Web Data Management - Some Issues

Properties of Web Data

- Lack of a schema
  - Data is at best "semi-structured"
  - Missing data, additional attributes, "similar" data but not identical
- Volatility
  - Changes frequently
  - May conform to one schema now, but not later
- Scale
  - Does it make sense to talk about a schema for Web?
  - How do you capture "everything"?
- Querying difficulty
  - What is the user language?
  - What are the primitives?
  - Aren't search engines or metasearch engines sufficient?

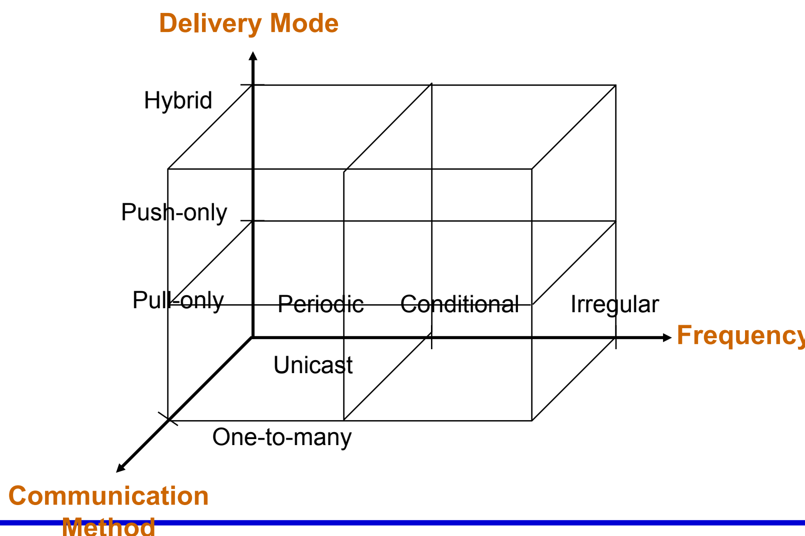
Outline

- Distribution Models
- Modeling Issues
- Web Data Integration
- Web Querying
- Web Caching

Data Delivery on the Internet

- Properties of information supply
  - It is very large in volume
  - It is highly heterogeneous
  - May not have a properly defined schema
  - Data available from too many devices and in streaming fashion
    - Data stream systems
- Properties of information consumption
  - It is data intensive
    - Use of large data sets is common
  - It requires access to diverse data sources
    - Existing databases and/or repositories must somehow be "glued" together
    - Application integration

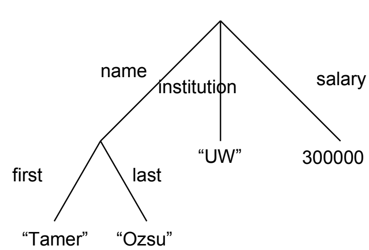
Data Delivery Alternatives



Web Data Modeling

- Can't depend on a strict schema to structure the data
- Data are self-descriptive

  {name: {first:"Tamer", last: "Ozsu"}, institution: "University of Waterloo", salary: 300000}
- Usually represented as an edge-labeled graph
  - XML can also be modeled this way



Web Data Integration

- What is being integrated?
- Integration or interoperation?
- More flexible architectures
  - Barriers to joining and leaving federations should be minimum
  - Participants should be able to maintain their own environments as much as possible
  - Application as well as data integration
- Role of XML
  - “Data model”
  - Exchange format
- Flexible operation
  - Ability to deal with data inconsistencies as well as schema inconsistencies
  - Systems should be able to deal with failures and incomplete federations

Approaches to Web Querying

- Search engines and metasearchers
  - Keyword-based
  - Category-based
- Information integration
- Semistructured data querying
- Special Web query languages
- Learning-based systems
- Question-Answering

Information Integration

- Basic principle: Integrate part of the Web data into a database as either virtual or materialized views and query over these views
- Example systems:
  - Information Manifold [Levy et al., 1996]
  - Araneus [Atzeni et al., 1997]
  - WSQ/DSQ [Goldman & Widom, 2000]

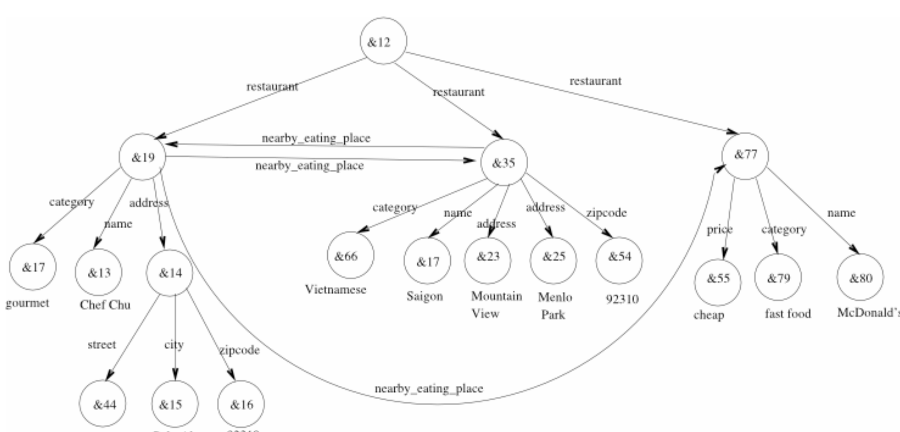
Evaluation

- Advantages
  - Well-understood
  - Well-known database techniques can be brought to bear
- Disadvantages
  - Not querying the *entire* Web; more querying some data on the Web
  - Does not scale well; integration methodology should be low overhead

Semistructured Data Querying

- Basic principle: Consider Web as a collection of semistructured data and use those techniques
- Uses an edge-labeled graph model of data
- Example systems & languages:
  - Lore/Lorel [Abiteboul et al., 1997]
  - UnQL [Buneman et al., 1996]
  - StruQL [Fernandez et al., 1997]

Lorel Example



Select zip codes of all cheap restaurants

```
Select Guide.restaurant(.address)?.zipcode
Where Guide.restaurant.% grep "cheap"
```

Evaluation

- Advantages
  - Simple and flexible
  - Fits the natural link structure of Web pages
- Disadvantages
  - Data model too simple (no record construct or ordered lists)
  - Graph can become very complicated
    - Aggregation and typing combined
    - DataGuides
  - No differentiation between connection between documents and subpart relationships

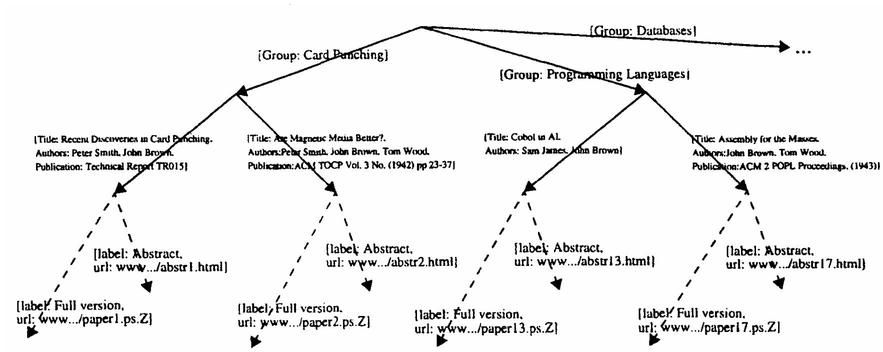
Web Query Languages

- Basic principle: Take into account the documents' content and internal structure as well as external links
- The graph structures are more complex
- Examples
  - WebSQL [Mendelzon et al., 1996]
  - W3QS [Kanopnicki & Shmueli, 1995]
  - WebLog [Lakshmanan et al., 1993]
  - WebOQL [Arocena & Mendelzon, 1999]
  - StruQL [Fernandez et al., 1997]

First Generation (WebSQL, W3QS, WebLog)

Second Generation (WebOQL, StruQL)

WebOQL Example



Find, in the csPapers database, all the papers authored by “Smith” and extract their title and URL of the full version of the papers.

```
select [y.Title, y'.Url]
from x in csPapers, y in x'
where y.Authors ~ ``Smith''
```


Evaluation

- Advantages
  - More powerful data model - Hypertree
    - Ordered edge-labeled tree
    - Internal and external arcs
  - Language can exploit different arc types (structure of the Web pages can be accessed)
  - Languages can construct new complex structures.
- Disadvantages
  - You still need to know the graph structure
  - Complexity issue

Learning-Based Approaches

- Basic principle: Learn what the user's intent is from the query and find the data
- Some based on NLP, others metasearch systems; agent technology and mining-based
- Examples:
  - InfoSpider [Menczer & Below, 1998]
  - WebWatcher [Joachims & Freitag, 1997]
  - Fab [Balabanovic, 1997]
  - Syskill & Webert [Pazzani et al., 1996]
  - WebSifter II [Kerschberg et al., 2001]

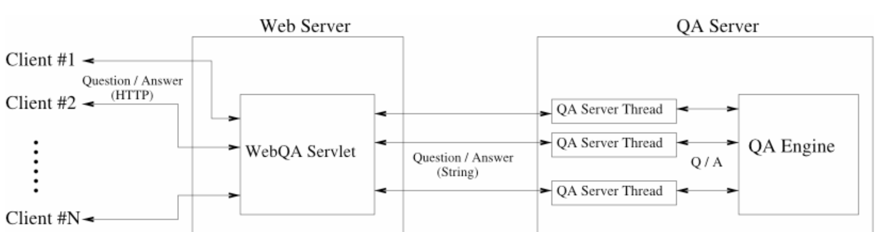
Question-Answer Approach

- Basic principle: Web pages that could contain the answer to the user query are retrieved and the answer *extracted* from them.
- NLP and information extraction techniques
- Used within IR in a closed corpus; extensions to Web
- Examples
  - QASM [Radev et al., 2001]
  - Ask Jeeves
  - Mulder [Kwok et al, 2001]
  - WebQA [Lam & Özsu, 2002]

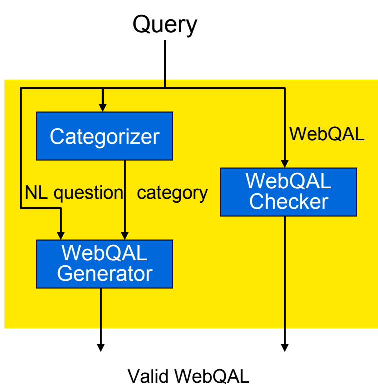
WebQA Objectives

- Query the *entire* Web
- Return actual answers, not URLs
- Scale with additional data sources
- Accept fuzziness (precision/recall)
- Do not depend on existence of a schema

Interaction with Web Server

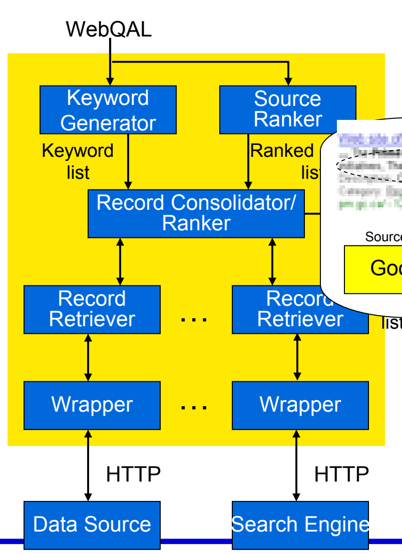


Query Parser

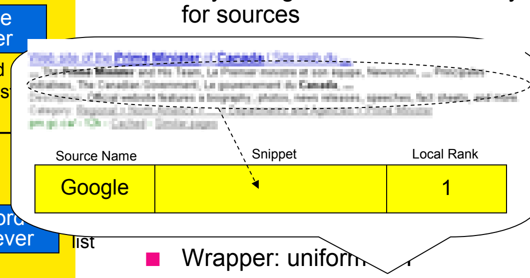


- Query can be NL or WebQAL (internal language)
  - <Category> [-output <output option>] -keywords <keyword list>
- Elimination of stopwords
- Categorization
  - Name
  - Place
  - Time
  - Quantity
  - Abbreviation
  - Weather
  - Other
- Very light weight NLP
  - Rule-based
  - Only categorization
  - 99% accurate on TREC-9 questions

Summary Retriever



- Keyword generator: a set of keywords for sources



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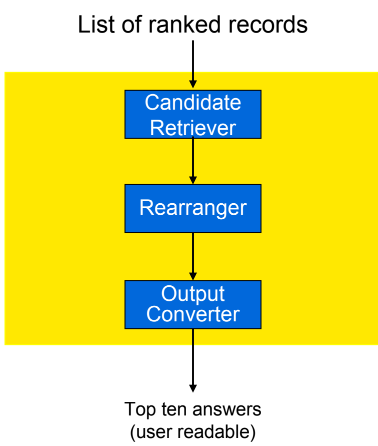
- Wrapper: uniform
  - Submit
  - Next

Answer Extraction



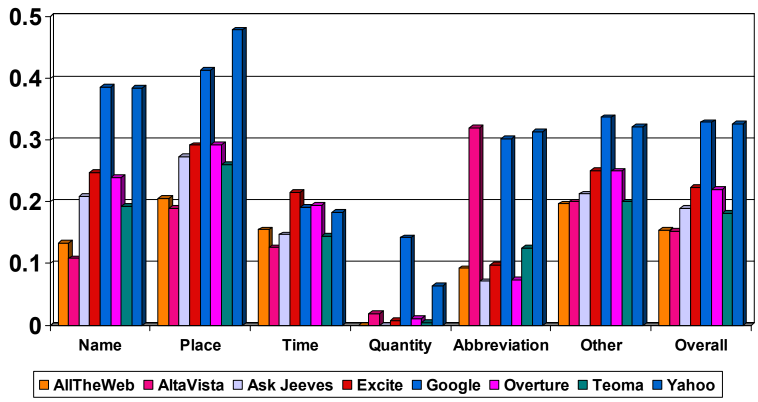
- Candidate identification
  - Rule-based based on the category
  - Candidates are scored based on frequency of occurrence in records
- Rearranger takes care of anomalies
  - Score(Bell) > Score(Alexander Graham Bell)

Evaluation

- Using TREC-9
  - List of 693 questions and a list of documents
  - Answers should be 50-byte or 250-byte passage, not exact answers
  - Ranked score between 0 (worst) and 1 (best)
    - Score = 1/*n* where *n* is the rank of the correct answer
- Two measures
  - Accuracy
  - Efficiency

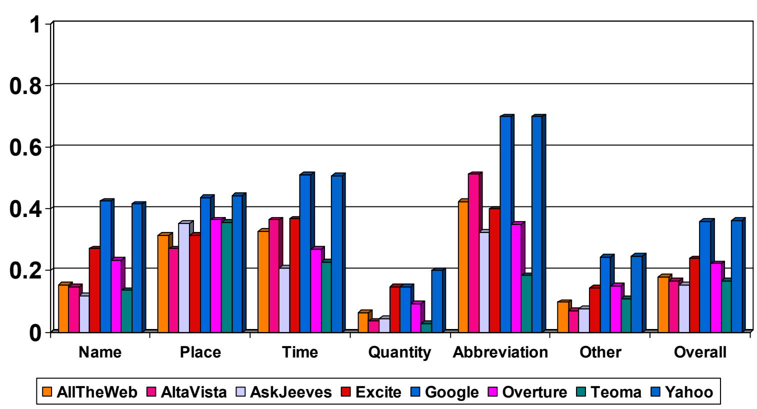
Experiment 1

- Run TREC-9 queries directly against the search engines



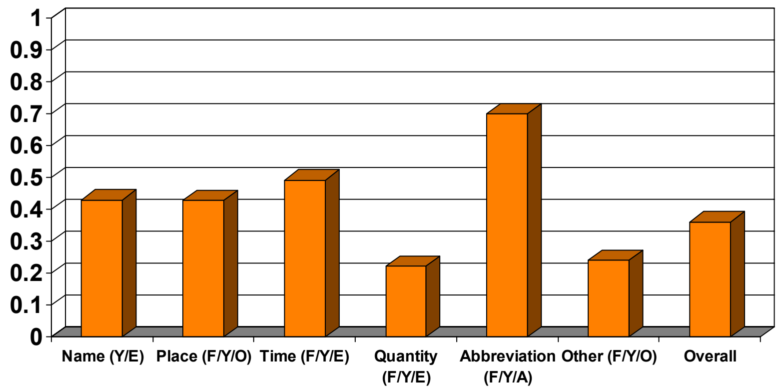
Experiment 2

- Run TREC-9 queries through WebQA; use CIA Fact Book 2001 as secondary

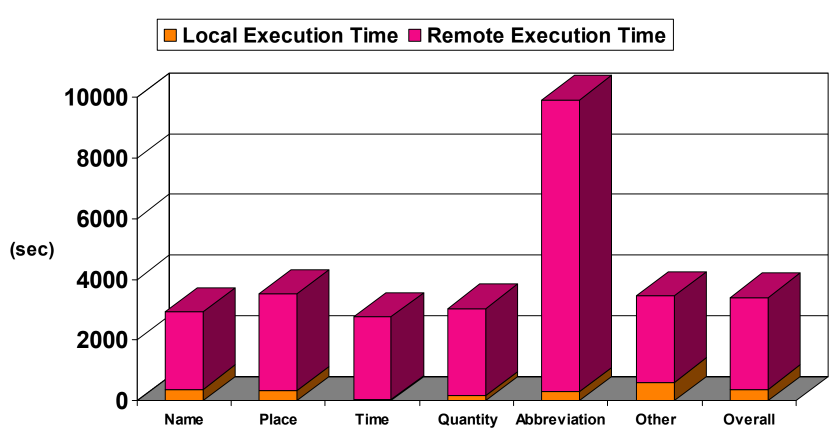


Experiment 3

- Run TREC-9 queries using best combination



WebQA Performance



Web Caching

- Storing objects at places through which a users request passes.
  - browser cache, proxy cache, server cache
- Merits of Web caching:
  - reduces network traffic
  - reduces client latency
  - reduces server load
- Caching architectures
  - With respect to location
  - Hierarchical, distributed
- Cache consistency issues
  - Weak cache consistency algorithms
  - Strong cache consistency algorithms

Classification

	Client-Validation	Server Invalidation	C/S Interaction
Strong	Polling-every-time	Invalidation	Lease
Weak	TTL,PCV	PSI	N/A

Why Strong Consistency ? Motivating Examples

- Online Shopping Store
- Travel Tickets Reservation
- Stock Quotes
- Online Auction