# Web Data Extraction

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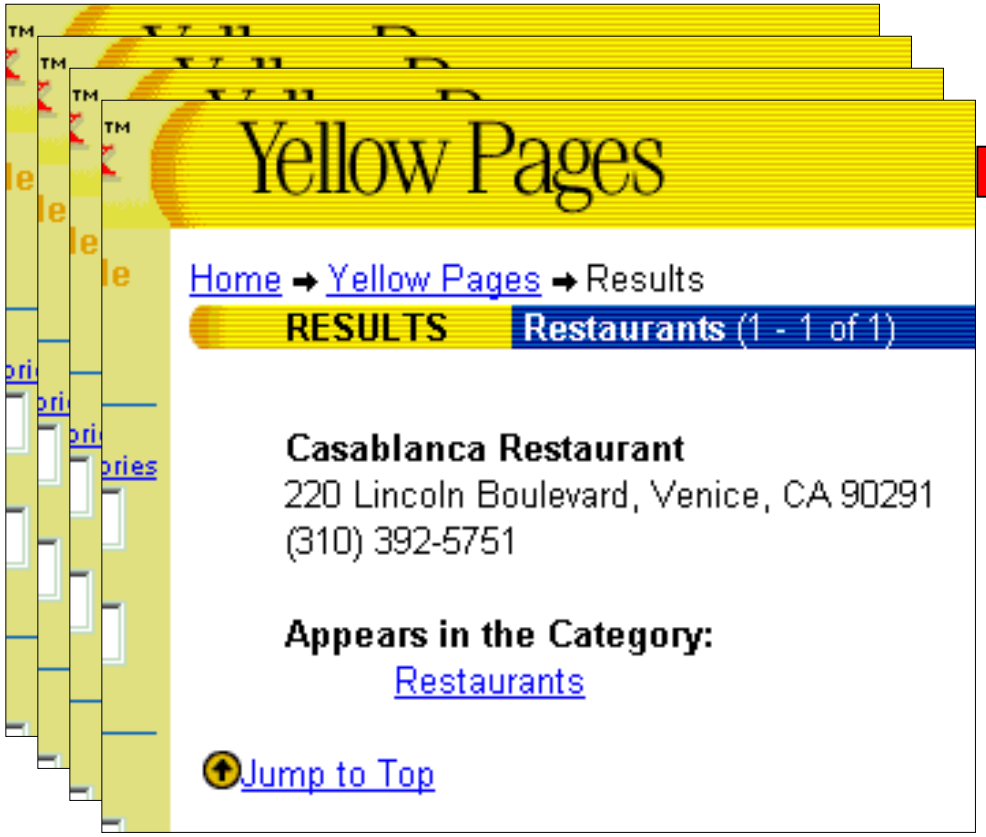
University of Southern California

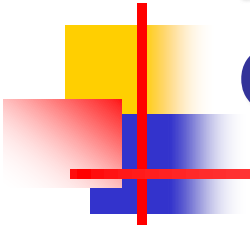
This presentation is based on slides prepared
by Ion Muslea and Kristina Lerman

# Extracting Data from Semi-structured Sources

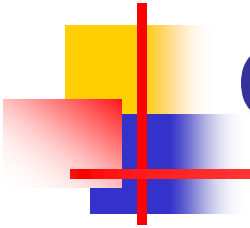



| | |
|---|---|
| **NAME** | Casablanca Restaurant |
| **STREET** | 220 Lincoln Boulevard |
| **CITY** | Venice |
| **PHONE** | (310) 392-5751 |

# Approaches to Wrapper Construction

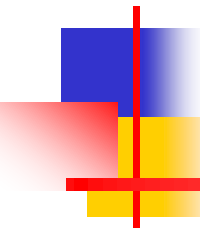


- Manual Wrapper Construction
- Learning-based Wrapper Construction
- Automatic Wrapper Construction

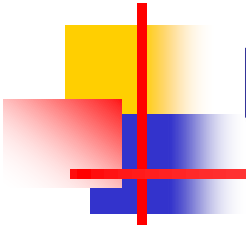


# Grammar Induction Approach

- Pages automatically generated by scripts that encode results of db query into HTML
  - Script = grammar
- Given a set of pages generated by the same script
  - Learn the grammar of the pages
    - Wrapper induction step
  - Use the grammar to parse the pages
    - Data extraction step



# RoadRunner: Towards Automatic Data Extraction from Large Web Sites by Crescenzi, Mecca, & Merialdo



# RoadRunner Overview

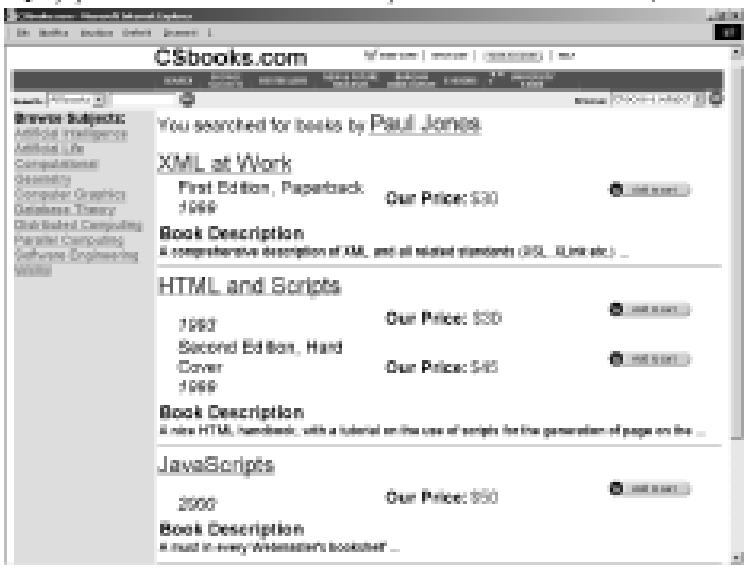
- Automatically generates a wrapper from large web pages
  - Pages of the same *class*
  - No dynamic content from javascript, ajax, etc
- Infers source schema
  - Supports nested structures and lists
  - Extracts data from pages
- Efficient approach to large, complex pages with regular structure

# Example Pages

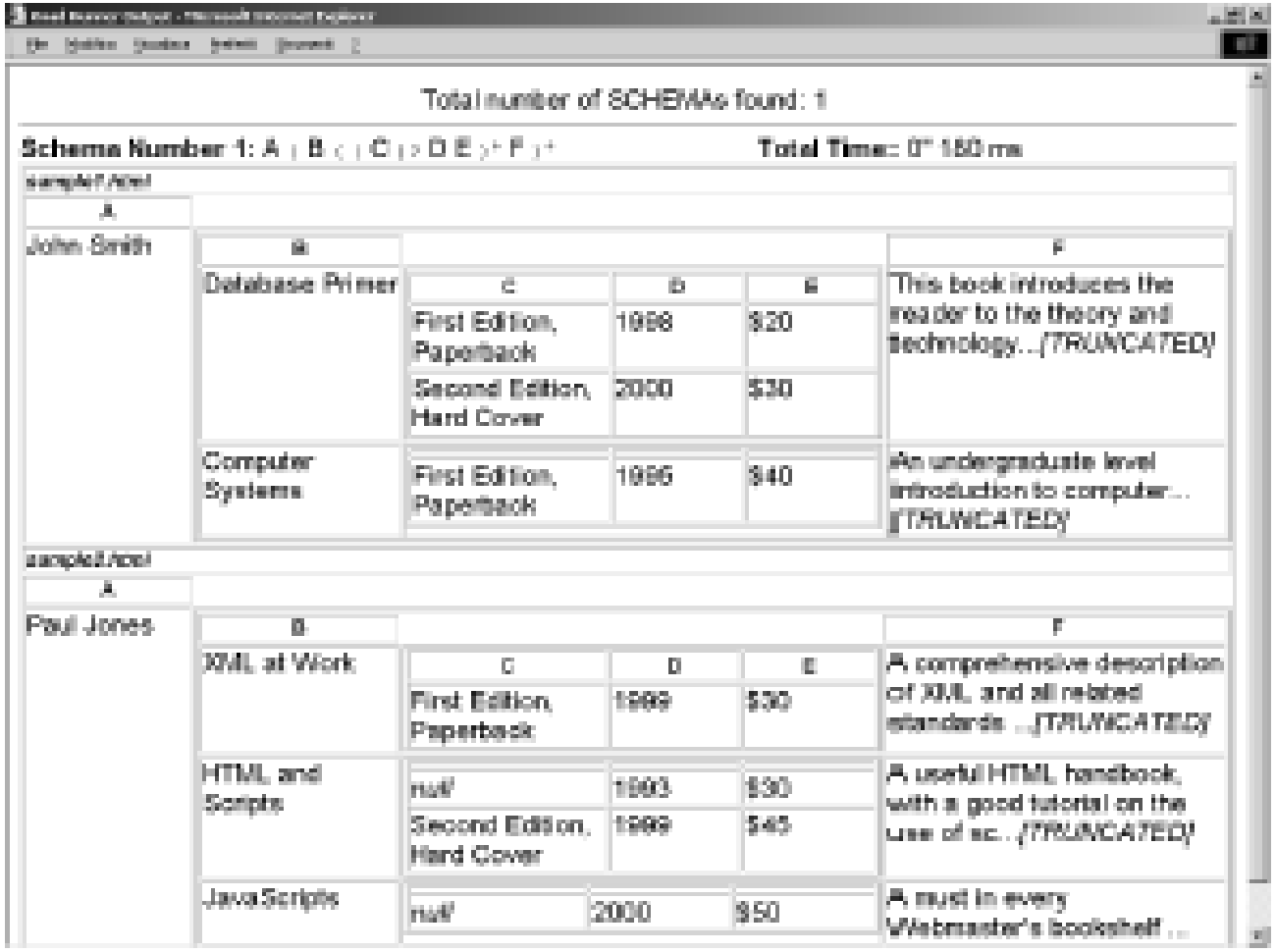
- Compares two pages at a time to find similarities and differences
- Infers nested structure (schema) of page
- Extracts fields

http://www.csbooks.com/author?John+Smith


http://www.csbooks.com/author?Paul+Jones



# Extracted Result



Total number of SCHEMAs found: 1

**Schema Number 1:** A | B | C | D E | F | **Total Time:** 0" 180 ms

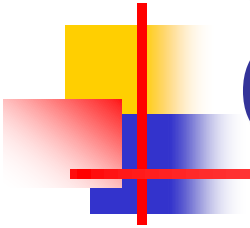
sample1.html

| A | B | C | D | E | F |
|---|---|---|---|---|---|
| John Smith | Database Primer | First Edition, Paperback | 1998 | $20 | This book introduces the reader to the theory and technology...[TRUNCATED] |
| | | Second Edition, Hard Cover | 2000 | $30 | |
| | Computer Systems | First Edition, Paperback | 1996 | $40 | An undergraduate level introduction to computer... [TRUNCATED] |

sample2.html

| A | B | C | D | E | F |
|---|---|---|---|---|---|
| Paul Jones | XML at Work | First Edition, Paperback | 1999 | $30 | A comprehensive description of XML and all related standards ...[TRUNCATED] |
| | HTML and Scripts | null | 1993 | $30 | A useful HTML handbook, with a good tutorial on the use of sc...[TRUNCATED] |
| | | Second Edition, Hard Cover | 1999 | $45 | |
| | JavaScripts | null | 2000 | $50 | A must in every Webmaster's bookshelf ... |

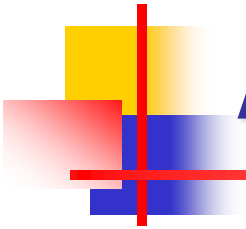
# Union-Free Regular Expression (UFRE)



- Web page structure can be represented as *Union-Free Regular Expression* (UFRE)
  - UFRE is Regular Expressions without *disjunctions*
  - If *a* and *b* are UFRE, then the following are also UFREs
    - a.b
    - (a)+
    - (a)?

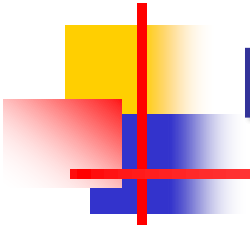
# Union-Free Regular Expression (UFRE)

- Web page structure can be represented as *Union-Free Regular Expression* (UFRE)
  - UFRE is Regular Expressions without *disjunctions*
  - If *a* and *b* are UFRE, then the following are also UFREs
    - a.b → string fields
    - (a)+ → lists (possibly nested)
    - (a)? → optional fields
  - Strong assumption that usually holds



# Approach

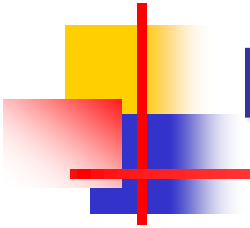
- Given a set of example pages
- Generate the *Union-Free Regular Expression* which contains example pages
- Find the least upper bounds on the RE lattice to generate a wrapper in *linear time*
- Reduces to finding the least upper bound on two UFREs



# Matching/Mismatches

Given a set of pages of the same type

- Take the first page to be the *wrapper* (UFRE)
- Match each successive sample page against the wrapper
- *Mismatches* result in generalizations of wrapper
  - String mismatches
  - Tag mismatches

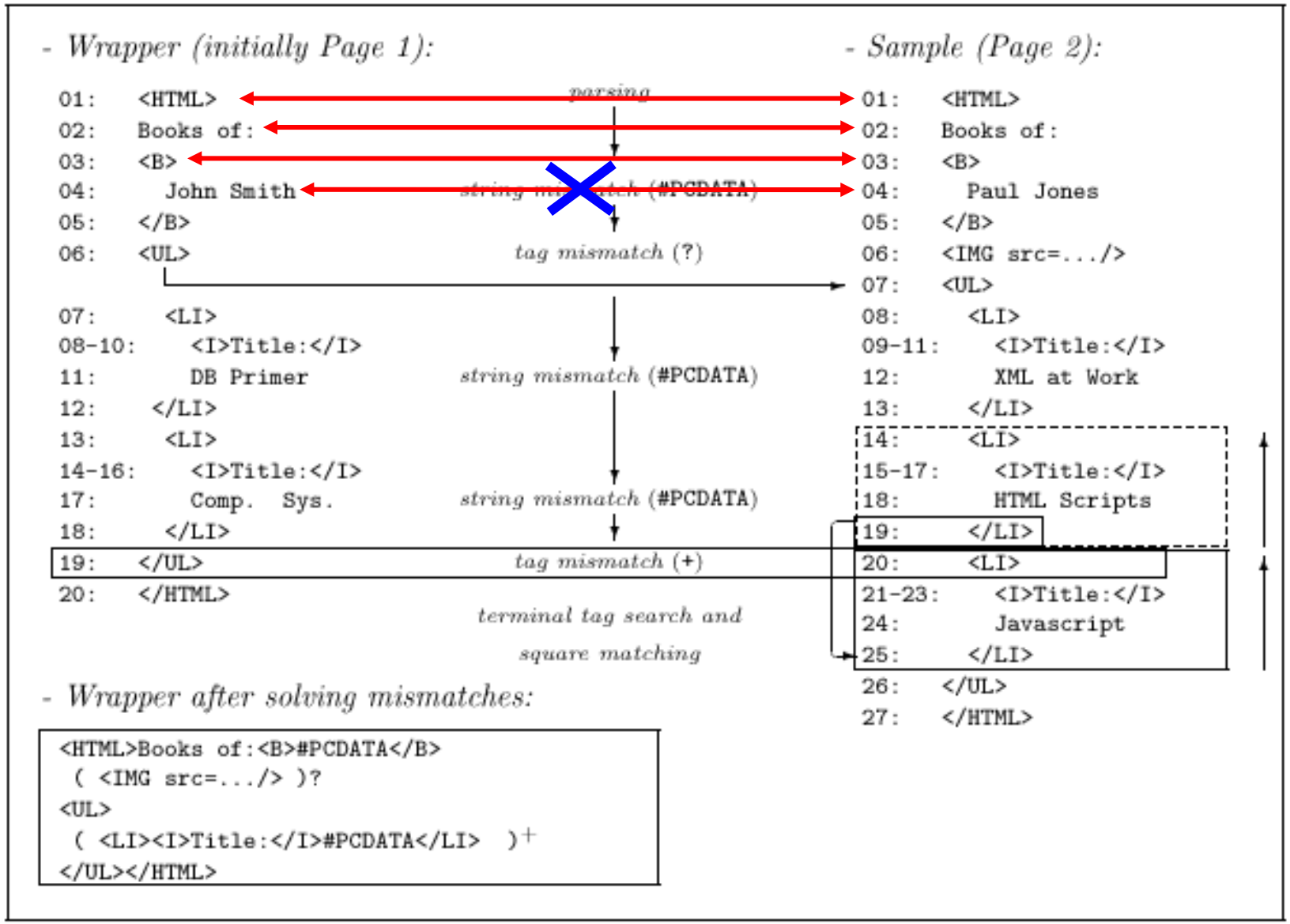


# Matching/Mismatches

Given a set of pages of the same type

- Take the first page to be the *wrapper* (UFRE)
- Match each successive sample page against the wrapper
- *Mismatches* result in generalizations of wrapper
  - String mismatches
    - Discover fields
  - Tag mismatches
    - Discover optional fields
    - Discover iterators

# Example Matching



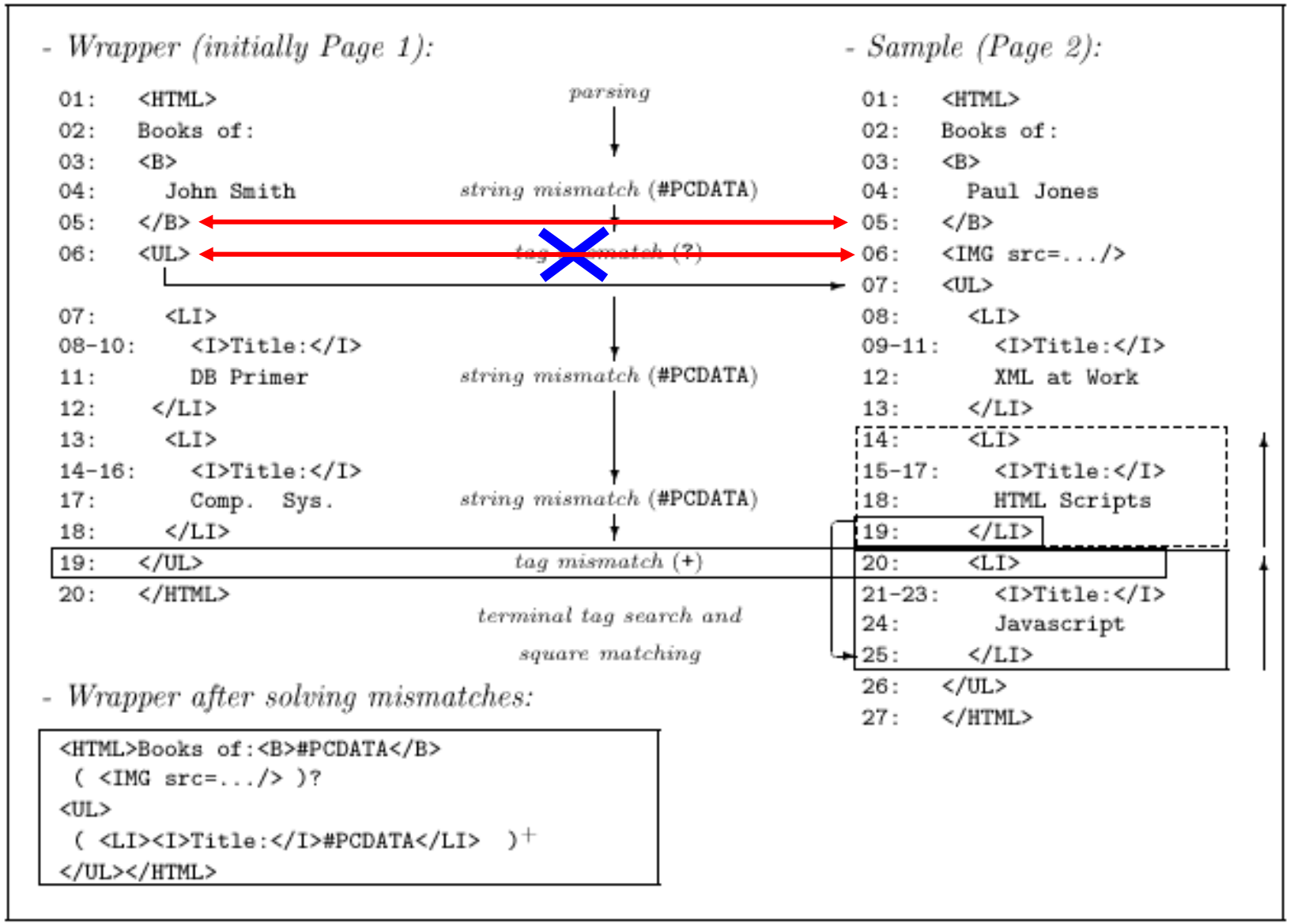
# String Mismatches: Discovering Fields

- String mismatches are used to discover fields of the document
- Wrapper is generalized by replacing "John Smith" with #PCDATA

<HTML>Books of: <B>John Smith

→ <HTML> Books of: <B>#PCDATA

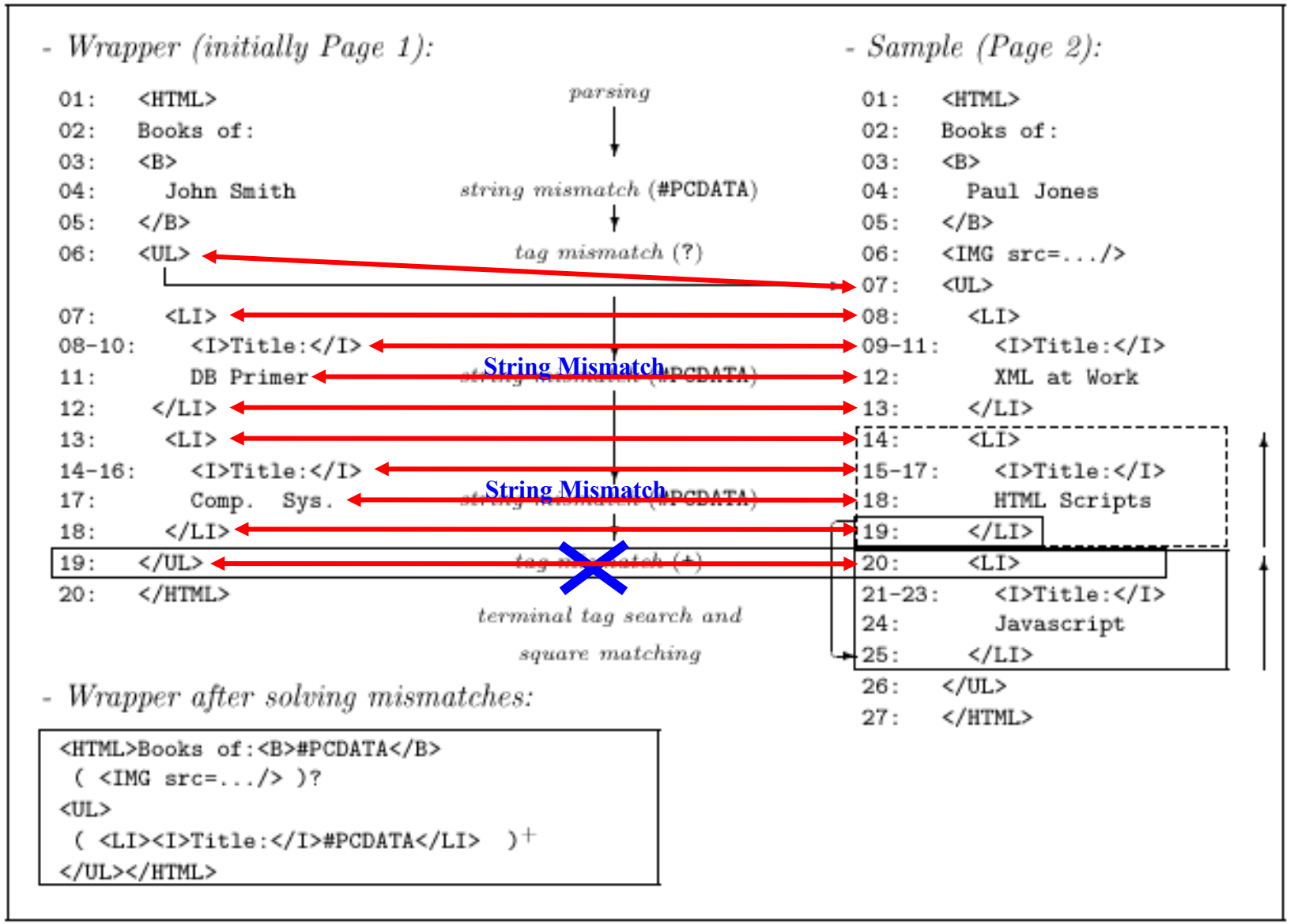
# Example Matching



# Tag Mismatches: Discovering Optionals

- First check to see if mismatch is caused by an iterator (described next)
- If not, could be an optional field in wrapper *or* sample
- Cross search used to determine possible optionals
- Image field determined to be optional:
  - ( <img src=.../>)?

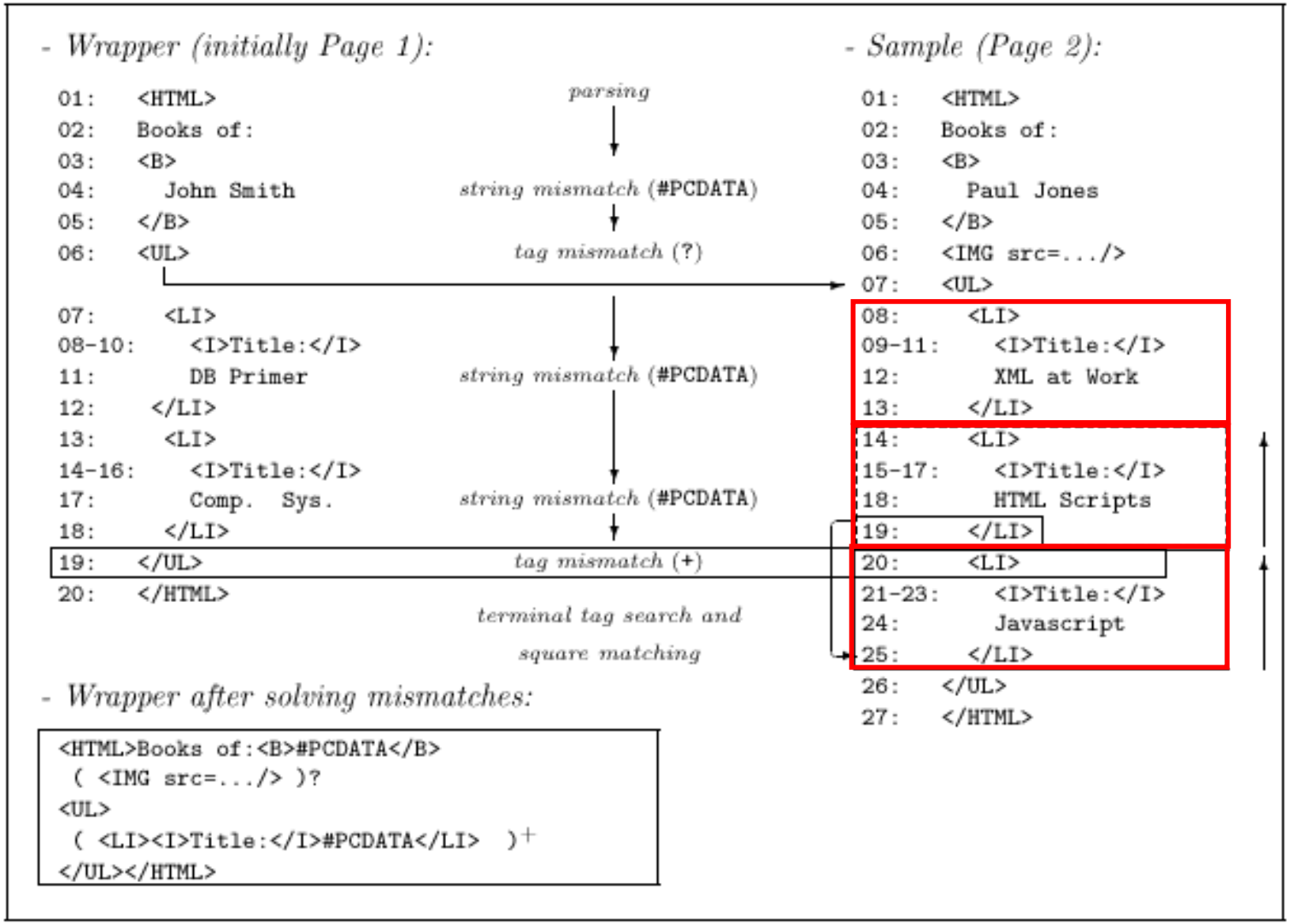
# Example Matching

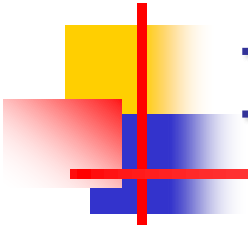


# Tag Mismatches: Discovering Iterators

- Assume mismatch is caused by repeated elements in a list
  - End of the list corresponds to last matching token: </LI>
  - Beginning of list corresponds to one of the mismatched tokens: <LI> or </UL>
  - These create possible “squares”
- Match possible squares against earlier squares
- Generalize the wrapper by finding all contiguous repeated occurrences:
  - ( <LI><I>Title:</I>#PCDATA</LI> )+

# Example Matching

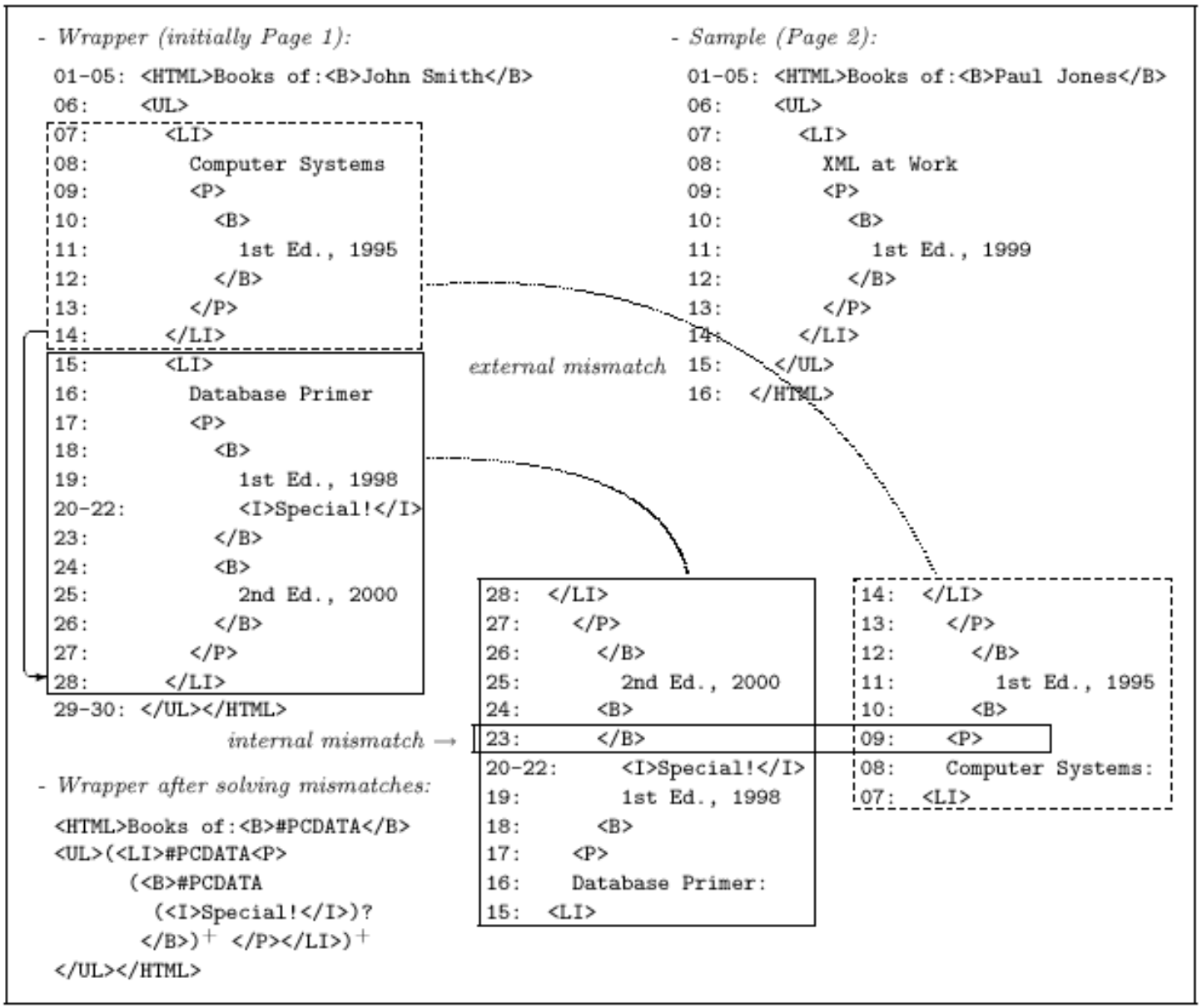


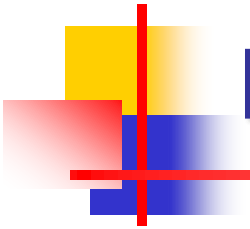


# Internal Mismatches

- Generate *internal mismatch* while trying to match square against earlier squares on *the same page*
  - Solving internal mismatches yield further refinements in the wrapper
    - List of book editions
    - <I>Special!</I>

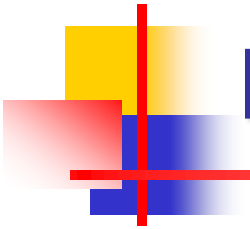
# Recursive Example





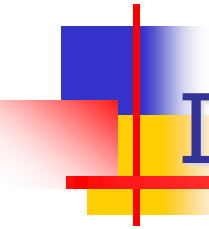
# Discussion

- Assumptions:
  - Pages are well-structured
  - Structure can be modeled by UFRE (no disjunctions)
- Search space for explaining mismatches is huge
  - Uses a number of heuristics to prune space
    - Limited backtracking
    - Limit on number of choices to explore
    - Patterns cannot be delimited by optionals
  - Will result in pruning possible wrappers

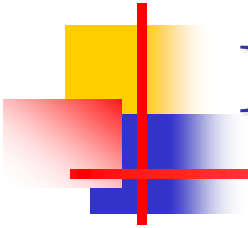


# Limitations

- Learnable grammars
  - Union-Free Regular Expressions (RoadRunner)
    - Variety of schema structure: tuples (with optional attributes) and lists of (nested) tuples
    - Does not efficiently handle disjunctions – pages with alternate presentations of the same attribute
  - Context-free Grammars
    - Limited learning ability
- User needs to provide a set of pages of the same type



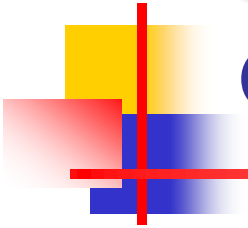
# Inferlink Web Extraction Software



# Inferlink Web Extraction Software

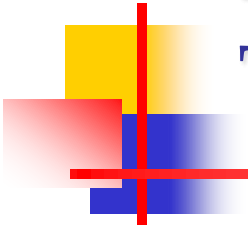
- Two phase processing
  - Step 1: Cluster the pages based on the layout of the pages
  - Step 2: Build a template to extract the data for each cluster

# Inferlink Web Extraction Software: Clustering

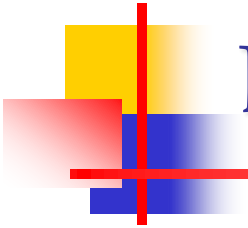


- Cluster
  - Based on the visible text
  - Page is broken into chunks
    - These are continuous blocks of text
  - Search for common visible chunks
    - Remove chunks that occur in all pages
    - Remove chunks that occur in less than 10 pages
  - Greedy algorithm to cluster the pages based on the remaining chunks
    - Sort by the size of the clusters created by each chunk

# Inferlink Web Extraction Software: Template Learning

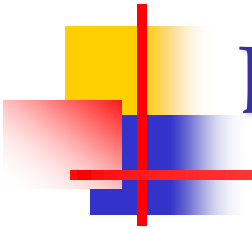


- Input: cluster {Pi}
- Select 5 random pages to build a template
  - Tokenize on space & punctuation
  - Start with n-grams of tuples of size n, n=6
    - Find those n-grams that occur on all pages
    - Keep only those n-grams that occur exactly once per pages
    - Decompose pages based on these n-grams
    - Run algorithm recursive on decomposed page
  - Repeat above for size n-1 down to n=2
  - Construct template based on the decomposition

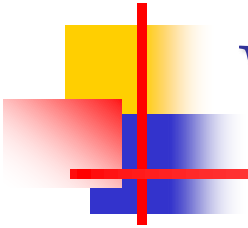


# Discussion

- Inferlink approach solves some of the key limitations of Roadrunner
  - Pages do not all have to be of the same type
  - Multiple optionals would be treated as different page types
  - Scales well with complex pages



# Demonstration



# Web Data Extraction Software

- Beautiful Soup
  - http://www.crummy.com/software/BeautifulSoup/
  - Python library to manually write wrappers
- Jsoup
  - http://jsoup.org/
  - Java library to manually write wrappers
- ScrapingHub
  - http://scrapinghub.com/
  - Portia provides a wrapper learner
- Others
  - https://www.quora.com/Which-are-some-of-the-best-web-data-scraping-tools
  - Tell us if you find a good one!