Chapter 4 Webpage Information Extraction

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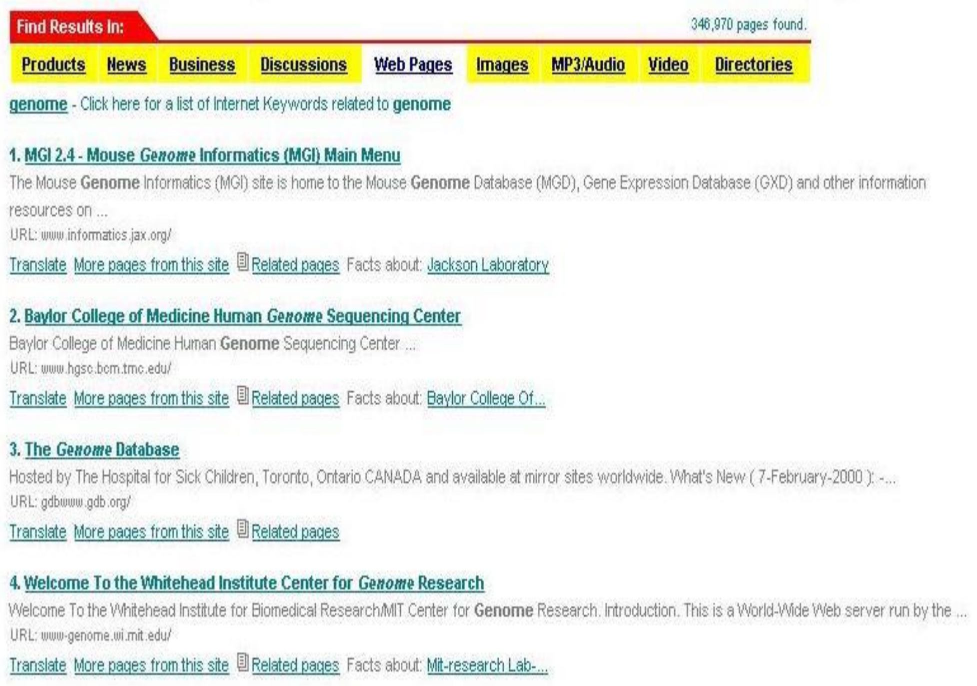
Contents

- Overview of Information Extraction tools from Web pages
- Wrapper Induction
- Wrapper Maintenance

Two kinds of webpages

- Multiple-record page extraction (left)
- One-record page extraction (right)



346,970 pages found.

genome - Click here for a list of Internet Keywords related to **genome**

1. MGI 2.4 - Mouse *Genome* Informatics (MGI) Main Menu
The Mouse **Genome** Informatics (MGI) site is home to the Mouse **Genome** Database (MGD), Gene Expression Database (GXD) and other information resources on ...
URL: www.informatics.jax.org/
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2. Baylor College of Medicine Human *Genome* Sequencing Center
Baylor College of Medicine Human **Genome** Sequencing Center ...
URL: www.hgsc.bcm.tmc.edu/
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3. The *Genome* Database
Hosted by The Hospital for Sick Children, Toronto, Ontario CANADA and available at mirror sites worldwide. What's New (7-February-2000): -...
URL: gdbwww.gdb.org/
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4. Welcome To the Whitehead Institute Center for *Genome* Research
Welcome To the Whitehead Institute for Biomedical Research/MIT Center for **Genome** Research. Introduction. This is a World-Wide Web server run by the ...
URL: www-genome.wi.mit.edu/
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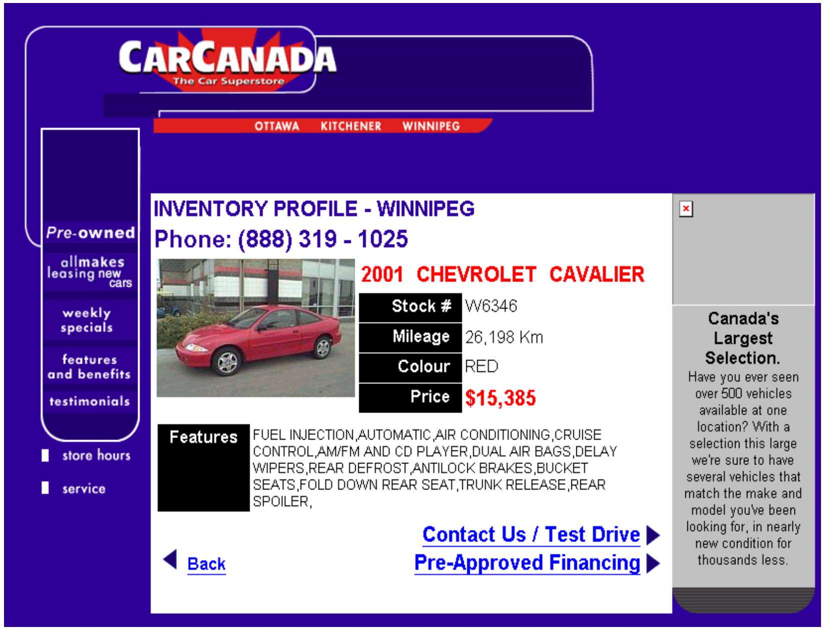

INVENTORY PROFILE - WINNIPEG
Phone: (888) 319 - 1025

2001 CHEVROLET CAVALIER

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Colour	RED
Price	$15,385
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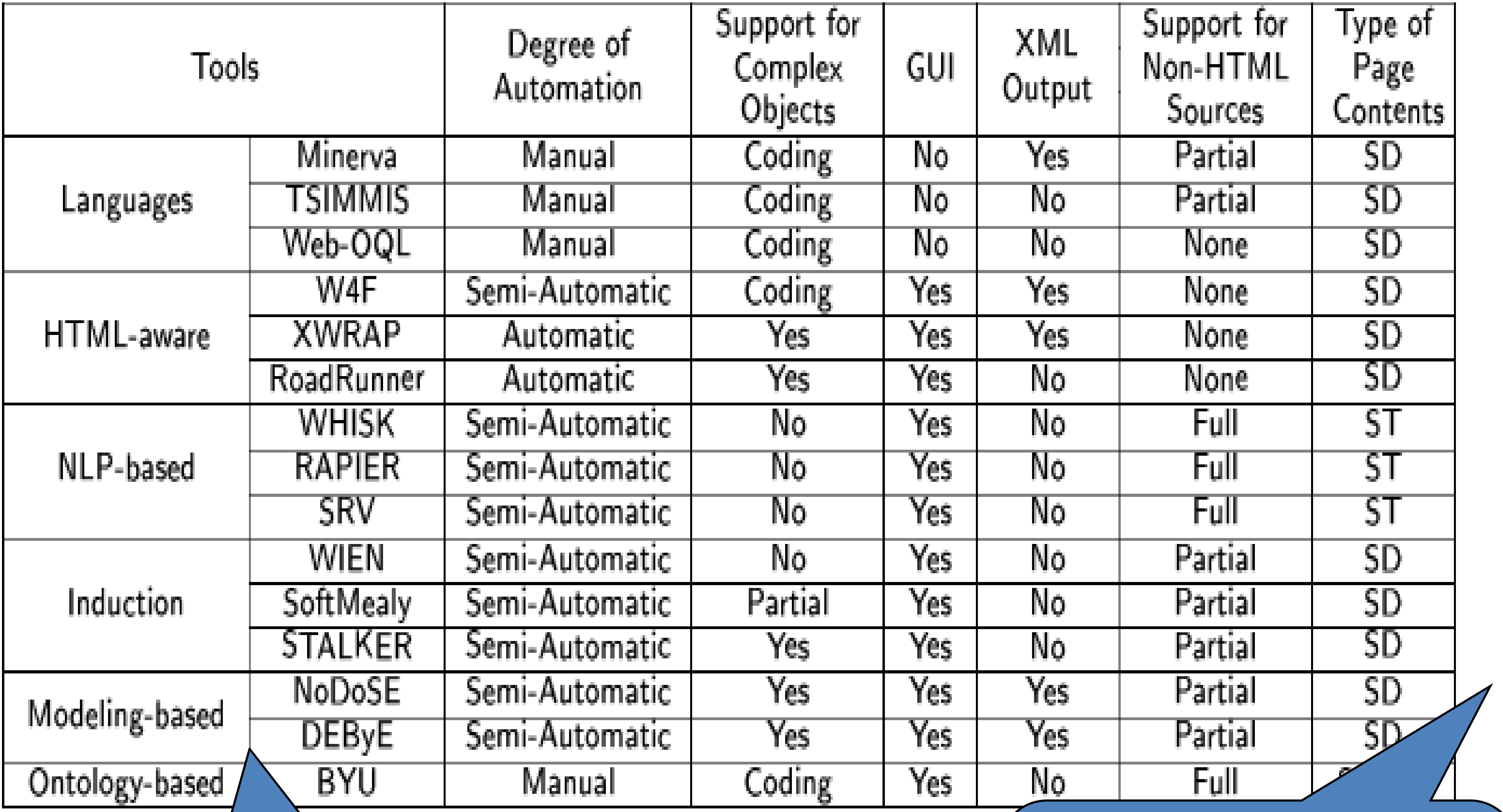
Have you ever seen over 500 vehicles available at one location? With a selection this large we're sure to have several vehicles that match the make and model you've been looking for, in nearly new condition for thousands less.



Tools		Degree of Automation	Support for Complex Objects	GUI	XML Output	Support for Non-HTML Sources	Type of Page Contents
Languages	Minerva	Manual	Coding	No	Yes	Partial	SD
	TSIMMIS	Manual	Coding	No	No	Partial	SD
	Web-OQL	Manual	Coding	No	No	None	SD
HTML-aware	W4F	Semi-Automatic	Coding	Yes	Yes	None	SD
	XWRAP	Automatic	Yes	Yes	Yes	None	SD
	RoadRunner	Automatic	Yes	Yes	No	None	SD
NLP-based	WHISK	Semi-Automatic	No	Yes	No	Full	ST
	RAPIER	Semi-Automatic	No	Yes	No	Full	ST
	SRV	Semi-Automatic	No	Yes	No	Full	ST
Induction	WIEN	Semi-Automatic	No	Yes	No	Partial	SD
	SoftMealy	Semi-Automatic	Partial	Yes	No	Partial	SD
	STALKER	Semi-Automatic	Yes	Yes	No	Partial	SD
Modeling-based	NoDoSE	Semi-Automatic	Yes	Yes	Yes	Partial	SD
	DEByE	Semi-Automatic	Yes	Yes	Yes	Partial	SD
Ontology-based	BYU	Manual	Coding	Yes	No	Full	[illegible]

Summary of the Qualitative A

Methods of extraction pages

SD:semi-structured data
ST:semi-structured text

lecture of Internet-based IE technolgies

Language for wrapper development—for manually constructed IE systems

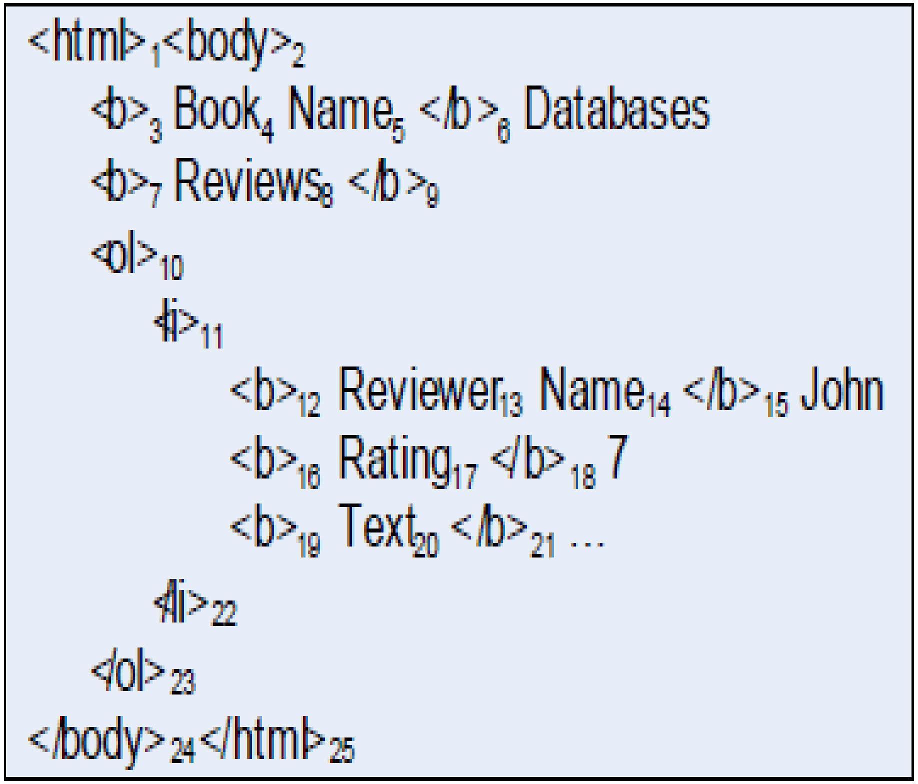
Minerva: combines a declarative grammar-based approach with features typical of procedural programming languages.

Tsimmis: includes wrappers that can be configured through specification files written by the user.

Web-OQL: originally aimed at performing SQL-like queries over the Web.

Web-OQL

- **Hypertrees are arc-lableled ordered trees.**



<html>$_1$<body>$_2$

<b>$_3$ Book$_4$ Name$_5$ </b>$_6$ Databases

<b>$_7$ Reviews$_8$ </b>$_9$

<ol>$_{10}$

<li>$_{11}$

<b>$_{12}$ Reviewer$_{13}$ Name$_{14}$ </b>$_{15}$ John

<b>$_{16}$ Rating$_{17}$ </b>$_{18}$ 7

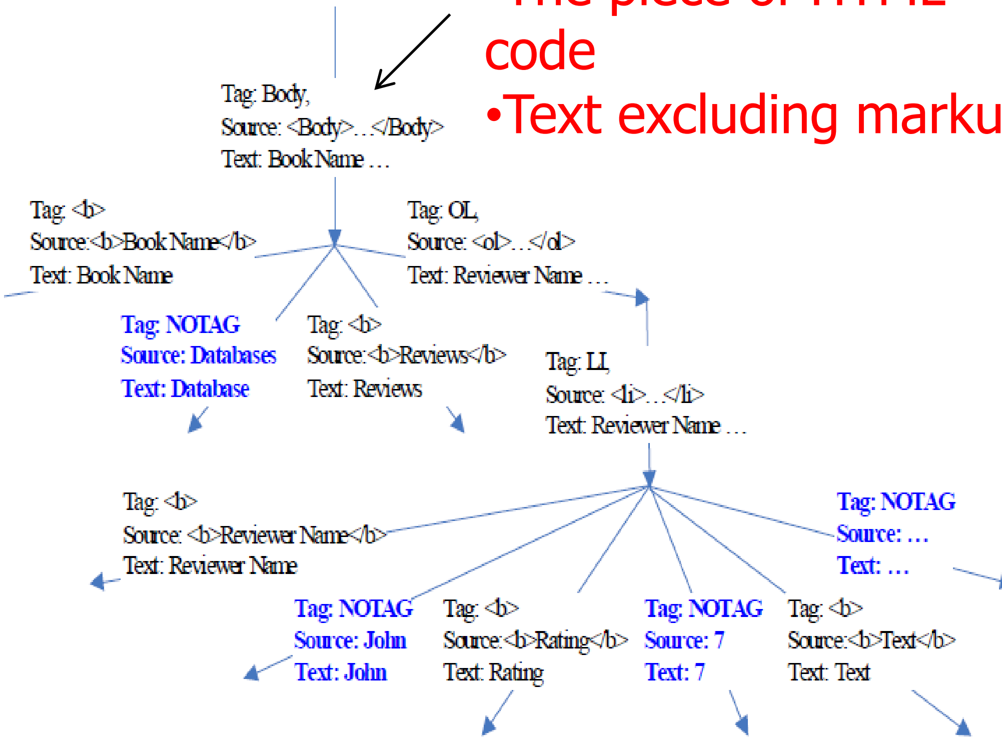
<b>$_{19}$ Text$_{20}$ </b>$_{21}$ …

</li>$_{22}$

</ol>$_{23}$

</body>$_{24}$</html>$_{25}$

- Tag name
- The piece of HTML code
- Text excluding marku



Tag: Body,
Source: <Body>…</Body>
Text: Book Name …

Tag: <b>
Source:<b>Book Name</b>
Text: Book Name

Tag: OL,
Source: <ol>…</ol>
Text: Reviewer Name …

Tag: NOTAG
Source: Databases
Text: Database

Tag: <b>
Source:<b>Reviews</b>
Text: Reviews

Tag: LI,
Source: <li>…</li>
Text: Reviewer Name …

Tag: <b>
Source: <b>Reviewer Name</b>
Text: Reviewer Name

Tag: NOTAG
Source: …
Text: …

Tag: NOTAG
Source: John
Text: John

Tag: <b>
Source:<b>Rating</b>
Text: Rating

Tag: NOTAG
Source: 7
Text: 7

Tag: <b>
Source:<b>Text</b>
Text: Text

Web-OQL (cont.)

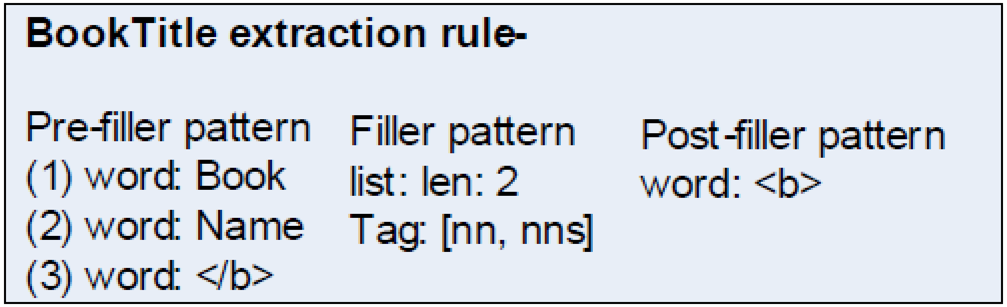
- Query: extracts the reviewer names "Jeff" and "Jane" from page *pe2*。

Overview of Web data extraction tools (cont.)

- **HTML-aware Tools**
- W4F(world wide web wrapper factory): a toolkit for building wrappers.
- XWRAP: a component library that provides basic building blocks for wrapper development.
- **NLP-based tools**

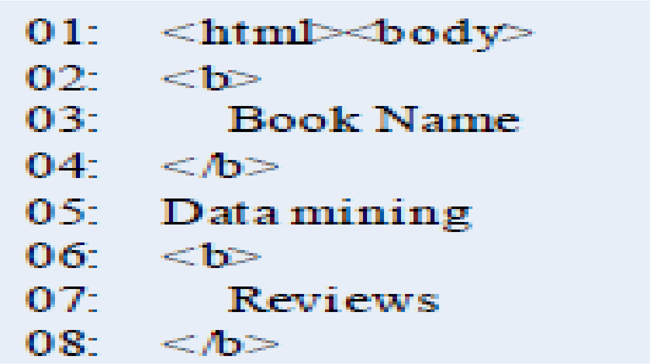
PAPIER (job posting), SRV, WHISK: suitable for Web pages consisting of grammatical text, such as job listings, apartment rental advertisements, seminar announcements.

NLP based tools: PAPIER



BookTitle extraction rule-

Pre-filler pattern	Filler pattern	Post-filler pattern
(1) word: Book	list: len: 2	word: <b>
(2) word: Name	Tag: [nn, nns]	
(3) word: </b>		



```
<html><body>
<b>
   Book Name
</b>
Data mining
<b>
   Reviews
</b>
```

- Extraction rule for the book title:

- Preceded by words “Book”, “Name”, and “</b>”
- Followed by the word “<b>”.
- The “Filler pattern” specifies that the title consists of at most two words that were labeled as “nn” or “nns” by the POS tagger (i.e., one or two singular or plural common nouns).

Overview of Web data extraction tools (cont.)

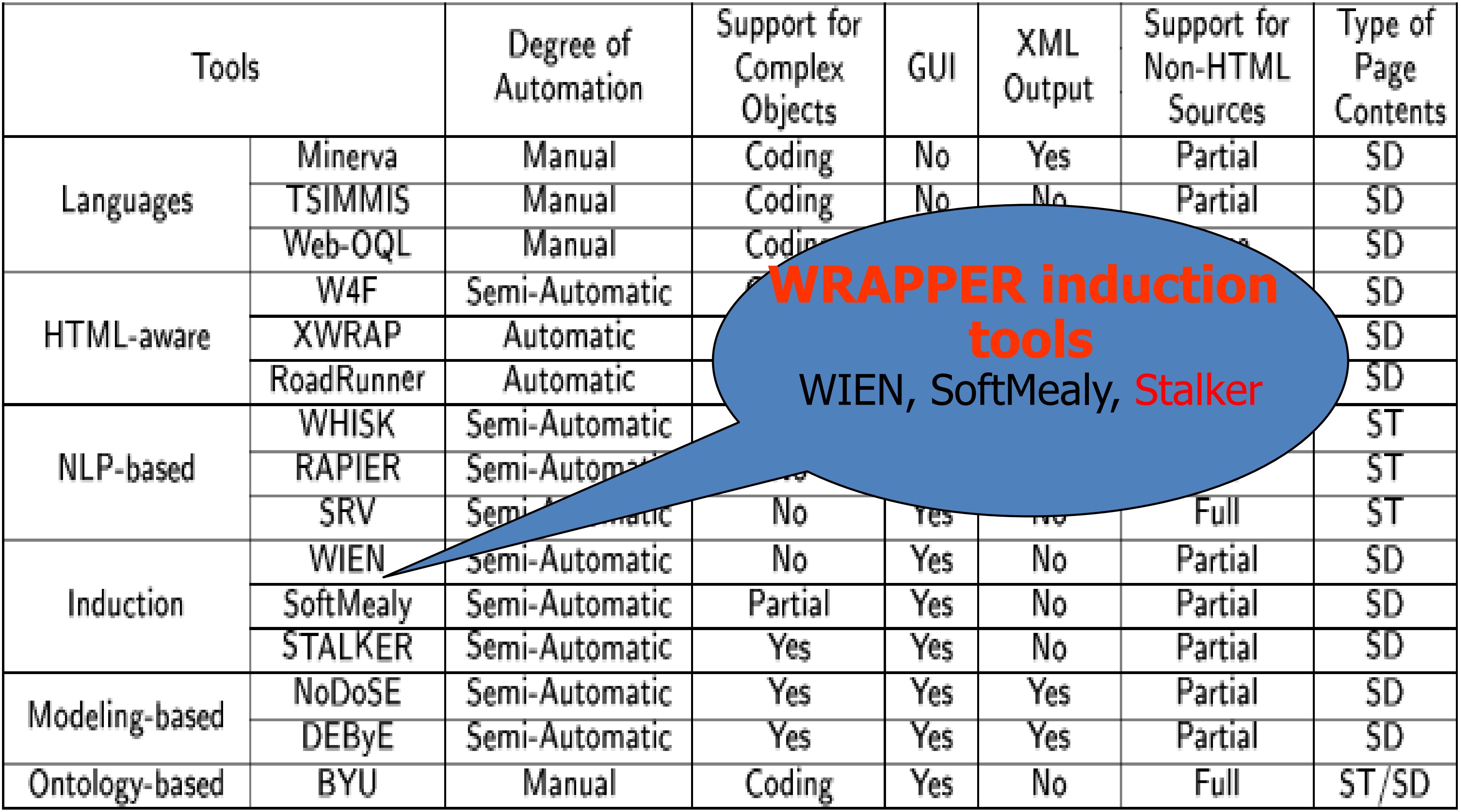
- **Modeling-based Tools**
- NoDoSE: an interactive tool for semi-automatically determining the structure of Web page.

- DEByE: an interactive tool to extract page contents based on a set of example objects.

- **Ontology-based Tools**

Ontologies are previously constructed to describe the data of interest, including relationships, lexical appearance and context keywords.

Overview of Web data extraction tools



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	XWRAP	Automatic	[illegible]	[illegible]	[illegible]	[illegible]	SD
	RoadRunner	Automatic	[illegible]	[illegible]	[illegible]	[illegible]	SD
NLP-based	WHISK	Semi-Automatic	[illegible]	[illegible]	[illegible]	[illegible]	ST
	RAPIER	Semi-Automatic	No	[illegible]	[illegible]	[illegible]	ST
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Induction	WIEN	Semi-Automatic	No	Yes	No	Partial	SD
	SoftMealy	Semi-Automatic	Partial	Yes	No	Partial	SD
	STALKER	Semi-Automatic	Yes	Yes	No	Partial	SD
Modeling-based	NoDoSE	Semi-Automatic	Yes	Yes	Yes	Partial	SD
	DEByE	Semi-Automatic	Yes	Yes	Yes	Partial	SD
Ontology-based	BYU	Manual	Coding	Yes	No	Full	ST/SD

WRAPPER induction tools

WIEN, SoftMealy, Stalker

Table 1: Summary of the Qualitative Analysis

Wrapper Technologies

- What is wrapper
- Wrapper induction
- Wrapper maintenance

What is Wrapper?

- For information integration

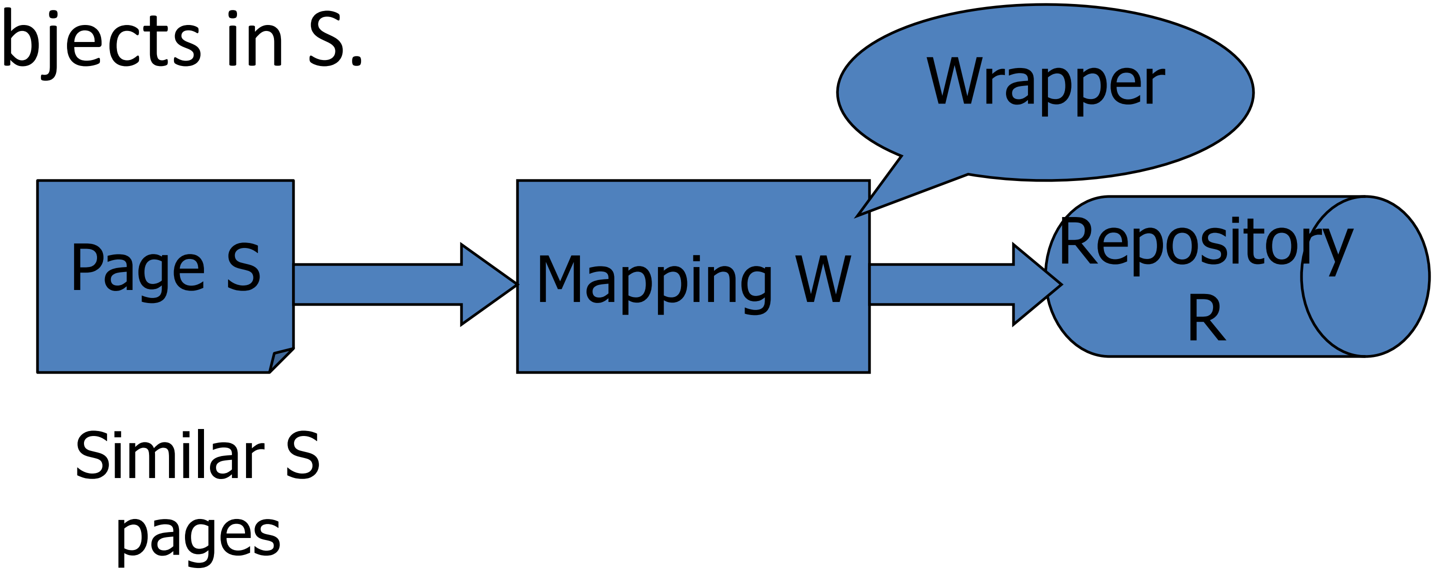
  A procedure that is designed for extracting content of a particular information source and delivering the content of interesting in a self-describing representation (eg.XML)

- For Web application
  - An extracting program to extract desired information from Web pages.

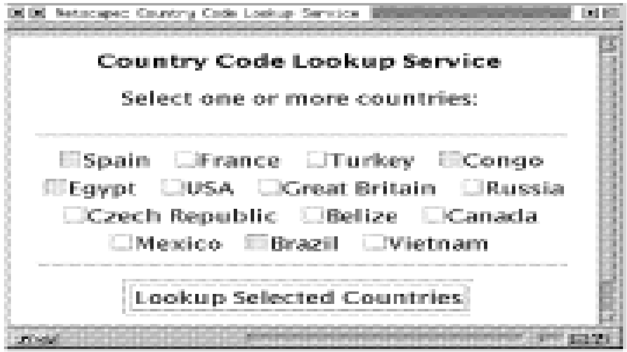
    Semi-Structure Doc.– wrapper→ Structure Info.

For Web Applications:

- Given a Web page S containing a set of implicit objects, determine a mapping W that populates a data repository R with the objects in S.



An example for a wrapper



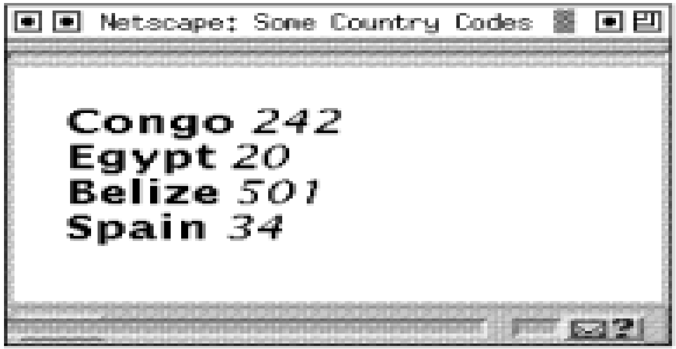
Netscape: Country Code Lookup Service

Country Code Lookup Service

Select one or more countries:

▨Spain □France □Turkey ▨Congo
▨Egypt □USA □Great Britain □Russia
□Czech Republic □Belize □Canada
□Mexico ▨Brazil □Vietnam

(a)



Netscape: Some Country Codes

Congo *242*
Egypt *20*
Belize *501*
Spain *34*

(b)

```
<HTML><TITLE>Some Country Codes</TITLE><BODY>
<B>Congo</B> <I>242</I><BR>
<B>Egypt</B> <I>20</I><BR>
<B>Belize</B> <I>501</I><BR>
<B>Spain</B> <I>34</I><BR>
```

```
procedure ccwrap$_{LR}$(page $P$)
  while there are more occurrences in $P$ of '<B>'
    for each $(\ell_k, r_k) \in \{$('<B>', '</B>'), ('<I>', '</I>')$\}$
      scan in $P$ to next occurrence of $\ell_k$; save position as start of $k$th attribute
      scan in $P$ to next occurrence of $r_k$; save position as end of $k$th attribute
  return extracted $\{\ldots,$ (country, code)$, \ldots\}$ pairs
```

Wrapper Induction

- Web wrappers wrap...
  - "Query-able" or "Search-able" Web sites
  - Web pages with large itemized lists
- The primary issues are:
  - How to build the extractor quickly?
  - Wrapper induction algorithms search a hypothesis space of possible wrapper programs for a wrapper that has high extraction accuracy on a set of training pages.

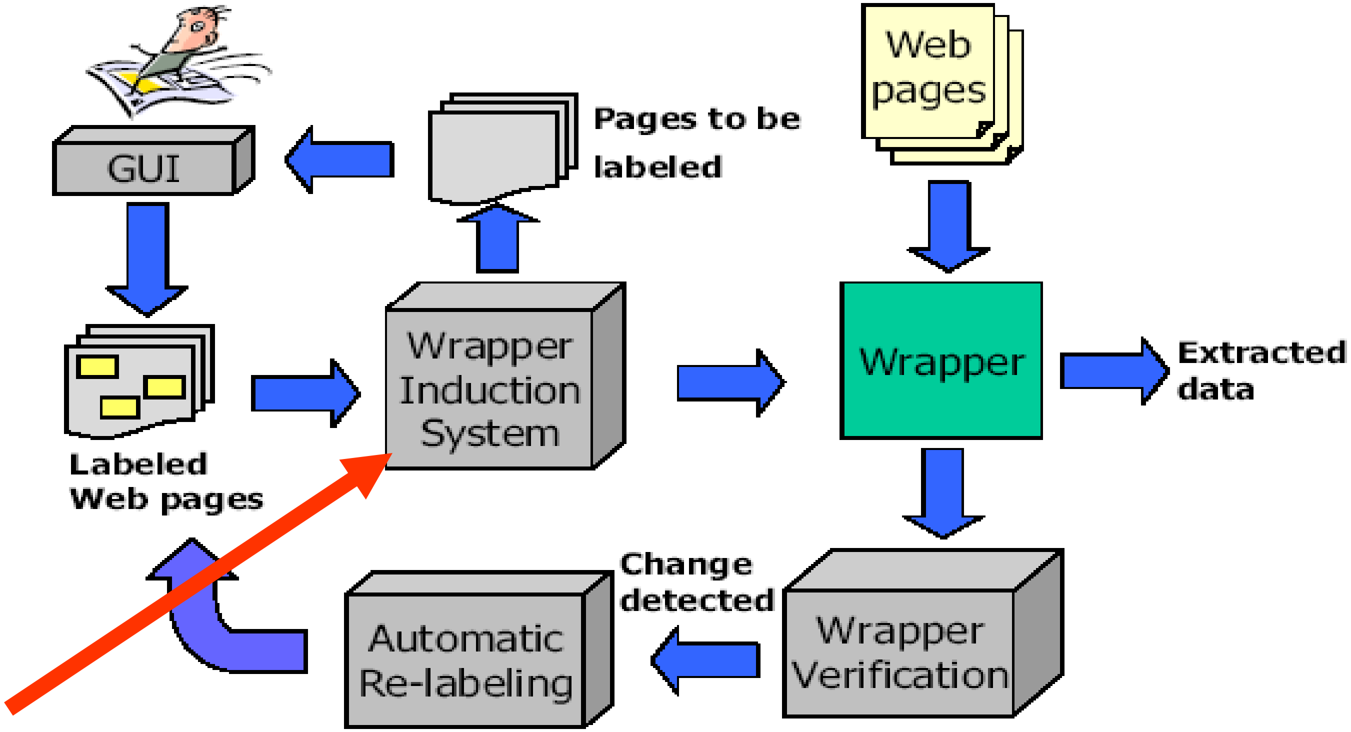
Wrapper Induction: Methods

- **Manually writing wrappers**
- Tedious, time consuming task, eg. TSIMMIS, Minerva, …
- **Wrapper programming languages**
- Florid (a logic-programming formalism), pillow (an HTML/XML programming library for logic programming systems) …
- **Machine learning methods**
- Stalker, Softmealy, WIEN …
- **Supervised interactive wrapper**
- W4F (uses an SQL-like query called HEL), Xwrap (uses a procedural rule system), …

Wrapper Induction Tools

- WIEN:
- Input: a set of pages where data of interest is labeled to serve as examples
- Output:a wrapper that is consistent with each labeled page.
- SoftMealy
- Using finite-state transducers (FST) which takes a sequence of tokens as input and matches the context separators with contextual rules to determine state transitions
- Stalker
- The wrapper induction techniques used in WIEN and SoftMealy are further developed in Stalker

Wrapper Induction: machine learning methods (Stalker)



Our focus here

Figure 1: The Lifecycle of a Wrapper

Learning Extraction Rules
---from pages

- Aim:

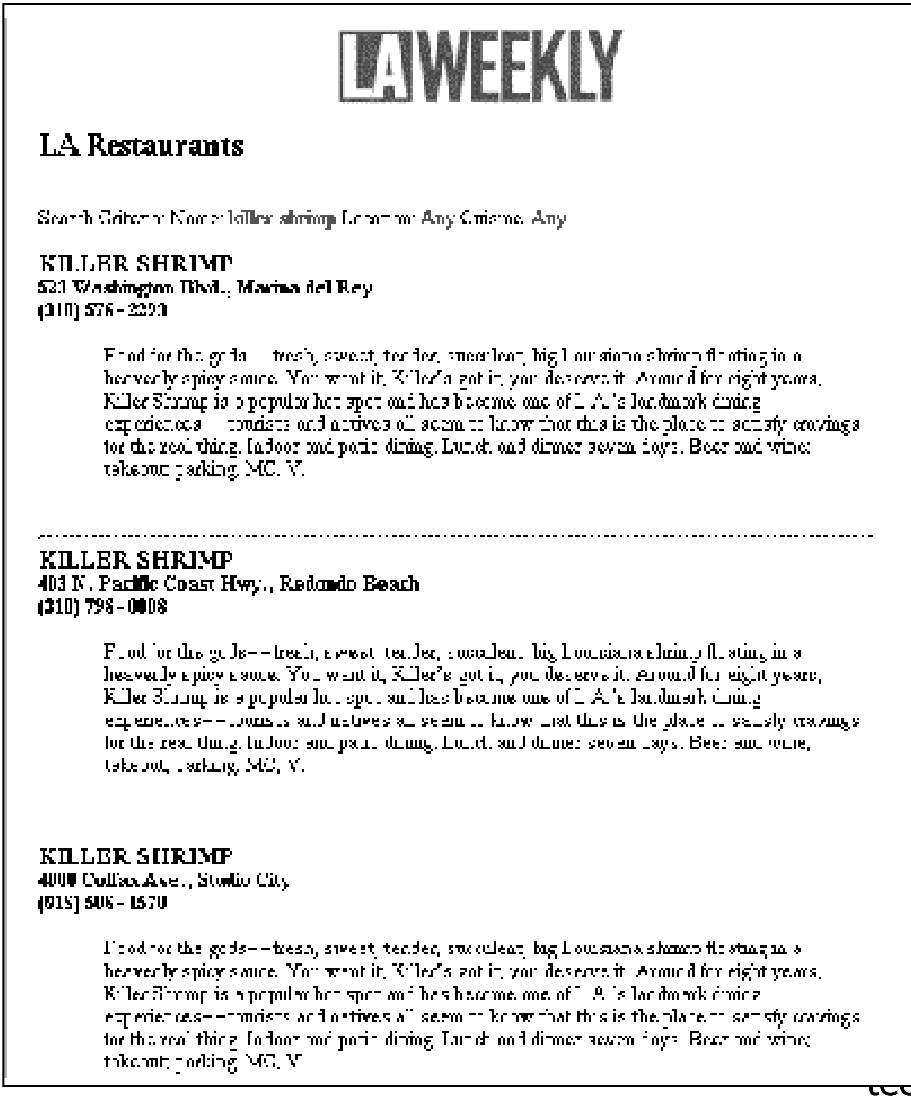
Defining a set of extraction rules that precisely define how to locate the information on the page.

→ How to describe the content of a page?

Describing the content of a page: Embedded Catalog Tree

- Embedded catalog (EC): a tree-like structure to represent a Web page.
- Leaves: items of interest for the user
- Internal nodes: lists of k-tuples where each item in the k-tuple can be either a *leaf* or another *list L.*

Embedded Catalog Tree (for example)



LA WEEKLY

LA Restaurants

Search Criteria: Name: killer shrimp Location: Any Cuisine: Any

KILLER SHRIMP
523 Washington Blvd., Marina del Rey
(310) 578-2293

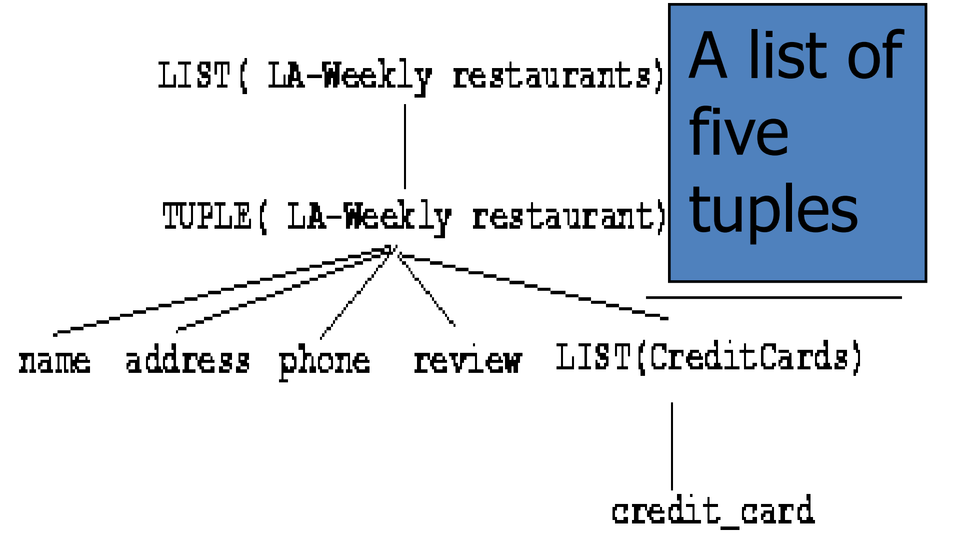
Food for the gods—fresh, sweet, tender, succulent, big Louisiana shrimp floating in a heavenly spicy sauce. You want it, Killer's got it; you deserve it. Around for eight years, Killer Shrimp is a popular hot spot and has become one of L.A.'s landmark dining experiences—tourists and natives all seem to know that this is the place to satisfy cravings for the real thing. Indoor and patio dining. Lunch and dinner seven days. Beer and wine; takeout; parking. MC, V.

KILLER SHRIMP
403 N. Pacific Coast Hwy., Redondo Beach
(310) 798-0008

Food for the gods—fresh, sweet, tender, succulent, big Louisiana shrimp floating in a heavenly spicy sauce. You want it, Killer's got it; you deserve it. Around for eight years, Killer Shrimp is a popular hot spot and has become one of L.A.'s landmark dining experiences—tourists and natives all seem to know that this is the place to satisfy cravings for the real thing. Indoor and patio dining. Lunch and dinner seven days. Beer and wine; takeout; parking. MC, V.

KILLER SHRIMP
4000 Colfax Ave., Studio City
(818) 508-1570

Food for the gods—fresh, sweet, tender, succulent, big Louisiana shrimp floating in a heavenly spicy sauce. You want it, Killer's got it; you deserve it. Around for eight years, Killer Shrimp is a popular hot spot and has become one of L.A.'s landmark dining experiences—tourists and natives all seem to know that this is the place to satisfy cravings for the real thing. Indoor and patio dining. Lunch and dinner seven days. Beer and wine; takeout; parking. MC, V.



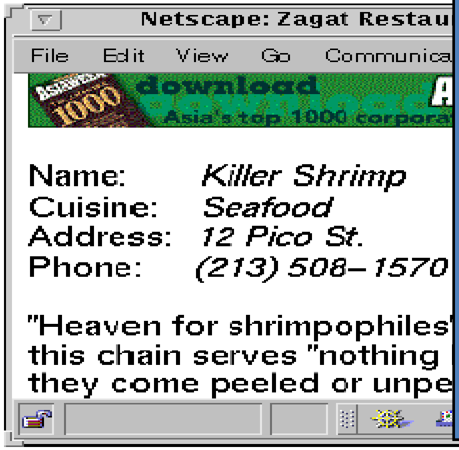
A list of five tuples

Figure 2: $\mathcal{EC}$ description of LA-Weekly pages.

Extracting Rule based on EC

- **A rule:** for each node ***x*** in the EC Tree, the wrapper needs a rule ***r*** that extracts that particular node from its root, ***p*** is a path from the root to the leaf.
- **A list iteration rule:** decomposes ***p*** into individual tuples, and then apply ***r*** to each extracted tuple for each list node.

Example for extraction rules



Name: *Killer Shrimp*
Cuisine: *Seafood*
Address: *12 Pico St.*
Phone: *(213) 508–1570*

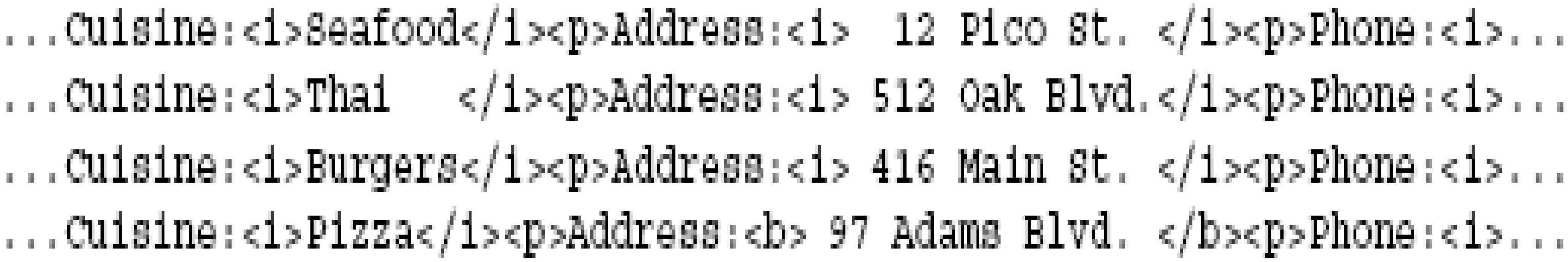
"Heaven for shrimpophiles"
this chain serves "nothing
they come peeled or unpe

R1=SkipTo(Address) SkipTo(I)

R2=SkipTo(Address : <I>)

R3=SkipTo(Cuisine : <I>)
SkipTo(Address : <I>)

Figure 2: Two Sample Restaurant Documents Fr at Guide.



```
...Cuisine:<i>Seafood</i><p>Address:<i>  12 Pico St. </i><p>Phone:<i>...
...Cuisine:<i>Thai   </i><p>Address:<i> 512 Oak Blvd.</i><p>Phone:<i>...
...Cuisine:<i>Burgers</i><p>Address:<i> 416 Main St. </i><p>Phone:<i>...
...Cuisine:<i>Pizza</i><p>Address:<b> 97 Adams Blvd. </b><p>Phone:<i>...
```

Example for extraction rules (cont.)

R4=SkipTo(Cuisine : <I> _Capitalized_</I> <p> Address : <I>)

R4 is defined based on a 9-token landmark that uses the wildcard_Capitalized_, which is a placeholder for any capitalized alphabetic string.

Disjunctive rules: either R1 or R2

To deal with variations in the format of the documents, disjunctions are allowed to use.

Extraction Rules as Finite Automata

- Landmarks: each argument of a skipTo()
  - A sequence of tokens and wildcards
- Landmark automata
  - A non-deterministic finite automata

$$S_i \xrightarrow{l_{i,j}} S_j$$

The transition takes place if the automaton is in the state S_i and the landmark $l_{i,j}$ matches the sequence of tokens at the input.

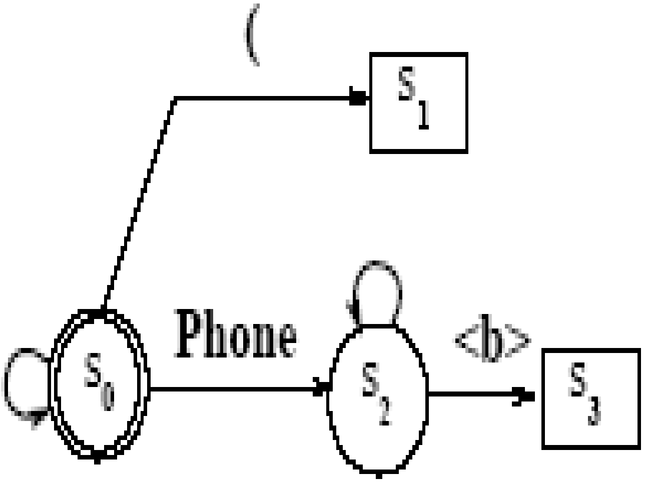
Landmark Automata (linear LA)

- A linear LA has one accepting state.
- from each non-accepting state, there are exactly two possible transitions: a loop to itself, and a transition to the next state;
- each non-looping transition is labeled by a landmarks;
- all looping transitions have the meaning “consume all tokens until you encounter the landmark that leads to the next state”.

Rules and its automaton

R1::=skipTo((),
R2::=skipTo(phone) skipTo(<b>).

Disjunctive rule either R1 or R2

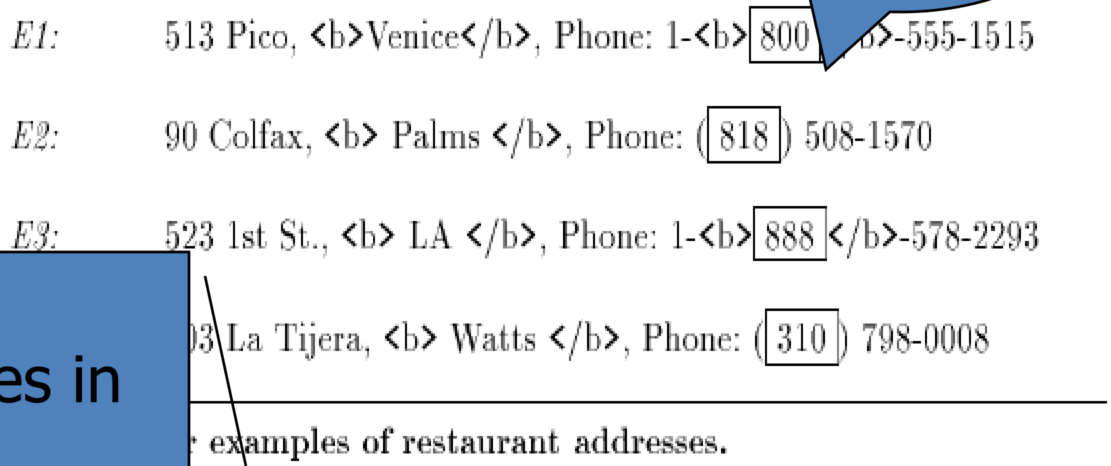


: An $\mathcal{SLG}$ for the start of the area code.

- The initial state S_0 has a branching-factor of k.
- It has exactly k accepting states. (one per branch)
- All k branches that leave the S_0 are sequential LA.

Learning Extraction Rules

User marking



E1: 513 Pico, <b>Venice</b>, Phone: 1-<b>800</b>-555-1515

E2: 90 Colfax, <b> Palms </b>, Phone: (818) 508-1570

E3: 523 1st St., <b> LA </b>, Phone: 1-<b>888</b>-578-2293

03 La Tijera, <b> Watts </b>, Phone: (310) 798-0008

examples of restaurant addresses.

Marked samples

S

STALKER algorithm

-it accepts the positive examples in E2 and E4
-it rejects both E1 and E3 because R1 can not be matched on them. R2 can do.

Extraction Rules

R1::=skipTo((),
R2::=skipTo(-<b>)

Process of the example (STALKER)

1. Generating a linear LA that covers as many as possible of the four positive examples.
2. Create another linear LA for the remaining examples, and so on.
3. Once STALKER covers all examples. It returns the disjunction of all the induced LAs.

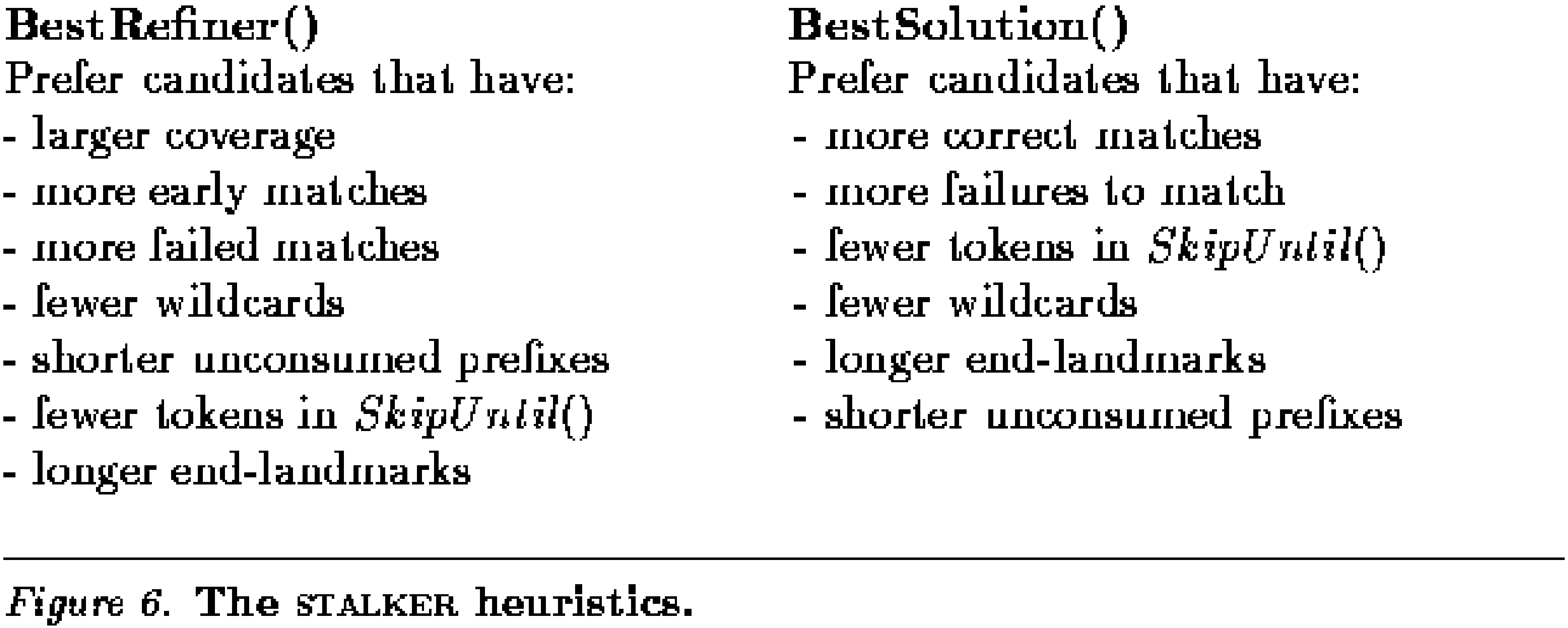
STALKER Algorithm

```
LearnRule( $Examples$ )
- let $RetVal$ be an empty rule
- WHILE $Examples \neq \emptyset$
  - $aDisjunct$ =LearnDisjunct($Examples$)
  - remove all examples covered by $aDisjunct$
  - add $aDisjunct$ to $RetVal$
- return OrderDisjuncts($RetVal$)
```

See example

```
LearnDisjunct( $Examples$ )
- let $Seed \in Examples$ be the shortest example
- $Candidates$ = GetInitialCandidates( $Seed$ )
- DO
    - $BestRefiner$ = GetBestRefiner( $Candidates$ )
    - $BestSolution$ = GetBestSolution( $Candidates \cup \{BestSolution\}$ )
    - $Candidates$ = Refine($BestRefiner, Seed$)
  WHILE IsNotPerfect($BestSolution$) AND $BestRefiner \neq \emptyset$
- return PostProcess($BestSolution$)
```

STALKER Algorithm (cont.)



BestRefiner()

Prefer candidates that have:
- larger coverage
- more early matches
- more failed matches
- fewer wildcards
- shorter unconsumed prefixes
- fewer tokens in *SkipUntil*()
- longer end-landmarks

BestSolution()

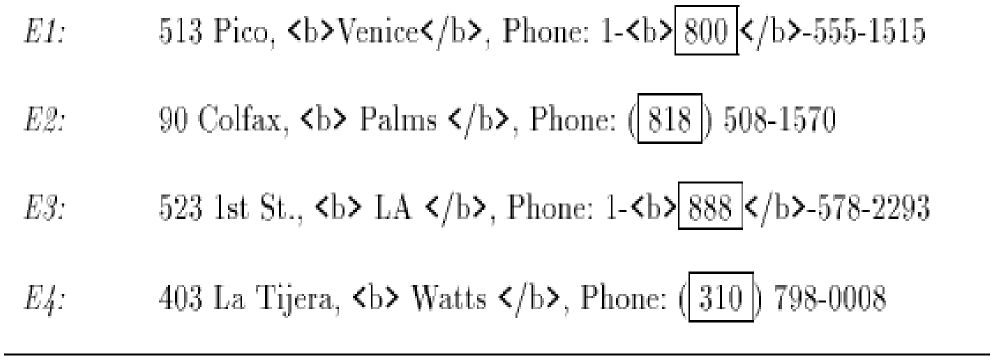
Prefer candidates that have:
- more correct matches
- more failures to match
- fewer tokens in *SkipUntil*()
- fewer wildcards
- longer end-landmarks
- shorter unconsumed prefixes

Figure 6. **The STALKER heuristics.**

STALKER Algorithm (cont.)

- Refine() function: obtain better disjuncts either by making its landmarks more specific (landmark refinements), or by adding new states in the automaton (topology refinements).
- Landmark refinements
- Topology refinements

Landmark Refinement



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E3: 523 1st St., <b> LA </b>, Phone: 1-<b>$\boxed{888}$</b>-578-2293

E4: 403 La Tijera, <b> Watts </b>, Phone: ($\boxed{310}$) 798-0008

Figure 4. **Four examples of restaurant addresses.**

- R4 = SkipTo<b>

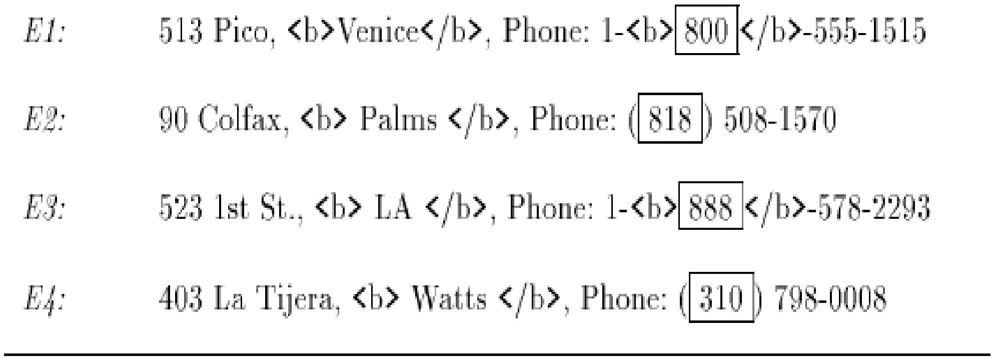
Refine as :

$$\mathbf{R7} = SkipTo(\ \text{-}\ \texttt{<b>})$$

$$\mathbf{R8} = SkipTo(\ Punctuation\ \texttt{<b>})$$

$$\mathbf{R9} = SkipTo(\ Anything\ \texttt{<b>})$$

Topology Refinements



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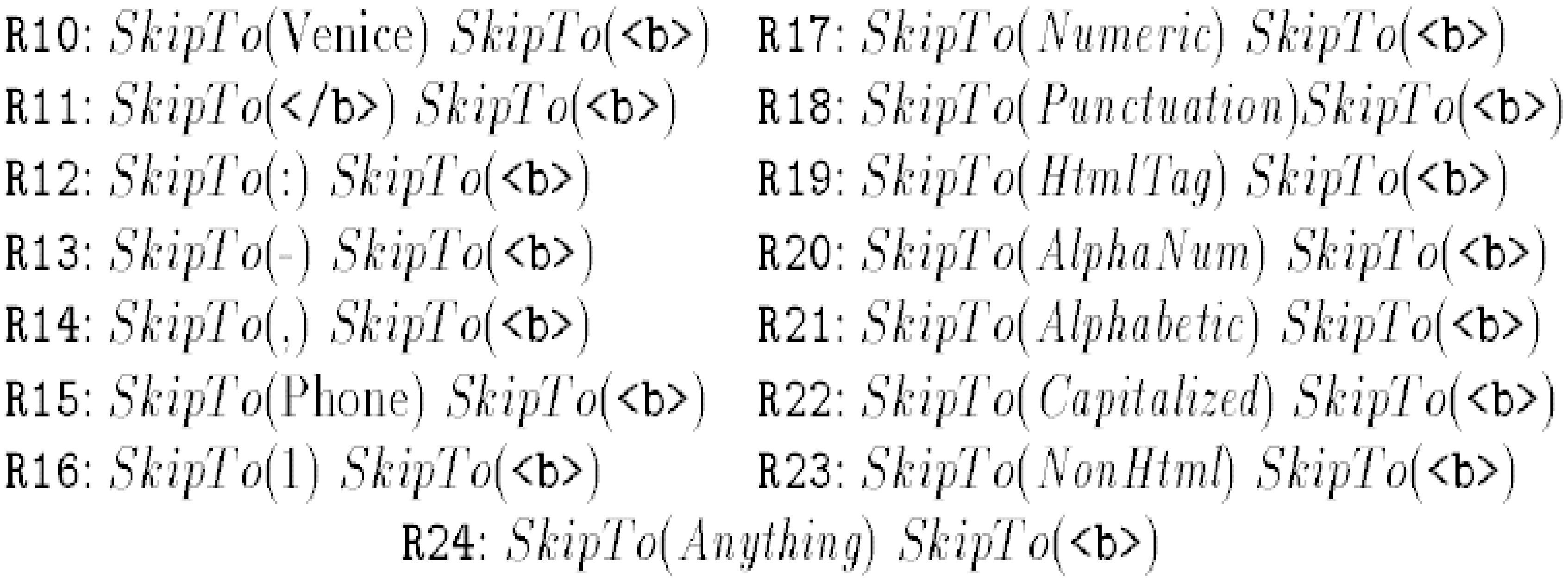
E4: 403 La Tijera, <b> Watts </b>, Phone: (310) 798-0008

Figure 4. Four examples of restaurant addresses.

- R4 = skipTo<b>

Refine as :



R10: *SkipTo*(Venice) *SkipTo*(<b>)

R11: *SkipTo*(</b>) *SkipTo*(<b>)

R12: *SkipTo*(:) *SkipTo*(<b>)

R13: *SkipTo*(-) *SkipTo*(<b>)

R14: *SkipTo*(,) *SkipTo*(<b>)

R15: *SkipTo*(Phone) *SkipTo*(<b>)

R16: *SkipTo*(1) *SkipTo*(<b>)

R17: *SkipTo*(*Numeric*) *SkipTo*(<b>)

R18: *SkipTo*(*Punctuation*)*SkipTo*(<b>)

R19: *SkipTo*(*HtmlTag*) *SkipTo*(<b>)

R20: *SkipTo*(*AlphaNum*) *SkipTo*(<b>)

R21: *SkipTo*(*Alphabetic*) *SkipTo*(<b>)

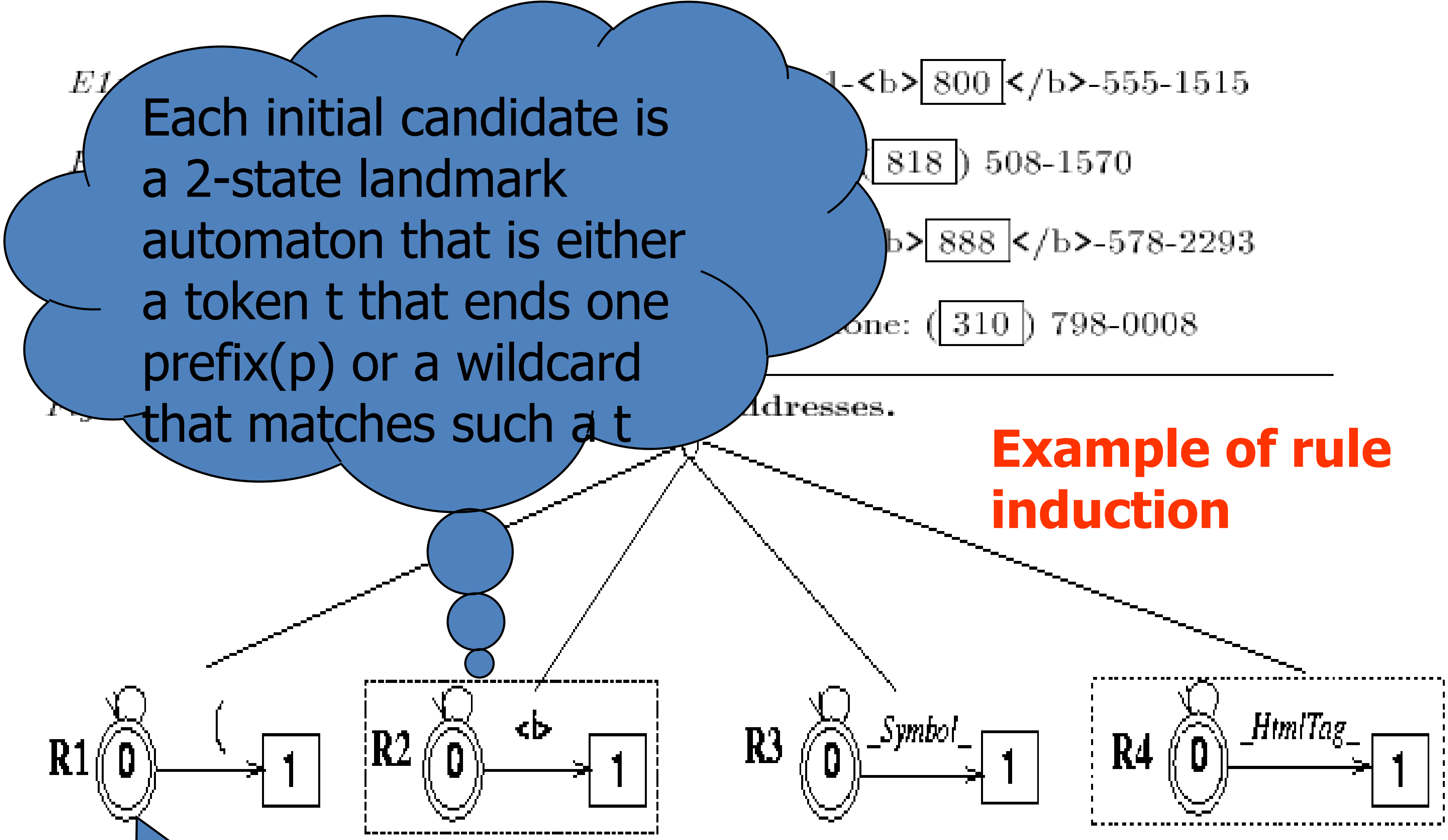
R22: *SkipTo*(*Capitalized*) *SkipTo*(<b>)

R23: *SkipTo*(*NonHtml*) *SkipTo*(<b>)

R24: *SkipTo*(*Anything*) *SkipTo*(<b>)

Example of rule induction

Each initial candidate is a 2-state landmark automaton that is either a token t that ends one prefix(p) or a wildcard that matches such a t



ure 8: Initial candidate-rules generated in the first DO. . . WHILE iteration.

R1 is a perfect disjunct as a result for first iteration.

A perfect rule which matches examples

During the second iteration with E1 and E3 example, the initial candidate rules R5 and R6

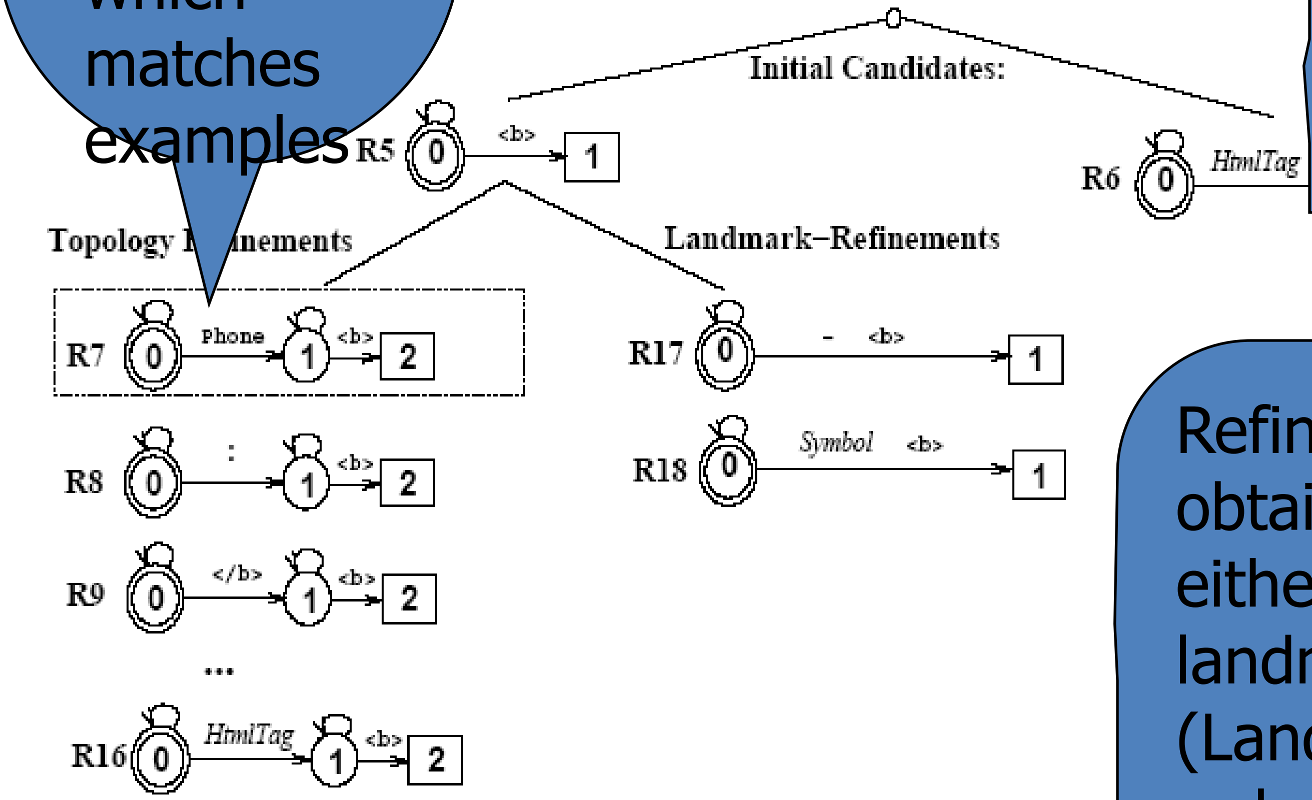


Figure 7: Rule induction (second iteration).

Refinement:tries to obtain better disjuncts either by marking its landmarks more specific (Landmark refinement) or by adding new states in the automaton (Topology refinements)

Seed examples →

Identifying highly informative examples

- The most informative examples illustrate exceptional cases
- Active learning :analyzes the set of unlabeled example to automatically select examples for the user to label
- forward and backward rules:

Fwd R1=SkipTo(Address)SkipTo(<I>)

Bwd R1=BackTo(Phone) BackTo(_Number_)

If two rules disagree on the sample, which is selected for user to label –highly informative training example.

Results reported from STALKER

- From 28 sources, 206 extraction rules: 182 rules (100% correct),18 rules (>90%),3% rules are<90%.
- Active learning:

Average accuracy from 85.7% → 94.2%

STALKER features

- the ability to wrap a larger variety of sources.
- capable of learning most of the extraction rules based on just a couple of examples.
- Using single-slot rules, keep high accuracy.
- improving the efficiency based on active learning for hardest items.

Other Wrappers

- WIEN: learns the landmarks by searching *common prefixes* at the *character level*, needs more training data.
- SoftMealy: its extraction rules are less expressive than STALKER, complex to deal with missing items and various orderings of items

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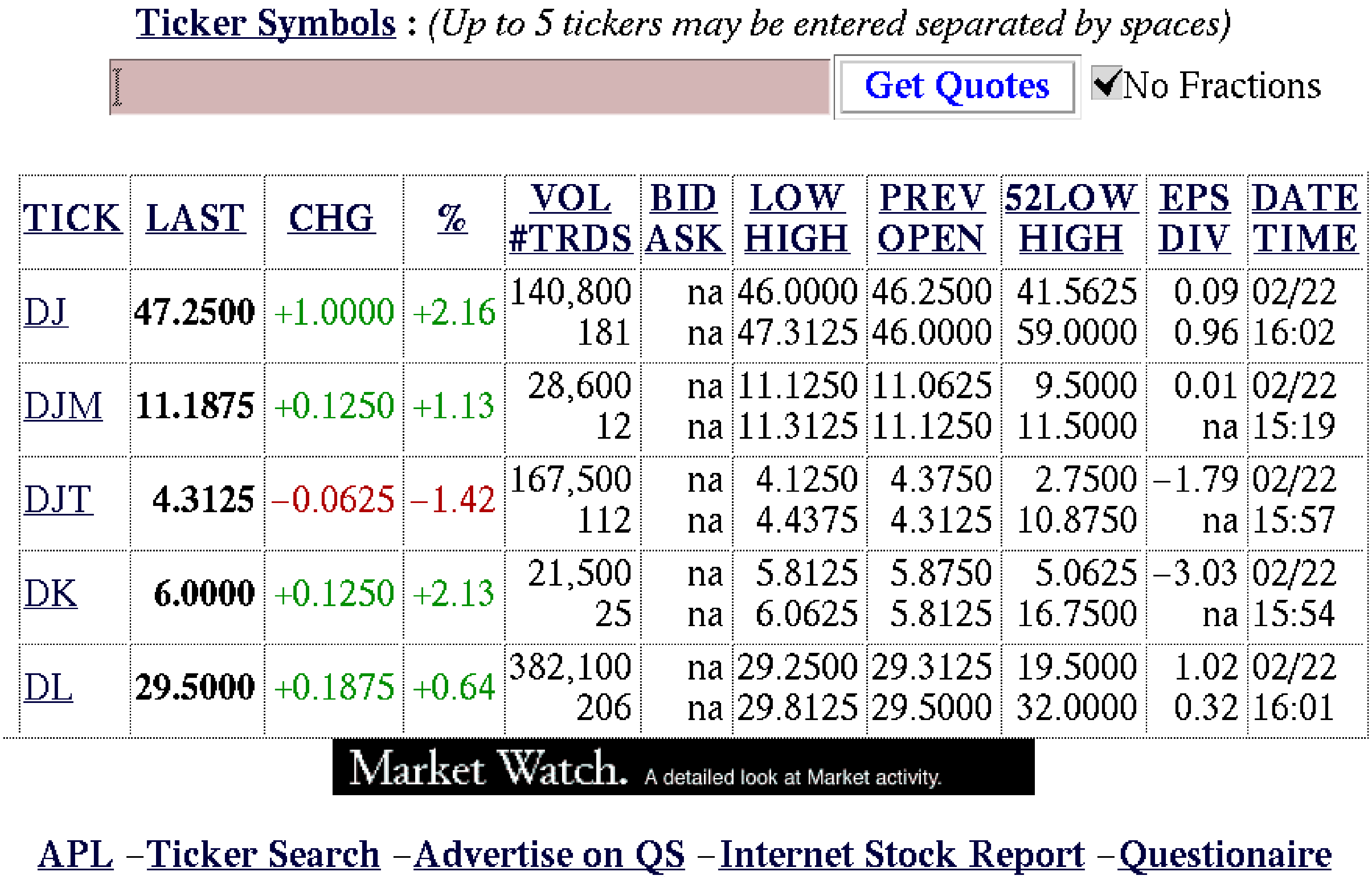
Test page

Quote Server: Tabular style document



Ticker Symbols : *(Up to 5 tickers may be entered separated by spaces)*

☑No Fractions

TICK	LAST	CHG	%	VOL	BID	LOW	PREV	52LOW	EPS	DATE
				#TRDS	ASK	HIGH	OPEN	HIGH	DIV	TIME
DJ	**47.2500**	+1.0000	+2.16	140,800	na	46.0000	46.2500	41.5625	0.09	02/22
				181	na	47.3125	46.0000	59.0000	0.96	16:02
DJM	**11.1875**	+0.1250	+1.13	28,600	na	11.1250	11.0625	9.5000	0.01	02/22
				12	na	11.3125	11.1250	11.5000	na	15:19
DJT	**4.3125**	–0.0625	–1.42	167,500	na	4.1250	4.3750	2.7500	–1.79	02/22
				112	na	4.4375	4.3125	10.8750	na	15:57
DK	**6.0000**	+0.1250	+2.13	21,500	na	5.8125	5.8750	5.0625	–3.03	02/22
				25	na	6.0625	5.8125	16.7500	na	15:54
DL	**29.5000**	+0.1875	+0.64	382,100	na	29.2500	29.3125	19.5000	1.02	02/22
				206	na	29.8125	29.5000	32.0000	0.32	16:01

Market Watch. A detailed look at Market activity.

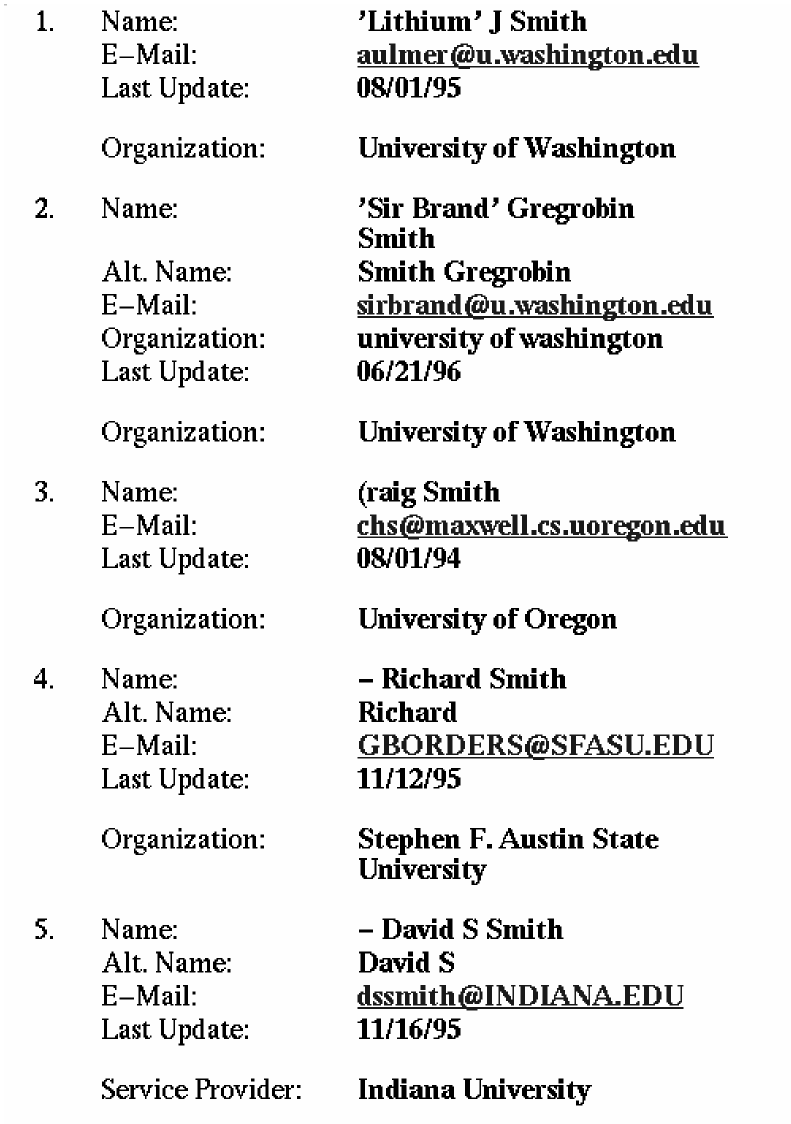
APL – Ticker Search – Advertise on QS – Internet Stock Report – Questionaire

technolgies

Test Pages

Internet Address Finder:

Tagged-list style document



1.	Name:	’Lithium’ J Smith
	E–Mail:	aulmer@u.washington.edu
	Last Update:	08/01/95
	Organization:	University of Washington
2.	Name:	’Sir Brand’ Gregrobin Smith
	Alt. Name:	Smith Gregrobin
	E–Mail:	sirbrand@u.washington.edu
	Organization:	university of washington
	Last Update:	06/21/96
	Organization:	University of Washington
3.	Name:	(raig Smith
	E–Mail:	chs@maxwell.cs.uoregon.edu
	Last Update:	08/01/94
	Organization:	University of Oregon
4.	Name:	– Richard Smith
	Alt. Name:	Richard
	E–Mail:	GBORDERS@SFASU.EDU
	Last Update:	11/12/95
	Organization:	Stephen F. Austin State University
5.	Name:	– David S Smith
	Alt. Name:	David S
	E–Mail:	dssmith@INDIANA.EDU
	Last Update:	11/16/95
	Service Provider:	Indiana University

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Result Comparison

- Quote Server
  - **Stalker: 10 example tuples, 79%, 500 test**
  - WIEN: the collection beyond learn’s capability
  - SoftMealy: multi-pass **85%**, **single-pass 97%**
- Internet Address Finder
  - **Stalker: 85% ~ 100%, 500 test**
  - WIEN: the collection beyond learn’s capablity
  - SoftMealy: multi-pass **68%**, single-pass **41%**,

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Result Comparison (cont.)

- Okra (tabular pages)
  - **Stalker: 97%, 1 example tuple**
  - WIEN: **100%** , 13 example tuples, 30 test
  - SoftMealy: single-pass **100%**, 1 example tuple, 30 test
- Big-book (tagged-list pages)
  - **Stalker: 97%, 8 example tuples**
  - WIEN: **perfect**, 18 example tuples, 30 test
  - SoftMealy: single-pass **97%**, 4 examples, 30 test

    multi-pass **100%**, 6 examples, 30 test

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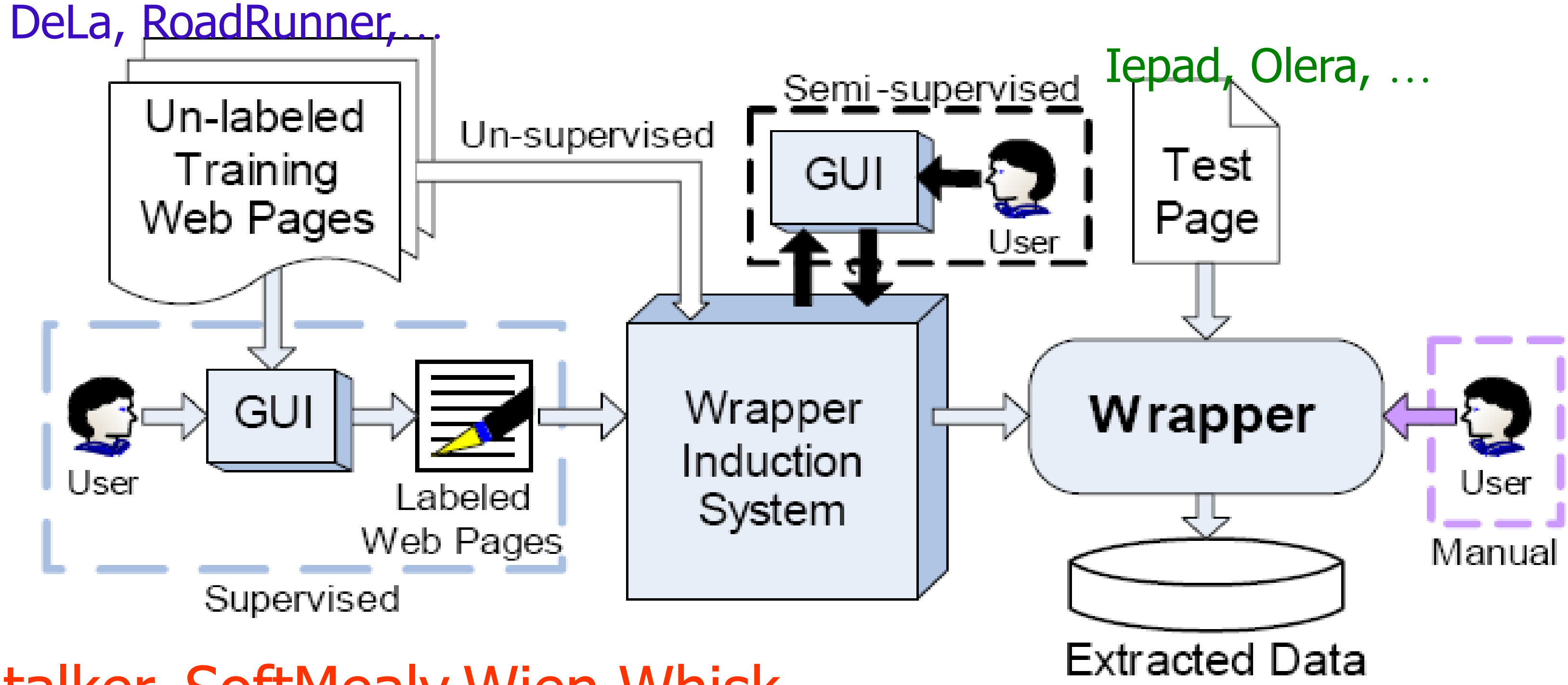
A General View of Wrapper (as Summarization)

- Machine learning method for Wrapper Induction

DeLa, RoadRunner,…

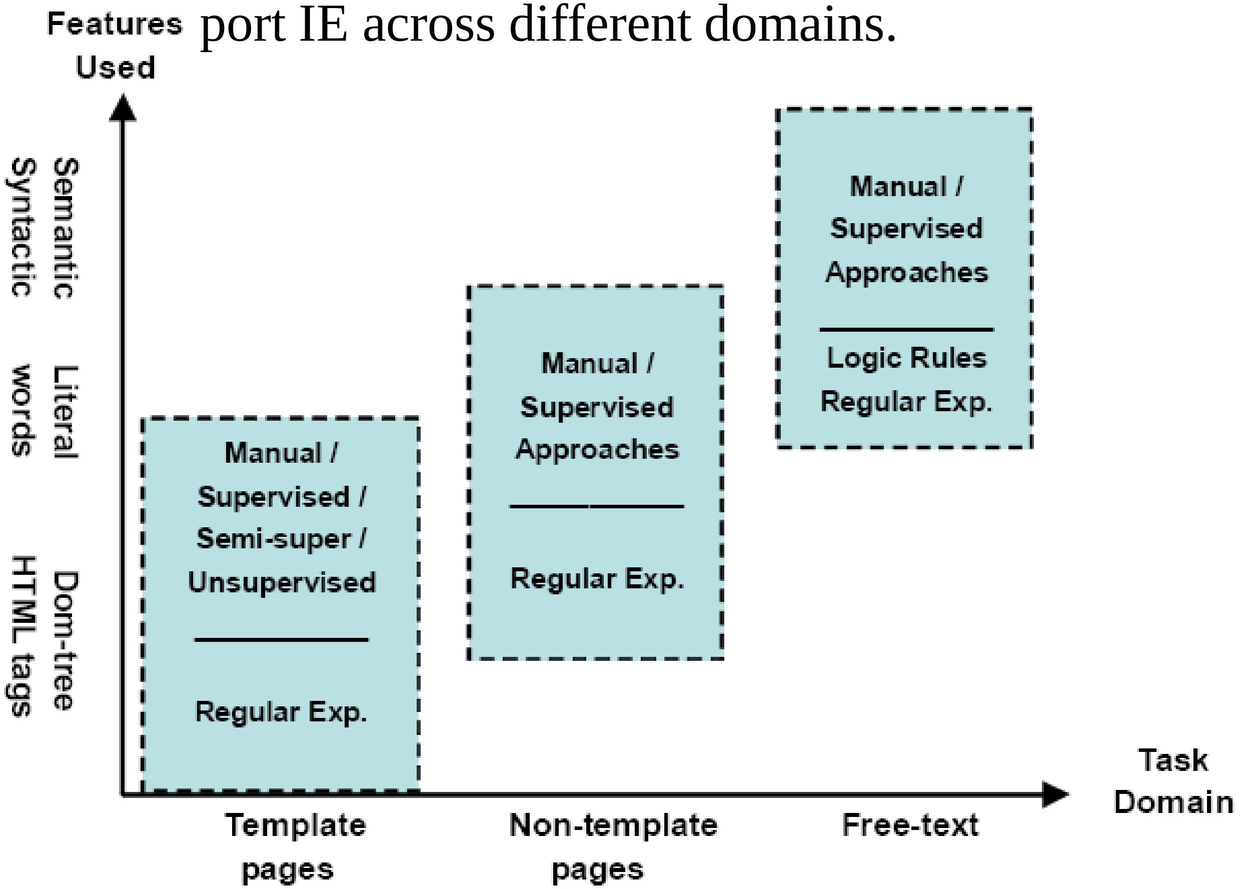
Iepad, Olera, …



Stalker, SoftMealy,Wien,Whisk

Overall Comparison

Three dimensions: the difficulty of IE task, the techniques used, the effort made by the user for the training process and necessity to port IE across different domains.

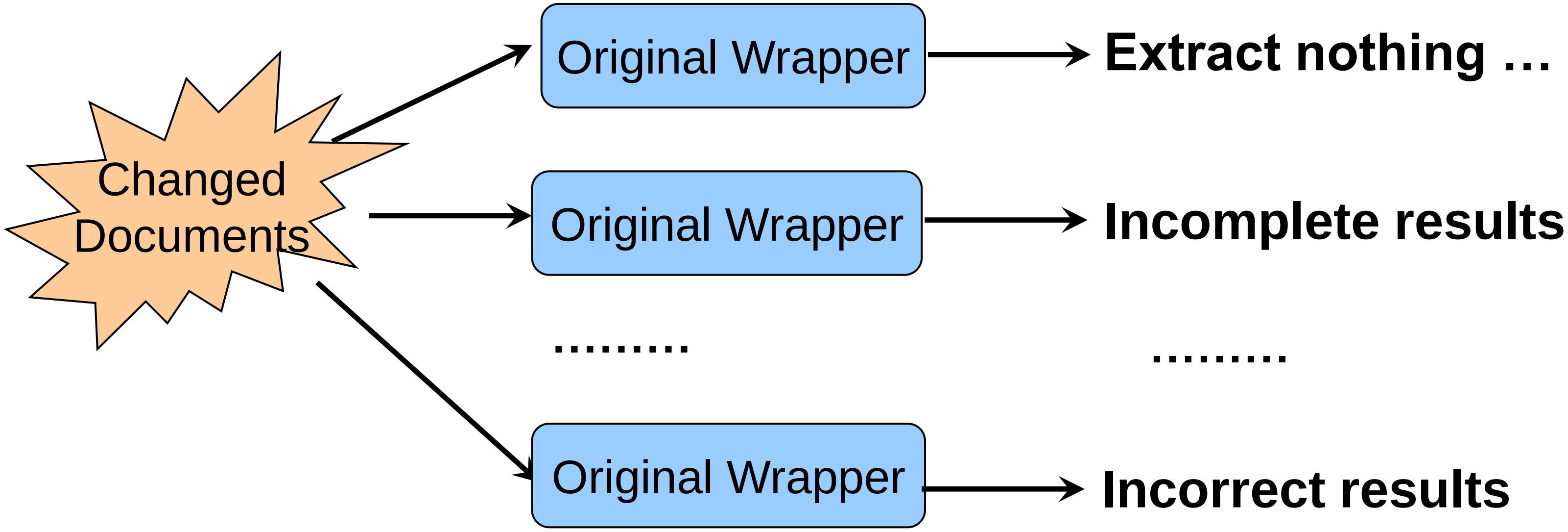


Conclusion:

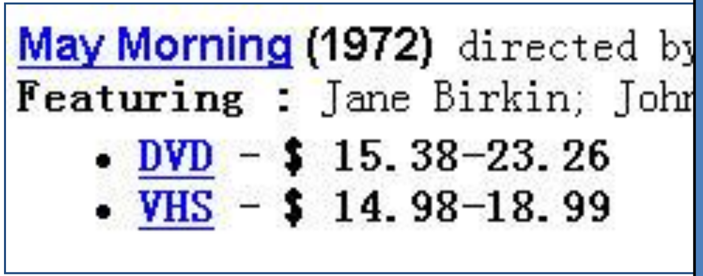
- Template-based pages have high automation degree.
- IE cross-site pages and free texts, semantic features are required.
- Manual IE systems can be applied to all kinds of inputs
- Semi-supervised and unsupervised IE systems can be applied only to template-based pages
- Unsupervised systems usually apply superficial features.

Problem?

- The Web are very dynamic: contents, page structures
- Original wrappers can stop working: rely on Web page structures
- Re-generating wrappers is not easy: heavy workload to system developers



Example

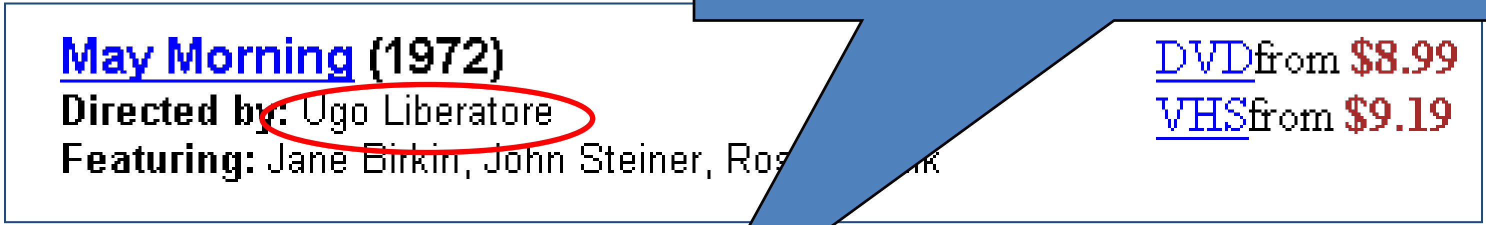


May Morning (1972) directed by

Featuring : Jane Birkin; John

- DVD - $ 15.38-23.26
- VHS - $ 14.98-18.99

The original wrapper fails



May Morning (1972)

Directed by: Ugo Liberatore

Featuring: Jane Birkin, John Steiner, Ros ik

DVD from $8.99

VHS from $9.19

- Monitoring a set of generic features
- Machine learning techniques to learn a set of patterns that describe the information that is being extracted from each of the relevant fields.
- …

How to solve it? (discussion)

Wrapper Mainte

- DataProg algorithm, whic information (**patterns**) abou a field from a set of examples of the field →

Street address: 12 Pico St.,512 Oak Blvd, 416 Main st. and 97 Adams Blvd.→ (_Number_ _ capitalized_) (Blvd.) or (St.)

- **wrapper verification**: Is a wrap correctly?

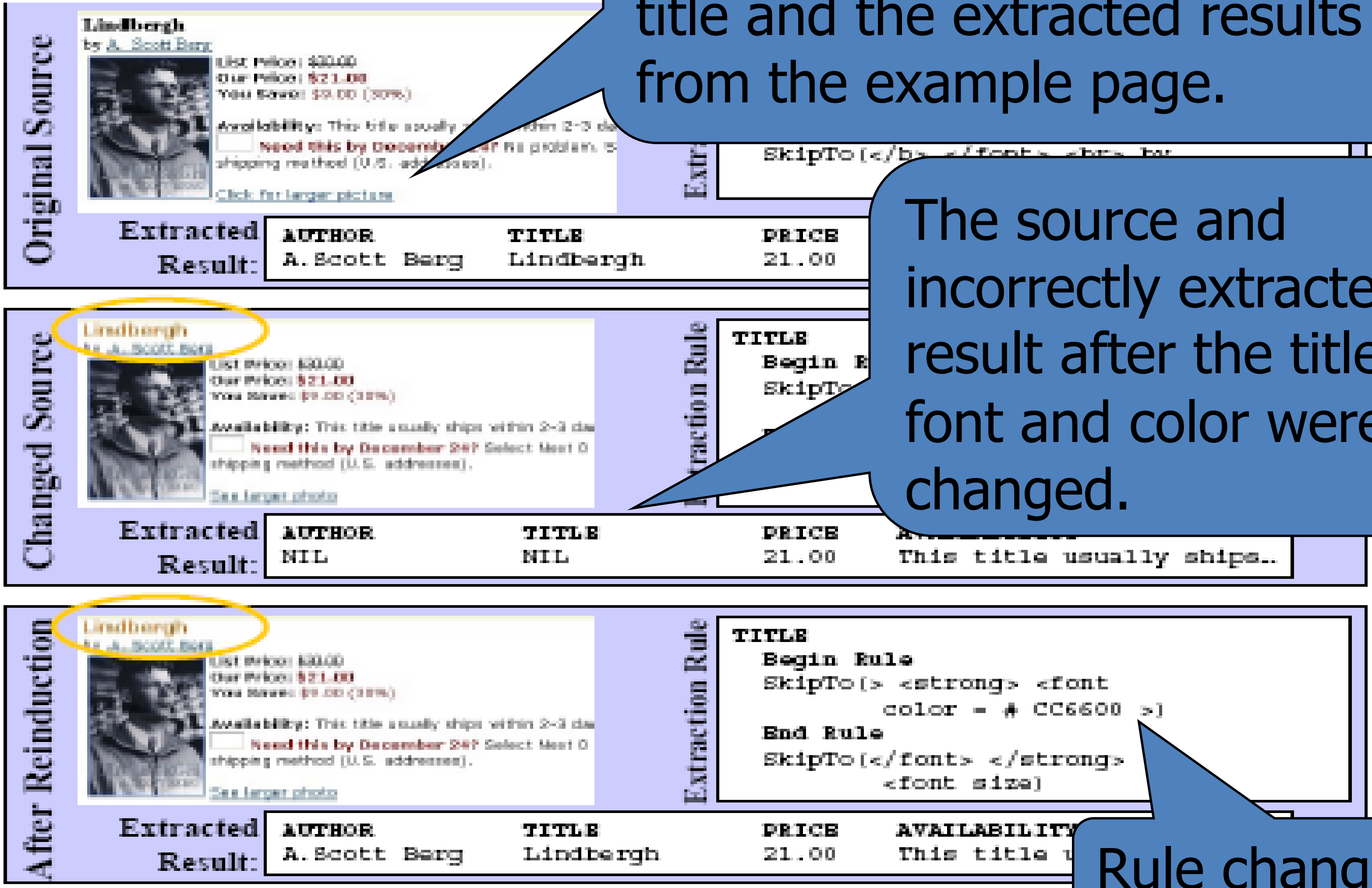
detecting when a wrapper stops extracting data correctly from a Web source.

- **Wrapper maintenance**: how to a a wrapper when the pages have changed?

identify new examples of the data field in order to rebuild the wrapper if it stops working.

Example for Wra
S

an example of the original site, the extracting rule for a book title and the extracted results from the example page.



Extracted Result:

```
AUTHOR          TITLE            PRICE
A.Scott Berg    Lindbergh        21.00
```

```
SkipTo(</b> </font> <br> by
```

```
TITLE
  Begin R
  SkipTo
```

Extracted Result:

```
AUTHOR          TITLE            PRICE     A
NIL             NIL              21.00     This title usually ships..
```

```
TITLE
  Begin Rule
  SkipTo(> <strong> <font
            color = # CC6600 >)
  End Rule
  SkipTo(</font> </strong>
            <font size)
```

Extracted Result:

```
AUTHOR          TITLE            PRICE     AVAILABILITY
A.Scott Berg    Lindbergh        21.00     This title u
```

The source and incorrectly extracted result after the titles’s font and color were changed.

Rule changed.

Wrapper Maintenance Methods (Kushmerick's method)

- Each data field was described by a collection of global features, such as word count, average word length, and density of types.
- Calculated the mean and variance of each feature's distribution over the training examples.
- Individual feature probabilities are then combined to produce a value.
- If the value exceeds a threshold, the wrapper is correct, otherwise, it is failed.

A prototype for tracking changes to webpages – *Microsoft Research*

Diff-IE is a prototype Internet Explorer add-on that:

- Highlights the changes to a webpage since the last time you visited it.
- Enables you to view and compare previously cached version of a page.

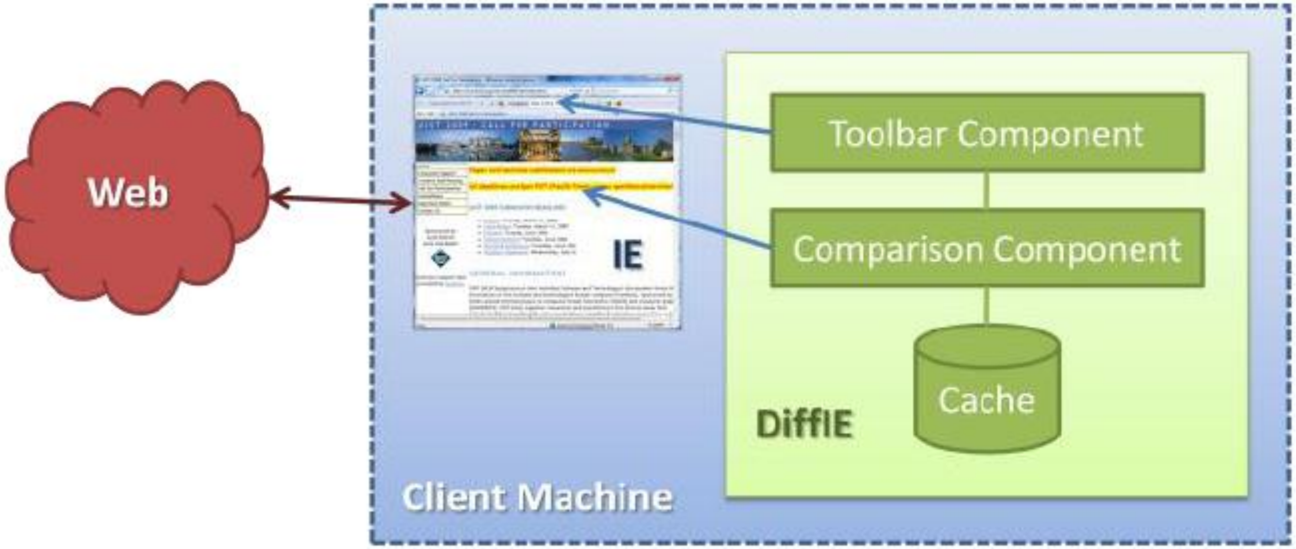
→**Tracking changes to webpages.**

Download DIFF-IE

From: Microsoft research

http://research.microsoft.com/en-us/projects/diffie/default.aspx

- How it was implemented?



- Cache: stores the previous versions of the page, in order to highlight how a page has changed.
- Comparison component: is responsible for detecting and highlighting the changes.
- Toolbar component: is the portion of the application with which the user interacts.

Comparison Component (1)

Web page representation

- DiffIE identifies changes to text-based Web content at the Document Object Model (DOM) level. Pages are represented internally as a tree of hash values to support this DOM-level comparison of text across pages.
- The text nodes of a Web page: the leaves e.
- The content of these nodes are hash algorithm.

MD5:
A message of arbitrary length → 128-bit fingerprint

Two messages will not Produce the same Fingerprint.

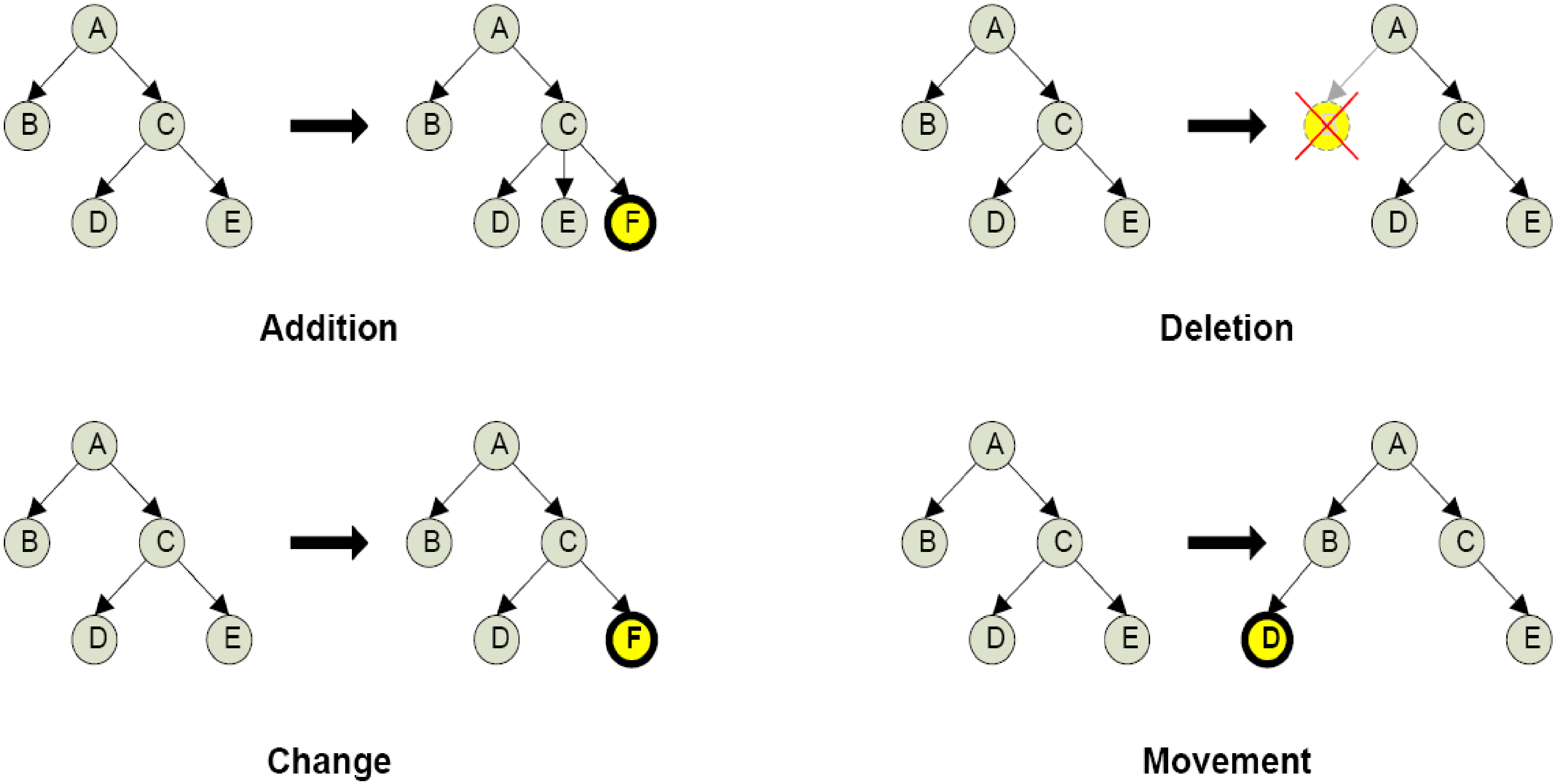
Comparison Component (2)

Detecting Differences:

- Starting at the root node, DiffIE compares the pre-computed subtree hash of the live version and the cached version.
- If same, DiffIE terminates comparison of the corresponding subtree, since identical hashes implies the content must not have changed.

Comparison Component (3)

- 4 Types of Differences: only addition and changes are highlighted.



Addition

Deletion

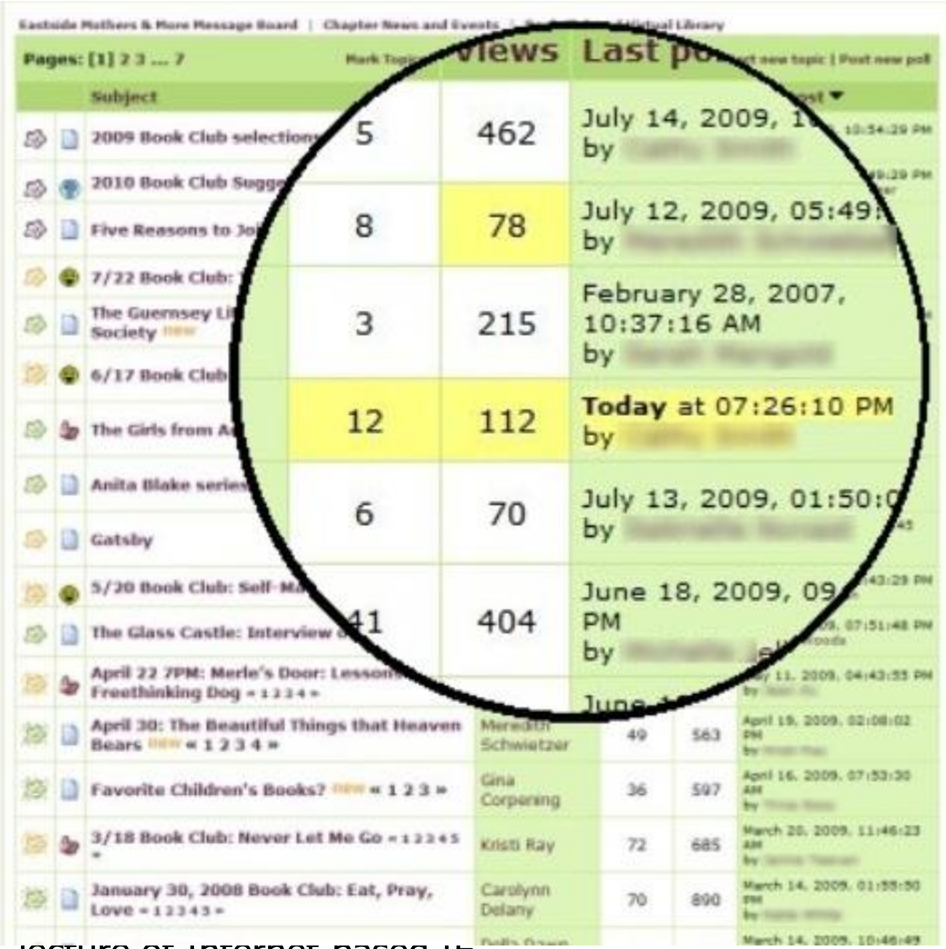
Change

Movement

Figure 3. An illustration of the types of changes that can occur at the DOM level of a Web page.

Application 1

- Monitoring a page for change, to keep track of the latest stock prices, or latest updates on the page.



Eastside Mothers & More Message Board | Chapter News and Events | Book Club Lending Library

Pages: [1] 2 3 ... 7

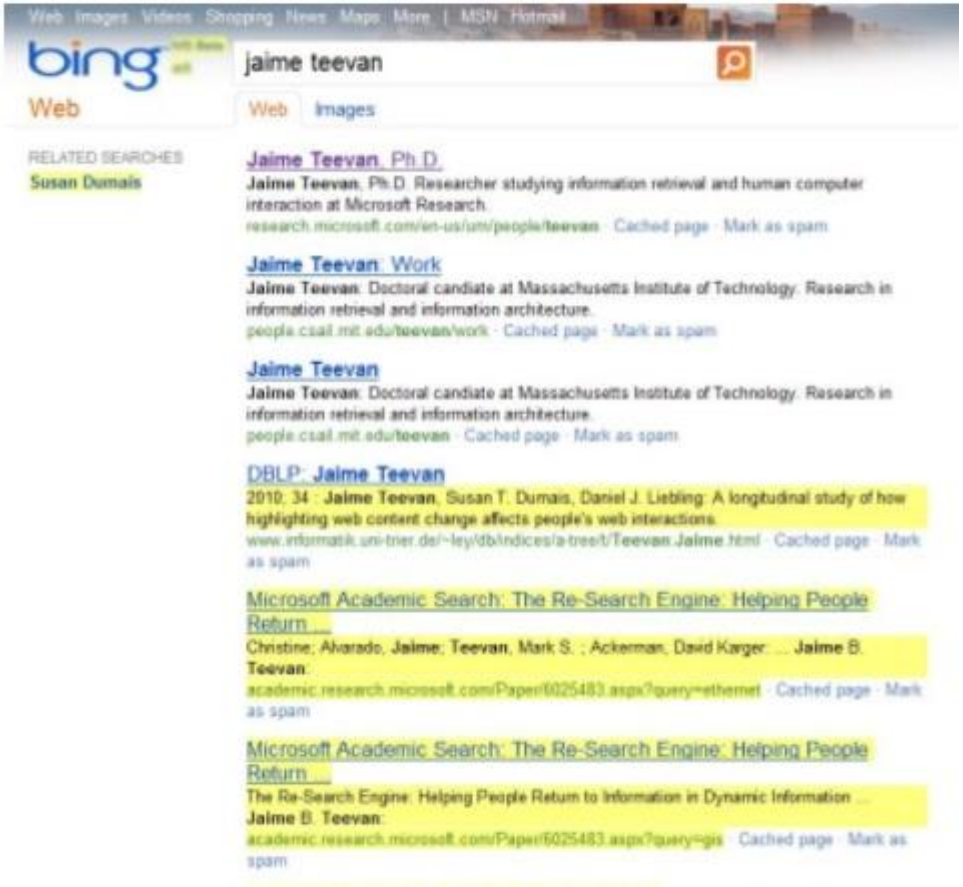
Mark Topics | Start new topic | Post new poll

Subject	Replies	Views	Last post
2009 Book Club selections	5	462	July 14, 2009, 10:54:29 PM by [redacted]
2010 Book Club Sugg			
Five Reasons to Jo	8	78	July 12, 2009, 05:49: by [redacted]
7/22 Book Club:			
The Guernsey Li Society new	3	215	February 28, 2007, 10:37:16 AM by [redacted]
6/17 Book Club			
The Girls from A	12	112	**Today** at 07:26:10 PM by [redacted]
Anita Blake series	6	70	July 13, 2009, 01:50:0 by [redacted]
Gatsby			
5/20 Book Club: Self-M			
The Glass Castle: Interview &	41	404	June 18, 2009, 09 PM by [redacted]
April 22 7PM: Merle's Door: Lesson Freethinking Dog « 1 2 3 4 »			June 1

Subject	Started by	Replies	Views	Last post
April 30: The Beautiful Things that Heaven Bears new « 1 2 3 4 »	Meredith Schwietzer	49	563	April 19, 2009, 02:08:02 PM by [redacted]
Favorite Children's Books? new « 1 2 3 »	Gina Corpening	36	597	April 16, 2009, 07:53:30 AM by [redacted]
3/18 Book Club: Never Let Me Go « 1 2 3 4 5 »	Kristi Ray	72	685	March 20, 2009, 11:46:23 AM by [redacted]
January 30, 2008 Book Club: Eat, Pray, Love « 1 2 3 4 5 »	Carolynn Delany	70	890	March 14, 2009, 01:55:50 PM by [redacted]
	Della Dawn			March 14, 2009, 10:46:49

Application 2

- See new or different search results.



jaime teevan

RELATED SEARCHES

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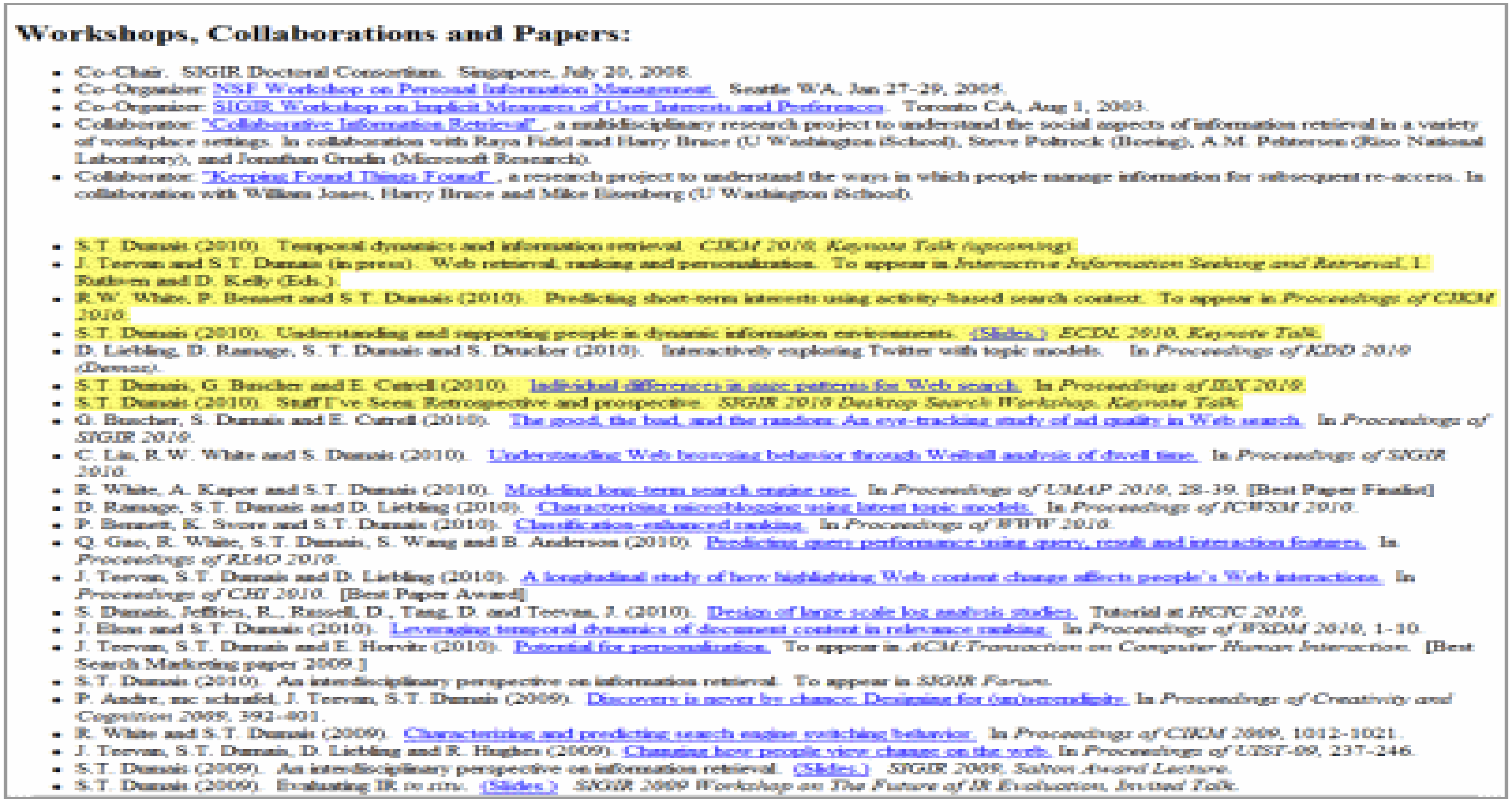
Application 3

Find changes in long lists of text

It can be hard to see changes in long lists of text, but Diff-IE identifies these automatically.



Workshops, Collaborations and Papers:

- Co-Chair. SIGIR Doctoral Consortium. Singapore, July 20, 2008.
- Co-Organizer: NSF Workshop on Personal Information Management. Seattle WA, Jan 27-29, 2005.
- Co-Organizer: SIGIR Workshop on Implicit Measures of User Interests and Preferences. Toronto CA, Aug 1, 2003.
- Collaborator: "Collaborative Information Retrieval", a multidisciplinary research project to understand the social aspects of information retrieval in a variety of workplace settings. In collaboration with Raya Fidel and Harry Bruce (U Washington iSchool), Steve Poltrock (Boeing), A.M. Pehtersen (Riso National Laboratory), and Jonathan Grudin (Microsoft Research).
- Collaborator: "Keeping Found Things Found", a research project to understand the ways in which people manage information for subsequent re-access. In collaboration with William Jones, Harry Bruce and Mike Eisenberg (U Washington iSchool).

- S.T. Dumais (2010). Temporal dynamics and information retrieval. *CIKM 2010, Keynote Talk (upcoming).*
- J. Teevan and S.T. Dumais (in press). Web retrieval, ranking and personalization. To appear in *Interactive Information Seeking and Retrieval*, I. Ruthven and D. Kelly (Eds.).
- R.W. White, P. Bennett and S.T. Dumais (2010). Predicting short-term interests using activity-based search context. To appear in *Proceedings of CIKM 2010.*
- S.T. Dumais (2010). Understanding and supporting people in dynamic information environments. (Slides) *ECDL 2010, Keynote Talk.*
- D. Liebling, D. Ramage, S. T. Dumais and S. Drucker (2010). Interactively exploring Twitter with topic models. In *Proceedings of KDD 2010 (Demo).*
- S.T. Dumais, G. Buscher and E. Cutrell (2010). Individual differences in gaze patterns for Web search. In *Proceedings of IIiX 2010.*
- S.T. Dumais (2010). Stuff I've Seen: Retrospective and prospective. *SIGIR 2010 Desktop Search Workshop, Keynote Talk.*
- G. Buscher, S. Dumais and E. Cutrell (2010). The good, the bad, and the random: An eye-tracking study of ad quality in Web search. In *Proceedings of SIGIR 2010.*
- C. Liu, R.W. White and S. Dumais (2010). Understanding Web browsing behavior through Weibull analysis of dwell time. In *Proceedings of SIGIR 2010.*
- R. White, A. Kapoor and S.T. Dumais (2010). Modeling long-term search engine use. In *Proceedings of UMAP 2010*, 28-39. [Best Paper Finalist]
- D. Ramage, S.T. Dumais and D. Liebling (2010). Characterizing microblogging using latent topic models. In *Proceedings of ICWSM 2010.*
- P. Bennett, K. Svore and S.T. Dumais (2010). Classification-enhanced ranking. In *Proceedings of WWW 2010.*
- Q. Guo, R. White, S.T. Dumais, S. Wang and B. Anderson (2010). Predicting query performance using query, result and interaction features. In *Proceedings of RIAO 2010.*
- J. Teevan, S.T. Dumais and D. Liebling (2010). A longitudinal study of how highlighting Web content change affects people's Web interactions. In *Proceedings of CHI 2010.* [Best Paper Award]
- S. Dumais, Jeffries, R., Russell, D., Tang, D. and Teevan, J. (2010). Design of large scale log analysis studies. Tutorial at *HCIC 2010.*
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- J. Teevan, S.T. Dumais and E. Horvitz (2010). Potential for personalization. To appear in *ACM Transaction on Computer Human Interaction.* [Best Search Marketing paper 2009.]
- S.T. Dumais (2010). An interdisciplinary perspective on information retrieval. To appear in *SIGIR Forum.*
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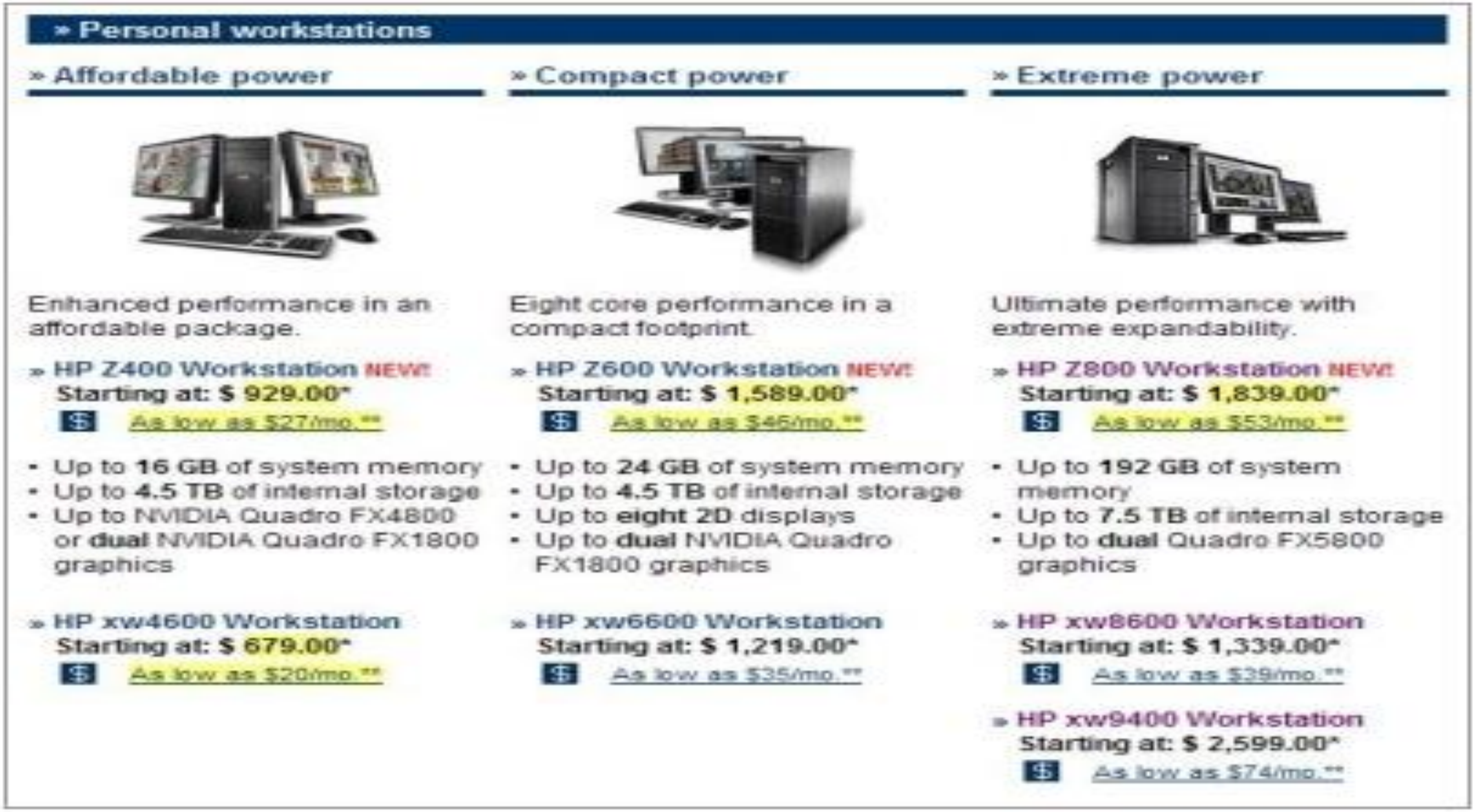
- R. White and S.T. Dumais (2009). Characterizing and predicting search engine switching behavior. In *Proceedings of CIKM 2009*, 1012-1021.
- J. Teevan, S.T. Dumais, D. Liebling and R. Hughes (2009). Changing how people view changes on the web. In *Proceedings of UIST-09*, 237-246.
- S.T. Dumais (2009). An interdisciplinary perspective on information retrieval. (Slides) *SIGIR 2009, Salton Award Lecture.*
- S.T. Dumais (2009). Evaluating IR *in situ.* (Slides) *SIGIR 2009 Workshop on The Future of IR Evaluation, Invited Talk.*

Application 4

Track price changes

We rarely remember prices, but Diff-IE does. Here, the prices of these HP workstations dropped.



» Personal workstations

» Affordable power

Enhanced performance in an affordable package.

» HP Z400 Workstation NEW!
Starting at: $ 929.00*
$ As low as $27/mo.**

- Up to **16 GB** of system memory
- Up to **4.5 TB** of internal storage
- Up to NVIDIA Quadro FX4800 or **dual** NVIDIA Quadro FX1800 graphics

» HP xw4600 Workstation
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» Compact power

Eight core performance in a compact footprint.

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$ As low as $46/mo.**

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- Up to **dual** NVIDIA Quadro FX1800 graphics

» HP xw6600 Workstation
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$ As low as $35/mo.**

» Extreme power

Ultimate performance with extreme expandability.

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Starting at: $ 1,839.00*
$ As low as $53/mo.**

- Up to **192 GB** of system memory
- Up to **7.5 TB** of internal storage
- Up to **dual** Quadro FX5800 graphics

» HP xw8600 Workstation
Starting at: $ 1,339.00*
$ As low as $39/mo.**

» HP xw9400 Workstation
Starting at: $ 2,599.00*
$ As low as $74/mo.**

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- Chun-Nan Hsu and Ming-Tzung Dung. Generating finite-state transducers for semistructured data extraction from the web. *Information Systems*, 23(8):521-538, Special Issue on Semistructured Data, 1998.
- **Ion Muslea**, Steve Minton, Craig Knoblock. Hierarchical Wrapper Induction for Semistructured Information Sources, ***Journal of Autonomous Agents and Multi-Agent Systems****, 4:93-114, 2001* .

References sites

- Repository of online information sources used in information extraction task: http://www.isi.edu/info-agents/RISE/index.html
- Chia-Hui Chang, et al, “ A survey of Web Information Extraction Systems” in IEEE Transactions on Knowledge and Data Engineering.
- Papers, tutorials, lectures, code
  - http://www.cs.cmu.edu/~wcohen/10-707

Summarization

- What is wrapper?
- How to do wrapper induction?
- How to maintenance wrapper?