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?

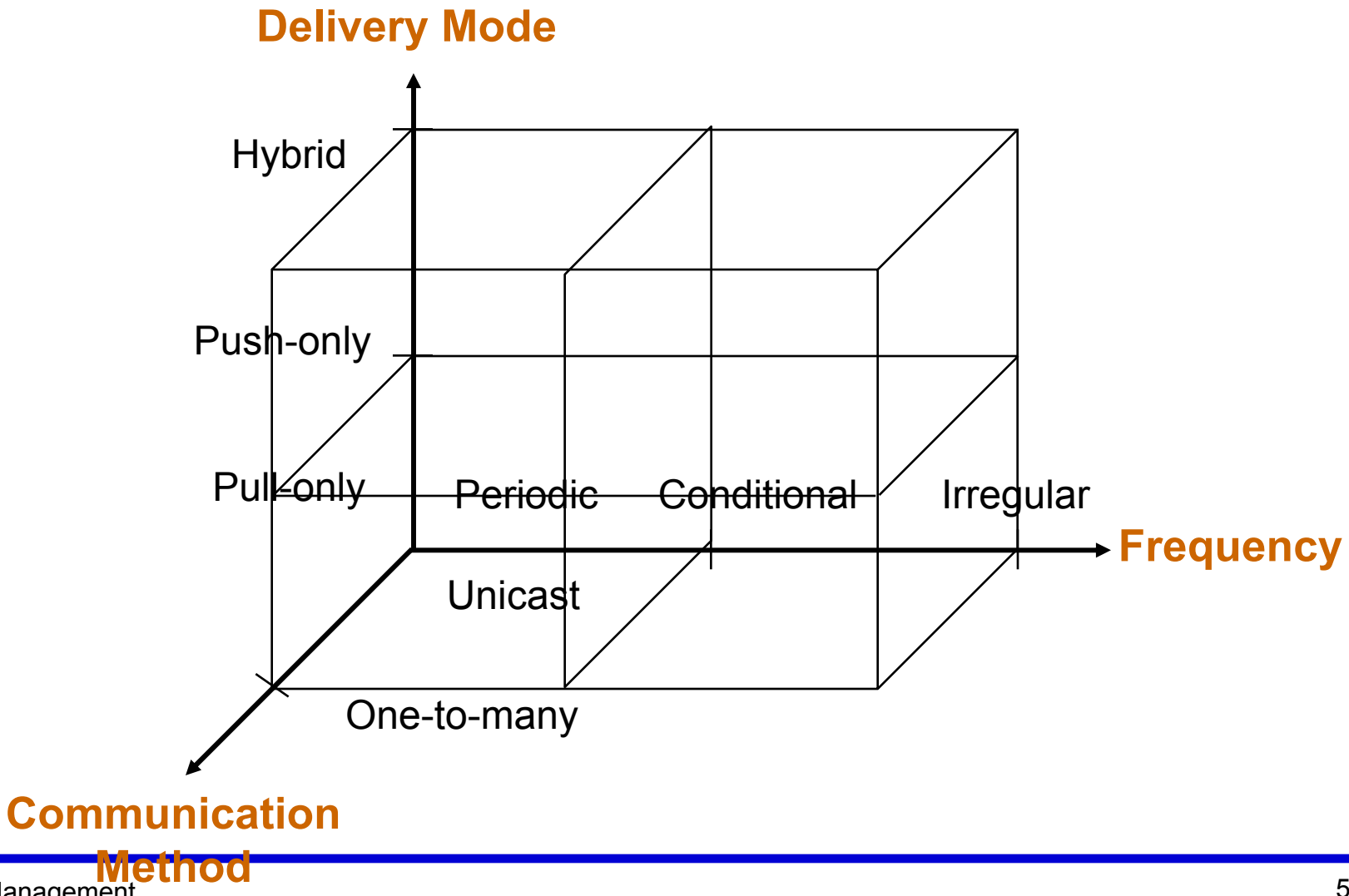
Outline

- 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

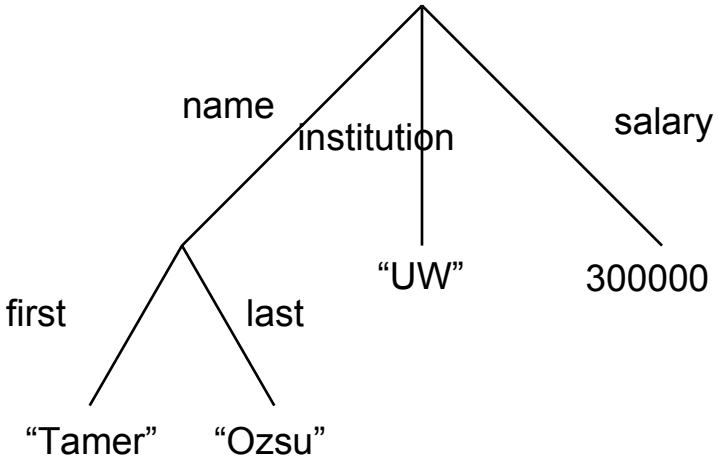
Data Delivery Alternatives



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]

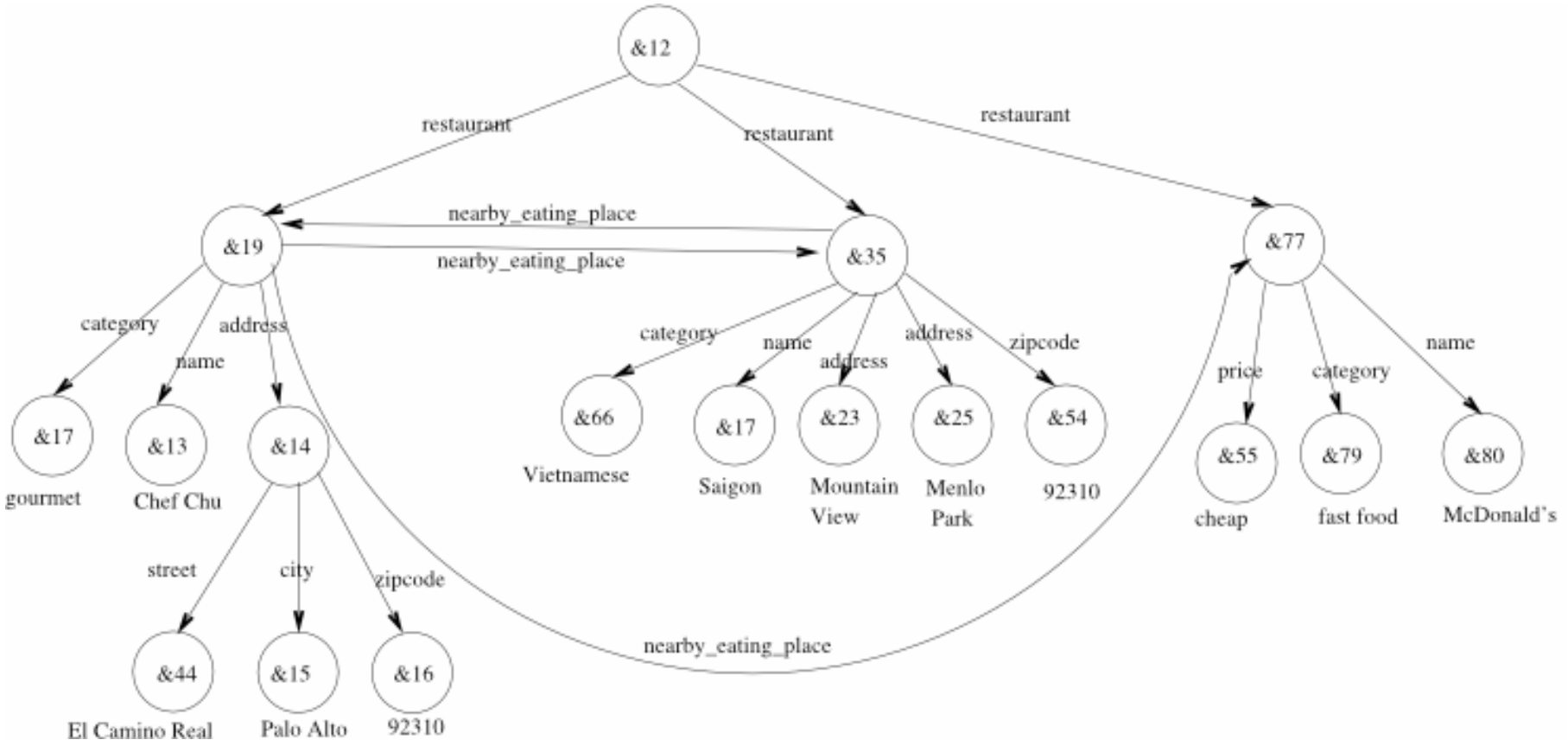
Evaluation

- 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

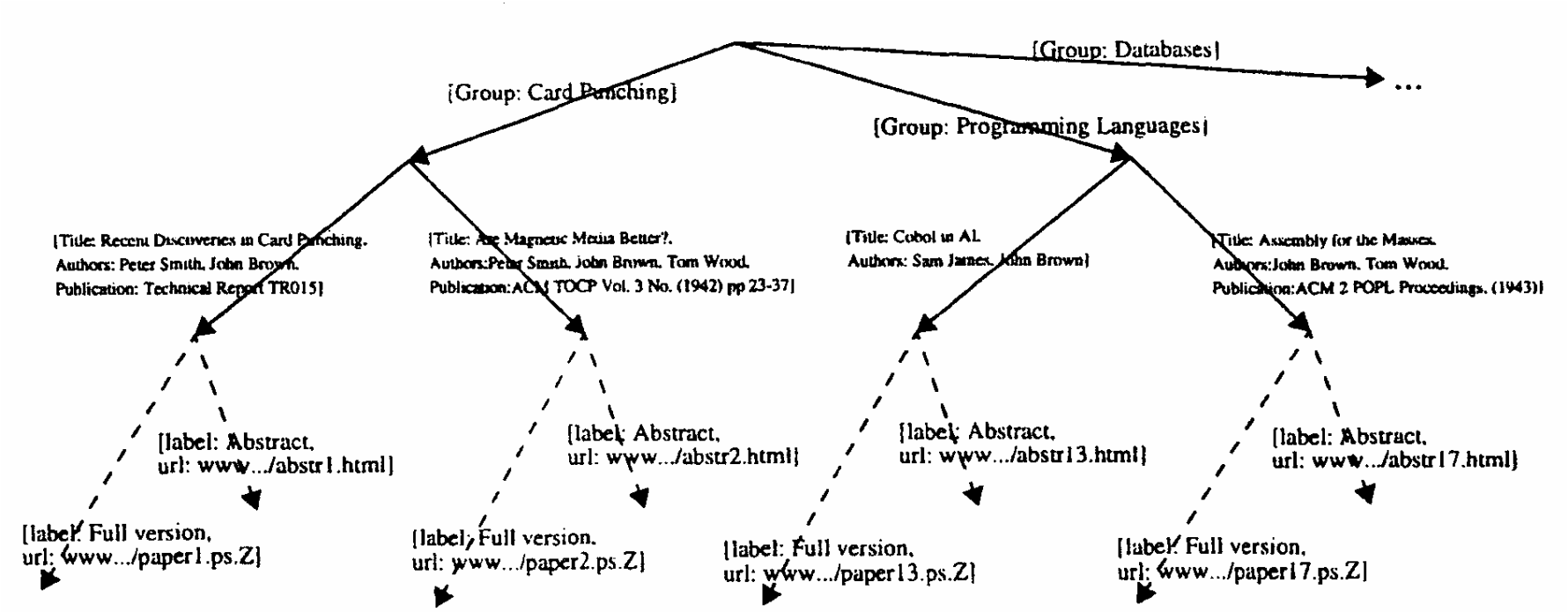
Web Query Languages

- 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

Second Generation

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]

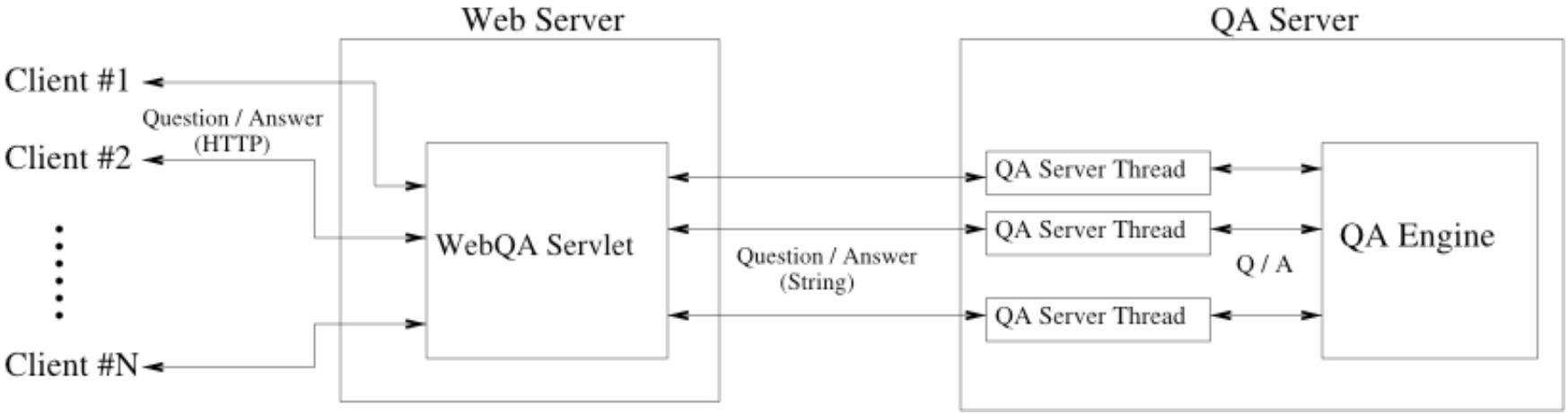
Question-Answer Approach

- 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]

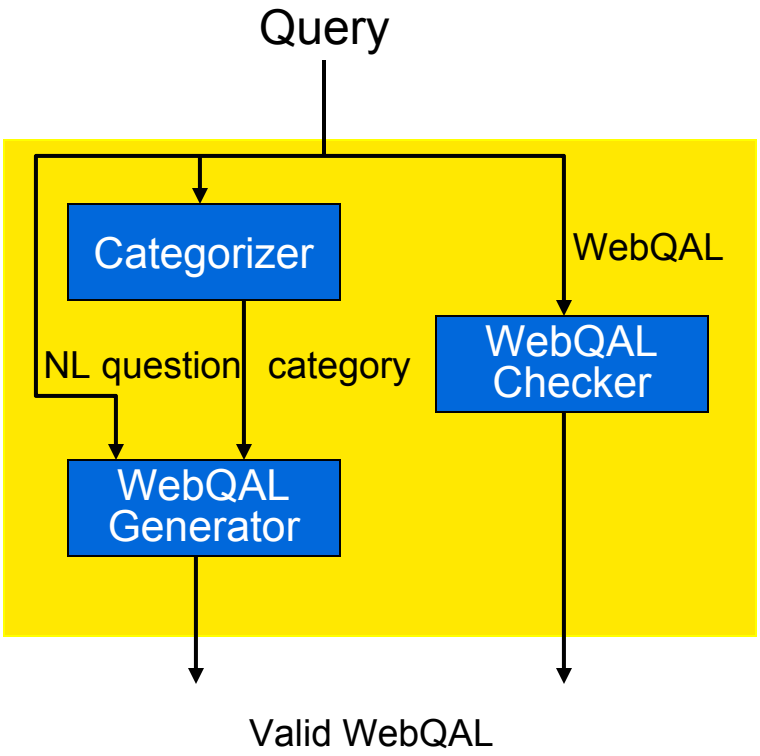
WebQA Objectives

- 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

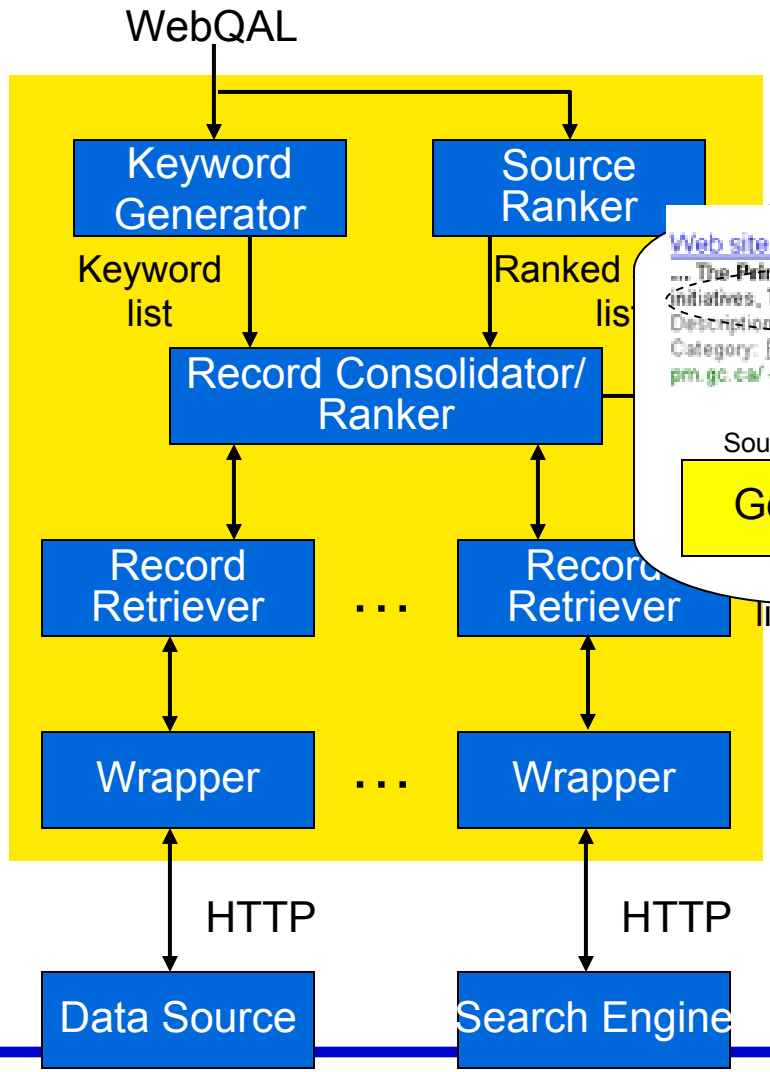


Query Parser

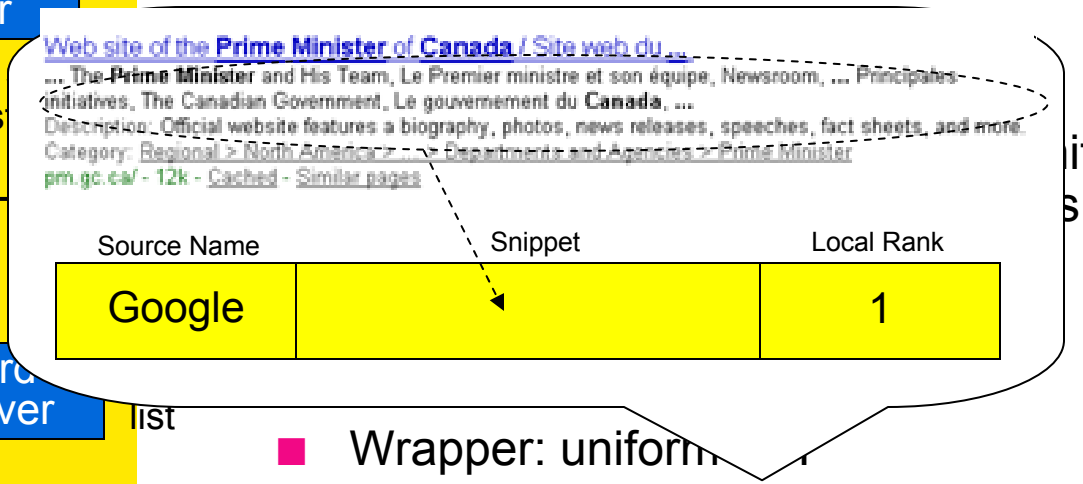


- Query can be NL or WebQAL (internal language)
  - <Category> [-output <output option>] -keywords <keyword list>
- Elimination of stopwords
- Categorization
  - Name
  - Place
  - Time
  - Quantity
  - Abbreviation
  - Weather
  - Other
- Very light weight NLP
  - Rule-based
  - Only categorization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

Summary Retriever

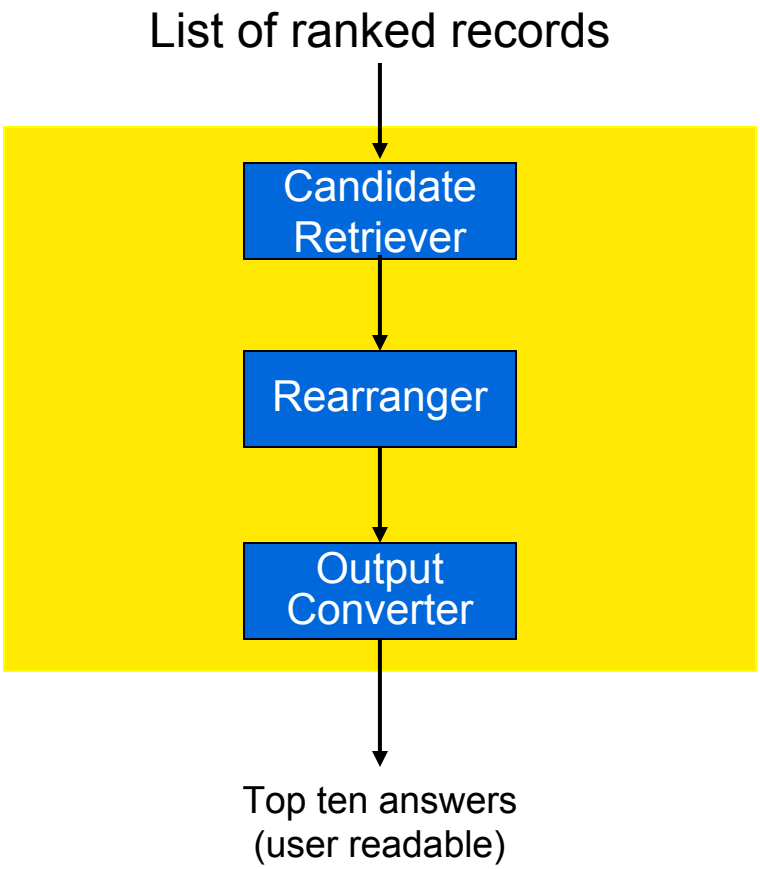


- Keyword generator: a set of keywords for sources



- Wrapper: uniform
  - Submit
  - Next

Answer Extraction



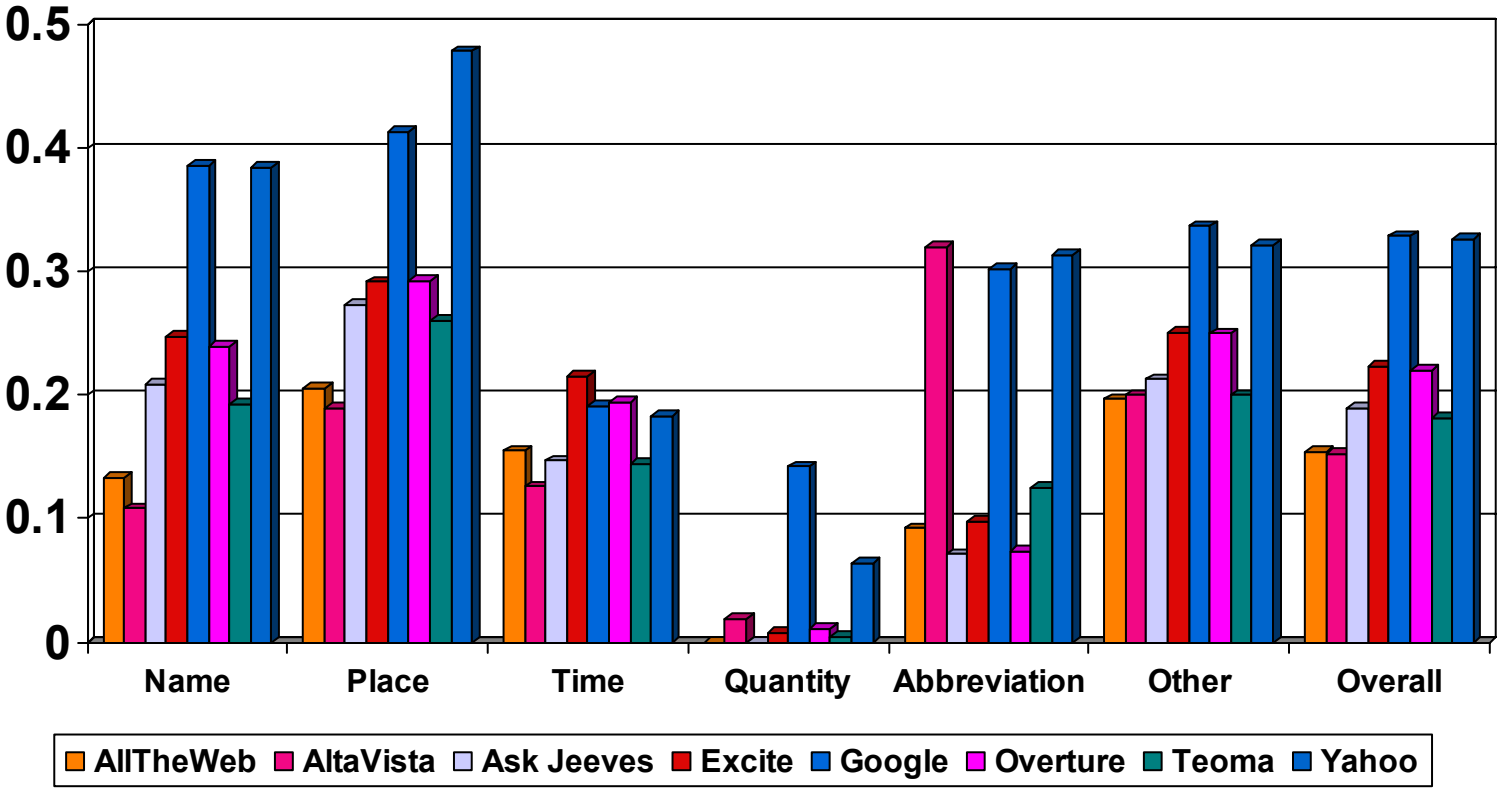
- Candidate identification
  - Rule-based based on the category
  - Candidates are scored based on frequency of occurrence in records
- Rearranger takes care of anomalies
  - Score(Bell) > Score(Alexander Graham Bell)

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

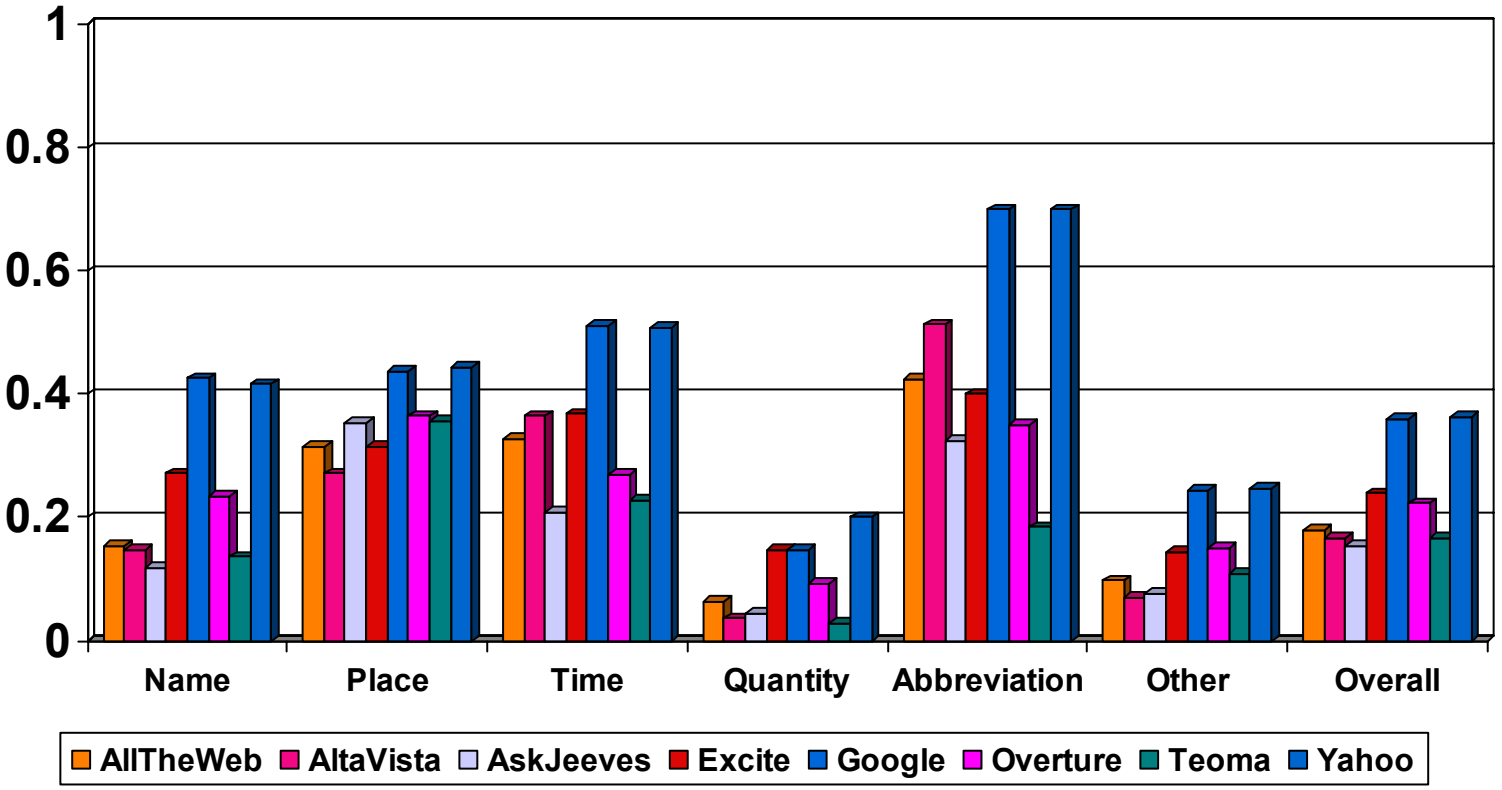
Experiment 1

- Run TREC-9 queries directly against the search engines



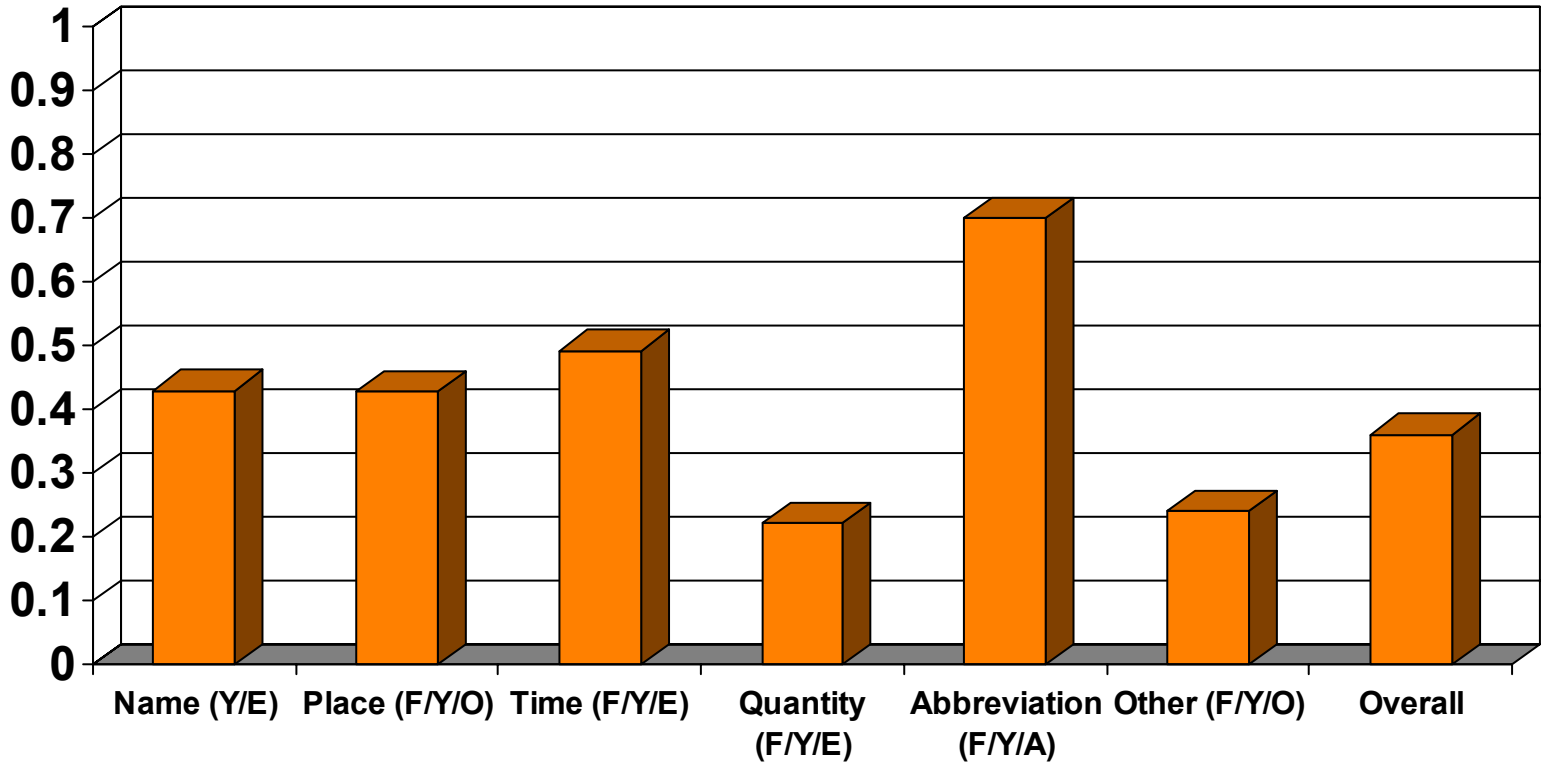
Experiment 2

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

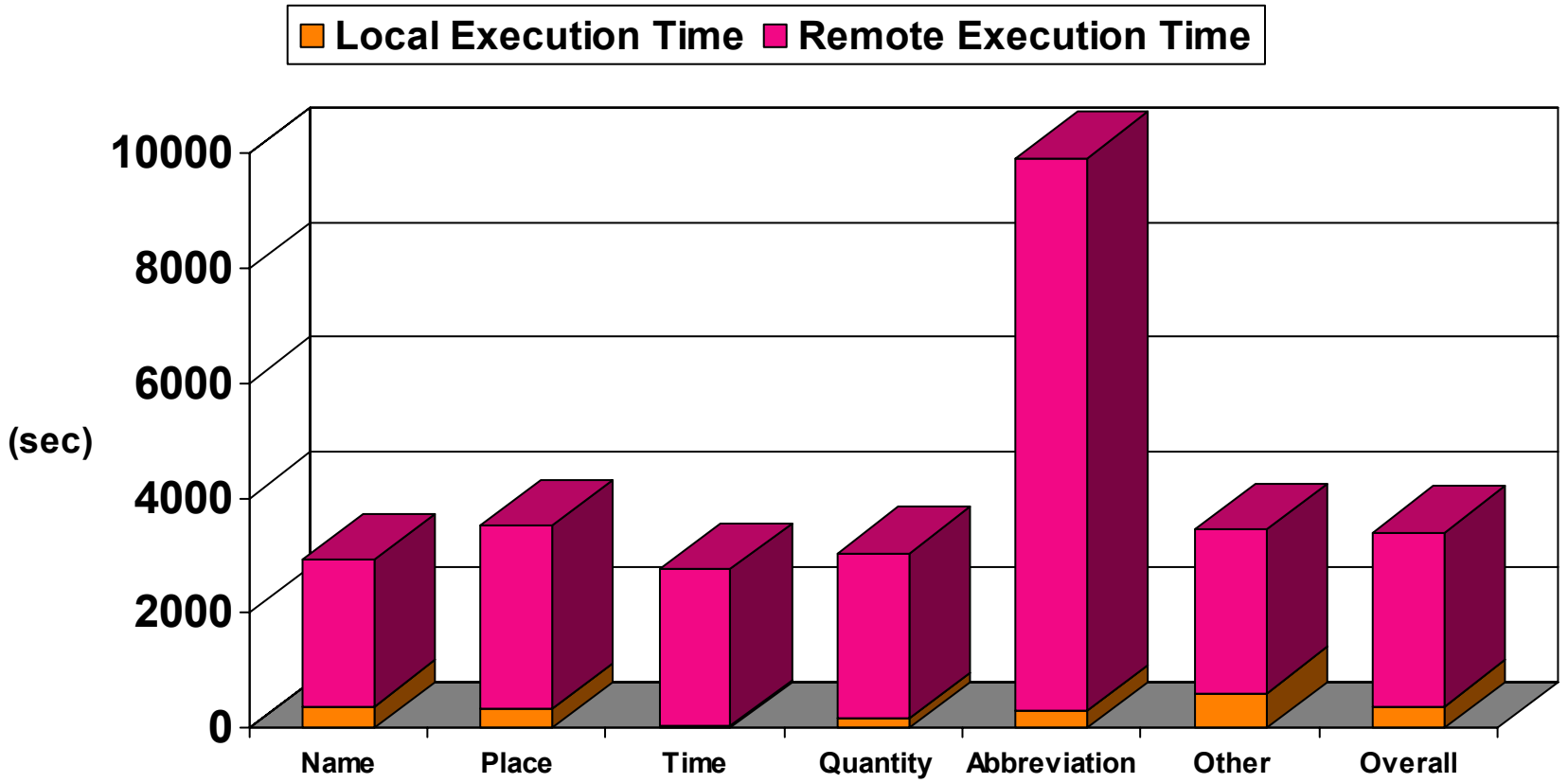


Experiment 3

- 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