Beyond Content-Based Retrieval:
Modeling Domains, Users, and Interaction

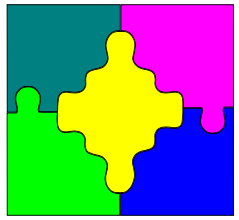
Susan Dumais

Microsoft Research

http://research.microsoft.com/~sdumais

IEEE ADL'99 - May 21, 1998

Research in IR at MS



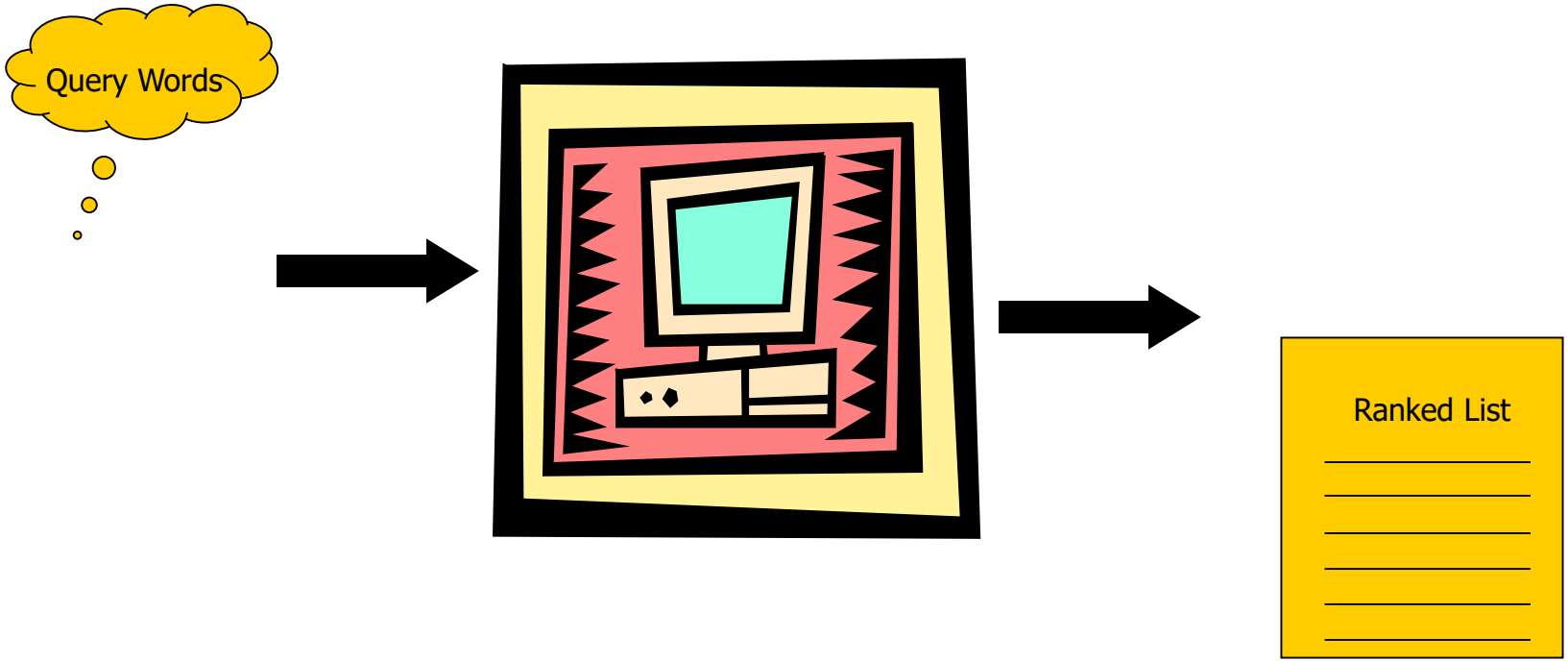
- Microsoft Research (http://research.microsoft.com)
  - Adaptive Systems and Interaction - IR/UI
  - Machine Learning and Applied Statistics
  - Data Mining
  - Natural Language Processing
  - Collaboration and Education
  - Database
  - MSR Cambridge; MSR Beijing
- Microsoft Product Groups … many IR-related

IR Themes & Directions

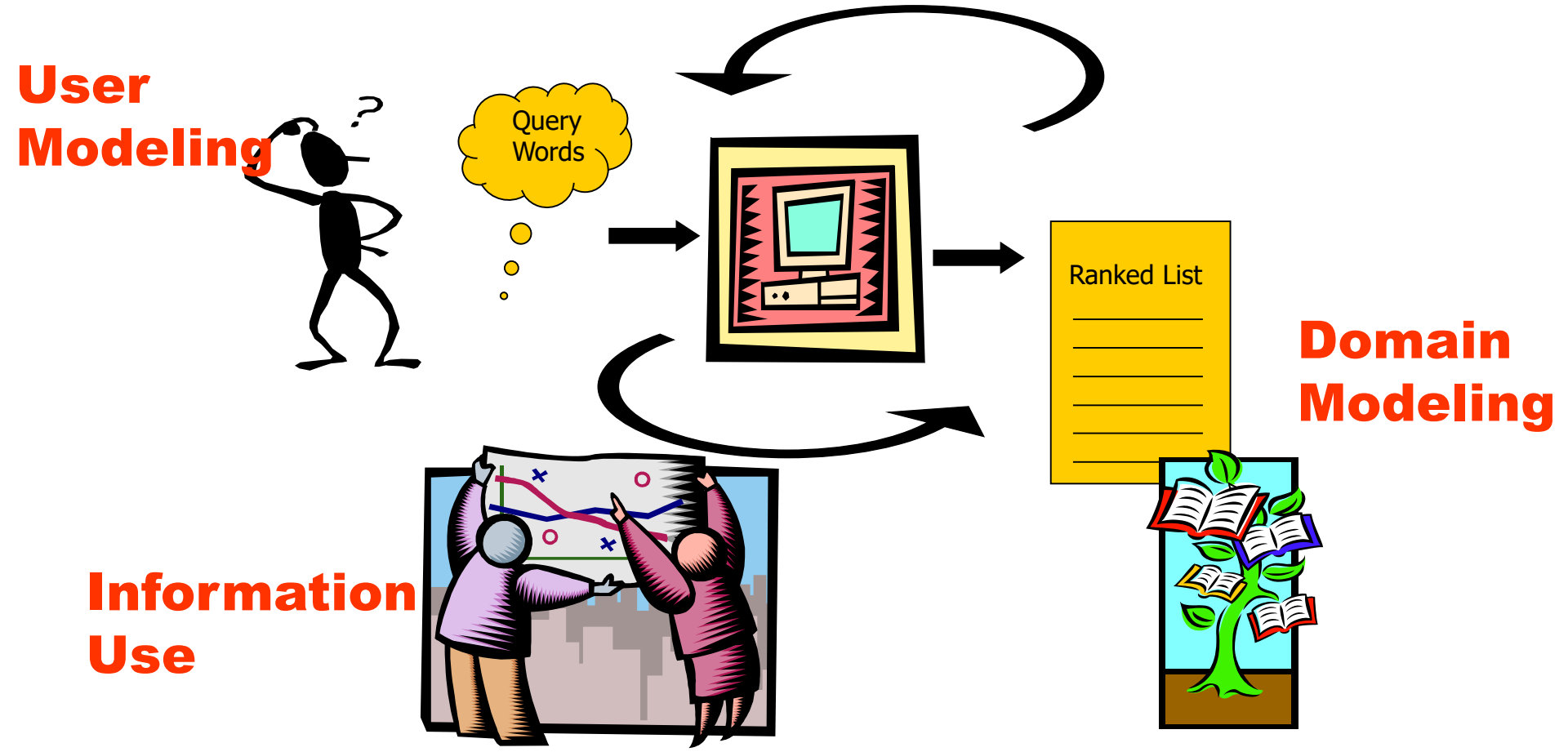
- Improvements in matching algorithms and representation
  - Probabilistic/Bayesian models
    - *p(Relevant|Document), p(Concept|Words)*
  - NLP: Truffle, MindNet
- Beyond content-matching
  - User/Task modeling
  - Domain/Object model
  - Advances in presentat

WWW8 Panel
Finding Anything in the Billion-Page Web: Are Algorithms the Answer?
Moderator: Prabhakar Raghavan, IBM Almaden

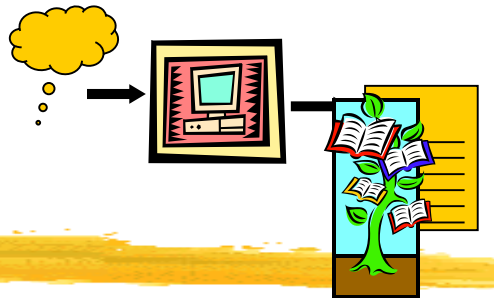
Traditional View of IR



What's Missing?

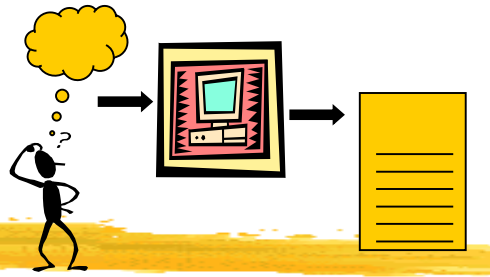


Domain/Obj Modeling



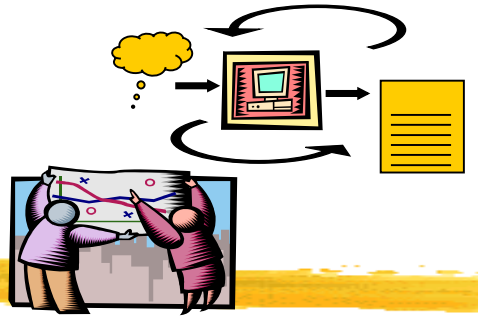
- Not all objects are equal … potentially big win
  - *A priori importance*
  - Information use (“readware”; collab filtering)
- Inter-object relationships
  - Link structure / hypertext
  - *Subject categories - e.g., text categorization. text clustering*
- Metadata
  - E.g., reliability, recency, cost -> combining

User/Task Modeling



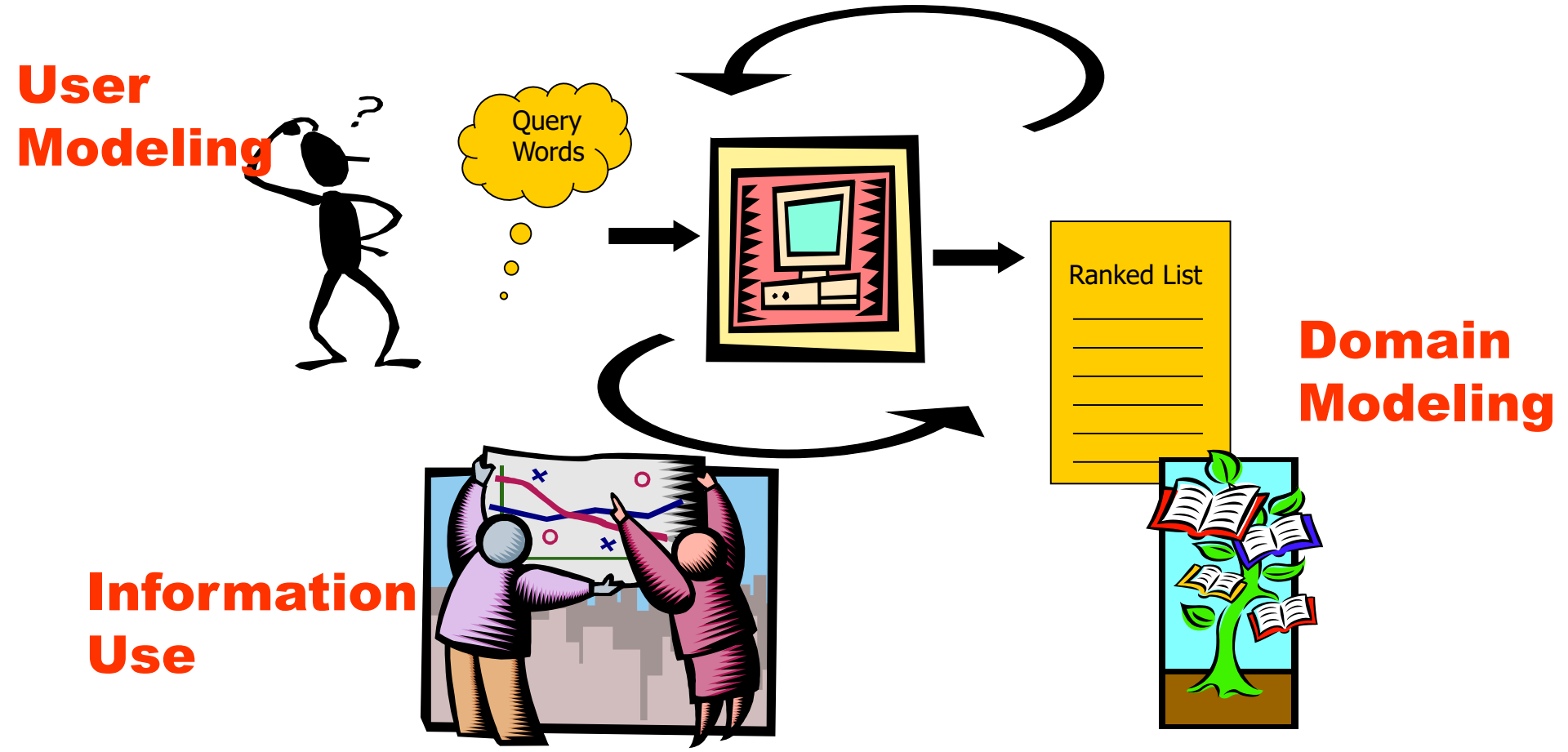
- Demographics
- Task -- What's the user's goal?
  - e.g., Lumiere
- Short and long-term content interests
  - *e.g., Implicit queries*
    - Interest model = f(content_similarity, time, interest)
  - e.g., Letiza, WebWatcher, Fab

Information Use



- Beyond batch IR model ("query->results")
  - Consider larger task context
- Human attention is critical resource … no Moore's Law for human capabilities
  - Techniques for automatic information summarization, organization, discover, filtering, mining, etc.
- *Advanced UIs and interaction techniques*
  - E.g, tight coupling of search, browsing to support information management

The Broader View of IR

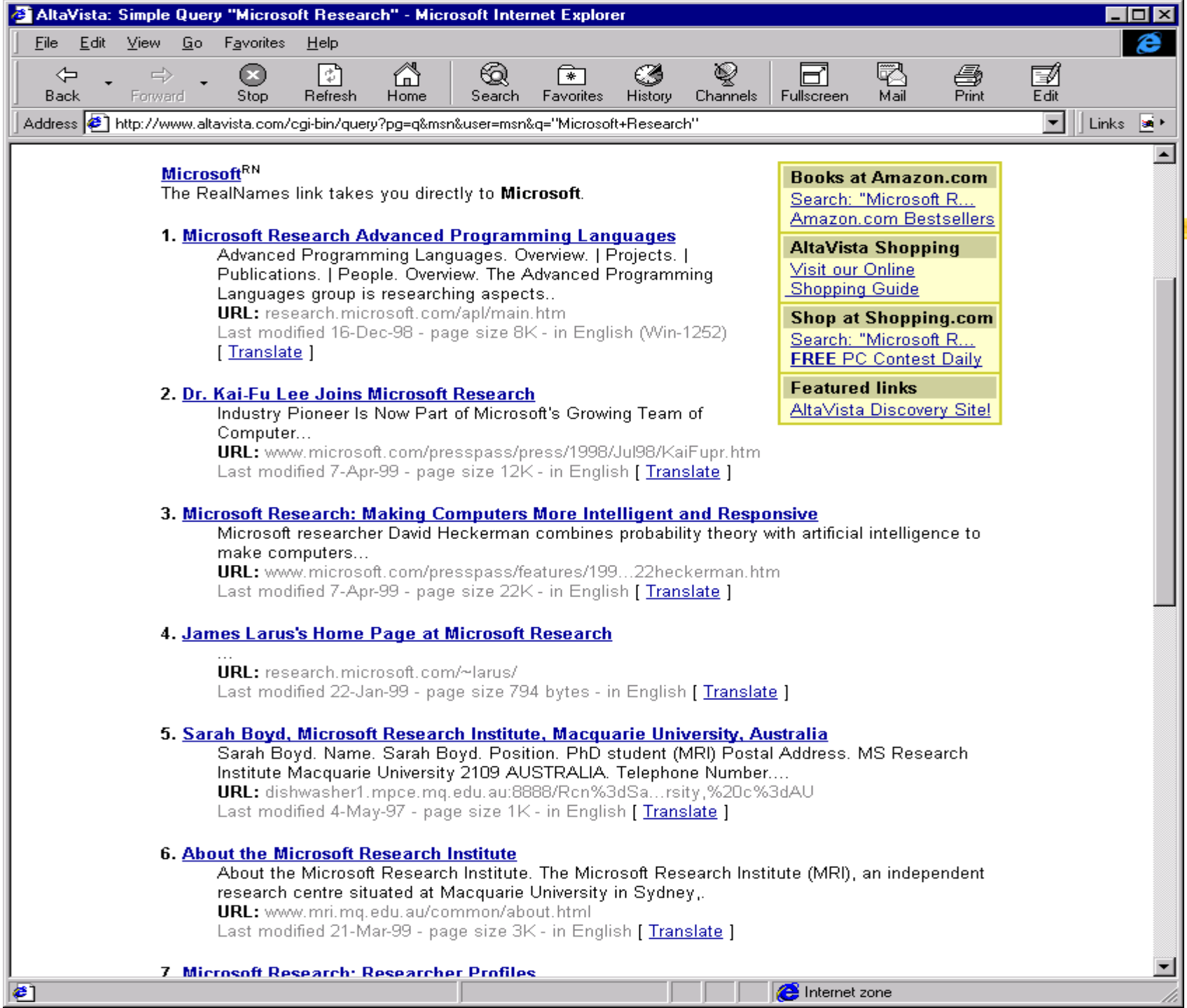


Beyond Content Matching

- Domain/Object modeling
  - A priori importance
  - Text classification and clustering
- User/Task modeling
  - Implicit queries and Lumiere
- Advances in presentation and manipulation
  - Combining structure and search (e.g., DM)

- Example:

  Web query for “Microsoft Research”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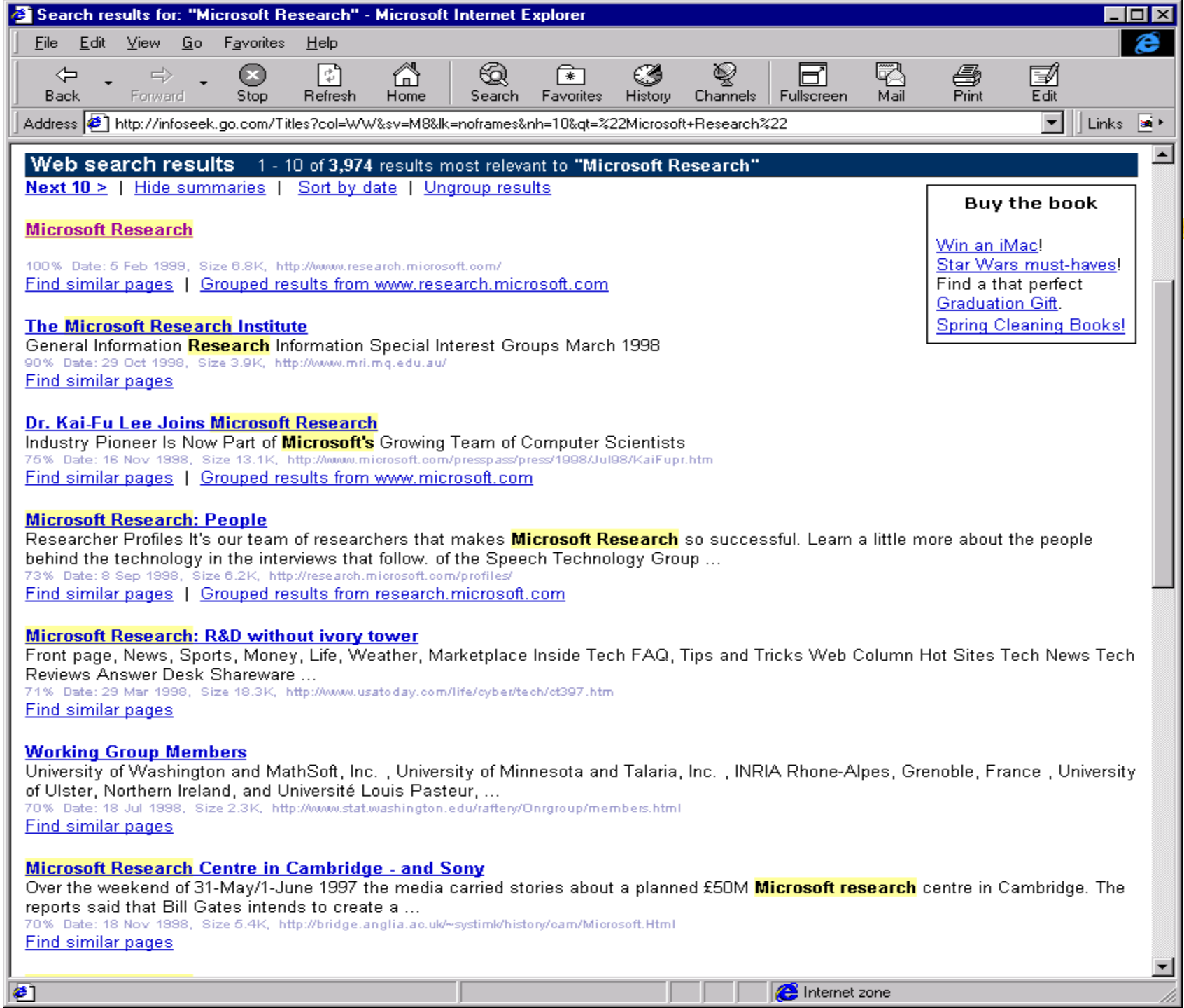
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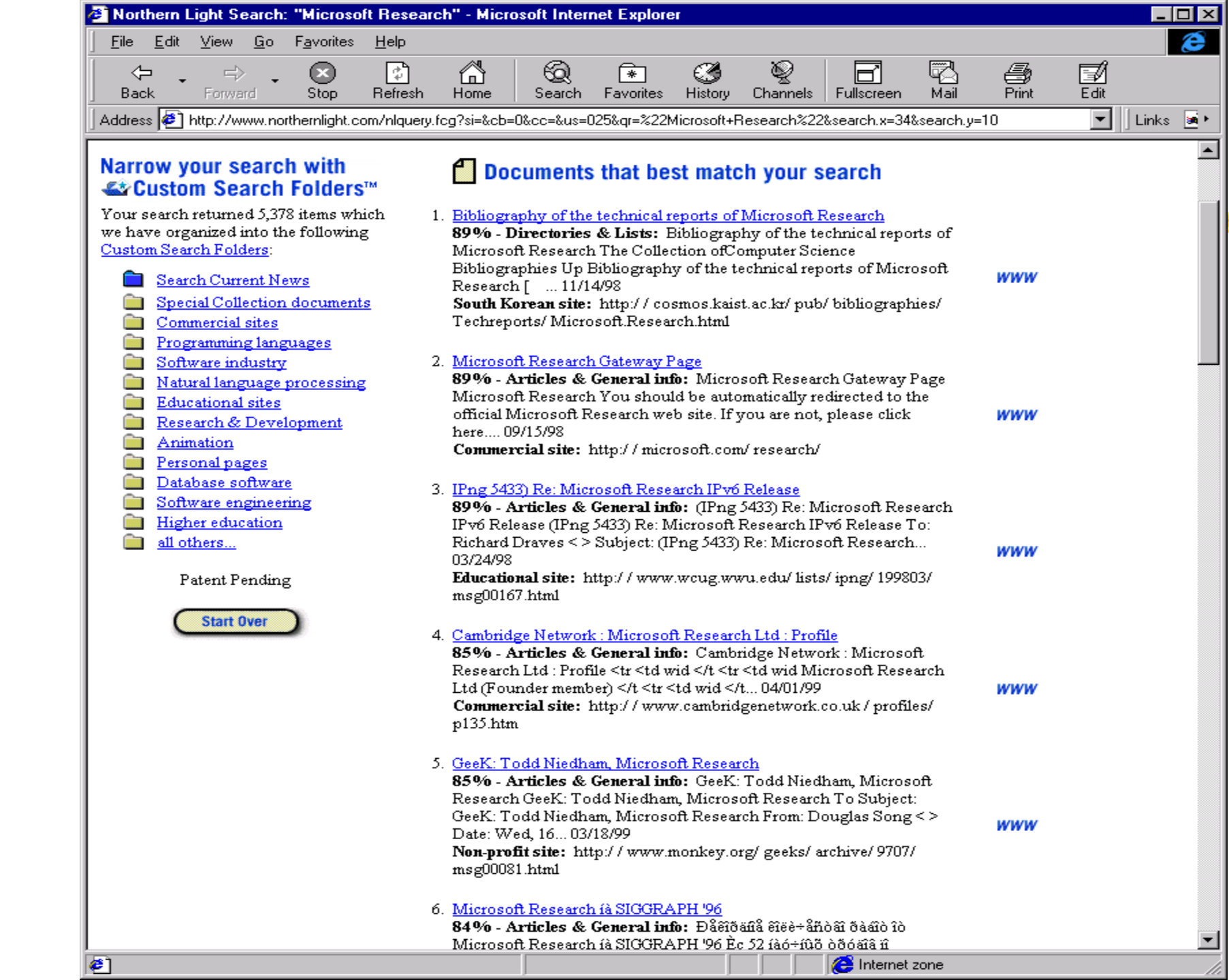
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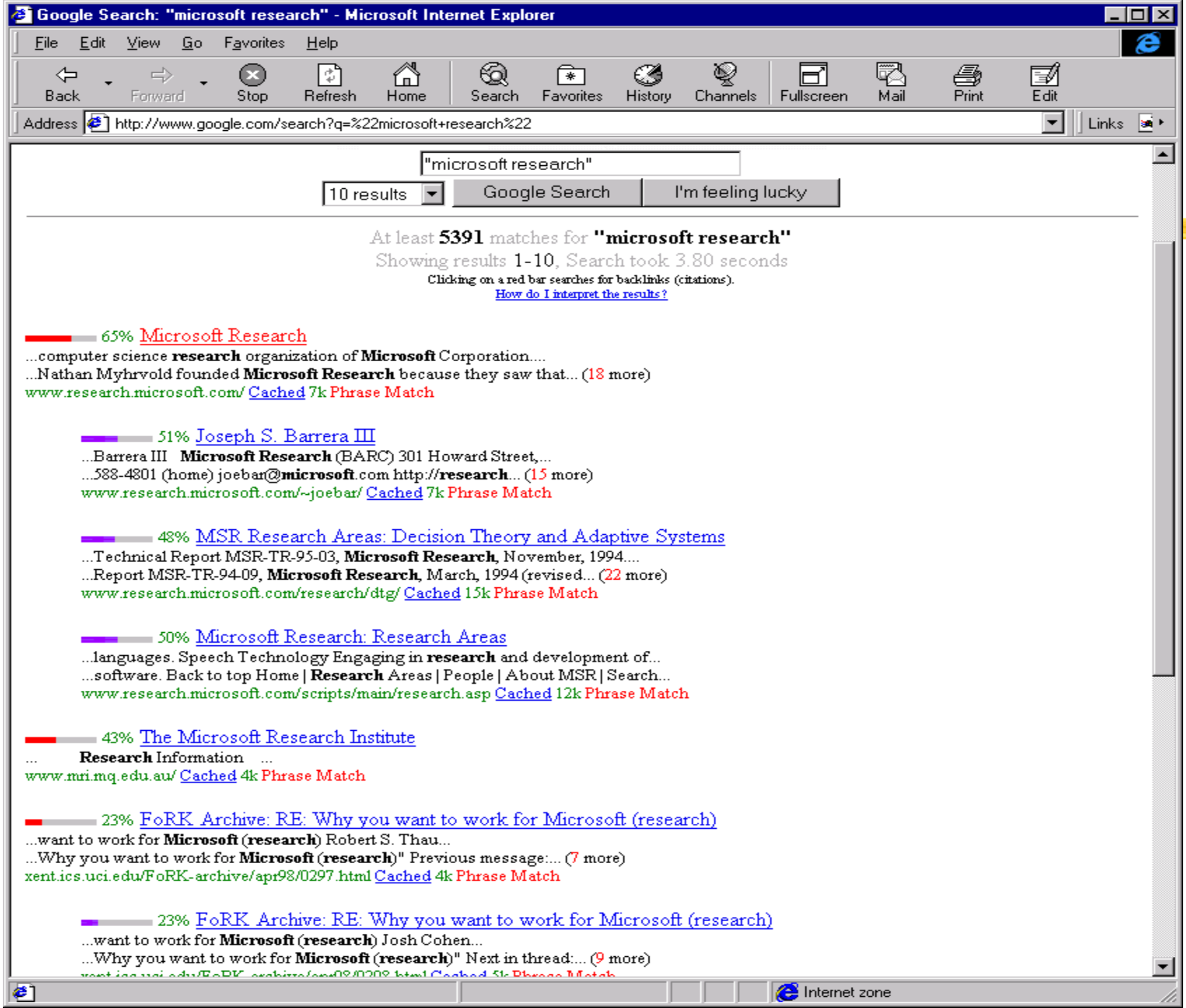
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Estimating Priors

- Link Structure
  - Google - Brin & Page
  - Clever (Hubs/Authorities) - Kleinberg et al.
  - Web Archeologist - Bharat, Henzinger
  - similarities to citation analysis
- Information Use
  - Access Counts - e.g., DirectHit
  - Collaborative Filtering

New Relevance Ranking

- Relevance ranking can include:
  - content-matching … of couse
  - page/site popularity <external link count; proxy stats>
  - page quality <site quality, dates, depth>
  - spam or porn or other downweighting
  - etc.
- Combining these - relative weighting of these factors tricky and subjective

Text Classification

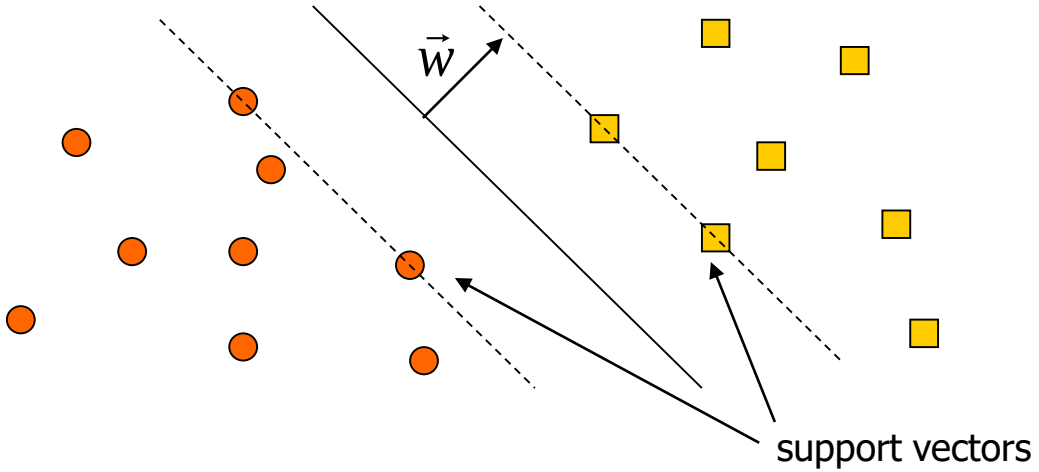
- *Text Classification*: assign objects to one or more of a predefined set of categories using text features
  - E.g., News feeds, Web data, OHSUMED, Email - spam/no-spam
- Approaches:
  - Human classification (e.g., LCSH, MeSH, Yahoo!, CyberPatrol)
  - Hand-crafted knowledge engineered systems (e.g., CONSTRUE)
  - Inductive learning methods
    - (Semi-) automatic classification

Inductive Learning Methods

- Supervised learning from *examples*
  - Examples are easy for domain experts to provide
  - Models easy to learn, update, and customize
- Example learning algorithms
  - Relevance Feedback, Decision Trees, Naïve Bayes, Bayes Nets, Support Vector Machines (SVMs)
- Text representation
  - Large vector of features (words, phrases, hand-crafted)

Support Vector Machine

- Optimization Problem
  - Find hyperplane, h, separating positive and negative examples
  - Optimization for maximum margin: $\min \|\vec{w}\|^2, \vec{w}\cdot\vec{x}-b \geq 1, \vec{w}\cdot\vec{x}-b \leq -1$
  - Classify new items using: $f(\vec{w}\cdot\vec{x})$



Reuters Data Set (21578 - ModApte split)

- 9603 training articles; 3299 test articles
- Example "interest" article

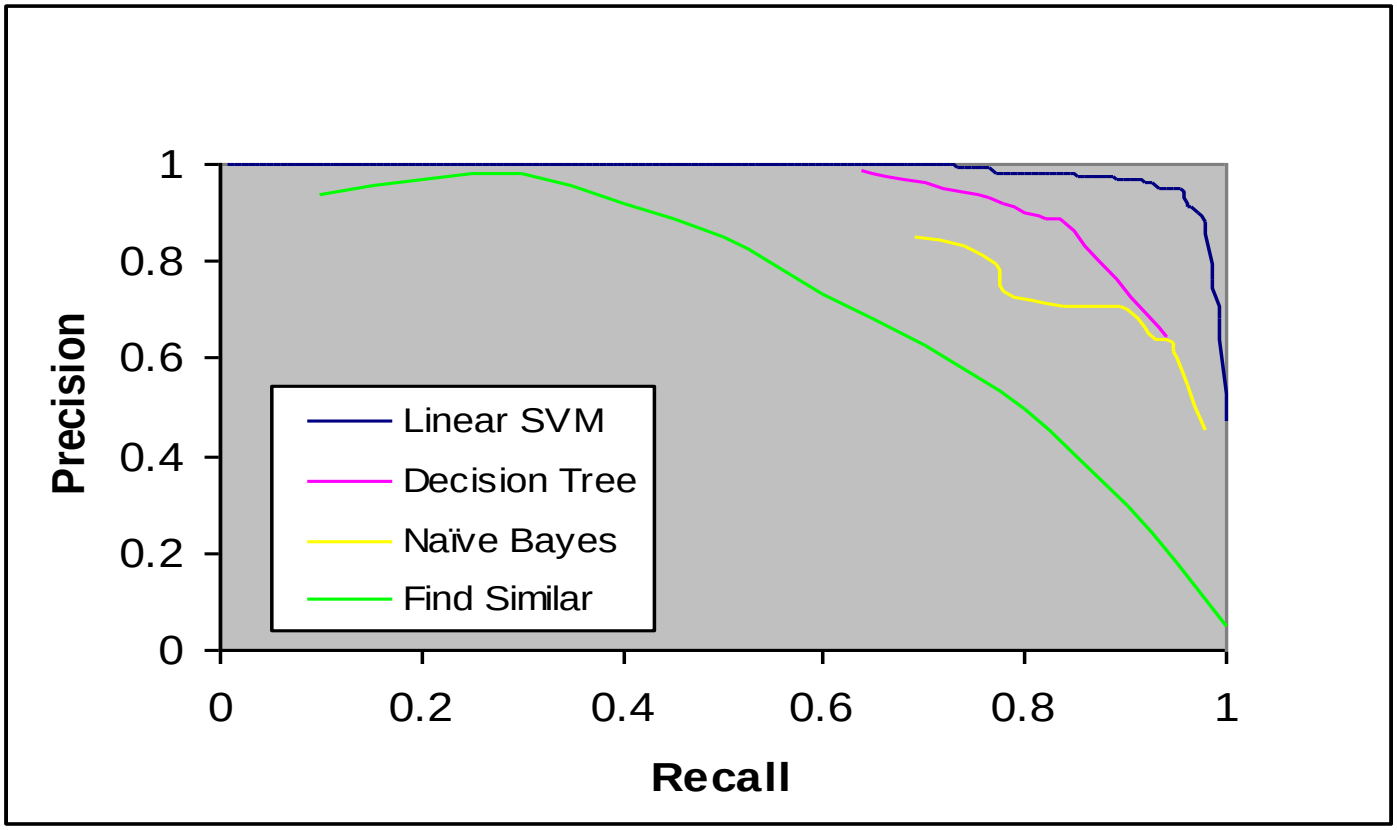
  2-APR-1987 06:35:19.50
  west-germany
  b f BC-BUNDESBANK-LEAVES-CRE 04-02 0052
  FRANKFURT, March 2
  The Bundesbank left credit policies unchanged after today's regular meeting of its council, a spokesman said in answer to enquiries. The West German discount rate remains at 3.0 pct, and the Lombard emergency financing rate at 5.0 pct.
  REUTER

- Average article 200 words long

Example: Reuters news

- 118 categories (article can be in more than one category)
- Most common categories (#train, #test)
  - Earn (2877, 1087)
  - Acquisitions (1650, 179)
  - Money-fx (538, 179)
  - Grain (433, 149)
  - Crude (389, 189)
  - Trade (369,119)
  - Interest (347, 131)
  - Ship (197, 89)
  - Wheat (212, 71)
  - Corn (182, 56)
- Overall Results
  - Linear SVM most accurate: 87% precision at 87% recall

ROC for Category - Grain



Recall: % labeled in category among those stories that are really in category

Precision: % really in category among those stories labeled in category

Text Categ Summary

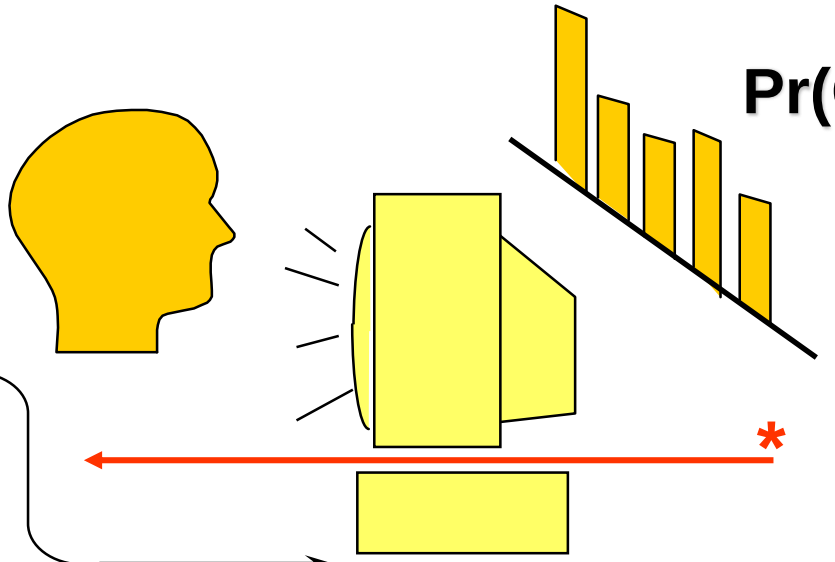
- Accurate classifiers can be learned automatically from training examples
- Linear SVMs are efficient and provide very good classification accuracy
- Widely applicable, flexible, and adaptable representations
  - Email spam/no-spam, Web, Medical abstracts, TREC

Beyond Content Matching

- Domain/Object modeling
  - A priori importance
  - Text classification and clustering
- User/Task modeling
  - → Implicit queries and Lumiere
- Advances in presentation and manipulation
  - → Combining structure and search (e.g., DM)

Lumiere

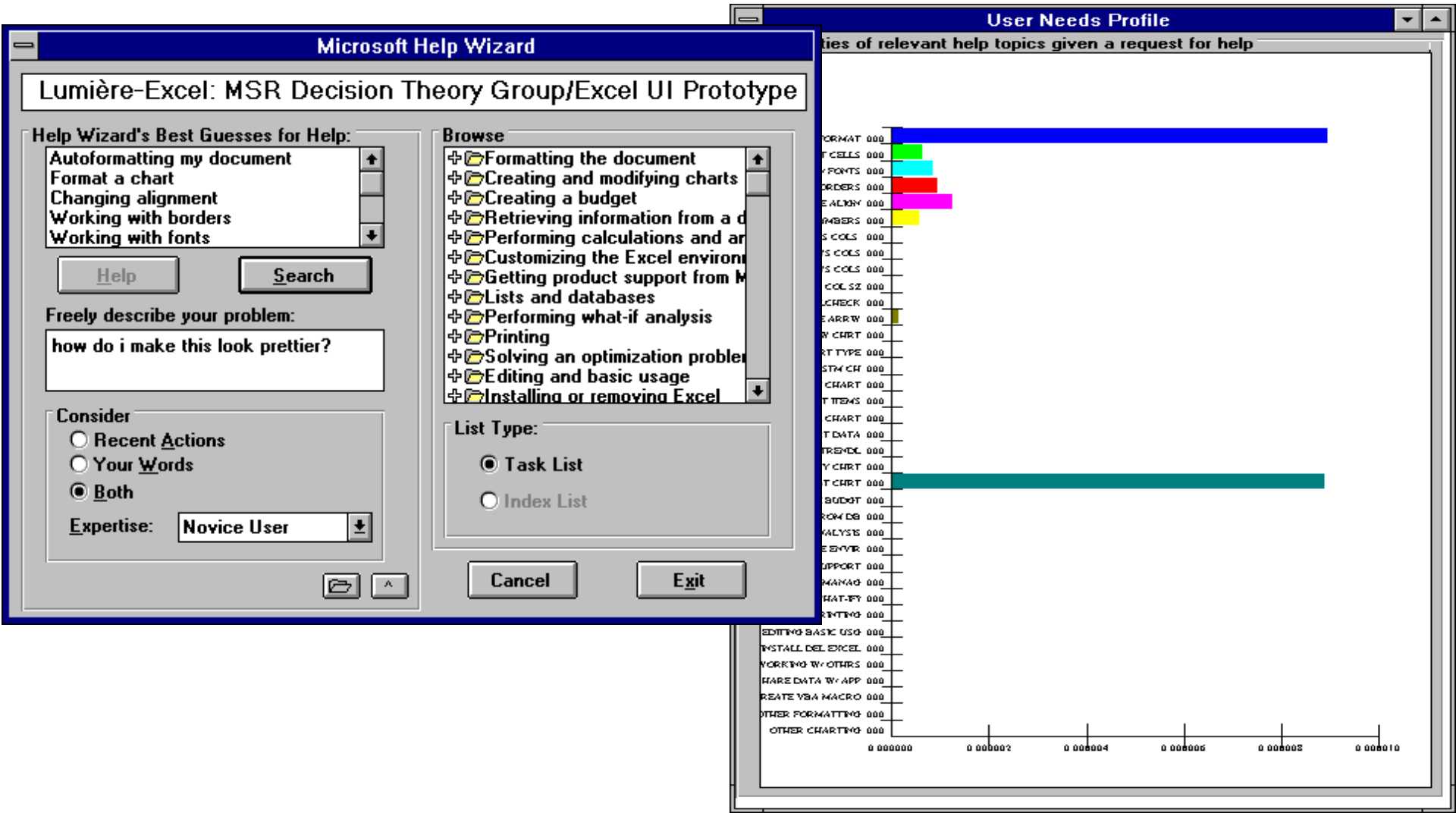
- **Inferring beliefs about user's goals and ideal actions under uncertainty**



- User query
- User activity
- User profile
- Data structures

E. Horvitz, et al.

Lumiere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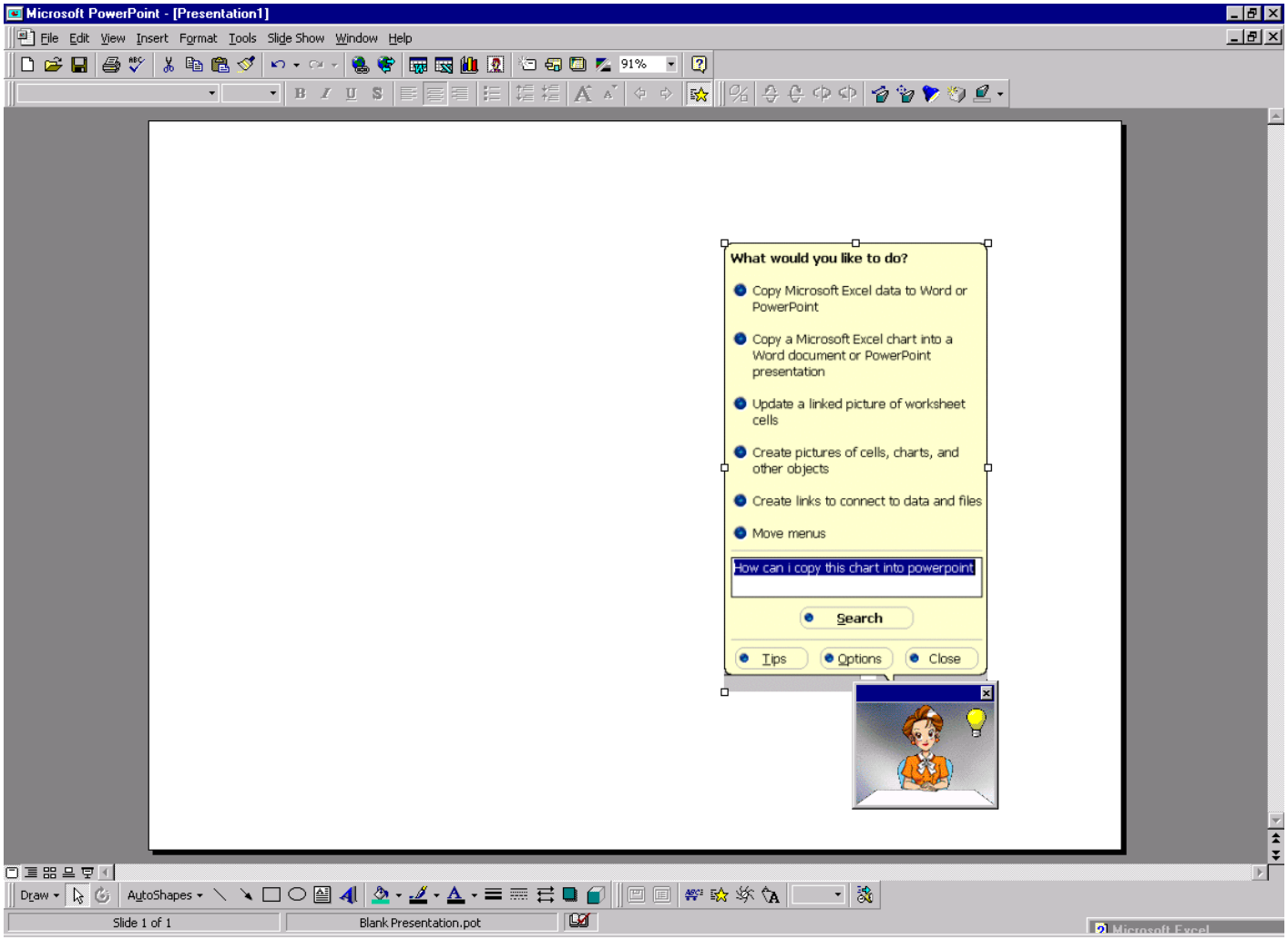
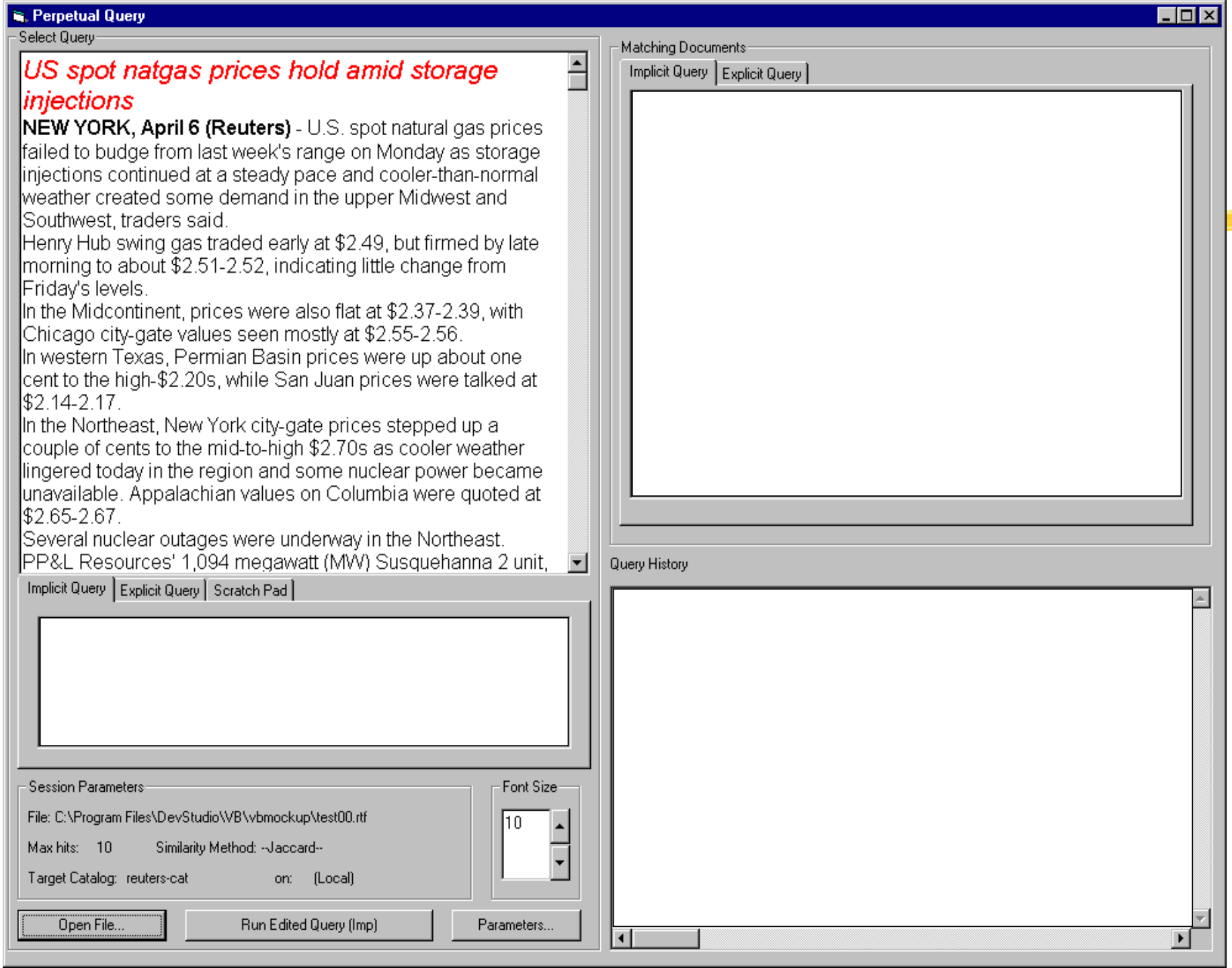
Lumiere ➡ Office Assistant



Visualizing Implicit Queries

- Explicit queries:
  - Search is a separate, discrete task
  - Results not well integrated into larger task context
- **Implicit queries**:
  - Search as part of normal information flow
  - Ongoing query formulation based on user activities
  - Non-intrusive results display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Select Query
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NEW YORK, April 6 (Reuters) - U.S. spot natural gas prices failed to budge from last week's range on Monday as storage injections continued at a steady pace and cooler-than-normal weather created some demand in the upper Midwest and Southwest, traders said.
Henry Hub swing gas traded early at $2.49, but firmed by late morning to about $2.51-2.52, indicating little change from Friday's levels.
In the Midcontinent, prices were also flat at $2.37-2.39, with Chicago city-gate values seen mostly at $2.55-2.56.
In western Texas, Permian Basin prices were up about one cent to the high-$2.20s, while San Juan prices were talked at $2.14-2.17.
In the Northeast, New York city-gate prices stepped up a couple of cents to the mid-to-high $2.70s as cooler weather lingered today in the region and some nuclear power became unavailable. Appalachian values on Columbia were quoted at $2.65-2.67.
Several nuclear outages were underway in the Northeast. PP&L Resources' 1,094 megawatt (MW) Susquehanna 2 unit,
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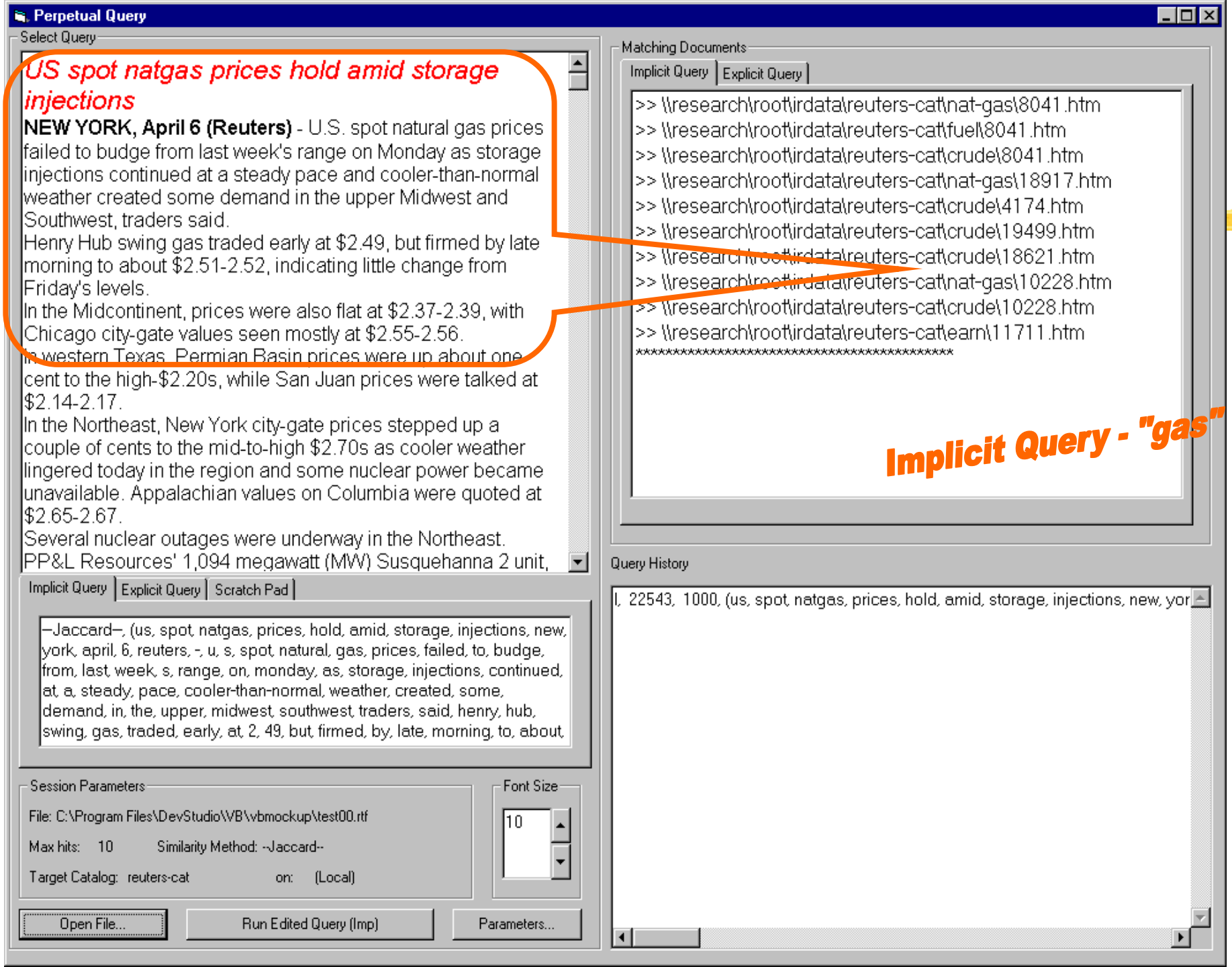
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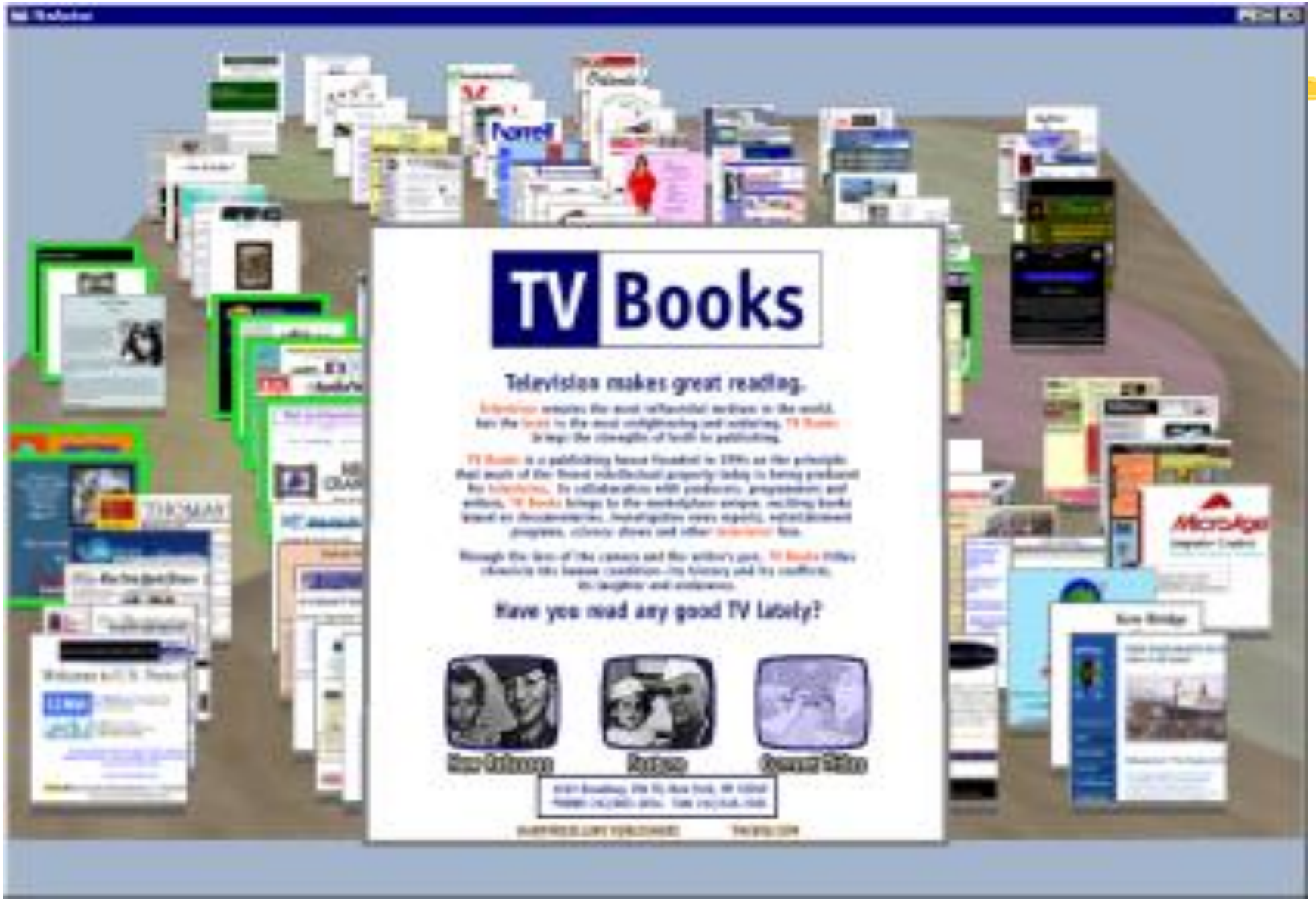
File: C:\Program Files\DevStudio\VB\vbmockup\test00.rtf
Max hits: 10
Similarity Method: --Jaccard--
Target Catalog: reuters-cat
on: (Local)
Font Size
10
Open File...
Run Edited Query (Imp)
Parameters...
Matching Documents
Implicit Query
Explicit Query
>> \\research\root\irdata\reuters-cat\nat-gas\8041.htm
>> \\research\root\irdata\reuters-cat\fuel\8041.htm
>> \\research\root\irdata\reuters-cat\crude\8041.htm
>> \\research\root\irdata\reuters-cat\nat-gas\18917.htm
>> \\research\root\irdata\reuters-cat\crude\4174.htm
>> \\research\root\irdata\reuters-cat\crude\19499.htm
>> \\research\root\irdata\reuters-cat\crude\18621.htm
>> \\research\root\irdata\reuters-cat\nat-gas\10228.htm
>> \\research\root\irdata\reuters-cat\crude\10228.htm
>> \\research\root\irdata\reuters-cat\earn\11711.htm
****
Implicit Query - "gas"
Query History
I, 22543, 1000, (us, spot, natgas, prices, hold, amid, storage, injections, new, yor

Data Mountain with 100 web pages.

Data Mountain with Implicit Query results shown (highlighted pages to left of selected page).



IQ Study: Experimental Details

- Store 100 Web pages
  - 50 popular Web pages; 50 random pages
  - With or without Implicit Query highlighting
    - IQ0: No IQ
    - IQ1: Co-occurrence based IQ - 'best case'
    - IQ2: Content-based IQ
- Retrieve 100 Web pages
  - Title given as retrieval cue -- e.g., "CNN Home Page"
  - No implicit query highlighting at retrieval

Results: Information Storage

- Filing strategies

	Filing Strategy		
IQ Condition	**Semantic**	**Alphabetic**	**No Org**
IQ0: No IQ	11	3	1
IQ1: Co-occur based	8	1	0
IQ2: Content-based	10	1	0

Results: Information Storage

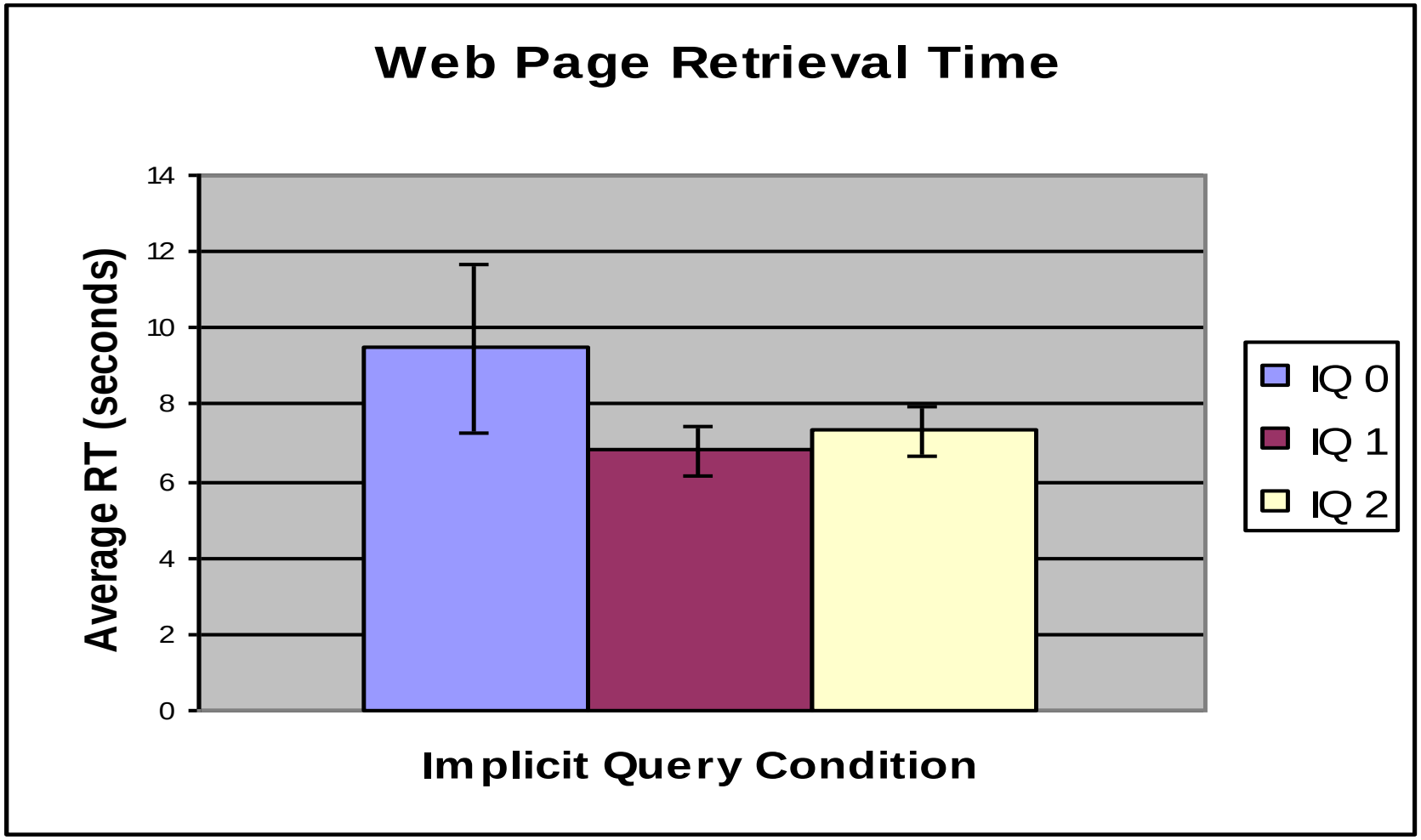
- Number of categories (for semantic organizers)

IQ Condition	Average Number of Categories (std error)
IQ0: No IQ	10.0 (3.6)
IQ1: Co-occur based	15.8 (5.8)
IQ2: Content-based	13.6 (5.9)

7 Categ

23 Categ

Results: Retrieval Time



Results: Retrieval Time

- Large variability across users
  - min: 3.1 secs
  - max: 39.1 secs
- Large variability across queries
  - min: 4.9 secs (*NASA home page*)
  - max: 24.3 secs (*Welcome to Mercury Center*)
- Popularity of Web pages did not matter
  - Top50: 12.9 secs
  - Random50: 12.8 secs

Implicit Query Highlights

- IQ built by observing user's reading behavior
  - No explicit search required
  - Good matches returned
- IQ user model:
  - Combines present context (+ previous interests)
- Results presented in the context of a user-defined organization

Summary

- Improving content-matching
- And, beyond ...
  - Domain/Object Models
  - User/Task Models
  - Information Presentation and Use
- Also ...
  - non-text, multi-lingual, distributed
- http://research.microsoft.com/~sdumais

The View from Wired, May 1996

- *"information retrieval seemed like the easiest place to make progress … information retrieval is really only a problem for people in library science -- if some computer scientists were to put their heads together, they'd probably have it solved before lunchtime" [GS]*