

Adaptive Information Systems: From Adaptive Hypermedia to the Adaptive Web

Peter Brusilovsky

School of Information Sciences

University of Pittsburgh, USA

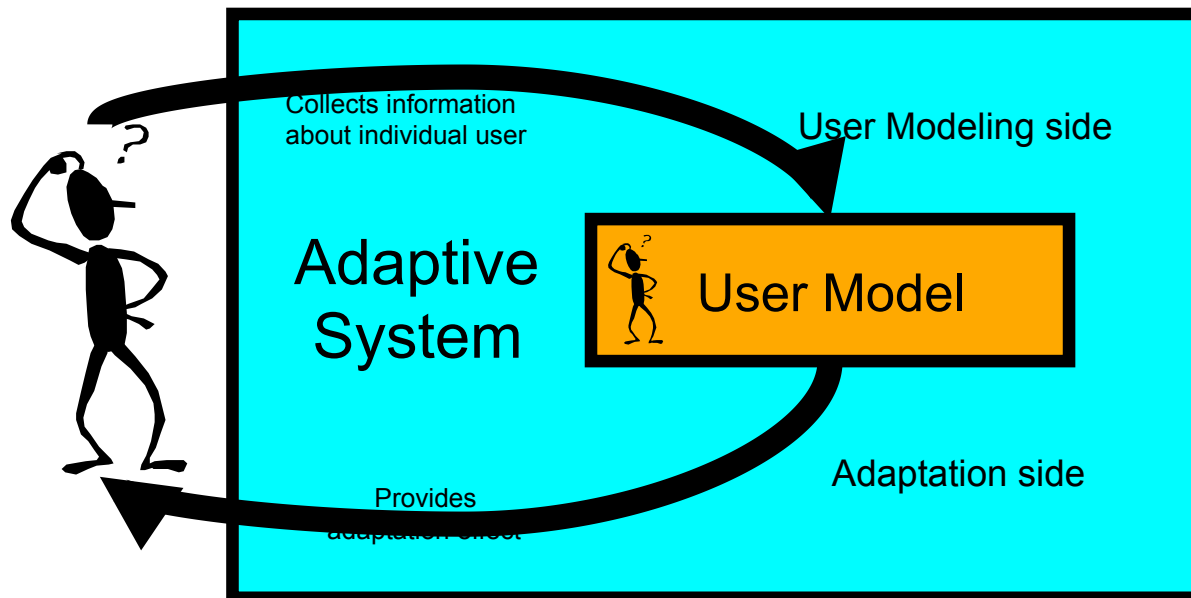
`peterb@pitt.edu`

`http://www.sis.pitt.edu/~peterb`

Information Systems: One Size Fits All?

- Number of users is increasing
- Yet almost all of them offer the same content and the same links to all
 - Stores
 - Museums
 - Courses
 - News sites
- Adaptive information systems offer an alternative. They attempt to treat differently users that are different from the system's point view

Adaptive systems



Classic loop “user modeling - adaptation” in adaptive systems

What can be taken into account?

- Knowledge about the content and the system
- Short-term and long-term goals
- Interests
- Navigation / action history
- User category, background, profession, language, capabilities
- Platform, bandwidth, context...

What Can be Adapted?

- Intelligent Tutoring Systems
 - adaptive course sequencing
 - adaptive group formation
 - ...
- Adaptive GUI
 - menu adaptation
 - dialog form adaptation
- ...
- Adaptive Hypermedia Systems
 - adaptive presentation
 - adaptive navigation support
- Adaptive Help Systems
- Adaptive . . .

Personalized Information Access

- Adaptive IR systems (IR, from 1980)
 - Use word-level profile of interests and remedial feedback to adapt search and result presentation
- Adaptive hypermedia (HT, ITS, from 1990)
 - Use explicit domain models and manual indexing to deliver a range of adaptation effects to different aspects of user models
- Web recommenders (AI, ML, from 1995)
 - Use explicit and implicit interest indicators, apply clickstream analysis/log mining to recommend best resources for detected use interests
 - Content-based recommenders
 - Collaborative recommenders

Why Search Personalization?

- Different users need different documents in response to the same query
- Relevance is not enough if the volume of data is high
 - R. Larsen: With the growth of DL even a good query can return not just tens, but thousands of "relevant" documents¹
- Personalization is an attempt to find most relevant documents using information about user's goals, knowledge, preferences, navigation history, etc.

¹ Larsen, R.L. Relaxing Assumptions . . . Stretching the Vision: A Modest View of Some Technical Issues. D-Lib Magazine, 3, April (1997), available online at <http://www.dlib.org/dlib/april97/04larsen.html>

Adaptive Search

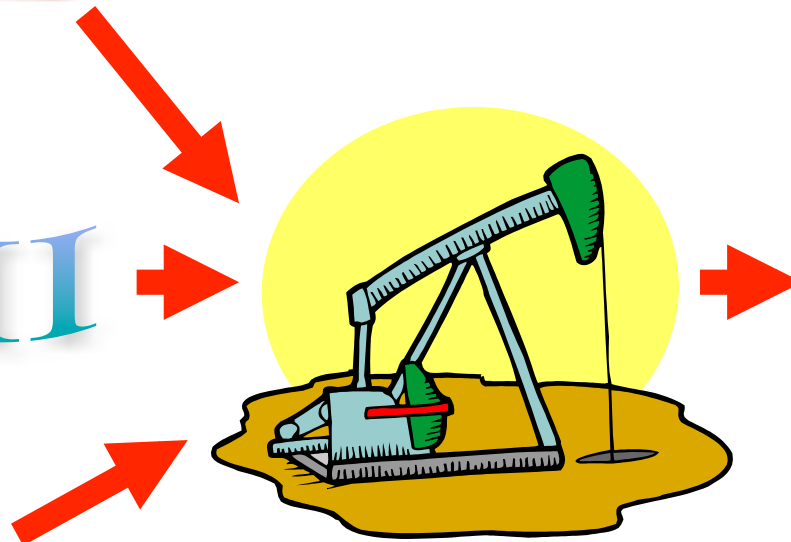
- How search process can be adapted to the user?
- How we can model the user in adaptive search?
- Which adaptation technologies can be applied?

How Search Can be Adapted?

- Let's look by stages

peter brusilovsky

HCI



Google social web Search

Web News Results 1 - 10 of about 104,000,000 for **social web**. (0.07 seconds)

[Social Web: Bringing people together through Events, Academics ...](#)
The **Social Web** is a community interactive portal site and calendar hosting service bringing people together through events, academics, common interests, ...
[www.socialweb.net/](#) - 36k - [Cached](#) - [Similar pages](#)

[Social web - Wikipedia, the free encyclopedia](#)
The **Social Web** refers to two different, yet related concepts. The first is as a description of **web 2.0** technologies that are focused on **social** interaction ...
[en.wikipedia.org/wiki/Social_Web](#) - 22k - [Cached](#) - [Similar pages](#)

[The Social Web | ZDNet.com](#)
Facebook have announced that they are going to license their APIs and proprietary markup language to other **social web** sites - the first of which is Bebo. ...
[blogs.zdnet.com/social/](#) - 124k - [Cached](#) - [Similar pages](#)

News results for social web

 [MySpace Agrees to Youth Protections](#) - 9 hours ago
By BRIAN STELTER The **social networking Web** site MySpace and the attorneys general for 49 states announced Monday that they had reached an agreement under ...
[New York Times](#) - [1095 related articles >](#)

[Predictions for a Web 2.0 social experience](#)
Ben Hunt casts an eye to the future of a more connected **web**, and predicts that Yahoo will be the dominant online brand for the next 5 years.
[www.webdesignfromscratch.com/future-social-web-experience.cfm](#) - 53k - [Cached](#) - [Similar pages](#)

[PlaNetwork Journal](#)
Democracy Ecological Design Economics Global Systems Independent Media · Infrastructure Networks Collective Intelligence **Social** Sculpture Transparency ...
[journal.planetwork.net/article.php?lab=reed0704](#) - 12k - [Cached](#) - [Similar pages](#)

[Flock - The Social Web Browser](#)
Flock is a free **web** browser that makes it easy to connect with your friends and express yourself online. Upload photos, blog anything, subscribe to RSS, ...
[www.flock.com/](#) - 32k - [Cached](#) - [Similar pages](#)

Before search

During search

After search

Modeling Users in Adaptive Search

- Most essential feature: user interests
- Observing user document selection, adaptive IR systems build *profile* of user interests
- Keyword-level modeling
 - Uses a long list of keywords (terms) in place of domain model
 - User interests are modeled as weighed vector or terms
 - More advanced systems use several profiles for different domains or timeframes

Keyword User Profiles

Art

0.60	0.72
Portrait	Sculpture

0.45	0.33
Watercolor	Painting

Sports

0.88	0.27
Soccer	Bat

0.79	0.33
Touchdown	Score

Music

0.15	0.87
Rock	Symphony

0.31	0.63
Score	Orchestra

Pre-Process: Query Expansion

- User profile is applied to add terms to the query
 - Popular terms could be added to introduce context
 - Similar terms could be added to resolve indexer-user mismatch
 - Related terms could be added to resolve ambiguity
 - Works with any IR model or search engine

Post-Processing

- The user profile is used to organize the results of the retrieval process
 - present to the user the most interesting documents
 - Filter out irrelevant documents
- Extended profile can be used effectively
- In this case the use of the profile adds an extra step to processing
- Similar to classic information filtering problem
- Typical way for adaptive Web IR

Post-Filter: Re-Ranking

- Re-ranking is a typical approach for post-filtering
- Each document is rated according to its relevance (similarity) to the user or group profile
- This rating is fused with the relevance rating returned by the search engine
- The results are ranked by fused rating
 - User model: WIFS, group model: I-Spy

YourNews: Adaptive Search and Filtering with Open User Profile

The screenshot shows the 'YourNews' website interface. At the top, there is a search bar with the text 'YourNews' and a 'Search' button. Below the search bar is a navigation menu with tabs for 'National', 'World', 'Business', 'Technology', 'Sports', 'Entertainment', 'Health', 'Computing', 'Palm', and 'YourTab 3'. The 'Palm' tab is currently selected. Below the navigation menu, there is a section for 'Recent News | Recommended News' with a checkbox for 'Show all duplicate articles'. The main content area displays a list of news articles:

- Treocnti Palms App Store Called App Catalog (11 hours ago) ★★**
Palms new Developer Website reveals name of Palms app store...
- PIC1 Palm Pre Overview and Impressions from CES (2 days ago) ★★**
In the two days following Palms WebOS and Palm Pre announcement, Ryan and I have spent a great deal of time speaking with Palm representatives, watching demos, and talking at length about the new hardware and software platforms. In this article I take a close look at the Palm Pre hardware and answer many of the questions surrounding Palms new hotly anticipated smartphone. Read on for our in-depth Palm Pre impressions review and a ton of high res photos.
- BrightHand Palm Unveils the Pre Smartphone (4 days ago) ★★**
Palm has announced its new Pre smartphone. A touchscreen device with a sliding keyboard, the Pre will use the just as new Palm webOS.
- PIC1 Palm Stock Soars on Positive Pre Buzz (3 days ago) ★★**
After a long down out decline and near dips below the dollar line, Palms stock has make a commanding recovery since the new announcements. After the conclusion of Palms presentation, late-day trading activity responded strongly in Palms favor, sending the stock up 35%. The market seems to be responding positively to the new Pre smartphone and WebOS platform. In trading today price is continuing its climb and is currently trading around \$6. This is a pleasant turn of events from Palms dismal ...
- PIC1 Palm Pre Hands on Videos Part 2 (3 days ago) ★★**
Next in our series of video updates from CES, weve put together three new hands on clips of the Palm Pre. In the first clip we have a demonstration of the Palm webOS Copy and Paste ability. Following that we have a ~2 minute clip of the Pres web browser visiting everyones favorite Palm site...

On the right side of the page, there is a sidebar for 'Customize YourTab' with a 'Manage your feeds' button. Below that, there is a section for 'peterb's Interests for Palm News [Hide]' with 'Short term' and 'Long term' tabs. The interests list includes: PALM HANDHELD BIT, COLLIGAN PDA TREO NBSP, DEVELOP EOL LEOPARD INTEL POSTERITY CUFF, ASTRWARE INDICATE ANNOUNCEMENT SNOW LONG, PRACTICALLY SALE RESTART NEW APP CONTINUE, FOUNDATIONS DIVIDE DISPLAY STORE VERSION, SUFFICIENT INEVITABLE FACEBOOK POTENTIAL, ENTERPRISE SCREENSHOT MODE PREFERENCE ED, BLACKBERRY VEGA. At the bottom of the sidebar, there is a text input field for 'Add your custom keywords' and an 'OK' button, along with a checkbox for 'Read this tab in RSS format'.

<http://amber.exp.sis.pitt.edu/yournews/>

Adaptive Hypermedia

- How hypertext and hypermedia can become adaptive?
- Which adaptation technologies can be applied?
- How we can model the user in adaptive hypertext?

Why Adaptive Hypermedia?

Hypermedia systems are almost adaptive but ...

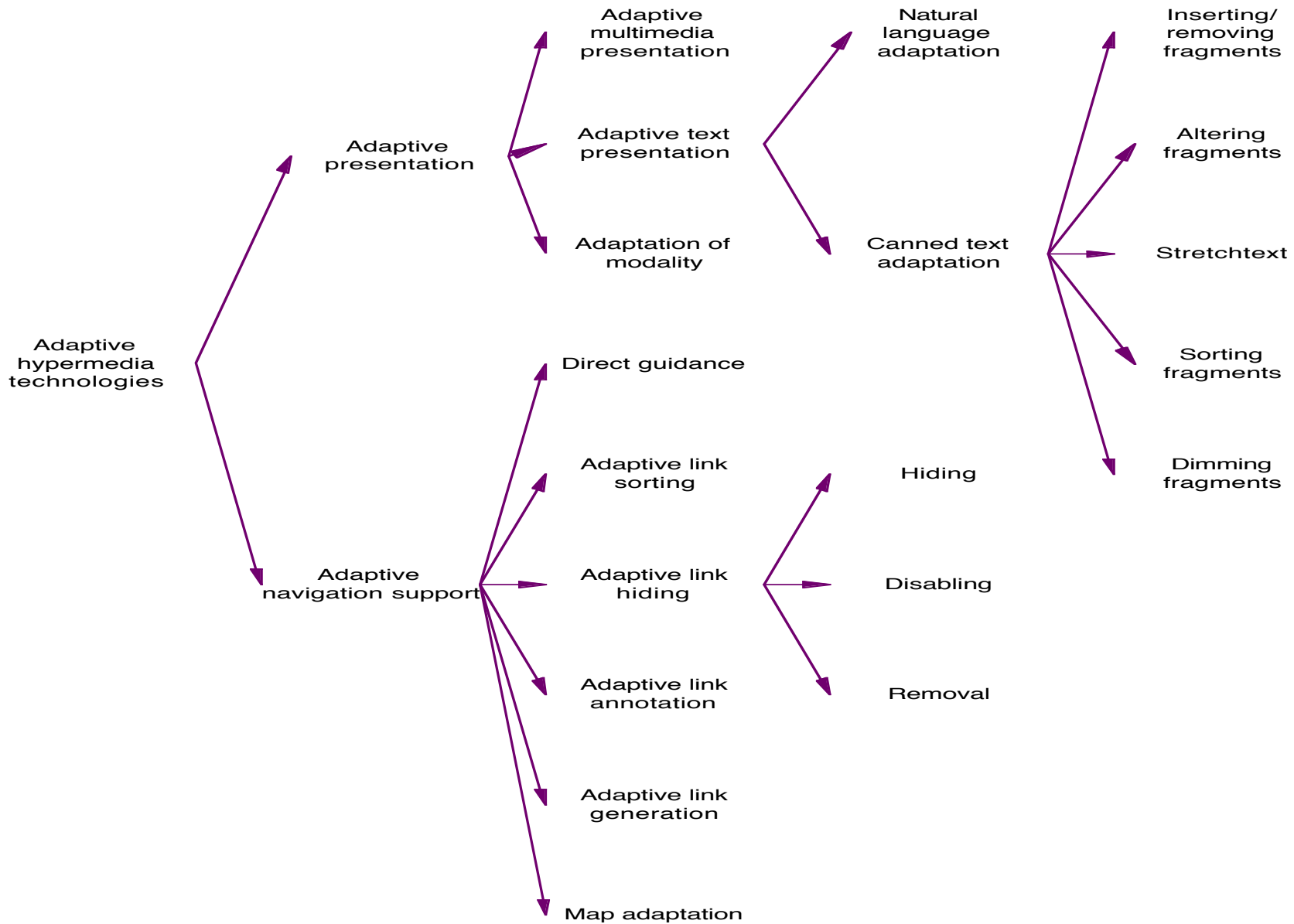
- ☑ Different people are different
- ☑ Individuals are different at different times
- ☑ "Lost in hyperspace"

We may need to make hypermedia adaptive where ..


- ⇒ There us a large variety of users
- ⇒ Same user may need a different treatment
- ⇒ The hyperspace is relatively large

What Can Be Adapted?

- Web-based systems = Pages + Links
- Adaptive presentation
 - content adaptation
- Adaptive navigation support
 - link adaptation



Adaptive presentation

- Conditional text filtering
 - ITEM/IP
- Adaptive *stretchtext*
 - MetaDoc, KN-AHS
- Frame-based adaptation
 - Hypadapter, EPIAIM
- Natural language generation
 - PEBA-II, ILEX 

Adaptive Stretchedtext (PUSH)

[task](#)

[summary](#)

[basic introduction](#)

[purpose](#)

[what is done in this process](#)

[how to work in this process](#)

[list of activities](#)

[release information](#)

[input objects](#)

[output objects](#)

[entry criteria](#)

[exit criteria](#)

[roles](#)

[simple example](#)

[advanced example](#)

▷ **task**

▽ **summary**

In iom we perform and document an **object-oriented analysis** [1-1] [Describe object-oriented analysis | Compare object-oriented analysis and object-oriented design] of a subsystem. The model should include the abstractions (represented as **object types** [1-1]) necessary to understand how the subsystem described by the functional requirements is expressed in an object-oriented world. This analysis will render us a high-level view of the subsystem without any consideration (or at least as little consideration as possible) taken to distribution, persistence aspects or other design and implementation considerations. The goal is a model that clearly describes and gives an understanding of a subsystem without the gory details of design and implementation.

The ideal object model resulting from the ideal object modelling process, is functionally complete in the sense that it covers all areas of the functional specification of a subsystem.

▷ **basic introduction**

▽ **purpose**

The ideal object model resulting from the ideal object modelling process, is functionally complete in the sense that it covers all areas.

The intention behind the ideal object modelling process is to focus on

Adaptive navigation support

- Direct guidance
- Hiding, restricting, disabling
- Generation
- Sorting
- Annotation
- Map adaptation

Adaptive annotation in InterBook

Netscape: ACT-R Lesson Units

ACT-R Lesson Units

- Unit 0: Interpreting Production Rules
 - Section 0.1: Production Rule Forms
 - 0.1.1 Declarative Units in ACT-R
 - 0.1.2 Production Rules in ACT-R
 - 0.1.3 Production Rule Format
 - 0.1.4 ACT-R's Condition Form
 - 0.1.5 ACT-R's Action Side

0.1.1 Declarative Units in ACT-R

In ACT-R, elements of declarative knowledge are called **chunks** or **WMEs** (for working memory elements).

Content	?
Glossary	?
Help	?
Search	?
Hint	?

Background:

ACT-R ✓

declarative knowledge

1. State of concepts (unknown, known, ..., learned)

2. State of current section (ready, not ready, nothing new)

3. States of sections behind the links (as above + visited)

1. State of concepts (unknown, known, ..., learned)
2. State of current section (ready, not ready, nothing new)
3. States of sections behind the links (as above + visited)

QuizGuide: Dual Annotations

The screenshot shows a web browser window titled "QuizGuide. Adaptive quiz recommender." with the URL `http://www.sis.pitt.edu/~ir/qplus/bin/qguide.cgi?group=1&kt_sid=824&kt_user=`. The browser's address bar includes a search engine icon and the text "Google". Below the address bar is a navigation bar with various links: Apple, Amazon, Cyberspace Atlas, citeseer, NRHM04, eBay, Yahoo!, News, 0012-42, Blackboard, KT, and ELENA.

Quiz Guide

← ?

- arithmetic expressions
- variables
- constants (define)
- loops (while)
- increment decrement
- compound assignments
- logical expressions
- loops (do while)
- conditionals (if else)
Quiz1
Quiz2
- conditional operator
- character processing
- ~~logical operators~~

Question 1

```
main()
{
    int i = 0;

    if (7 % 2)
        i += 2;
    else
        i++;
}
```

What is the final value of i

i =

Submit

Annotations in CourseAgent

Spring 2006 List

Click to see the schedule

CourseAgent
Adaptive Online Course Recommendation System

Control Panel Schedules Career Scope Course Catalog Faculties Register

Rosta's CourseAgent Help Log off

Schedule of spring 2006

Taken Courses, Planned Courses, Currently Taken Courses, Recommend by Advisor, Degree of Relevance to Career Goals

CRN	Course No	Title	Day	Time	Location	Instructor	Workload	Relevance	Action
2692	TELCOM 2940	PRACTICUM	apt			Richard Thompson			Plan It
16084	INESCI 2120	INFORMATION AND CODING THEORY	tue	6:00-8:50 P	302 CL	Paul Munro	🔧🔧	👍👍👍	Plan It
16077	INESCI 2130	DECISION ANALYSIS AND DECISION SUPPORT SYSTEMS	wed	6:00-8:50	411 IS	Marek Cruzdzel	🔧🔧	👍👍👍	Plan It
16080	LIS 2194	ETHICS IN THE INFORMATION SOCIETY	mon	3:00-5:50 P	403 IS	Toni Carbo			Plan It
16099	INESCI 2350	HUMAN FACTORS IN SYSTEMS	thu	6:00-8:50 P	411 IS	Michael Lewis	🔧🔧	👍👍👍	Register It
16056	INESCI 2470	INTERACTIVE SYSTEM DESIGN	wed	6:00-8:50 P	405 IS	Peter Brusilovskiy	🔧🔧	👍👍👍	Evaluate It
16079	INESCI 2511	INFORMATION SYSTEMS ANALYSIS, DESIGN, AND EVALUATION	tue	6:00-8:50 P	411 IS	Glenn Bay	🔧		Plan It
16011	INESCI 2610	DATA STRUCTURES	thu	3:00-5:50 P	501 IS	Roger Flynn	🔧🔧	👍👍👍	Plan It
16118	INESCI 2611	ALGORITHM DESIGN	tue	3:00-5:50 P	406 IS	Hassan Karimi	🔧		Plan It
16065	INESCI 2720	GEOGRAPHIC INFORMATION SYSTEMS	thu	6:00-8:50 P	405 IS	Hassan Karimi	🔧🔧	👍👍👍	Plan It

Planned to take (can be registered)

Already taken (can be evaluated)

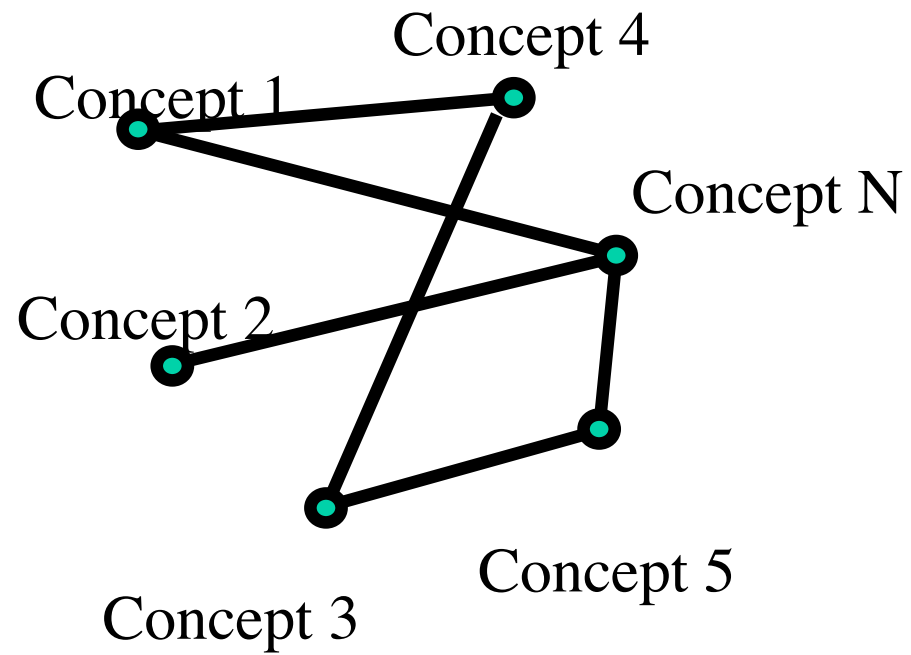
Difficulty level of the course
Low 🔧 , Medium 🔧🔧 , High 🔧🔧🔧

Degree of relevance to students' career goal
Marginally relevant
Relevant
Very Relevant

User Modeling in Classic AH

- Classic AH use external models
 - Domain models, pedagogical modes, stereotype hierarchy, etc.
- Users are modeled in relation to these models
 - User is *field-independent*
 - User knowledge of *loops* is *high*
 - User is interested in *19th century architecture styles*
- Resources are connected (indexed) with elements of these models (aka *knowledge behind pages*)
 - This section presents *while loop* and *increment*
 - This page is for *field-independent* learners
 - This church is built in 1876

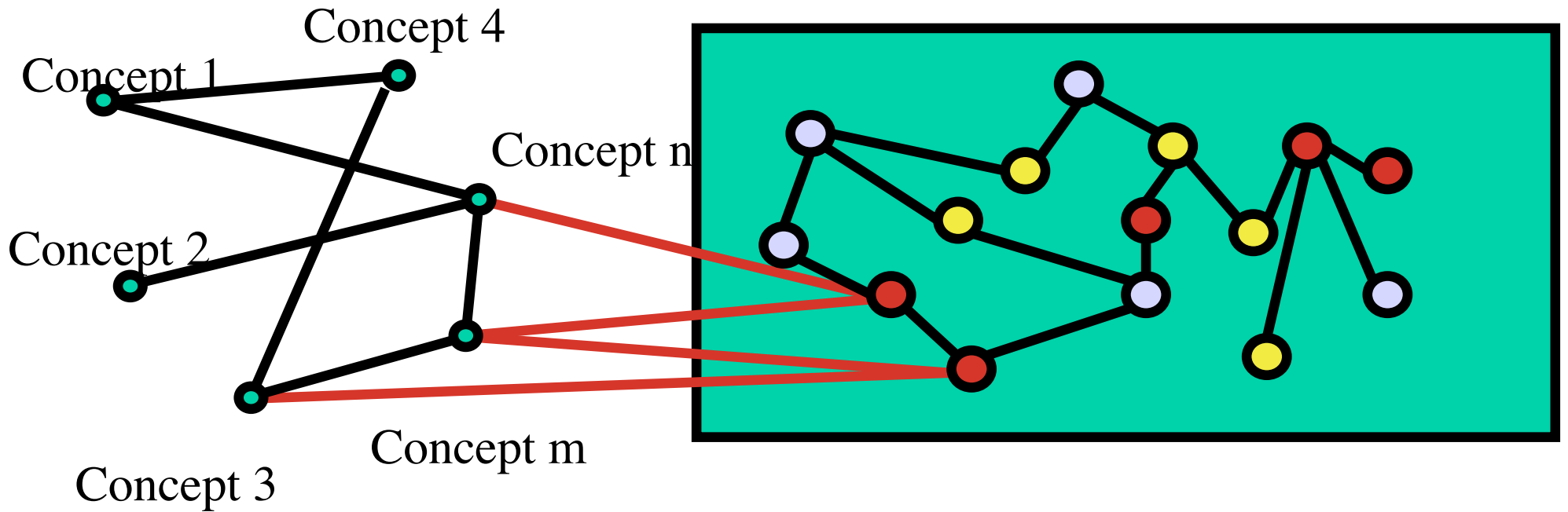
Domain Model



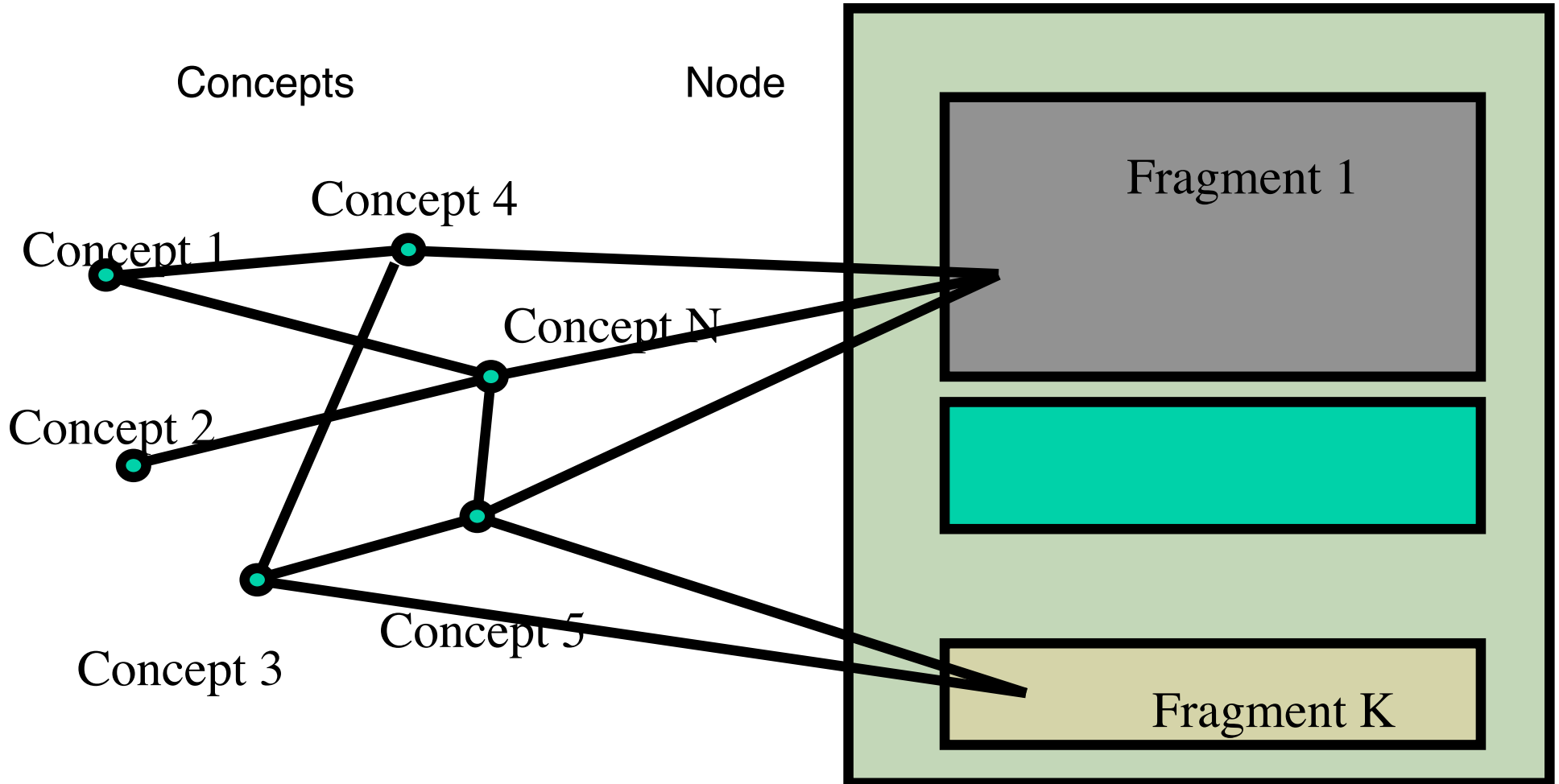
Indexing of Nodes

External (domain) model

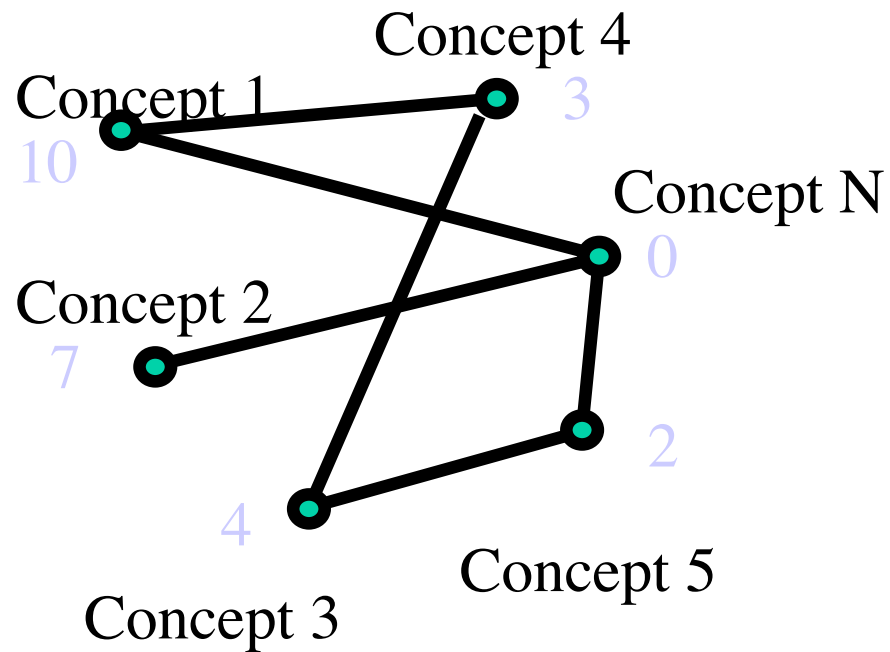
Hyperspace



Indexing of Fragments



Concept-Level User Model



AH: Evaluation Data

- Adaptive presentation makes user to understand the content faster and better
- Adaptive navigation support reduces navigation efforts and allows the users to get to the right place at the right time
- Altogether AH techniques can significantly improve the effectiveness of hypertext and hypermedia systems

Recommender Systems

- “Native” adaptive information access approach
- How we can model the user in recommender systems?
- Which adaptation technologies can be applied?

Recommender Systems

- Started as extension of work on adaptive information filtering
- What is filtering? Search without explicit query
- Started as SDI – user provided profiles
- Later considered user feedback (yes/no or ratings) to automatically improve profile
- Modern IF can start without profile, constructing it by observation and user feedback
 - Rating, bookmarking, downloading, purchasing

Example: Syskill and Webert

Syskill & Webert- Lycos Search

Lycos search: GRANTS CONTROL WUSTL DATA
GENOME CDC INFECTIOUS UNIVERSITY
RESEARCH PHARMACY HEALTH JOURNAL
BIOLOGY MEDICAL

Lycos Nov 15, 1995 catalog, 11646653 unique URLs

1) .008 [Research & Data](#) [1.0000, 5 of 14 terms, adj 1.0]

Abstract: **Research & Data** HHS makes a substantial investment in improving understanding of **health** and social services. An increasing amount of the information generated by HHS organizations will be made available on the Internet and through this page. Program evaluation and policy **research** * Abstracts of HHS program evaluation studies * The 1994 Green Book: **Data** and information on selected social welfare programs * Office of the Assistant Secretary for Planning and Evaluation Biomedical **research** * National Institutes of **Health** (NIH) * National Library of
<http://www.as.dhhs.gov/resdata.html> (3k)

2) 1.0 [Online Journals](#) [0.9902, 6 of 14 terms]

Abstract: American Chemical Society Publications DOE Whitepaper on Bio-Informatics Emerging **Infectious** Diseases (EID) - **CDC** European Molecular **Biology** Network Newsletter Human **Genome** Newsletter GCG Transcript **Journal** of Biological Chemistry **Journal** of Clinical Monitoring **Journal** of Computer-Aided Molecular Design Mathematics and **Biology** Protein Science Recombinant DNA/Protein Resource Facility News Report: NCHGR GESTEC Director's Meeting on **Genome** Informatics Informatics Center, Vanderbilt **University Medical** Center Last Modified: Wednesday, 04 October 1995
webmaster@www.mc.vanderbilt.edu
<http://vumclib.mc.vanderbilt.edu/resources/interests/journal.html> (3k)

3) .996 [Selected Internet Resources Starting Points Subject Specific](#)
[Site Institution](#) [0.9750, 5 of 14 terms, adj 1.0]

Amazon.com Recommendations

amazon.com

Hello, Peter Brusilovsky. We have [recommendations](#) for you. (Not Peter?)

FREE 2-Day Shipping: [See details](#)

[Peter's Amazon.com](#) | [Today's Deals](#) | [Gifts & Wish Lists](#) | [Gift Cards](#)

[Your Digital Items](#) | [Your Account](#) | [Help](#)

Shop All Departments All Departments

Your Amazon.com | Your Browsing History | Recommended For You | Rate These Items | Improve Your Recommendations | Your Profile | Learn More

Peter, Welcome to Your Amazon.com (If you're not Peter Brusilovsky, [click here.](#))

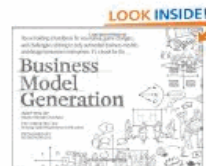
Today's Recommendations For You

Here's a daily sample of items recommended for you. Click here to [see all recommendations](#).

Page 1 of 35



[Shrek Forever After \(Single-Disc... DVD](#) ~ Mike Myers
★★★★☆ (143) \$19.49
[Fix this recommendation](#)



[Business Model Generation](#) (Paperback) by Alexander Osterwalder
★★★★☆ (102) \$20.38
[Fix this recommendation](#)



[Kingston 4 GB Class 4 SDHC Flash Memory Card SD...](#)
★★★★☆ (677) \$6.49
[Fix this recommendation](#)



[SE 19 PCS Watch Tool Kit](#)
★★★★☆ (44) \$21.22
[Fix this recommendation](#)



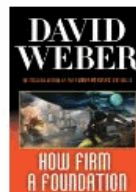
[Sony 2 GB Memory Stick PRO Duo Flash Memory Car...](#)
2 GB 32Mb/s WRITE SPEED
★★★★☆ (675) \$4.98
[Fix this recommendation](#)

Coming Soon for You

Page 1 of 2



[Source Code \[Blu-ray\]](#) Blu-ray ~ Jake Gyllenhaal
★★★★☆ (41) \$19.99
[Fix this recommendation](#)



[How Firm a Foundation \(Safehold\)](#) (Hardcover) by David Weber
\$16.79



[Bleach Uncut Box Set 9 DVD](#) ~ Artist Not Provided
★★★★☆ (6) \$36.99
[Fix this recommendation](#)

Tap into Your Friends

BETA



Connect to Facebook to get Amazon recommendations for you and discover your friends' Favorites and Likes.

Log in or sign up and we'll suggest some shows and movies we think you'll enjoy.

Brought to you by



Top Recommendations



Mexican Made Easy

Recommended because it's highly rated by other Hulu users



The Cisco Kid

Recommended because it's highly rated by other Hulu users



House Hunters

Recommended because it's highly rated by other Hulu users



Alfred Hitchcock Hour

Recommended because it's highly rated by other Hulu users



Top Recommendations



Diners, Drive-ins and Dives

Recommended because you recently watched The Best Thing I Ever Ate

Are you interested?

yes no I've seen it



Chopped

Recommended because you recently watched The Best Thing I Ever Ate

Are you interested?

yes no I've seen it



The Simpsons

Recommended because you recently watched American Dad!

Are you interested?

yes no I've seen it



The Cleveland Show

Recommended because you recently watched American Dad!

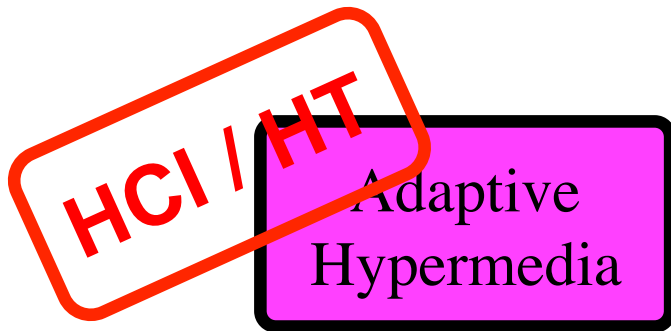
Are you interested?

yes no I've seen it

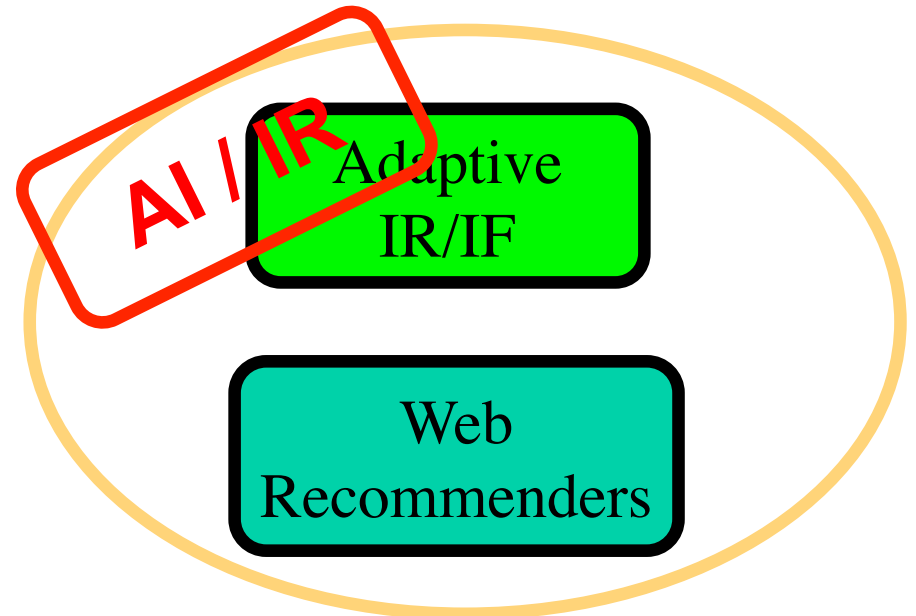
Recommender Technologies

- Classic content-based recommendation
 - Content-based user profile
- Collaborative recommender systems
 - Started with proactive push and pull systems, but merged the “filtering” movement
 - User profile as rating history
- Rule-based (purchasing printer)
- Case-based
 - Metadata-based user profile
- Demographic
 - User demographic data

Web Personalization 2000



- Explicit domain model
- Concept-level user model
- Manual indexing
- Use “classic” AI
- Use many adaptation techniques
- Reliable adaptation
- Adapt to many user factors



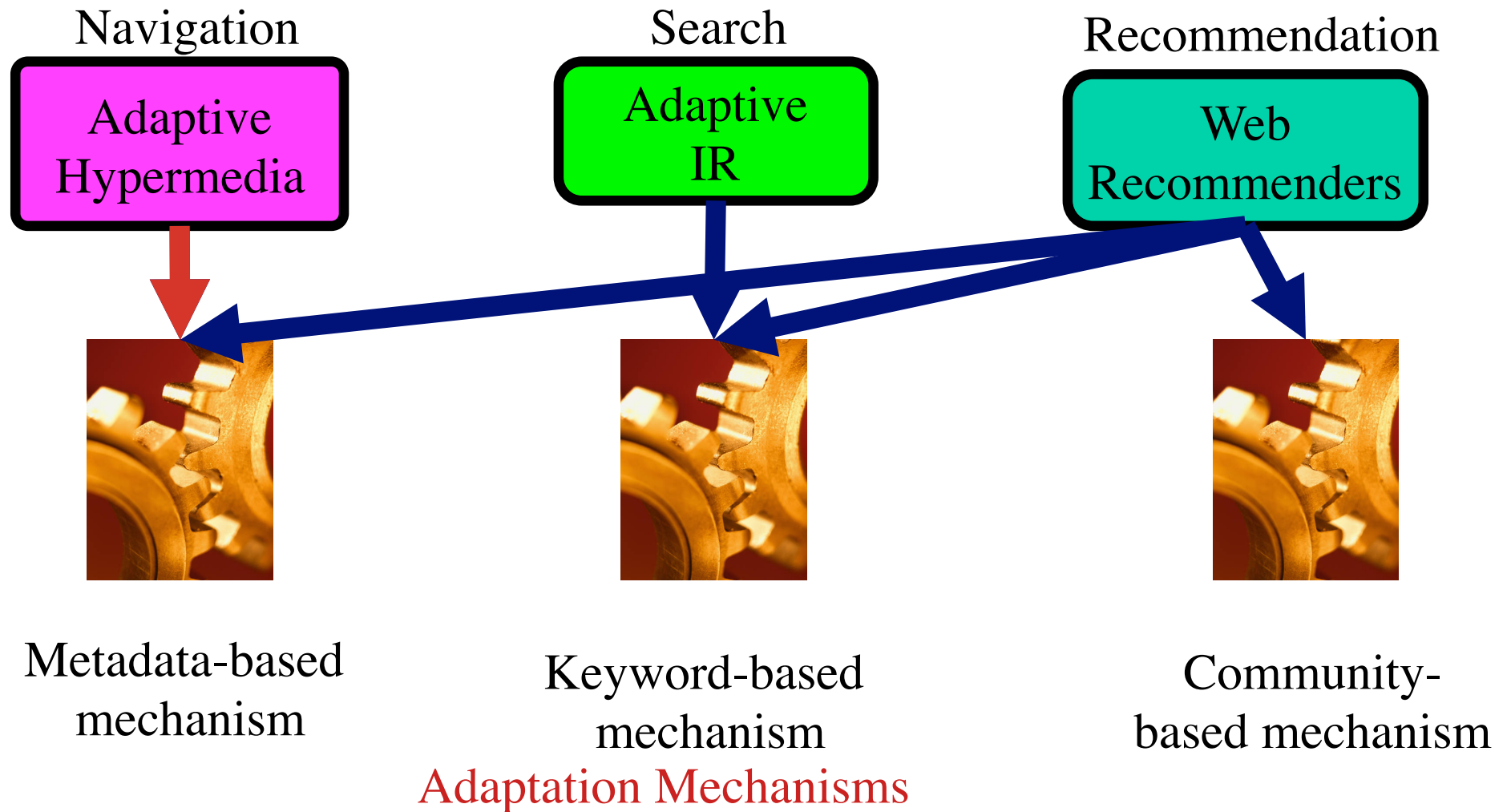
- No domain model
- Keyword-level user model
- No manual indexing
- Adapt to user interests
- Use ranked list of links/docs
- Use “modern” AI

Access Type vs. Engine

- Recommendation is a type of information access – proactive ranked suggestion based on user data and observing behavior
- Engine behind decides to what extent information is relevant (answers goals, interests, knowledge)
- Types of engines:
 - Classic content based (keywords, same as IR)
 - Metadata-based (still content!)
 - Collaborative
 - Hybrid

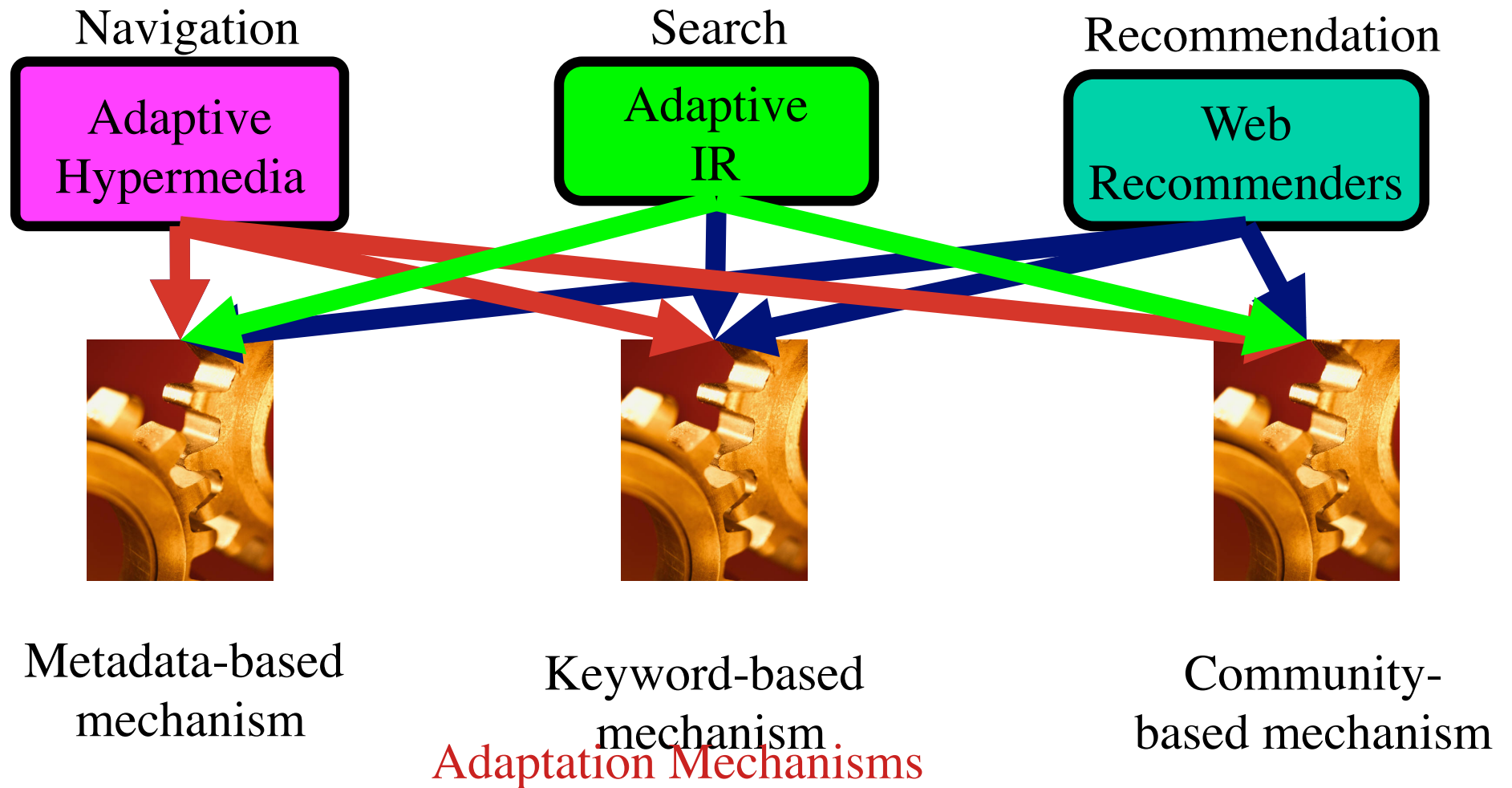
A Look under the Hood

Types of information access



Personalized Information Access

2012



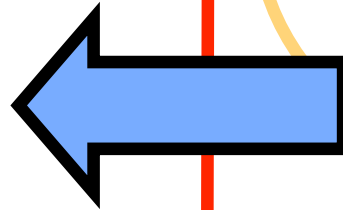
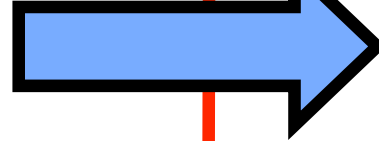
Personalized Information Access

2012

Open Corpus

Adaptive
Hypermedia

- No Manual indexing
- Use ML and log mining
- Extensive use of BN
- Adapt to many user factors
- Use many adaptation techniques



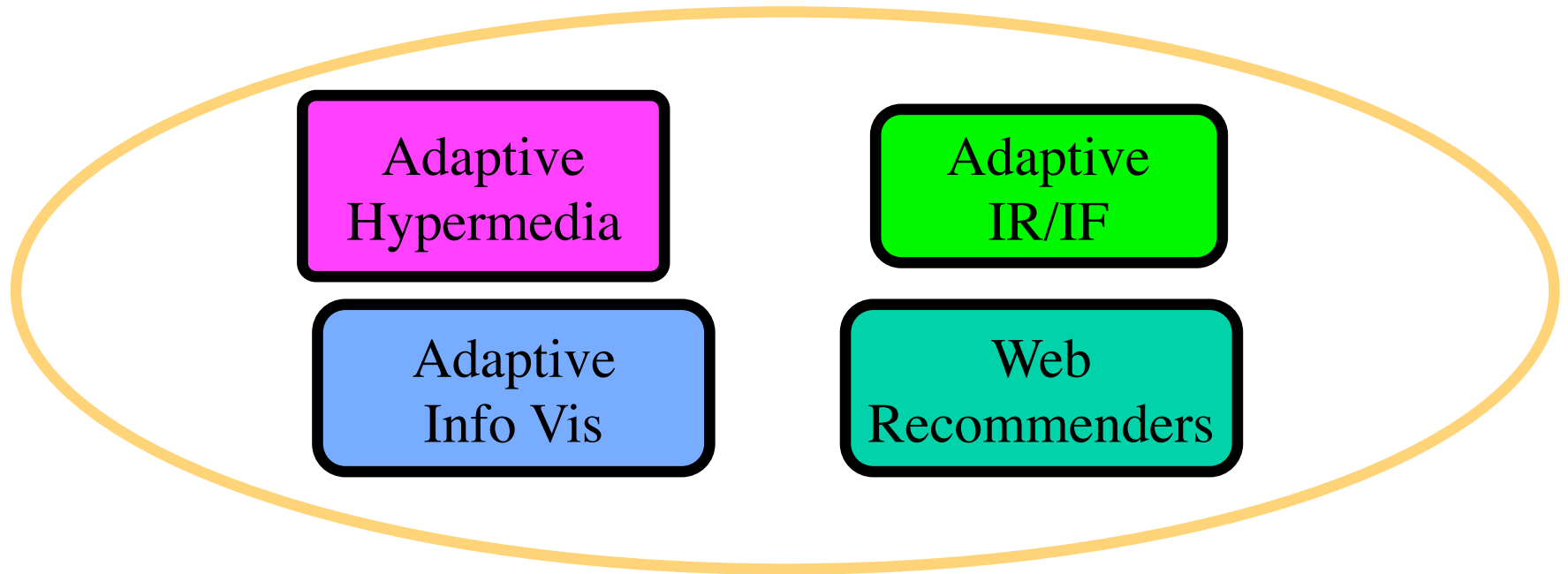
Adaptive
IR/IF

Ontology-based

Web
Recommenders

- No manual indexing
- Explicit or derived domain ontology
- Concept-level user model
- Adapt to more than just interests

Personalized Information Access: Integrated Prospect



- With and without domain models
- Keyword- and concept-based UM
- Use of any AI techniques that fit

- Use many forms of information access
- Use a range of adaptation techniques
- Adapt to more than just interests

Why Integrated Prospect?

- Use larger variety of user models
- Use larger variety of user modeling techniques
 - Even for the same kind of models
- Use larger variety of information access techniques and adaptation techniques
 - Especially for the same kind of models
 - About 90% of user information needs are not solved by classic search-based access

What will we learn?

Document Modeling

User Modeling



Adaptive Information Access Technologies

How to implement adaptive information access: interfaces and engines



Special Topics

Personalized Information Access

- Adaptive search
- Adaptive filtering (recommendation)
 - Content-based
 - Collaborative
 - Hybrid
- Adaptive navigation support
- Adaptive presentation

Special Topics

- Some special kinds of personalization
 - Mobile, 3D, collaborative work
- Personalization in special domain
 - Cultural heritage, education
- Cross-cutting issues and challenges
 - Privacy, evaluation, group-level personalization

Mobile Personalization

- Mobile platform emerges as a leader
- New personalization approaches
 - Taking into account location/time/other context
 - Sensors and affective computing
 - Adapting to screen, power, bandwidth
- Mobile personalized systems
 - News and entertainment recommender
 - Location-based recommenders
 - Adaptive mobile guides