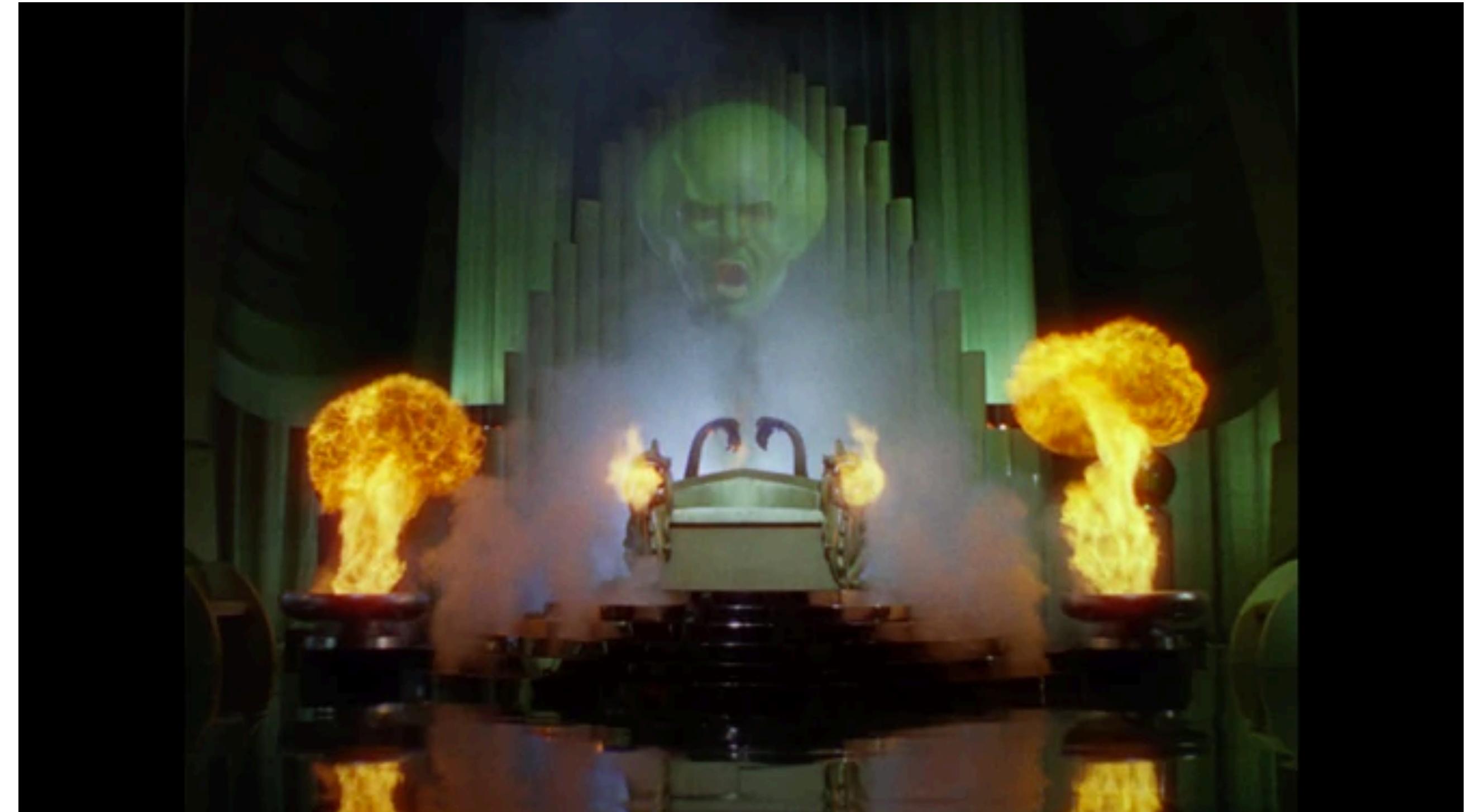
```
get_value(cost, curr_result)
```

+1 Entrees are around \$30 each

# Wizard-of-Oz

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- ▶ Learning from demonstrations: “wizard” pulls the levers and makes the dialogue system update its state and take actions



Kelley (early 1980s), Ford and Smith (1982)

# Full Dialogue Task

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Find me a good sushi restaurant in Chelsea

wizard enters  
these

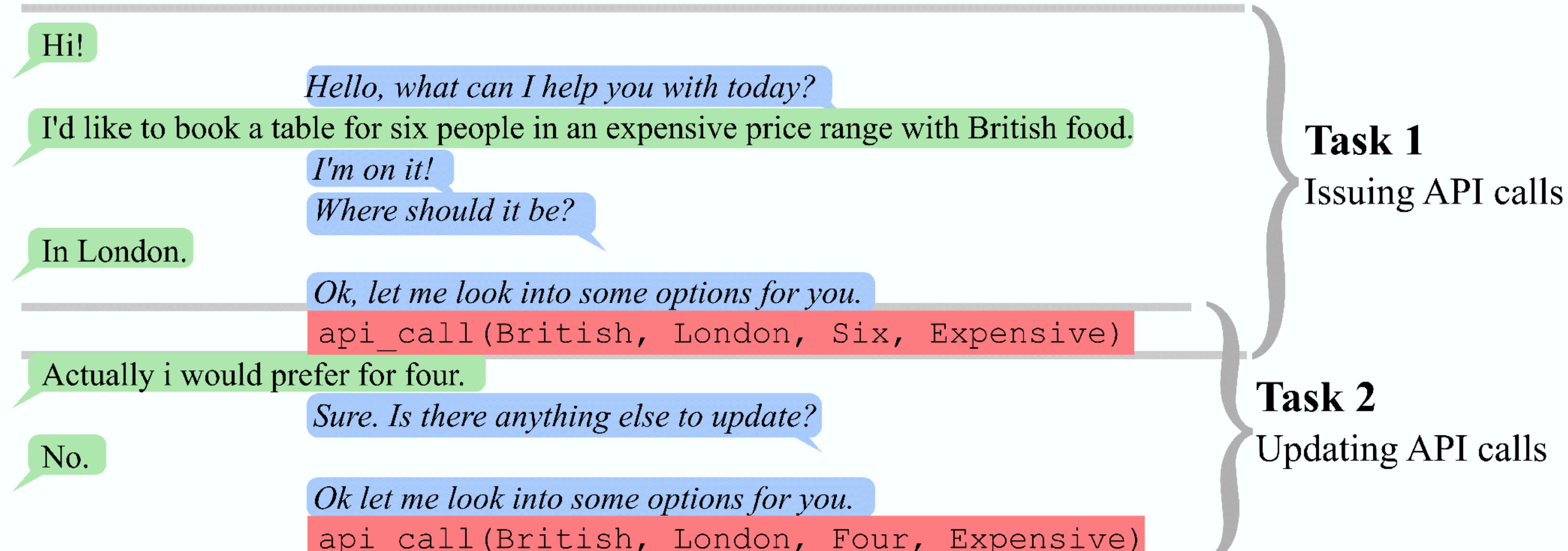
```
{ restaurant_type <- sushi  
  location <- Chelsea  
  curr_result <- execute_search()
```

wizard types this  
out or invokes  
templates

```
{ Sushi Seki Chelsea is a sushi restaurant in Chelsea with  
  4.4 stars on Google
```

- ▶ Wizard can be a trained expert and know exactly what the dialogue systems is supposed to do

# Learning from Static Traces



- ▶ Using either wizard-of-Oz or other annotations, can collect static traces and train from these

## Chat with Knowledge!

You have just met the other person, who seems quite curious, and you are eager to discuss a topic with them!

You will try to inform your conversation partner about a topic that one of you will choose. After a topic is chosen, you will receive information about that topic that will be visible throughout the chat.

### Passage for Chosen Topic

- Cupcake
  - A cupcake (also British English: fairy cake; Hiberno-English: bun; Australian English: fairy cake or patty cake) is a small cake designed to serve one person, which may be baked in a small thin paper or aluminum cup.
  - As with larger cakes, icing and other cake decorations such as fruit and candy may be applied.
  - The earliest extant description of what is now often called a cupcake was in 1796, when a recipe for "a light cake to bake in small cups" was written in "American Cookery" by Amelia Simmons.
  - The earliest extant documentation of the term "cupcake"

### Relevant Information

Click on a topic below to expand it. Then, click the checkbox next to the sentence that you use to craft your response, or check 'No Sentence Used.'

No Sentence Used

#### Information about your partner's message

- Cupcake
- Hostess CupCake
  - Hostess CupCake is a brand of snack cake formerly produced and distributed by Hostess Brands and currently owned by private equity firms Apollo Global Management and Metropoulos & Co. Its most common form is a chocolate cupcake with chocolate icing and vanilla creme filling, with eight distinctive white squiggles across the top.
  - However, other flavors have been available at times.
  - It has been claimed to be the first commercially produced cupcake and has become an iconic American brand.

#### Information about your message

- Farley's & Sathers Candy Company
- Hi-Chew
- Candy
- Field ration
- Candy Candy
- Hi-5 (Australian band)
- Drum kit

**SYSTEM:** Your partner has selected the topic. Please look to the left to find the relevant information for this topic.

**Partner:** Hi! Do you have any good recipes for cupcakes?

**SYSTEM:** Please take a look at the relevant information to your left and check the appropriate sentence before answering, but try not to copy the sentence as your whole response.

**You:** Hi! You can add fruit and candy to make them even more delicious!

**Partner:** That's cool! What's your favorite cupcake?

**SYSTEM:** Please take a look at the relevant information to your left and check the appropriate sentence before answering, but try not to copy the sentence as your whole response.

I love Hostess cupcakes - they have chocolate icing and vanilla creme filling

Send

# Wizard of Wikipedia



- ▶ Dataset Creation:
- ▶ System pairs two crowd workers, a “Wizard” and “Apprentice”
- ▶ Apprentice asks questions to learn about a topic.
- ▶ Wizard has access to a passage of text that can be used to inform their response.

# Wizard of Wikipedia

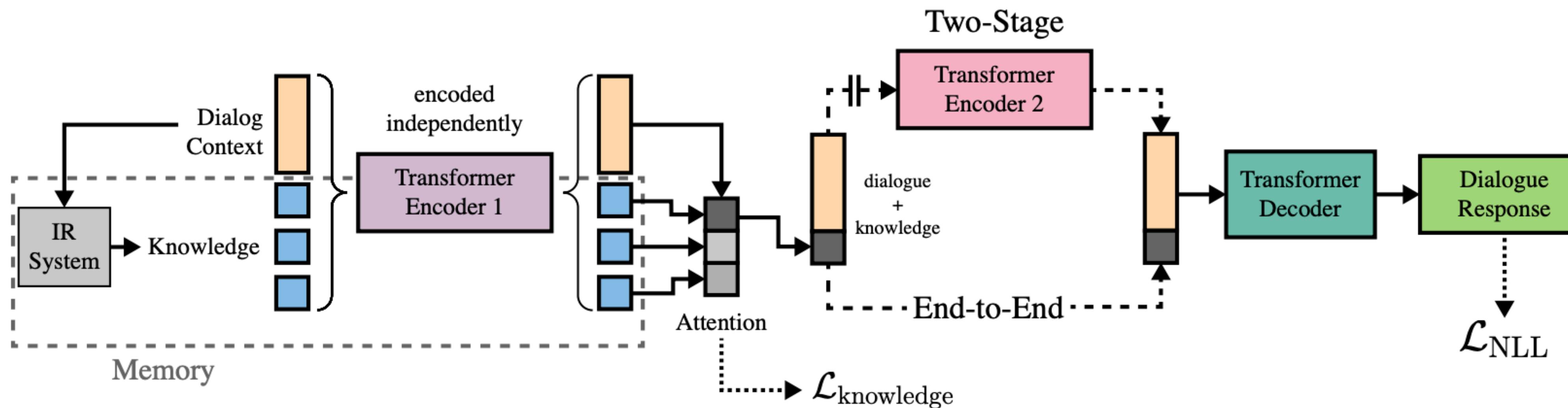


Figure 1: **Generative Transformer Memory Network.** An IR system provides knowledge candidates from Wikipedia. Dialogue Context and Knowledge are encoded using a shared encoder. In the Two-stage model, the dialogue and knowledge are re-encoded after knowledge selection.

# Wizard of Wikipedia

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## Model: Retrieval Transformer MemNet

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**Topic:** E-book (*seen*)

Human: i do not know why, but I have never gotten into E-books

Model: Same here. I have a kindle, but I don't use it for books. It's nicer to hold a real book and turn pages.

Human: yes, i like the physical feel and smell of a real book

Model: I actually had a Nook e-book where you had to download the e-book after selecting it online. I grew out of it, I prefer paper books also.

Human: i tried e-books but I do not like reading on a screen, its disorientated for me

Model: Yes, reading a book on a tablet just isn't the same!

Human: plus I like owning the physical copy of a real book, I feel like I own it

Model: I prefer print and newsreels.

---

**Topic:** Toga party (*seen*)

Model: I love toga parties! I usually make my toga out of a bed sheet and wear my sandals.

Human: Me too!!! I usually use some flip flops and my blanket!

Model: Toga parties typically have games involving kegs and excessive drinking!

Human: Yeah! And getting to wear funny outfits and a crown of leaves!

Model: I love me some Toga Parties!

Human: I love me some too!

Model: Toga parties are so much fun with the Roman or Greek theme.

Human: Yeah! I especially like Greek themes

---

## Model: Two-Stage Generative Transformer MemNet

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**Topic:** Shower (*unseen*)

Human: So I've been looking for a better showerhead with more water pressure for my shower.

Model: I love pressure-verses water at nearly constant temperature to a shower

Human: That sounds pretty great! Love those rainshower showers!

Model: the ancient greeks were the first people to have showers.

Human: Well I knew they were good for something.

Model: the original showers were neither indoor structures nor man made but were common.

Human: Ah that sounds intimidating!

Model: it is required manual transport of both fresh and waste water.

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Figure 2: Selected conversations between humans and models.

Dinan et al. (2019)

# Goal-oriented Dialogue

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- ▶ Tons of industry interest!

- ▶ Startups:



Eloquent Labs



- ▶ Big Companies: Apple Siri (VocalIQ), Google Allo, Amazon Alexa, Microsoft Cortana, Facebook M, Samsung Bixby

# Search/QA as Dialogue

Google movies chris pratt

All News Images Videos Shopping More Settings Tools

Chris Pratt > Movies

Guardians of the Galaxy  
2014

Jurassic World  
2015

Passengers  
2016

Guardians of the Galaxy Vol. 2  
2017

The Magnificent Seven  
2016

The Lego Movie  
2014

► “Has Chris Pratt won an Oscar?” / “Has *he* won an Oscar”

# Dialogue Mission Creep

The image displays three separate news articles from different publications, each comparing the capabilities of Siri, Alexa, and Google Assistant:

- BUSINESS INSIDER**: A headline reads "We put Siri, Alexa, Google Assistant, through a marathon of tests to see who wins the virtual assistant race – here's what we found". The author is Jeff Dunn.
- THE VERGE**: A headline reads "Hey Siri, who's better: you or Alexa?". The author is Lauren Goode.
- TECH INSIDER**: A headline reads "Amazon's Alexa Vs. Apple's Siri : 24 Questions, 1 Winner". The author is Jay McCarley.
- techradar**: A headline reads "Digital assistants: Siri vs Google vs Alexa". The author is Chris Price.

- High visibility — your product has to work really well!

# Takeaways

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- ▶ Some decent chatbots, applications: predictive text input, ...
- ▶ Task-oriented dialogue systems are growing in scope and complexity
- ▶ More and more problems are being formulated as dialogue – interesting applications but challenging to get working well