INFSCI 2480: Adaptive Information Systems

# User Models for Adaptive Hypermedia and Adaptive Educational Systems

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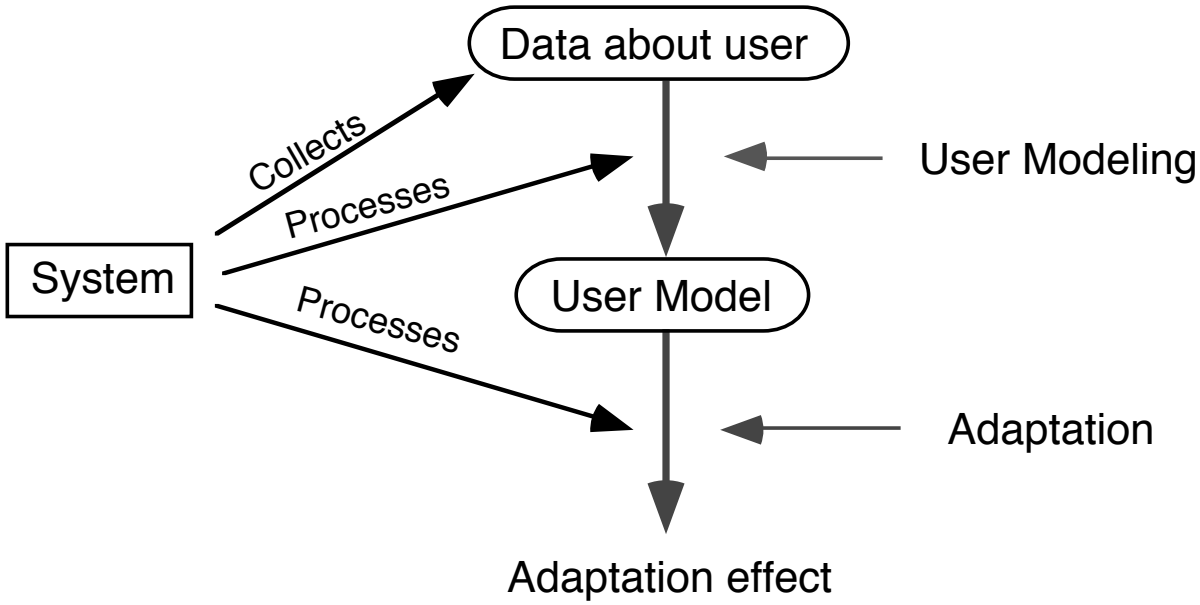
# Where we are?

| | Search | Navigation | Recommendation |
|---|---|---|---|
| Content-based | | | |
| Semantics / Metadata | |  | |
| Social | | | |

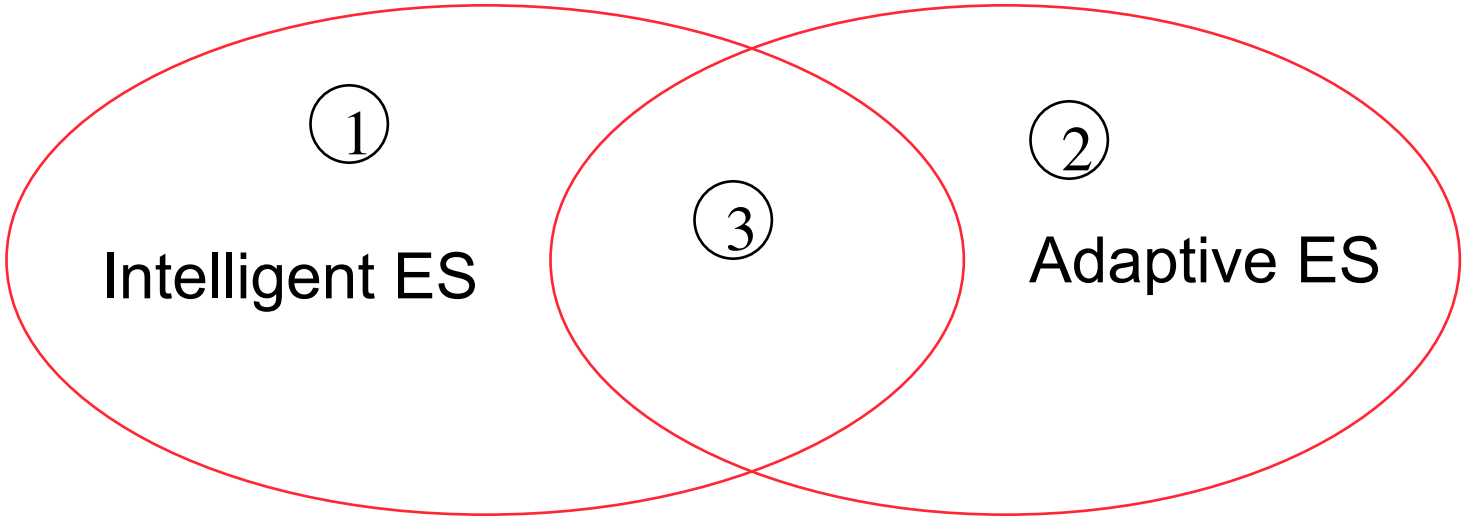
# Adaptive systems




Classic loop user modeling - adaptation in adaptive systems

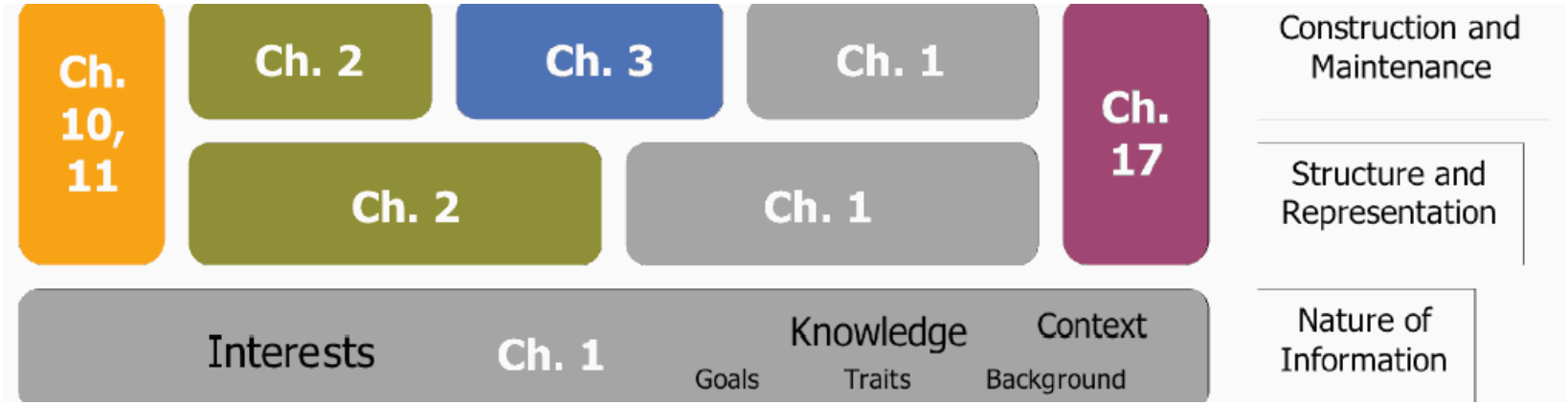
# Intelligent vs. Adaptive

1. Intelligent but not adaptive (no user model!)
2. Adaptive but not really intelligent
3. Intelligent and adaptive



# 3 Dimensions of User Models

- What is being modeled (nature)
- How this information is represented (structure
- How the models are constructed and maintained




Brusilovsky, P. and Millan, E.: User models for adaptive hypermedia and adaptive educational systems. In: The Adaptive Web: Methods and Strategies of Web Personalization. Lecture Notes in Computer Science, Vol. 4321. Springer-Verlag, Berlin Heidelberg New York, 2007

# What is Being Modeled?

- User knowledge of the subject
- User interests
- User goals
- User background
- User individual traits

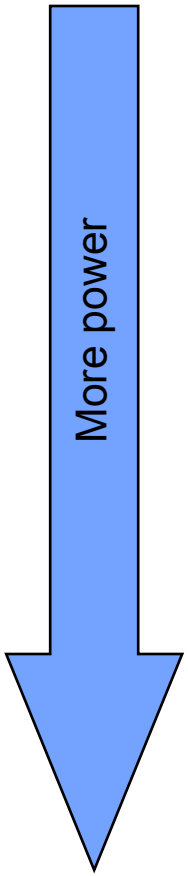
# How to Model User Knowledge

- Scalar model
  - The user knowledge level is modeled as one value
  - Example: MetaDoc, CAT
- Structural model
  - What kind of knowledge?
    - Declarative, procedural, episodic
  - How it relates to expert knowledge?
    - Overlay model -> Bug mode -> Genetic model

# Overlay Model of Knowledge

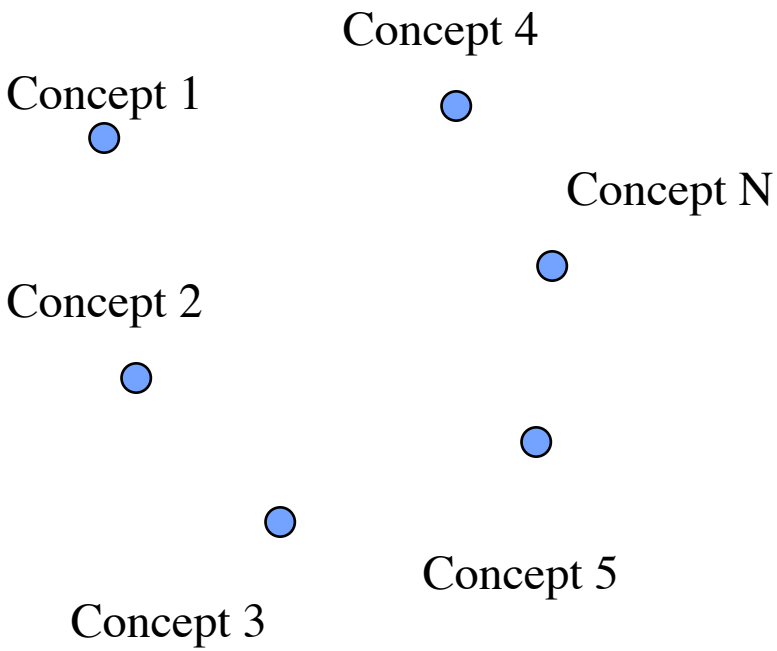
- Domain model
  - The whole body of domain knowledge is decomposed into set of smaller knowledge units
  - A set of concepts, topics, etc
- User knowledge model (aka student model)
  - Overlay of the Domain model
  - Student knowledge is measured independently for each knowledge unit

# Vector vs. Network Domain Models

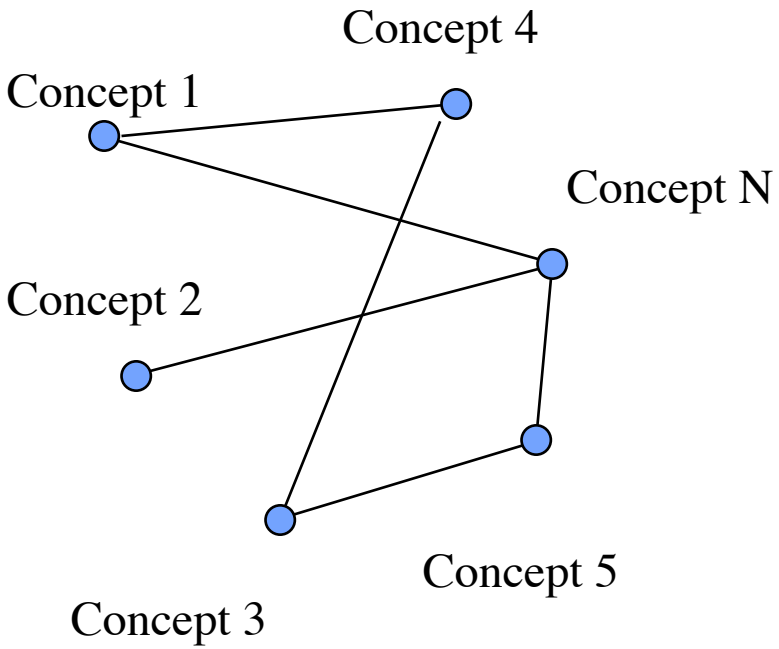



- Vector - no relationships
- Precedence (prerequisite) relationship
- is-a, part-of, analogy
  - Wescourt et al, 1977
- Genetic relationships
  - Goldstein, 1979

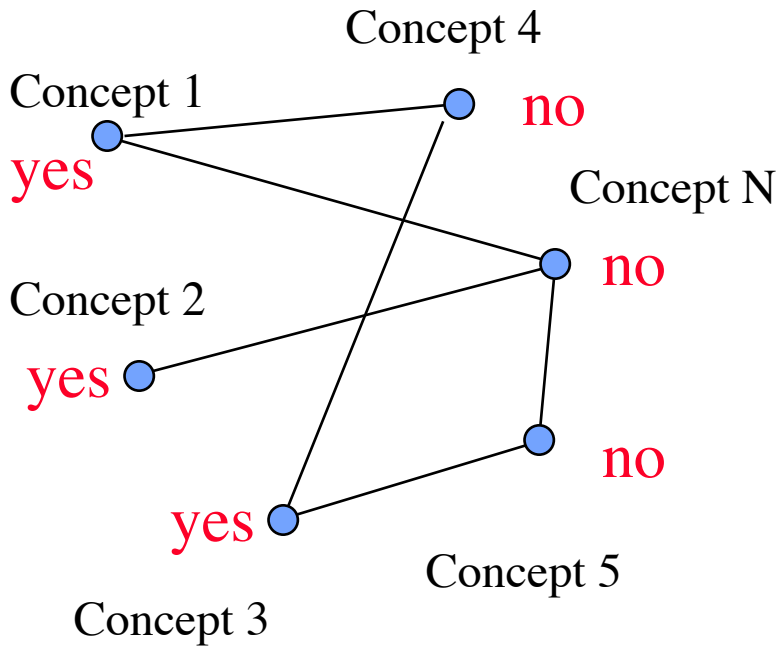
# Vector model



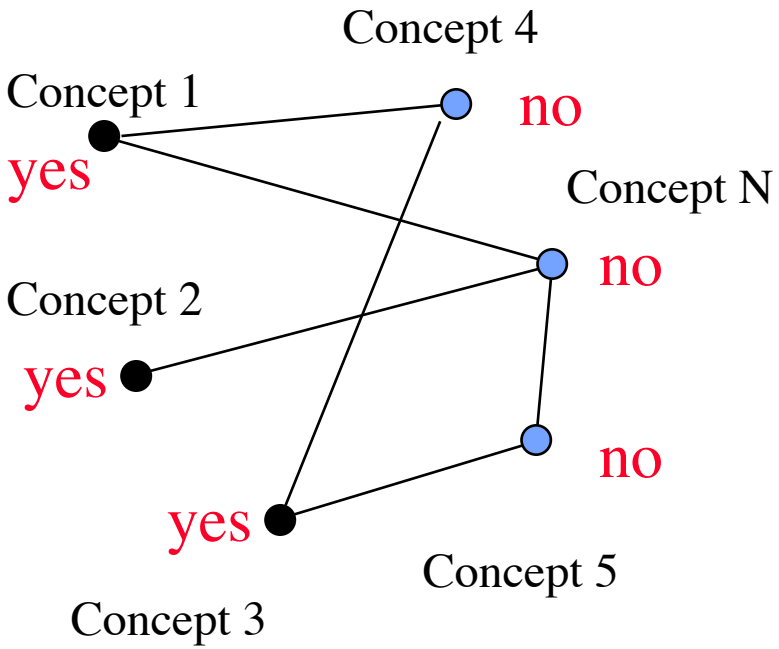
# Network model



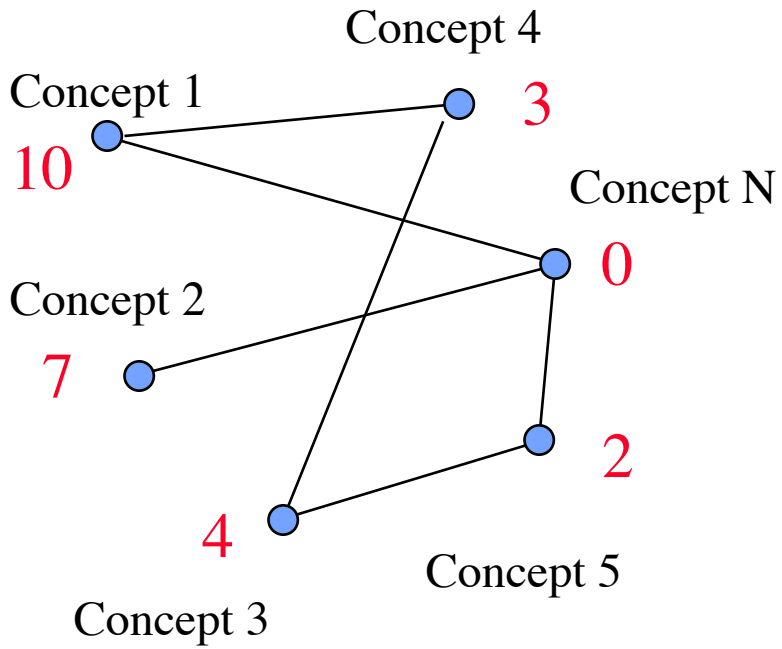
# Simple overlay model



# Simple overlay model



# Weighted overlay model

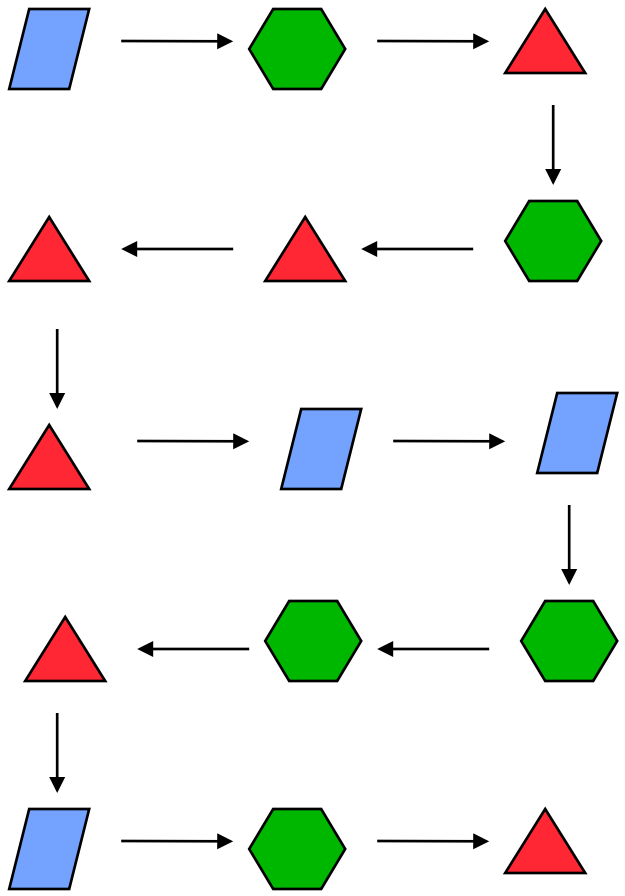


# Student Modeling Approaches

- Ad Hoc (1-100)
- Heuristic and rule-based (qualitative)
- Simple statisctical (Bush, Atkinson)
- Probabilistic and Bayesian (BN, D-S…)
- Fuzzy
- Neural networks
- Combine approaches and layered models

# How to do Course Sequencing

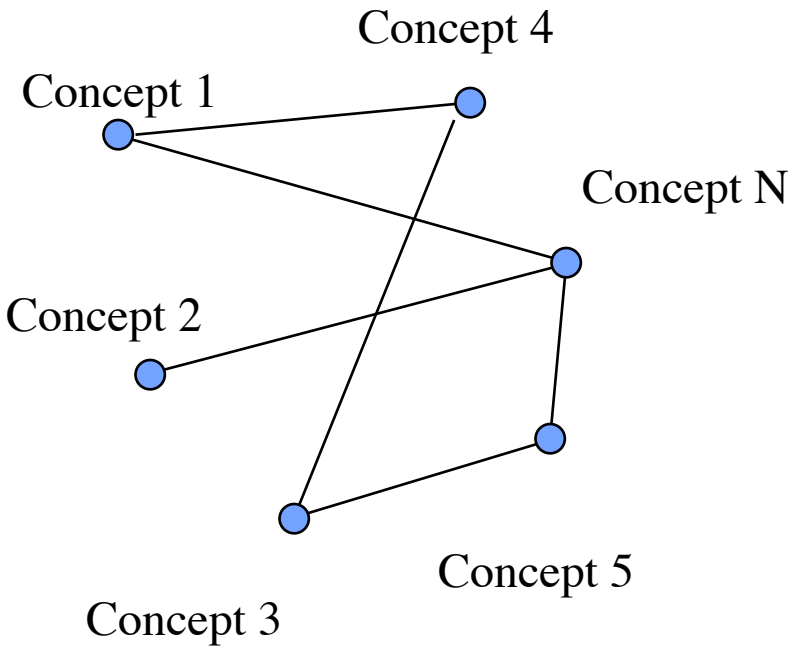
- Needs a Domain Model
- Uses classic or weighted overlay model
- Needs indexing of learning material with domain model
- May also need a learning goal (also based on domain model)



# Indexing teaching material

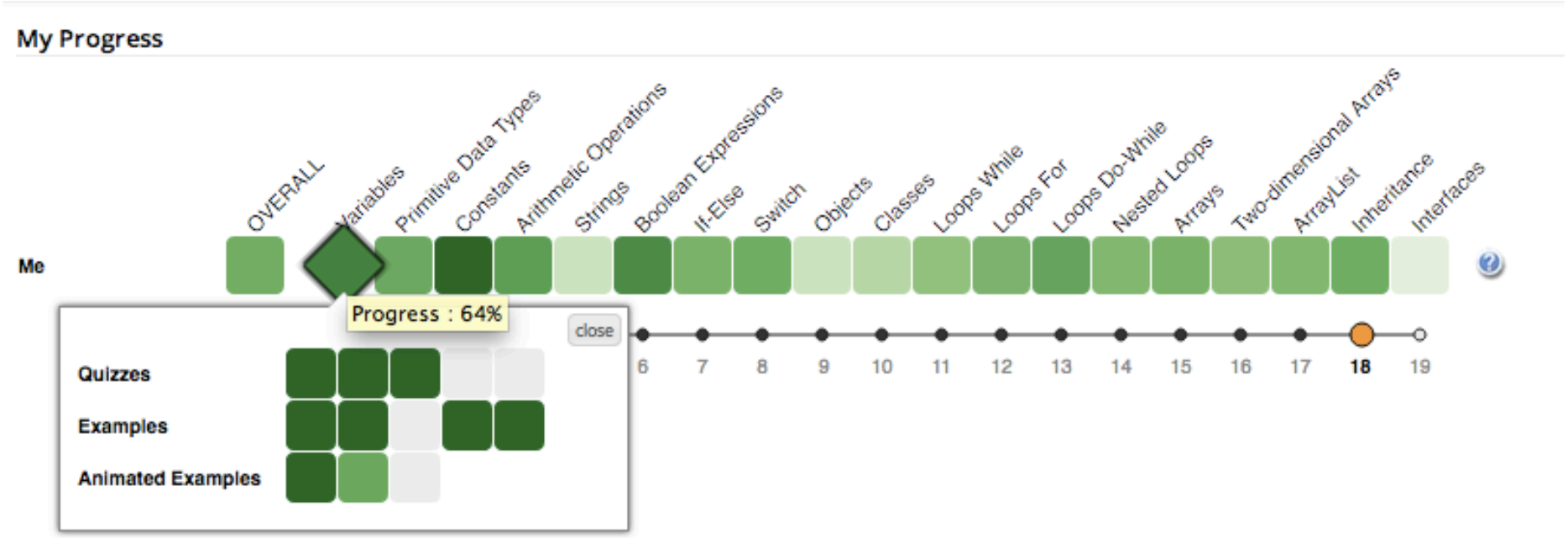
- Types of indexing
  - One concept per ULM
  - Indexing of ULMs with concepts
- How to get the ULMs indexed?
  - Manual indexing (closed corpus)
  - Computer indexing (open corpus)

# Simple case: one concept per learning activity

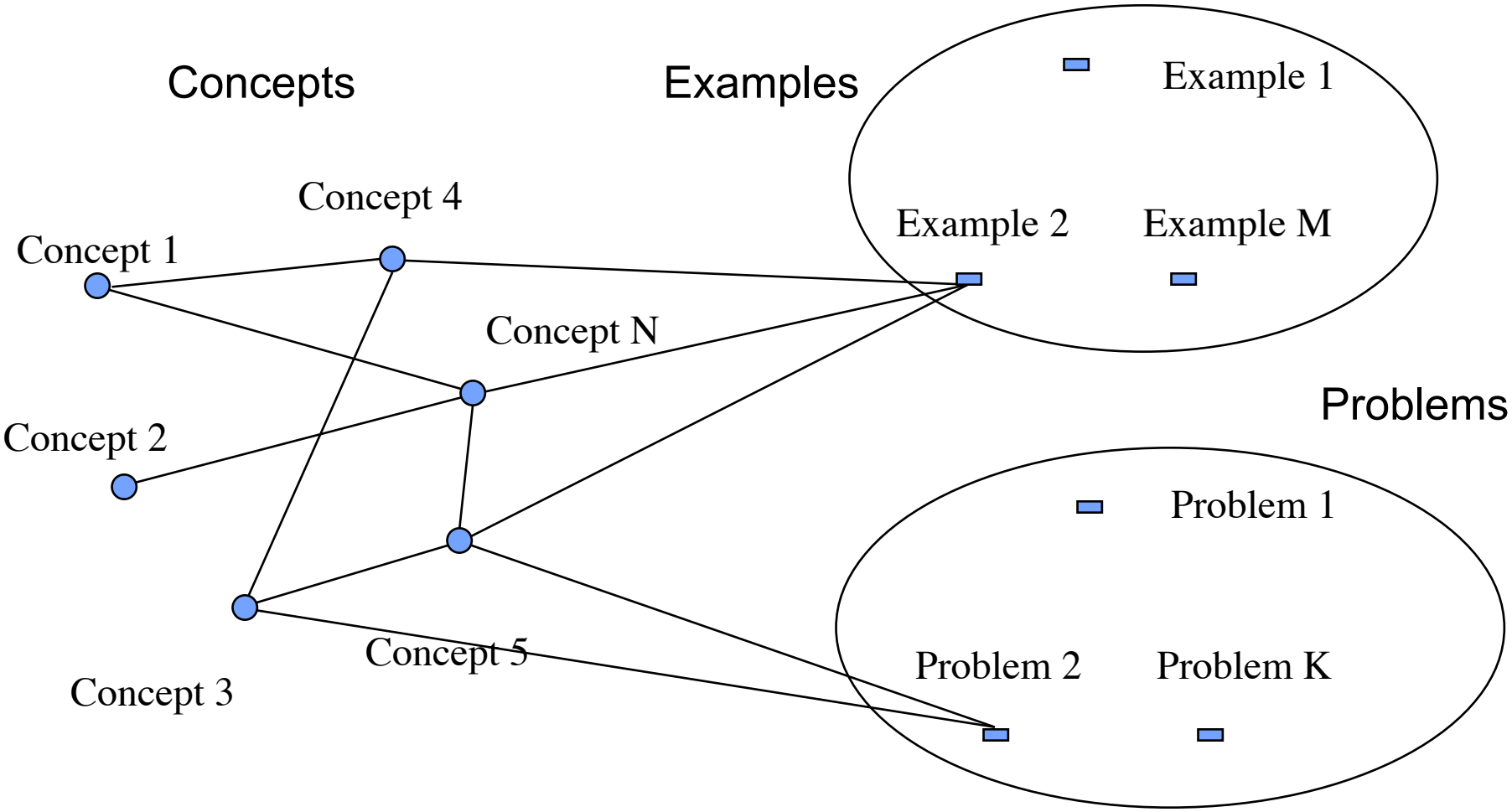



- Random selection if there are no links -Scholar
- Links can be used to restrict the order

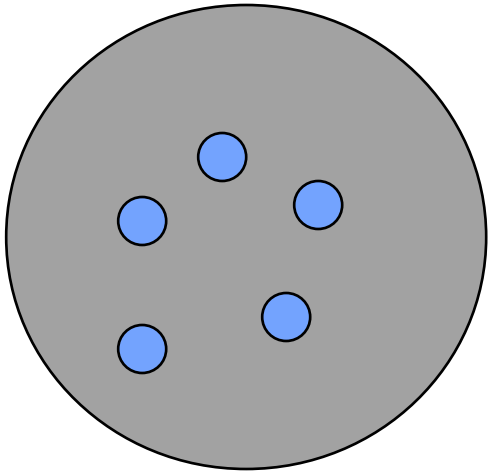
# MasteryGrids Interface:
# one *topic* per learning activity



# Indexing content with concepts

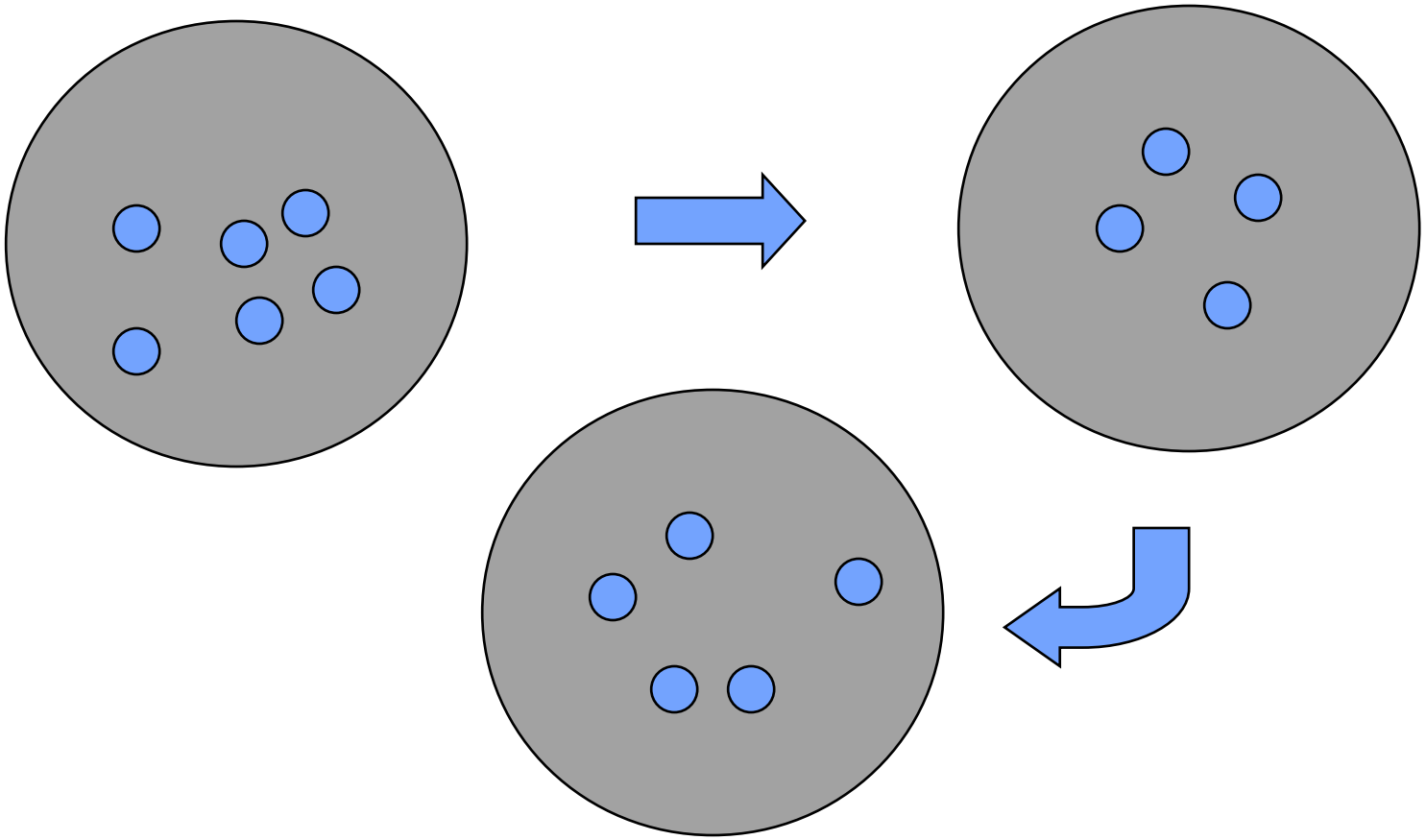


# Simple goal model



- Learning goal as a set of topics

# More complicated models



- Sequence, stack, tree

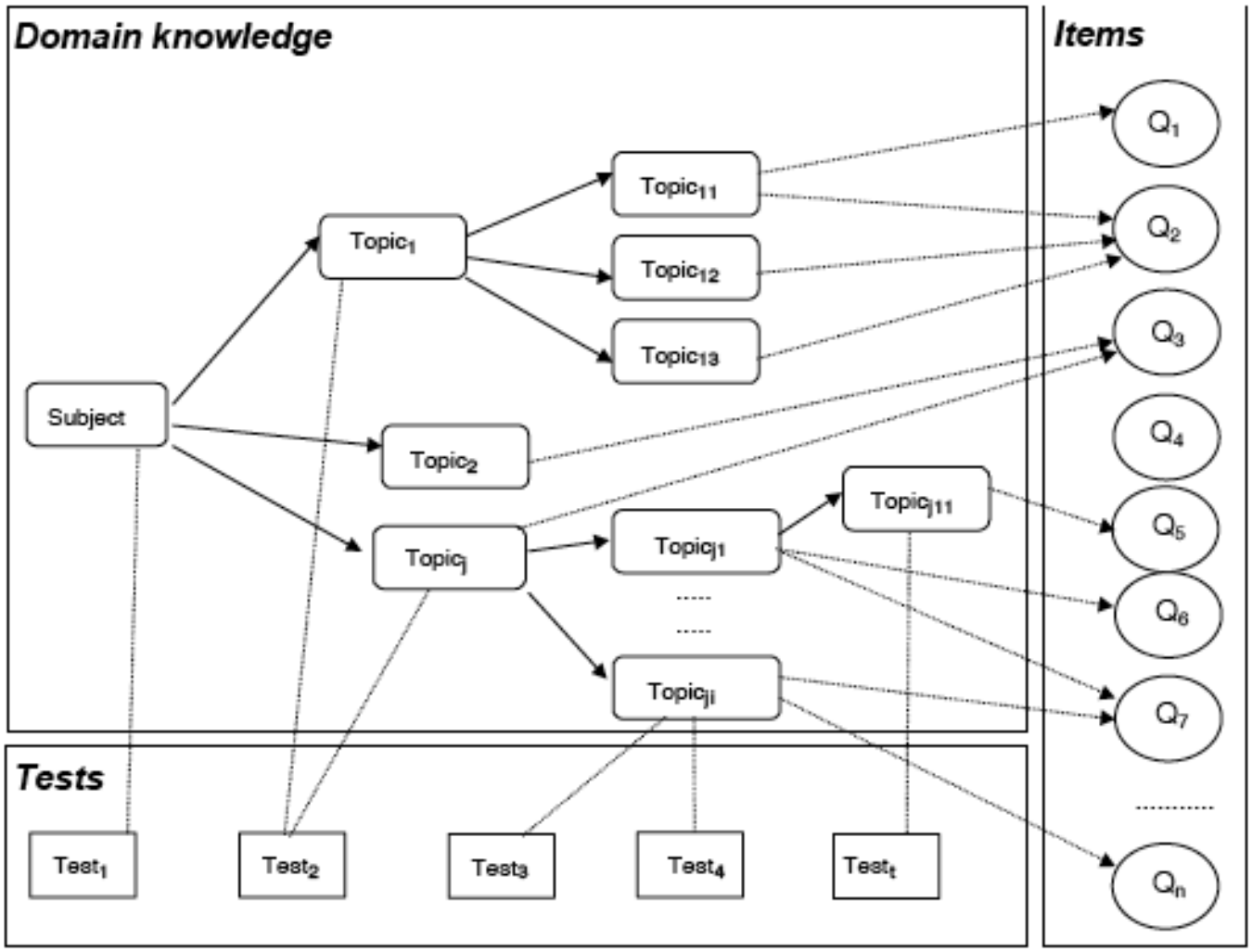
# Sequencing with models

- Given the state of UM and the current goal pick up the best topic or ULM within a subset of relevant ones (defined by links)
- Special cases with multi-topic indexing and several kinds of ULM
- Applying explicit pedagogical strategy to sequencing

# Maintaining Overlay Models

- Adaptive educational systems use problems, questions, and other evaluation activities to model student knowledge
- If a page is read, an example is browsed, or a problem is solved, knowledge of all involved concepts increases (example: jWADEIn)
  - Links could be used to propagate knowledge
- If problem is not solved, the system needs to allocate "blame" for involved concepts
  - Links could be helpful to avoid *noise*

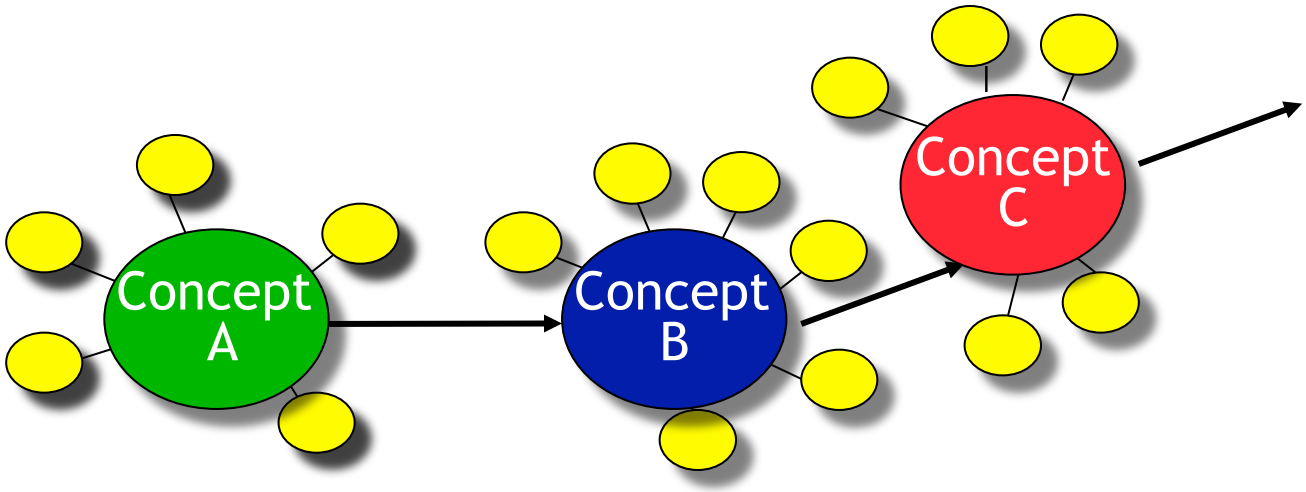
# Models in SIETTE



# Models for interactive problem-solving support and diagnosis

- Domain model
  - Concept model (same as for sequencing)
  - Bug model
  - Constraint model
- Student model
  - Generalized overlay model (works with bug model and constraint model too)
- Teaching material - feedback messages for bugs/ constraints

# Bug models

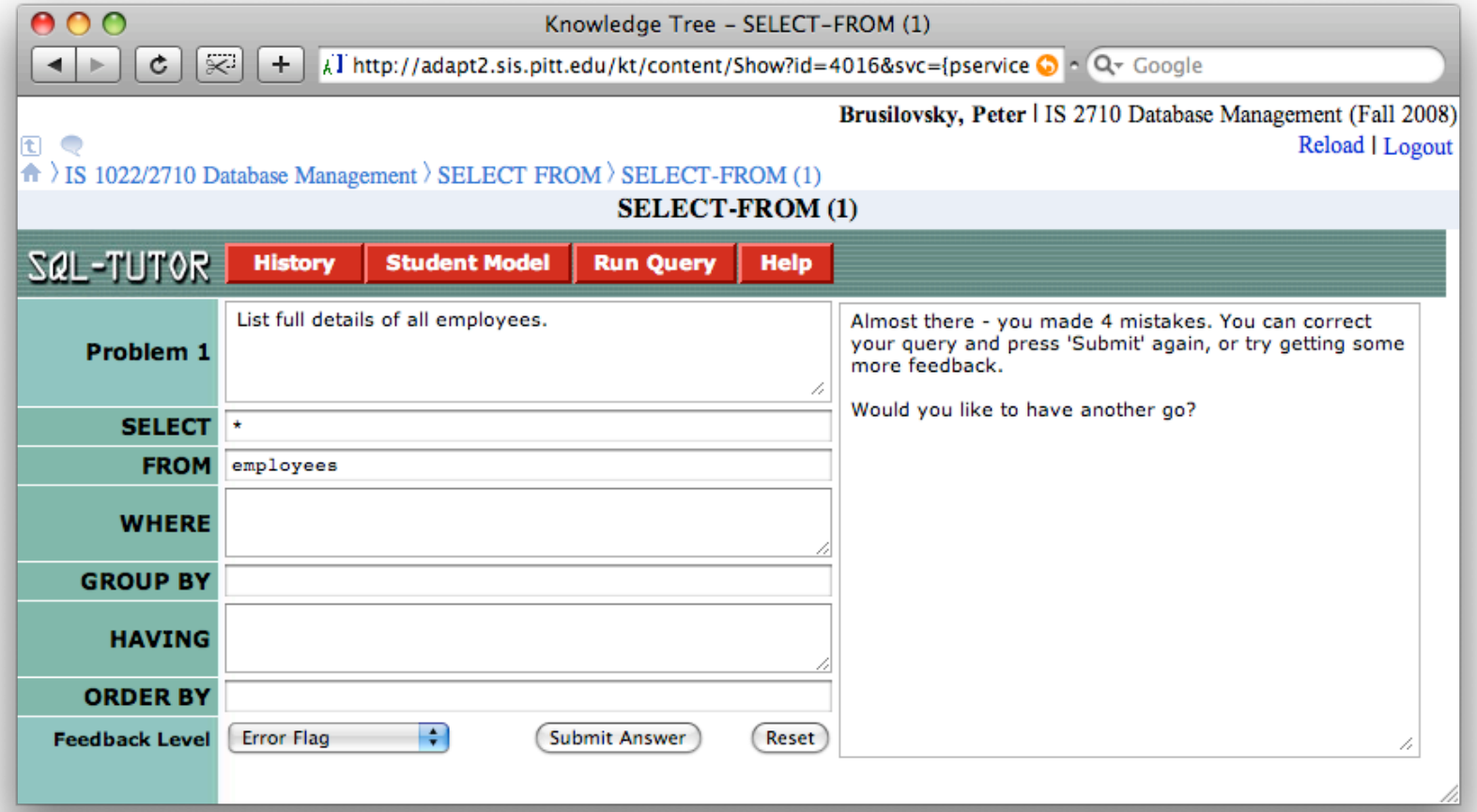



- Each concept/skill has a set of associated bugs/misconceptions and sub-optimal skills
- There are help/hint/remediation messages for bugs

# Do we need  bug models?

- Lots of works on bug models in the between 1974-1985
- Bugs has limited applicability
  - Problem solving feedback only. Sequencing does not take bugs into account: whatever misconceptions the student has - effectively we only can re-teach the same material
  - Short-term model: once corrected should disappear, so not necessary to keep

# Constraint Model: SQL-Tutor

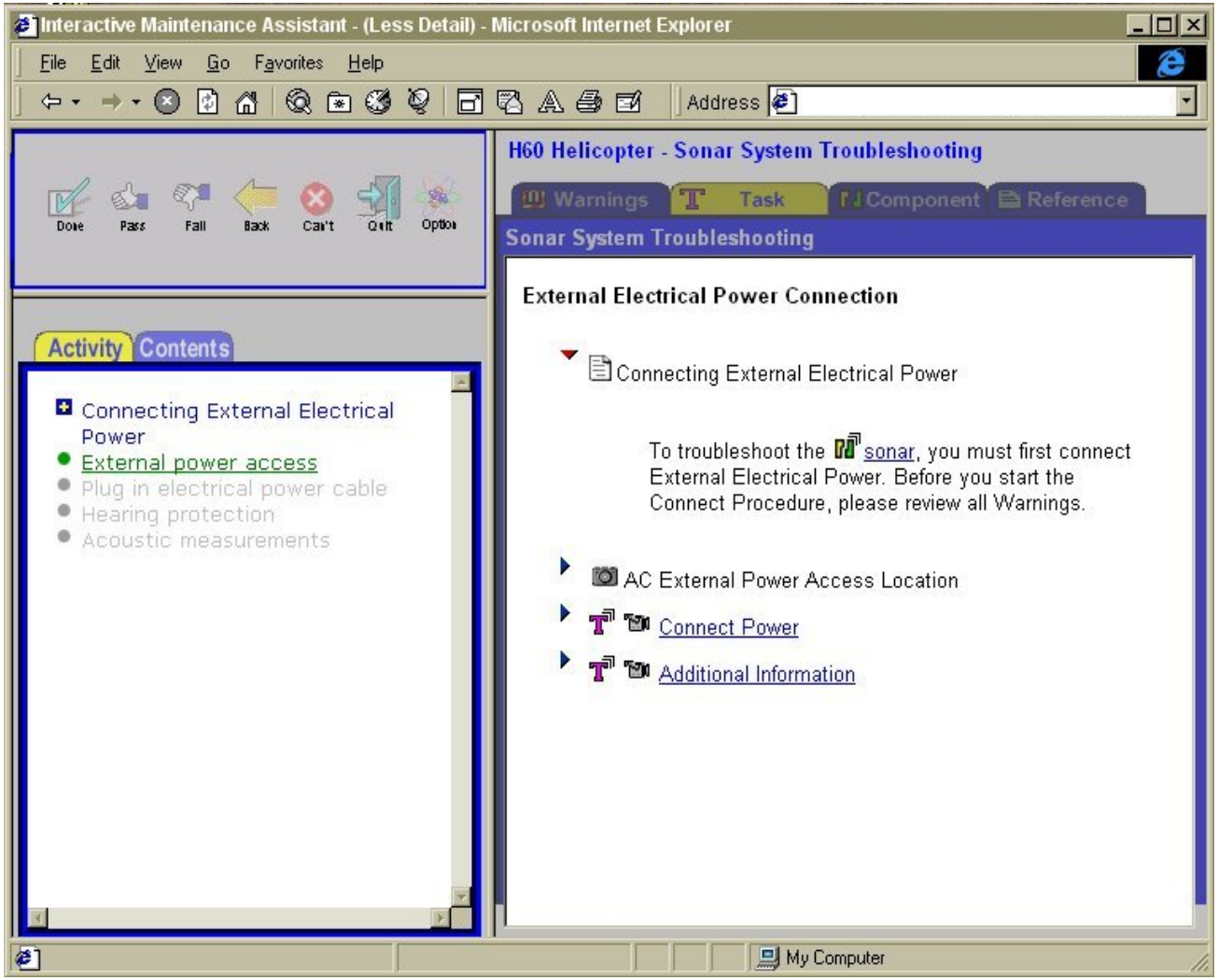



- Domain model: Set of constraints (procedural, evaluation knowledge); Student model: Bug model

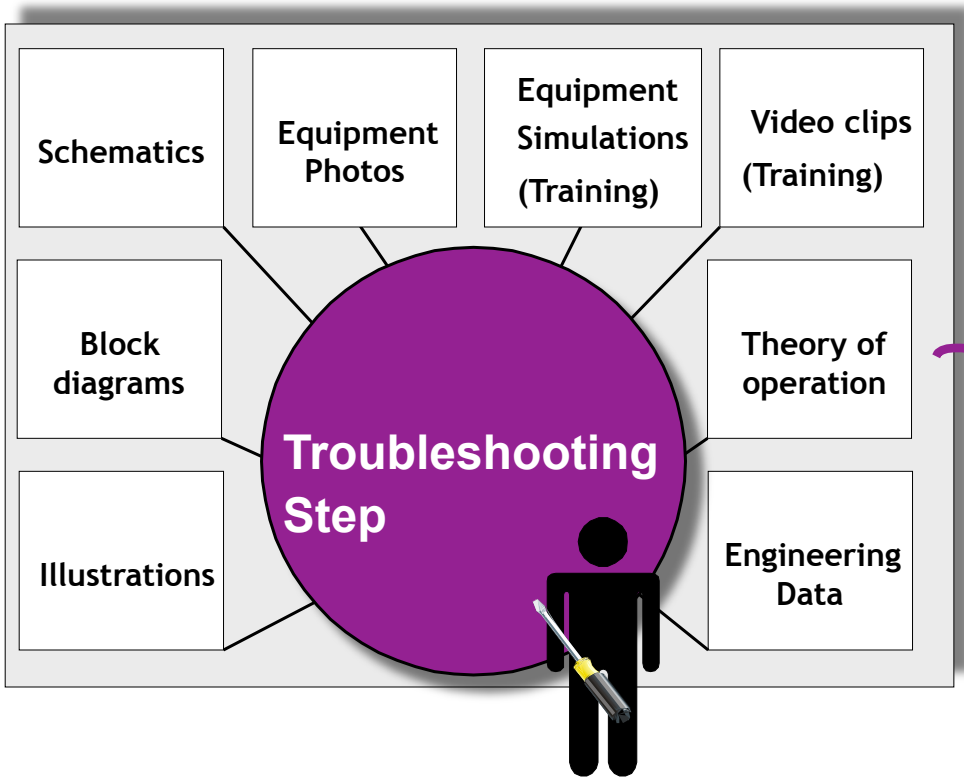
# Models for example-based problem solving support

- Need to represent problem-solving cases
- Episodic learner model
  - Every solution is decomposed on smaller components, but not concepts!
  - Keeping track what components were used and when - not an overlay!
- ELM-PE and ELM-ART - only systems that use this model

# Multi-Aspect Models in ADAPTS - an adaptive IETM



# What's in adaptive content?



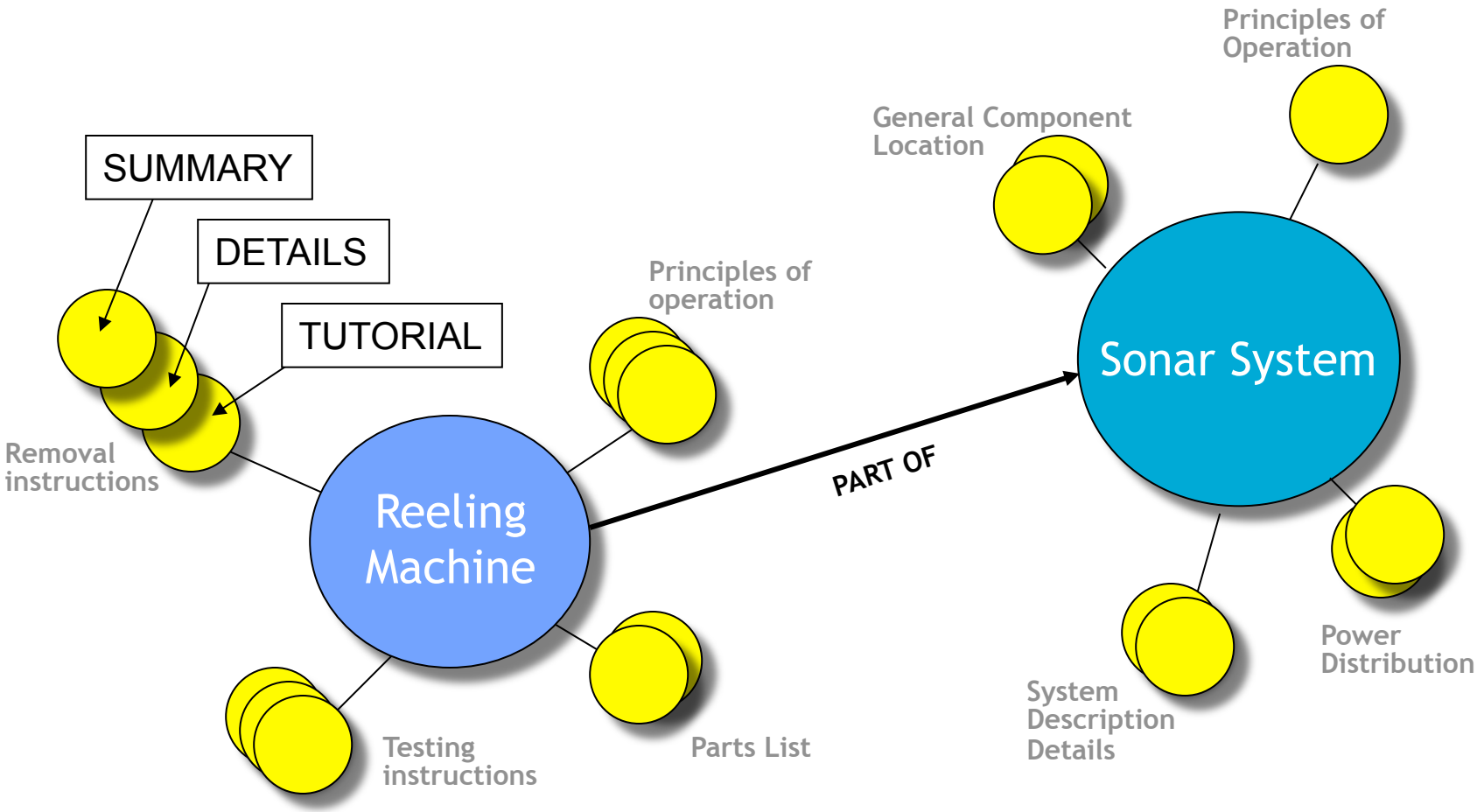

Troubleshooting step plus hypermedia support information, custom-selected for a specific technician within a specific work context.

*ADAPTS dynamically assembles custom-selected content.*

# Domain model example

| | | | | |
|---|---|---|---|---|
| **CONCEPT**<br>**Reeling Machine** | **Principles of Operation** | **Removal Instructions** | **Testing Instructions** | **Illustrated Parts Breakdown** |
| **CONCEPT**<br>**Sonar Data Computer** | **Principles of Operation** | **Removal Instructions** | **Testing Instructions** | **Illustrated Parts Breakdown** |
| **CONCEPT**<br>**Sonar System** | **Principles of Operation** | **Removal Instructions** | **Testing Instructions** | **Illustrated Parts Breakdown** |

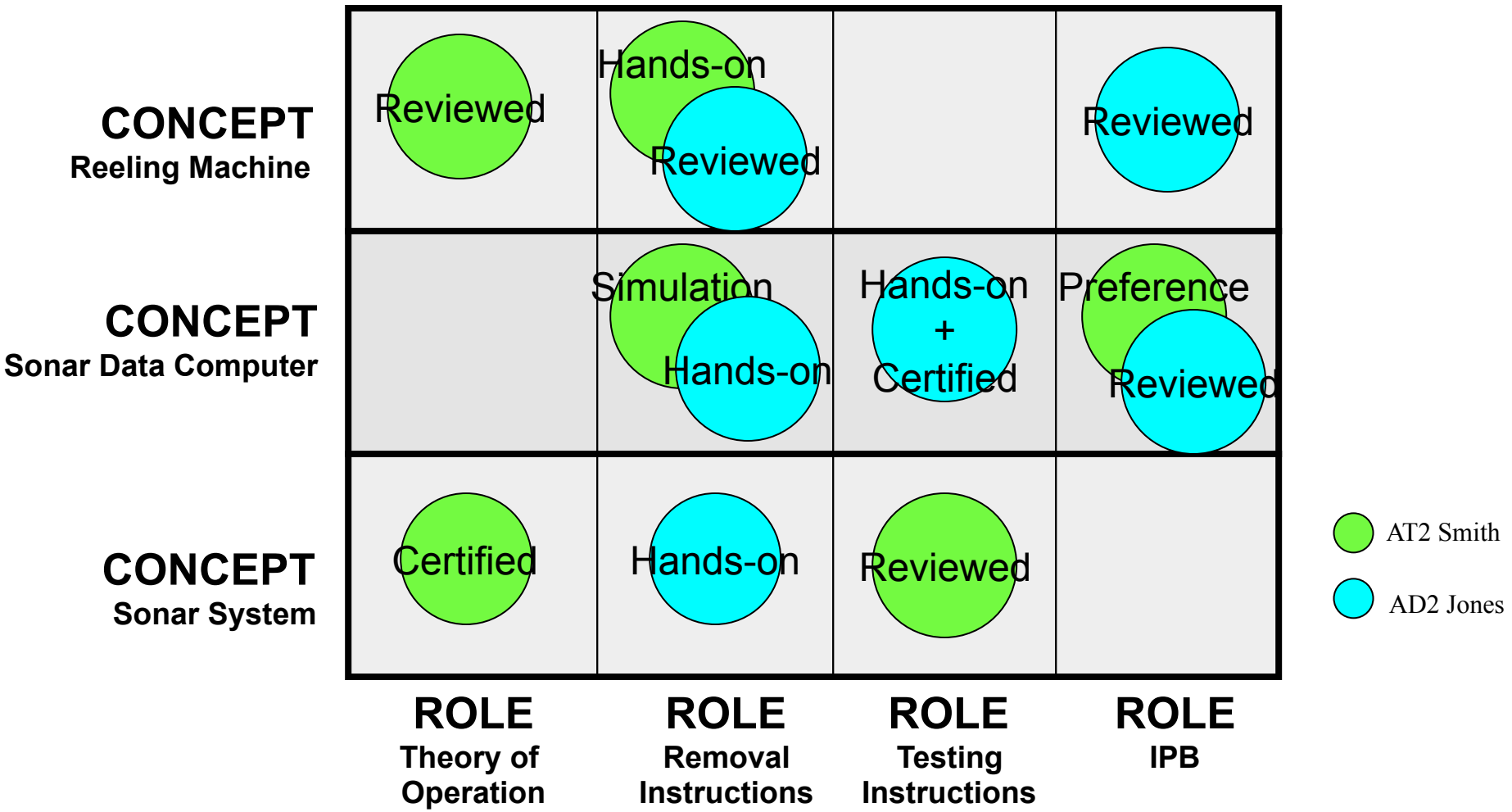
# Domain content



# User model

- Characterizes user ability at each element of the domain model
  - Size of model is bounded by domain
  - Weights on different types of elements account for learning styles and preferences
  - Can be time sensitive
- Constrains the diagnostic strategy

# User model example



# Adaptive content selection

- Information is custom-selected for a user
  - Level of detail offered depends upon who the user is (i.e., his level of expertise)
  - Selected at a highly granular level, e.g., for each step within a procedure
- Performance-oriented training is presented as part of content

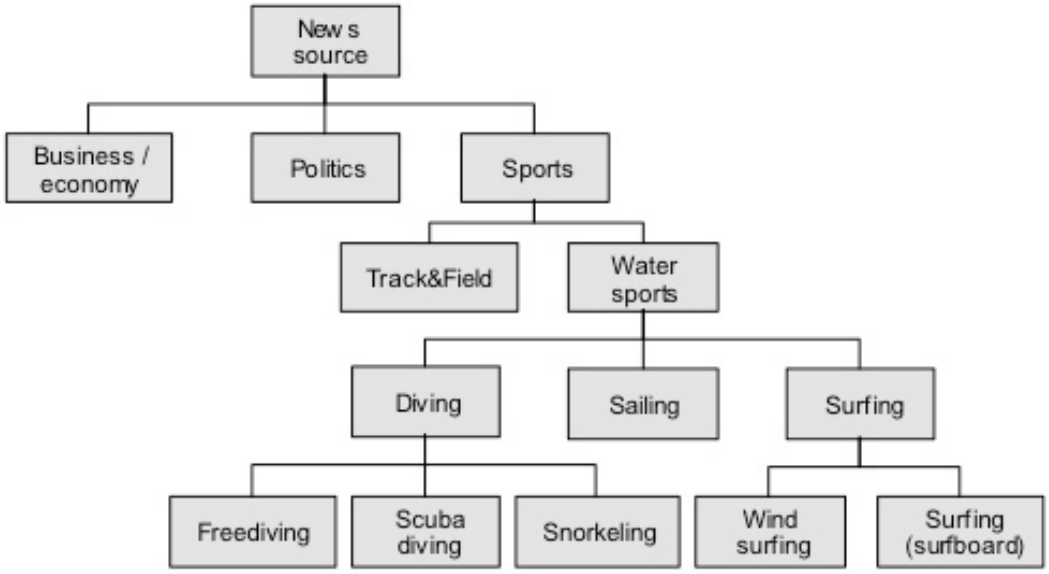
# Interest Modeling

- User interests are typically modeled by overlay models as well
- Keyword model of user interests (profile)
  - Learned about it in user profiling lecture
  - User profile is a *keyword overlay*
    - "sub-symbolic" model
- Concept-level model of user interests
  - Concept overlay

# Domain Models

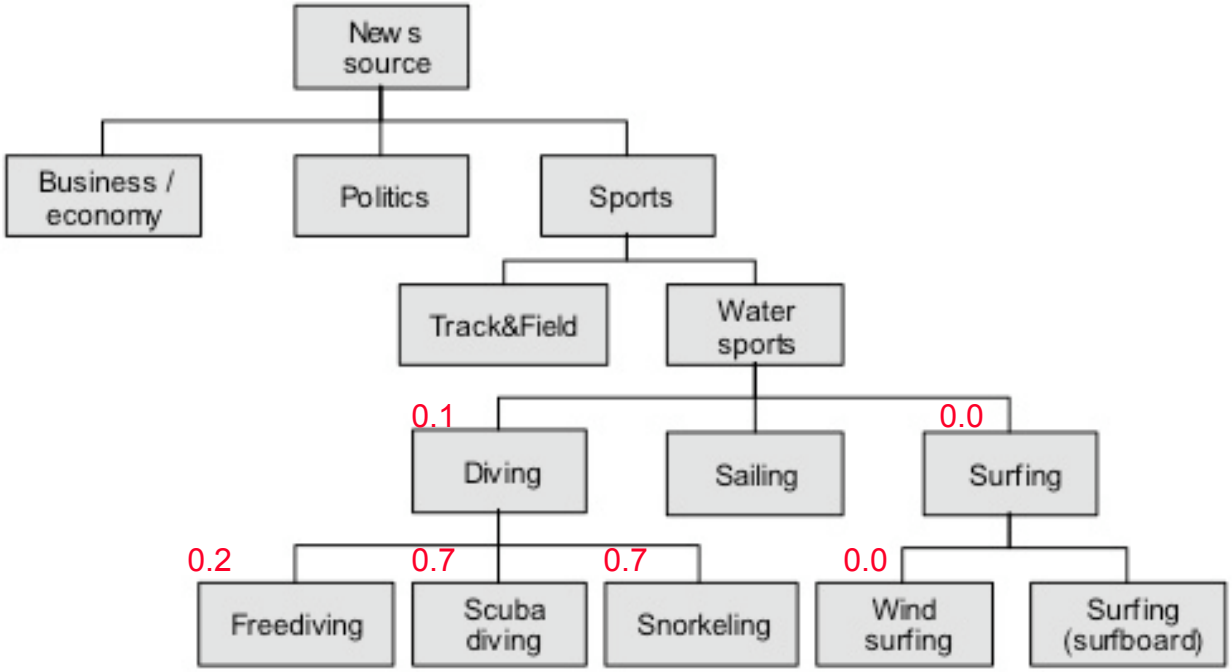
- A domain model is required for interest modeling
  - Traditional domain model for interest modeling in educational context
  - A taxonomy of interest areas for non-educational areas

Example:
Domain model
for adaptive
News system



# Overlay Model of Interests

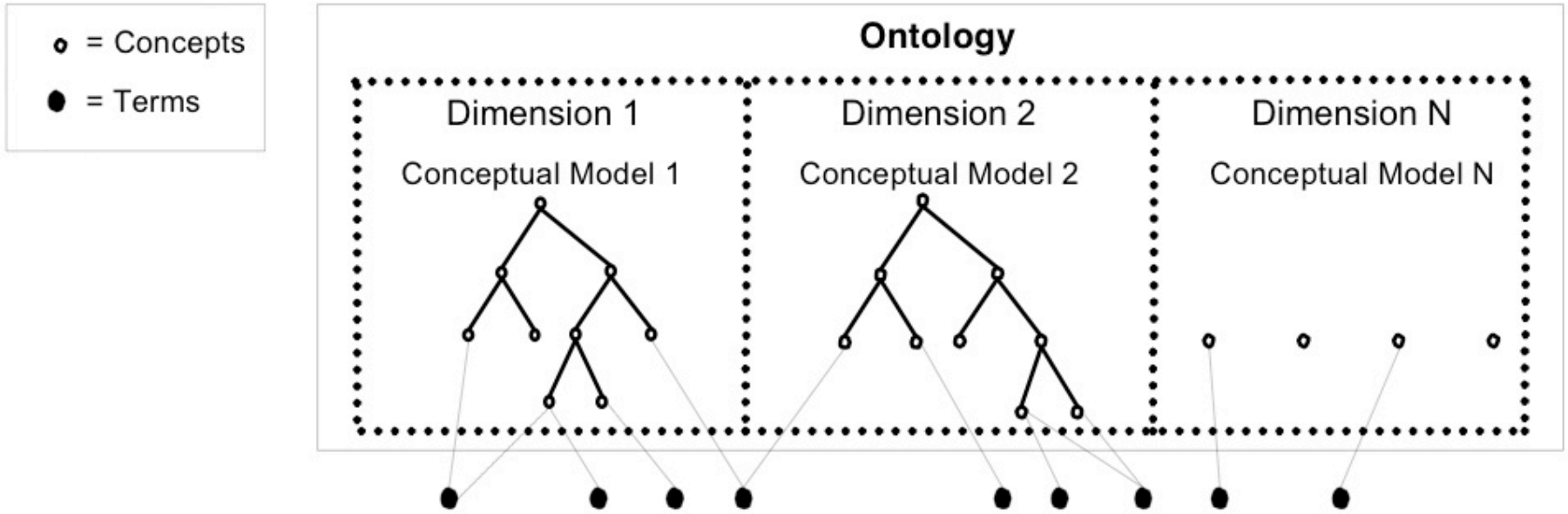
- For each domain concept or taxon an overlay model stores estimated level of interest



# Benefits of Concept-Level Overlay Interest Modeling

- The ability to use formal ontologies
  - Developed for a range of reasons
  - Pushed by the Semantic Web
- Links allow spreading activation
- *Understandable* by the users
  - Could be initialized and edited by the users
  - Can be used for explaining personalization

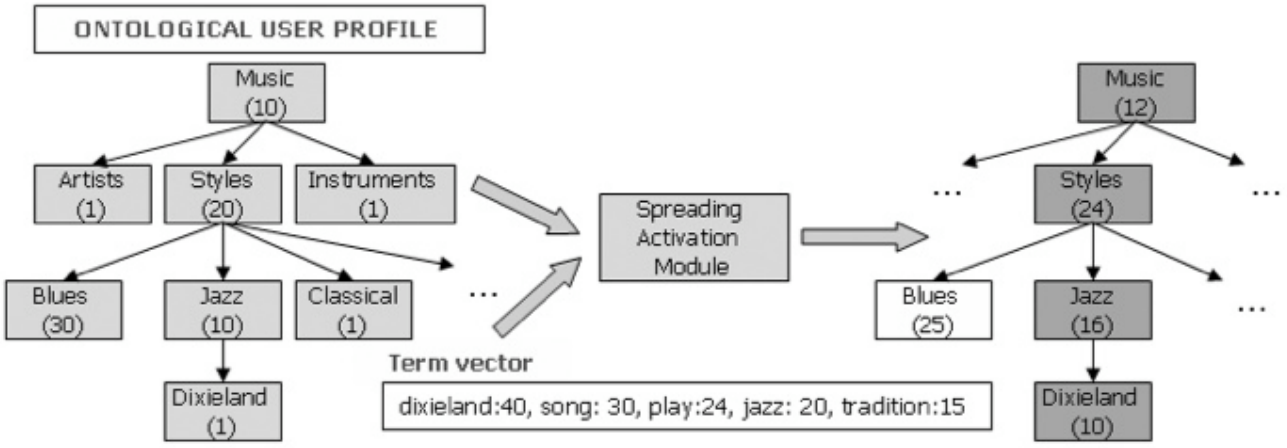
# Ontological Interest Modeling




- Interests are deduced from the content of "interesting documents"
- Needs manual or automatic document to ontology matching

Jokela, S., Turpeinen, M., and Sulonen, R. (2000) *Ontology Development for Flexible Content*, Proceedings of the HICSS-33, IEEE Computer Society, January 4-7, 2000, Maui, Hawaii, USA,

# Spreading Activation

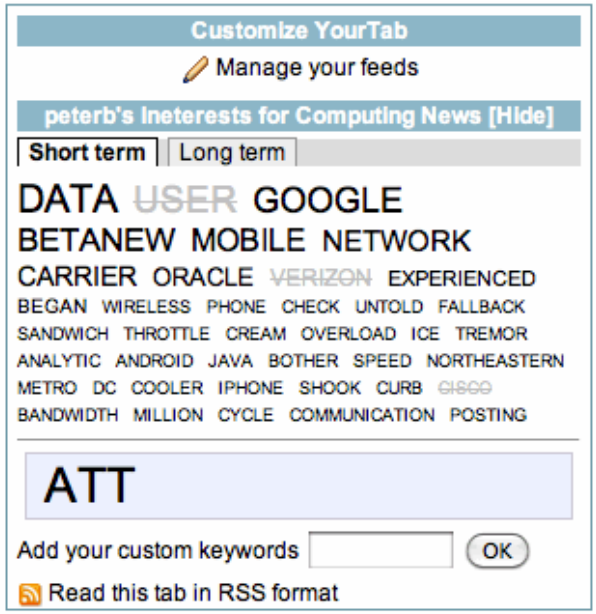



- Evidence of user interests can be propagated along the links
- Spreading activation over the model may be used for more reliable modeling and to deal with sparsity

A. Sieg, B. Mobasher, R. Burke. Web Search Personalization with Ontological User Profiles.
In Proceedings of the ACM Sixteenth Conference on Information and Knowledge Management, CIKM 2007

# Initializing and editing models

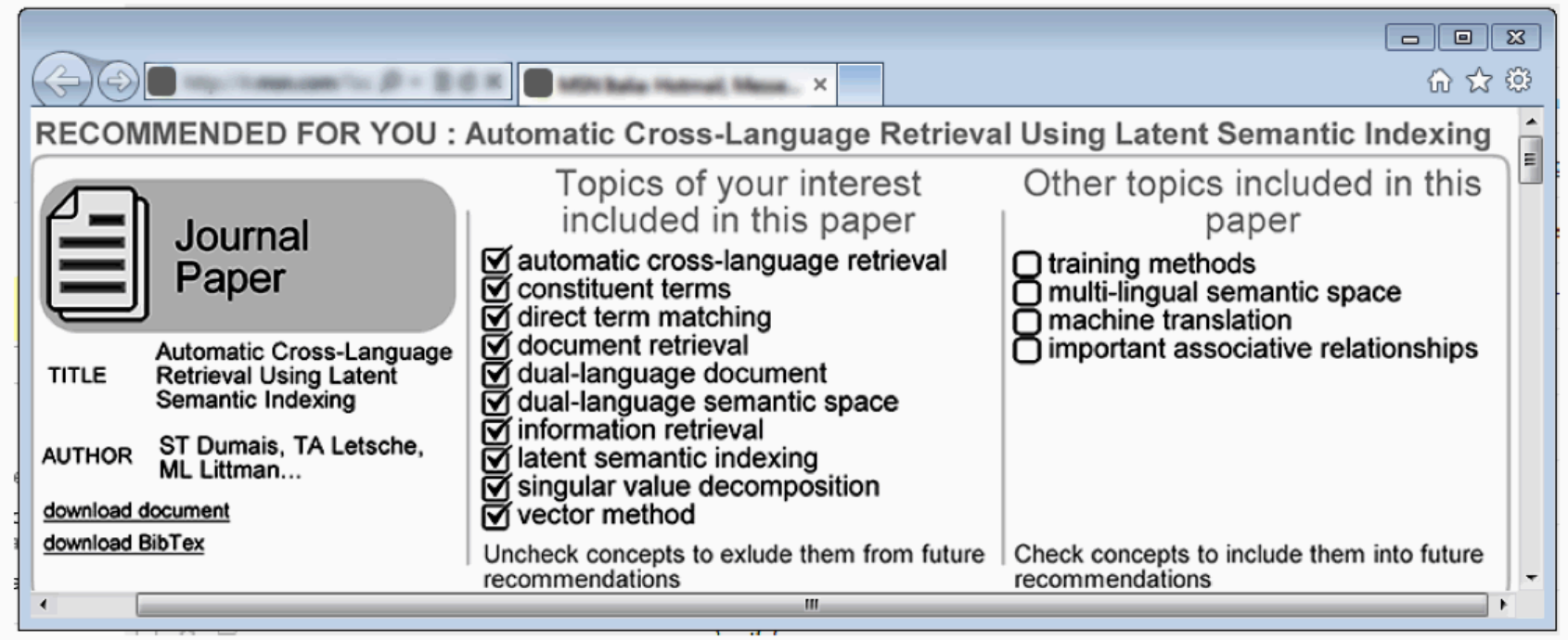
- Concept-level models are *understandable* by end users since they appeal to their own conceptualization of the domain
- Users can initialize a model or edit it if she thinks that the system is not reflecting her interests
- Editing keyword-level models produces poor results (Ahn YourNews study)




Ahn, J.-w., Brusilovsky, P., Grady, J., He, D., and Syn, S. Y. (2007) Open user profiles for adaptive news systems: help or harm? 16th international conference on World Wide Web, WWW '07, Banff, Canada, May 8-12, 2007

# Explanations

- The presence of concepts or topics allows to better explain why a specific item is recommended to the user




Personalized access to scientific publications: from recommendation to explanation
Dario De Nart, Felice Ferrara, Carlo Tasso, 2013

# Overlay model and content indexing

- The use of overlay models requires content to be related to domain concepts/topics, this is known as *content indexing*
- A range of indexing approaches exist in AH
  - Simplest case: Nodes *are* concepts
    - InterBook, ELM-ART, ISIS-Tutor
  - Indexing *nodes* with concepts
    - InterBook, ELM-ART, ISIS-Tutor, AHA
  - Indexing *fragments* with concepts
    - MetaDoc, AHA, PT

# Generalized overlay models

- The overlay approach is quite generic, many aspects could be modeled as “generalized overlays”
- What has been learned so far
  - Knowledge modeling with overlays
    - Domain model - network of concepts
    - User model – weighed overlay of the domain model indicating concept knowledge
  - Interest modeling with overlays
    - Domain model – topic ontology
    - User model – overlay of the ontology indicating topic interests

# Generalized overlay model for user goals and stereotypes

- Goals
  - Domain model: a set  of possible goals, tree of goals
  - User model: on overlay of this set/tree showing probabilities that the user has one of these goals
- Stereotypes
  - Domain Model: a set or a taxonomy of user stereotypes
  - User model: on overlay of this DM showing probabilities that the user belongs to one of these stereotypes

# Indexing with generalized model

- goals are nodes
  - HYPERFLEX
- content fragments are indexed with goals
  - PUSH
- nodes are indexed with user's tasks
  - HYNECOSUM:
- nodes are indexed with stereotypes
  - EPIAIM, Anatom-Tutor, C-Book