Automatic Generation of Web Interfaces from Discourse Models and Their Evaluation

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Outline

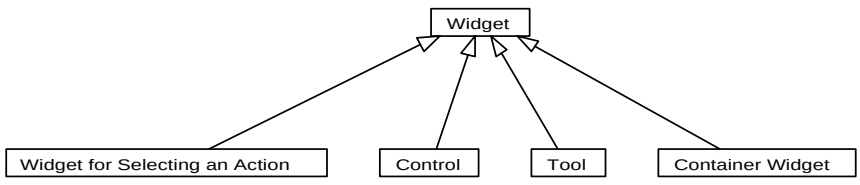
- Background
- Theories underpinning discourse modeling for HCI
- Interaction design based on discourse modeling
- Exercises
- Sketch of automated user-interface generation
- Evaluation of Web GUIs
- Summary and conclusion

Traditional UI development

- Based on toolkits employing widgets
- Widgets grouped according to their graphical appearance
- Highly-specialized designers and programmers needed
- Lots of UI code
- Error-prone, low maintainability
- Expensive

Widgets

- Interactive objects presented on the display
  - windows
  - buttons
  - scroll bars
- User interface elements
- Classification hierarchy of widgets



Interaction design

- Design of interactions between human and computer
- Relation to requirements engineering
- Relation to task analysis
- No commitment to specific user interface

Scenarios – Stories and narratives

- For representation of
  - cultural heritage
  - explanations of events
  - everyday knowledge
- Human understanding in terms of specific situations
- Human verbal interactions by exchanging stories

Ontologies

- Tom Gruber
- Actually, the old Greeks
- Domain models
- Conceptualizations of a domain
- Often using taxonomies and object-based ideas
- Ontology languages based on knowledge-representation theories
- E.g., OWL based on description logic

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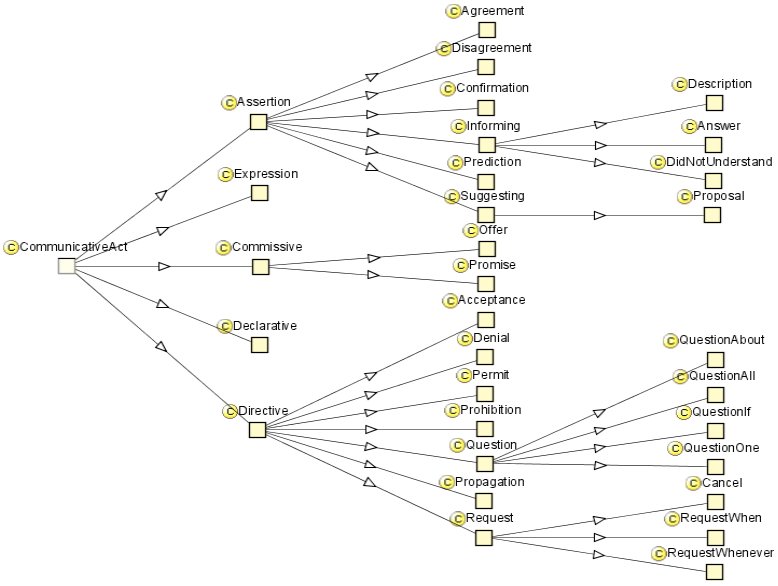
Speech acts

- John R. Searle
- Theory from philosophy of language
- Human speech also used to do something with intention — to act
- "Speaking a language is performing speech acts, act such as making statements, giving commands, asking questions and so on"
- Speech acts: basic units of language communication
- Communicative acts: abstraction from speech

Conversation Analysis

- Harvey Sacks; Luff, Gilbert and Frohlich
- Theory from sociology
- Focus on sequences of naturally-occurring talk "turns"
- To detect patterns that are specific to human oral communication
- Adjacency pair: e.g., a question should have a related answer
- Inserted sequence: subordinate interactions

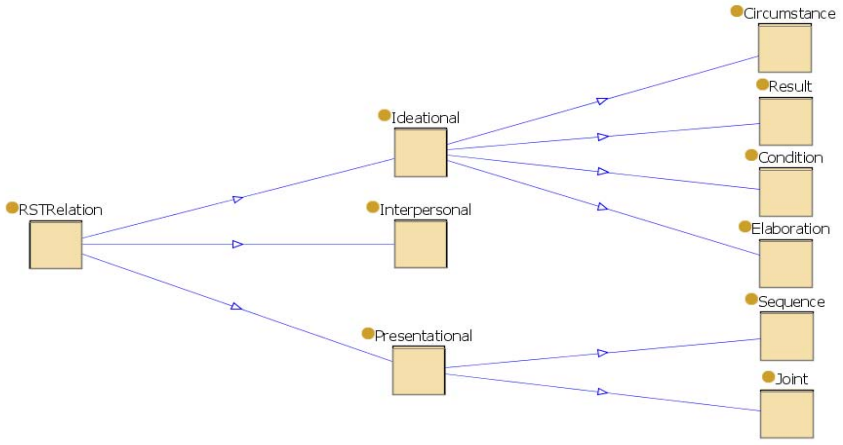
Communicative Acts Taxonomy (selection)



Rhetorical Structure Theory (RST)

- Mann and Thompson
- Linguistic theory
- Internal relationships among text portions and associated constraints and effects
- Relationships in a text are organized in a tree structure
- Rhetorical relations associated with non-leaf nodes, and text portions with leaf nodes

RST Taxonomy (selection)



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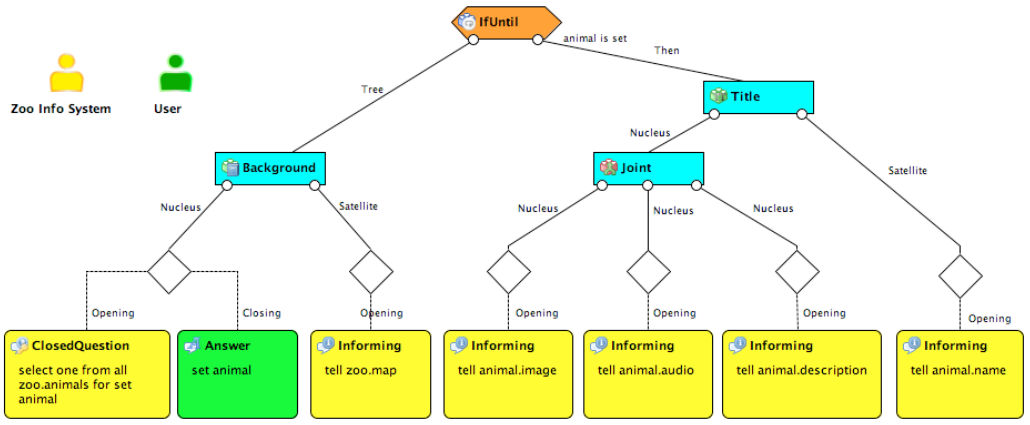
Discourse Example



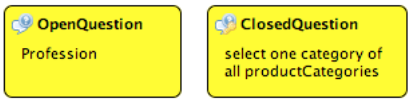
Discourse Model

Discourse "atoms" and "molecules"

- Metaphorical view
  - Communicative acts as atoms
  - Adjacency pairs as molecules
- Communicative acts instead of RST text portions
  - Interaction instead of text
- Two dimensions
  - Tree with discourse relations (monologue)
  - Adjacency pair (dialogue)
- Integration of RST and procedural constructs with Conversation Analysis

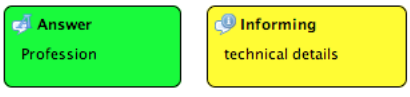
Communicative Acts – Open & Closed Question

- Open Questions enable asking for a particular type of information, respectively, an instance of a domain class.
- Closed Questions restrict the possible answer to a list of provided domain instances to choose from.



Communicative Acts – Informing & Answer

- Both are used to convey information.
- Answer communicative acts are always directly related to questions, whereas Informing is uttered standalone or together with acknowledgment.



Communicative Acts – Request

Used to request the communication partner to act. Thus, the propositional content of a request is always an action that has to be carried out. The action can be defined either for the given application, or it can be the request to utter a particular communicative act.

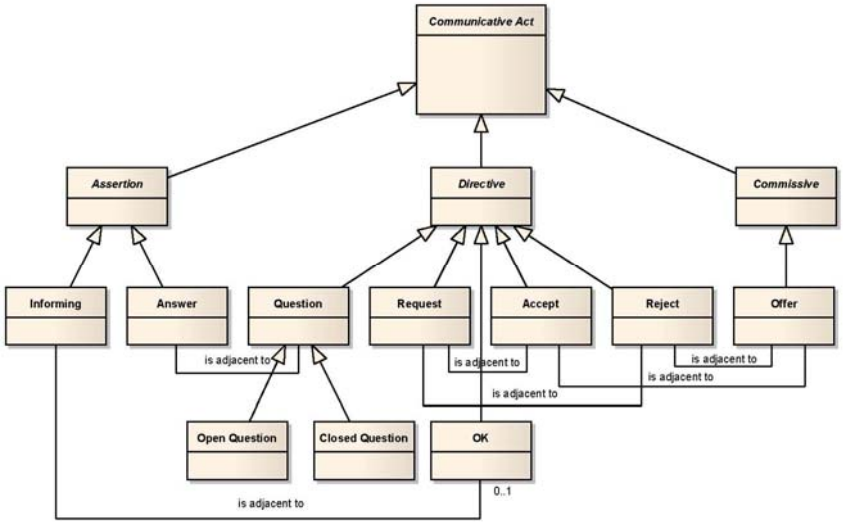
Communicative Acts – Offer

Offers to carry out an action or to add information to the shared knowledge.

Communicative Acts – Accept & Reject

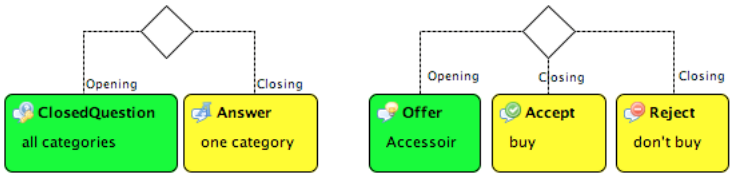
Accept and Reject provide for accepting or rejecting a particular request or offer.

Communicative Acts Taxonomy



Adjacency Pair

- Relates an initial communicative act with one subsequent communicative act or two alternative subsequent communicative acts.
- Typical adjacency pairs of communicative acts are:
  - ClosedQuestion–Answer, OpenQuestion–Answer
  - Offer–Accept, Offer–Reject
  - Request–Informing, Request–Accept, Request–Reject

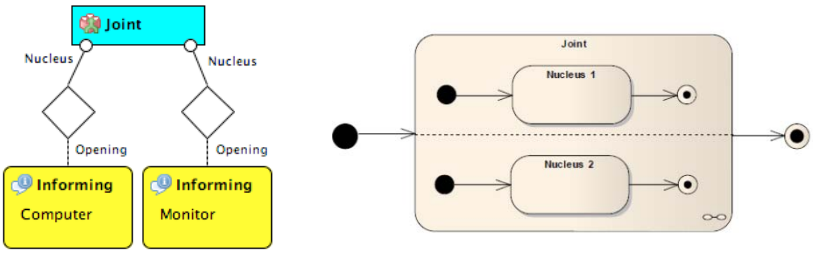


RST relations (in our approach)

- Nucleus: the main part of the communication
- Satellite: the helper part
- Communicative acts instead of text portions

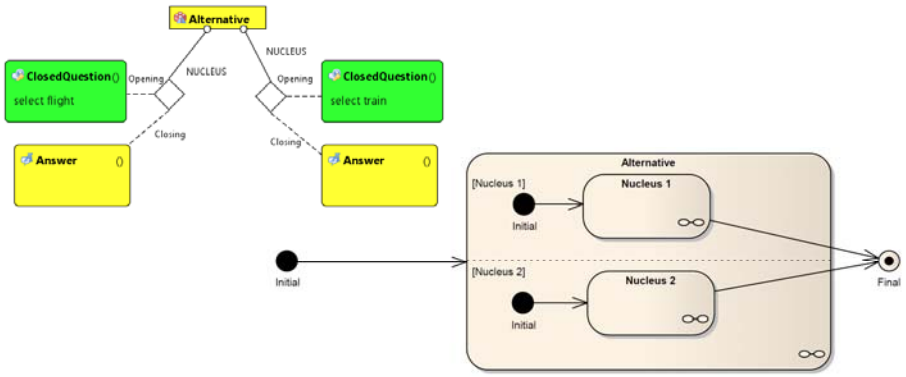
RST relation – Joint

Relates independent subtrees with communicative acts of the same kind. It does not imply any order. So, it is also possible to issue both nuclei concurrently (e.g., on a GUI).



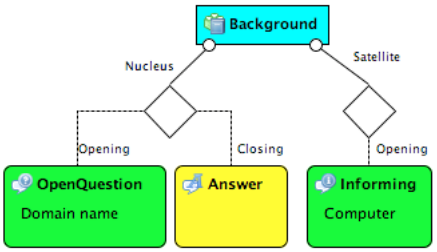
RST relation – Alternative

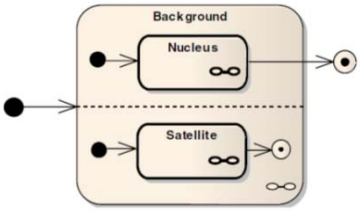
Relates alternative subtrees with communicative acts. Only one subtree can be finished.



RST relation – Background

- General information of any sort that is likely to help understand the nucleus.
- Thus, satellite of the background relation shall only contain Informing communicative acts.

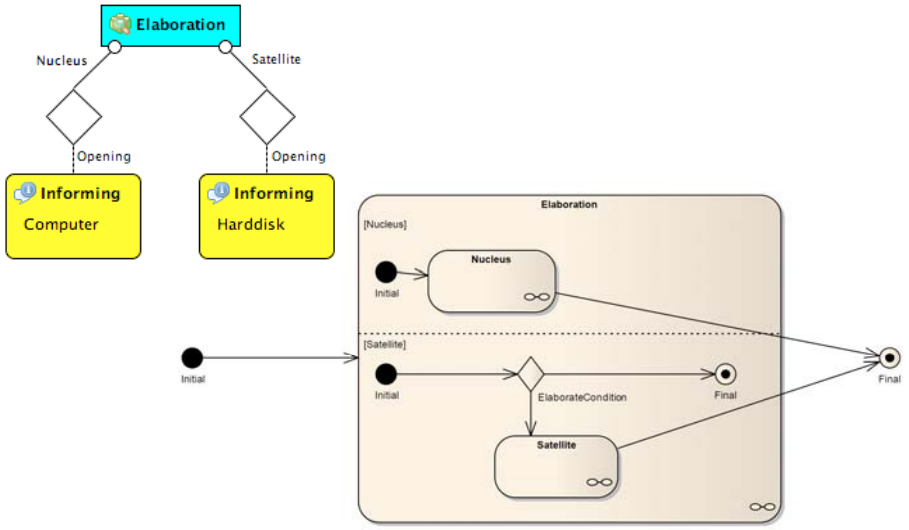




RST relation – Elaboration

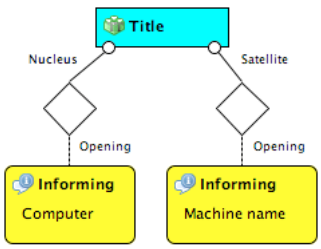
- Satellite contains additional detail about some element of subject matter which is presented in the nucleus, in one or more of the ways listed below (nucleus :: satellite):
  - set :: member
  - abstraction :: instance
  - whole :: part
  - process :: step
  - object :: attribute
  - generalization :: specific
- The communicative acts can also be questions, for example, if one communicative partner wants to figure out additional details about the subject matter.

RST relation – Elaboration (cont.)

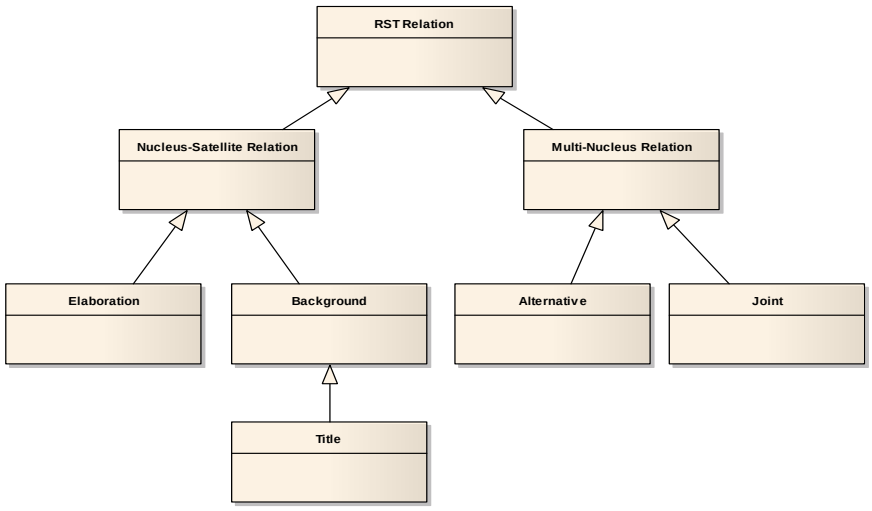


RST relation – Title

Specialization of Elaboration, restricting the additional detail of some element of subject matter to a short description, either title or caption.

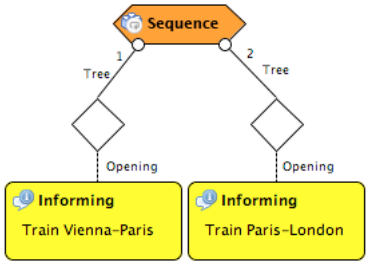


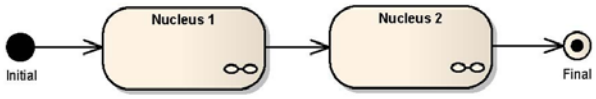
Taxonomy of RST relations



Procedural construct – Sequence

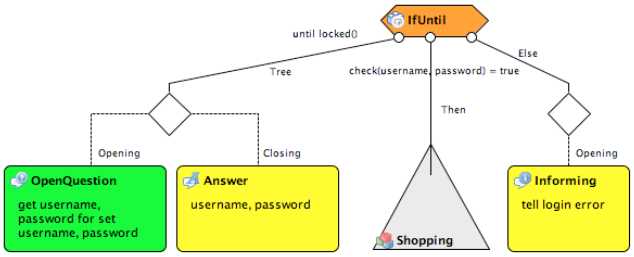
Defined order of uttering the communicative acts or subtrees.



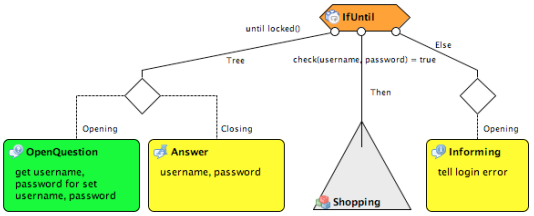


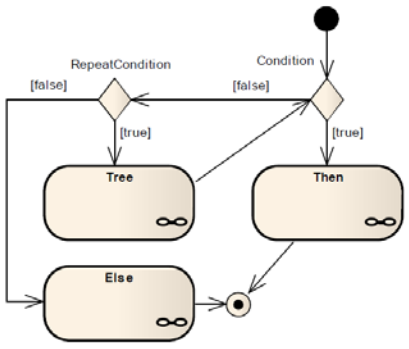
Procedural construct – IfUntil

- If-statement combined with a conditional loop
- Utterance of the <Then> subtree depends on successful execution of the related Condition.
- Repetition of the <Tree> branch until Condition becomes fulfilled, while RepeatCondition is fulfilled

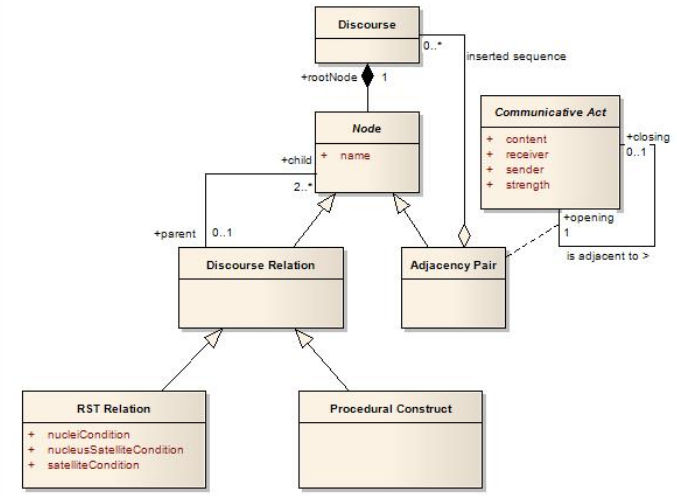


Procedural construct – IfUntil (cont.)





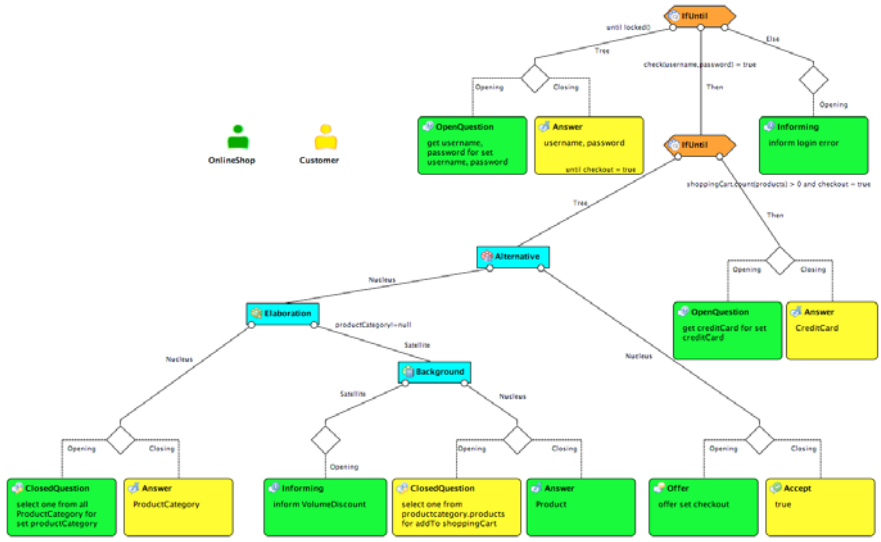
Conceptual Discourse Metamodel



Domain representation

- Speech act usually talks about something in the domain of discourse
- Model of the domain
- Integration and use of ontologies

Example model



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Exercises

- **Given at the tutorial**

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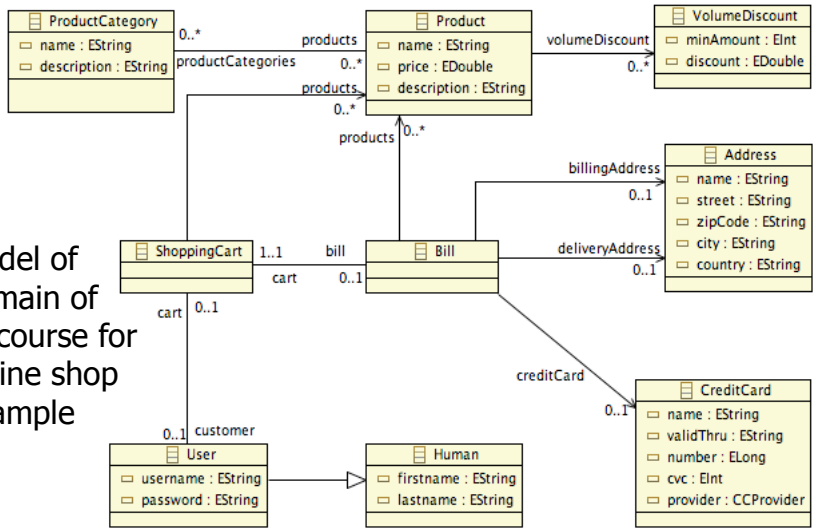
Integration and Use of Ontologies

- Speech act usually talks about something in the domain of discourse.
- Selection from ontology in Domain-of-Discourse Model
- References from Discourse Model to Domain-of-Discourse Model

Domain-of-discourse model

Model of domain of discourse for online shop example



Interface to Application Logic

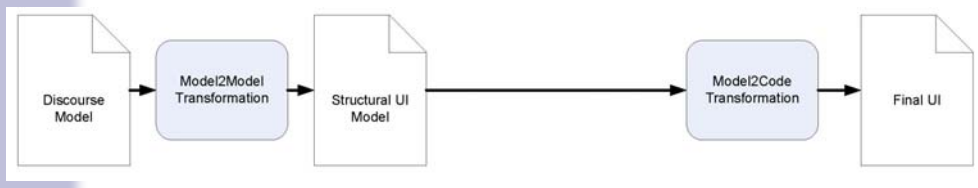
- Specification of (interfaces of) methods of the application logic
- Action-Notification Model
  - Access or change of data (Domain-of-Discourse Model), and
  - Application-specific actions
    - Actions of software, or
    - Physical actions (of a robot)
- References from Discourse Model to Action-Notification Model

Rendering of Final User Interfaces

- Automated generation of final (multimodal) UIs
- Generation of GUIs (WIMP UIs)
  - Generation of Structural UI Model
  - Optimization (for Smartphones)
  - Generation of Behavioral UI Model
  - Weaving of Structural and Behavioral Models
- Even for multiple platforms

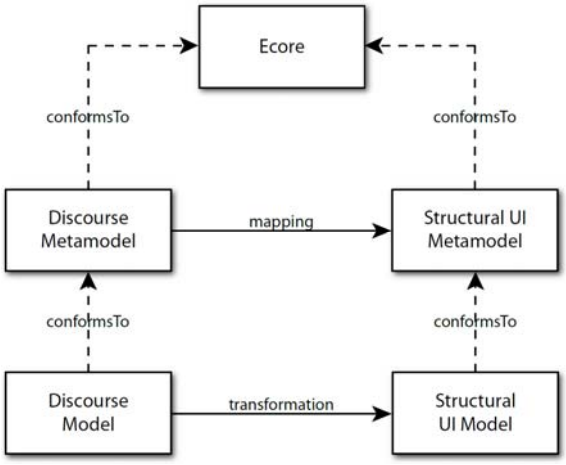
Generation of Structural UI Model

- Model-driven transformations
- Two major steps to structure of Final GUI



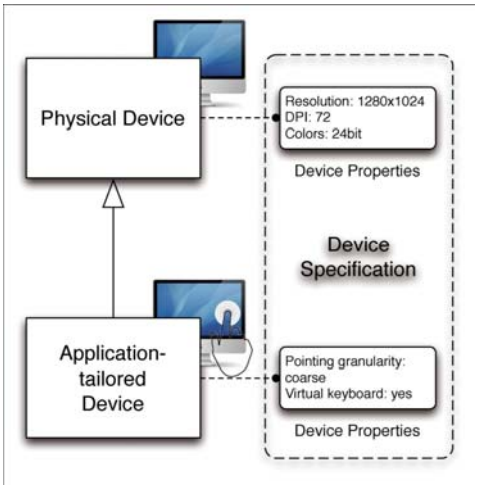
Generation of Structural UI Model – MDA

- Model Driven Architecture
- Metamodels
- Transformation Rules
- Model transformation by rule application



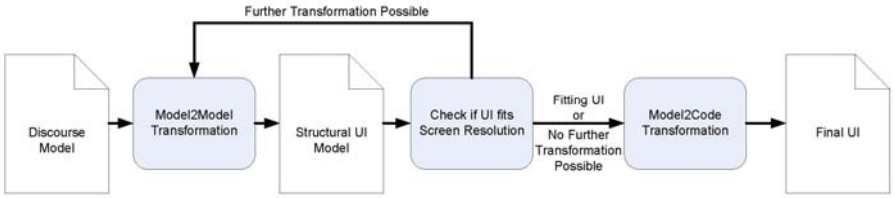
Generation of Structural UI Model – Devices

- Generation according to device specifications
- Application-tailored device specifications in addition to physical ones



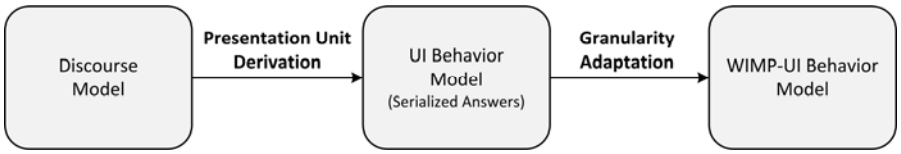
Optimization for Smartphones

- Objectives:
  - Maximum use of the available space
  - Minimum amount of navigation clicks, and
  - Minimum scrolling (except list widgets)
- Heuristic search for optimization (Branch & Bound)



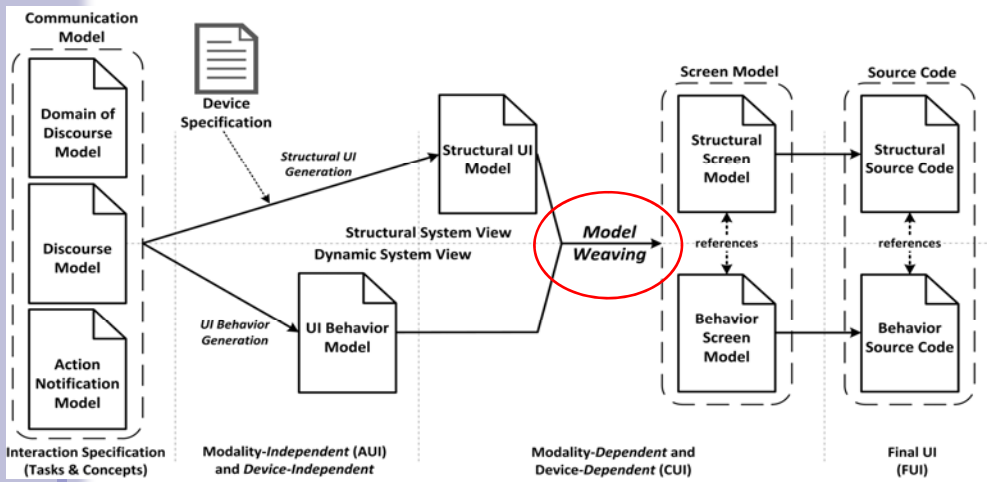
Generation of Behavioral UI Model

- UML state machines for each part defined
- Composition of state machines according to structure of Discourse Model
- Determination of Presentation Units (for GUI)
- Parallelism and Granularity of Communication Units



Weaving of Structural and Behavioral Models

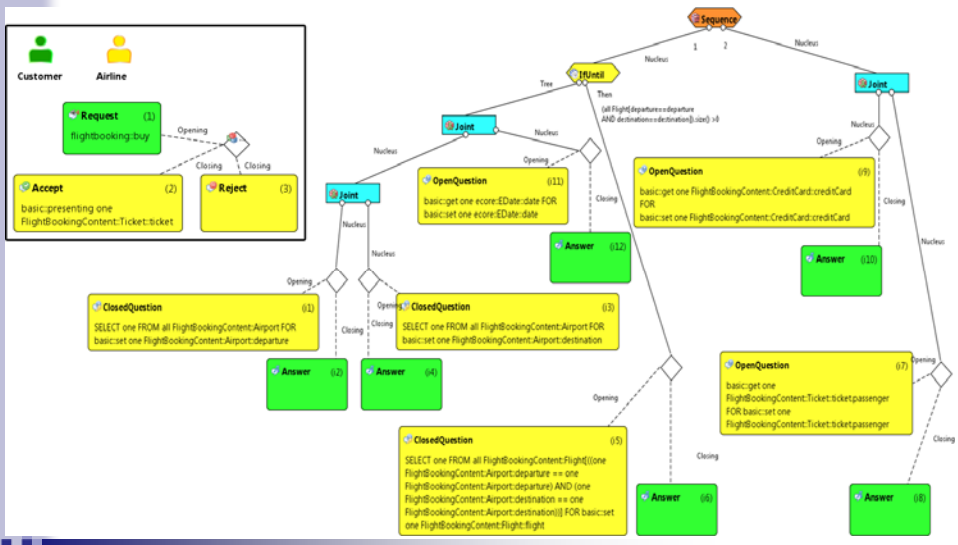
- Different levels of abstraction



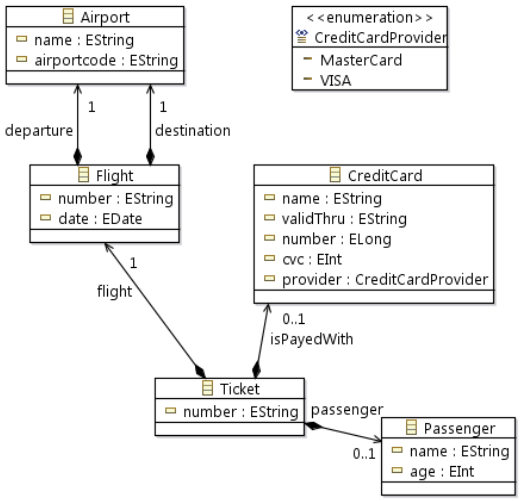
Examples of Final User Interfaces – Phones

- Simple flight-booking GUI
- Optimized for various Smartphones, see http://ontoucp.ict.tuwien.ac.at/UI/FlightBooking
- Potentially different UIs for different phones (screens)

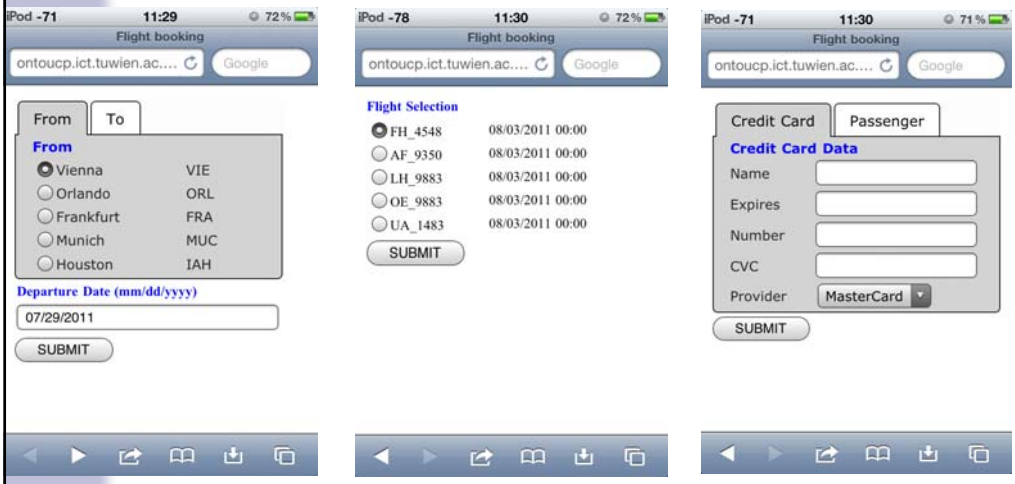
Flight Booking Discourse Model



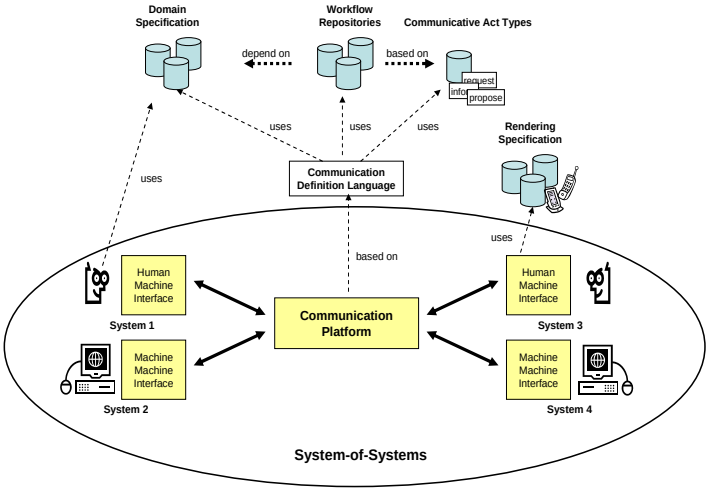
Flight Booking Domain-of-Discourse Model



Flight Booking Rendered for iPod Touch



Unified Communication Platform



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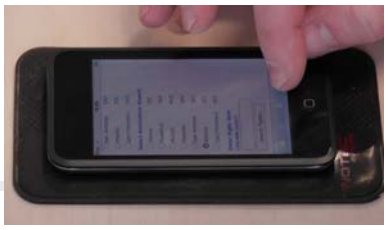
Introduction to Smartphone Study

- Tailoring for smartphones is important:
  - Relatively small screens
  - Touch-based devices
- What is better?
  - Vertical scrolling
  - Tab-based navigation (tapping)
- User study for investigation of this question



User Study Design — Participants

- 30 participants:

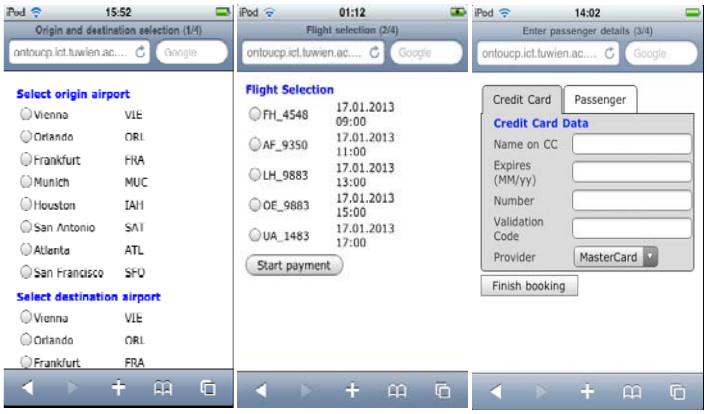
Age:	18–39 years
Gender:	3 female and 27 male
Educational level:	28 students and 2 assistants with doctoral degrees
Use of mobile devices:	56.7% regular, 40% sometimes but never owned one, 3.3% never
Online flight booking:	20% regular, 40% sometimes and 40% never

User Study Design — Procedure

- Informing the participants
- Scenario description (printed version on the table):
  "Imagine it is Tuesday 14/02/2012, 11:55am and your boss Mr. Huber tells you to book a flight ticket for his wife as quickly as possible. Mrs. Huber is already waiting at the airport!"
  Book a flight from *Munich* to *Atlanta* on *02/14/2012* at *1pm* for Mrs. *Anna Huber* (age 47). Pay for it using her husband's (Max Huber's) *VISA Credit Card* with the number: *1258 8569 7532 1569* (validation code: *354*) and the expiration date *12/14* ."
- After both tasks (layouts) subjective opinions

User Study Design — Study Setup

- Two different layouts:



a) Vertical scroll-based layout (Screen 1) b) Both layouts (Screen 2) c) Tab-based layout (Screen 3)

User Study Design — Analysis

- Correlations between task time / error rate and the type of layout
- *Independent variables:*
  - GUI: tab-based (T-UI), vertical scroll-based (V-UI)
  - The order in which the two layouts were tested
- *Dependent variables:*
  - Adjusted task completion time
  - Error rate
- *Point-biserial Pearson correlation coefficients*

User Study Design — Null Hypotheses

- $NH_{VT,T}$: *There is no statistically significant correlation (p-value = 0.05) between the adjusted task time and the type of GUI: V-UI and T-UI.*
- $NH_{VT,E}$: *There is no statistically significant correlation (p-value = 0.05) between the error rate and the type of GUI: V-UI and T-UI.*

Results — Statistical Results

Table 2. Correlation between adjusted task time on a screen and its layout.

	Pearson Corr.	Sig. (1-tailed)	*V-UI* av. time	*T-UI* av. time
Time Screen1 × GUI	**0.35**	0.003	12.79s	17.98s
Time Screen2 × GUI	0.12	0.189	8.17s	9.50s
Time Screen3 × GUI	**0.43**	0.000	4.85s	9.31s

- Adjusted task time using V-UI is significantly smaller than using T-UI in Screen 1 and Screen 3.
- The null hypothesis $NH_{VT,T}$ can be rejected for this experiment.
- It took 54% longer to operate T-UI.

Results — Statistical Results (cont.)

Table 3. Correlation between the number of errors on a screen and its layout.

	Pearson Corr.	Sig. (1-tailed)	*V-UI* av. errors	*T-UI* av. errors
Errors Screen1 × GUI	**0.363**	0.002	0	0.23
Errors Screen2 × GUI	-	-	0	0
Errors Screen3 × GUI	**0.285**	0.014	0	0.2

- The error rate for V-UI is significantly smaller than that of T-UI in Screens 1 and 3.
- The null hypothesis $NH_{VT,E}$ can also be rejected.
- There were no errors for V-UI.

Results — Subjective Opinions

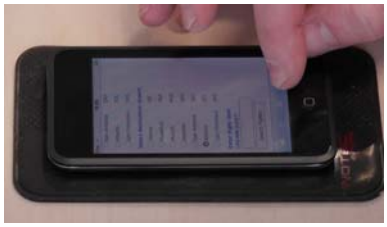
- Results of the *subjective questionnaire:*
  - 60% preferred V-UI
  - 30% preferred T-UI
  - V-UI was considered
    - More intuitive to navigate
    - More intuitive to interact with
    - Slightly less demanding
    - More efficient to use
- *Interviews* confirmed error rate result.

Conclusion of Smartphone Study

- Participants performed significantly better when scrolling vertically, as opposed to tapping on widget elements (tabs).
- This preference was also reflected in their subjective opinions.
- The study also suggests that minimizing the number of taps is important on a smartphone.
- Study variable-sized lists, since it is not clear if vertical lists of *any* length are necessarily better than a tab-based layout.

Introduction to Smartphone &Tablet PC Study

- Tailoring for smartphones and tablet PCs is important:
  - Relatively small screens
  - Touch-based devices
- What is better?
  - Horizontal scrolling
  - Tab-based navigation (tapping)
- User study for investigation of this question



User Study Design — Participants

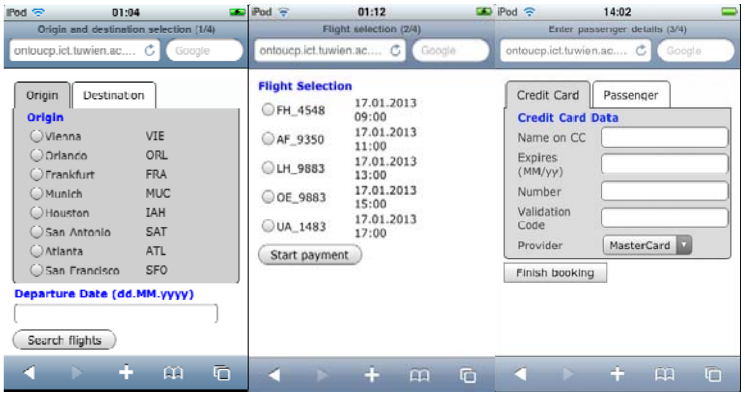
- 20 participants:
  - Age: 21—35 years
  - Gender: 1 female and 19 male
  - Educational level: Students
  - Use of mobile devices: 75% regular, 25% sometimes but never owned one
  - Online flight booking: 20% regular, 35% sometimes, 45% never

User Study Design — Procedure

- Informing the participants
- Scenario description (printed version on the table):
  "Imagine it is Tuesday 14/02/2012, 11:55am and your boss Mr. Huber tells you to book a flight ticket for his wife as quickly as possible. Mrs. Huber is already waiting at the airport!"
  Book a flight from *Munich* to *Atlanta* on *02/14/2012* at *1pm* for Mrs. *Anna Huber* (age 47). Pay for it using her husband's (Max Huber's) *VISA Credit Card* with the number: *1258 8569 7532 1569* (validation code: *354*) and the expiration date *12/14* ."
- After both tasks (layouts) subjective opinions

User Study Design — Two different layouts

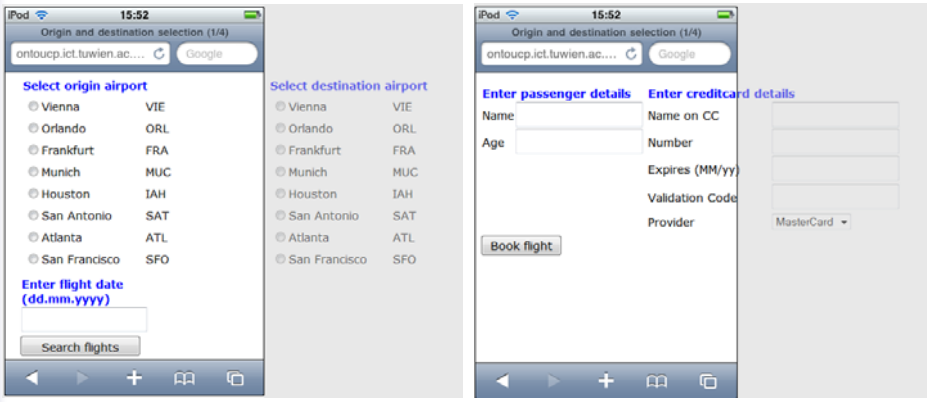
- Tab-based layout:



Screen 1 Screen 2 Screen 3

User Study Design — Two different layouts

- Horizontal scroll-based layout:



Screen 1 Screen 3

User Study Design — Analysis

- Correlations between task time / error rate and the type of layout
- *Independent variables:*
  - GUI: tab-based (T-UI), horizontal scroll-based (H-UI)
  - The order in which the two layouts were tested
- *Dependent variables:*
  - Adjusted task completion time
  - Error rate
- *Point-biserial Pearson correlation coefficients*

User Study Design — Null Hypotheses

- $NH_{TH,T}$: *There is no statistically significant correlation (p-value = 0.05) between the adjusted task time and the type of GUI: T-UI and H-UI.*
- $NH_{TH,E}$: *There is no statistically significant correlation (p-value = 0.05) between the error rate and the type of GUI: T-UI and H-UI.*

Results — Statistical Results

CORRELATION BETWEEN ADJUSTED TASK TIME ON A SCREEN AND ITS LAYOUT ON AN IPODTOUCH.

	Pearson Corr.	Sig. (1-tailed)	*T-UI* av. time	*H-UI* av. time
Time Screen1 × UI	**0.52**	0.01	14.23s	29.57s
Time Screen2 × UI	0.12	0.31	8.96s	9.98s
Time Screen3 × UI	**0.37**	0.05	8.09s	13.34s

CORRELATION BETWEEN ADJUSTED TASK TIME ON A SCREEN AND ITS LAYOUT ON A MOTOROLA XOOM.

	Pearson Corr.	Sig. (1-tailed)	*T-UI* av. time	*H-UI* av. time
Time Screen1 × UI	**-0.56**	0.01	13.37s	7.43s
Time Screen2 × UI	-0.17	0.23	7.45s	6.38s
Time Screen3 × UI	**-0.66**	0.00	8.00s	4.57s

- Adjusted task time using T-UI is significantly smaller / larger than using H-UI in Screen 1 and Screen 3.
- The null hypothesis $NH_{TH,T}$ can be rejected for this experiment on both devices.
- Task times on the tablet PC were on average smaller than on the iPodTouch.

Results — Statistical Results (cont.)

CORRELATION BETWEEN THE NUMBER OF ERRORS ON A SCREEN AND ITS LAYOUT ON AN IPODTOUCH.

	Pearson Corr.	Sig. (1-tailed)	*T-UI* av. errors	*H-UI* av. errors
Errors Screen1 × UI	**0.65**	0.01	0.2	1.7
Errors Screen2 × UI	-	-	0	0
Errors Screen3 × UI	-0.33	0.08	0.2	0

CORRELATION BETWEEN THE NUMBER OF ERRORS ON A SCREEN AND ITS LAYOUT ON A MOTOROLA XOO

	Pearson Corr.	Sig. (1-tailed)	*T-UI* av. errors	*H-UI* av. errors
Errors Screen1 × UI	-0.229	0.17	0.1	0
Errors Screen2 × UI	-	-	0	0
Errors Screen3 × UI	-0.229	0.17	0.1	0

- The error rate for T-UI is significantly smaller than for H-UI for Screen 1.
- The null hypothesis $NH_{TH,E}$ can be rejected for the experiment on the iPodTouch and Screen 1 only.
- There were no errors for H-UI.

Results — Subjective Opinions

- Results from the *subjective questionnaires*
- For the smartphone:
  90% of the users preferred T-UI overall. In their opinion:
  - It lent itself more to how they like to work.
  - It was clearer to use.
  - It was more visually attractive.
  - It was more efficient to use.
- For the tablet:
  90% of the users preferred H-UI overall, and also on each category besides visual attractiveness.

Conclusion of Smartphone &Tablet PC Study

- Further evidence that it is important to tailor GUIs to fit the size of the screen.
- A GUI tailored for a smaller screen may lead to efficiency loss on a larger screen due to additional tapping on tabs for splitting unnecessary for the larger screen.
- Size matters in terms of efficiency of use.

Discussion of Generality

- Prototypical and simplified flight booking application
- GUIs HTML-based
- Only two distinct screen sizes used

Outline

- Background
- Theories underpinning discourse modeling for HCI
- Interaction design based on discourse modeling
- Exercises
- Sketch of automated user-interface generation
- Evaluation of Web GUIs
- Summary and conclusion

Summary and Conclusion

- Interaction design can be based on discourse modeling.
- These discourse models can also be used for generating GUIs.
- The GUIs can be automatically tailored according to evaluated optimization criteria.

Thank you for your attention!

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