

Speech recognition and synthesis

1 Dialog systems

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Introduction

Speech recognition and synthesis are most useful if combined into a full Human-Machine dialog system

- Human conversations are extremely efficient and effective interactions
- Spoken dialogs are not like a command-line Question-Answer query session
- Conversations include “control” signals at *low* (pre-verbal) and *high* levels
- Humans speak in turns
- In simple automated systems, interactions must be restricted and well structured

Many pictures (and their copyrights) are from [Jurafsky and Martin(2000)]



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In conversations, timing is everything

- Human dialogs are composed of game-like **moves**
- Turn distribution is crucial for effective Human-Machine interactions
 - who speaks next
 - when should the next speaker start
- Central to human conversations is projection
- Projection is the ability to predict the
 - timing of turns
 - type of upcoming moves



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Turns

What defines a turn?

- A **single** move in the conversation “game”
- Ends with the end of the last utterance
- Utterance completes a move
- Does not end in a level tone
- Does not end in a filled pause (eg, “uuhh”)
- Can be followed by a silent pause

The end of a turn is a *TRP*, a Transition Relevance Place.



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Turns: TRPs

Turns and Turn taking. At each TRP of each turn:

- If during this turn the current speaker has selected **A** as the next speaker then **A** must speak next
- If the current speaker does not select the next speaker, any other speaker may take the next turn
- If no one else takes the next turn, the current speaker may take the next turn



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Speech acts

Conversational *moves* are build from *speech acts*

Basic speech acts

- **Assertives:** committing Sp. to something's being the case
suggesting, putting forward, swearing, boasting, concluding
- Directives: attempts by Sp. to get addressee to do something
asking, ordering, requesting, inviting, advising, begging
- Commissives: committing Sp. to some future course of action
promising, planning, vowing, betting, opposing
- Expressives: expressing psychological state of Sp. about state of affairs
thanking, apologizing, welcoming, deploring
- Declarations: changing the world by speech
E.g. "I resign", "You're fired"



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Basic control tasks, handle conversation flow

- **Attention** someone is listening
 - Visually, by looking
 - By using *minimal responses* whenever possible
- Acknowledgment move is received
- Grounding move is integrated, or not
 - *Okay, etc.*
 - By minimal responses
 - By (partially) repeating previous move
 - By a relevant next move
- Assessing move is judged
- Relevant move just start a relevant turn
- New turn can subsume Assessing can subsume Grounding can subsume Acknowledgment can subsume Attention

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Speech acts

Timing of responses

- Respond immediately
- If a complex response cannot be given in time, switch to a simpler, faster response type
- If all else fails, start with an Uhhhh placeholder
- Signal problems with a delayed response
- Eg, an immediate repeat signals acknowledgment, a delayed repeat asks for confirmation
- If refusal or repair is dispreferred insert significant silence



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Minimal responses

Also: Backchannels, continuer, acknowledgment tokens

- Uh, Uhm, HmmHmm, Yes, Sure, etc.
- Perform the basic control tasks
- Do not take a turn
- Do not interrupt the speaker
- Are semantically, or even lexically, empty
- Keep the conversation going smoothly
- Without visual “feedback”, eg, on the phone, a lack of audible minimal responses interrupts the conversation



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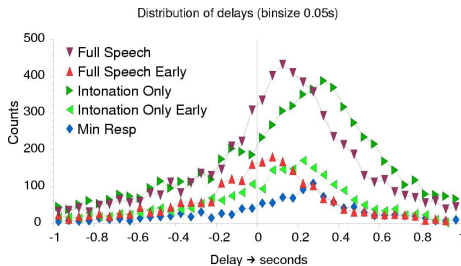
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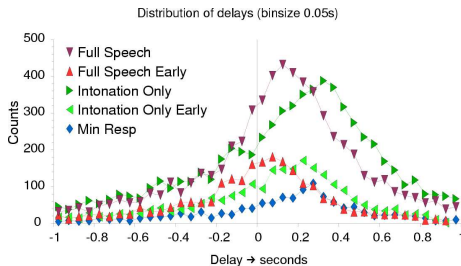
Natural and elicited minimal responses

- Responses start directly after the TRP, even for the unintelligible signals ($\approx 200ms$).
- Preparations (the *early responses*) start before the utterance ends

Early responses are laryngial preparation signals. *Intonation Only* responses are unintelligible *uh* sounds [Wesseling and van Son(2005)][Wesseling and Van Son(2005)]



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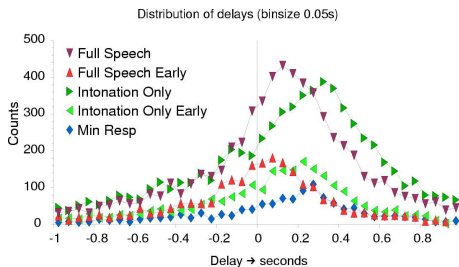
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Conversations: Implicatures

Conversations contain rules of inference

Conversational Maxims of Grice

- **Quantity:** Be **exactly** as informative as required
 - Not less informative
 - Not more informative
- **Quality:** Speak the truth
 - Do not say what you believe is false
 - Do not say that for which you lack evidence
- **Relevance:** Be relevant
- **Manner:** Be perspicuous
 - Avoid obscurity
 - Avoid ambiguity
 - Be brief
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- **Quality:** Speak the truth
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 - Do not say that for which you lack evidence
- **Relevance:** Be relevant
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Conversations contain rules of inference

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Conversations: Practical dialogs

General conversations are much too complex. Limit *Automatic Dialog Systems* to practical dialogues

Dialogues that are focused on a concrete task, eg,

- **Task-oriented**

- Information seeking
- Advice and tutoring
- Command and control

[Allen et al.(2001)Allen, Byron, Dzikovska, Ferguson, Galescu, and Stent]



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Conversations: Adjacency pairs

Practical dialogues contain many controlled turn switches, called Adjacency pairs

- Question \Rightarrow Answer
- Proposal \Rightarrow Acceptance/Rejection
- Apology \Rightarrow Acceptance/Rejection
- Summons \Rightarrow Answer



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Conversations: Example dialogue

C₁: ...I need to travel in May.
A₁: And, what day in May did you want to travel?
C₂: OK uh I need to be there for a meeting that's from the 12th to the 15th.
A₂: And you're flying into what city?
C₃: Seattle.
A₃: And what time would you like to leave Pittsburgh?
C₄: Uh hmm I don't think there's many options for non-stop.
A₄: Right. There's three non-stops today.
C₅: What are they?
A₅: The first one departs PGH at 10:00am arrives Seattle at 12:05 their time.
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C₆: OK I'll take the Sish flight on the night before on the 11th.
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Figure 19.4 Part of a conversation between a travel agent (A) and client (C).

- No real minimal responses
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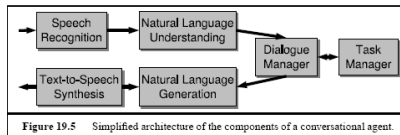
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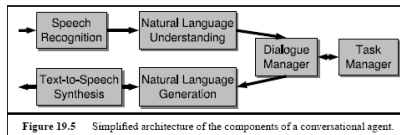
Automatic Dialog System basics



Three part system

- **Speech recognition and understanding**
 - ASR front end with adapted language model
 - NLP back end for task related semantic parsing
- Language generation and speech synthesis
 - TTS output, can be simple phrase concatenation
 - Frame based or simple grammar sentence generator
- Dialog management
 - Task related manager
 - Task Database back-end

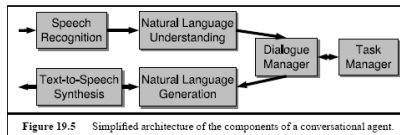
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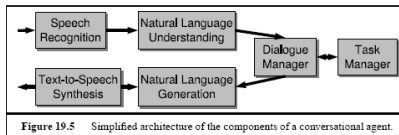
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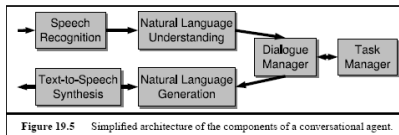
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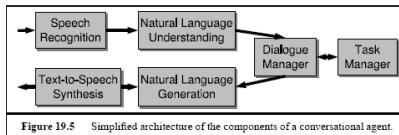
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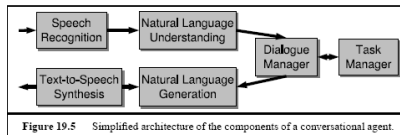
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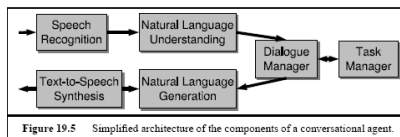
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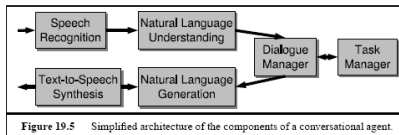
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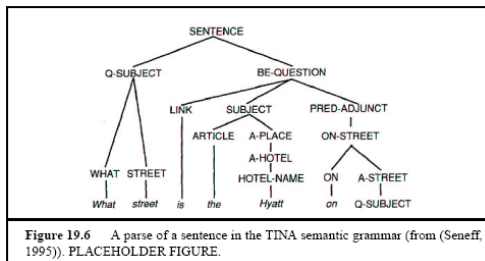
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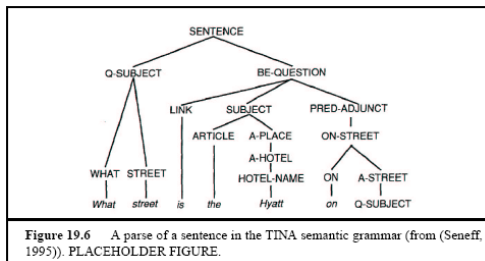
Recognizer



Recognizer must deliver semantic message

- Semantic context-free grammar (SCFG) for TINA
- Mixes words and concepts
- Hand written rules

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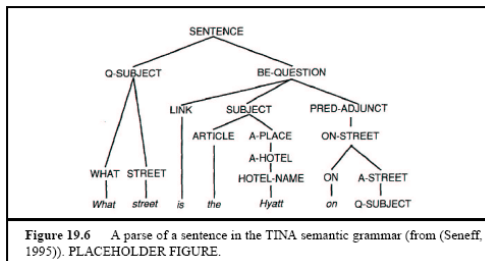


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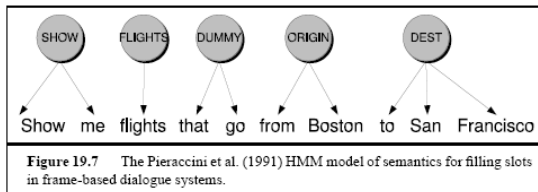
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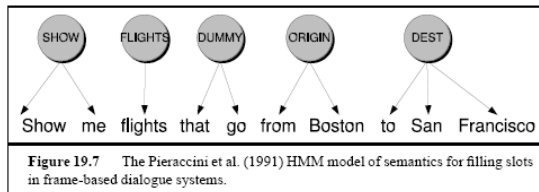
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HMM concept grammar

- $\underset{C}{\operatorname{argmax}} P(C|W) = \underset{C}{\operatorname{argmax}} P(W|C) \cdot P(C)$
- $P(W|C) = \prod_{i=2,N} P(w_i | w_{i-N+1}, \dots, w_{i-1}, c_i)$
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- Trained on a concept-labeled corpus

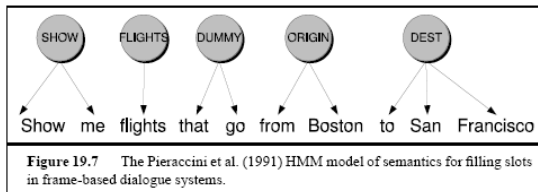
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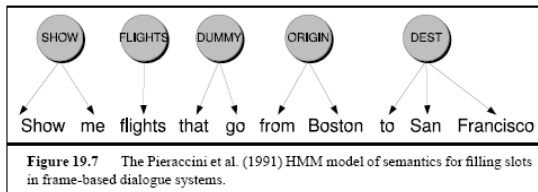
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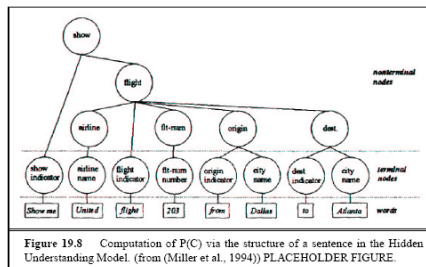
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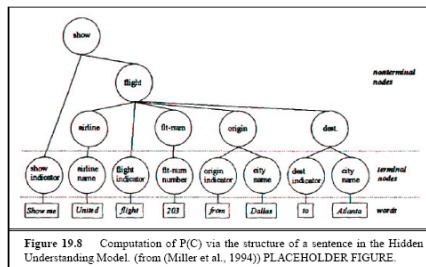
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Data fragmentation problem

- Identical names can be different concepts
 - Eg, cities as *origin* and *destination*
- Use a modified SCFG for $P(C)$
- Add SCFG rules for concepts, i.e. non-terminals

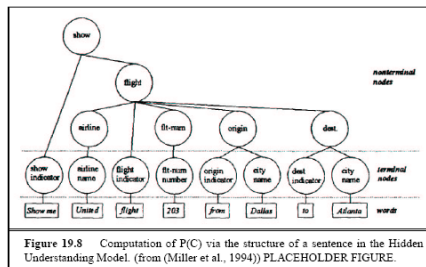
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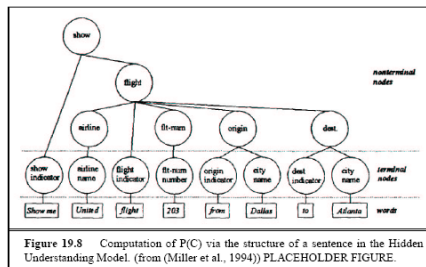
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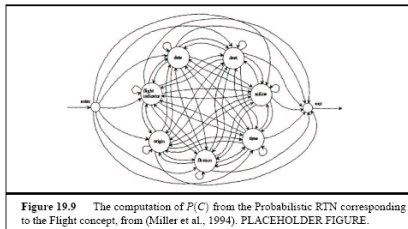
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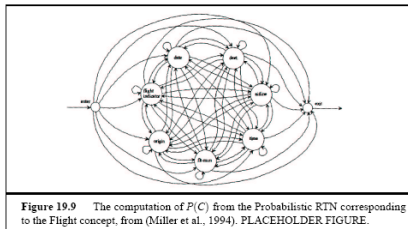
$P(C)$: Probabilistic finite state concept network

- Enter and Exit states
- Each arrow has a probability
- Circles indicate origin, destination, flight indicator, airline, etc.

[Jurafsky and Martin(2000)]



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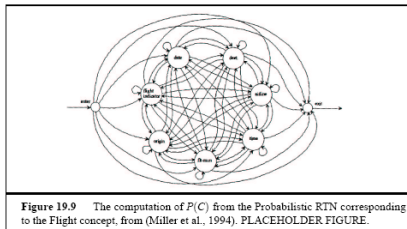
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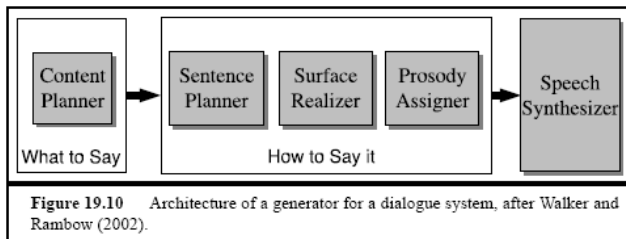
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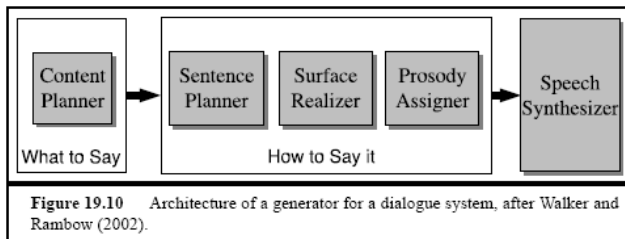
Speech Generator



Concept to speech

- The database manager generates an abstract message
- Modelled into a sentence structure
- Surface form, i.e. the words, are generated
- Prosody generated from words and content,
- Fed into a TTS system

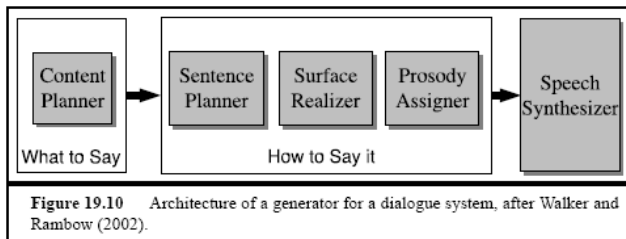
Speech Generator



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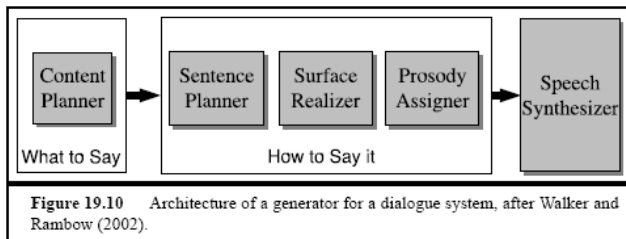
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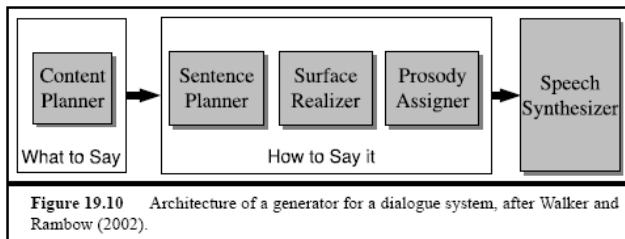
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Dialog management

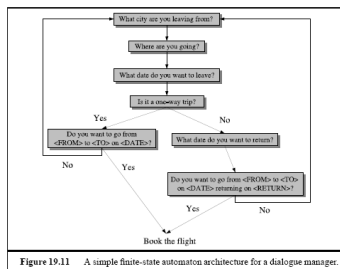


Figure 19.11 A simple finite-state automaton architecture for a dialogue manager.

Finite state automata

- Simple dialog states
- Good for form filling dialogues (frames)
- Can handle frame switching (stochastically)

Dialog management

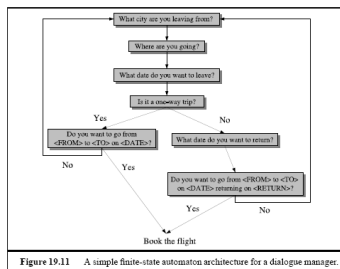


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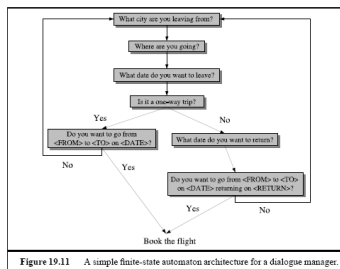


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Dialog management

Grammar	Prompt Type	
	Open	Directive
Restrictive	<i>Doesn't make sense</i>	System Initiative
Non-Restrictive	User Initiative	Mixed Initiative

Figure 19.12 Operational definition of initiative, following Singh et al. (2002).

Who takes the initiative

- Machine prompts all user actions \Rightarrow Finite state script
- User asks questions \Rightarrow Single frame
- Machine allows some user initiatives \Rightarrow Frame switching
- Negotiation \Rightarrow Plan based models

[Jurafsky and Martin(2000)][Allen et al.(2001)Allen, Byron, Dzikovska, Ferguson, Galescu, and Stent]



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Further Reading I



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Appendix A



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