Information Presentation in Spoken Dialogue Systems

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Overview of Talk

- Problem Setting
- User Modelling
- Content Structuring
- Integration of Clustering with User Modelling
- Implementation
- Evaluation and Results
- Summary

Problem

- Information presentation portion of dialogue is most time consuming
- Present sets of options and attributes sequentially
- Relies on users to remember complex trade-offs between multiple options
  - Places large memory burden on users

cf. Walker, Passonneau & Borland, ACL 2002

Typical Info Presentation

SYS: I found 9 round trips from Hartford to Orlando on 31st and returning Hartford on November 6th. For option 1, I have an outbound flight with US Air departing at 7 AM and arriving at 9 49 AM non-stop. A return flight is with U S Air departing at 10:30 AM and arriving at 12:28 AM with 1 stopover. Ticket price is 165 dollars. Please say “next option”, or, “flight details”, or, “I’ll take it”.

USER: NEXT OPTION

SYS: For option 2, I have an outbound flight with U S Air departing at 3:30 PM and arriving at 6 19 PM nonstop. A return flight is with U S Air departing at 8 25 PM and arriving at 12 28 AM with 1 stopover. Ticket price is 165 dollars. Say “next option”, or, “flight details”, or, “I’ll take it”.

USER: NEXT OPTION

SYS: . . .

User Modelling Approach

- elicit user model by asking users to rank attributes when they register to use system
- mention **relevant** options only
- **tailor** information

cf. Carenini & Moore 2000; Moore et al. 2004; Walker et al. 2004

Tailored Info Presentation

USER: I want to travel from Edinburgh to Brussels, arriving by 5 pm.

SYS: There's a direct flight on BMI with a good price. It arrives at four ten p.m. and costs one hundred and twelve pounds. The cheapest flight is on Ryanair. It arrives at twelve forty five p.m. and costs just fifty pounds, but it requires a connection in Dublin.

For a starving student

Tailored Info Presentation

USER: I want to travel from Edinburgh to Brussels, arriving by 5 pm.

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For a starving student

SYS: You can fly business class on British Airways, arriving at four twenty p.m., but you'd need to connect in Manchester. There's a direct flight on BMI, arriving at four ten p.m., but there's no availability in business class.

For a business traveller

UM Approach: Limitations

- Doesn´t scale up to domains with **many** relevant options

- Doesn´t provide user with **overview** of option space

Summarize-and-Refine Approach

- structure options by **clustering** them
- choose clustering that yields smallest number of clusters
- **summarize** these clusters
- user provides additional **constraints**

cf. Polifroni et al. 2003, Chung 2004

Example

SYS: I have found 983 restaurants. Most of them are located in Boston and Cambridge. There are 32 choices for cuisine. I also have information about price range.

USER: Okay tell me about the ones in Boston.

SYS: I have found 401 restaurants in Boston. There are 29 choices for cuisine.

USER: ...

Summarize-and-Refine Approach: Limitations

- **suboptimal** choice of attribute for summarization
- **exploration** of tradeoffs difficult
- structure contains **irrelevant** entities

Our Approach

Combine user modelling and content structuring

- **select** relevant options

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- **select** relevant options
- **structure** them based on user's valuations

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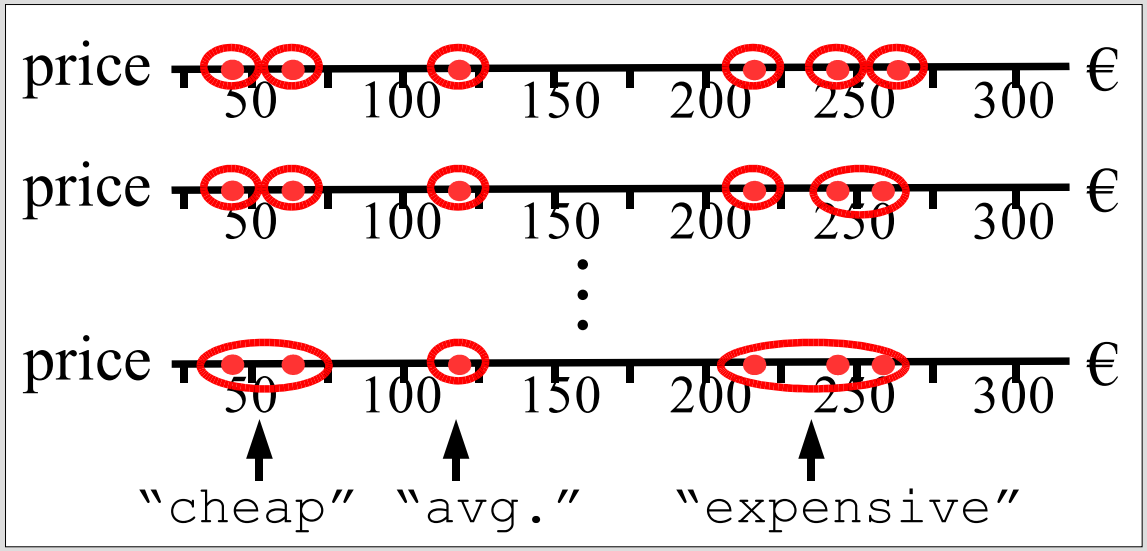
Our Approach

Combine user modelling and content structuring

- **select** relevant options
- **structure** them based on user's valuations
- automatically **determine tradeoffs**
- **tailor** summarizations
- **improve overview** of options space by briefly summarizing irrelevant options

Content Structuring and Content Selection

1. Cluster options
   (for each attribute: group-average agglomerative clustering)



flight 1

price:	49 €	→ cheap
airline:	KLM	→ good
#of legs:	2	→ bad
arriv.time:	9:30	→ good
travel dur:	4:30	→ bad
fare class:	econ.	→ ok

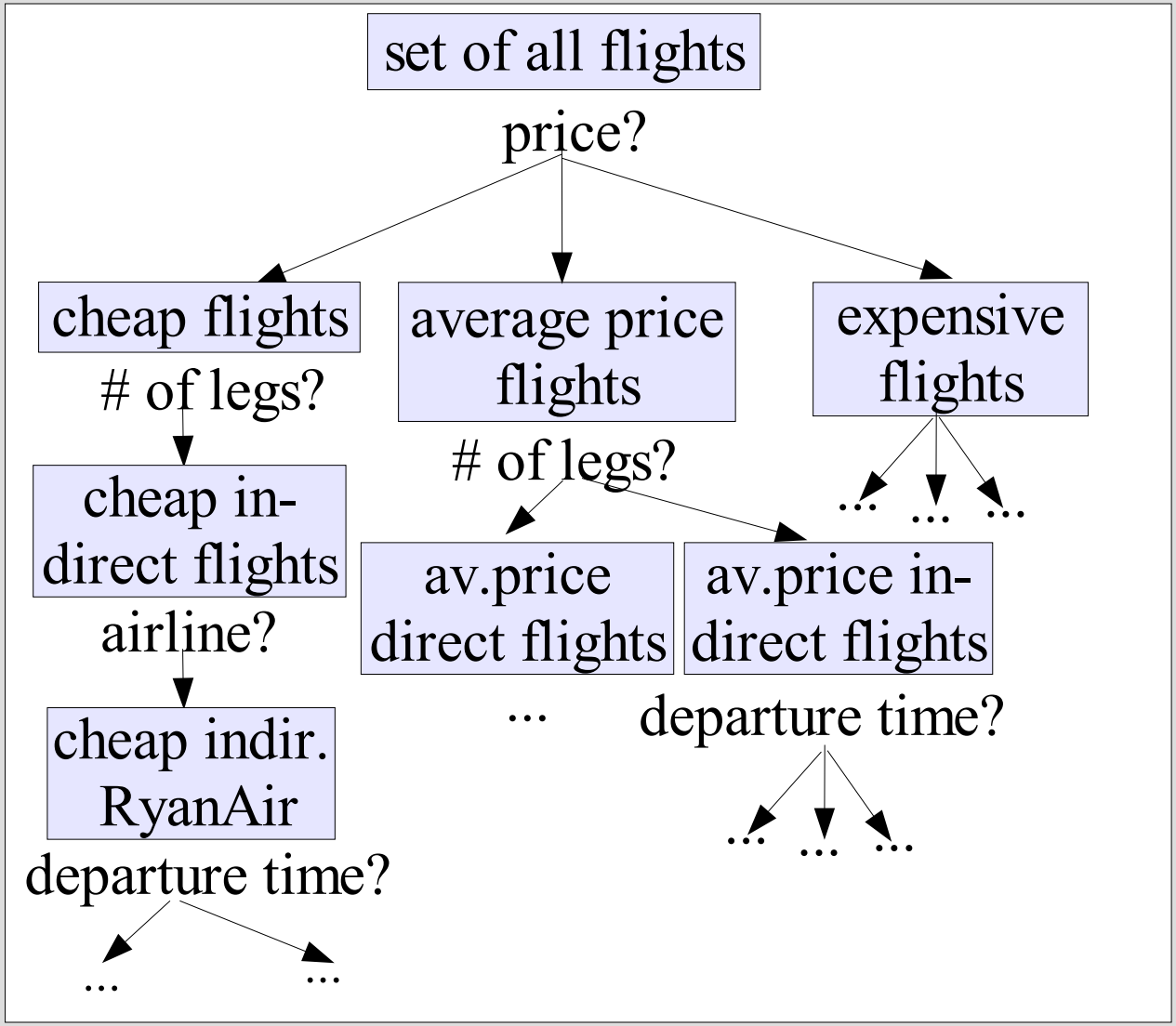
2. Build option tree

3. Prune irrelevant options from tree

Option Tree

Example User Profile "student":

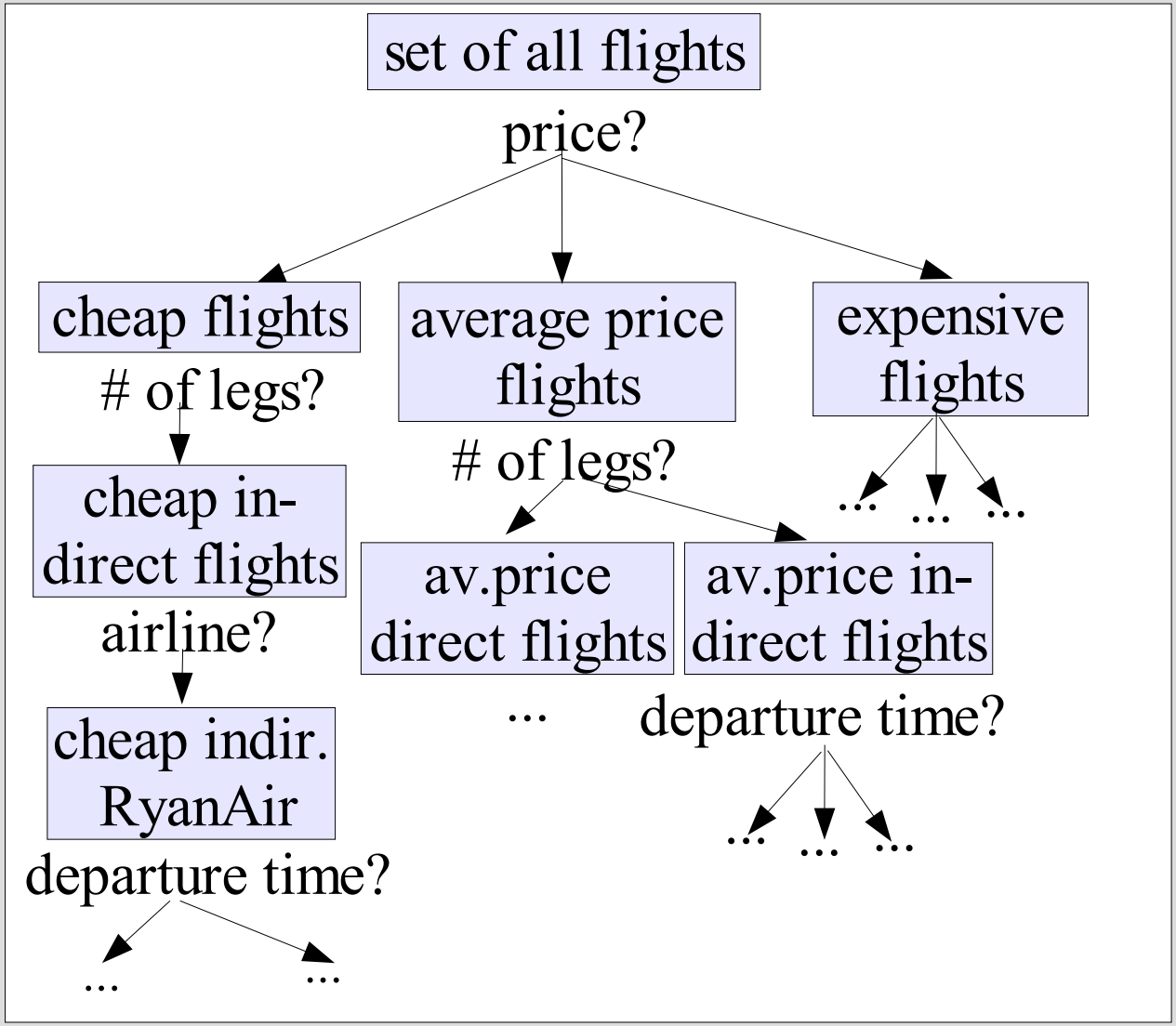
1 price
2 number of legs
  departure time
  arrival time
  travel time
6 airline
  fare class
  layover airport



Pruning irrelevant options

Domination:

A *dominated* option is in all respects equal to or worse than some other option in the relevant partition of the data base**.** *Dominant* options are those options for which there is no option in the data set that is better on all attributes.



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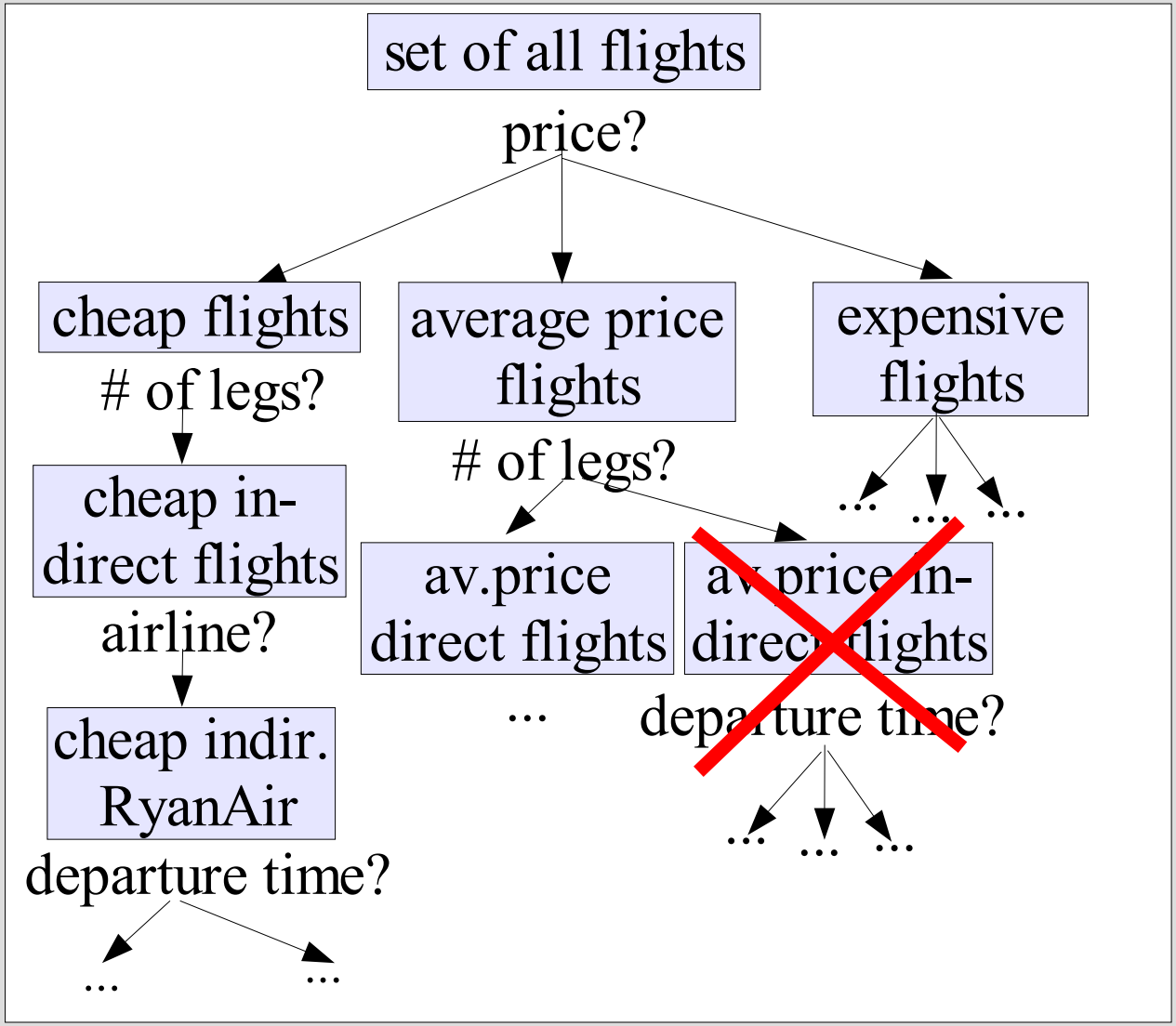

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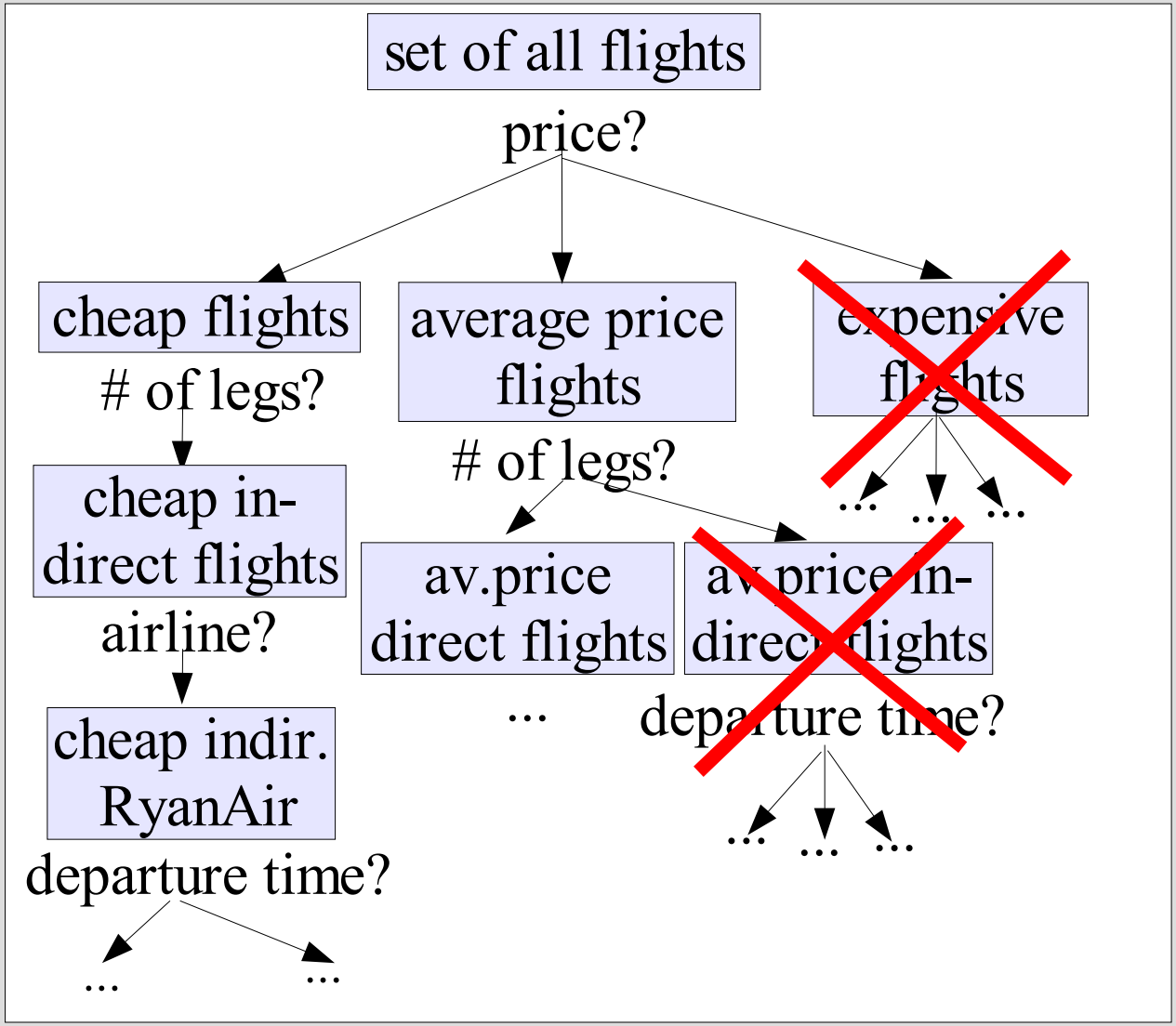

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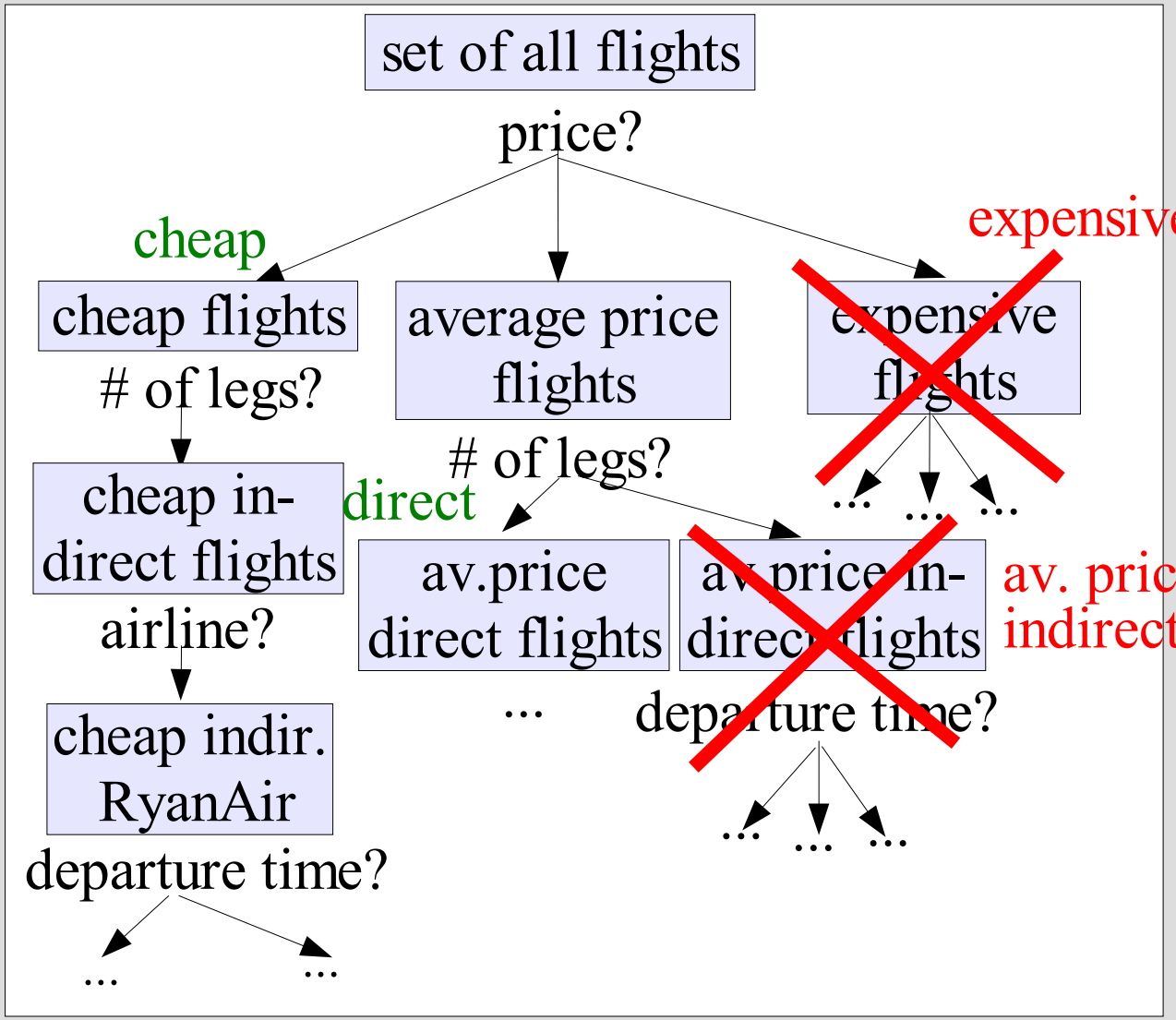
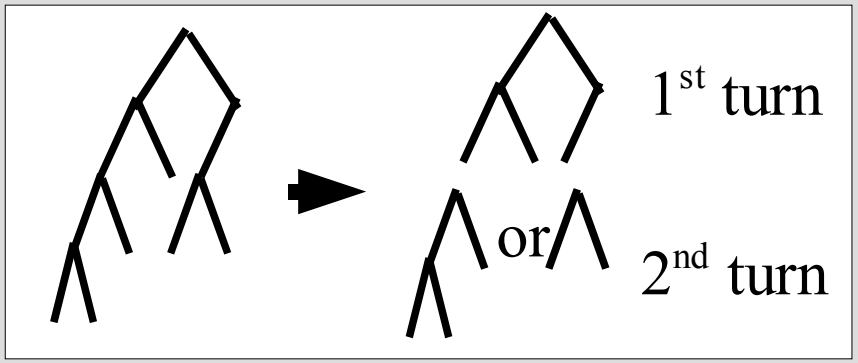


Content and Sentence Planning

- Content Planning
  - determine turn length



  - referencing clusters (using highest ranked or salient attr.)
  - argumentation structure

Content and Sentence Planning

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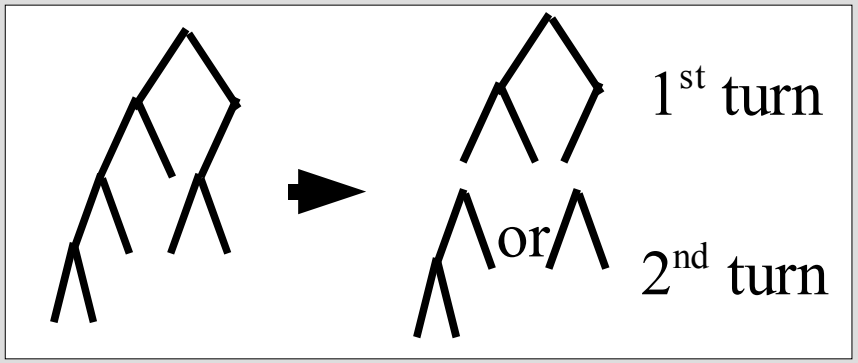
  - determine turn length



  - referencing clusters (using highest ranked or salient attr.)
  - argumentation structure
- Sentence Planning
  - summarize options (“all of them...”)
  - select structures (“If you're willing to...”)

Example Dialogue Turn

Example User Profile "student":

1 price
2 number of legs
  departure time
  arrival time
  travel time
6 airline
  fare class
  layover airport

User:
I'd like to book a flight from Edinburgh to Brussels for tomorrow.

Sys:
Ryan Air offers the cheapest flights to Brussels. They cost just 49 pounds but you would have to connect in Dublin. There are two flights to choose from. There's an early flight leaving Edinburgh at 8:05 am and arriving at 12:45 pm. To leave later, you can take the 1pm flight arriving Brussels at 5:30 pm.

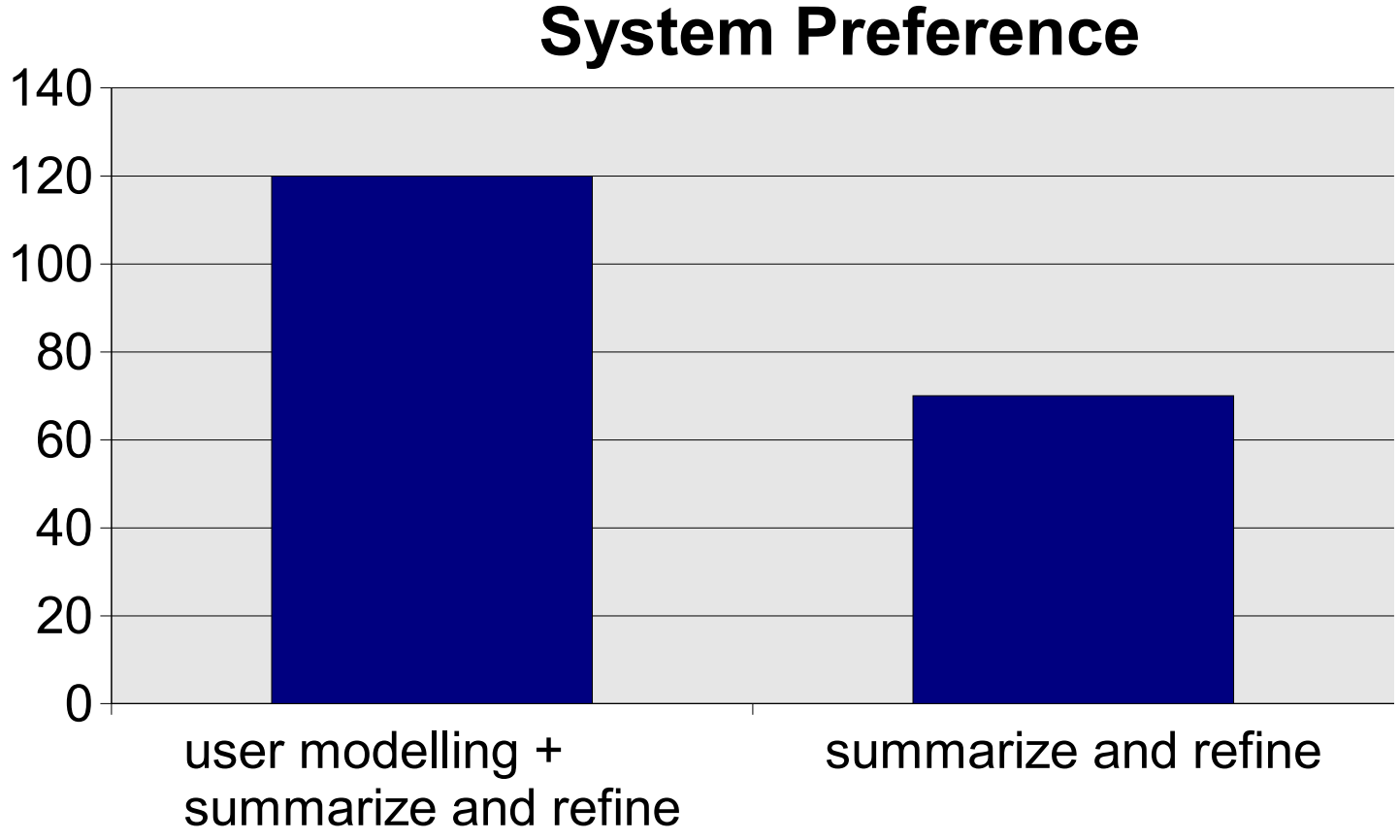
If you want to fly direct, there's a flight on BMI that leaves Edinburgh at 12 pm. It arrives at 1:35 pm and costs 112 pounds.

All other flights are more expensive.

Evaluation

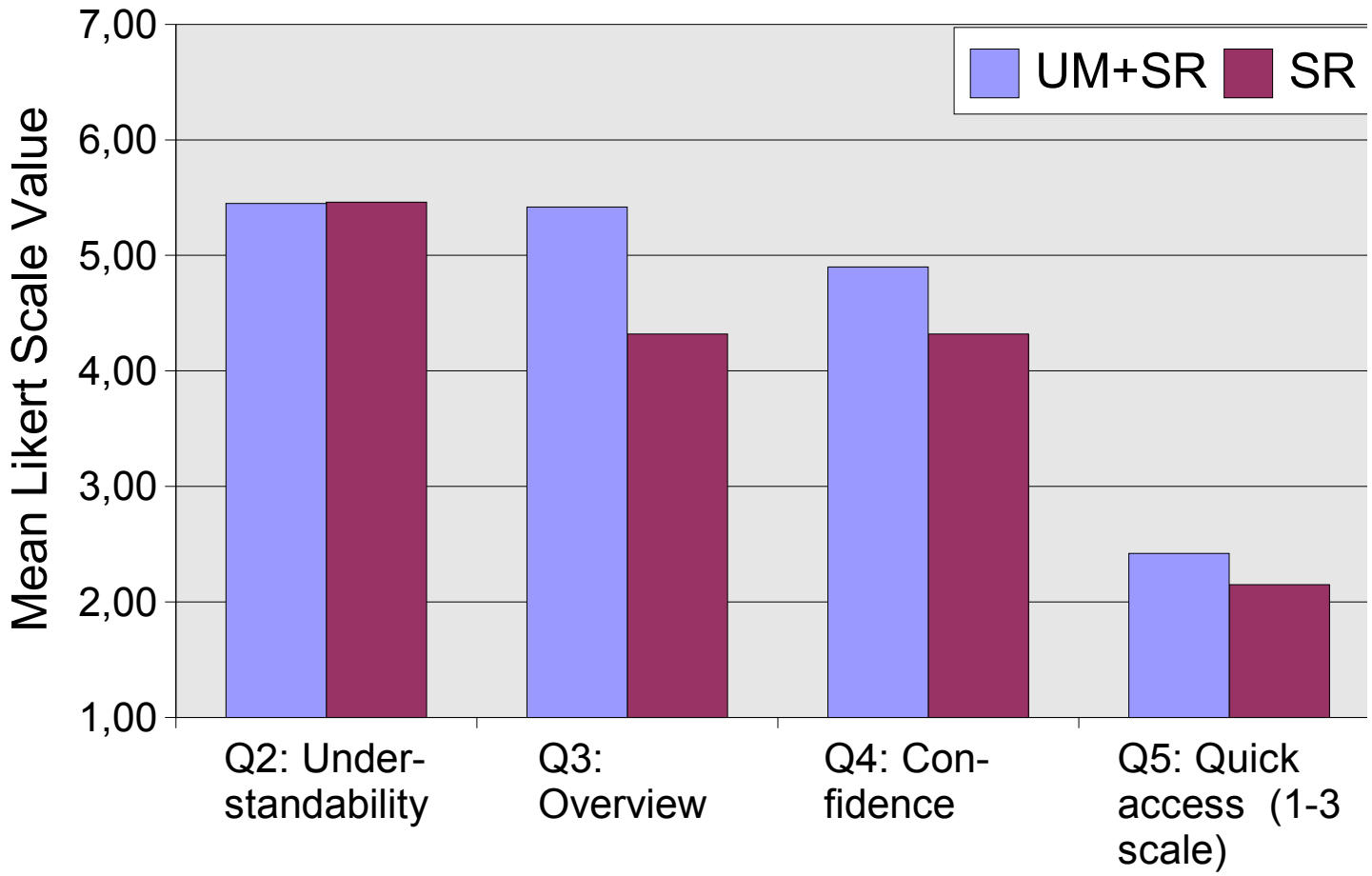
- within-participants laboratory experiment
- 38 subjects
- 6 dialogue pairs (UM+SR vs. SR)
- dialogues provided as texts for reading
- 5 questions after dialogue pair
- reading times were recorded

Results - Forced Choice Q.



$p < 0.001$ (two-tailed binomial test)

Results - Likert Scale Questions



Significance levels using two-tailed paired t-test

Q2: $p = 0.97$

Q3: $p < 0.0001$

Q4: $p < 0.0001$

Q5: $p < 0.001$

Summary

Integration of UM and Clustering allows to

- navigate through a **large set** of options
  - **structure** options according to users' valuations
  - present **relevant** options only
- automatically present **tradeoffs** between options, point out (dis-)advantages of options

Results in

- increased overall **user satisfaction**
- better **overview** of options
- increased users' **confidence** in system
- impression of **quicker access** to optimal option

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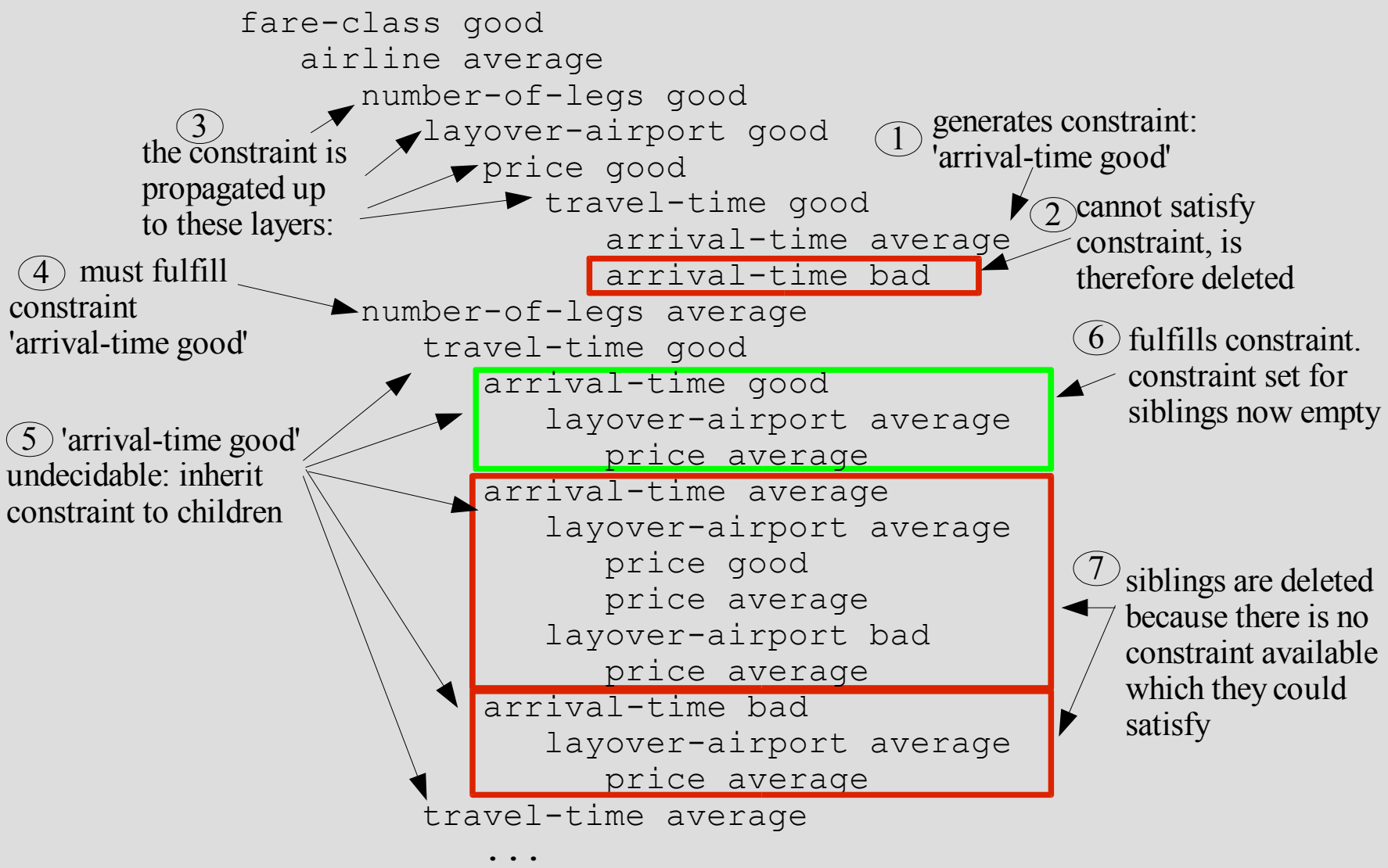
Future Directions

- evaluation with spoken dialogues
- evaluation while driving a car (complexity)
  cf. work by Andi Winterboer

The Pruning Process



Cleaning the Tree after Pruning

```
number-of-legs average
  travel-time good
    arrival-time good
     layover-airport average
       price average
  travel-time average
    arrival-time good
     layover-airport average
       price good
```

```
number-of-legs average
  arrival-time good
   layover-airport average
    travel-time good
      price average
    travel-time average
      price good
```

Questions

1) Which of the systems would you recommend to a friend?
   forced choice answer - system from 1st or 2nd dialogue
2) Did the system give the information in a way that was easy to understand?
   1 (very hard to understand) ... 7 (very easy to understand)
3) Did the system give you a good overview of the available options?
   1 (very poor overview) ... 7 (very good overview)
4) Do you think there may be flights that are better options for X that the system did not tell X about?
   1 (I think that is very possible) ... 7 (I feel the system gave a good overview of all options that are relevant for X)
5) How quickly did the system allow X to find the optimal flight?
   1 (slowly) ... 3 (quickly)

Problem Setting

Challenges in Information Presentation in SDS (such as a flight recommendation system):

- present information **linearly**
- overcome **memory constraints**
- enhance **understandability**
  - ➔ no simple enumeration
  - ➔ use contrast
  - ➔ highlight important properties of options

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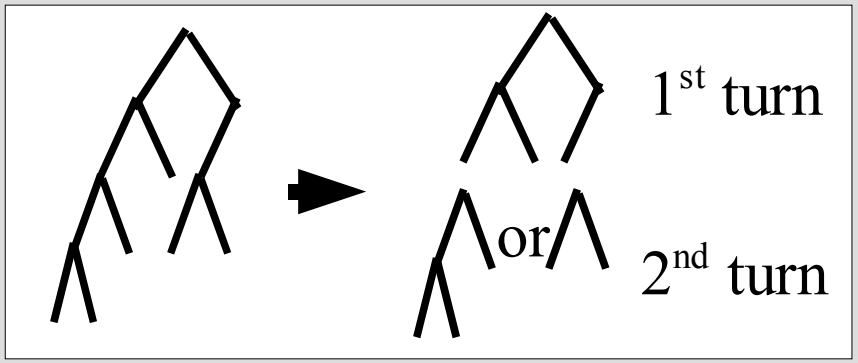
Challenges in Information Presentation in SDS (such as a flight recommendation system):

Content and Sentence Planning

- Content Planning
  - determine turn length



  - referencing clusters (using highest ranked or salient attr.)
  - argumentation structure
- Sentence Planning
  - summarize options (all of them...)
  - select structures (arriving at / that arrives at / It arrives at)