The Need for an Interaction Cost Model in Adaptive Interfaces

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Advances in Visual Interfaces (AVI'08)

Need for Software Customization

- Increasing complexity
  - Lost in interface/functionality
  - Repeated customization effort
- Most affected users
  - People with cognitive, sensory, motor impairments
  - Elderly people
  - Children
  - Novices

Intelligent Interfaces

- Design objectives
  - Minimize user effort
  - Maximize ease of interaction

- Existing implementations:
  - Auto-completion
  - Toolbar suggestions
  - Adaptive menus (add/hide/move)
  - Etc.

Research Objectives

- Account for existing interaction factors
- Predict costs/benefits of interaction
- Explain individual differences

Decision-Theoretic Framework

- Actions lead to outcomes probabilistically
- Impact of intelligent actions
- Tradeoffs between costs and benefits
- Maximizing (long-term) **expected utility**

Utility of Customization Actions

- Impact of actions:

Action	Savings	Processing	Occlusion	Bloat	Disruption	Interruption
AUTO	X					X
TOOLBAR	X	X	X			X
ADD	X			X	X	X
HIDE	X			X	X	X
MOVE	X				X	X
HINT	X	X	X			X
ASK	X	X	X			X

Utility of Customization Actions

- Compute utility of each interaction factor
- Overall Utility = $w_1 \text{utility}_{\text{factor1}} + w_2 \text{utility}_{\text{factor2}} + \ldots$
- Each component models:
  - **Objective value**
  - Subjective utility

Utility of Customization Actions

- Compute utility of each interaction factor

- Overall Utility = $w_1 \text{utility}_{\text{factor1}} + w_2 \text{utility}_{\text{factor2}} + \ldots$

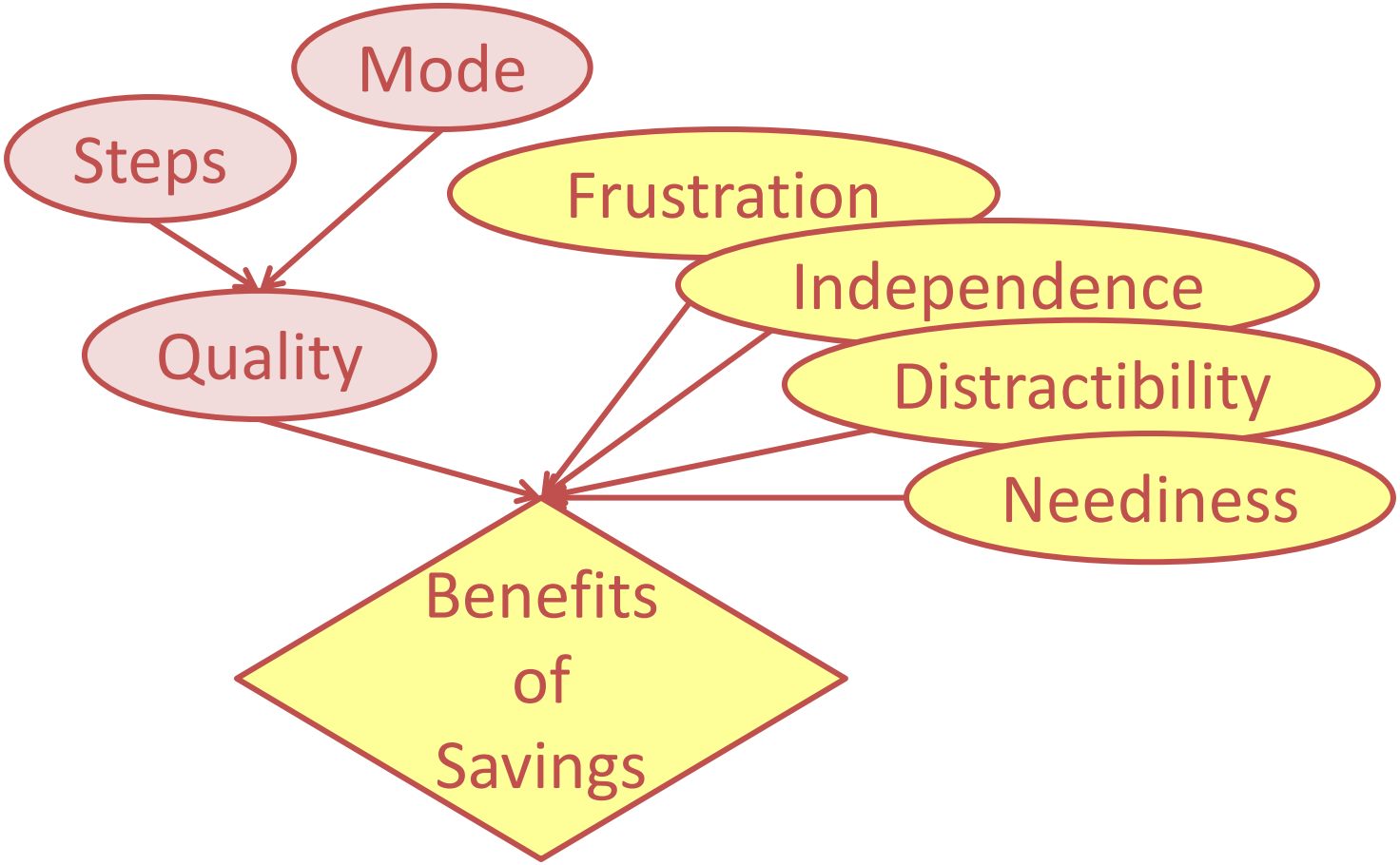
  Models existing interaction factors

- Each component models:
  - **Objective value** — **Predicts costs/benefits of interaction**
  - Subjective utility — **Models individual differences**

Interaction Cost Model

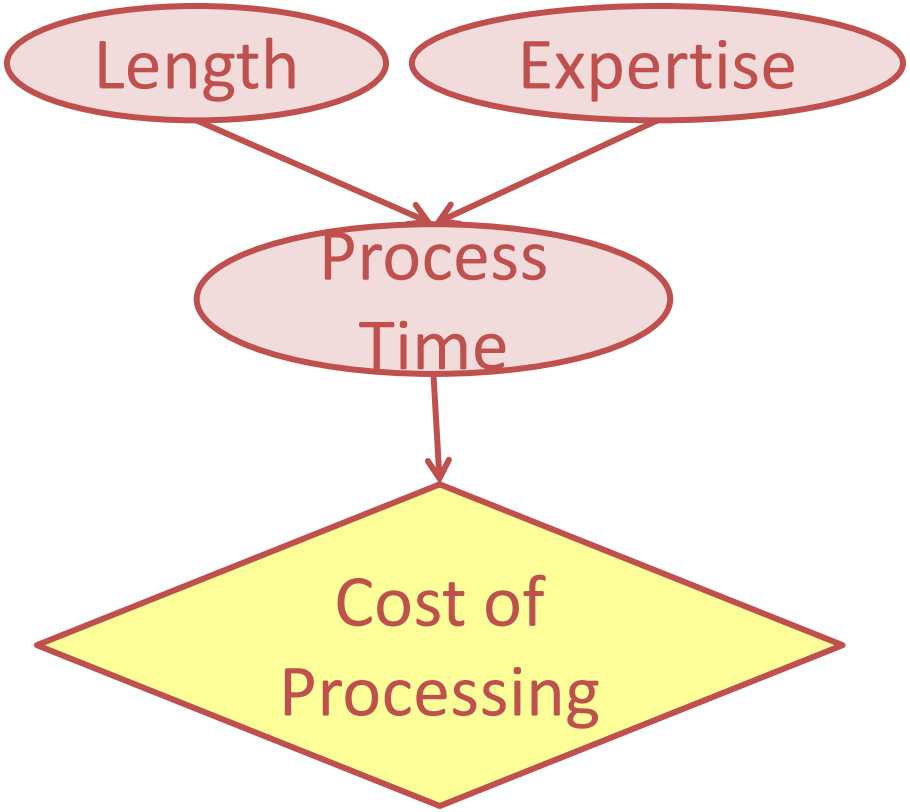
- Predictive model of interaction factors
  - Savings
  - Information processing
  - **Occlusion**
  - **Bloat**
  - Disruption
  - Interruption

Model of Savings



- Quality = GOMS(Steps, Mode)

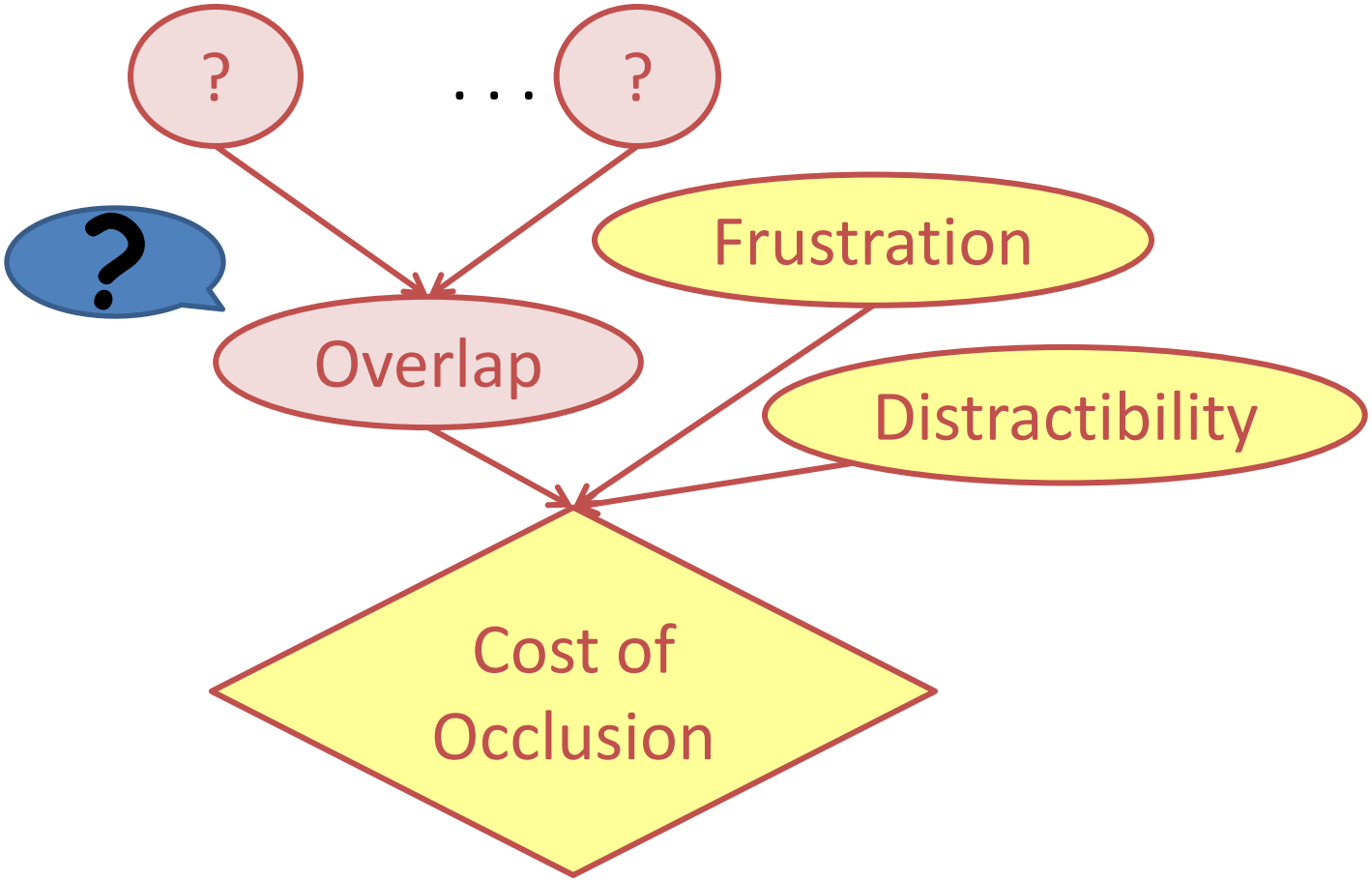
Model of Processing



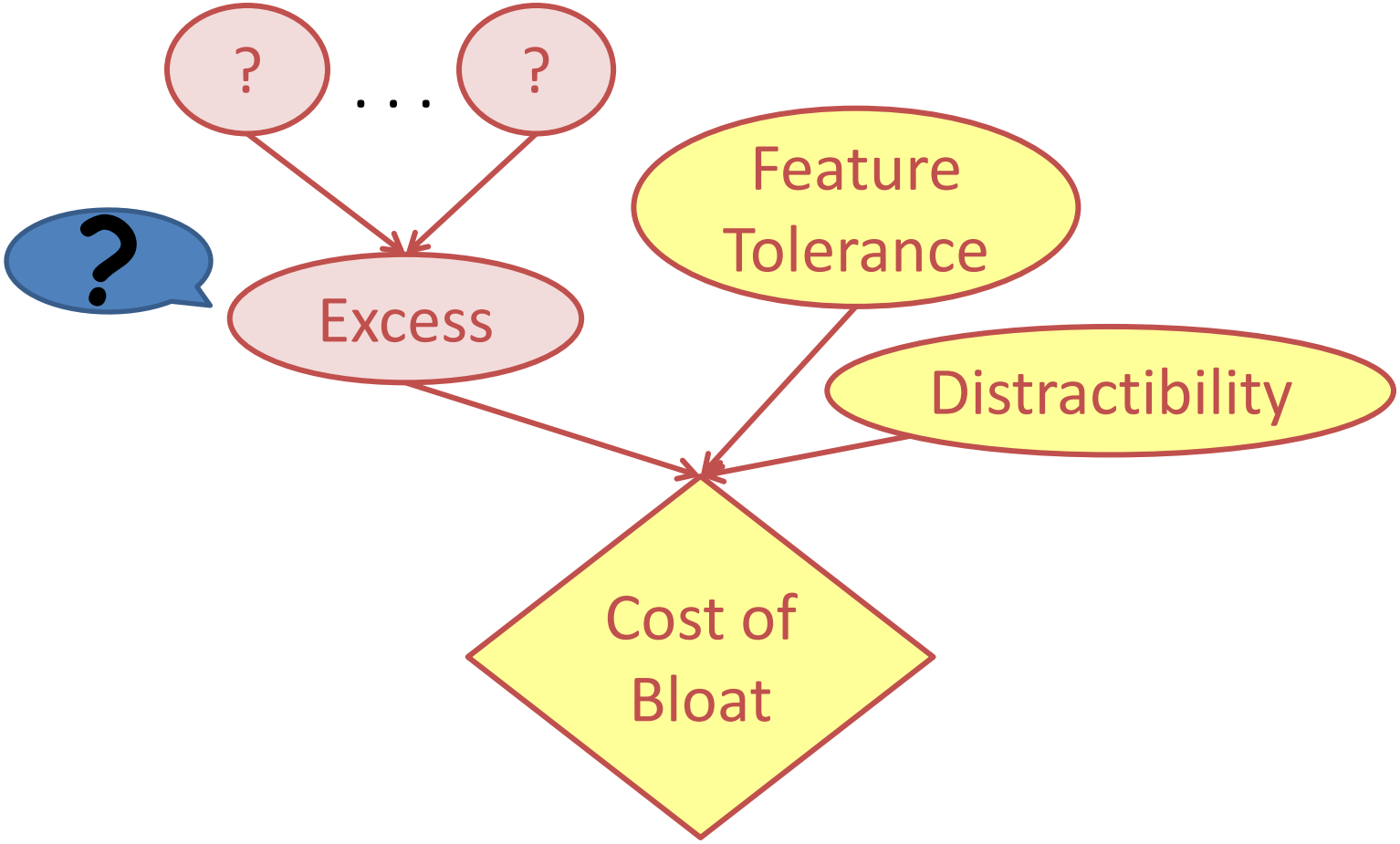
- ProcessTime = Hick-Hymann(Length) *if* expert
  = Visual_Search(Length) *if* naive

Expertise

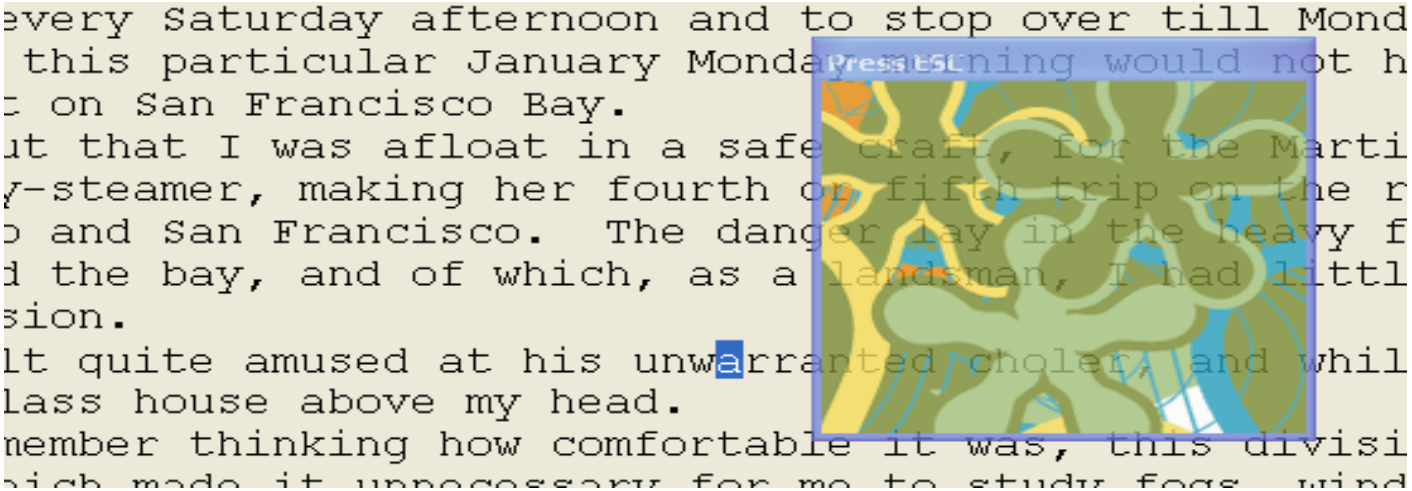
Model of Occlusion



Model of Bloat



Occlusion Experiment

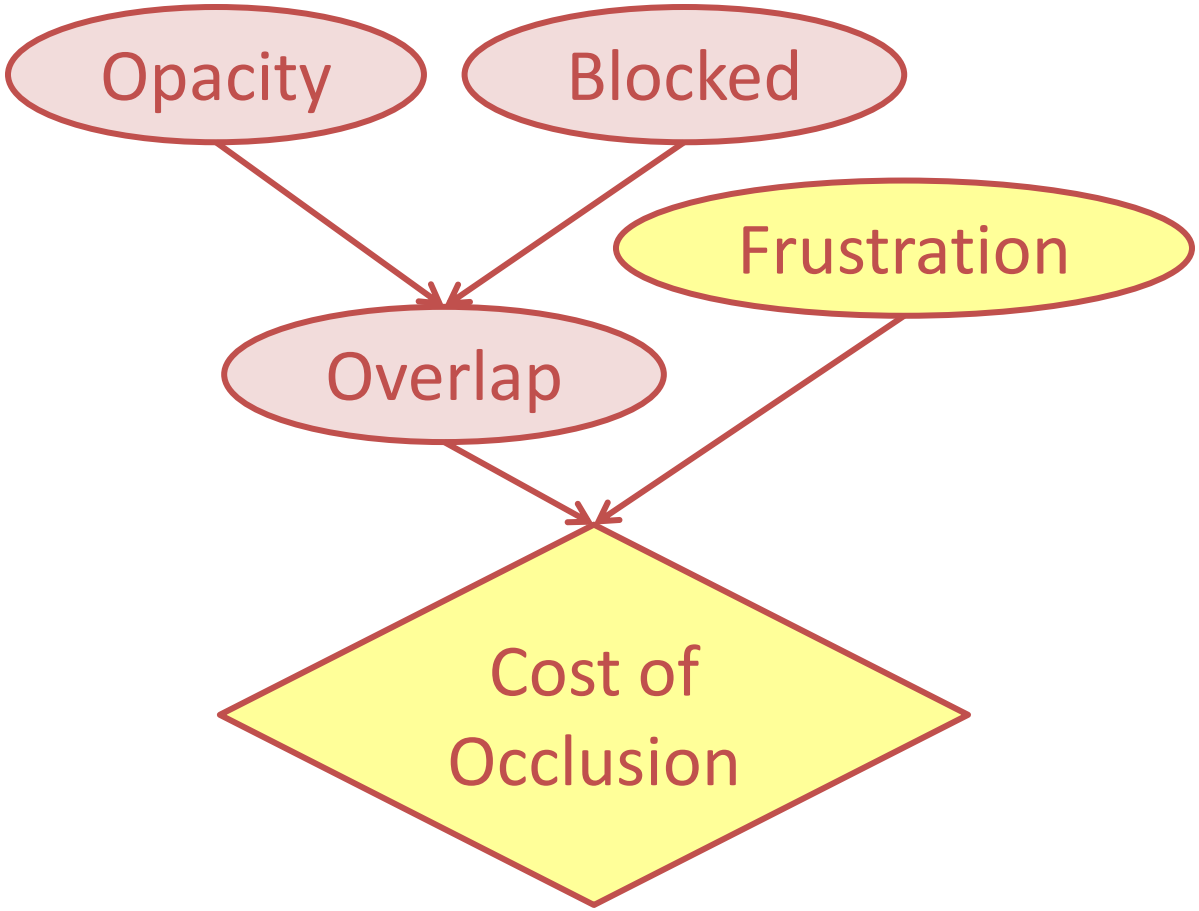


- Direction, Size, Opacity, Proximity, Intersection
- Task completion time
- 12 participants

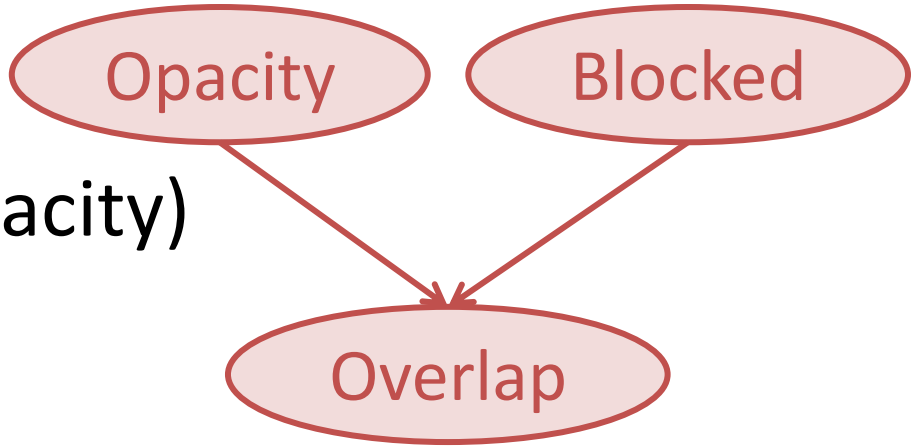
Analysis Techniques

- Factor analysis
  - Identifies most relevant variables
- ANOVA
  - Finds significance among means of different users
- F-test
  - Determines minimal model complexity required

Model of Occlusion

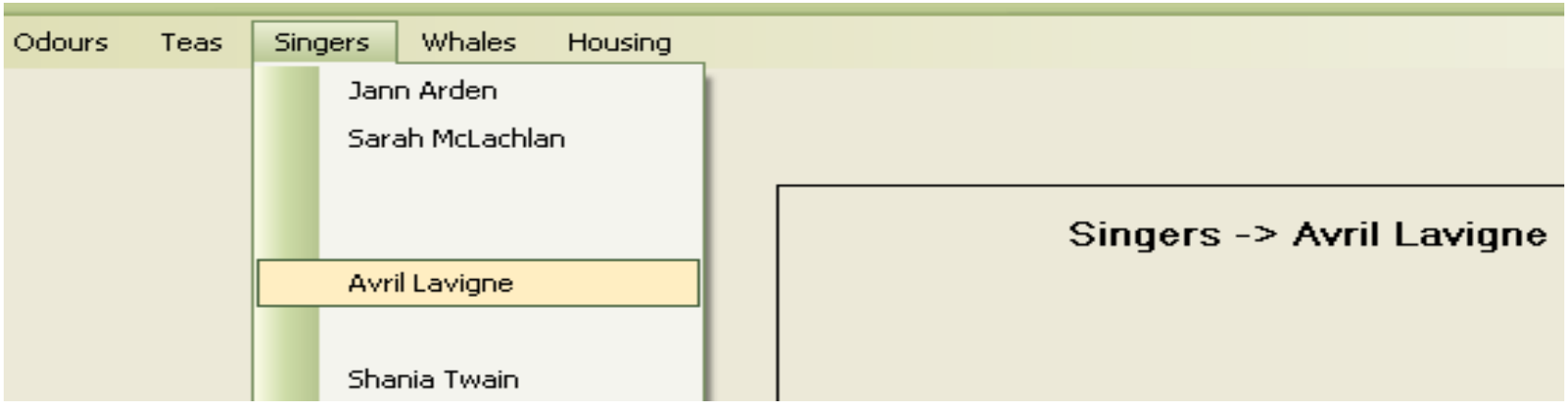


Objective Occlusion Function



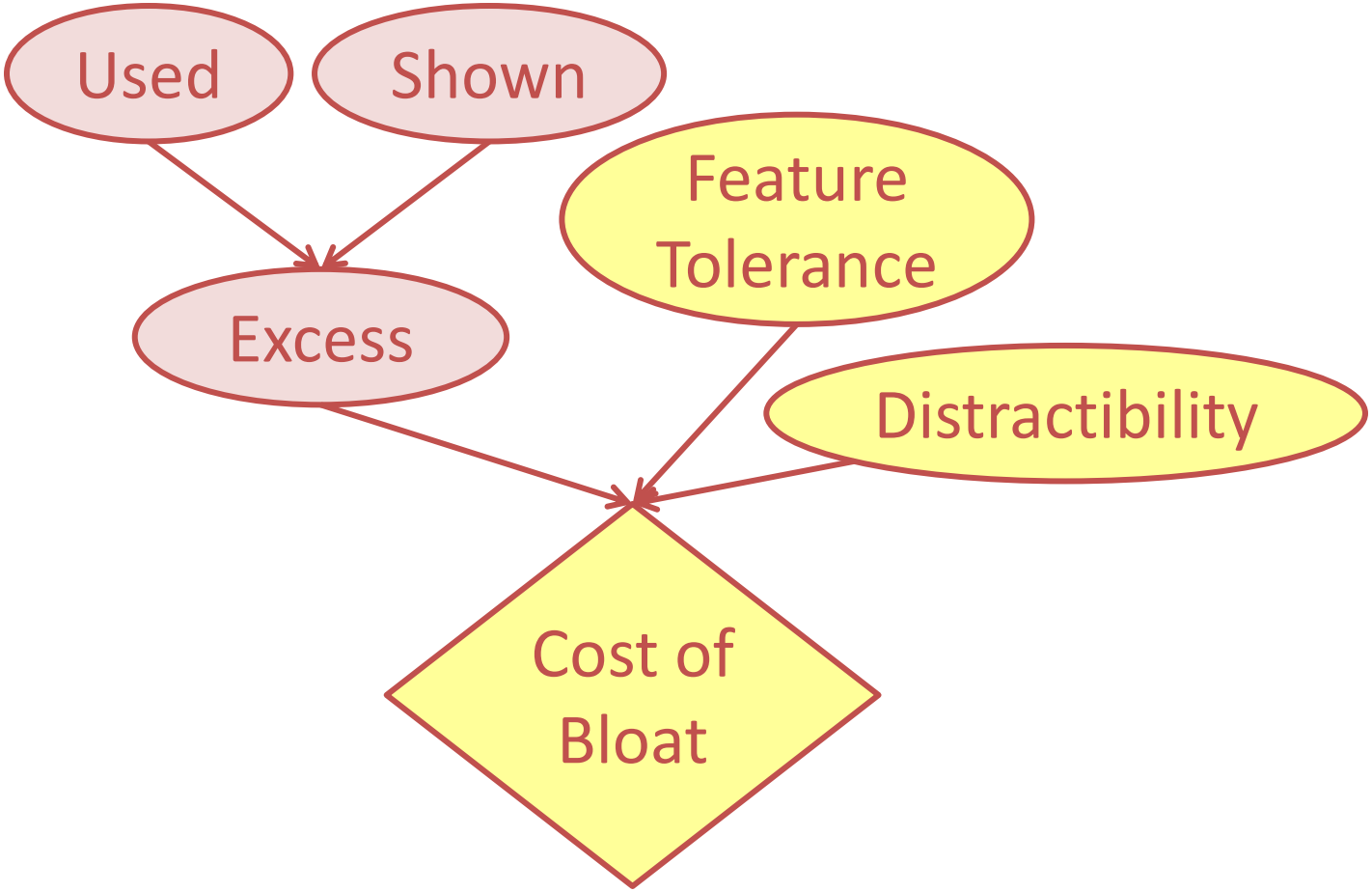
- Overlap = f(Blocked, Opacity)
  - Blocked=0:
    - overlap = constant
  - Blocked=1:
    - Cubic in Opacity, for half of the users
    - Linear in Opacity, for remaining users

Bloat Experiment



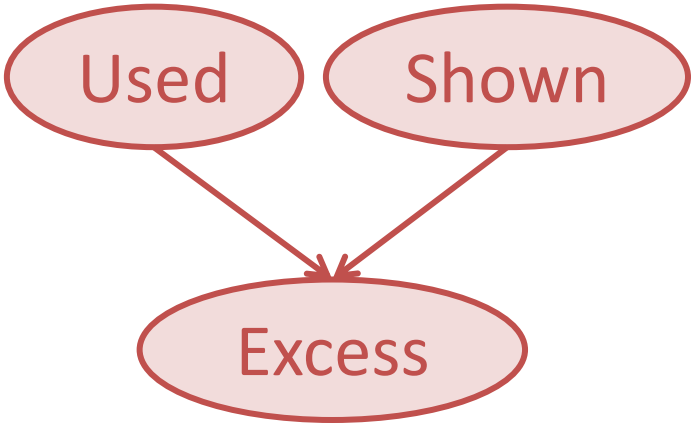
- Shown, Used
- Task completion time
- 12 participants

Model of Bloat



Objective Bloat Function

- Unused = Shown - Used

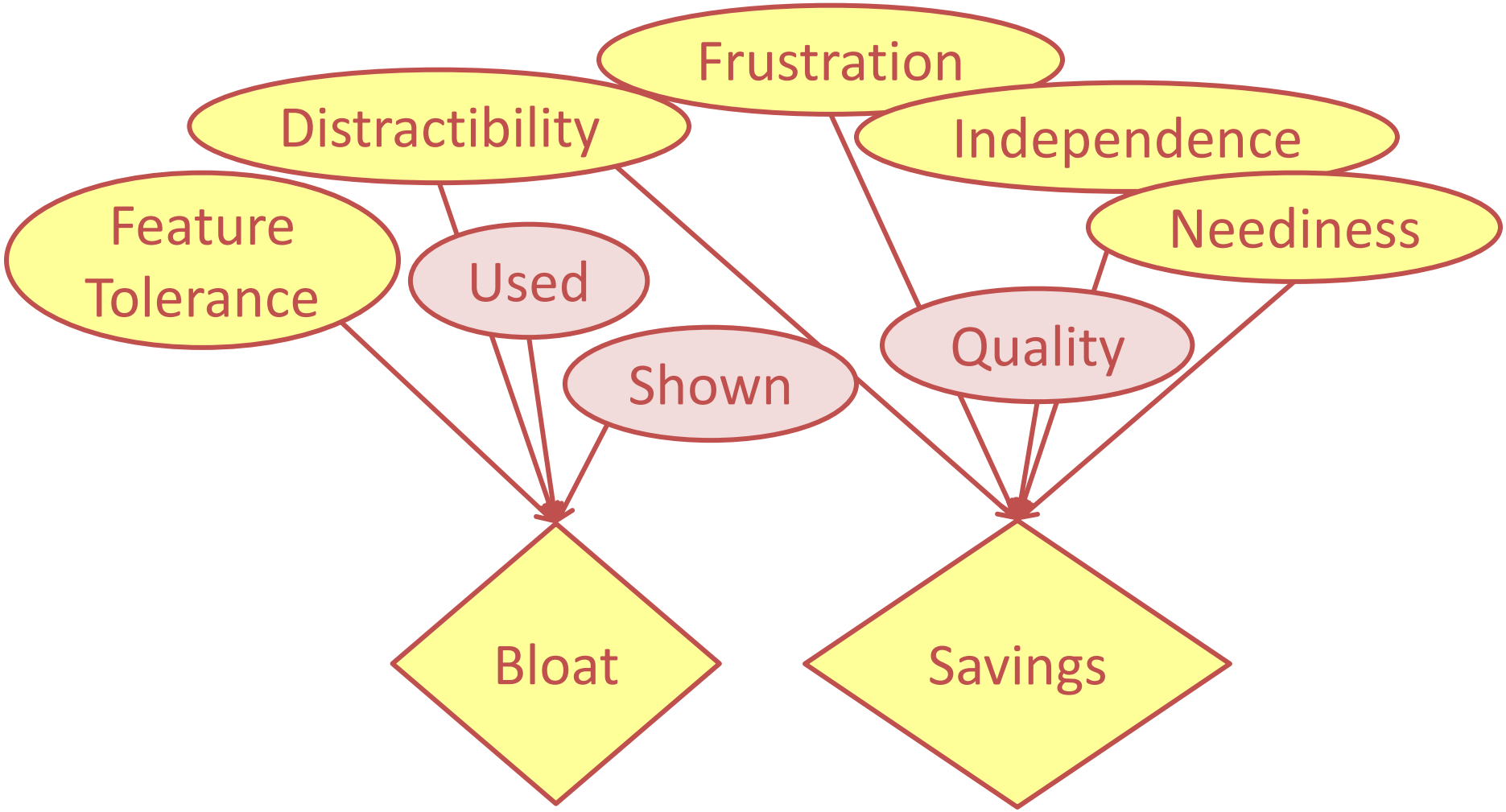


- Excess = f(Unused)
  - Linear, for most users
  - Quadratic, for 1 user
  - Cubic, for 1 user

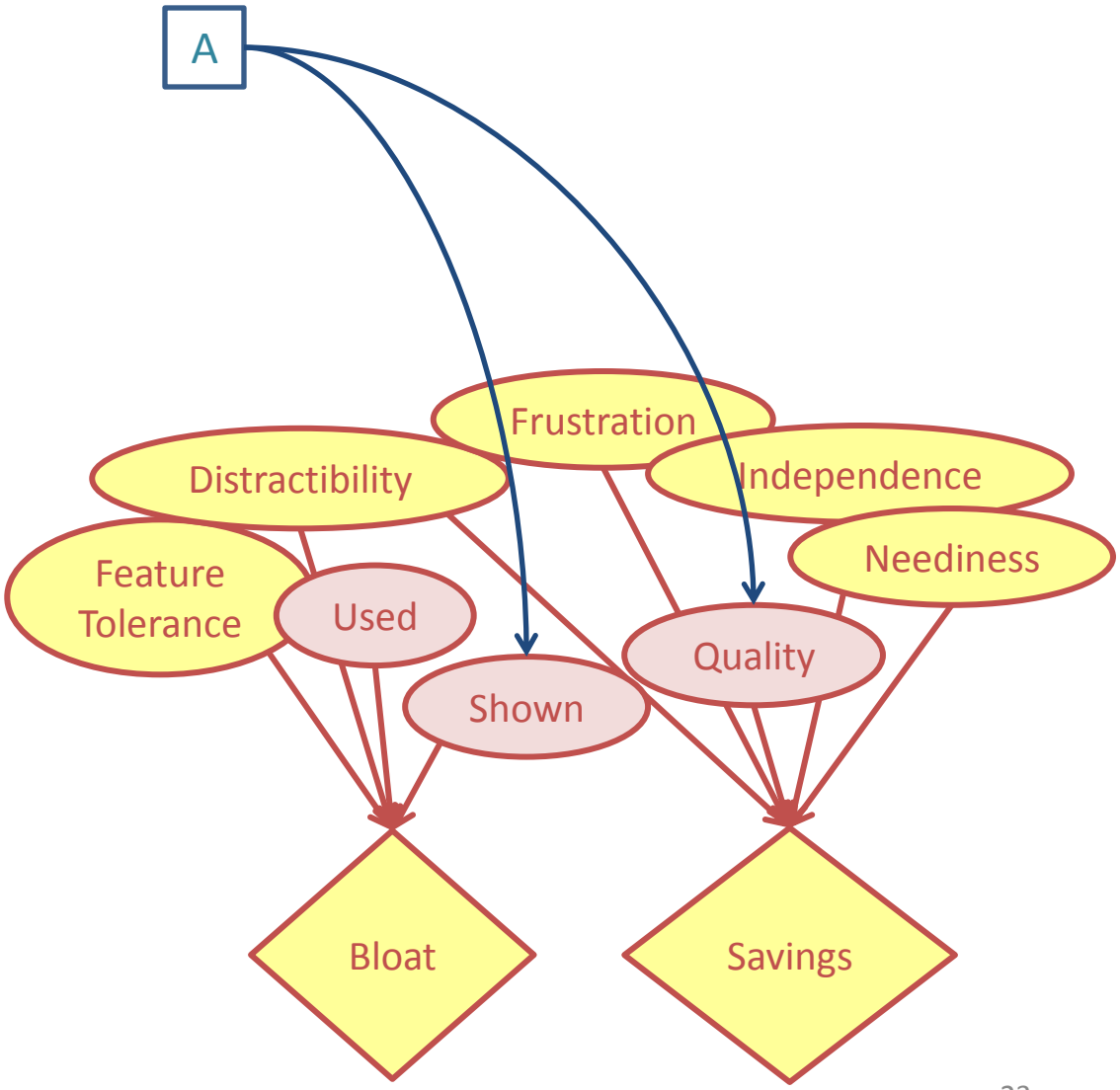
Simulations

- Markov decision process (MDP)
- Adaptive menu
- Actions: add/delete menu item or do nothing
- Utility = w_1Bloat + w_2Savings
- Bloat = f(*Excess*, Feature Tolerance, Distractibility)
- Savings = f(*Quality*, Frustration, Neediness, Distractibility, Independence)

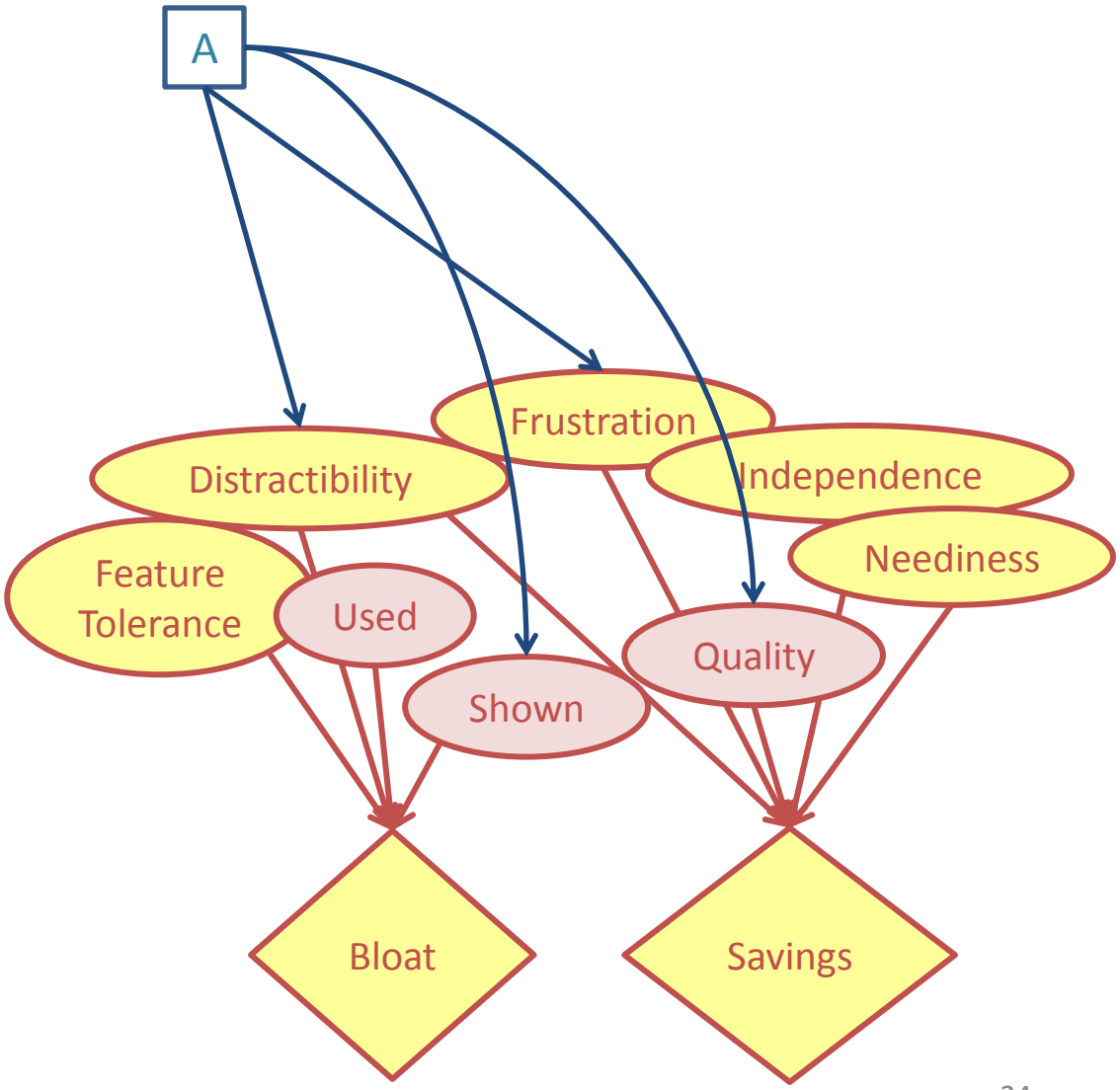
MDP for Adaptive Menu



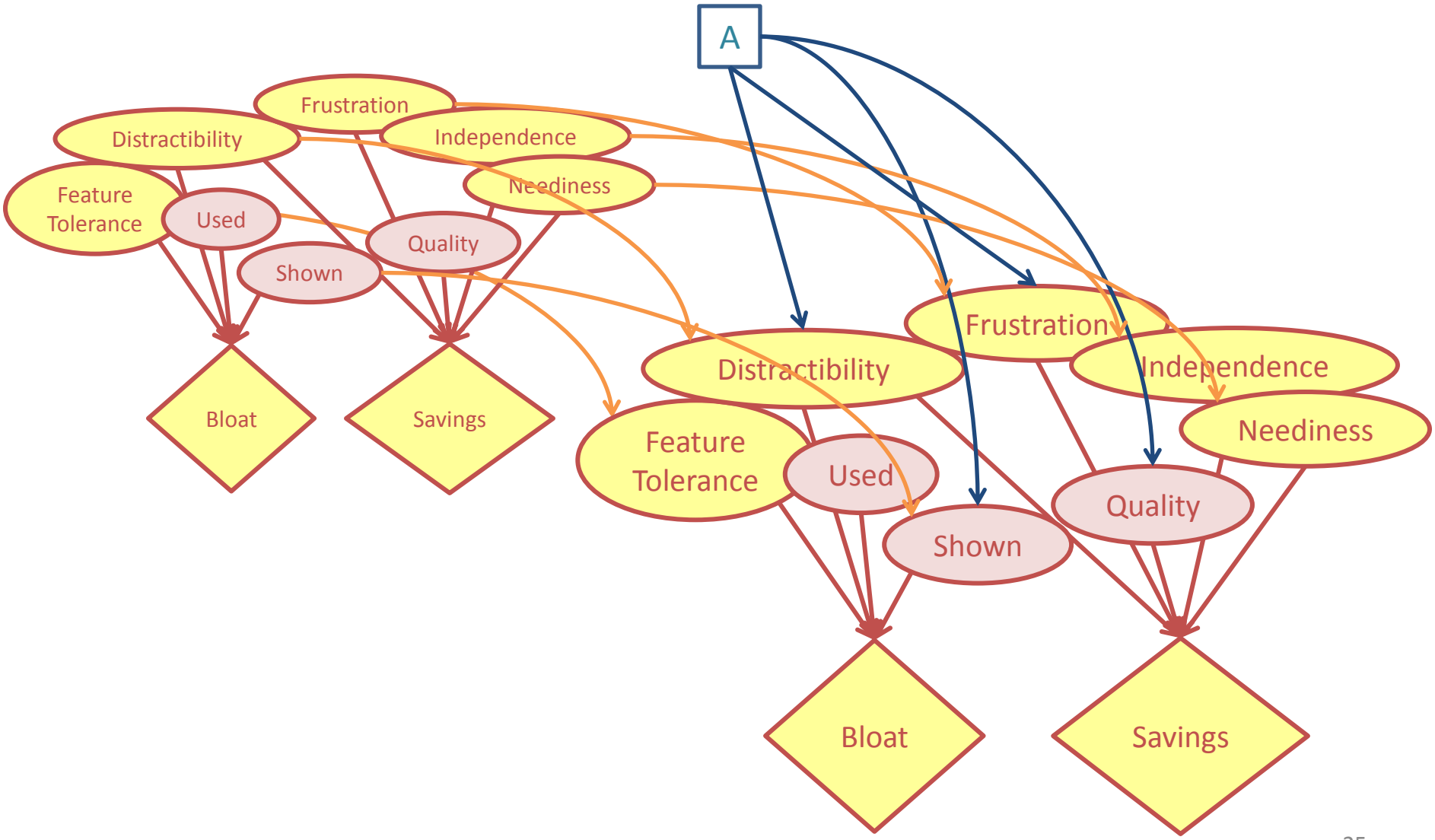
MDP for Adaptive Menu



MDP for Adaptive Menu



MDP for Adaptive Menu



Results: Effect of Bloat

Distractibility	Tolerance	Shown	Policy
Low/medium	Feature-keen	Any	Add
High	Feature-keen	Few	Add
Low	Feature-shy	Many	Delete
other	*other*	*other*	No action

Results: Individual Adaptation

- Most receptive user:

Distractibility	Tolerance	Shown	Policy
Low	Keen/shy	Any	Add
Medium/high	Feature-keen	Any	Add

- Least receptive user:

Distractibility	Tolerance	Shown	Policy
Low	Feature-keen	Any	Add
Low	Feature-shy	Many	Delete
Medium	Feature-shy	Many	Delete

- Do nothing for all other cases

Summary and Future work

- Decision-theoretic framework for adaptive interfaces
- Formal model for interaction costs
- Systematic analysis
- Models individual differences
- Simulation as proof of concept

- Usability evaluation (next)