High-Level Interaction Design with Discourse Models for Automated Web GUI Generation

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ICT

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Outline

- Background
- Interaction design based on discourse modeling
- GUI Generation
- Customization
- Improving Low-vision Accessibility
- Conclusion

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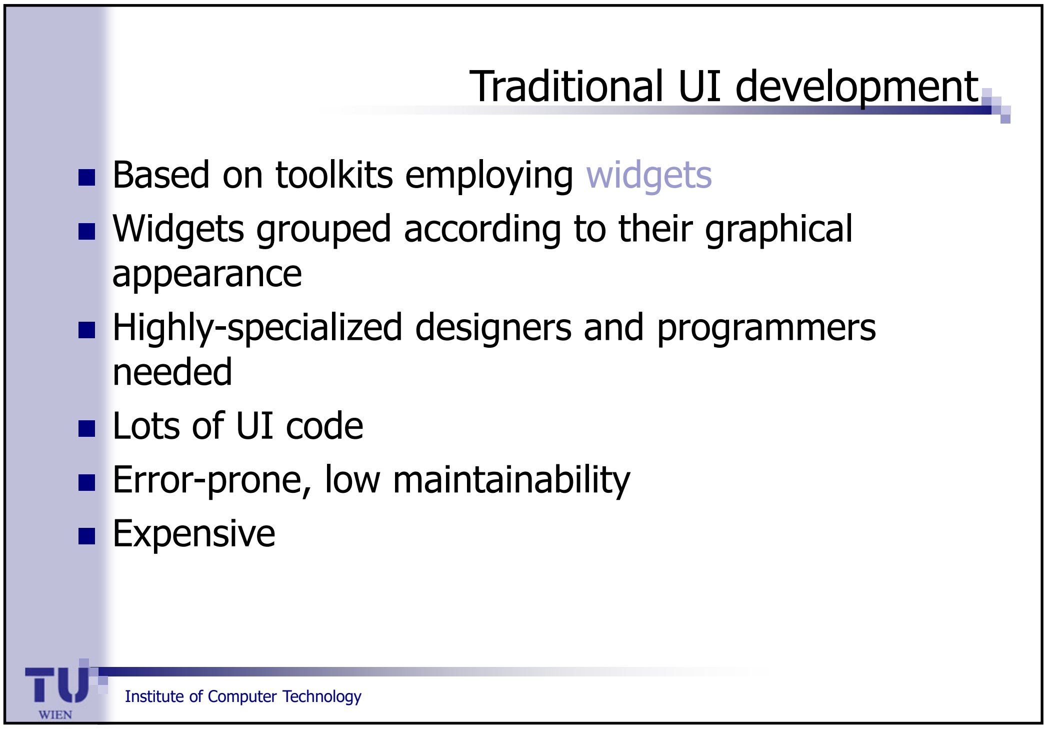

Traditional UI development

- 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

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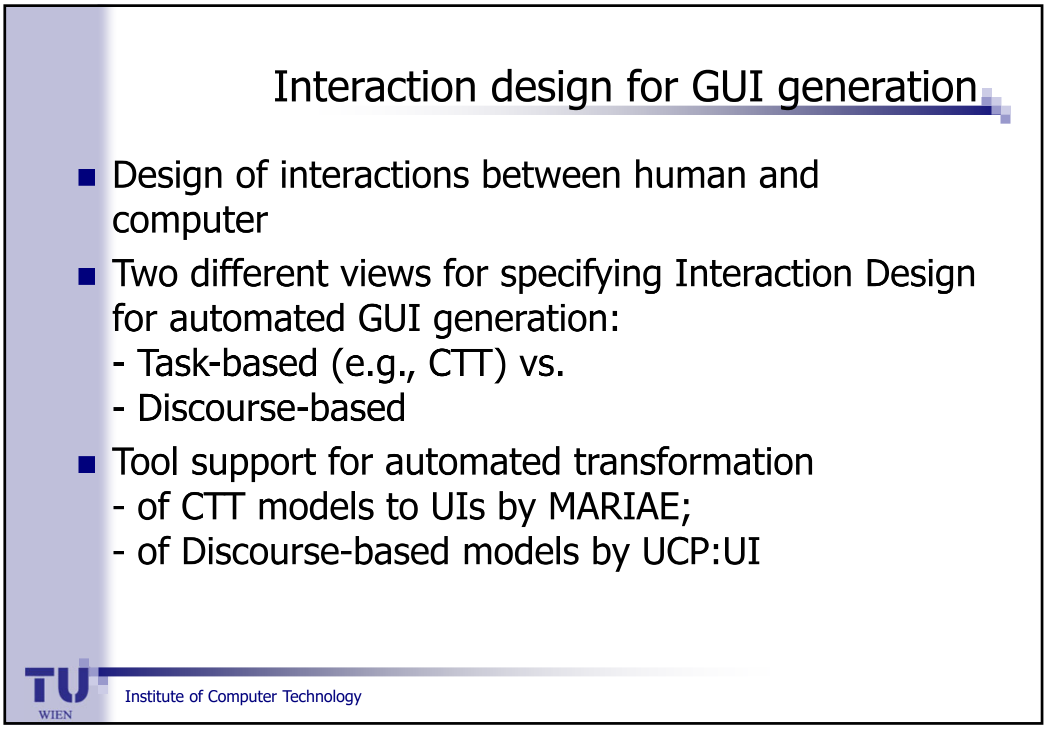

Interaction design for GUI generation

- Design of interactions between human and computer
- Two different views for specifying Interaction Design for automated GUI generation:
  - Task-based (e.g., CTT) vs.
  - Discourse-based
- Tool support for automated transformation
  - of CTT models to UIs by MARIAE;
  - of Discourse-based models by UCP:UI

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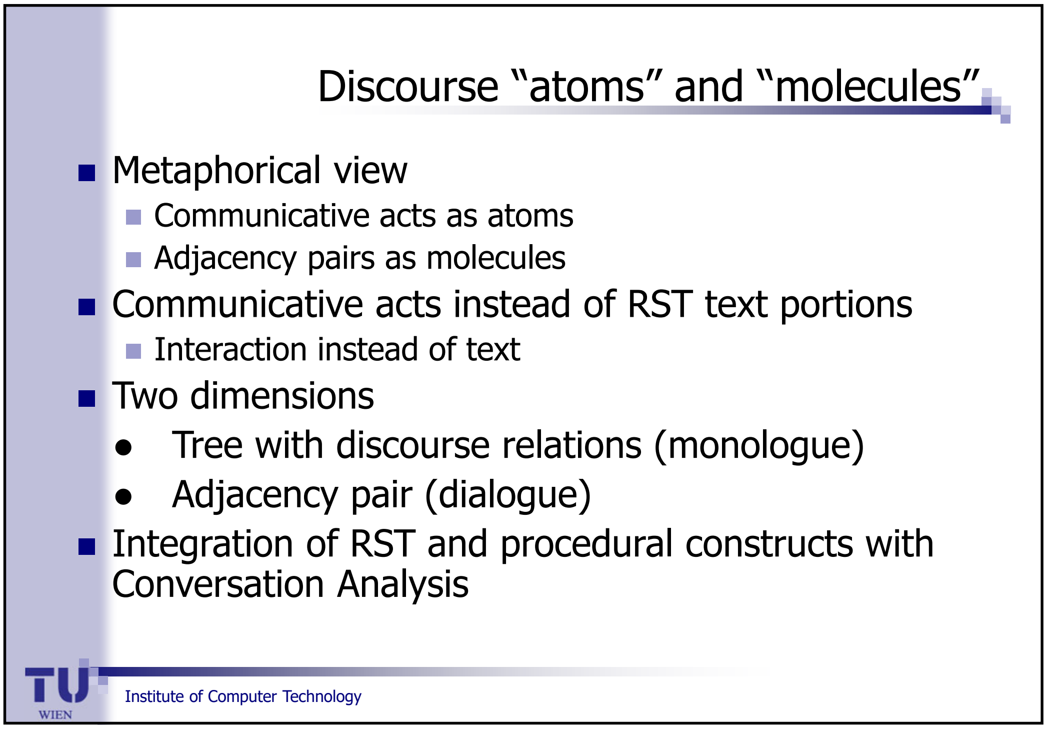

Discourse “atoms” and “molecules”

- 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

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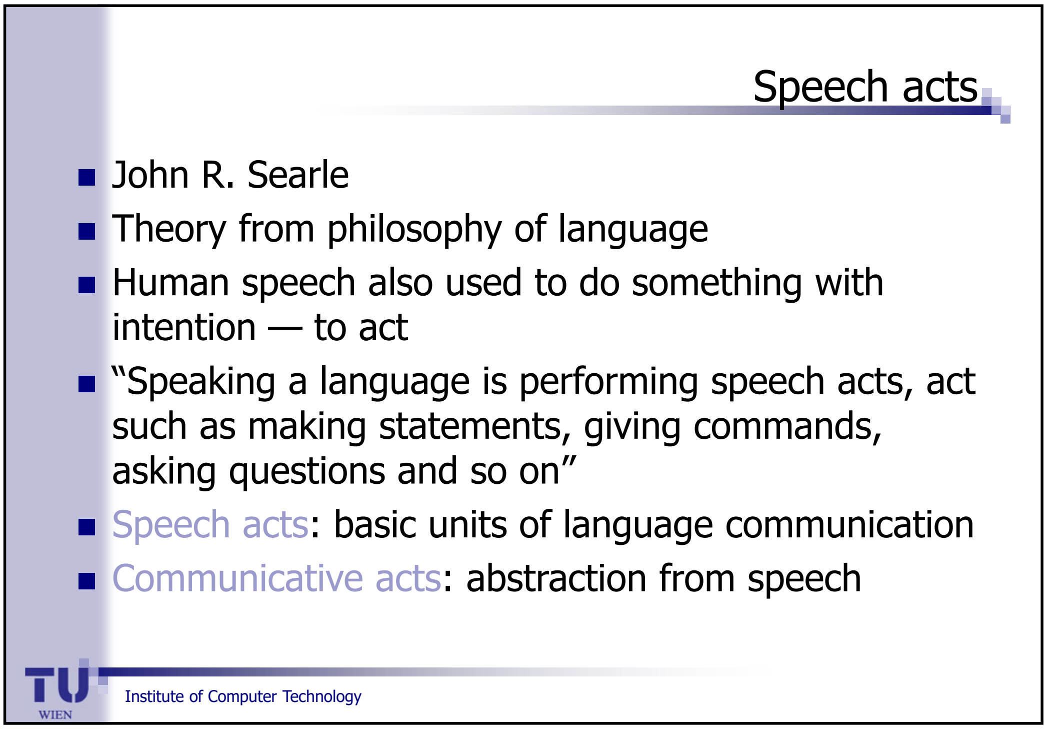

Speech acts

- 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

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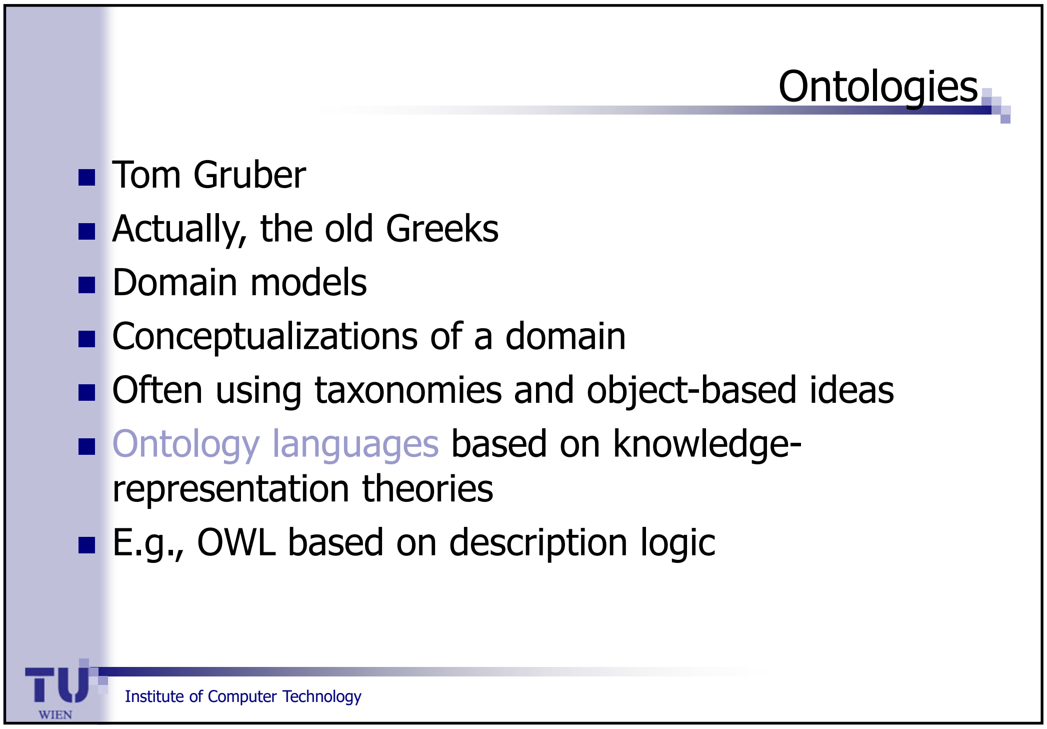

Ontologies

- 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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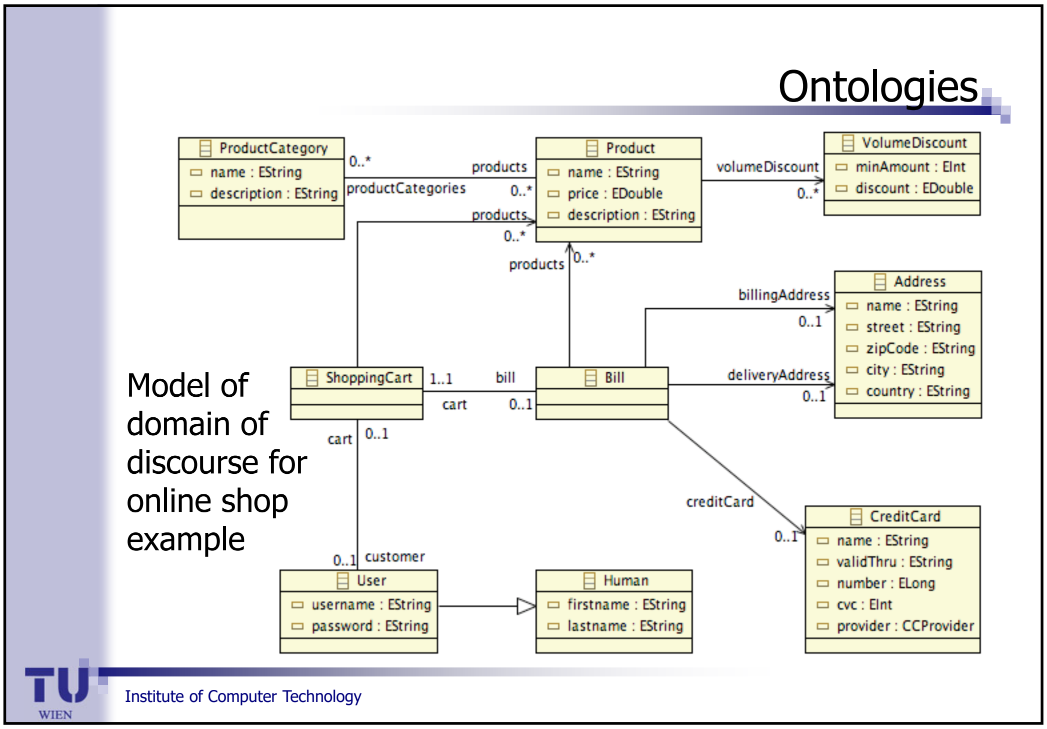

Ontologies

Model of domain of discourse for online shop example

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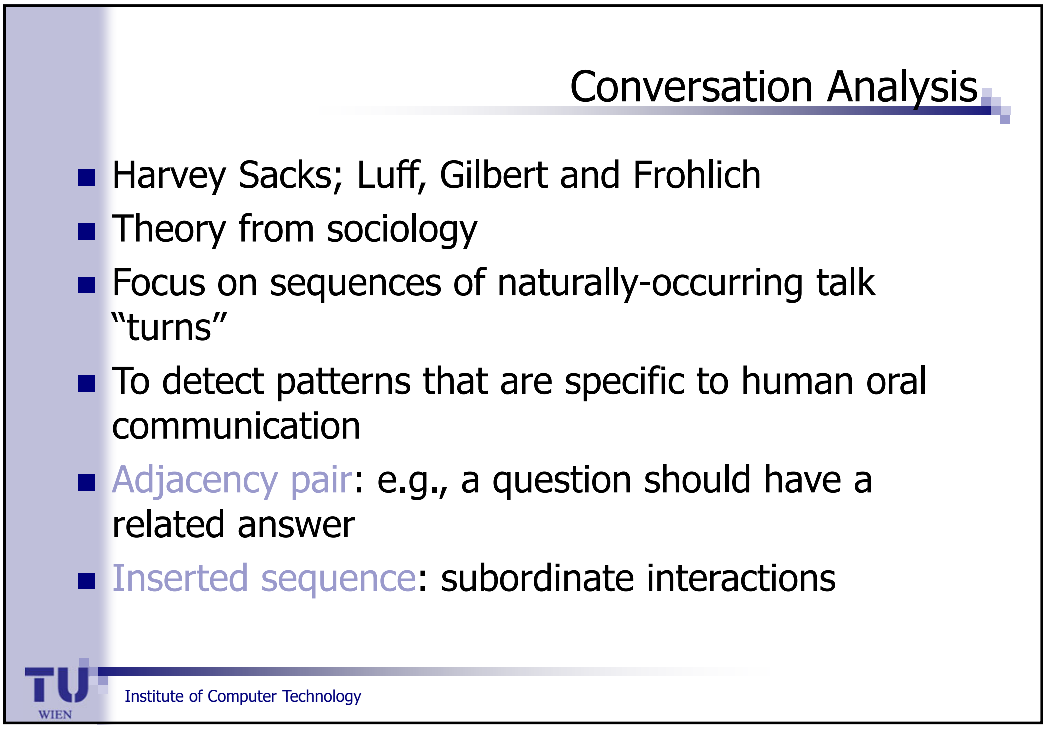

Conversation Analysis

- 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

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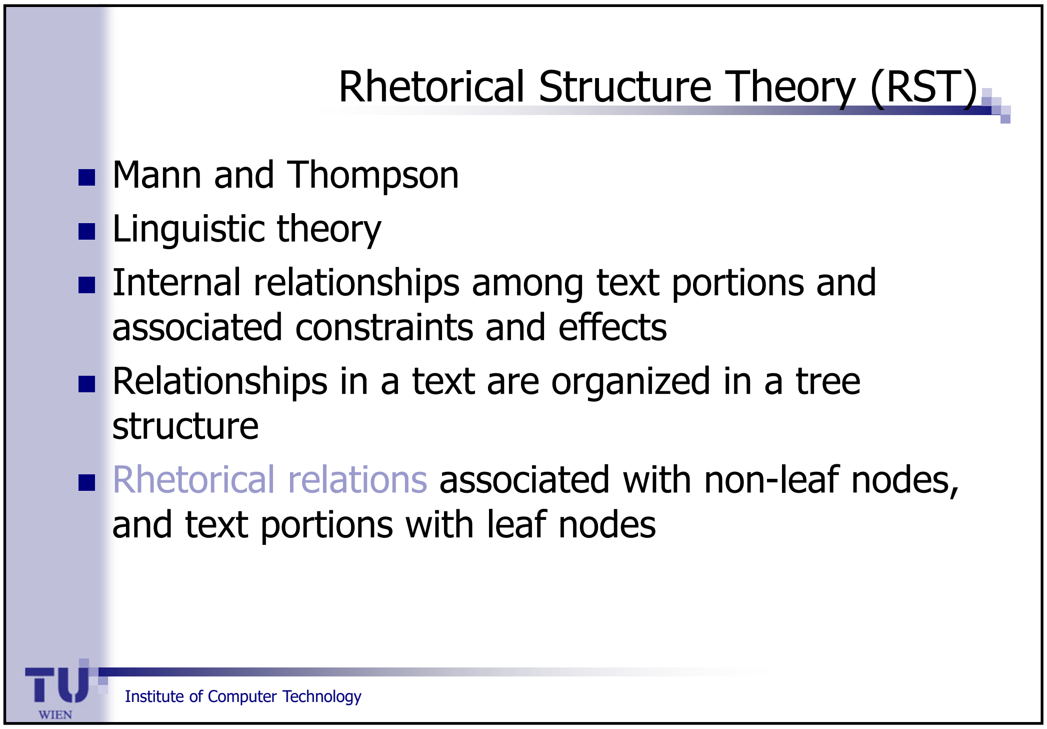

Rhetorical Structure Theory (RST)

- 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

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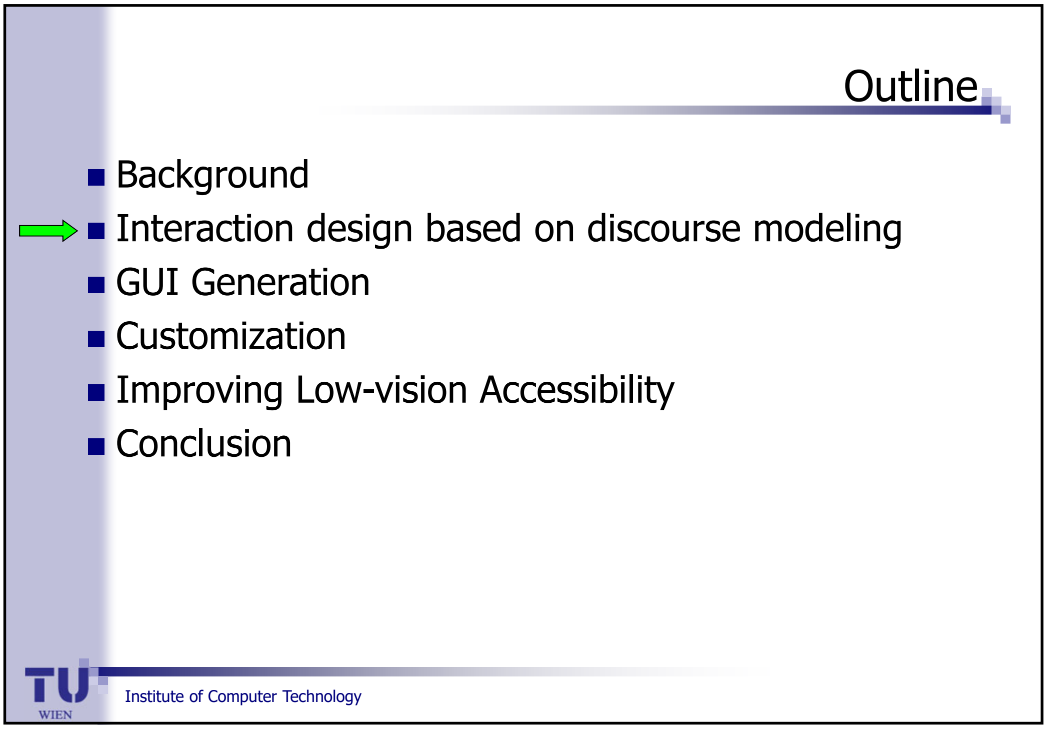

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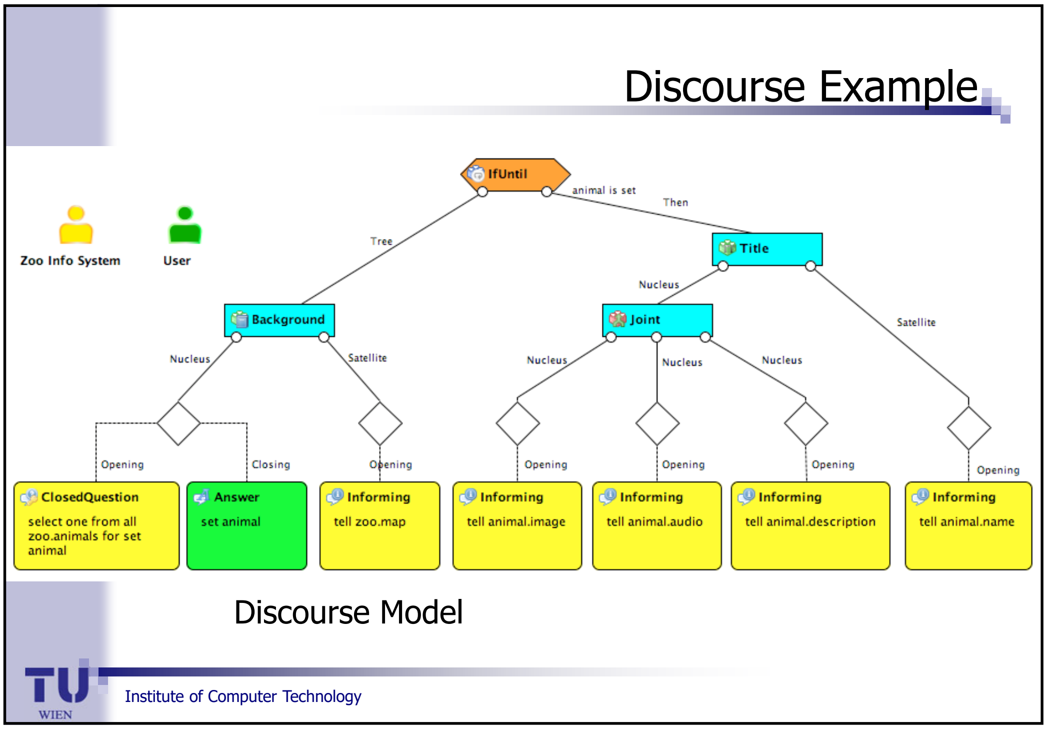

Discourse Example

Discourse Model

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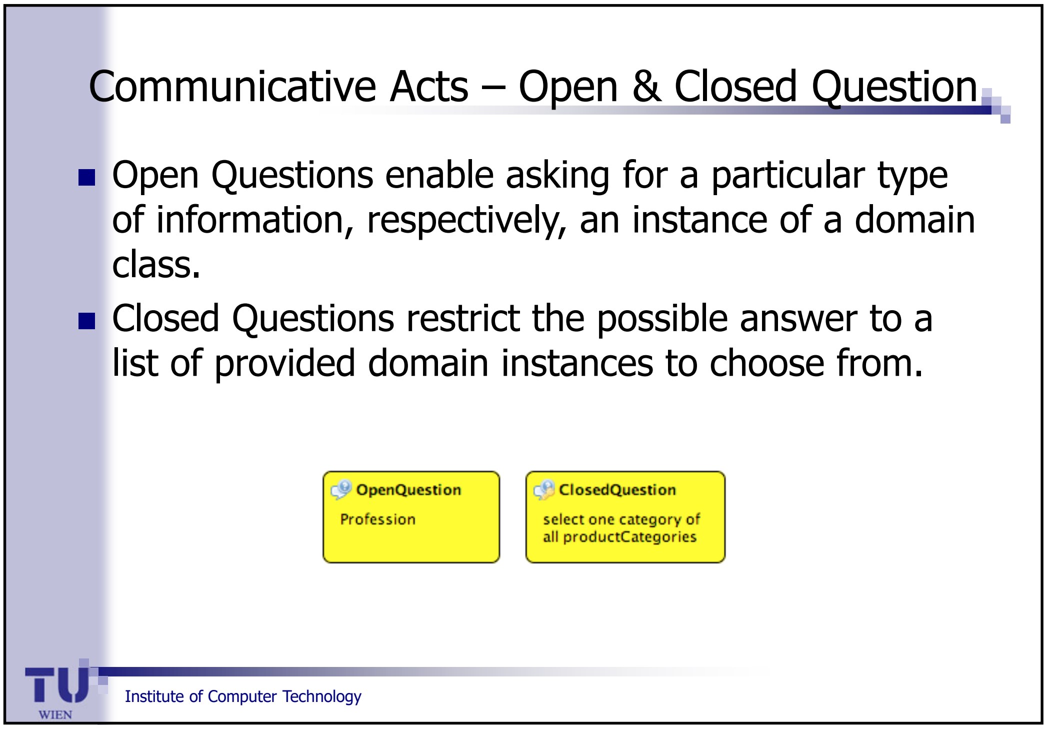

Communicative Acts – Open & Closed Question

- 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.

OpenQuestion
Profession
ClosedQuestion
select one category of all productCategories

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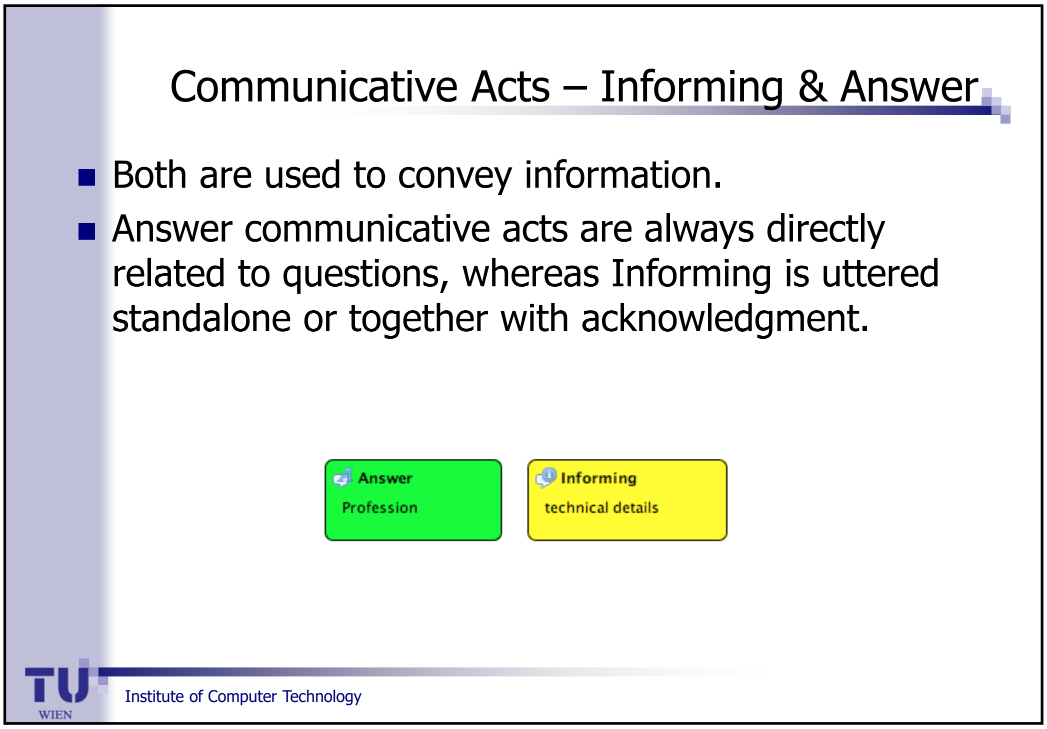

Communicative Acts – Informing & Answer

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

Answer
Profession
Informing
technical details

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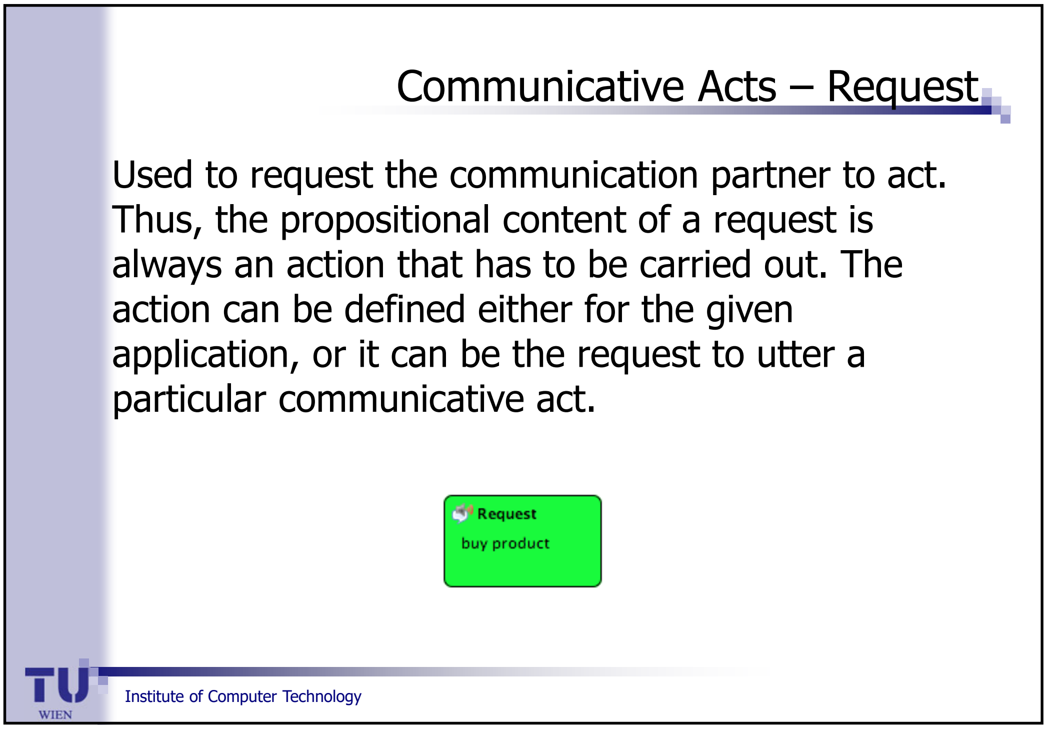

Communicative Acts – Request

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.

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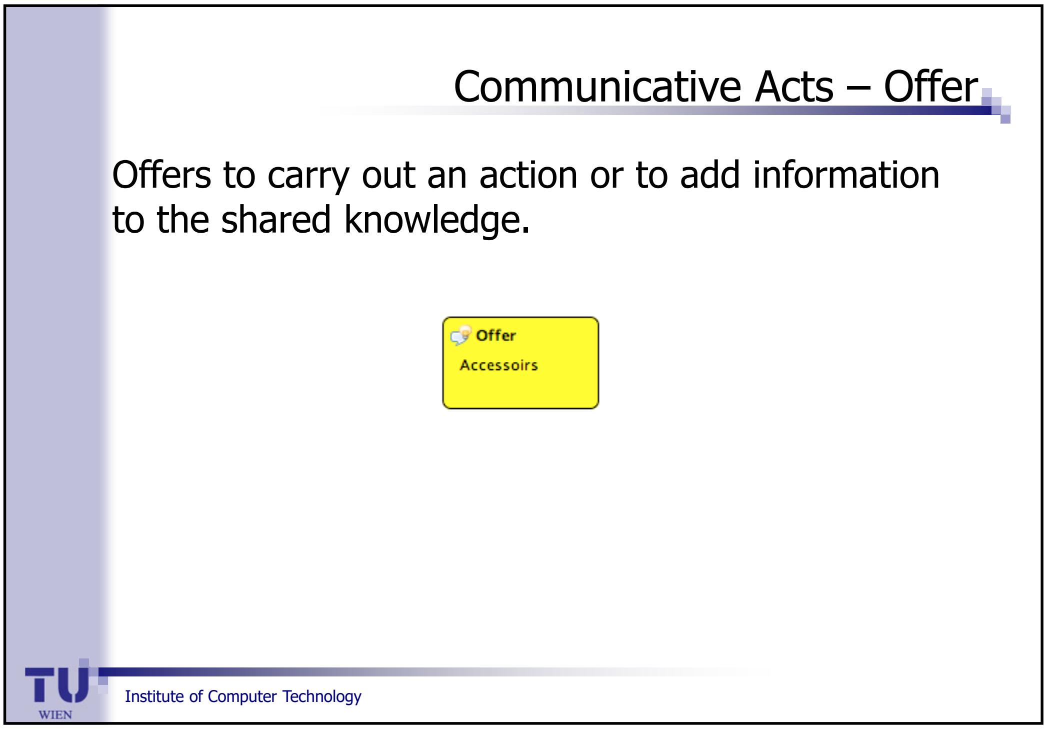

Communicative Acts – Offer

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

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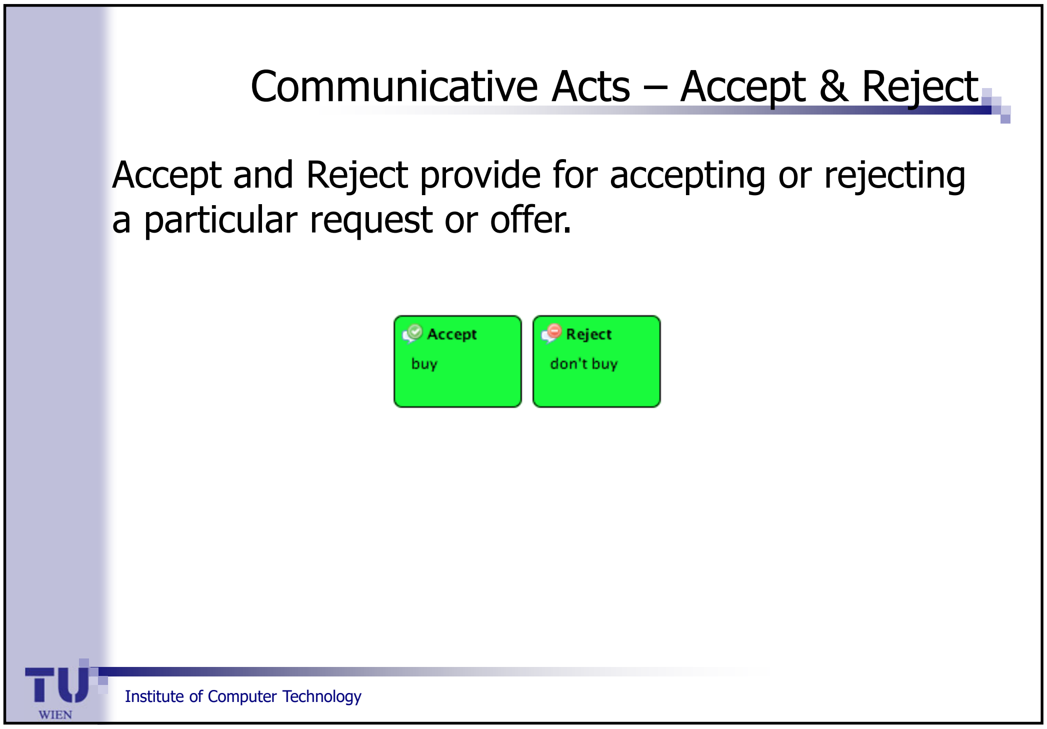

Communicative Acts – Accept & Reject

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

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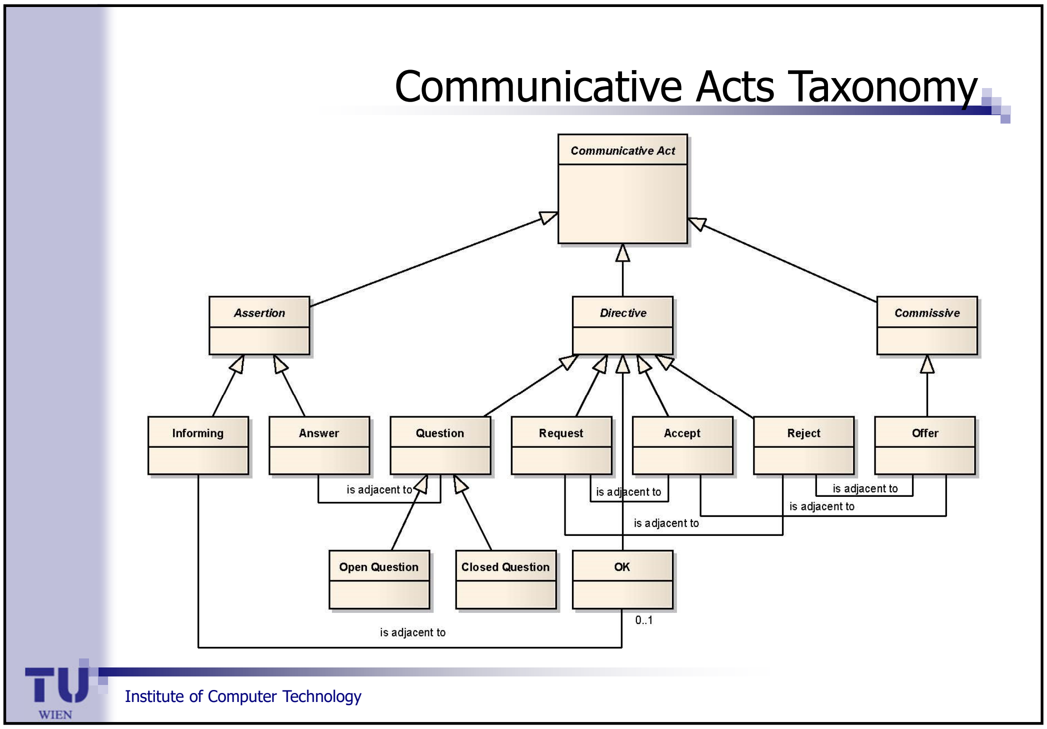

Communicative Acts Taxonomy

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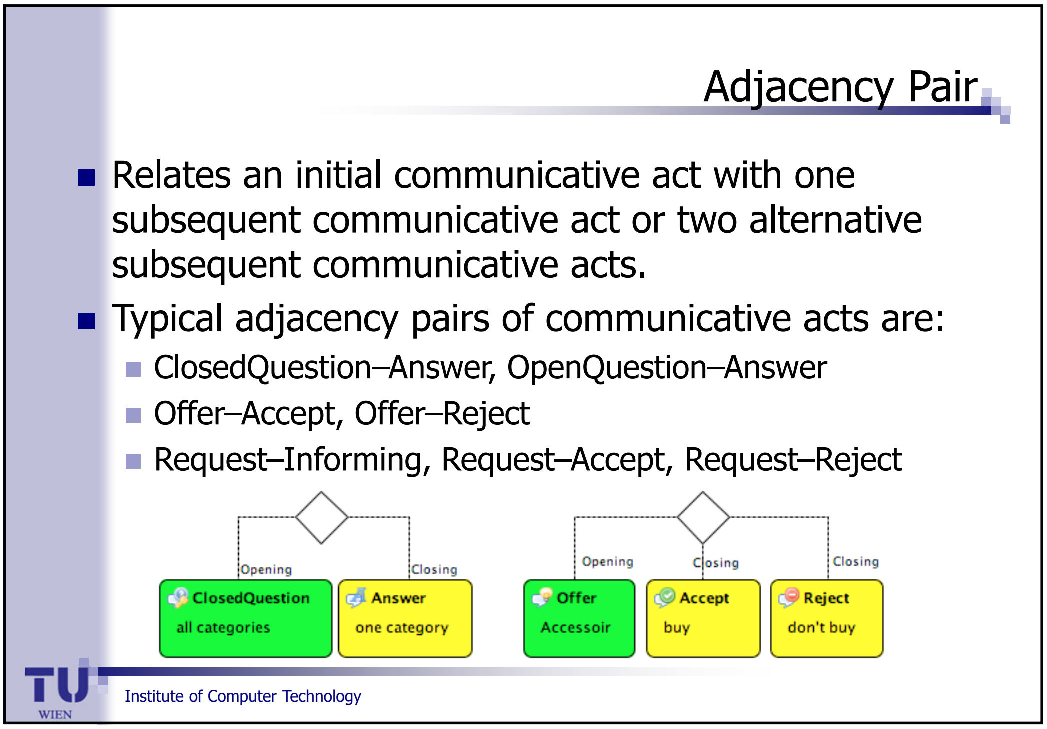

Adjacency Pair

- 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

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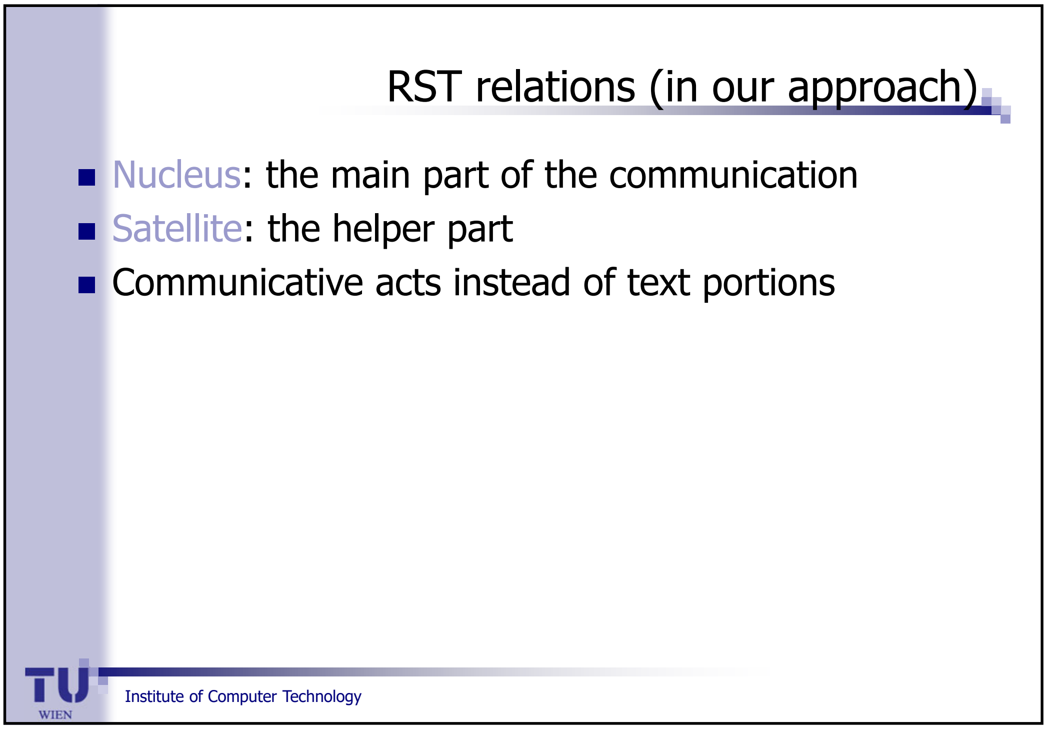

RST relations (in our approach)

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

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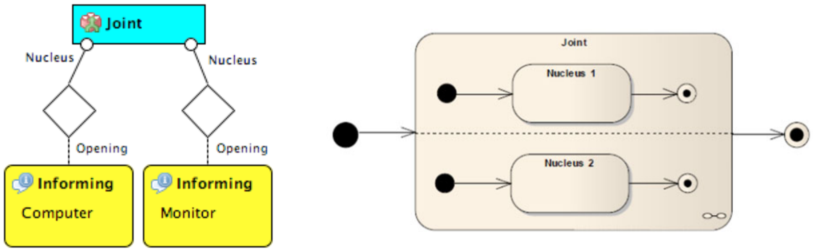
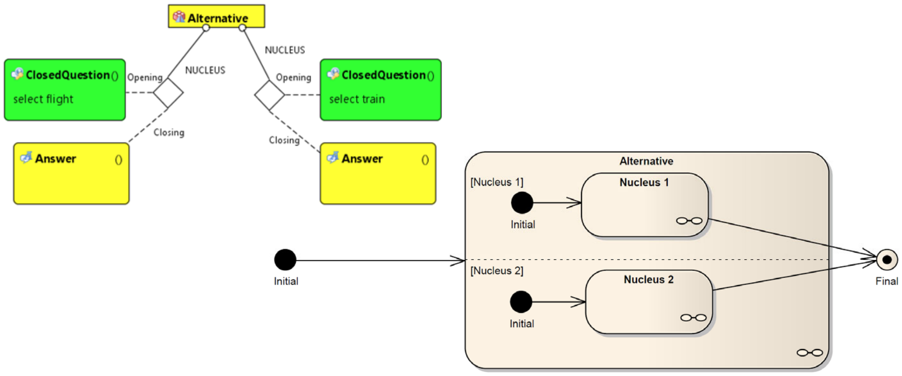
RST relation – Joint

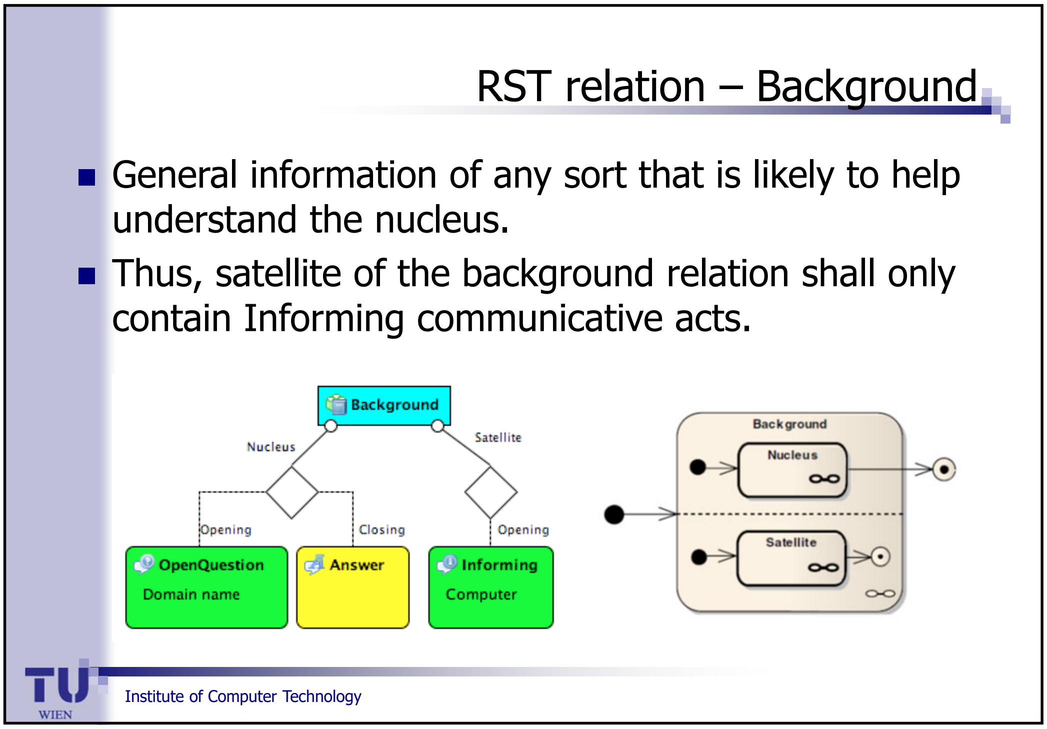
Relates independent subtrees with communicative acts of the same kind. It does not imply any order. So, it is also possible to issue both nuclei concurrently (e.g., on a GUI).



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.

Background
Nucleus
Satellite
Opening
Closing
Opening
OpenQuestion
Domain name
Answer
Informing
Computer
Background
Nucleus
Satellite

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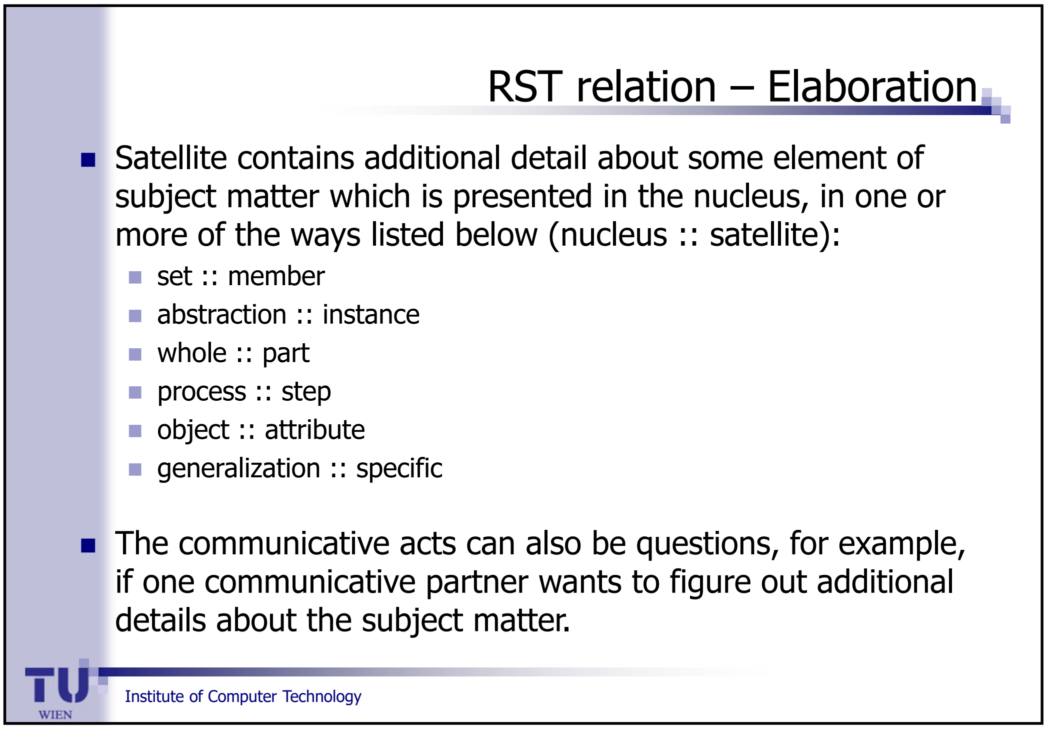

RST relation – Elaboration

- 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.

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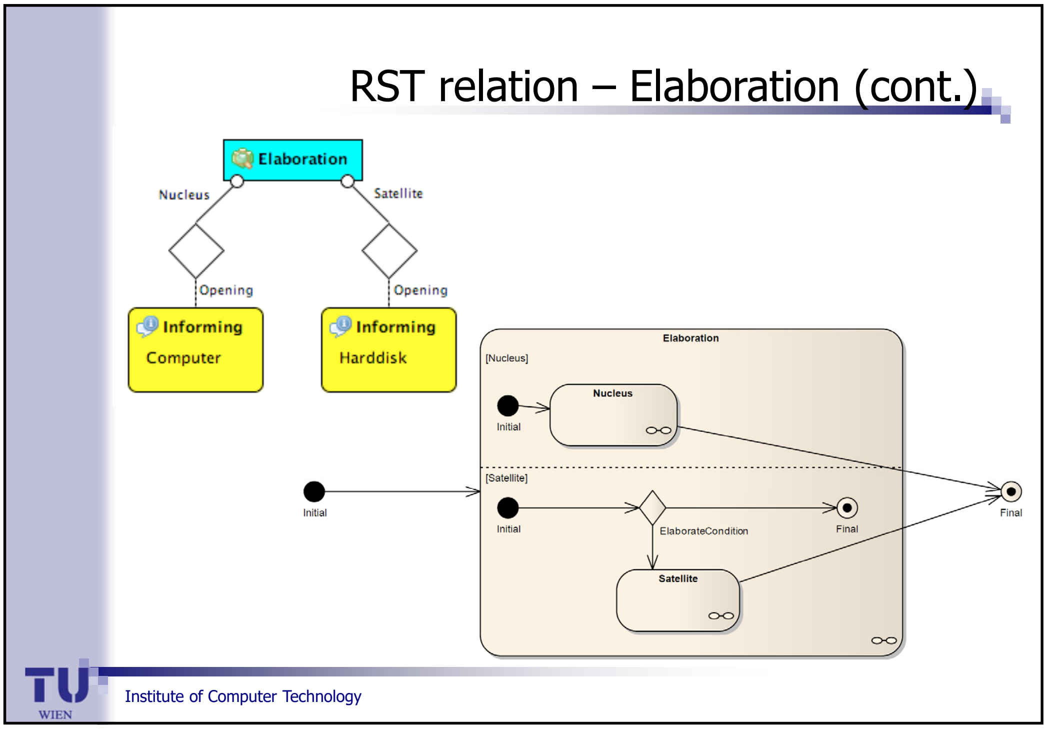

RST relation – Elaboration (cont.)

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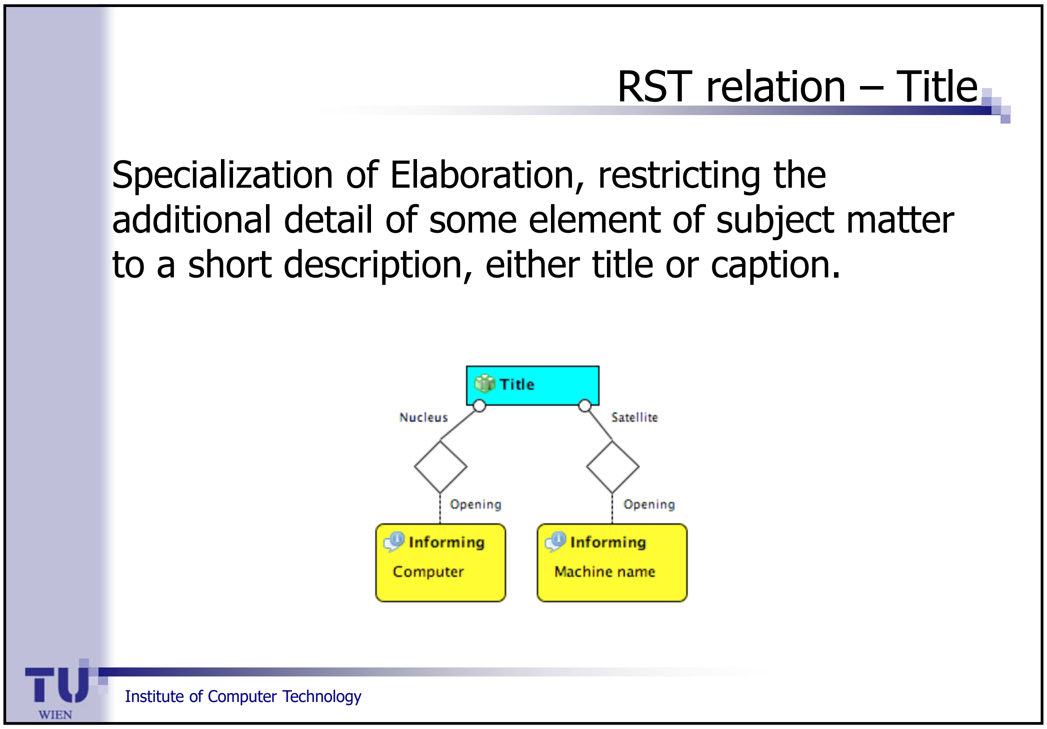

RST relation – Title

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

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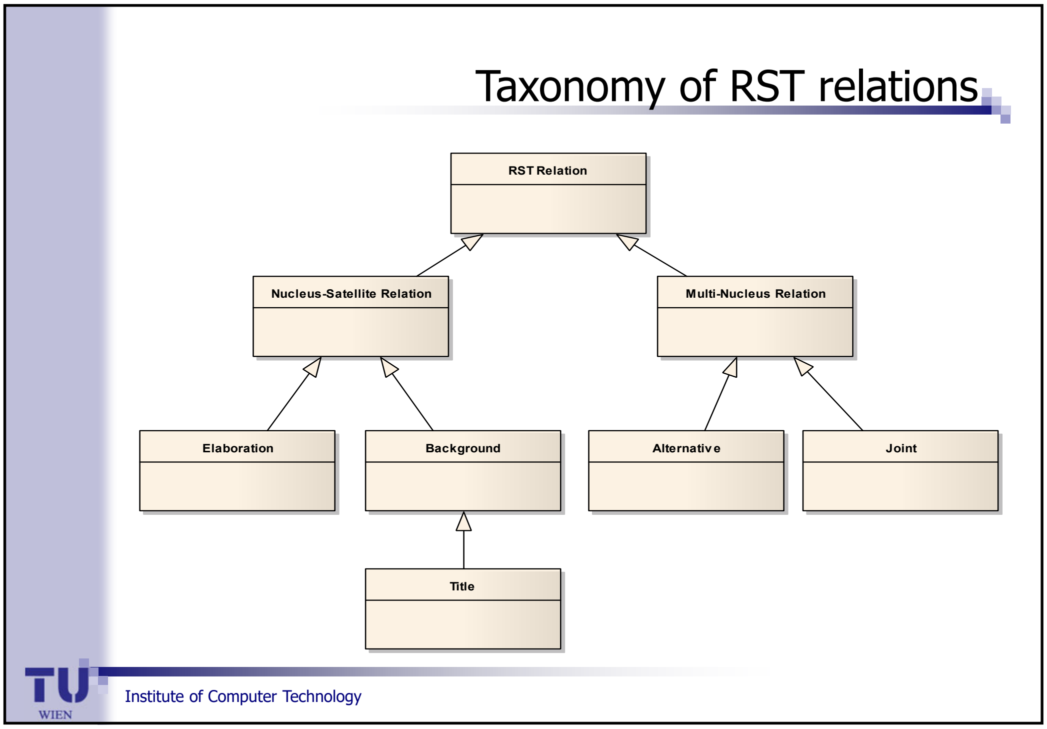

Taxonomy of RST relations

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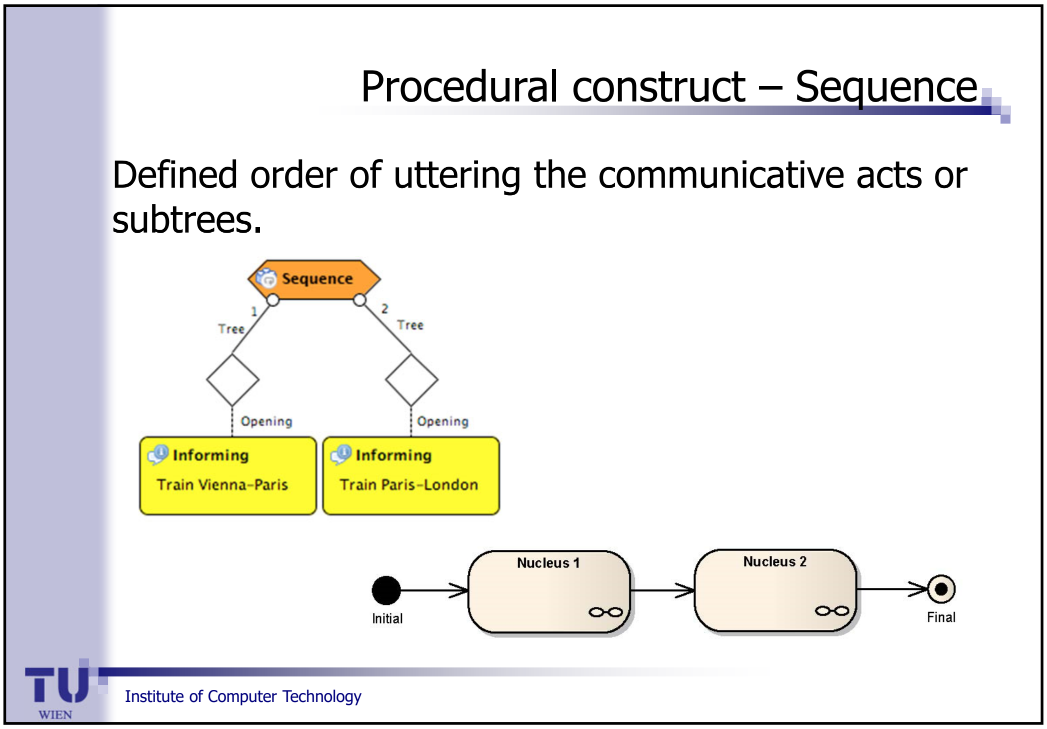

Procedural construct – Sequence

Defined order of uttering the communicative acts or subtrees.

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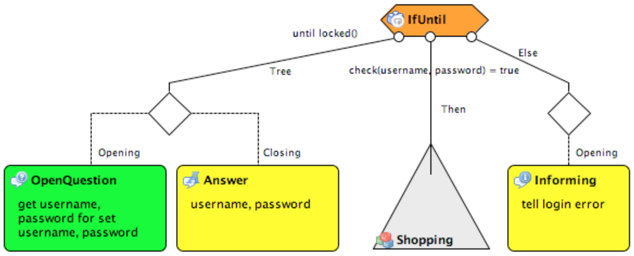
Procedural construct – IfUntil

- 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



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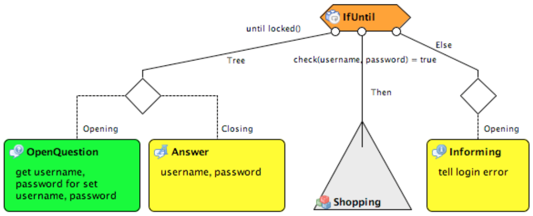
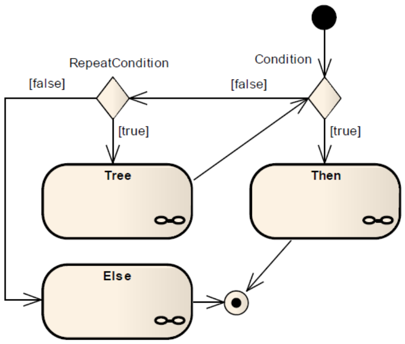
Procedural construct – IfUntil (cont.)





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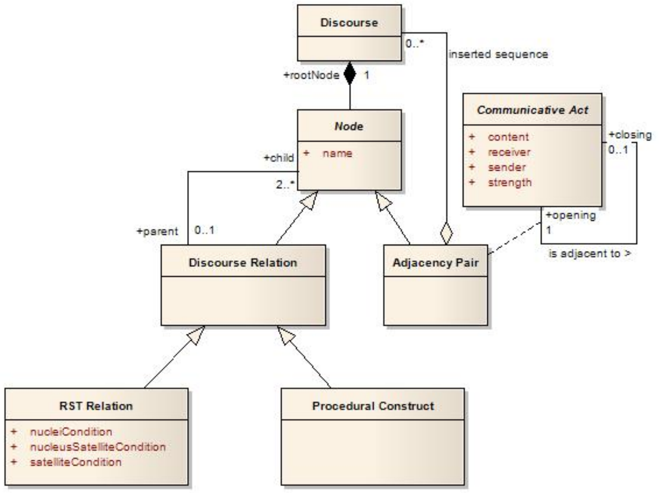
Conceptual Discourse Metamodel


Discourse
0..*
inserted sequence
+rootNode
1
Communicative Act
+ content
+ receiver
+ sender
+ strength
+closing
0..1
Node
+ name
+child
2..*
+parent
0..1
+opening
1
is adjacent to >
Discourse Relation
Adjacency Pair
RST Relation
+ nucleiCondition
+ nucleusSatelliteCondition
+ satelliteCondition
Procedural Construct

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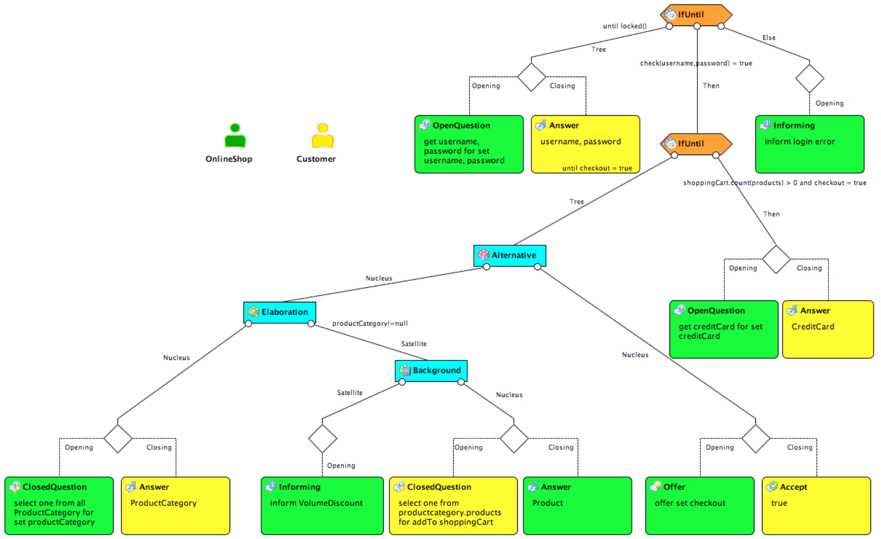
Exercise: Understand given model


IfUntil
until locked()
Tree
Else
check(username,password) = true
Opening
Closing
Then
Opening
OpenQuestion
get username, password for set username, password
Answer
username, password
until checkout = true
Informing
inform login error
OnlineShop
Customer
IfUntil
shoppingCart.count(products) > 0 and checkout = true
Tree
Then
Alternative
Opening
Closing
Nucleus
OpenQuestion
get creditCard for set creditCard
Answer
CreditCard
Elaboration
productCategory!=null
Satellite
Nucleus
Nucleus
Background
Satellite
Nucleus
Opening
Closing
Opening
Opening
Closing
Opening
Closing
ClosedQuestion
select one from all ProductCategory for set productCategory
Answer
ProductCategory
Informing
inform VolumeDiscount
ClosedQuestion
select one from productcategory.products for addTo shoppingCart
Answer
Product
Offer
offer set checkout
Accept
true

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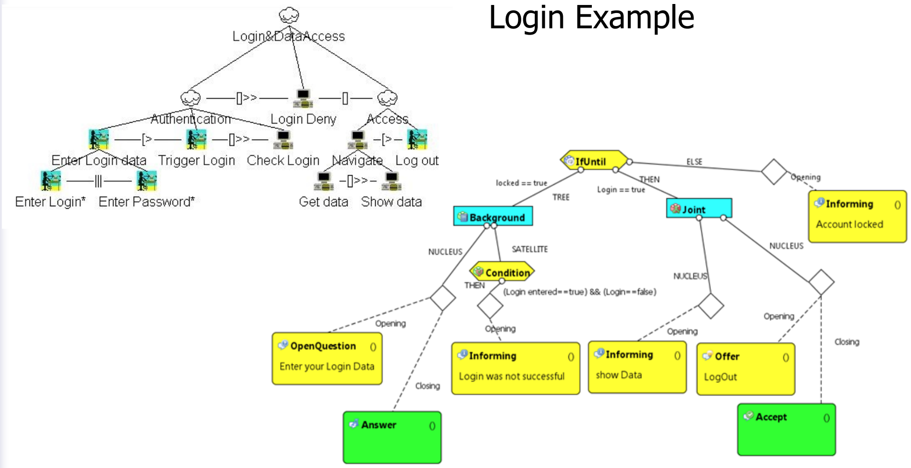
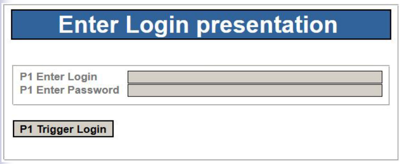
Examples of Interaction Design Models

- CTT Model of Login Example
- Discourse Model of Login Example

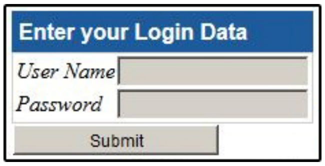


Automatically Generated Login Screens

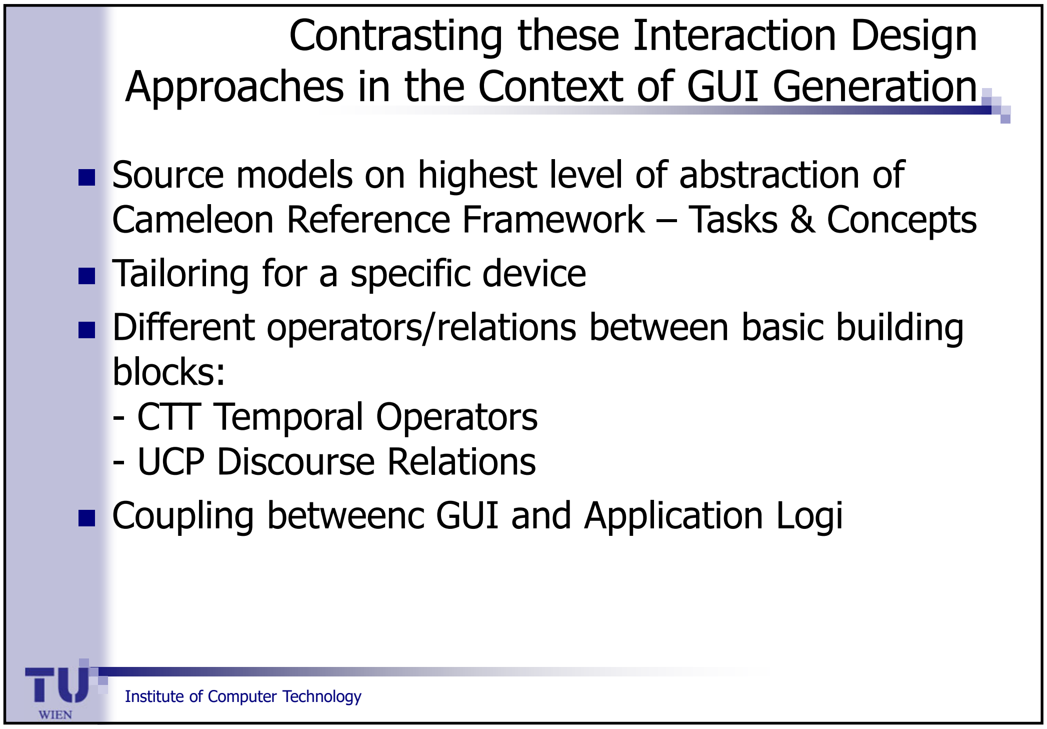
- Login Screen Generated with MARIAE
- Login Screen Generated with UCP


Enter Login presentation

P1 Enter Login
P1 Enter Password


Enter your Login Data

User Name
Password



Contrasting these Interaction Design Approaches in the Context of GUI Generation

- Source models on highest level of abstraction of Cameleon Reference Framework – Tasks & Concepts
- Tailoring for a specific device
- Different operators/relations between basic building blocks:
  - CTT Temporal Operators
  - UCP Discourse Relations
- Coupling betweenc GUI and Application Logi

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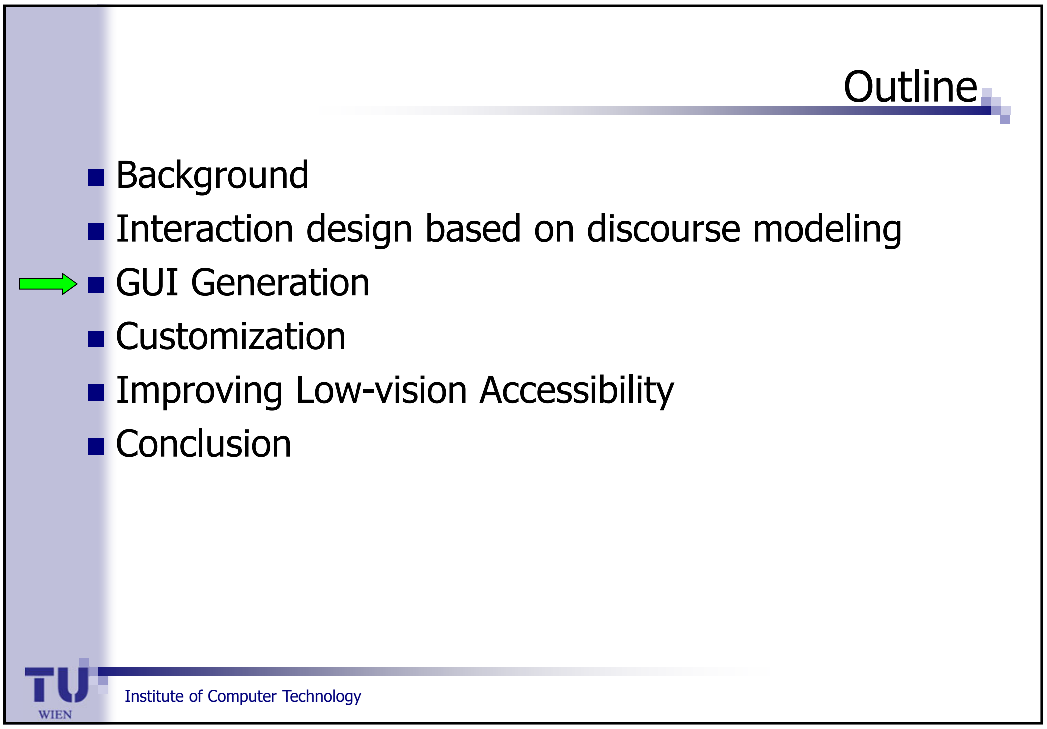

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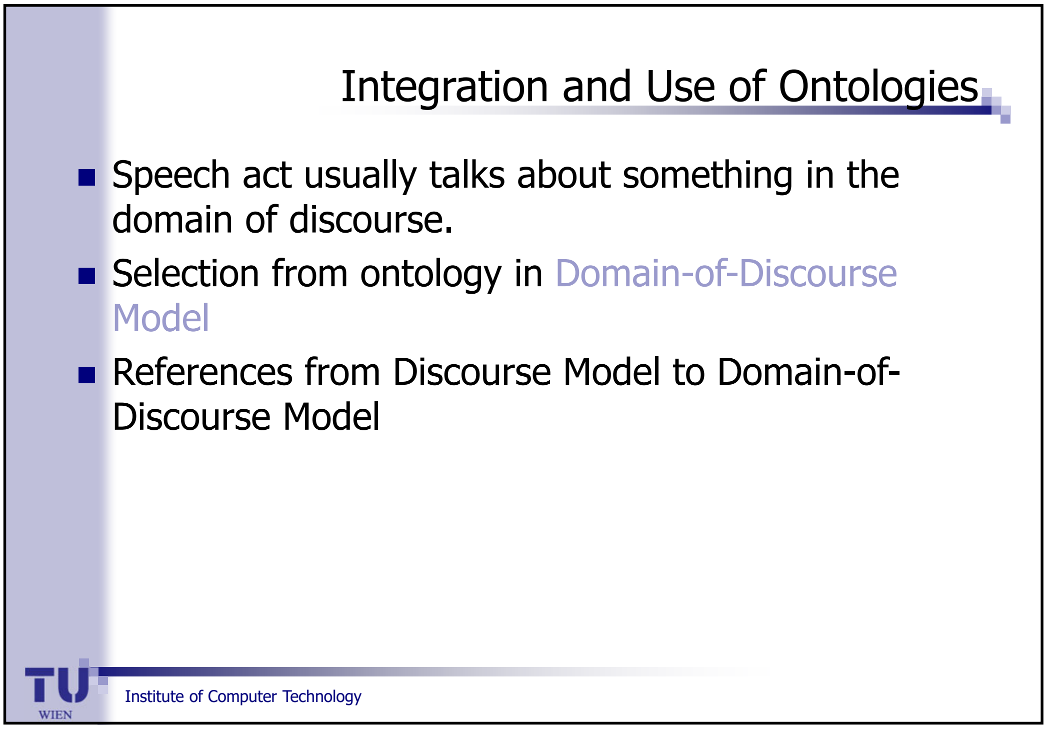

Integration and Use of Ontologies

- 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

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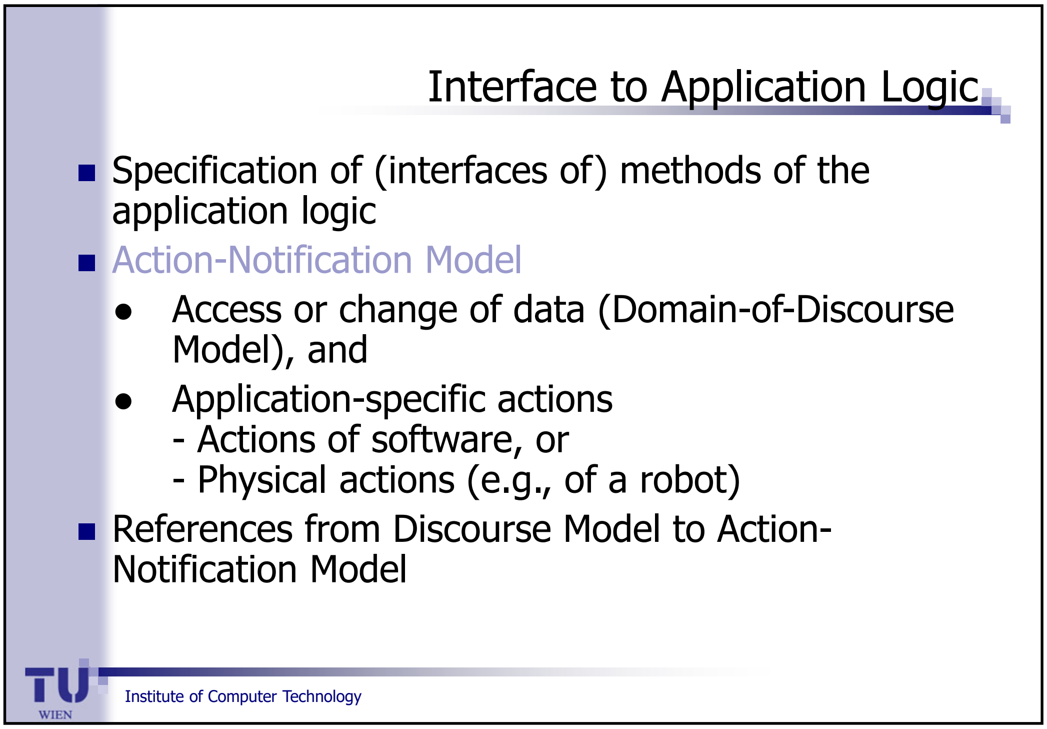

Interface to Application Logic

- 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 (e.g., of a robot)
- References from Discourse Model to Action-Notification Model

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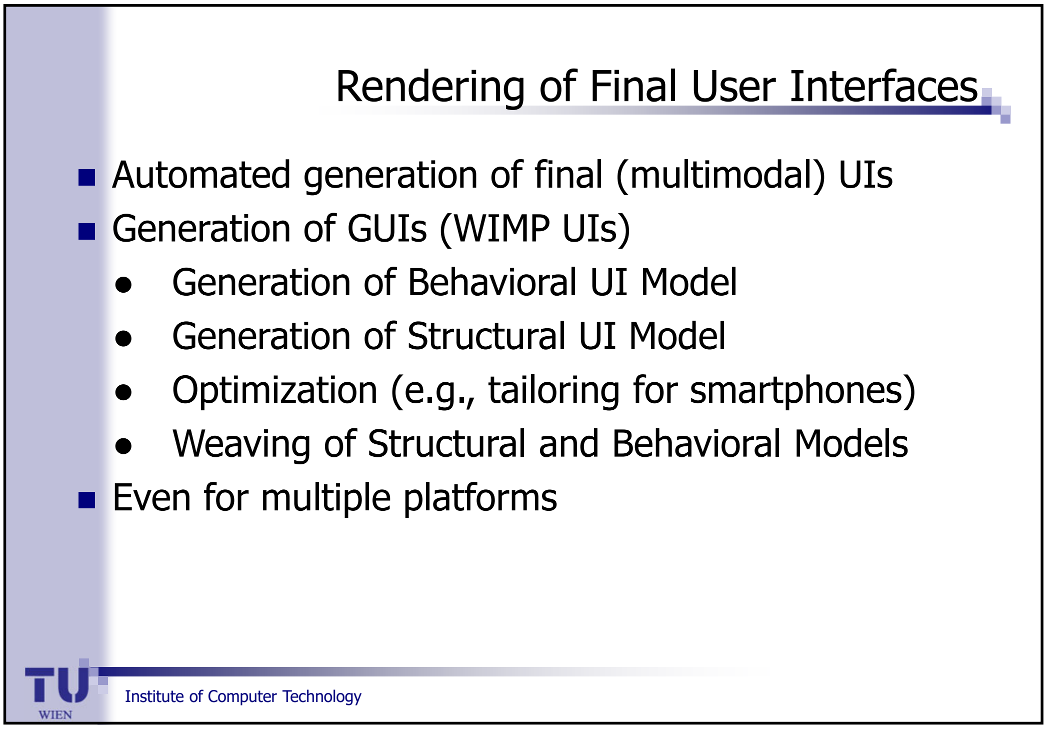

Rendering of Final User Interfaces

- Automated generation of final (multimodal) UIs
- Generation of GUIs (WIMP UIs)
  - Generation of Behavioral UI Model
  - Generation of Structural UI Model
  - Optimization (e.g., tailoring for smartphones)
  - Weaving of Structural and Behavioral Models
- Even for multiple platforms

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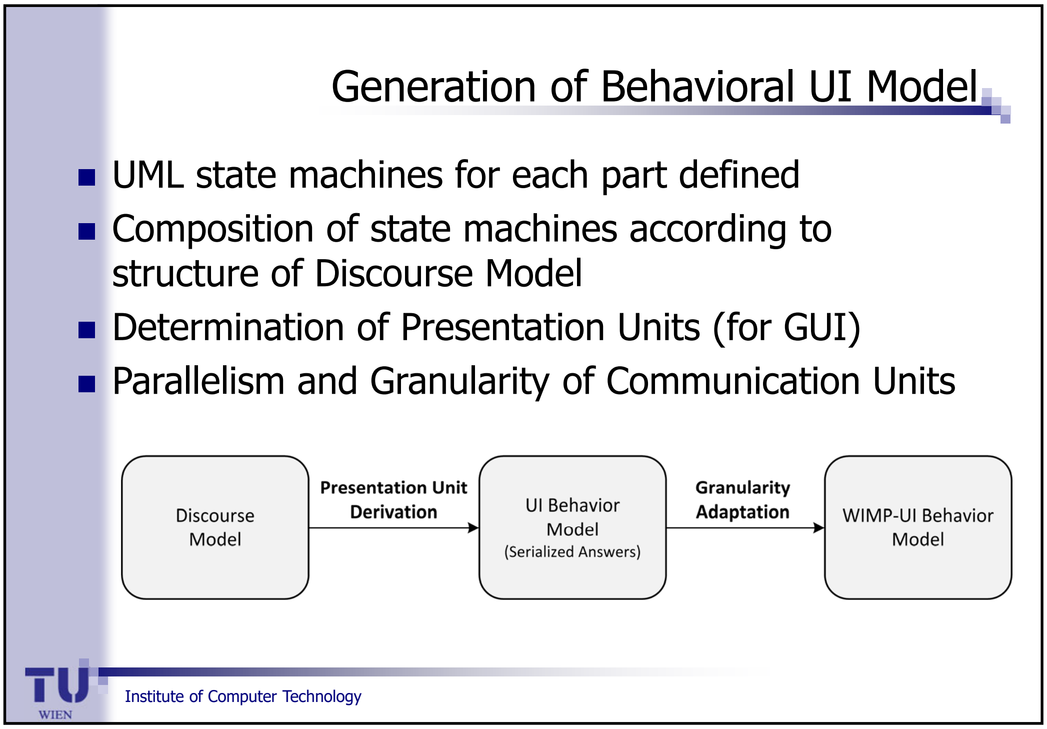

Generation of Behavioral UI Model

- 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

Discourse Model
Presentation Unit Derivation
UI Behavior Model (Serialized Answers)
Granularity Adaptation
WIMP-UI Behavior Model

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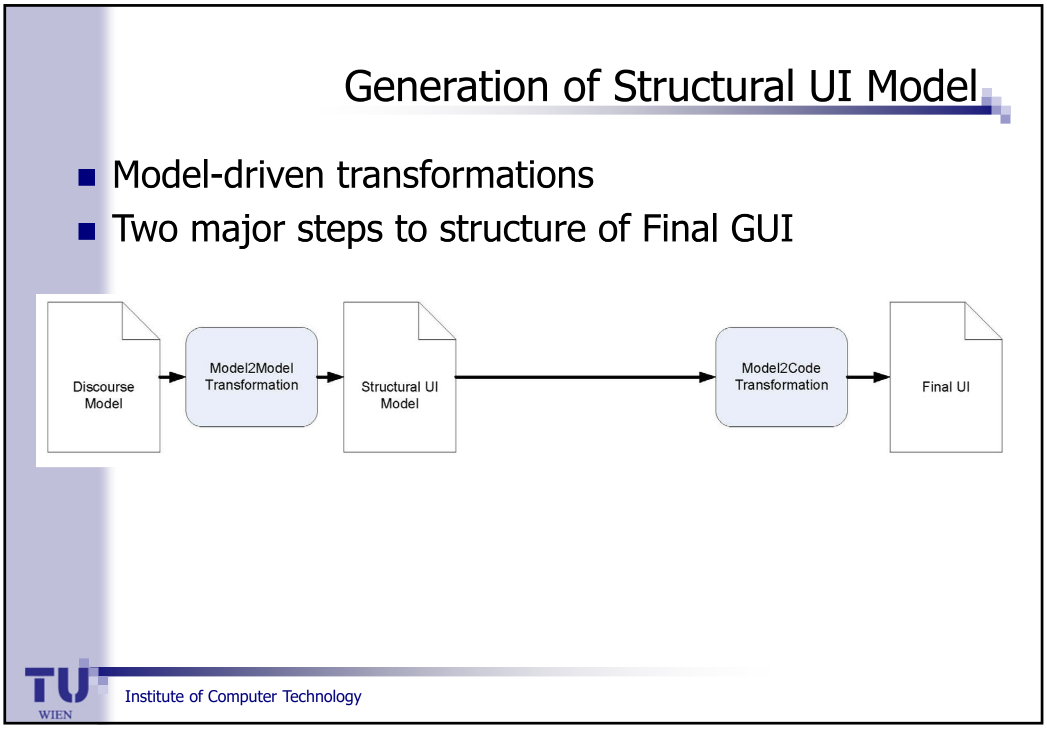

Generation of Structural UI Model

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

Discourse Model → Model2Model Transformation → Structural UI Model → Model2Code Transformation → Final UI

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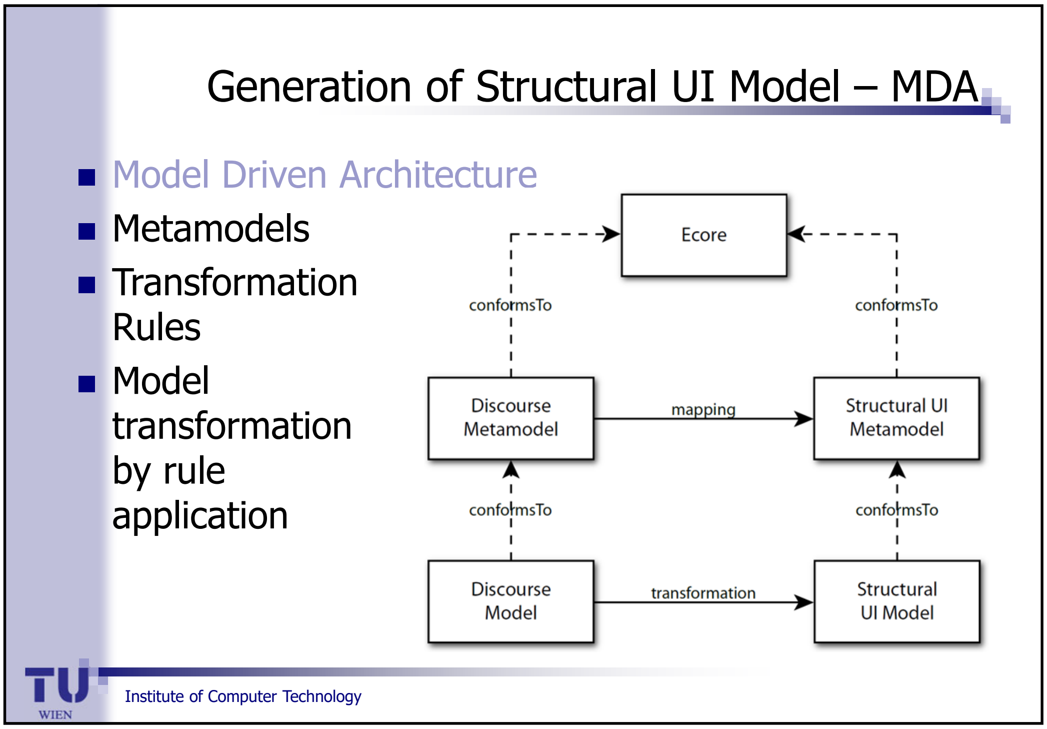

Generation of Structural UI Model – MDA

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

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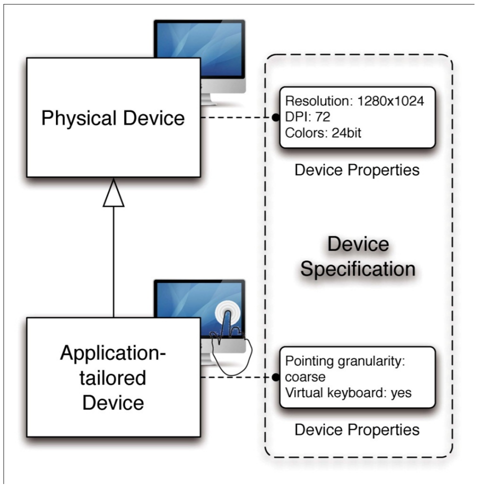
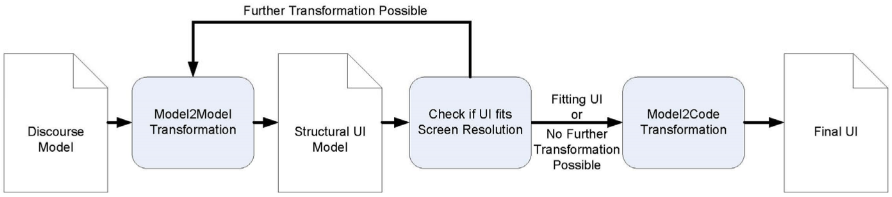
Generation of Structural UI Model – Devices

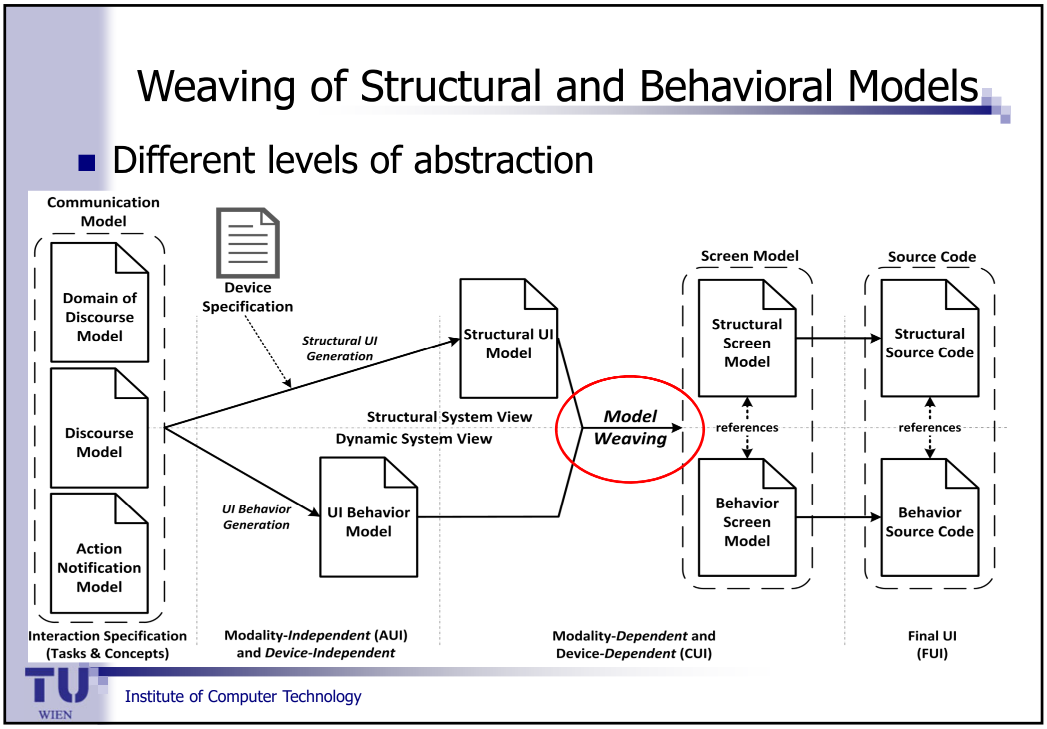
- Generation according to device specifications
- Application-tailored device specifications in addition to physical ones



Tailoring for Specific Device (e.g., Smartphone)

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


Further Transformation Possible
Discourse Model
Model2Model Transformation
Structural UI Model
Check if UI fits Screen Resolution
Fitting UI or No Further Transformation Possible
Model2Code Transformation
Final UI



Weaving of Structural and Behavioral Models

- Different levels of abstraction

Communication Model

Domain of Discourse Model

Discourse Model

Action Notification Model

Device Specification

Structural UI Generation

UI Behavior Generation

Structural UI Model

UI Behavior Model

Structural System View

Dynamic System View

Model Weaving

Screen Model

Structural Screen Model

Behavior Screen Model

references

Source Code

Structural Source Code

Behavior Source Code

references

Interaction Specification (Tasks & Concepts)

Modality-*Independent* (AUI) and Device-*Independent*

Modality-*Dependent* and Device-*Dependent* (CUI)

Final UI (FUI)

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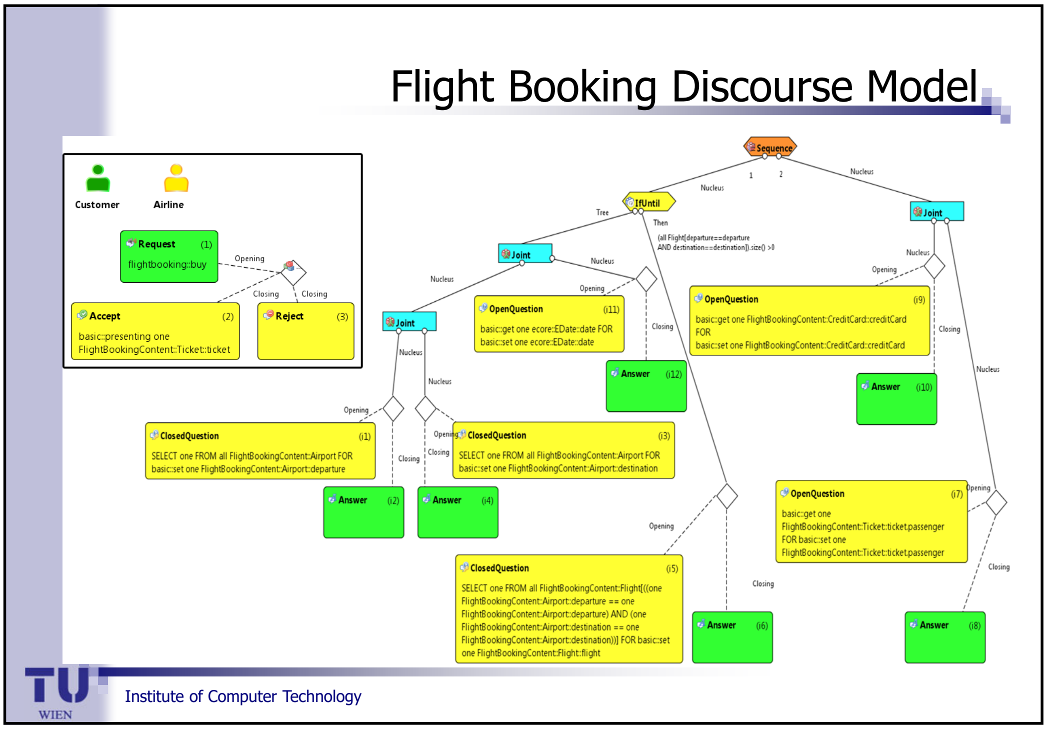

Flight Booking Discourse Model

Customer

Airline

Request (1)
flightbooking::buy

Accept (2)
basic::presenting one FlightBookingContent::Ticket::ticket

Reject (3)

Sequence

IfUntil

(all Flight[departure==departure AND destination==destination]).size() >0

Joint

OpenQuestion (i11)
basic::get one ecore::EDate::date FOR basic::set one ecore::EDate::date

Answer (i12)

Joint

ClosedQuestion (i1)
SELECT one FROM all FlightBookingContent::Airport FOR basic::set one FlightBookingContent::Airport::departure

Answer (i2)

ClosedQuestion (i3)
SELECT one FROM all FlightBookingContent::Airport FOR basic::set one FlightBookingContent::Airport::destination

Answer (i4)

ClosedQuestion (i5)
SELECT one FROM all FlightBookingContent::Flight[((one FlightBookingContent::Airport::departure == one FlightBookingContent::Airport::departure) AND (one FlightBookingContent::Airport::destination == one FlightBookingContent::Airport::destination))] FOR basic::set one FlightBookingContent::Flight::flight

Answer (i6)

Joint

OpenQuestion (i9)
basic::get one FlightBookingContent::CreditCard::creditCard FOR basic::set one FlightBookingContent::CreditCard::creditCard

Answer (i10)

OpenQuestion (i7)
basic::get one FlightBookingContent::Ticket::ticket.passenger FOR basic::set one FlightBookingContent::Ticket::ticket.passenger

Answer (i8)

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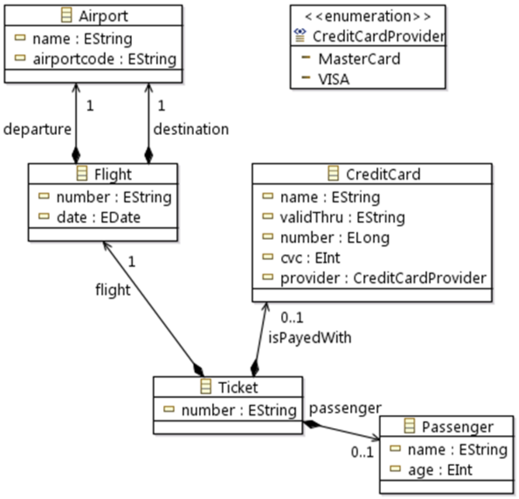
Flight Booking Domain-of-Discourse Model



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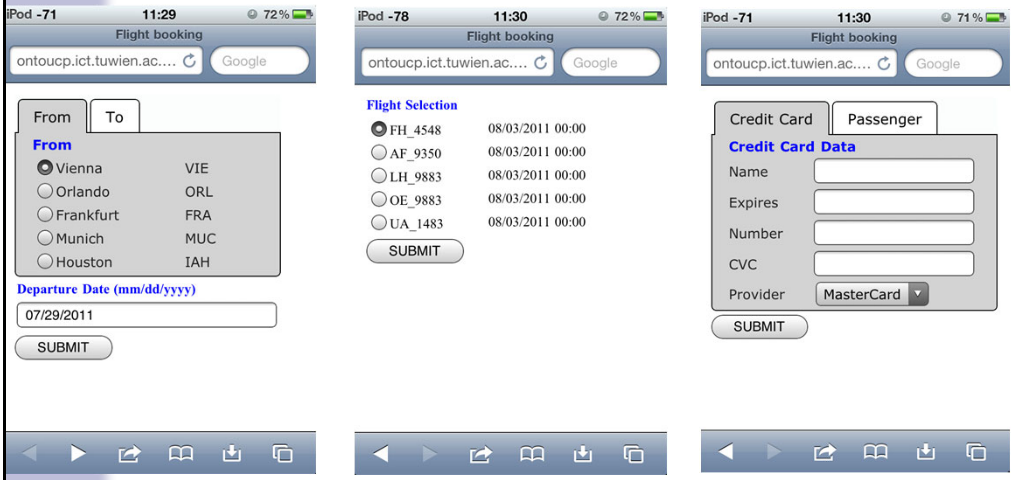
Flight Booking Rendered for iPod Touch



iPod -71 11:29 72 %

Flight booking

ontoucp.ict.tuwien.ac.... Google

From | To

From

● Vienna VIE
○ Orlando ORL
○ Frankfurt FRA
○ Munich MUC
○ Houston IAH

Departure Date (mm/dd/yyyy)

07/29/2011

SUBMIT

iPod -78 11:30 72 %

Flight booking

ontoucp.ict.tuwien.ac.... Google

Flight Selection

● FH_4548	08/03/2011 00:00
○ AF_9350	08/03/2011 00:00
○ LH_9883	08/03/2011 00:00
○ OE_9883	08/03/2011 00:00
○ UA_1483	08/03/2011 00:00

SUBMIT

iPod -71 11:30 71 %

Flight booking

ontoucp.ict.tuwien.ac.... Google

Credit Card | Passenger

Credit Card Data

Name
Expires
Number
CVC
Provider MasterCard

SUBMIT

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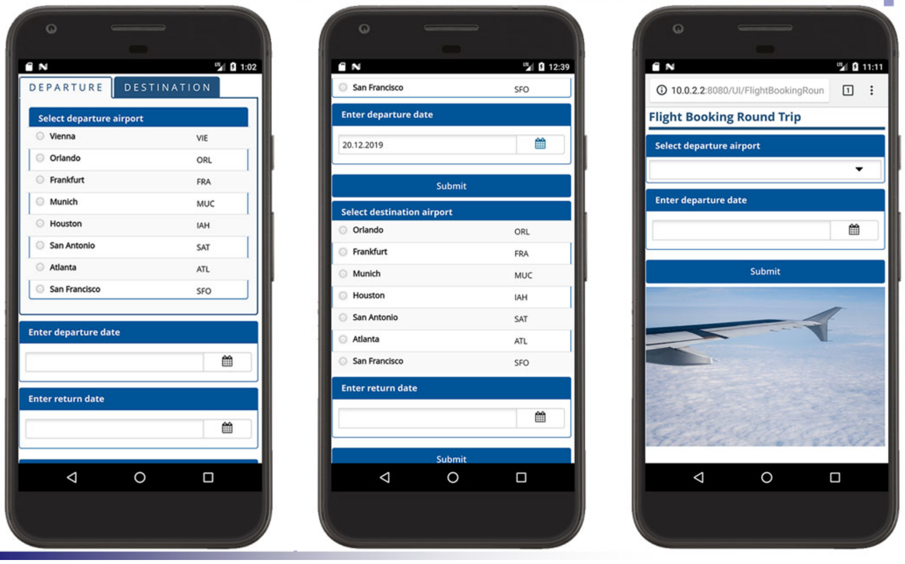
Flight Booking Rendered for Smartphone



○ Vienna	VIE
○ Orlando	ORL
○ Frankfurt	FRA
○ Munich	MUC
○ Houston	IAH
○ San Antonio	SAT
○ Atlanta	ATL
○ San Francisco	SFO

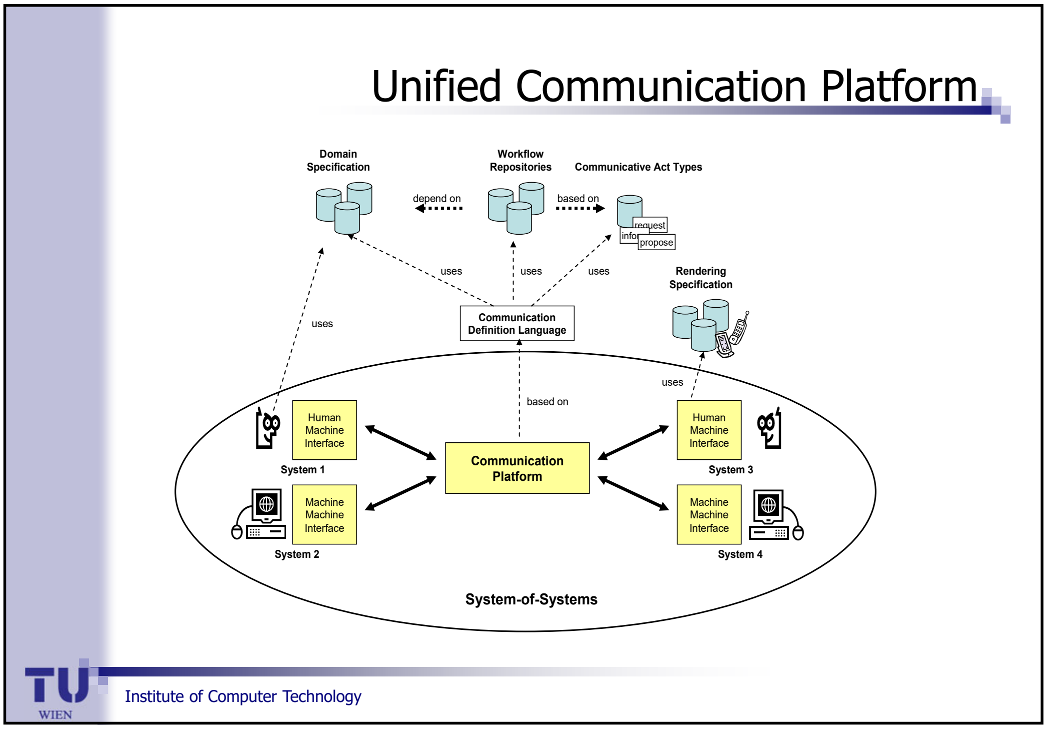
○ San Francisco	SFO

20.12.2019

○ Orlando	ORL
○ Frankfurt	FRA
○ Munich	MUC
○ Houston	IAH
○ San Antonio	SAT
○ Atlanta	ATL
○ San Francisco	SFO

Examples of Final User Interfaces – Desktop and Smartphones

- Simple flight-booking GUI: http://ucp.ict.tuwien.ac.at/UI/FlightBooking
  Vacation planning: http://ucp.ict.tuwien.ac.at/UI/accomodationBooking
- Potentially different GUIs tailored through optimization for different smartphones (screens)



Unified Communication Platform

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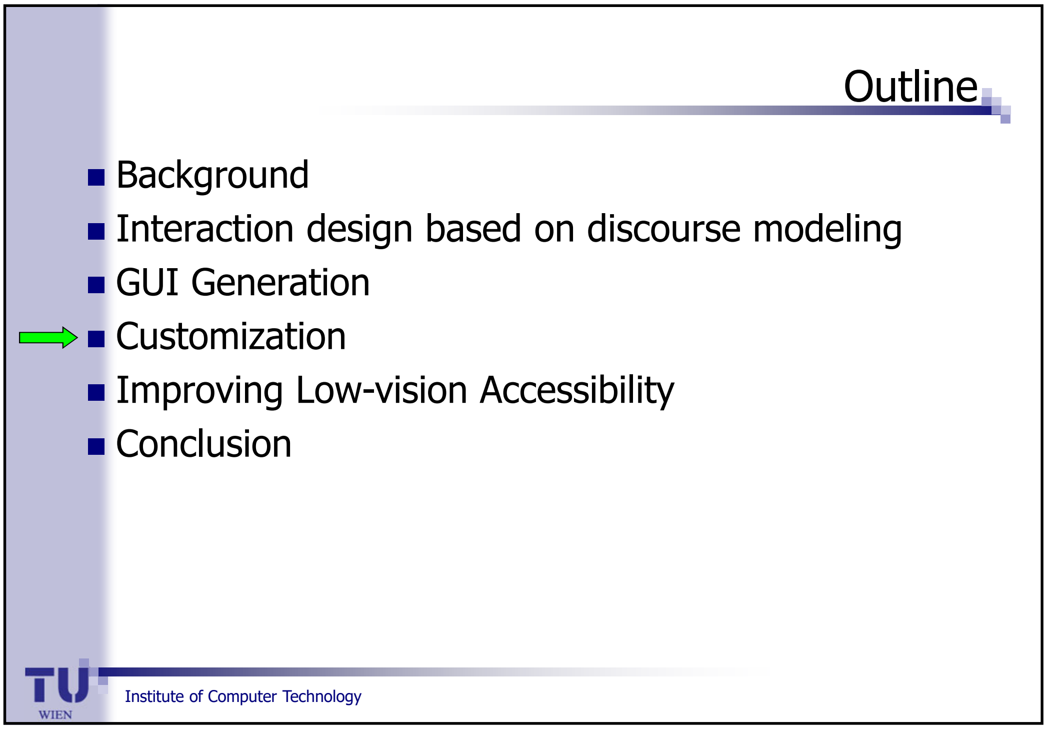

Outline

- Background
- Interaction design based on discourse modeling
- GUI Generation
- ➡ Customization
- Improving Low-vision Accessibility
- Conclusion

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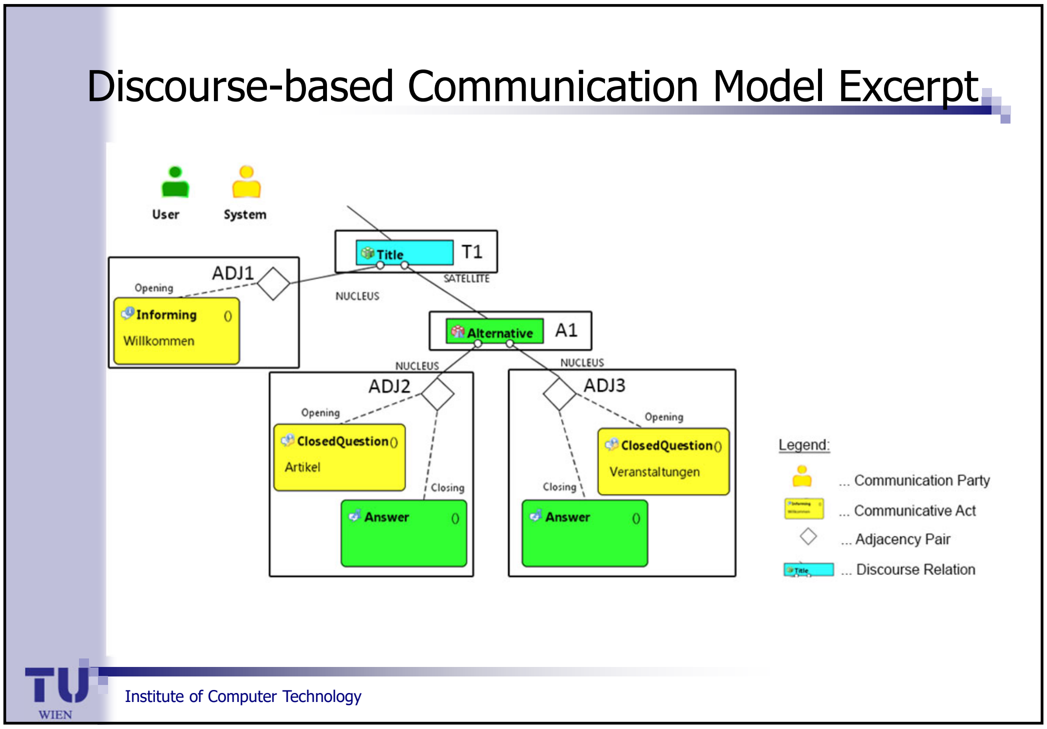

Discourse-based Communication Model Excerpt

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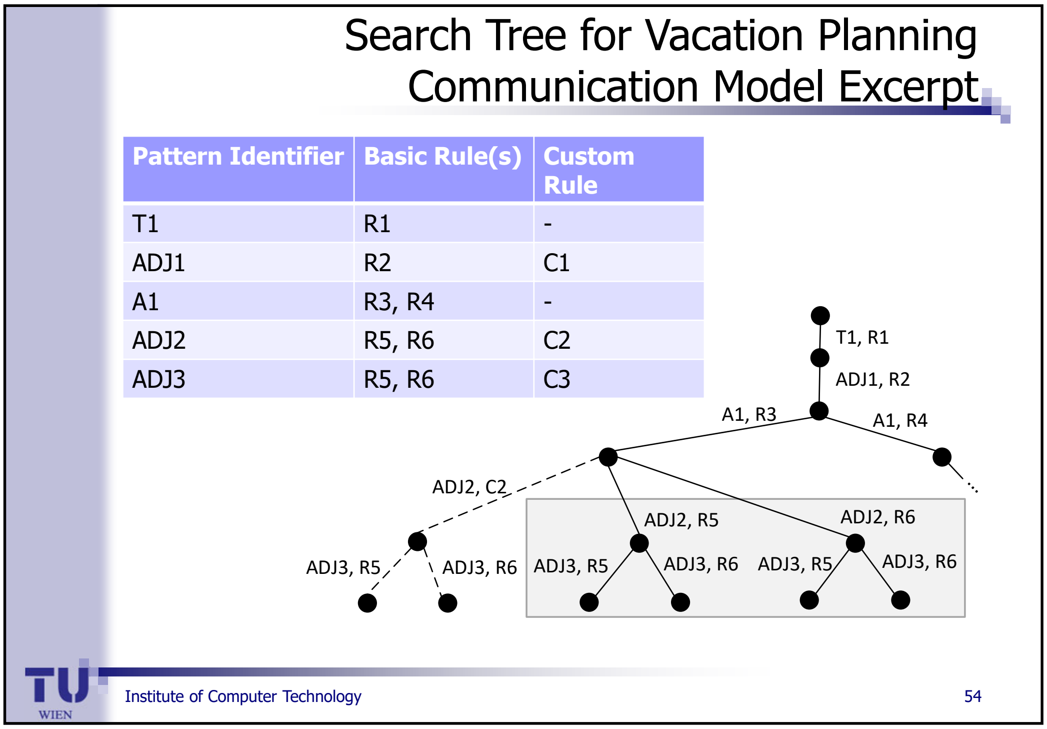

Search Tree for Vacation Planning Communication Model Excerpt

Pattern Identifier	Basic Rule(s)	Custom Rule
T1	R1	-
ADJ1	R2	C1
A1	R3, R4	-
ADJ2	R5, R6	C2
ADJ3	R5, R6	C3

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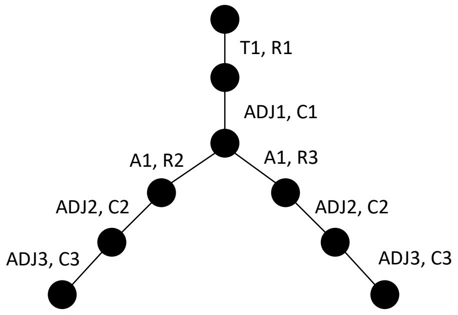
Customized Search Tree



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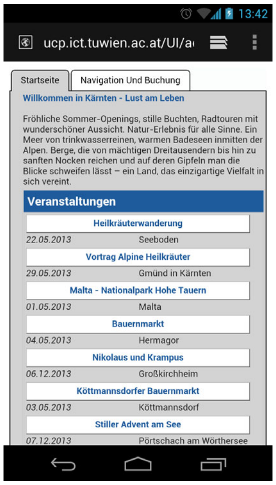
Vacation Planning GUI Displayed on a Samsung Galaxy Nexus Device



Willkommen in Kärnten - Lust am Leben

Fröhliche Sommer-Openings, stille Buchten, Radtouren mit wunderschöner Aussicht. Natur-Erlebnis für alle Sinne. Ein Meer von trinkwasserreinen, warmen Badeseen inmitten der Alpen. Berge, die von mächtigen Dreitausendern bis hin zu sanften Nocken reichen und auf deren Gipfeln man die Blicke schweifen lässt – ein Land, das einzigartige Vielfalt in sich vereint.

Veranstaltungen

Heilkräuterwanderung
22.05.2013 Seeboden

Vortrag Alpine Heilkräuter
29.05.2013 Gmünd in Kärnten

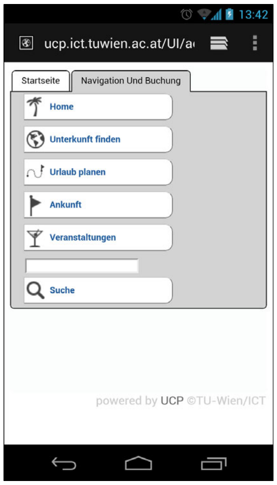
Malta - Nationalpark Hohe Tauern
01.05.2013 Malta

Bauernmarkt
04.05.2013 Hermagor

Nikolaus und Krampus
06.12.2013 Großkirchheim

Köttmannsdorfer Bauernmarkt
03.05.2013 Köttmannsdorf

Stiller Advent am See
07.12.2013 Pörtschach am Wörthersee



http://ucp.ict.tuwien.ac.at/UI/accomodationBookingSmartphone

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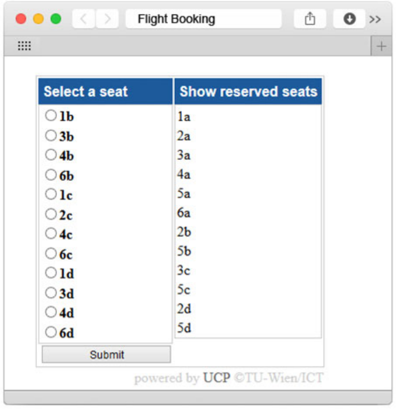
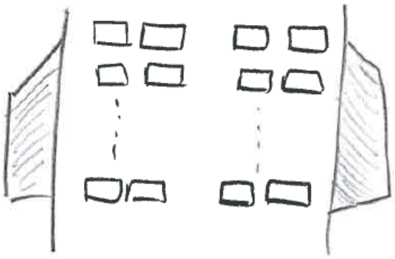
Custom Widgets – Problem Statement



Select a seat	Show reserved seats
○ 1b	1a
○ 3b	2a
○ 4b	3a
○ 6b	4a
○ 1c	5a
○ 2c	6a
○ 4c	2b
○ 6c	5b
○ 1d	3c
○ 3d	5c
○ 4d	2d
○ 6d	5d

Submit

powered by UCP ©TU-Wien/ICT



Result using predefined widgets

User expectation

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Custom Widget Template

- Defined using an existing Template Language (Velocity Template Language)
- Defines graphic representation
- Adds design-time variability
- Knowledge about the run-time engine needed

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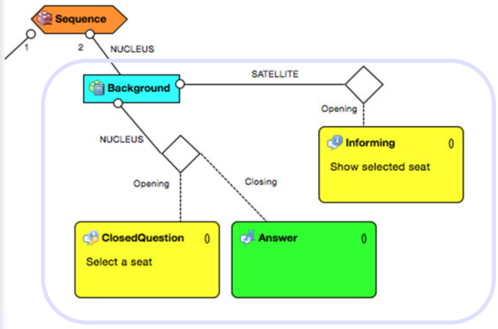
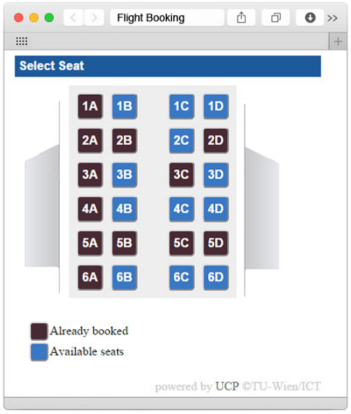
Custom Widget Rule

Source



Target



Flight Booking

Select Seat

1A	1B	1C	1D
2A	2B	2C	2D
3A	3B	3C	3D
4A	4B	4C	4D
5A	5B	5C	5D
6A	6B	6C	6D

🟫 Already booked

🟦 Available seats

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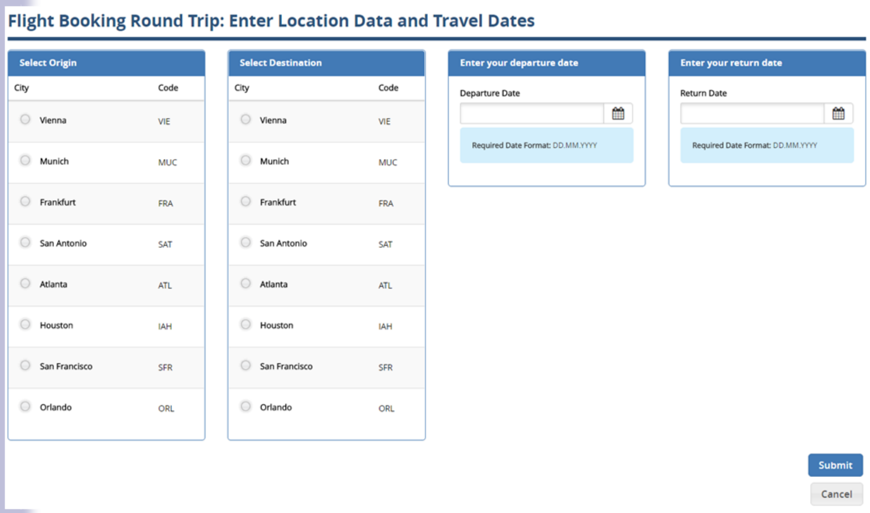
Background

- Laws require Web-sites and software applications to be accessible
- Low Vision Accessibility
- Runtime-generation and –adaptation approaches
- Responsive Design
- Design-time Generation

Running Example



Flight Booking Round Trip: Enter Location Data and Travel Dates

Select Origin

City	Code
○ Vienna	VIE
○ Munich	MUC
○ Frankfurt	FRA
○ San Antonio	SAT
○ Atlanta	ATL
○ Houston	IAH
○ San Francisco	SFR
○ Orlando	ORL

Select Destination

City	Code
○ Vienna	VIE
○ Munich	MUC
○ Frankfurt	FRA
○ San Antonio	SAT
○ Atlanta	ATL
○ Houston	IAH
○ San Francisco	SFR
○ Orlando	ORL

Enter your departure date

Departure Date

Required Date Format: DD.MM.YYYY

Enter your return date

Return Date

Required Date Format: DD.MM.YYYY

Concept for Combining Design-time Generation with Responsive Design

- Design-time
  - Responsible for: Grouping, Widget Selection
  - Results in an enriched CUI model, containing
    - the CUIs for different space requirements
    - allows the generation of one FUI containing the UI for different space requirements
- Responsive Design
  - Layouting according to device size as long as no switching of UI Parts is necessary
  - Switching of UI Parts, if required by space requirements

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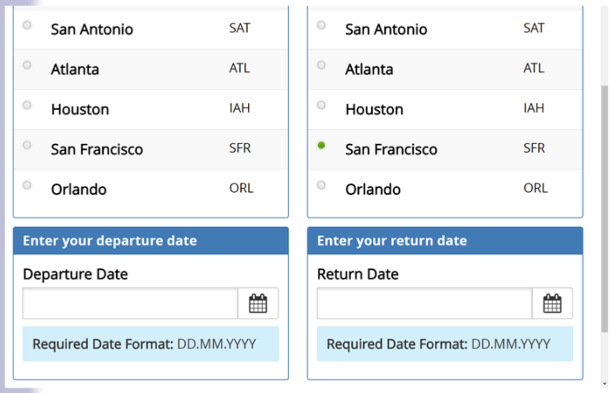
Wrapped widgets due to increased font size and zoom level of 125%



○	San Antonio	SAT
○	Atlanta	ATL
○	Houston	IAH
○	San Francisco	SFR
○	Orlando	ORL

Enter your departure date

Departure Date

Required Date Format: DD.MM.YYYY

○	San Antonio	SAT
○	Atlanta	ATL
○	Houston	IAH
●	San Francisco	SFR
○	Orlando	ORL

Enter your return date

Return Date

Required Date Format: DD.MM.YYYY

- Widget Layout changed by Bootstrap
- No additional actions required

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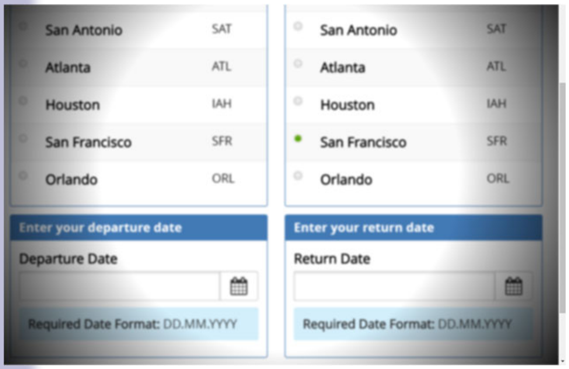
Added blur and effects of a disabled person with glaucoma



○	San Antonio	SAT
○	Atlanta	ATL
○	Houston	IAH
○	San Francisco	SFR
○	Orlando	ORL

Enter your departure date

Departure Date

Required Date Format: DD.MM.YYYY

○	San Antonio	SAT
○	Atlanta	ATL
○	Houston	IAH
●	San Francisco	SFR
○	Orlando	ORL

Enter your return date

Return Date

Required Date Format: DD.MM.YYYY

- For a disabled person with glaucoma, this is not adequate.
- So, another UI has to be presented to the person

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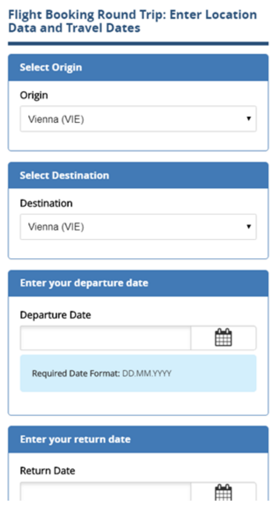
Widgets are replaced due to increased font size and zoom level of 125%



Flight Booking Round Trip: Enter Location Data and Travel Dates

Select Origin

Origin: Vienna (VIE)

Select Destination

Destination: Vienna (VIE)

Enter your departure date

Departure Date

Required Date Format: DD.MM.YYYY

Enter your return date

Return Date

- Widget Replacement done based on different CUI possibilities
- Not directly supported by bootstrap
- Additionally added vue.js

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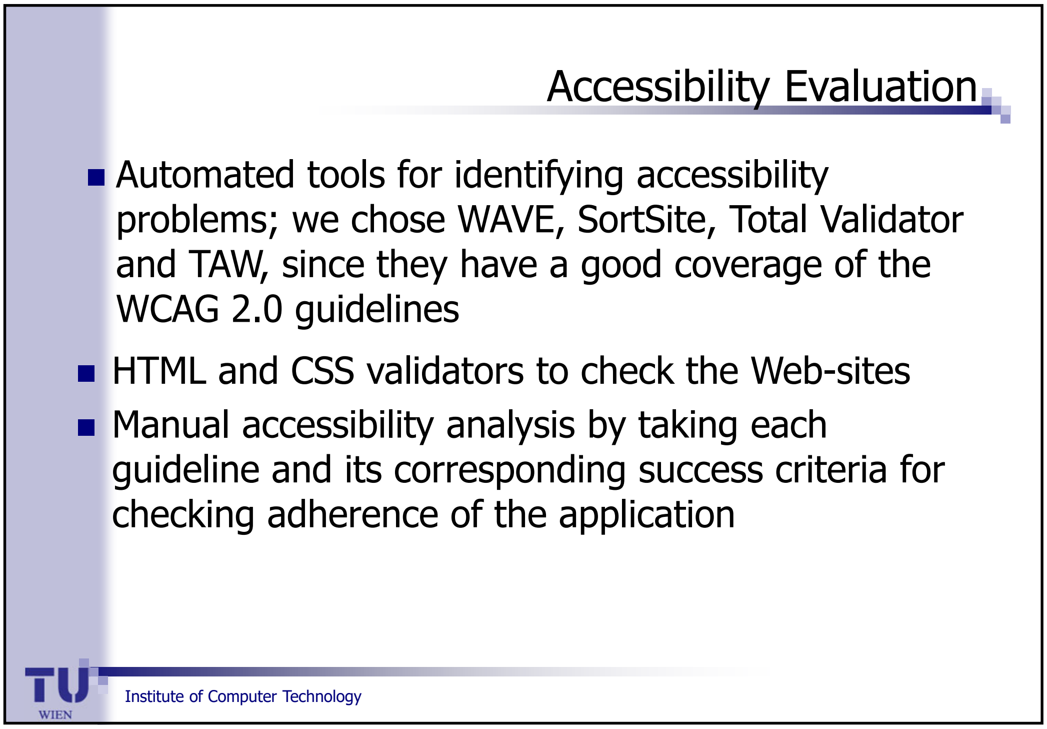
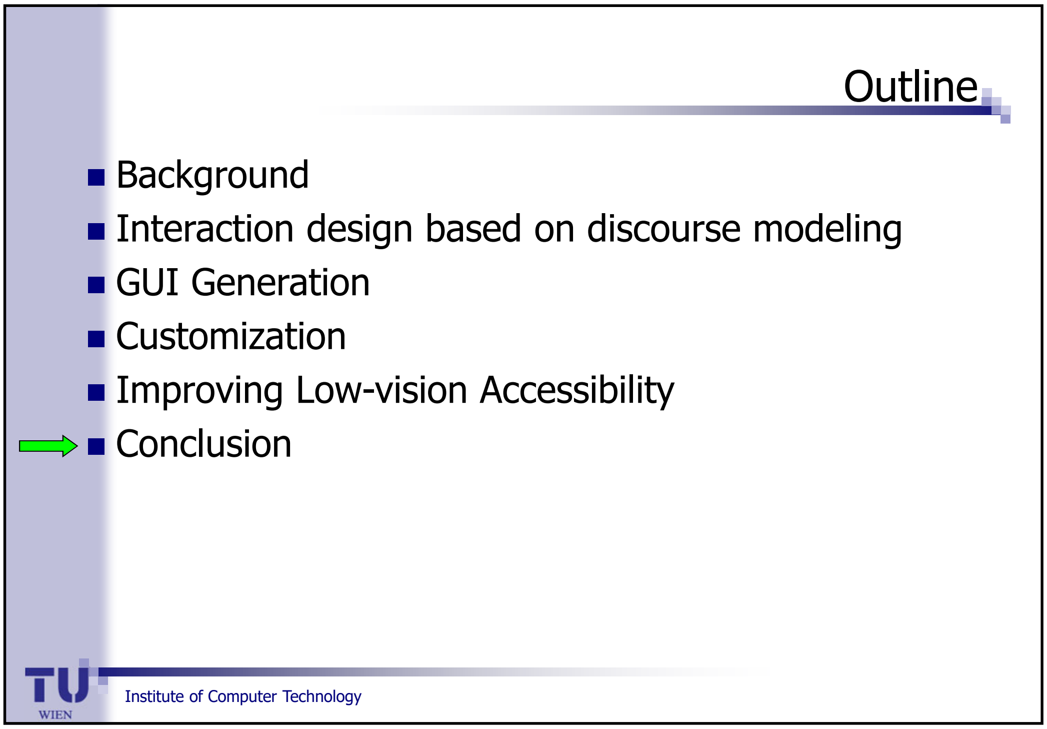


Accessibility Evaluation

- Automated tools for identifying accessibility problems; we chose WAVE, SortSite, Total Validator and TAW, since they have a good coverage of the WCAG 2.0 guidelines
- HTML and CSS validators to check the Web-sites
- Manual accessibility analysis by taking each guideline and its corresponding success criteria for checking adherence of the application



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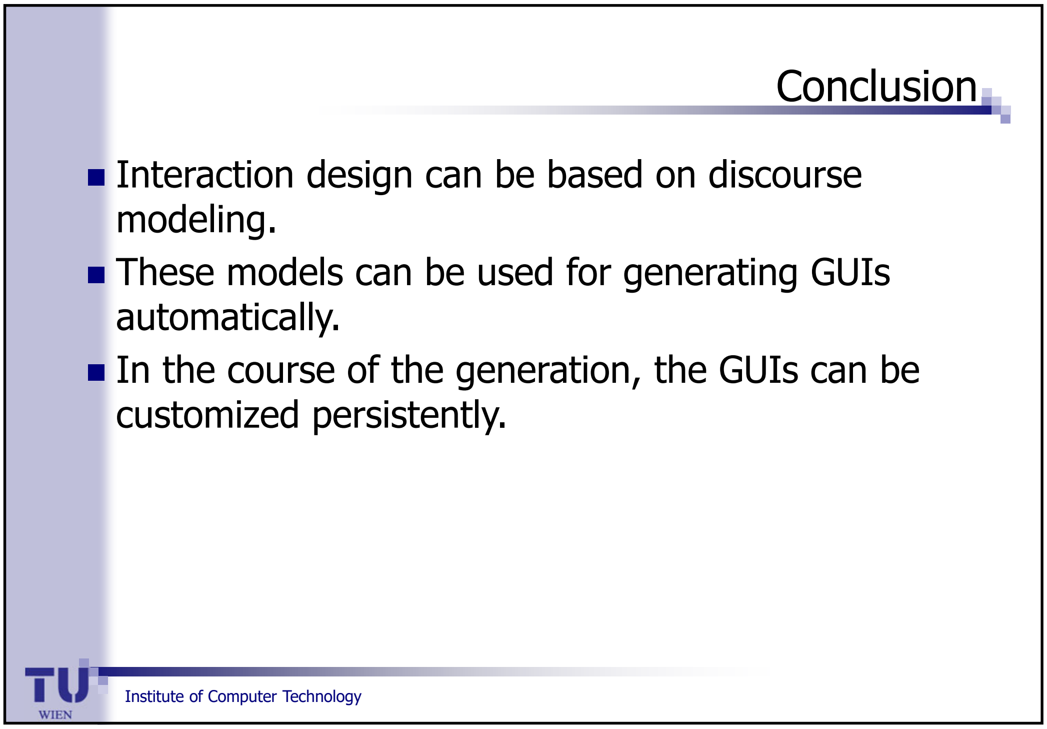

Conclusion

- Interaction design can be based on discourse modeling.
- These models can be used for generating GUIs automatically.
- In the course of the generation, the GUIs can be customized persistently.

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Thank you for your attention!

???

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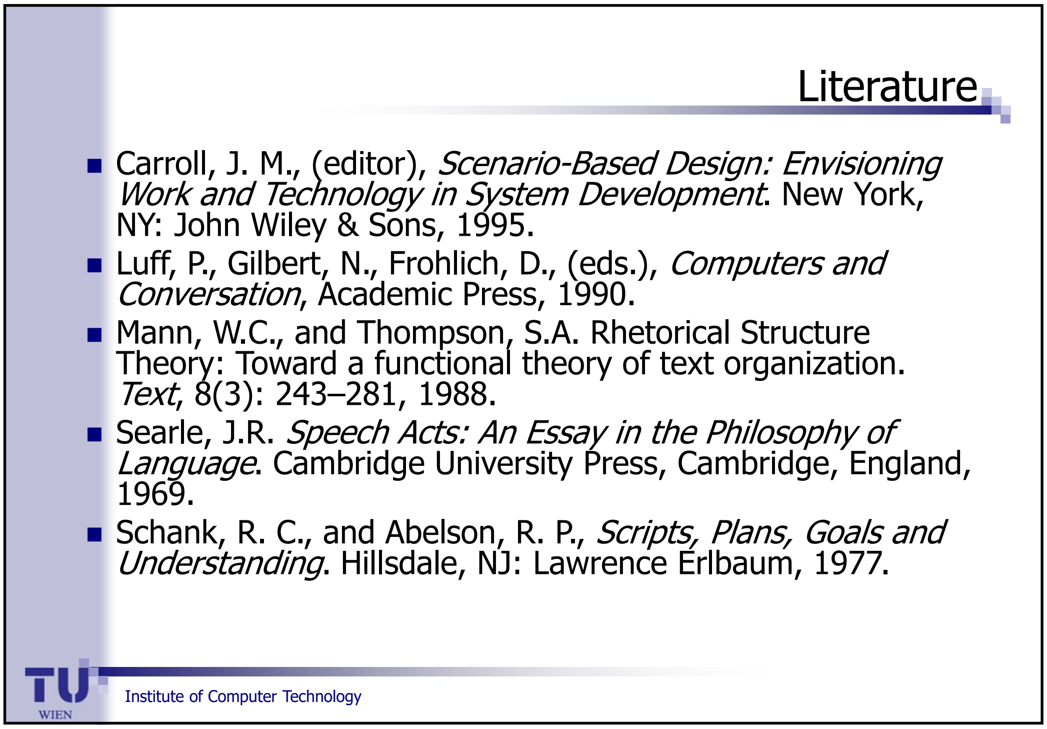

Literature

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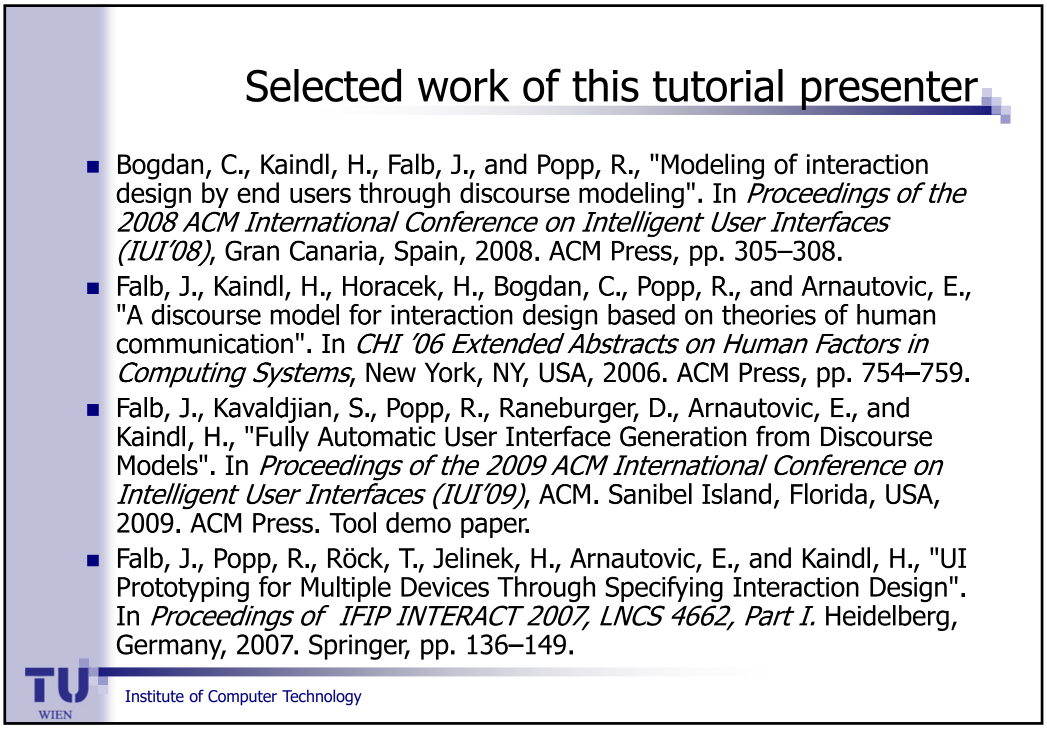

Selected work of this tutorial presenter

- Bogdan, C., Kaindl, H., Falb, J., and Popp, R., "Modeling of interaction design by end users through discourse modeling". In *Proceedings of the 2008 ACM International Conference on Intelligent User Interfaces (IUI'08)*, Gran Canaria, Spain, 2008. ACM Press, pp. 305–308.
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- Falb, J., Kavaldjian, S., Popp, R., Raneburger, D., Arnautovic, E., and Kaindl, H., "Fully Automatic User Interface Generation from Discourse Models". In *Proceedings of the 2009 ACM International Conference on Intelligent User Interfaces (IUI'09)*, ACM. Sanibel Island, Florida, USA, 2009. ACM Press. Tool demo paper.
- Falb, J., Popp, R., Röck, T., Jelinek, H., Arnautovic, E., and Kaindl, H., "UI Prototyping for Multiple Devices Through Specifying Interaction Design". In *Proceedings of IFIP INTERACT 2007, LNCS 4662, Part I.* Heidelberg, Germany, 2007. Springer, pp. 136–149.

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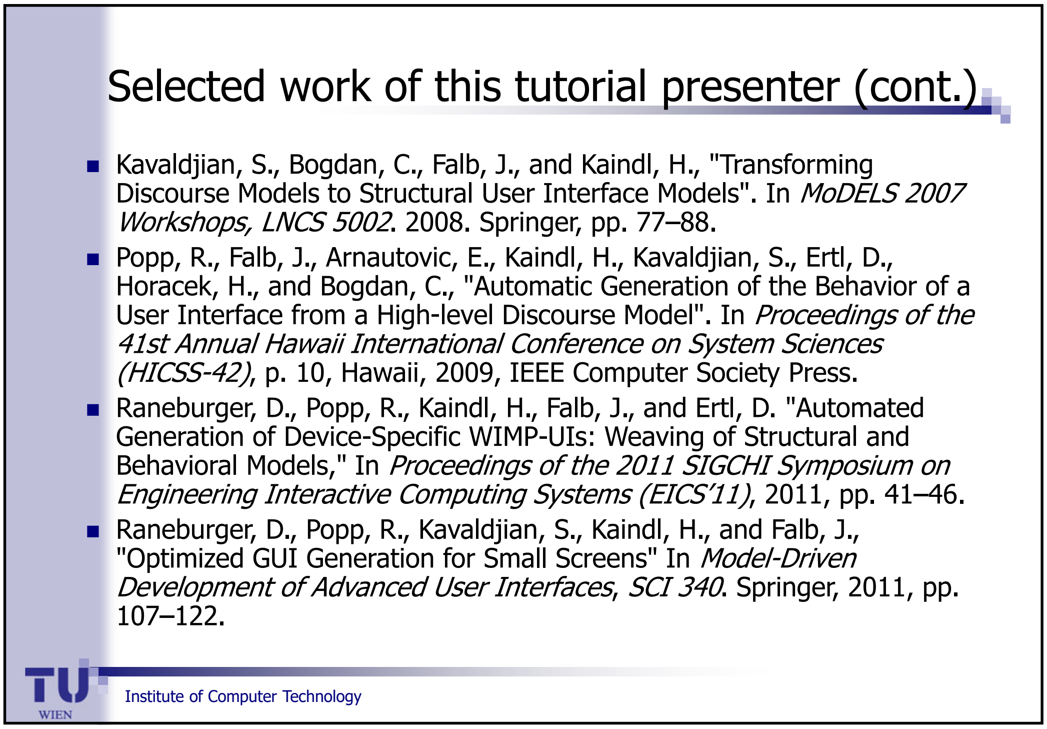

Selected work of this tutorial presenter (cont.)

- Kavaldjian, S., Bogdan, C., Falb, J., and Kaindl, H., "Transforming Discourse Models to Structural User Interface Models". In *MoDELS 2007 Workshops, LNCS 5002*. 2008. Springer, pp. 77–88.
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- Raneburger, D., Popp, R., Kavaldjian, S., Kaindl, H., and Falb, J., "Optimized GUI Generation for Small Screens" In *Model-Driven Development of Advanced User Interfaces*, *SCI 340*. Springer, 2011, pp. 107–122.

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