Developing a Decision-Theoretic User Model for Automatic Customization

Thesis Proposal

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Need for Automatic Customization

- Problems from industry practices:
  - Varying user needs and preferences
  - One-size-fits-all solution
  - Lost in interface/functionality

- Most affected users
  - People with cognitive, sensory, motor impairments
  - Elderly people
  - Children
  - Novices

General Approaches

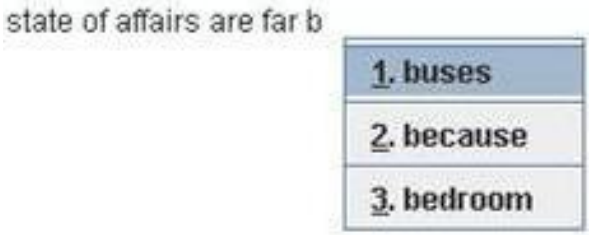
- Requirements engineering
  - Design solution
- Adaptable interfaces (HCI)
  - User has full control
  - Burden on user
- Adaptive interfaces (AI)
  - Automatic customization
  - Learns user-specific preferences
  - Mixed-initiative approach

Run-time solutions

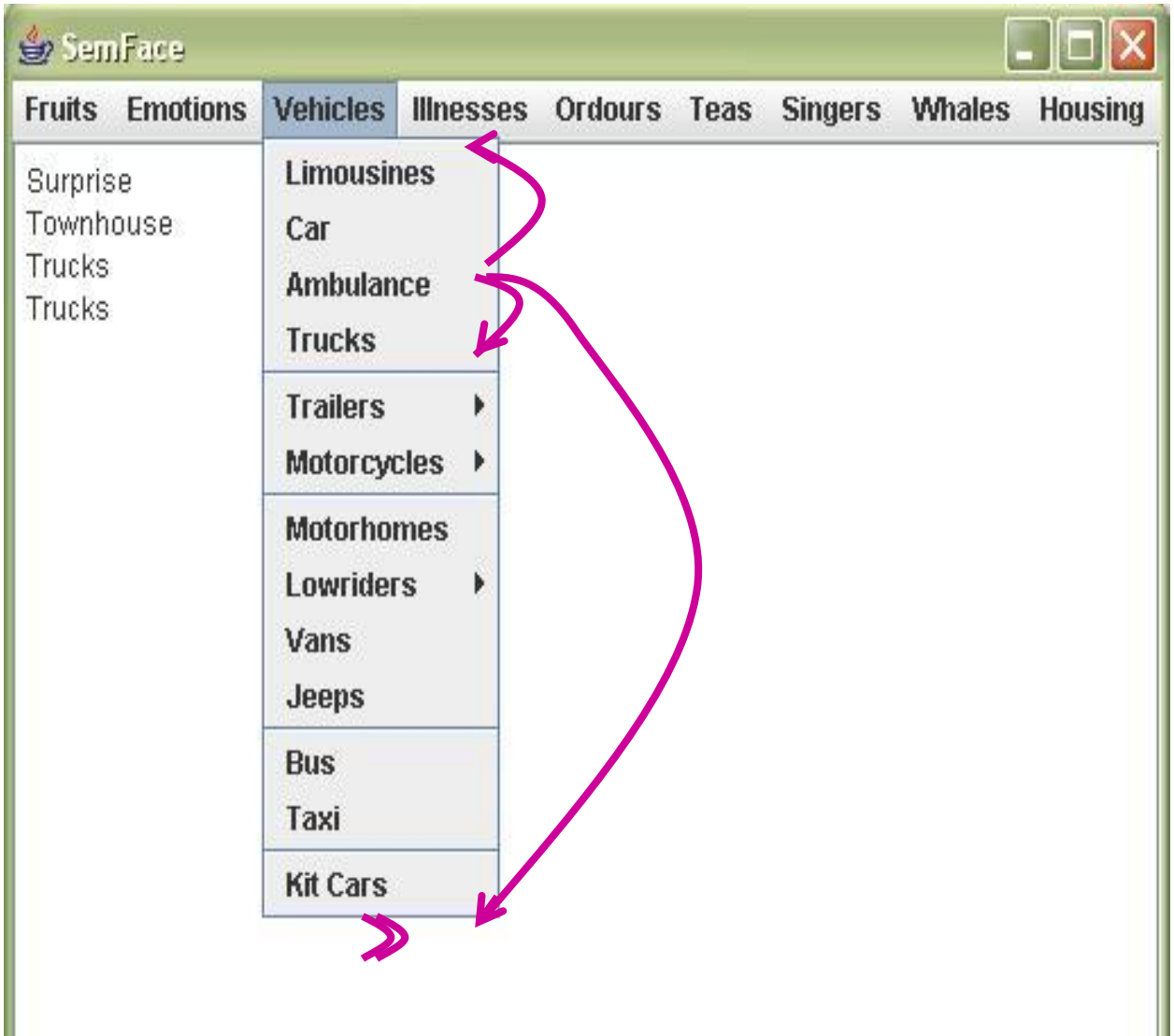
Interface Customization

- Objectives
  - Minimize user effort
  - Maximize interaction experience
- Existing implementations
  - Auto-completions
  - Toolbars
  - Adding/hiding widgets
  - Hints (balloons)
  - Questions (dialog boxes)

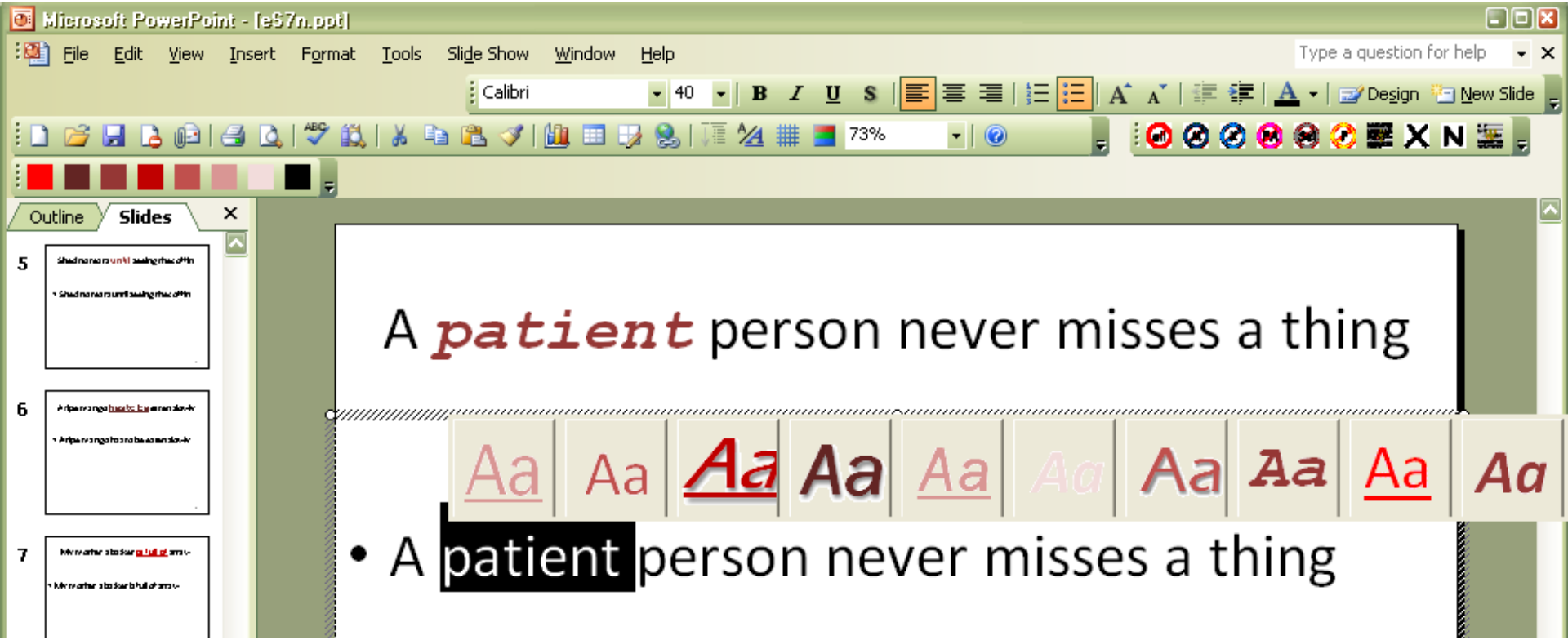
Example: Adaptive Word Completion Typing Task



Example: Adaptive Layout Menu Selection Task



Example: Adaptive Toolbar Highlighting Task



Customization Issues

- **Who:** user type,
  varying preferences
- **What:** kinds of help
  (e.g., auto-completion vs. toolbar)
- **When:** long term benefits and risks
- **Where:** near current focus,
  off to the side
- **How:** display mechanism (e.g., animation)
- **Why:** rationale,
  transparency

Specific Research Questions

- Individual differences?
- Influence on goal recognition?
- Influence on perceived value of help?

Specific Research Questions

- Individual differences?
  - General user characteristics?
  - Variation in “reactions” to adaptive help?
  - Explanatory model of differences?
  - Patterns of user behaviour?
  - Fast, online inference?
- Influence on goal recognition?
- Influence on perceived value of help?

Specific Research Questions

- Individual differences?
- Influence on goal recognition?
  - Modeling idiosyncrasies?
  - Classes of user-specific goals?
  - Quantifying quality of help?
  - Fast, online inference?
- Influence on perceived value of help?

Specific Research Questions

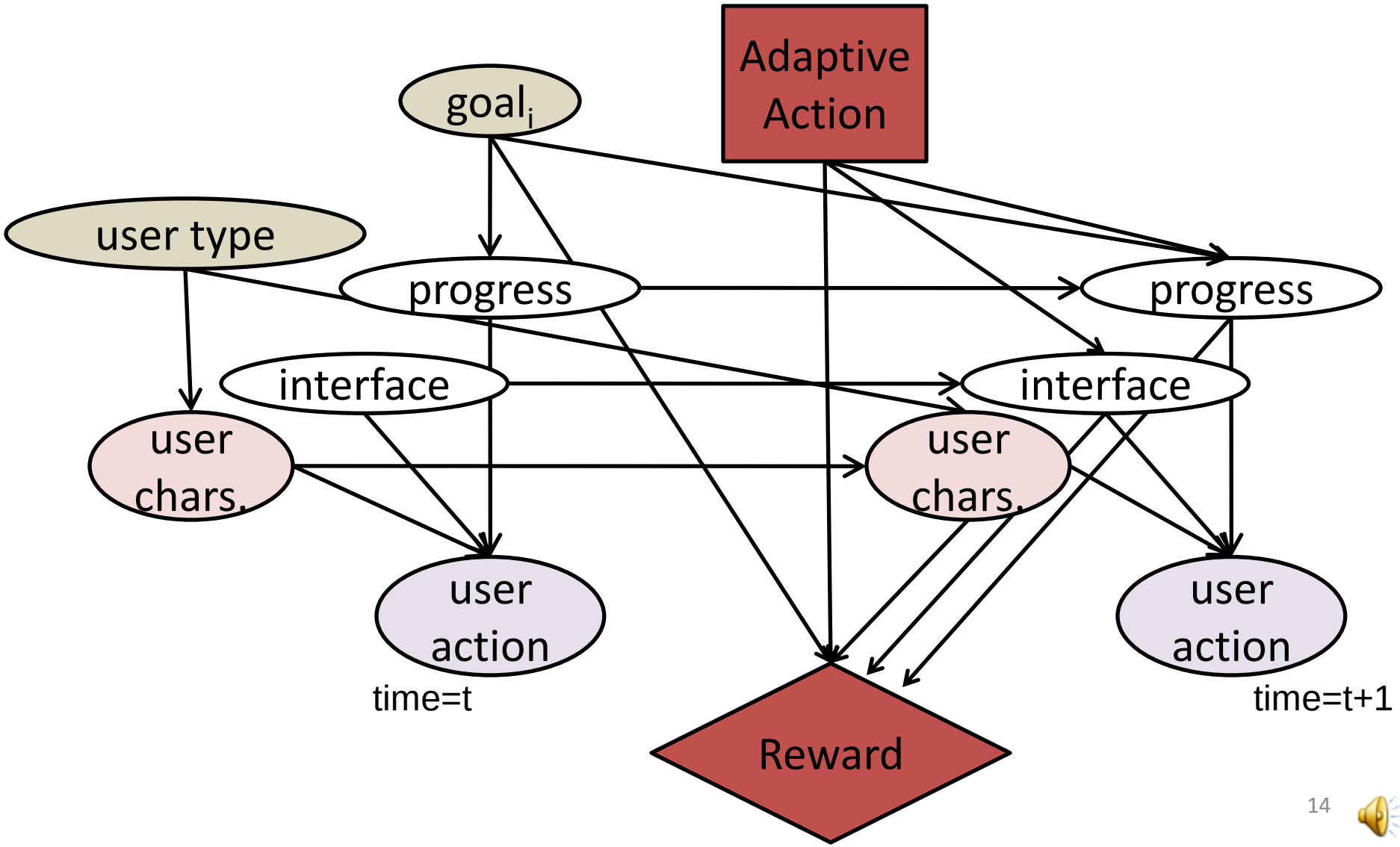
- Individual differences?
- Influence on goal recognition?
- Influence on perceived value of help?
  - Factors relevant to costs/benefits?
  - Predictive model of interaction factors?
  - Elicit preferences with real users?
  - Capture evolving preferences?

Our Approach/Thesis Structure

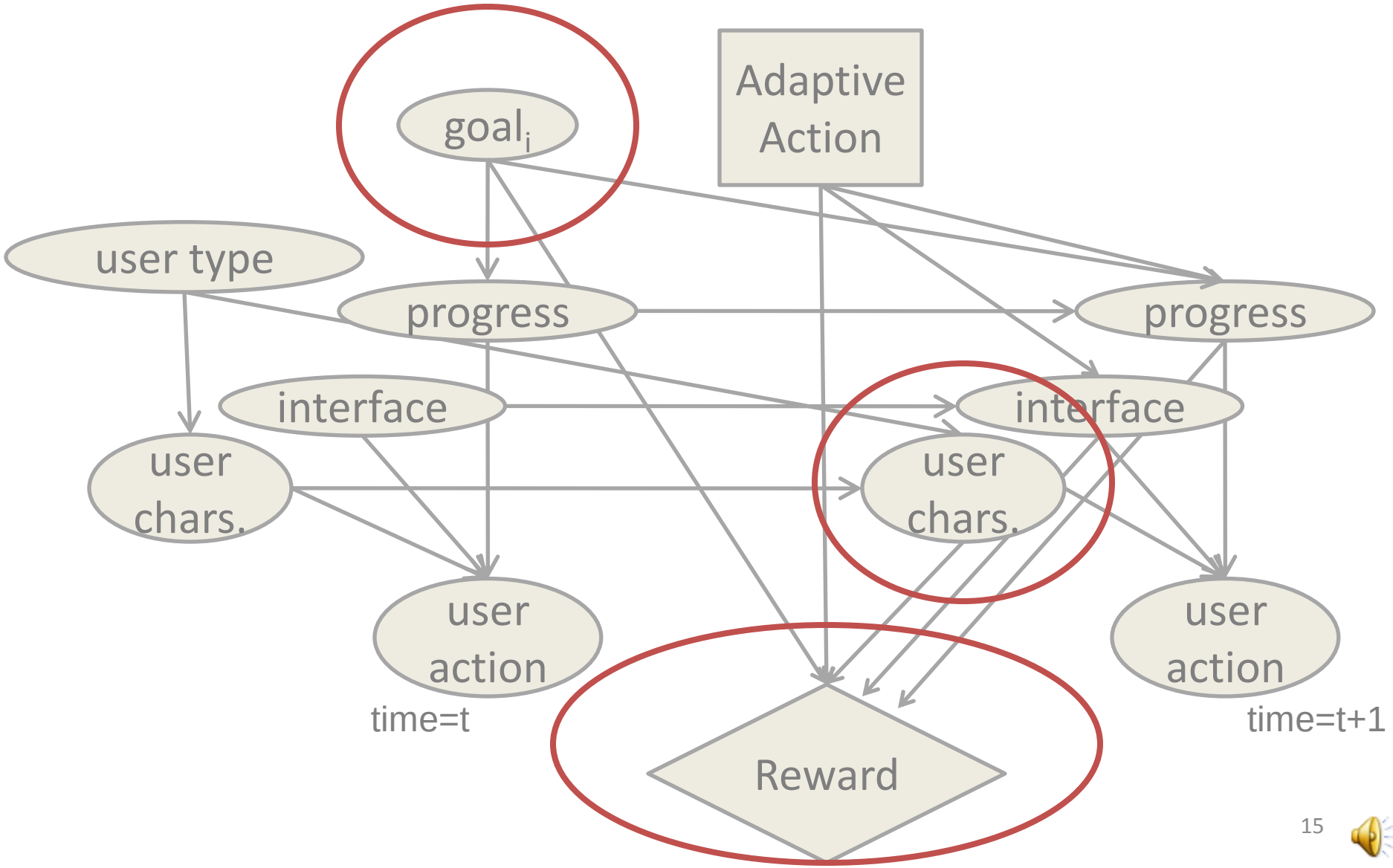
- Interface customization as a decision-theoretic planning problem
- General POMDP customization assistant
- Canonical system architecture
  - User characteristics prediction
  - User goal prediction
  - Action selection
- Evaluate integrated system

Ch 3
Ch 4
Ch 5
Ch 6
Ch 7

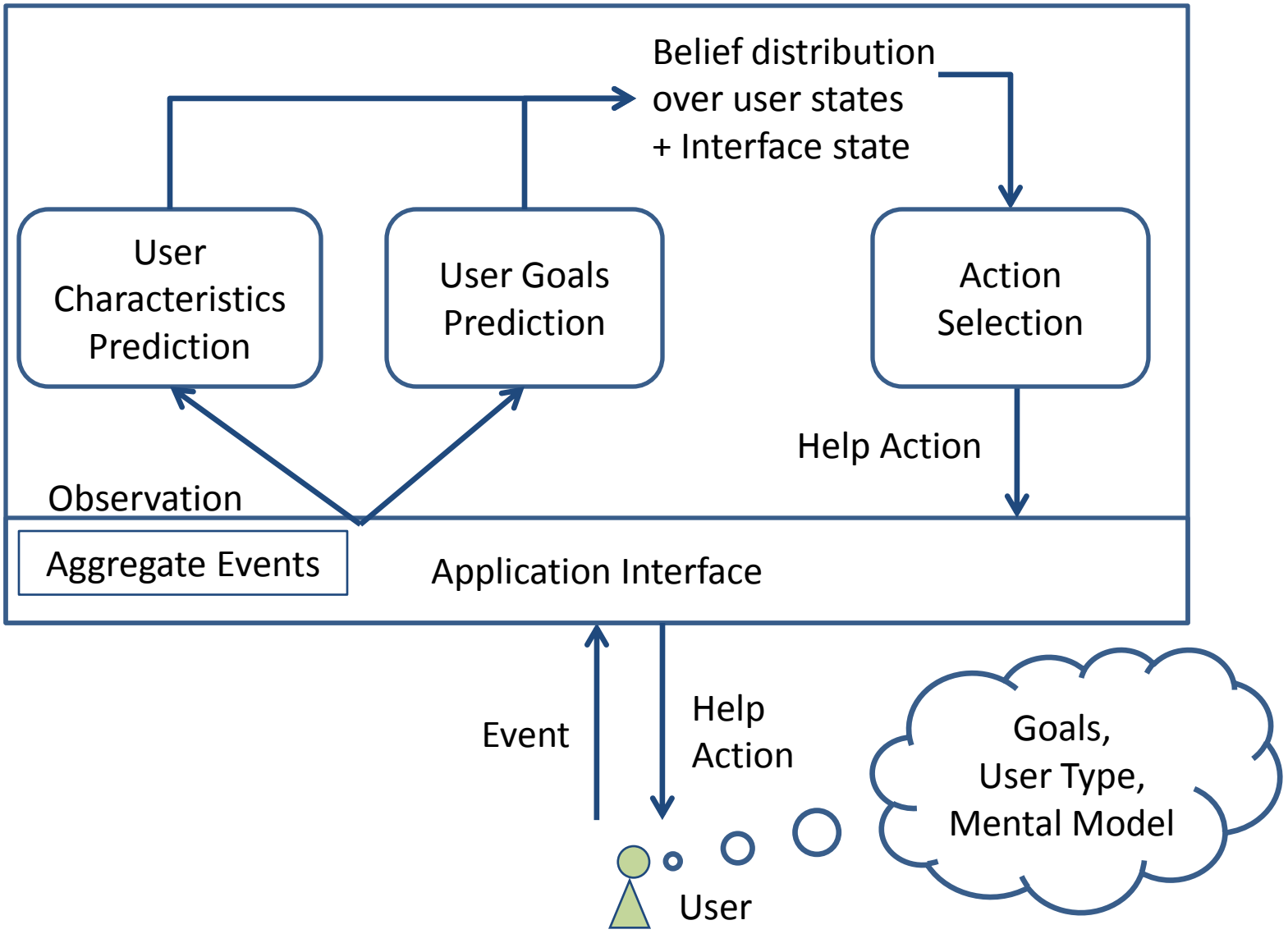
POMDP Assistance Model



POMDP Assistance Model



Canonical System Architecture



Chapter 4:
A Model of Individual Differences

- Evidence supporting individual differences
- Representing user characteristics
- Bayesian model of characteristics for savings
  - Domain: adaptive word prediction
  - Expm: data collection, simulation, usability
- Probabilistic model of mental model for disruption
  - Domain: adaptive menu
  - Expm: data collection, simulation, usability

Chapter 5:
Personalized Goal Recognition

- Common goal classes
- Finite state models
  - Indentation goals
  - Highlighting goals
- Inference procedure
- Evaluation
  - Domain: adaptive toolbar in PowerPoint
  - Expm: simulation **(incomplete)**

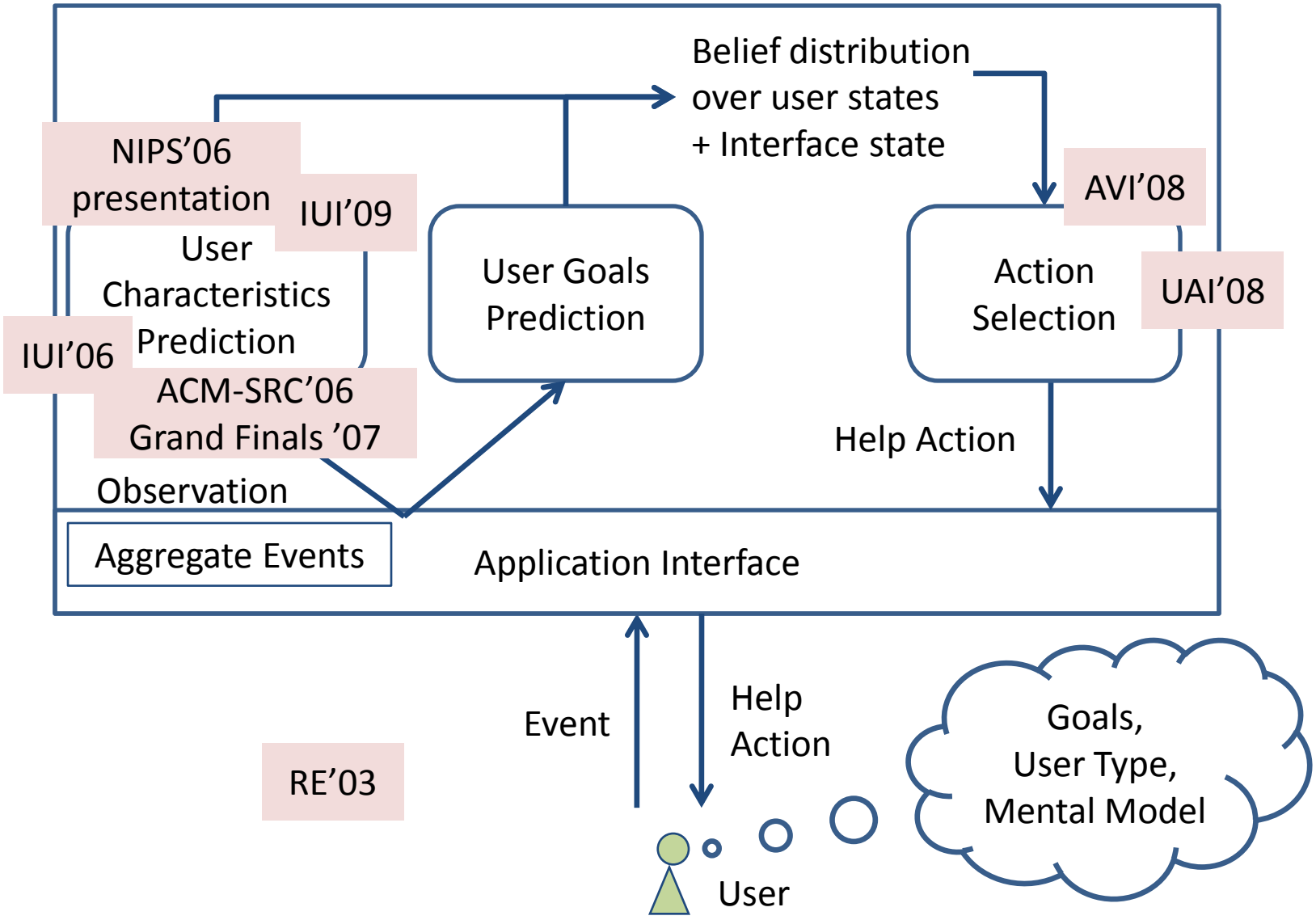
Chapter 6:
Utility of Intelligent Assistance

- Interaction factors as influence diagrams
- Bloat
  - Domain: adaptive menu
  - Expm: simulation
- Savings (summary)
- Disruption (summary)
- Eliciting subjective value of help
  - Domain: adaptive toolbar in PowerPoint
  - Expm: experiential elicitation

Chapter 7: Integrated System and Evaluation

- Main questions:
  - What is the impact of the user characteristics component on overall utility?
  - What is the impact of a decision-theoretic policy on overall utility?
- Measure utility as a function of changing accuracy
- Integrated system as test application
  - Domain: adaptive toolbar in PowerPoint
  - Expm: usability **(incomplete)**

Summary of Contributions



Major Steps Remaining

- Chapter 5 simulation
  - Set-up automatic simulation environment
- Chapter 7 evaluation
  - Modify design?
  - Experiments with people?
- Chapter 8 conclusions
  - Writing
- Editing throughout

Details on Integrated Evaluation

- Understand contribution to overall help utility
- Questions of interest:
  - impact of user characteristics component?
  - impact of decision-theoretic policy?
- Test Policies
  - Heur-G, Heur-GC, DT-G, DT-GC, Always, Never
- Prediction Accuracy
  - acc_G = distribution (or ranks) of goals
  - acc_C = distribution (or ranks) of user types

Design Options

acc_G	acc_C	Always	DT-G	DT-GC	Never	Heur-G	Heur-GC
100	100	C1	C2	C3	C4	C5	C6
50	100	C7	C8	C9	(C4)	C10	C11
100	50	(C1)	(C2)	C12	(C4)	(C5)	C13

- Within: ~100 people per 13 conditions
  - More controlled goal recognition
  - Allows comparison of multiple policies
- Across: ~10 people per condition (x13)
  - More realistic goal recognition
  - Experiences one policy only

Simplifying Assumptions

acc_G	acc_C	Always	DT-G	DT-GC	Never	Heur-G	Heur-GC
100	100	C1	C2	C3	C4	C5	C6
50	100	C7	C8	C9	(C4)	C10	C11
100	50	(C1)	(C2)	C12	(C4)	(C5)	C13

- Explore char comp impact in best case
  - Ignore acc_C=50% → 11 conditions
- Assume char comp works best with DT policy
  - Ignore Heur-GC → 9 conditions
- Drop one of the two questions?
  - Ignore impact of DT/Char → 7 conditions
- Drop one accuracy setting?
  - Ignore acc_G=50%,acc_C=100% → 5 conditions

Pilot Study

- Within-subjects design per accuracy setting
- 5 systems (1 accuracy setting) per experiment
- 10 highlighting tasks in augmented PowerPoint
- 4 events per goal (minimal)
- ~60 minutes per experiment
- Hypotheses to compare mean “utilities” across system policies

Sample Slide

Facts about ***Frogs***

- Some frogs have suction disks on the tip of their toes to help them climb

“H0”: Decreasing Goal Accuracy

- mean utility of sys A at acc_G=100%,acc_C=100% > mean utility of sys A at acc_G=50%,acc_C=100%
- Cases:
  - System policy = Always
  - System policy = Heur-G
  - System policy = DT-G
  - System policy = DT-GC
- Objective: replicability of literature results

H1: Impact of Char Comp

- mean utility of DT-G < mean utility of DT-GC
- Cases:
  - Setting at acc_G=100%,acc_C=100%
  - Setting at acc_G=50%,acc_C=100%
- Objective: benefit of characteristics component

H2: Impact of DT Policy

- mean utility of Heur-G < mean utility of DT-G
- Cases:
  - Setting at acc_G=100%,acc_C=100%
  - Setting at acc_G=50%,acc_C=100%
- Objective: benefit of decision-theoretic policy

Remaining Steps in Evaluation

- Testing/Debugging?
- Modify design?
- More experiments?
- Results analysis?