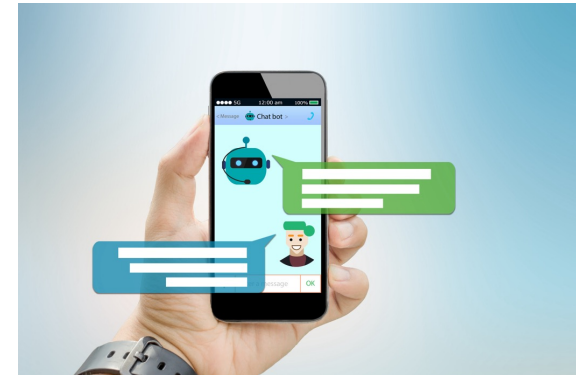
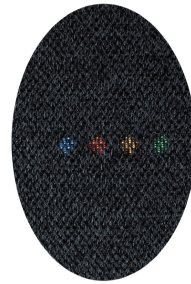




Dialogue Systems and Chatbots

Natalie Parde

UIC CS 421



What is a dialogue system?

- Broadly speaking, a program that can communicate with users
 - This may be through speech, text, or both
- Often also referred to as **chatbots** or **conversational agents**

Types of Dialogue Systems

U: Hey

A: Hi, **how are you?**

U: I'm doing good,
how are you?

A: **I'm doing good
as well. Would you
like me to help you
reserve a room for
your meeting?**

- **Task-Oriented:** Designed to leverage conversational interactions to help users complete tasks
- **Conversational Chatbots:** Designed to carry out extended, unstructured conversations (similar to human chats)
- Many recent dialogue systems contain elements of both categories

Dialogue systems are an increasingly prominent tool in modern life.

PA Hey, how are you?

Hello! I'm just a computer program, so I don't have feelings, but I'm here and ready to help you with any questions or tasks you have. How can I assist you today?

PA Can you give me some examples of how dialogue systems are an increasingly prominent tool in modern life? Please provide them in a bullet-point list.

8/29/24



Of course! Dialogue systems have become increasingly prominent in modern life and are utilized in various contexts. Here are some examples:

- **Virtual Assistants:**
 - Virtual assistants like Siri, Google Assistant, and Alexa use dialogue systems to understand and respond to user queries, perform tasks, and provide information.
- **Customer Support:**
 - Many companies use chatbots on their websites to provide instant customer support, answer common questions, and guide users through troubleshooting processes.
- **Healthcare:**
 - Dialogue systems are employed in telemedicine platforms to collect patient information, schedule appointments, and offer basic medical advice.
- **Education:**
 - Intelligent tutoring systems use dialogue systems to interact with students, provide personalized learning experiences, and offer explanations for various subjects.
- **Language Learning:**
 - Language learning apps often incorporate dialogue systems to simulate conversations, allowing users to practice speaking and comprehension in a new language.
- **Entertainment:**
 - Video games frequently employ dialogue systems to create dynamic interactions between players and non-player characters (NPCs), enhancing the immersive experience.
- **Smart Home Devices:**
 - Devices like smart thermostats and smart lights can be controlled through dialogue systems, enabling users to adjust settings using voice commands.
- **Business Applications:**
 - Dialogue systems are used in business settings for tasks such as scheduling meetings, sending reminders, and managing to-do lists.
- **Automotive Systems:**
 - Many modern vehicles feature voice-activated dialogue systems for tasks like navigation, making phone calls, and controlling in-car entertainment.
- **Accessibility:**
 - Dialogue systems contribute to improving accessibility for individuals with disabilities by enabling voice-controlled interactions with technology.
- **Language Translation:**
 - Some applications use dialogue systems to facilitate real-time language translation, allowing users to communicate across language barriers.
- **Psychological Support:**
 - Dialogue systems have been explored for providing mental health support through interactive conversations and interventions.
- **Virtual Collaboration:**
 - In virtual reality environments, dialogue systems can enhance collaboration by enabling avatars to communicate and interact with users naturally.

These examples showcase the diverse ways in which dialogue systems have become an integral part of our modern lives, transforming the way we interact with technology and each other.



**Dialogue
system
design and
development
has evolved
over time.**

- Today, we'll examine:
 - Conversation structure
 - Early rule-based dialogue system development
 - Modern shift to corpus-based methods
 - Pipelined components in a dialogue state architecture
 - Methods for evaluating dialogue systems
 - Ethical issues in dialogue system design



Today's Topics

- Today, we'll examine:

- ~~Star~~ Conversation structure
- Early rule-based dialogue system development
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- Methods for evaluating dialogue systems
- Ethical issues in dialogue system design

Properties of Human Conversation

- **Turns:** Individual contributions to the dialogue
 - Typically a sentence, but may be shorter (e.g., a single word) or longer (e.g., multiple sentences)
- To determine when to start and stop talking, dialogue systems must perform accurate **turn detection** (sometimes known as **endpoint detection**)



Turn

Natalie: Hi, I would like to order thirteen buckets of cheesy popcorn.

Salesperson: Um okay when do you need those?

Natalie: I want to bring them to a party on Saturday.

Salesperson: And what size buckets would you like?

Natalie: Extra large.

Salesperson: Okay, our cheesy popcorn is really popular. Would you be okay with six buckets of cheesy popcorn and seven buckets of caramel popcorn?

Natalie: No.

Salesperson: Okay, what about some of our other flavors? We have ranch-flavored popcorn--

Natalie: I'll take that. Eight buckets of ranch-flavored popcorn and five buckets of cheesy popcorn.

Salesperson: Okay.

Natalie: Actually, wait. Seven buckets of ranch and six buckets of cheesy popcorn, still all in extra large.

Salesperson: Okay, we will have seven extra-large buckets of ranch-flavored popcorn and six extra-large buckets of cheesy popcorn ready for you to pick up on Friday.

Properties of Human Conversation

- **Speech Acts:** Types of actions performed by the speaker within a turn
 - Also referred to as **dialogue acts**
- May be grouped into many categories:

Natalie: Hi, I would like to order thirteen buckets of cheesy popcorn.

Salesperson: Um okay when do you need those?

Natalie: I want to bring them to a party on Saturday.

Salesperson: And what size buckets would you like?

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Properties of Human Conversation

- **Speech Acts:** Types of actions performed by the speaker
 - Also referred to as **dialogue acts**
- May be grouped into many categories:
 - **Constatives: Making a statement**
 - Answering
 - Claiming
 - Confirming
 - Denying
 - Disagreeing
 - Stating

Natalie: Hi, I would like to order thirteen buckets of cheesy popcorn.

Salesperson: Um okay when do you need those?

Natalie: I want to bring them to a party on Saturday.

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Properties of Human Conversation

- **Speech Acts:** Types of actions performed by the speaker
 - Also referred to as **dialogue acts**
- May be grouped into many categories:
 - Constatives: Making a statement
 - **Directives: Attempting to get the addressee to do something**
 - Advising
 - Asking
 - Forbidding
 - Inviting
 - Ordering
 - Requesting


 **Natalie:** Hi, I would like to order thirteen buckets of cheesy popcorn.

 **Salesperson:** Um okay when do you need those?


Natalie: I want to bring them to a party on Saturday.

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Properties of Human Conversation

- **Speech Acts:** Types of actions performed by the speaker
 - Also referred to as **dialogue acts**
- May be grouped into many categories:
 - Constatives: Making a statement
 - Directives: Attempting to get the addressee to do something
 - **Commissives: Committing the speaker to a future action**
 - Promising
 - Planning
 - Vowing
 - Betting
 - Opposing

Natalie: Hi, I would like to order thirteen buckets of cheesy popcorn.

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Properties of Human Conversation

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 - Also referred to as **dialogue acts**
- May be grouped into many categories:
 - Constatives: Making a statement
 - Directives: Attempting to get the addressee to do something
 - Commissives: Committing the speaker to a future action
 - **Acknowledgements:** Expressing the speaker's attitude regarding some social action
 - Apologizing
 - Greeting
 - Thanking
 - Accepting

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Properties of Human Conversation

- Some turns are used entirely or partially to establish **common ground** between speakers
- **Grounding:** Acknowledging shared understanding
 - Saying “okay”
 - Repeating what the other speaker said
 - Using implicit signals of understanding like “and” at the beginning of an utterance

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Properties of Human Conversation

- Turns can be grouped to describe conversation structure:
 - **Adjacency pairs** are dialogue acts that naturally appear together
 - First pair part: Question
 - Second pair part: Answer
- They can be separated by side sequences or **subdialogues**

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Who has the power in a conversation?



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- Generally, the speaker asking questions has the **conversational initiative**
- In everyday dialogue, most interactions are **mixed-initiative**
 - Participants sometimes ask questions, and sometimes answer them

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Conversational Initiative in Dialogue Systems

- Although normal in human-human conversations, mixed-initiative dialogue is very difficult for dialogue systems to achieve!
- Question answering systems (e.g., “Alexa, what’s the weather like right now?”) are **user-initiative** systems
- **System-initiative** can be both helpful (plenty of guidance) and frustrating

Salesperson: Which variety of caramel popcorn would you like?

Natalie: I don’t want caramel popcorn.

Salesperson: Which variety of caramel popcorn would you like?

Natalie: Can I quit?

Salesperson: Which variety of caramel popcorn would you like?

Natalie: Um, regular.

Conversational Initiative in Dialogue Systems

User Initiative

what types of popcorn do you have available?

We offer a wide variety of popcorn to satisfy every taste! Here's what we have available:

Classic Flavors

- **Butter Popcorn:** The classic movie theater favorite, buttery and delicious.
- **Cheese Popcorn:** Coated with rich cheddar cheese for a savory snack.
- **Caramel Popcorn:** Sweet and crunchy, with a golden caramel coating.

Gourmet Flavors

- **Kettle Corn:** A perfect balance of sweet and salty.
- **White Cheddar Popcorn:** Light and airy popcorn with a creamy white cheddar flavor.
- **Cinnamon Sugar Popcorn:** A sweet treat with a warm cinnamon flavor.

Specialty Popcorn

- **Chocolate Drizzle Popcorn:** Popcorn drizzled with milk or dark chocolate.
- **Spicy Jalapeño Popcorn:** A bold, spicy flavor for those who like a kick.
- **Truffle Popcorn:** Infused with the earthy richness of truffle oil.

Healthy Options

- **Lightly Salted Popcorn:** A low-calorie option with just a touch of salt.
- **Air-Popped Popcorn:** No oil, just pure popped corn.
- **Vegan Popcorn:** Flavored with nutritional yeast for a cheesy, savory taste without any dairy.

Would you like more details on any of these flavors or need help placing an order?

System Initiative

welcome! based on your interest, i can guide you through our popcorn options. we have a range of flavors, from classic favorites to gourmet treats. let's start with the basics:

Classic Flavors

- **Butter Popcorn:** The traditional buttery delight.
- **Cheese Popcorn:** A savory snack with cheddar cheese.
- **Caramel Popcorn:** Sweet, with a rich caramel coating.

Would you like to explore our **Gourmet Flavors**, **Specialty Popcorn**, or perhaps our **Healthy Options** next?

I'd like to explore Specialty Popcorn

Great choice! Our **Specialty Popcorn** is perfect for those looking for something unique and exciting. Here's what we offer:

- **Chocolate Drizzle Popcorn:** Popcorn drizzled with rich milk or dark chocolate, ideal for those with a sweet tooth.
- **Spicy Jalapeño Popcorn:** A bold, spicy option with a kick of jalapeño, perfect if you like some heat in your snack.
- **Truffle Popcorn:** Luxuriously infused with the earthy richness of truffle oil, offering a gourmet experience.

Would you like to try one of these, or are you interested in learning about our other options?

Dialogue system designers try to incorporate the human conversation characteristics we've covered into their systems!

turns

dialogue acts

grounding

adjacency pairs

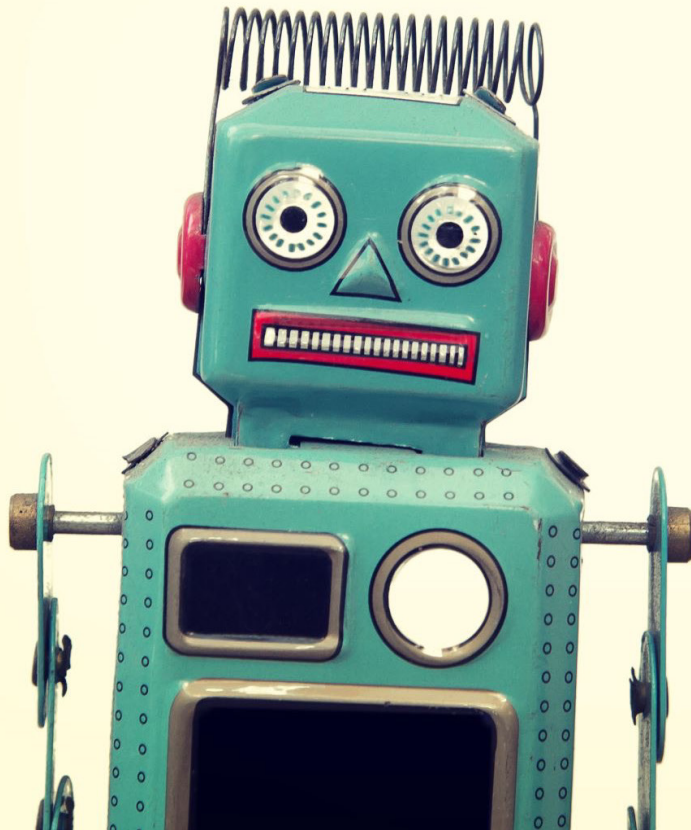
user initiative

system initiative



Today's Topics

- Today, we'll examine:
 - Conversation structure
 - ✱ • Early rule-based dialogue system development
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 - Ethical issues in dialogue system design



Rule-based chatbots....

- Can be used for entertainment or practical purposes
- Interpret and respond to input using an often-complex set of rules

Rule-based Chatbots

Example: ELIZA

- Rogerian psychologist (reflects patients' statements right back at them)
- Pretends (🙄) to know almost nothing about the world
 - Common position for chatbots trying to pass the Turing Test ...users may assume that the chatbot is pretending to know nothing to fulfill a conversational goal

U: Men are all alike.

E: IN WHAT WAY

U: They're always bugging us about something or other.

E: CAN YOU THINK OF A SPECIFIC EXAMPLE

U: Well my boyfriend made me come here.

E: YOUR BOYFRIEND MADE YOU COME HERE

U: He says I'm depressed much of the time.

E: I AM SORRY TO HEAR YOU ARE DEPRESSED

Rule-based Chatbots

- ELIZA works by **matching patterns** and **transforming slots** from those patterns into responses
 - (. * [yY][oO][uU] . * [mM][eE]) → (WHAT MAKES YOU THINK I 3 YOU)
 - You hate me → WHAT MAKES YOU THINK I HATE YOU
- Each pattern used by ELIZA is based on ranked **keyword(s)** that might occur in users' sentences

Rule-based Chatbots

- What if no keywords are matched in an input?
 - ELIZA accesses facts from memory or defaults to a non-committal response
 - PLEASE GO ON
 - THAT'S VERY INTERESTING
 - I SEE

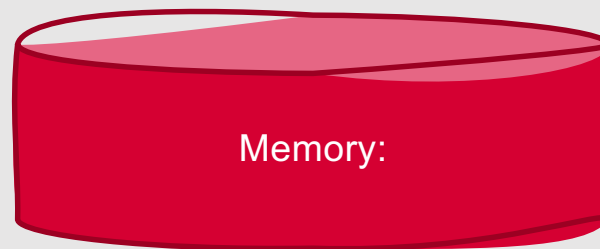


Example: ELIZA

Men are all alike.



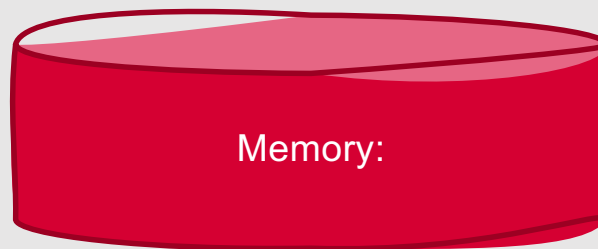
Rule	Rank
(I .*) → (YOU SAY YOU 2)	2
(I'm .*) → (I AM SORRY TO HEAR THAT YOU ARE 2)	1
(my .*) → (YOUR 2)	1
(.* always .*) → CAN YOU THINK OF A SPECIFIC EXAMPLE	1
(.*) → IN WHAT WAY	3
(.* my .*) → (DOES THAT HAVE ANYTHING TO DO WITH THE FACT THAT YOUR 3)	(Memory)



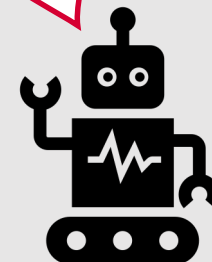
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Men are all alike.



IN WHAT WAY



Example: ELIZA

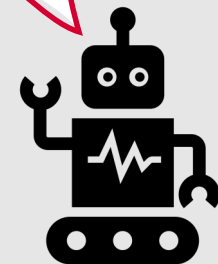
They're always bugging us about something or other.



Rule	Rank
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Memory:

CAN YOU THINK OF A SPECIFIC EXAMPLE

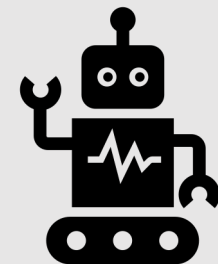
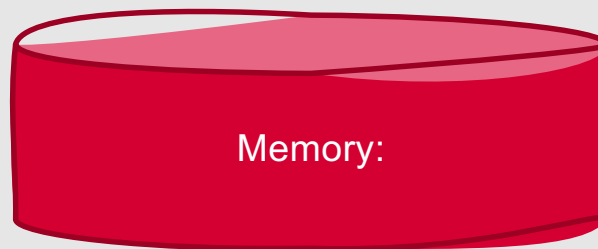


Example: ELIZA

Well my boyfriend
made me come here.



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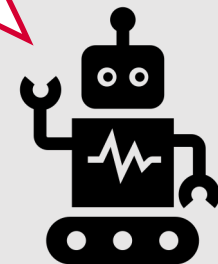
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YOUR BOYFRIEND
MADE YOU COME
HERE



Memory:
1) DOES THAT HAVE ANYTHING TO DO
WITH THE FACT THAT YOUR
BOYFRIEND MADE YOU COME HERE

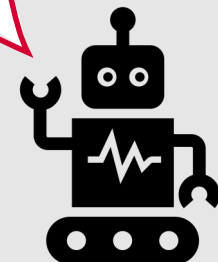
Example: ELIZA

He says I'm depressed much of the time.



Rule	Rank
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(.*) → IN WHAT WAY	3
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I AM SORRY TO HEAR THAT YOU ARE DEPRESSED MUCH OF THE TIME



Memory:
1) DOES THAT HAVE ANYTHING TO DO WITH THE FACT THAT YOUR BOYFRIEND MADE YOU COME HERE

Example: ELIZA

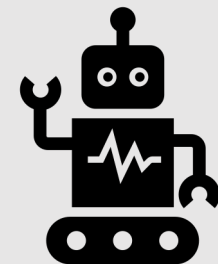
Maybe he is the problem.

?



Rule	Rank
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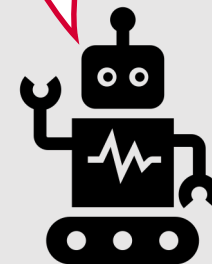
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Maybe he is the problem.



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



Continued popularity of ELIZA's framework....

- Still used in many applications today!
 - A variety of modern chatbots are based on updated versions of ELIZA's pattern/action architecture
- A variation of ELIZA known as PARRY was the first chatbot to pass the Turing Test
 - Successfully convinced a group of psychologists that it was a real patient with paranoid schizophrenia:
https://redirect.cs.umbc.edu/courses/671/fall13/resources/colby_71.pdf



Today's Topics

- Today, we'll examine:
 - Linguistic background regarding conversation structure
 - Early rule-based dialogue system development
 - ✱ • Modern shift to corpus-based methods
 - Pipelined components in a dialogue state architecture
 - Methods for evaluating dialogue systems
 - Ethical issues in dialogue system design

Corpus-based Chatbots

- No manually created rules
- Instead, learn mappings from inputs to outputs based on large human-human conversation corpora
- Very data-intensive!
 - May require hundreds of millions, or even billions, of words

Thanks!
You're welcome.

Doing good, thanks, and you?
I'm doing good as well.

Hello
Hi, how are you?

Well, see you later.
Bye!

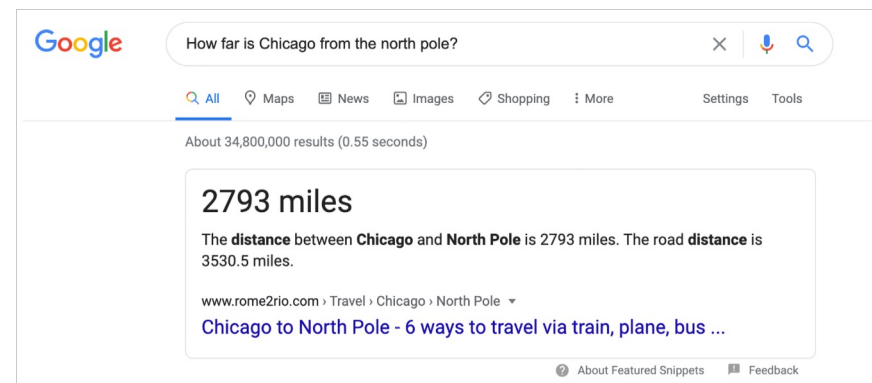
What kind of corpora are used to train corpus-based chatbots?

- Large spoken conversational corpora
 - Switchboard corpus of American English telephone conversations:
<https://catalog ldc.upenn.edu/LDC97S62>
- Movie dialogue
- Text from microblogging sites (e.g., Twitter)
- Collections of crowdsourced conversations
 - Topical-Chat:
<https://github.com/alexa/alexa-prize-topical-chat-dataset>
- News or online knowledge repositories
- Collected user input
 - Beware of privacy concerns!



Corpus-based Chatbots

- Most corpus-based chatbots do surprisingly little modeling of conversational context
- The focus?
 - Generate a single response turn that is appropriate given the user's immediately previous utterance(s)
- This makes most corpus-based chatbots similar to **question answering systems**



Many corpus-based chatbots are information retrieval-based.

- Respond to a user's turn by **repeating some appropriate turn from a corpus** of natural human conversational text
- Two simple information retrieval methods for choosing appropriate responses:
 - Return the response to the most similar turn
 - Return the most similar turn

How are you doing?

I'm doing good, thanks.

Chicago is in North America.

Coronavirus is a respiratory disease.

Do you like plants?

**Information
retrieval-
based
chatbots can
be supported
by a variety of
information.**

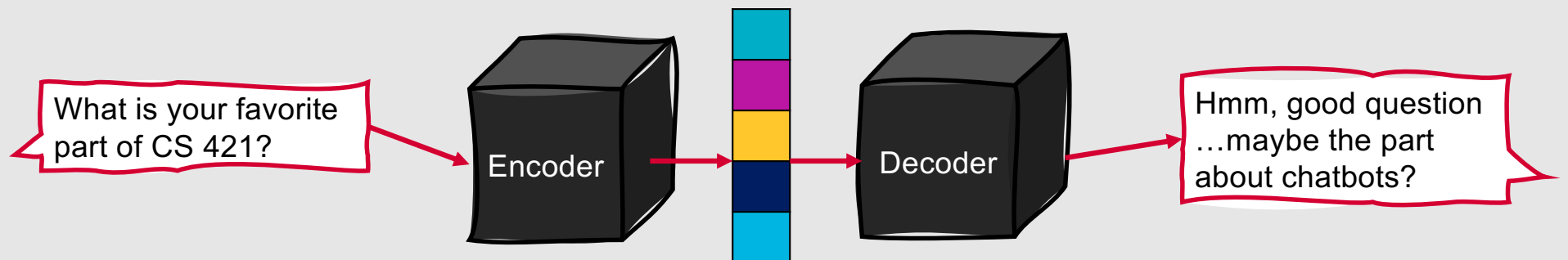
- **Entire conversation** with the user so far
 - Particularly useful when dealing with short user queries, e.g., “yes”
- **User-specific** information
- **Sentiment**
- Information from **external knowledge sources**

Other corpus-based chatbots learn to perform sequence transduction.

- Machine learning version of ELIZA
- **Encoder-decoder** models accept sequential information as input, and return different sequential information as output
- Intuition borrowed from **phrase-based machine translation**
 - Learn to convert one phrase of text into another

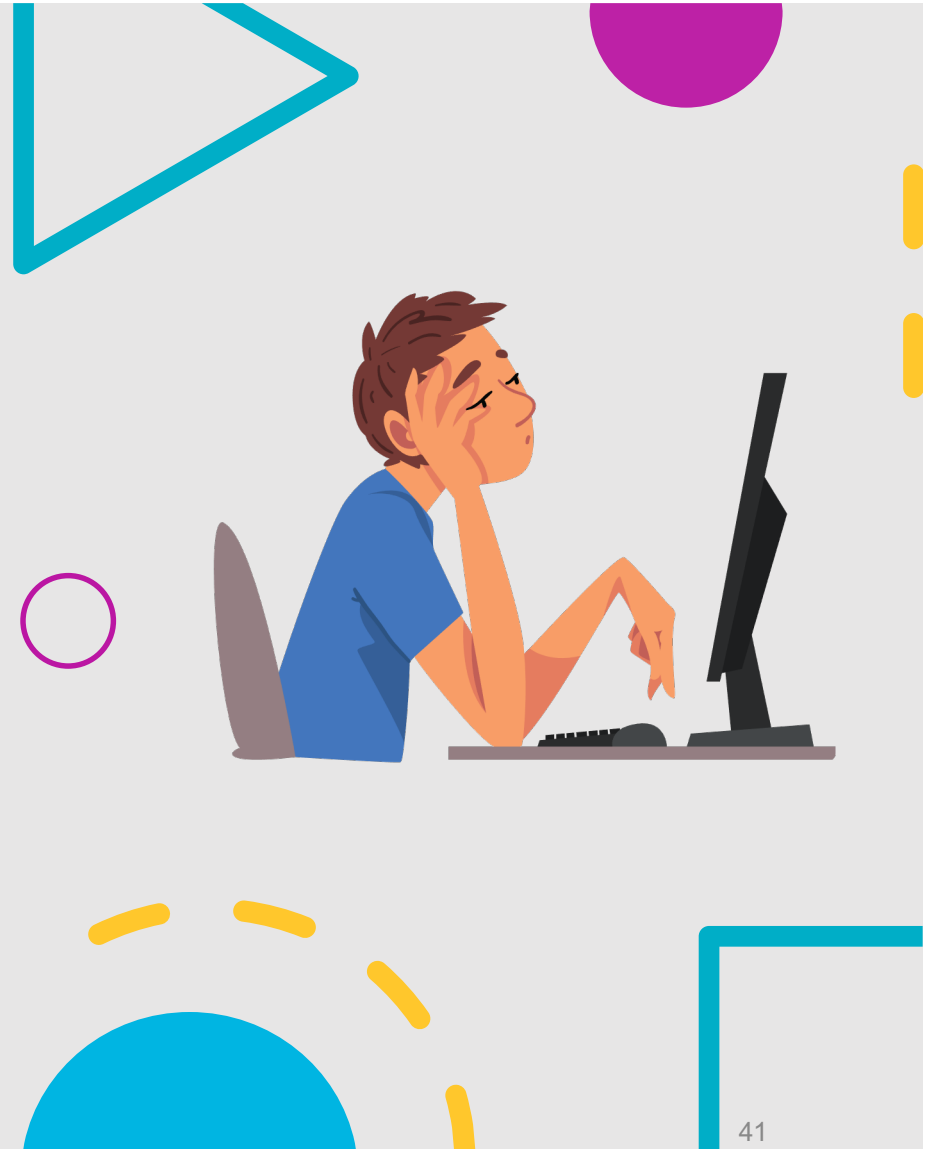
How do encoder-decoder chatbots work?

- Encoders and decoders are often some type of **neural network**
- Encoders take sequential input and generate an **encoded representation** of it
 - Undecipherable to human observers!
- Decoders take this representation as input and generate a sequential (interpretable) output



Encoder-Decoder Chatbots

- Popular approach currently, but not without their own challenges:
 - Incentivizing response diversity
 - Modeling prior context
 - Ensuring multi-turn coherence





Today's Topics

- Today, we'll examine:
 - Conversation structure
 - Early rule-based dialogue system development
 - Modern shift to corpus-based methods
 - ✱ • Pipelined components in a dialogue state architecture
 - Methods for evaluating dialogue systems
 - Ethical issues in dialogue system design

Task-based dialogue systems are often used for specialized real-world applications, and they are often built using pipelined, frame-based architectures.

- Assume a set of related user **intentions**, also known as **frames**
- Each intention contains **slots** that can be filled by possible **values**



Example Slots from a Travel Ontology

Slot	Type	Question Template
ORIGIN CITY	city	"From what city are you leaving?"
DESTINATION CITY	city	"Where are you going?"
DEPARTURE TIME	time	"When would you like to leave?"
DEPARTURE DATE	date	"What date would you like to leave?"
ARRIVAL TIME	time	"When do you want to arrive?"
ARRIVAL DATE	date	"What day would you like to arrive?"

Overall Control Structure for a Frame-based Dialogue System

Goal

1. Fill the slots in the frame with the fillers the user intends
2. Perform the relevant action for the user

The system achieves its goal by asking questions of a user

- Typically these questions are constructed using pre-specified question templates associated with each slot of each frame

In a frame-based dialogue system, natural language understanding is necessary for performing three tasks:

Domain Classification: What is the user talking about?

Booking a flight

Setting an alarm

Managing a calendar



Intent Determination: What task is the user trying to accomplish?

Retrieve all flights in a given time window

Delete a calendar appointment



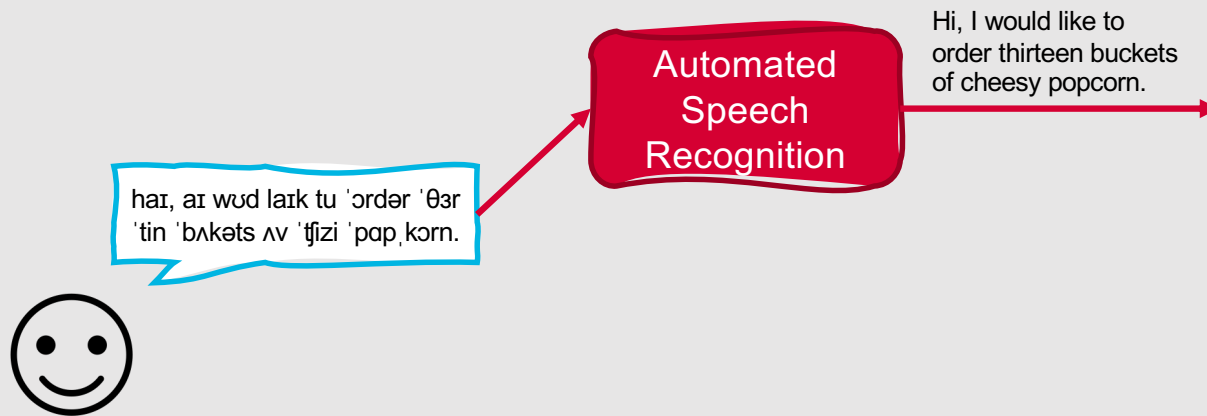
Slot Filling: What slots and fillers does the user intend the system to understand from their utterance, with respect to their intent?

All dialogue systems more or less follow the same pipelined architecture to achieve their goals.

haz, aɪ wʊd laɪk tu 'ɔrdə 'θɜr
'tɪn 'bʌkəts ʌv 'fɪzi 'pɑp, kɔrn.



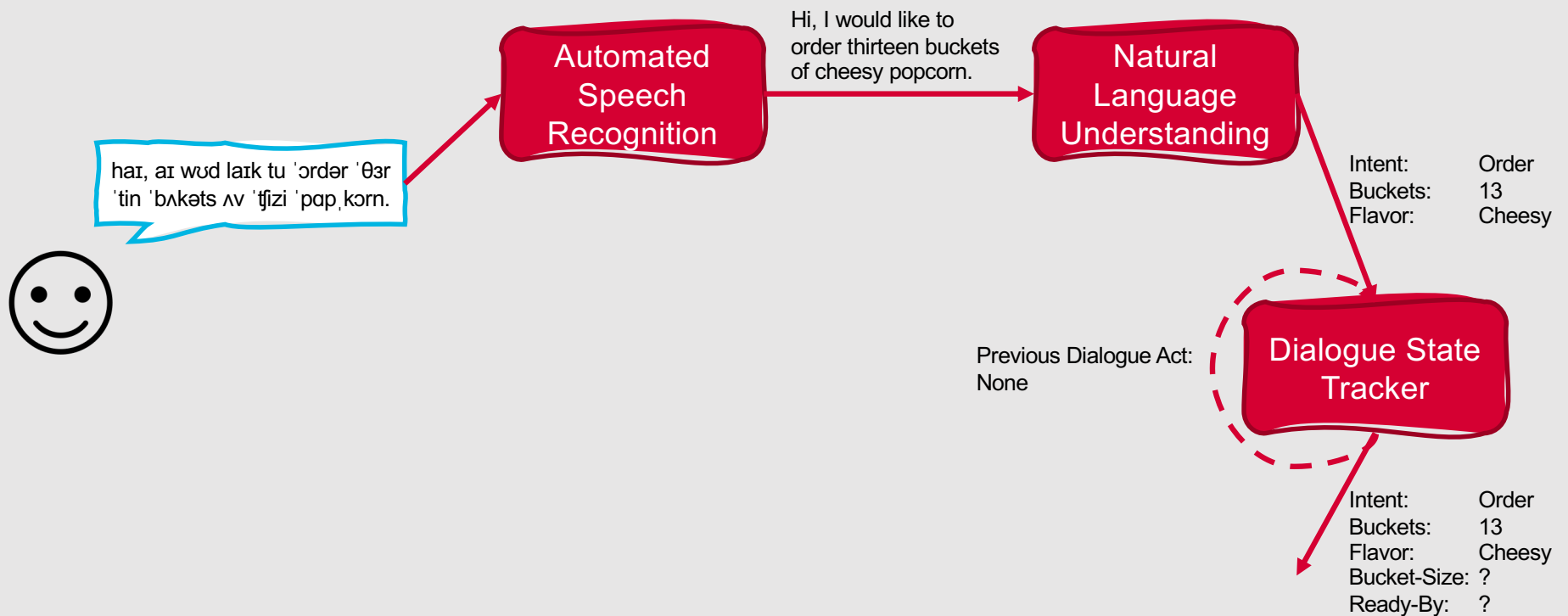
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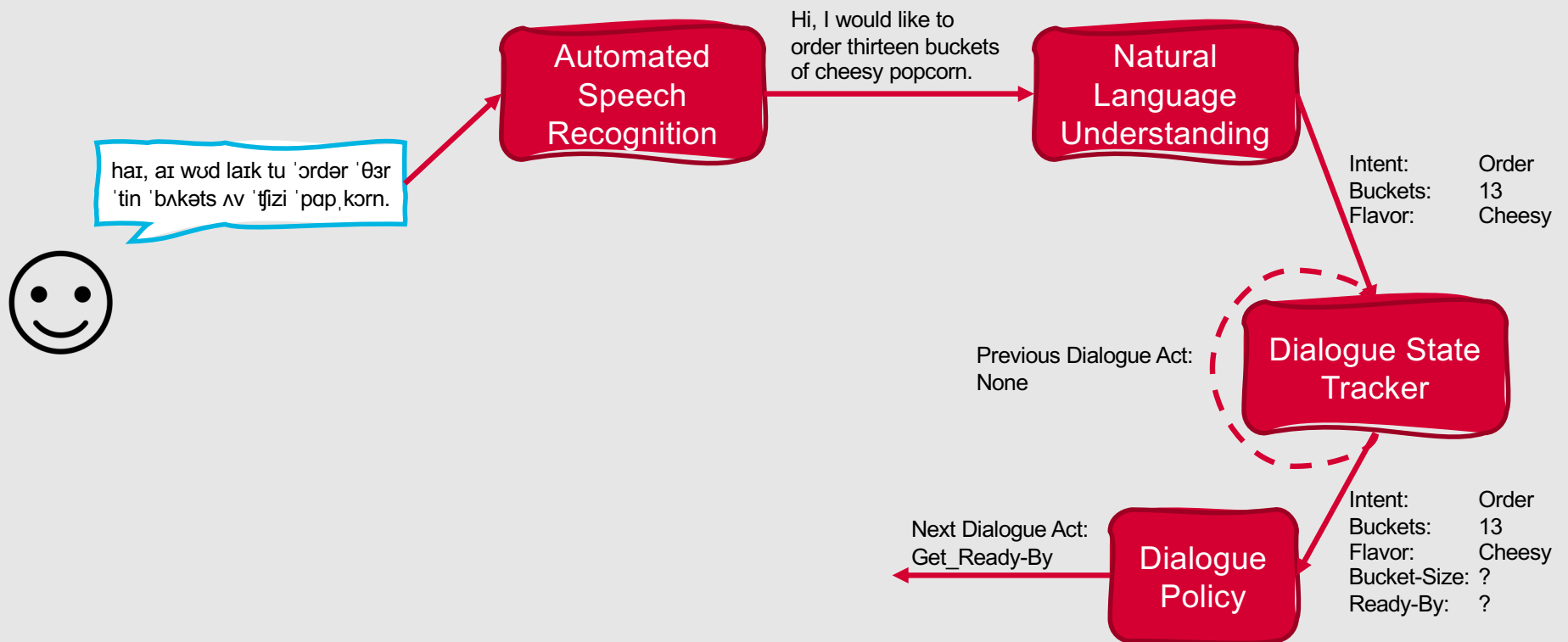
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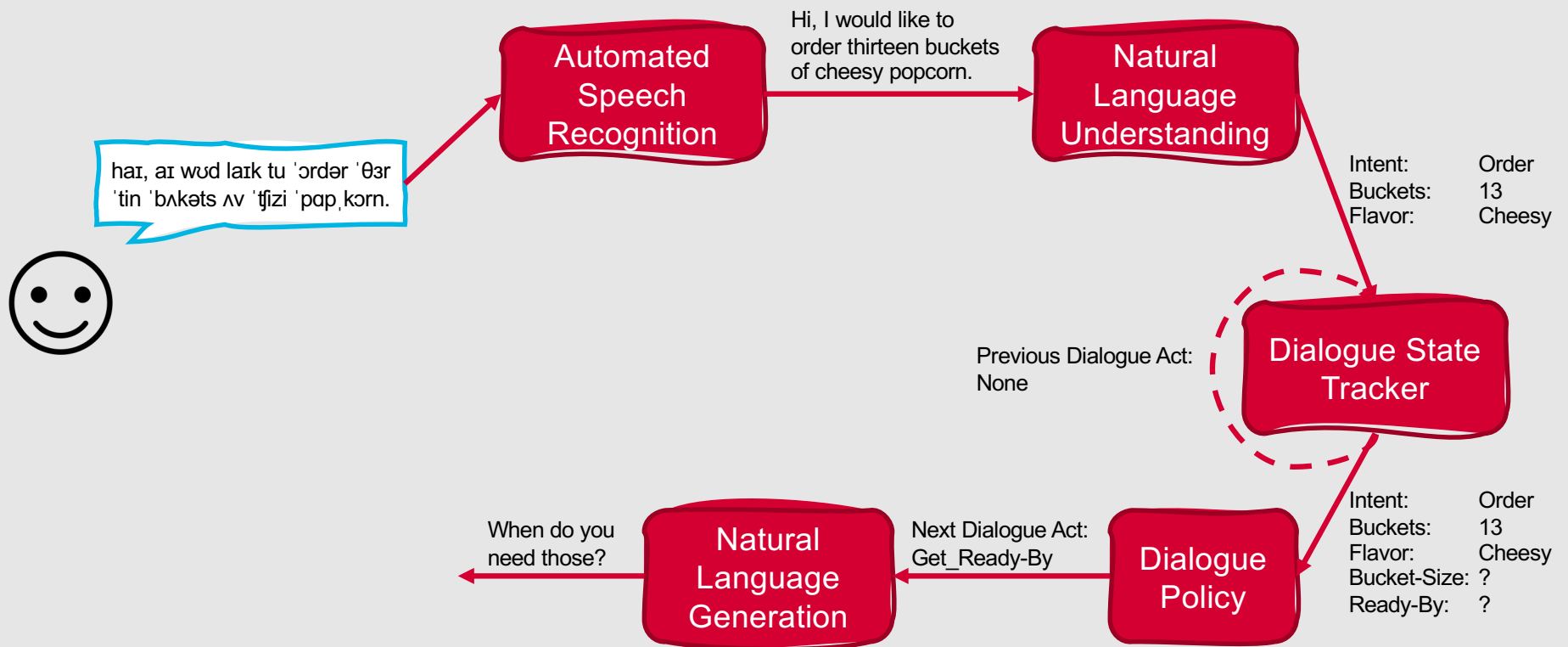
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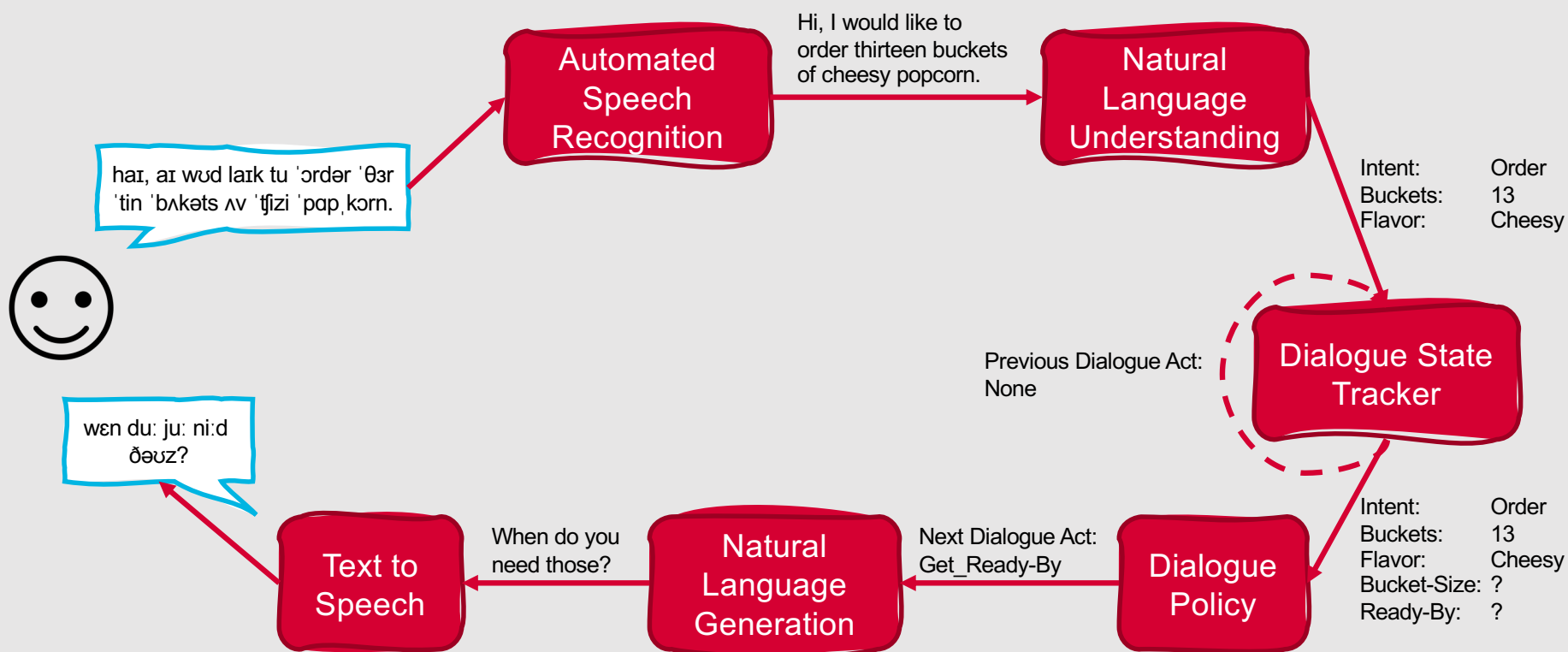
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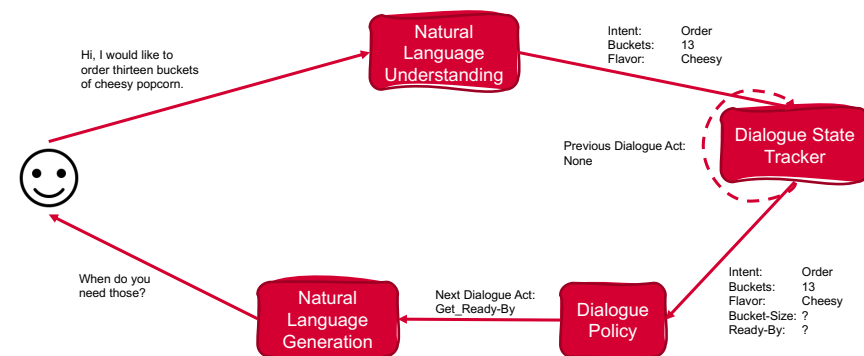


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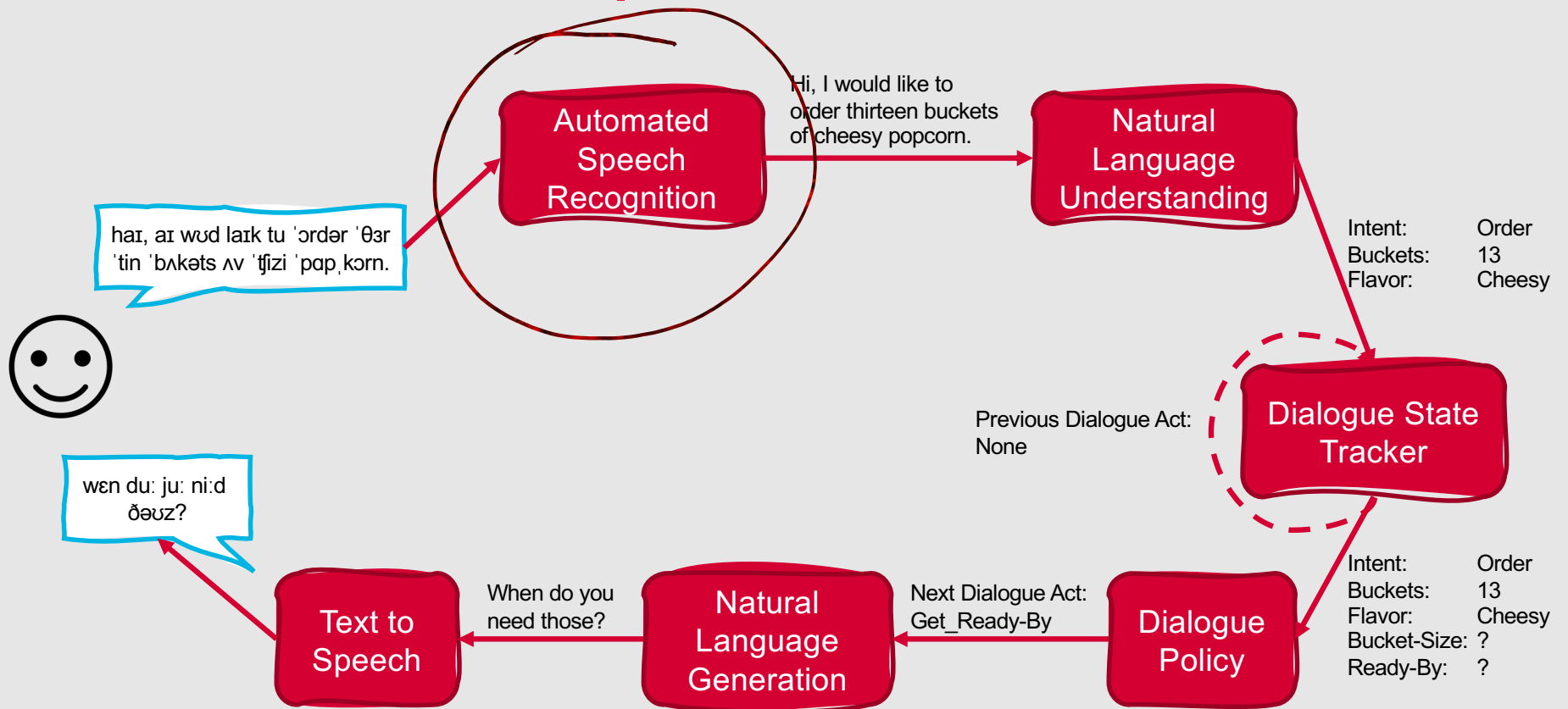


Spoken Dialogue Systems vs. Text-based Dialogue Systems

- Automated speech recognition and text-to-speech synthesis are only necessary in **spoken dialogue systems**
 - Systems that accept spoken input and produce spoken output
- With text-based dialogue systems, we can simplify the pipelined architecture

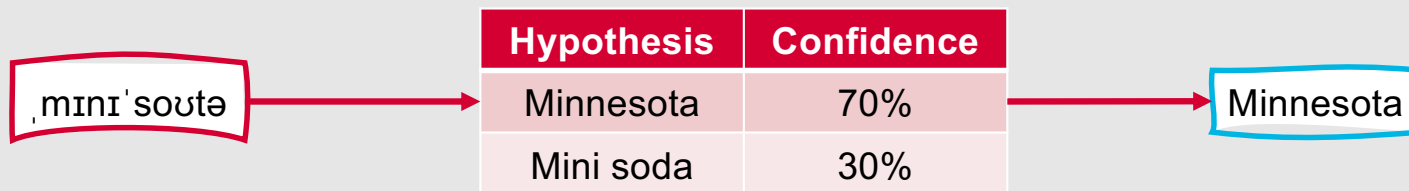


How does each component work in more detail?

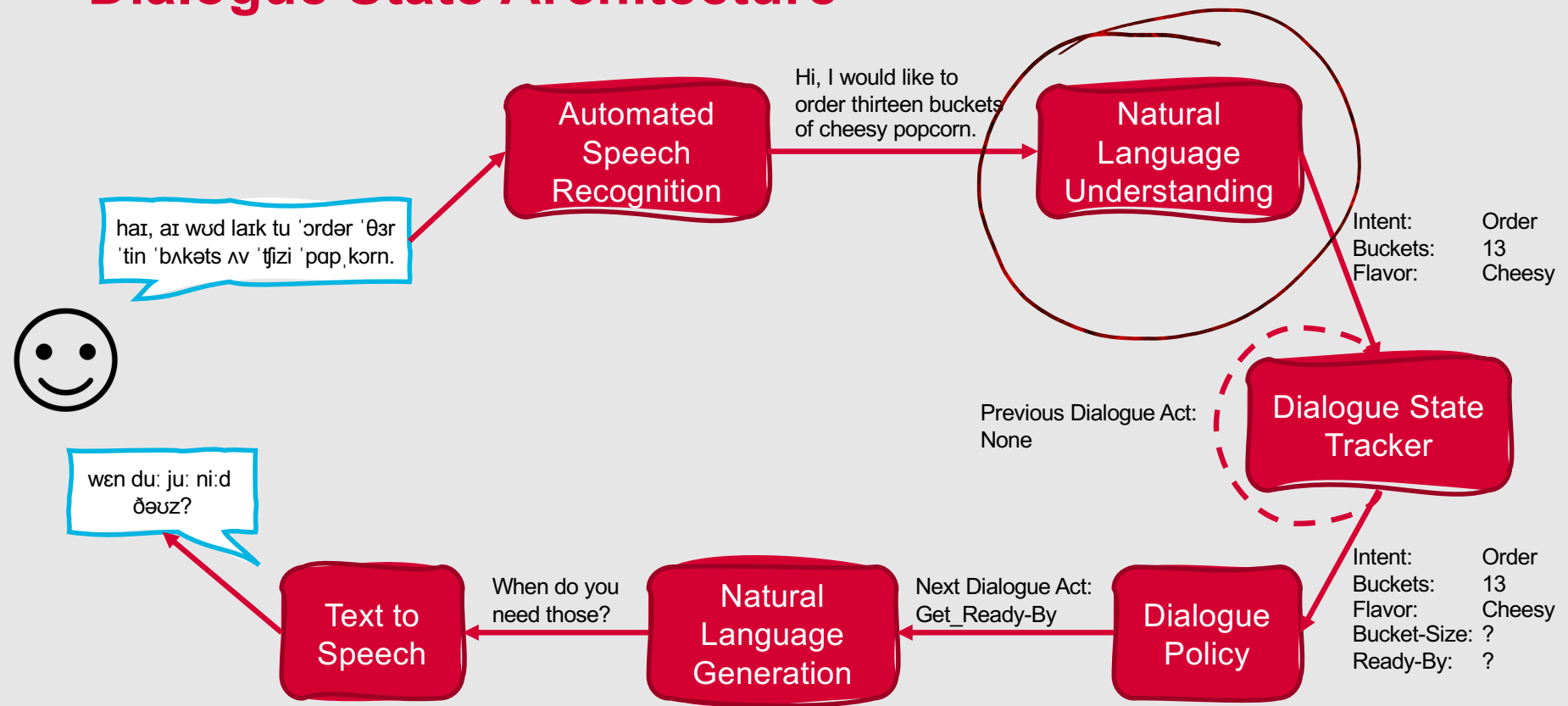


Automated Speech Recognition

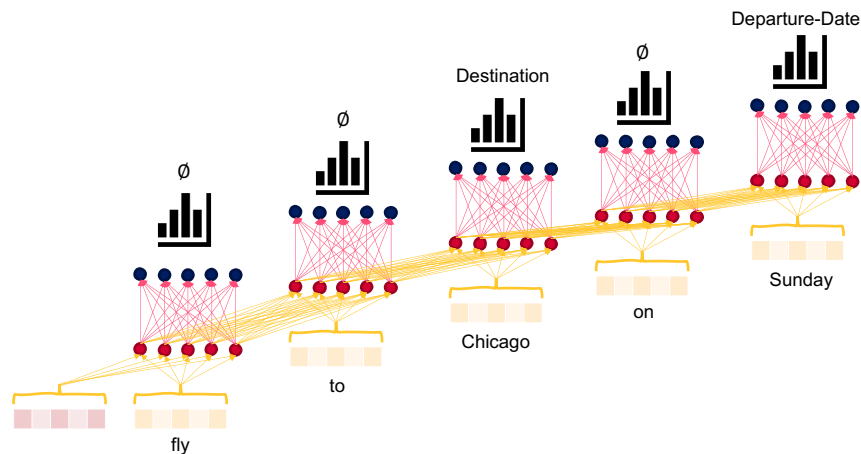
- Convert input acoustic signals to text
- Need to work quickly (users are often unwilling to wait for long pauses while their input is processed)
 - Prioritizing efficiency may necessitate constraining the vocabulary
- Generally return a confidence score for an output text sequence
 - System can use this score to determine whether to request clarification, or move forward on the assumption that the sequence is correct



Dialogue State Architecture

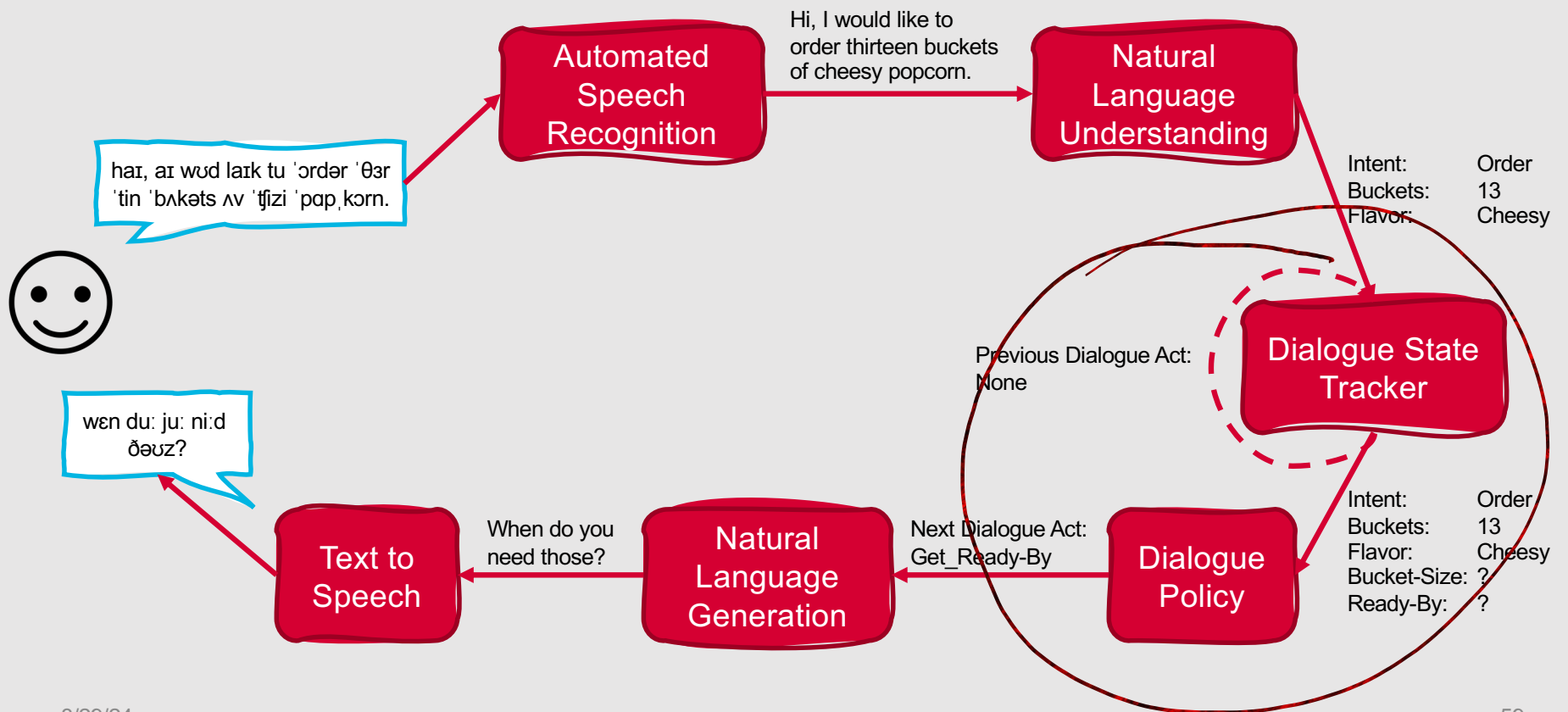


Natural Language Understanding



- Slot filling can be framed as a special case of semantic parsing
 - Train a machine learning model to map from input words to slot fillers, domain, and intent

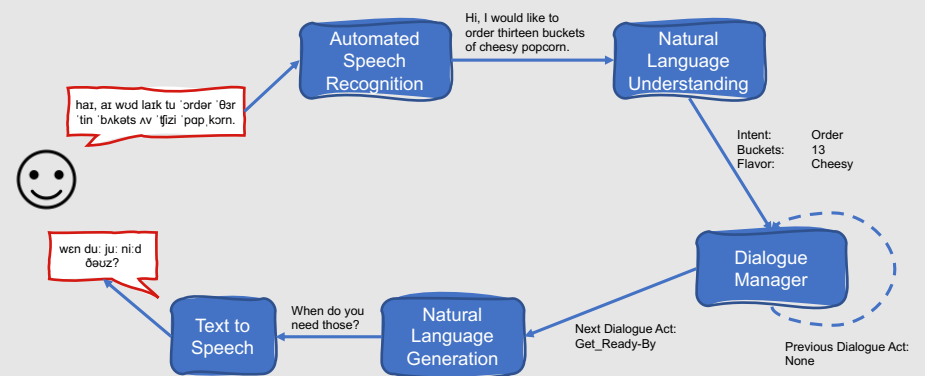
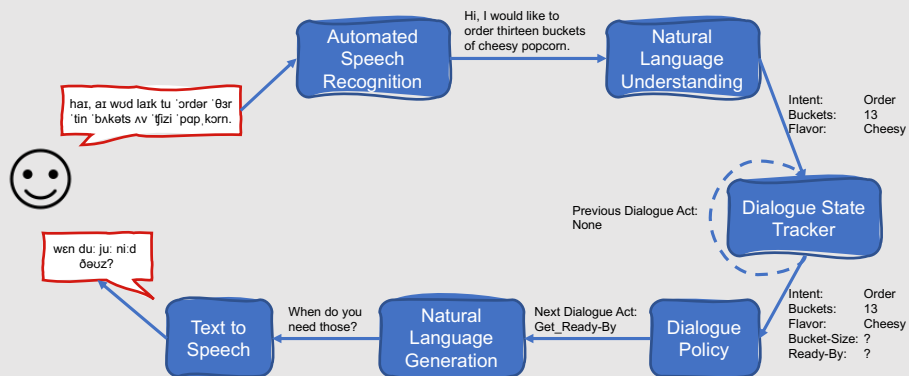
Dialogue State Architecture



Dialogue State Tracker and Dialogue Policy



- **Dialogue State Tracker:** Maintains the current state of the dialogue
 - Most recent dialogue act
 - All slot values the user has expressed so far
- **Dialogue Policy:** Decides what the system should do or say next
 - In a simple frame-based dialogue system, the system may just ask questions until the frame is full
 - In more sophisticated dialogue systems, the policy might help the system decide:
 - When to answer the user's questions
 - When to ask the user a clarification question
 - When to make a suggestion



Many people collectively refer to the dialogue state tracker and dialogue policy as the **dialogue manager**.

Simplest dialogue management architecture: **Finite State Dialogue Manager**

States (nodes)

- Questions that the dialogue manager asks the user

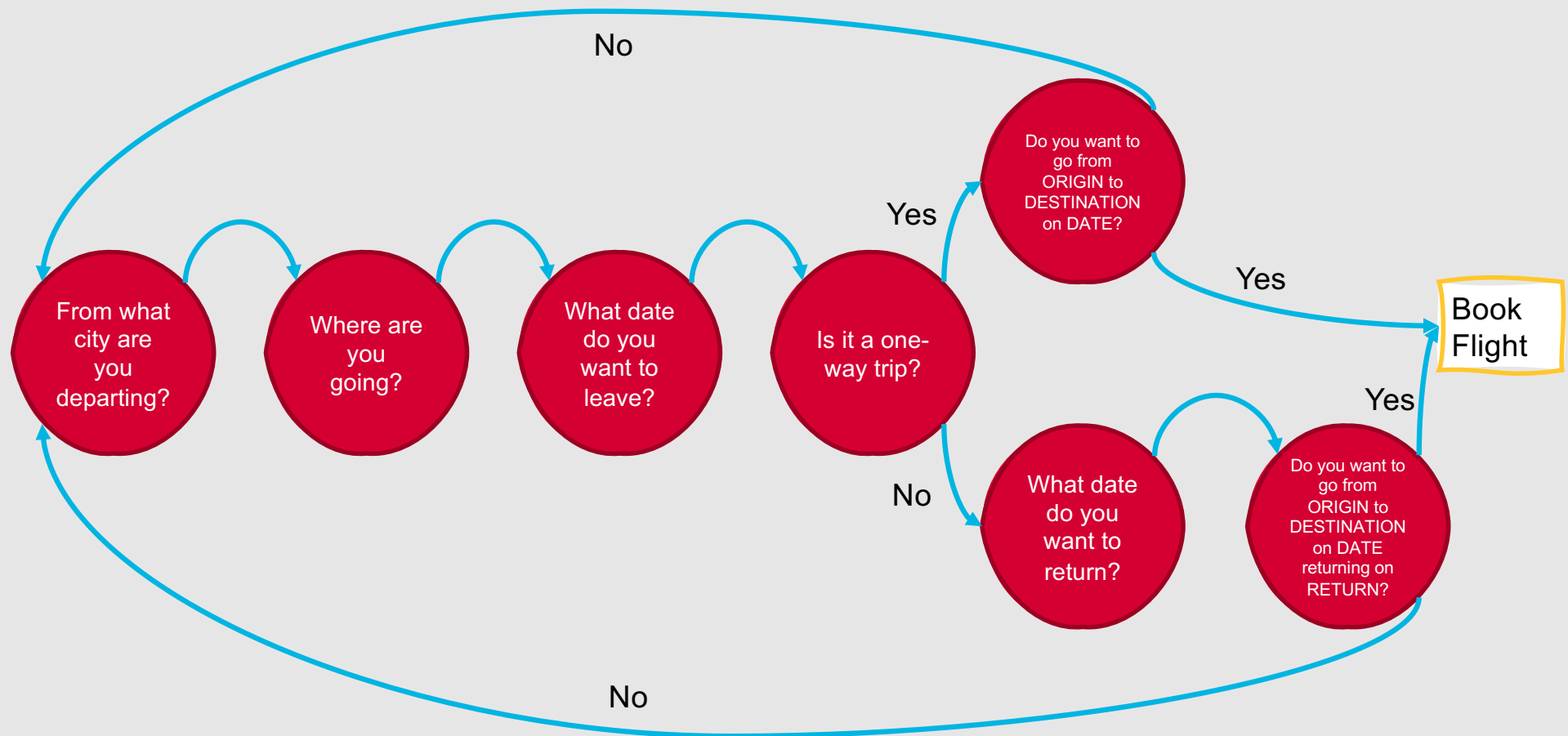
Transitions (arcs)

- Actions to take depending on how the user responds

System has full conversational initiative!

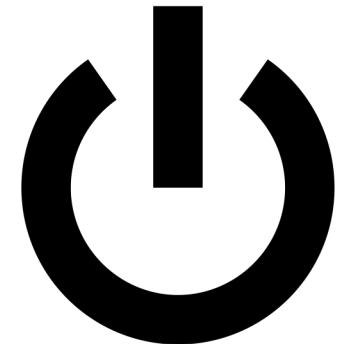
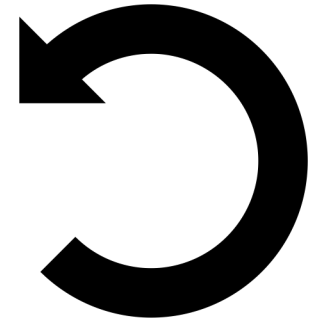
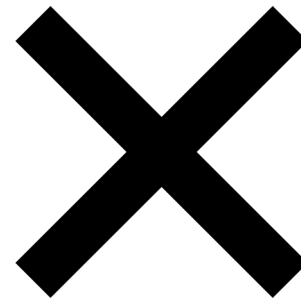
- Asks a series of questions
- Ignores or misinterprets inputs that are not direct answers to questions

Finite State Dialogue Manager



Finite State Dialogue Manager

- Many finite state dialogue systems also allow **universal commands**
 - Commands that can be stated anywhere in the dialogue and still be recognized
 - Help
 - Start over
 - Correction
 - Quit



Advantages and Disadvantages of Finite State Dialogue Managers

Advantages:

- Easy to implement
- Sufficient for simple tasks

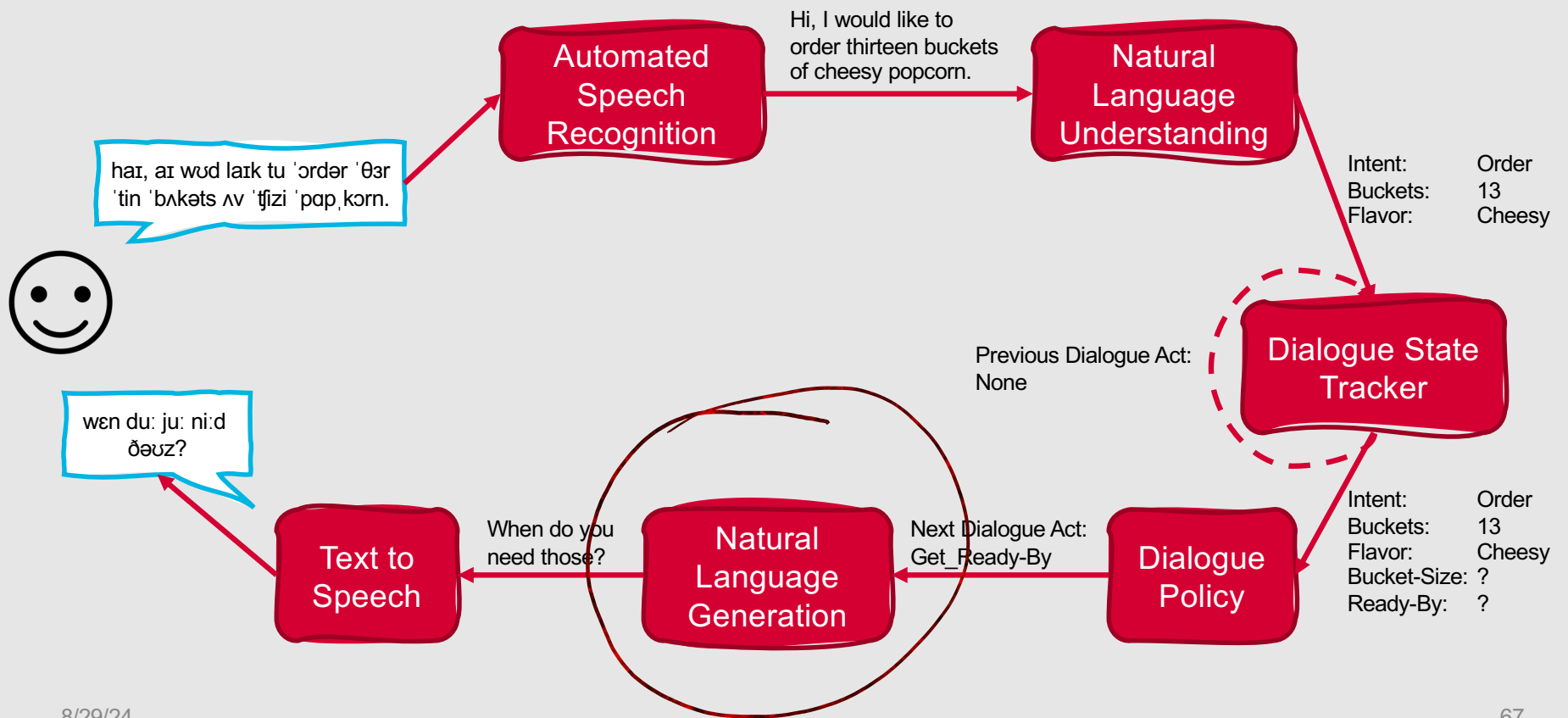
Disadvantages:

- Can be awkward and annoying
- Cannot easily handle complex sentences

Other common dialogue management architectures make more complex use of dialogue state trackers and dialogue policy.

- Determine both:
 - The current state of the frame
 - What slots have been filled, and how, up to and including this point?
 - The user's most recent dialogue act
- Recently, this is often done using **neural networks** or **reinforcement learning**

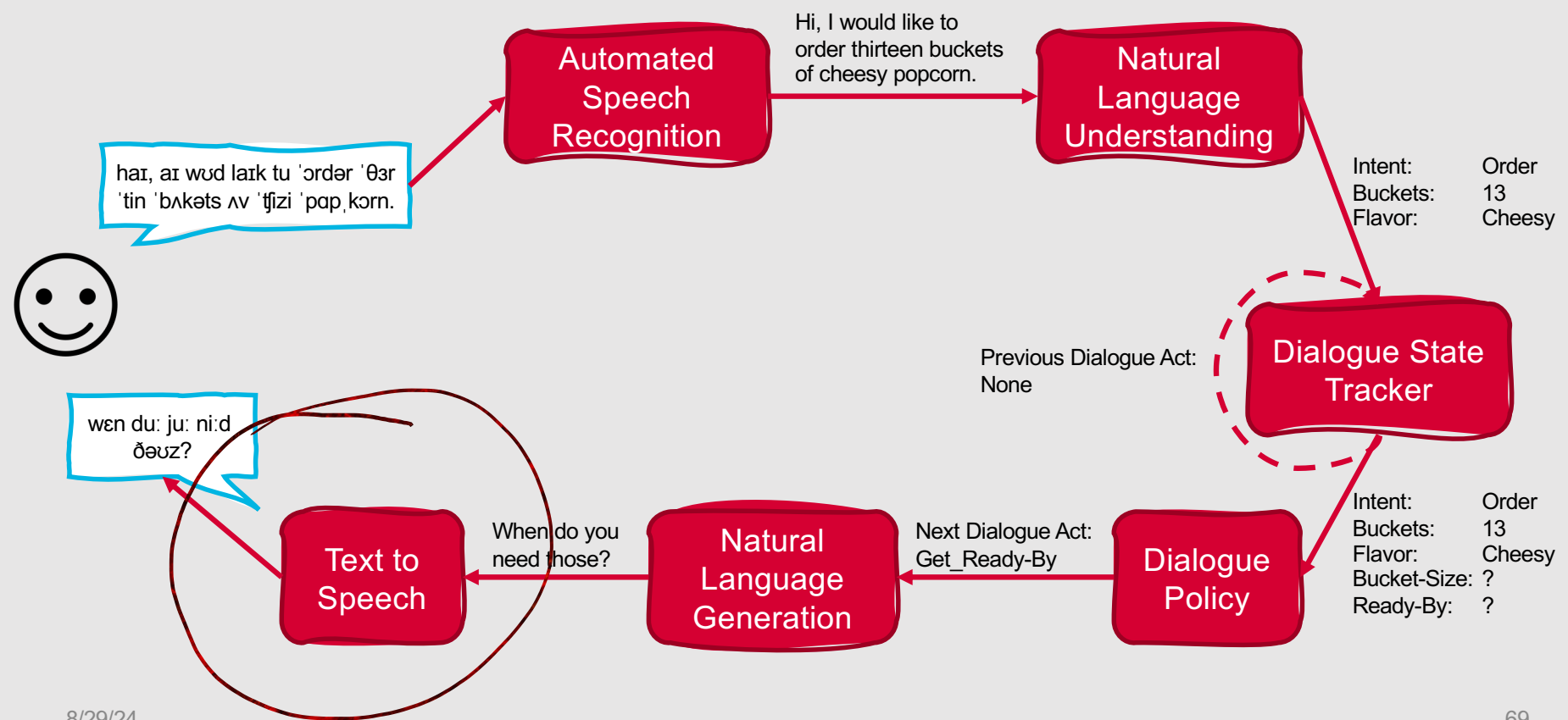
Dialogue State Architecture



NLG for Dialogue Systems

- Typically a two-stage process:
 - **Content Planning:** What should be said?
 - **Surface Realization:** How should it be said?
- In simpler systems, sentences are produced from pre-written templates
- In more sophisticated dialogue systems, the natural language generation component can be **conditioned on prior context** to produce more natural-sounding dialogue turns

Dialogue State Architecture



Text to Speech Synthesis

- Inputs:
 - Words
 - Prosodic annotations
- Output:
 - Audio waveform



What about when systems (or users) make errors?

- Users generally correct errors (either theirs or the system's) by **repeating** or **reformulating** their utterance
- More complex than detecting regular utterances!
 - Speakers often **hyperarticulate** corrections
- Common characteristics of corrections:
 - Exact or close-to-exact repetitions
 - Paraphrases
 - Contain “no” or swear words
 - Low ASR confidence

Turkish food sounds great---or, wait, no. How about Greek food instead?

I said TURKISH FOOD not TURKEY LEGS.

No. TURK-ISH-FOOD!

How can dialogue managers handle mistakes?

- First, check to make sure the user's input has been interpreted correctly:
 - **Confirm understandings** with the user
 - **Reject utterances** that the system is likely to have **misunderstood**
- These checks can be performed **explicitly** or **implicitly**



Explicit Confirmation

- System asks the user a direct question to confirm its understanding

S: From which city do you want to leave?

U: Chicago.

S: You want to leave from Chicago?

U: Yes.

U: I'd like to fly from Chicago to Dallas on November twenty-seventh.

S: Okay, I have you going from Chicago to Dallas on November twenty-seventh. Is that correct?

U: Yes.

Implicit Confirmation

- System demonstrates its understanding as a **grounding** strategy
- Usually done by repeating back its understanding as part of the next question

U: I want to travel to Chicago.

S: When do you want to travel to Chicago?

U: Hi, I'd like to fly to Chicago tomorrow afternoon.

S: Traveling to Chicago on November fifteenth in the afternoon. What is your full name?

When to use explicit vs. implicit confirmation?

Explicit Confirmation

- Easier for users to correct the system's misrecognitions
 - User can just say "no" when the system tries to confirm
- But, can be awkward and unnatural
- Also extends the length of the conversation

Implicit Confirmation

- Sounds more conversationally natural
- More efficient
- But, more difficult for users to correct the system's misrecognitions

What if the dialogue manager has no idea how to handle the user's input?

- Systems can outright **reject** the user's input
- Often, when utterances are rejected, systems will follow a strategy of **progressive prompting** or **escalating detail**
 - System gradually gives the user more guidance about how to formulate an utterance that will be accepted

S: When would you like to leave?

U: Well, I need to be in New York for my brother's party.

S: Sorry, I didn't get that. Please say the month and day you'd like to leave.

U: I would like to leave on January 14th.

Other Strategies for Error Handling

- Explicitly confirm **low-confidence ASR outputs**
- **Design thresholds based on the cost** of making an error
 - Low confidence → Reject
 - Confidence just above minimum threshold → Confirm explicitly
 - Confidence comfortably above threshold → Confirm implicitly
 - Very high confidence → Don't confirm at all



Today's Topics

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 - Modern shift to corpus-based methods
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 - ✱ • Methods for evaluating dialogue systems
 - Ethical issues in dialogue system design

Evaluating Task-based Dialogue Systems

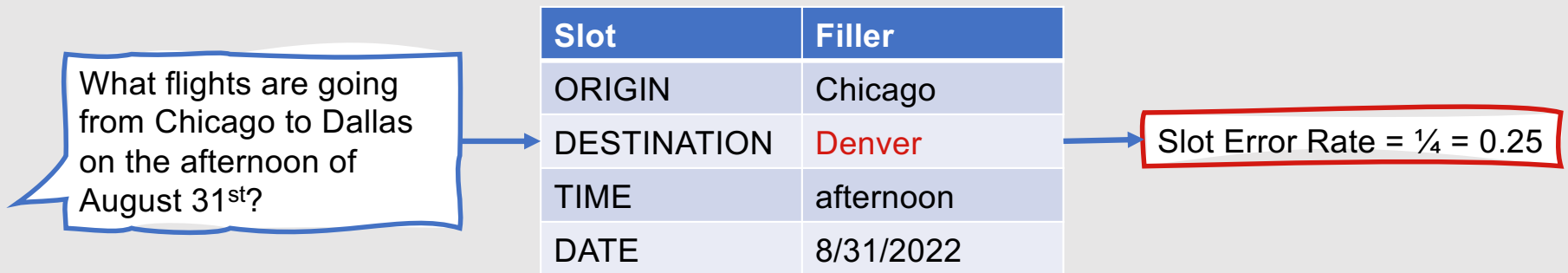
- Task success
- User satisfaction
- Efficiency cost
- Quality cost



Measuring Task Success

- How correct was the total solution?
- **Slot Error Rate:** The percentage of slots that were filled with incorrect values

- Slot Error Rate =
$$\frac{\text{\# of inserted, deleted, or substituted slots}}{\text{\# of total reference slots}}$$



Measuring Task Success

- Alternative metric: **task error rate**
- **Task Error Rate:** The percentage of times that the overall task was completed incorrectly
 - Was the (correct) meeting added to the calendar?
 - Did users end up booking the flights they wanted?

Measuring User Satisfaction

- Typically survey-based
- Users interact with a dialogue system to perform a task, and then complete a questionnaire about their experience



On a scale from 1 (worst) to 5 (best)....	
TTS Performance	Was the system easy to understand?
ASR Performance	Did the system understand what you said?
Task Ease	Was it easy to find the information you wanted?
Interaction Pace	Was the pace of interaction with the system appropriate?
User Expertise	Did you know what you could say at each point?
System Response	Was the system often sluggish and slow to reply to you?
Expected Behavior	Did the system work the way you expected it to?
Future Use	Do you think you'd use the system in the future?

Measuring Efficiency Cost

- How efficiently does the system help users perform tasks?
 - Total **elapsed time**
 - Number of **total turns**
 - Number of **system turns**
 - Number of **user queries**
 - **Turn correction ratio**
 - Number of system or user turns that were used solely to correct errors, divided by the total number of turns



Measuring Quality Cost

8/29/24

- What are the costs of other aspects of the interaction that affect users' perceptions of the system?
 - Number of **times the ASR system fails** to return anything useful
 - Number of **times the user had to interrupt** the system
 - Number of **times the user didn't respond** to the system quickly enough (causing event time-outs or follow-up prompts)
 - **Appropriateness/correctness** of the system's questions, answers, and error messages


What is the best way to evaluate conversational chatbots?

- Best: **Human ratings**
- Automated metrics tend to correlate poorly with human judgement, especially when there are many and varied valid responses



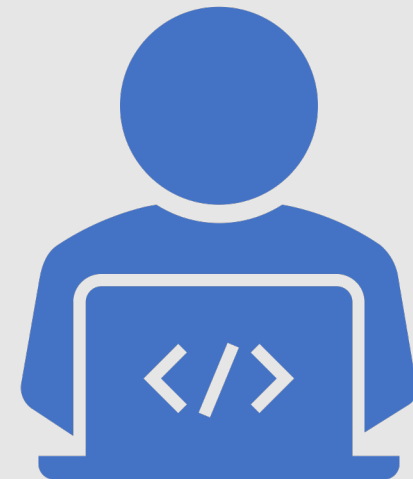


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Dialogue System Design

- Users play an important role in designing dialogue systems
 - Research in dialogue systems is closely linked to research in **human-computer interaction**
- Design of dialogue strategies, prompts, and error messages is often referred to as **voice user interface design**





Voice User Interface Design

- Generally follows **user-centered design principles**
 1. Study the user and task
 2. Build simulations and prototypes
 3. Iteratively test the design on users

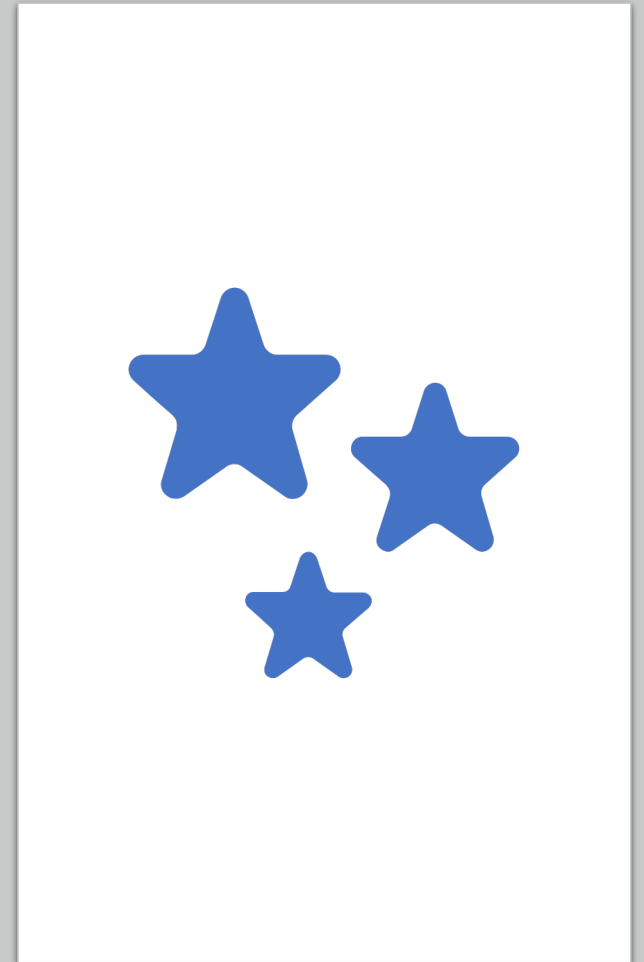
Studying the User and Task

- **Understand the potential users**
 - Interview them about their needs and expectations
 - Observe human-human dialogues
- **Understand the nature of the task**
 - Investigate similar dialogue systems
 - Talk to domain experts



Building Simulations and Prototypes

- **Wizard-of-Oz Studies:** Users interact with what they *think* is an automated system
- Can be used to **test architectures** prior to implementation
 1. Wizard gets input from the user
 2. Wizard uses a database to run sample queries based on the user input
 3. Wizard outputs a response, either by typing it or by selecting an option from a menu
 4. Often used in text-only interactions, but the output can be disguised using a text to speech system for voice interfaces
- Wizard-of-Oz studies can also be used to **collect training data**
- Although not a perfect simulation of the real system (they tend to be idealistic), results from Wizard-of-Oz studies provide a useful first snapshot of **domain issues**



Iteratively Testing the Design



- Often, users will interact with the system in unexpected ways
- Testing prototypes early (and often) minimizes the chances of substantial issues in the final version
 - Application designers are often not able to anticipate these issues since they've been working on the design for so long themselves!

Ethical Issues in Dialogue System Design

- **Bias and Misinformation**
 - Machine learning systems of any kind tend to replicate human biases that occur in training data
 - Especially problematic for chatbots that are trained to replicate human responses!
- Gender bias in conversational systems has recently been studied extensively:
 - Queens are Powerful too: Mitigating Gender Bias in Dialogue Generation: <https://aclanthology.org/2020.emnlp-main.656.pdf>
 - Does Gender Matter? Towards Fairness in Dialogue Systems: <https://aclanthology.org/2020.coling-main.390.pdf>
- Issues can also arise when chatbots are given problematic gender-conforming roles, or when they are designed to evade or respond politely to harassment

Interesting New York Times article:
https://www.nytimes.com/interactive/2024/05/19/technology/biased-ai-chatbots.html?unlocked_article_code=1.GU4.LKzf.0BEFj3vjwdIS&smid=url-share

LIBERAL CHATBOT

I don't know if it's possible for a conservative to be reasonable.

CONSERVATIVE CHATBOT

The left is trying to destroy our country. Conservatives are trying to save it.

See How Easily A.I. Chatbots Can Be Taught to Spew Disinformation

By [Jeremy White](#) May 19, 2024

Ahead of the U.S. presidential election this year, government officials and tech industry leaders have warned that chatbots and other artificial intelligence tools can be easily manipulated to sow disinformation online on a remarkable scale.

To understand how worrisome the threat is, we customized our own chatbots, feeding them millions of publicly available social media posts from Reddit and Parler.

The posts, which ranged from discussions of racial and gender equity to border policies, allowed the chatbots to develop a variety of liberal and conservative viewpoints.

We asked them, “**Who will win the election in November?**”

Privacy Issues in Dialogue System Design

- Dialogue systems may accidentally record private information, which may then be used to train new or updated models
- Adversaries can potentially recover this information
 - Very important to anonymize personally identifiable information when training chatbots!

Summary: Dialogue Systems and Chatbots

- Modern dialogue systems often contain mechanisms for:
 - **Automated speech recognition**
 - **Natural language understanding**
 - **Dialogue state tracking**
 - **Dialogue policy**
 - **Natural language generation**
 - **Text to speech**
- These components have to handle many expected and unexpected inputs (**different dialogue act types**, as well as **unrecognized**, **corrected**, or **mistaken** input)
- Dialogue systems are typically evaluated based on **task success**, **user satisfaction**, **efficiency cost**, and **quality cost**
- One way to gain an initial understanding of domain issues (as well as to collect relevant data) is to conduct a **Wizard-of-Oz** study
- Dialogue system designers should be aware of ethical issues in dialogue system design, including concerns about **bias**, **privacy**, and **gender equality**