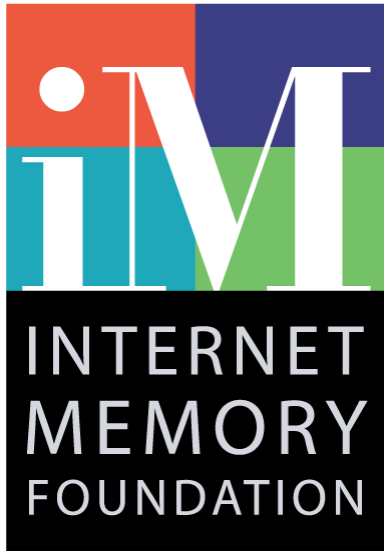
Adaptive Web Crawling through Stucture-Based Link Classification

Muhammad Faheem

Pierre Senellart

***Universiteit Twente*, 2 June 2016**

Web archiving



The CMS-Based Web

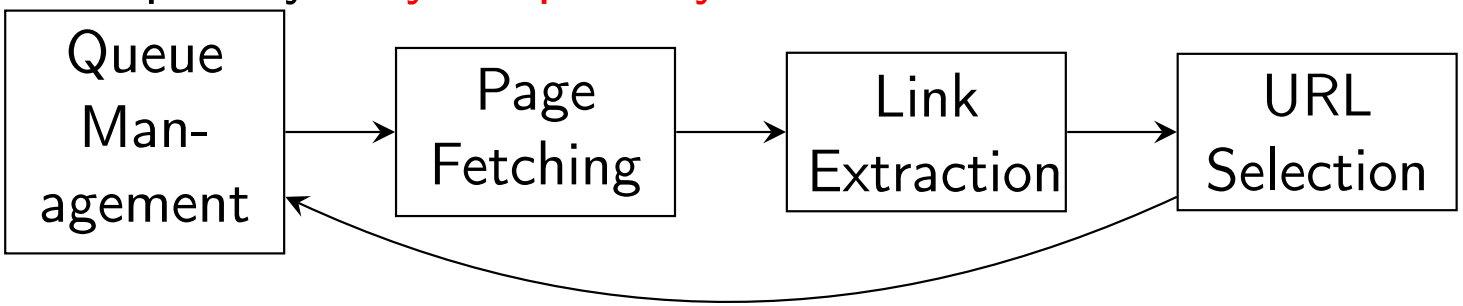
40–50% of Web content may rely on template-based content management systems (CMSs)

The CMS-Based Web

40–50% of Web content may rely on template-based content management systems (CMSs)

Traditional crawling approach

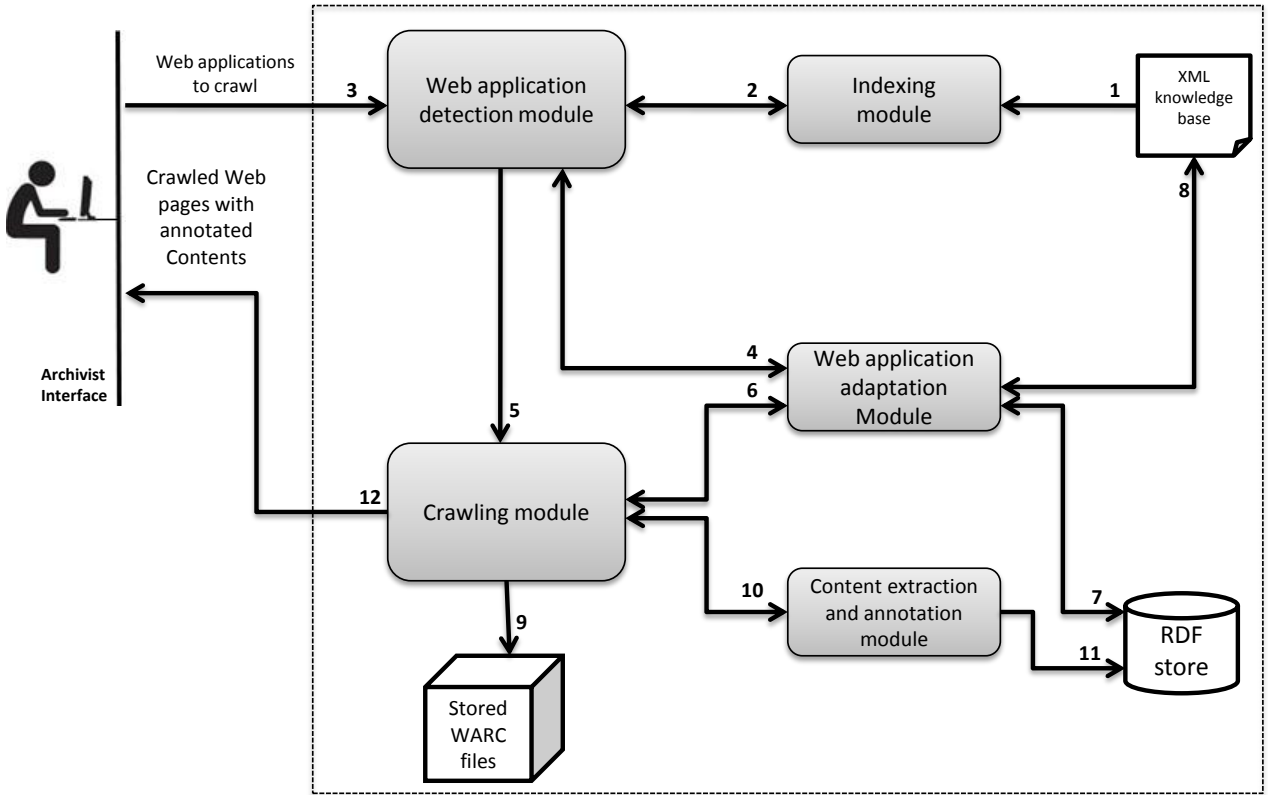
- A traditional Web crawler (such as Heritrix) crawls the Web in a conceptually very simple way.



- This approach does not take into account the nature of the Web site crawled, its structure, its template.
- Very inefficient! Most Web sites have lots of redundancies: several URLs host the same content, different ways to navigate within a Web site to the same content, etc.

Application-Aware Helper (AAH)

[ICWE 2013, CIKM 2013]



What is crawled depends on the CMS the Web site is based on, but relies on a hand-written knowledge base of existing CMSs

AAH: Web application detection module

- One main challenge in intelligent crawling and content extraction is to identify the Web application and then perform the best crawling strategy accordingly.
- Detecting Web application using:
  1. URL patterns,
  2. HTTP metadata,
  3. textual content,
  4. XPath patterns, etc.
- For instance the vBulletin Web forum content management system, that can be identified by searching for a reference to a `vbulletin_global.js` JavaScript script by using a simple `//script/@src` XPath expression.

Adaptation to template change

- Determine when a change has occurred wrt the template described in the knowledge base and adapting actions accordingly
- Two cases:

  Recrawl of a Web application Structural changes are detected by looking for the content in the archive. When structural change is detected, the system first marks the failed crawling actions and then aligns them using content from the archive.

  Crawl of a new Web application If actions in the knowledge base do not match, the system collects all candidate attributes, values, tag names from the knowledge base, creates all possible combinations of relaxed expressions, and then evaluates them.

Desiderata

- Fully automated system for Web crawling
- Crawls the content of template-based Web sites with fewer requests than traditional Web crawlers
- Automatically identifies interesting navigation patterns in a Web site
- Adapts to the structure of new Web sites, based on unknown CMSs

Outline

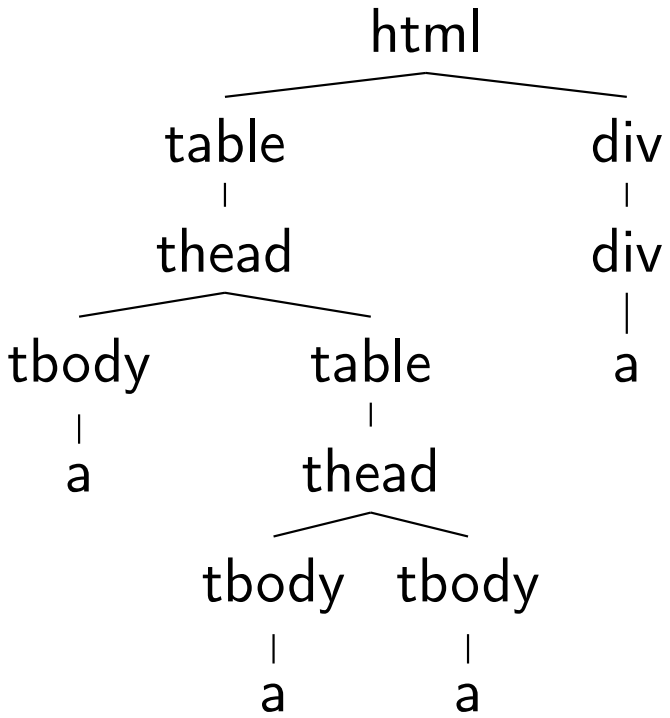
Structure-driven crawler [ICADL 2015]

- ACEBot (Adaptive Crawler Bot for data Extraction) is a fully automatic, structure-driven crawler.
- ACEBot utilizes the inner structure of the Web pages and guides the crawling process based on the importance of their content.
- ACEBot has two phases:

  Offline phase: constructs a dynamic site map (limiting the number of URLs retrieved), learns the best traversal strategy based on importance of navigation patterns (selecting those leading to valuable content).

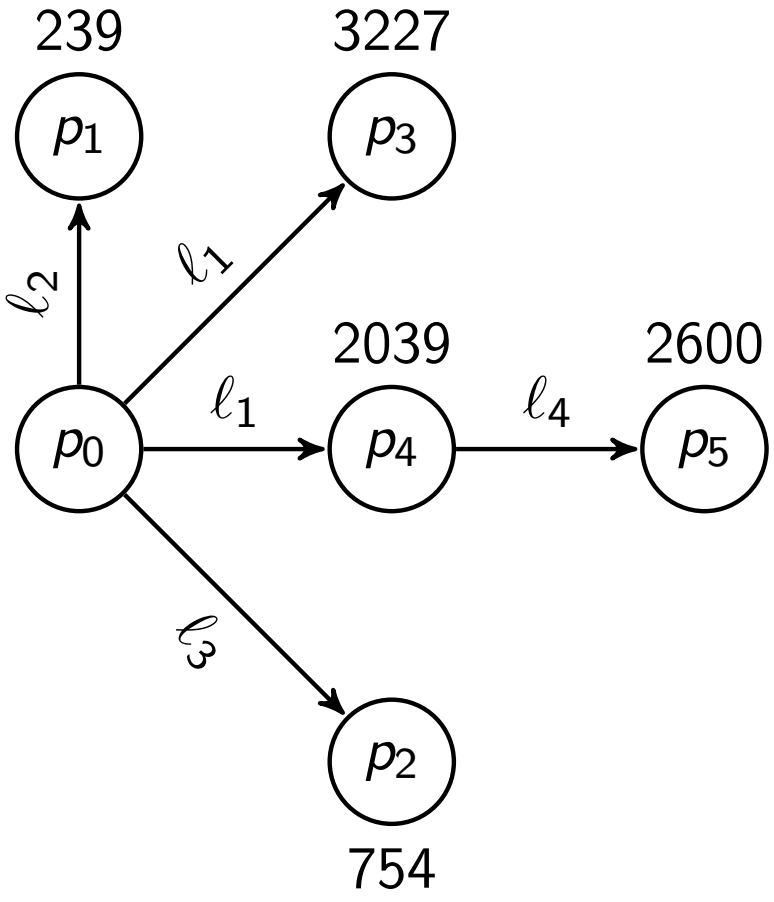
  Online phase: performs massive crawling following the chosen navigation patterns.

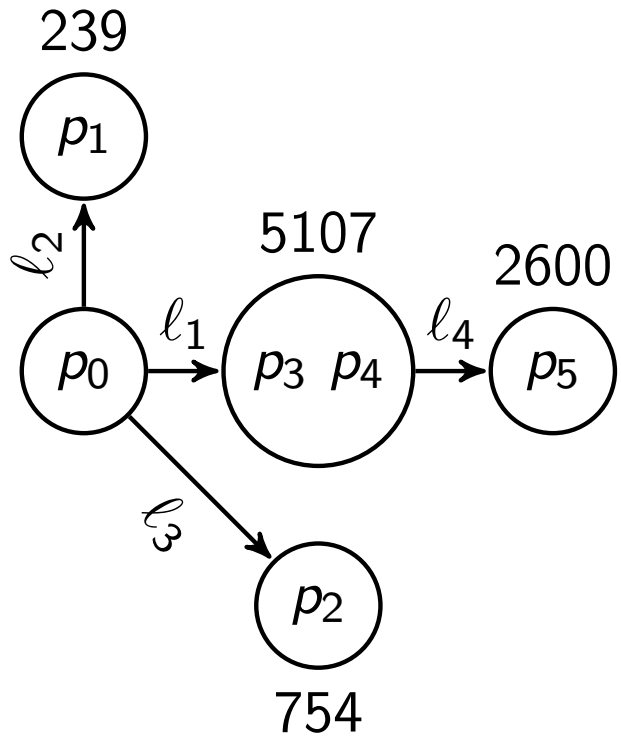
Simple example: structure of a Web page



- ℓ_1 html-table-thead-table-thead-tbody-a
- ℓ_2 html-div-div-a
- ℓ_3 html-table-thead-tbody-a

Simple example: structure of a Web site





Objective

- Determine the navigation patterns on a Web site that lead to most content items
- Content items: can be anything, e.g., k-grams (succession of k words)
- Score of a navigation pattern: $\dfrac{\text{number of distinct items}}{\text{number of requests}}$

Proposition

Finding a set of navigation patterns that optimizes the score is coNP-hard.

$\Rightarrow$ Greedy approach, until sufficiently many content items have been retrieved

Objective

- Determine the navigation patterns on a Web site that lead to most content items
- Content items: can be anything, e.g., k-grams (succession of k words)
- Score of a navigation pattern: $\frac{\text{number of distinct items}}{\text{number of requests}}$

Proposition

Finding a set of navigation patterns that optimizes the score is coNP-hard.

$\Rightarrow$ Greedy approach, until sufficiently many content items have been retrieved

Objective

- Determine the navigation patterns on a Web site that lead to most content items
- Content items: can be anything, e.g., k-grams (succession of k words)
- Score of a navigation pattern: $\dfrac{\text{number of distinct items}}{\text{number of requests}}$

Proposition

Finding a set of navigation patterns that optimizes the score is coNP-hard.

$\Rightarrow$ Greedy approach, until sufficiently many content items have been retrieved

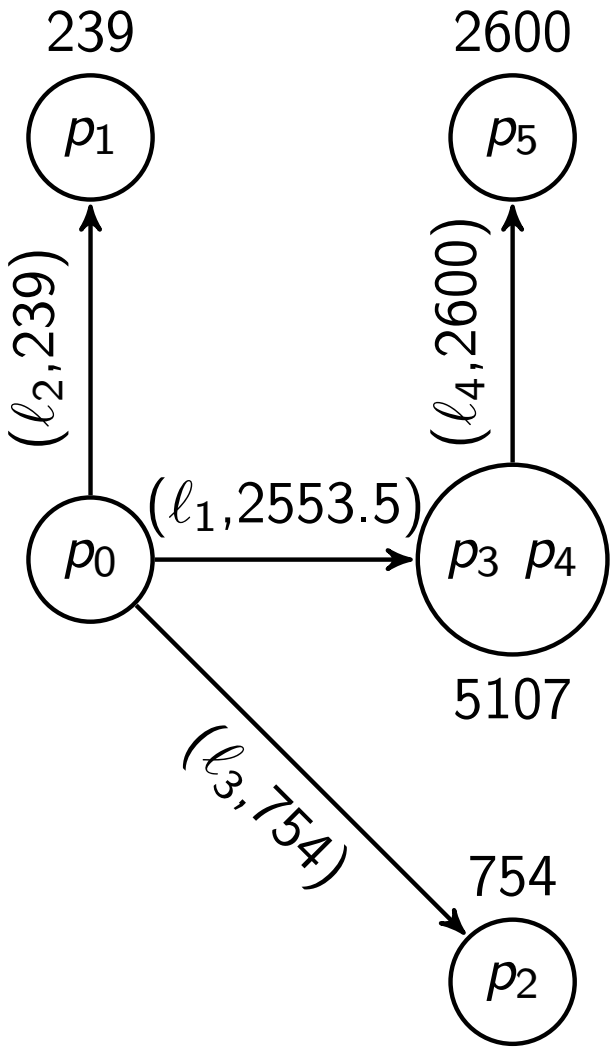
Language of navigation patterns

Non-disjunctive regular expressions over link paths, expressed as OXPath expressions (language for Web navigation)

⟨expr⟩ ::= "doc" "(" ⟨url⟩ ")" (⟨estep⟩)+

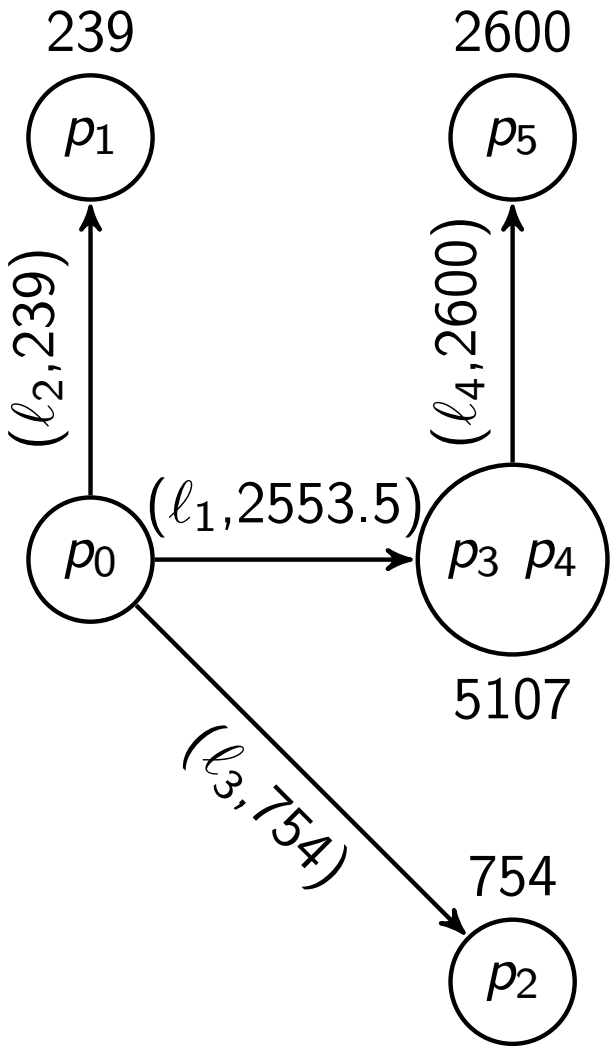
⟨estep⟩ ::= ⟨step⟩ | ⟨kleene⟩
⟨step⟩ ::= "/" "("⟨action⟩ ")"
⟨kleene⟩ ::= "/" "(" ⟨action⟩ ")" ("∗" | ⟨number⟩)
⟨action⟩ ::= ("/" ⟨nodetest⟩)+ "{click/}"
⟨nodetest⟩ ::= *tag* | "@" *tag*

Simple example: best navigation pattern



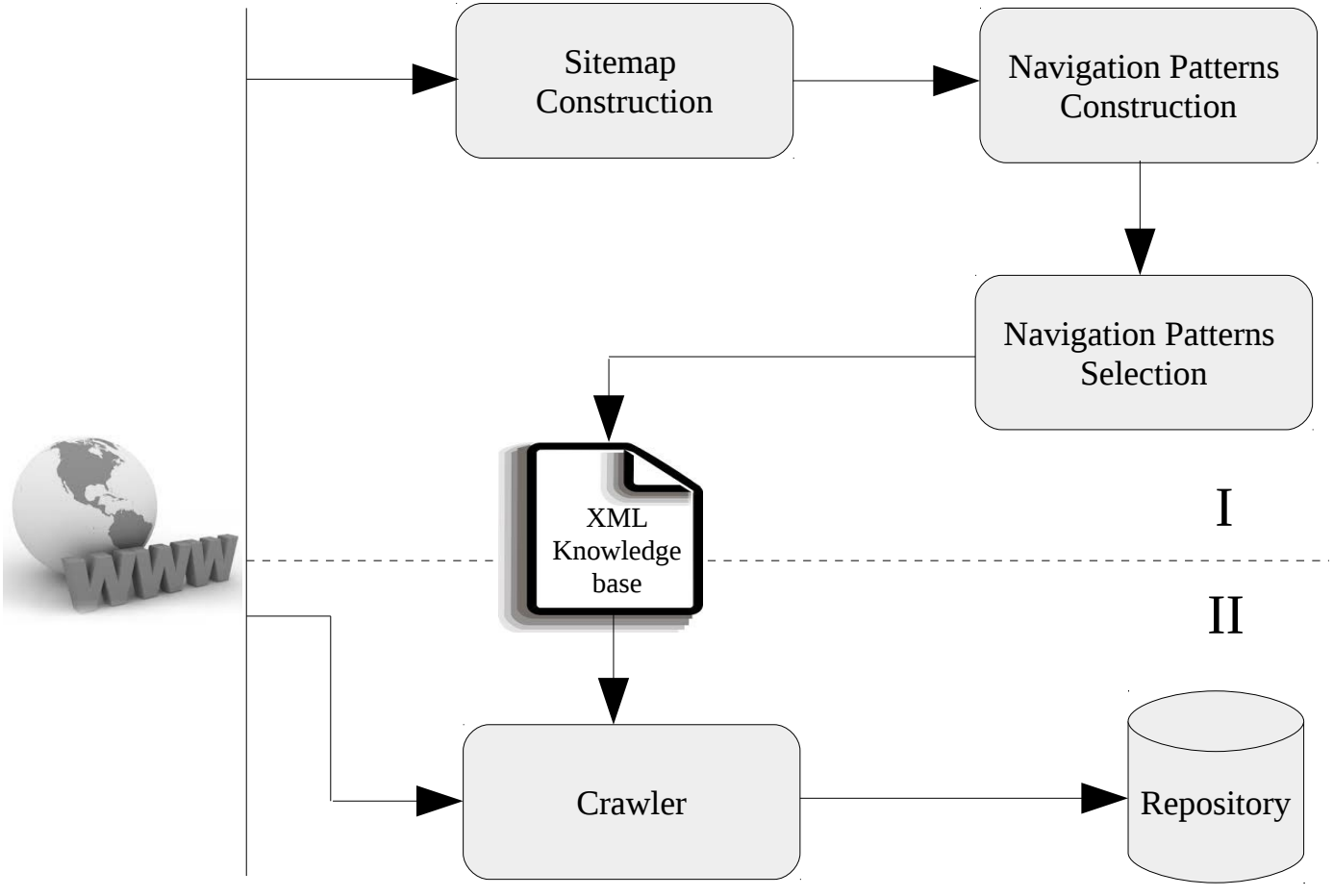
NP	total 2-grams	distinct 2-grams	score
ℓ_1	5266	5107	2553.5
ℓ_1, ℓ_4	7866	7214	2404.7
ℓ_3	754	754	754
ℓ_2	239	239	239

Simple example: best navigation pattern



NP	total 2-grams	distinct 2-grams	score
ℓ_1	5266	5107	2553.5
ℓ_1, ℓ_4	7866	7214	2404.7
ℓ_3	754	754	754
ℓ_2	239	239	239

ACEBot architecture



Outline

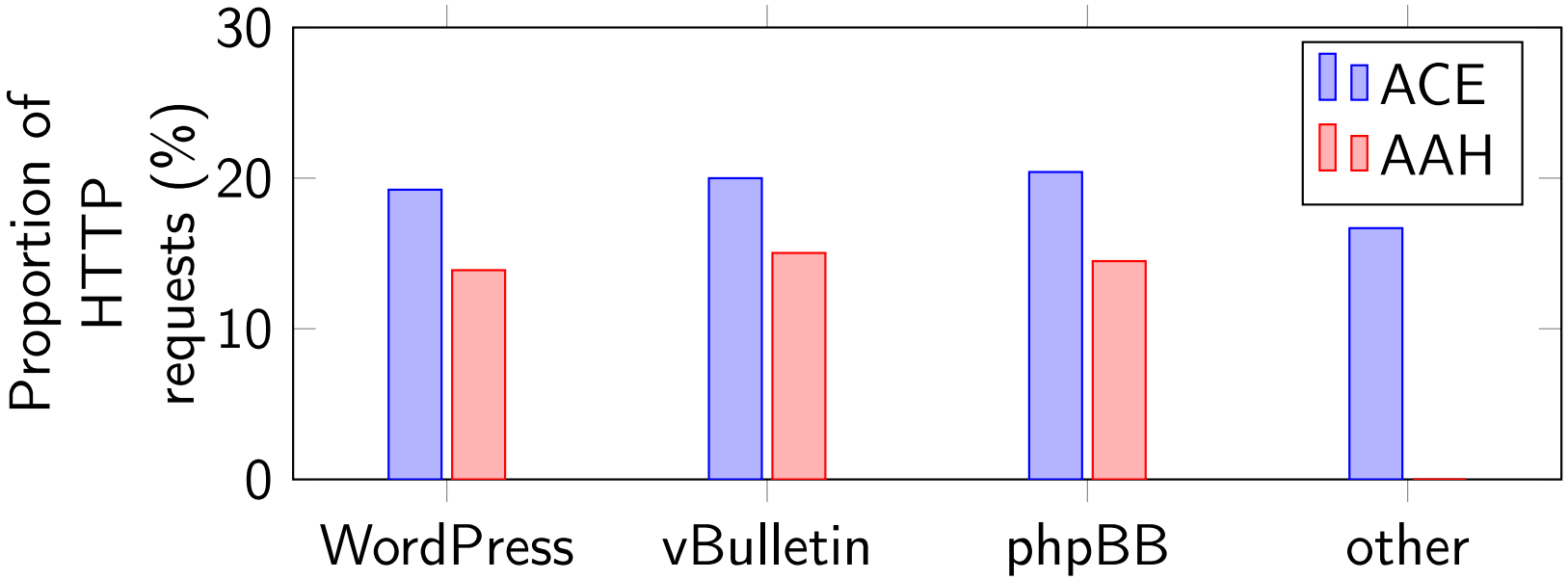
Experiment setup

- The experiments are performed with ACEBot, AHH and GNU wget
- Crawled 50 Web sites (totaling nearly 2 million Web pages) with both ACEBot and wget
- Crawled 10 Web sites (totaling nearly 0.5 million Web pages) with both ACEBot and AAH
- Dynamic site map has been constructed with randomly chosen 3000 Web pages

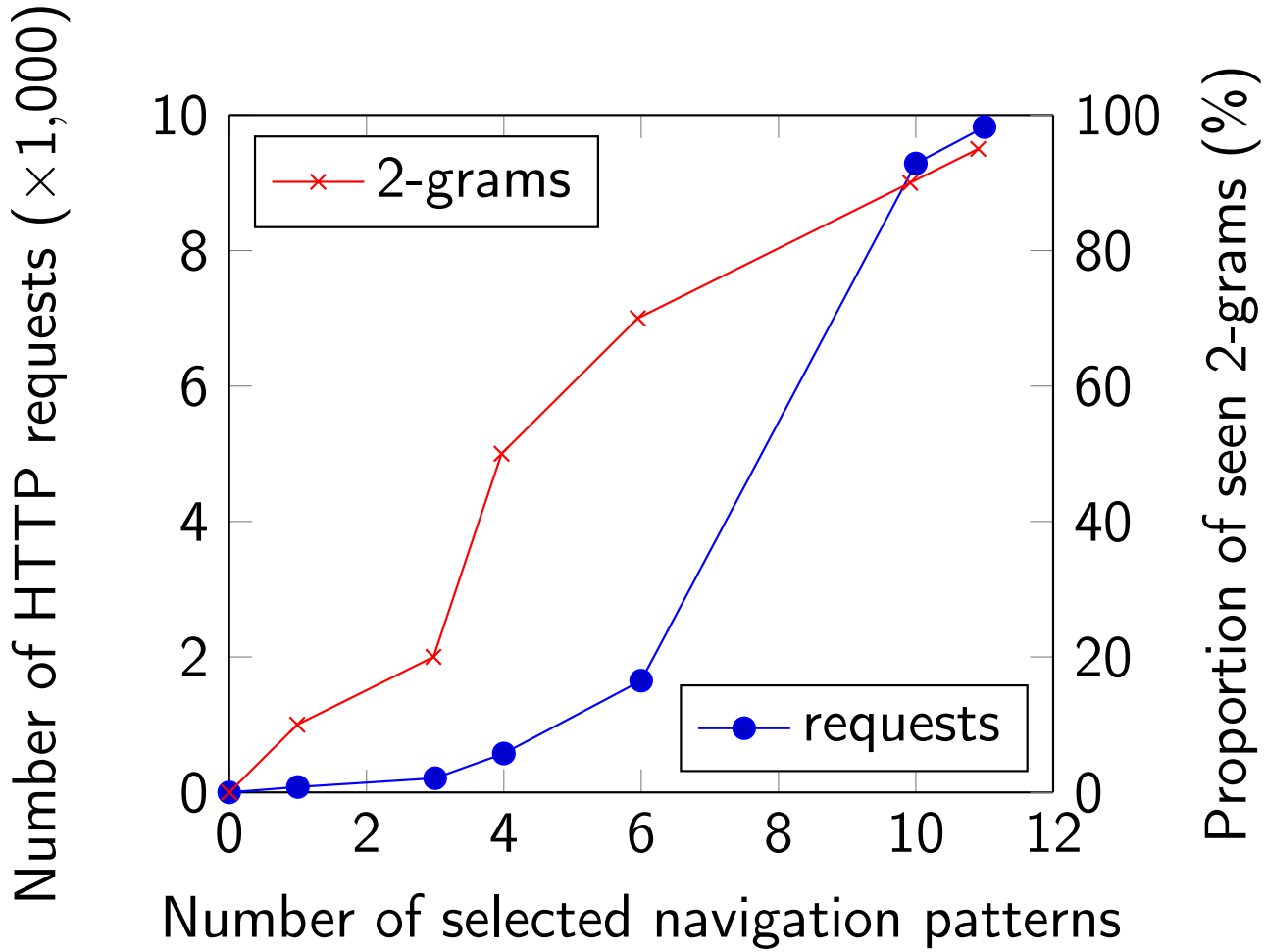
Performance metrics

- The number of HTTP requests made by both systems vs the amount of useful content retrieved
- Coverage of useful content is calculated by comparing the proportion of 2-grams in the crawl result of both systems for every WA and by counting the number of external links

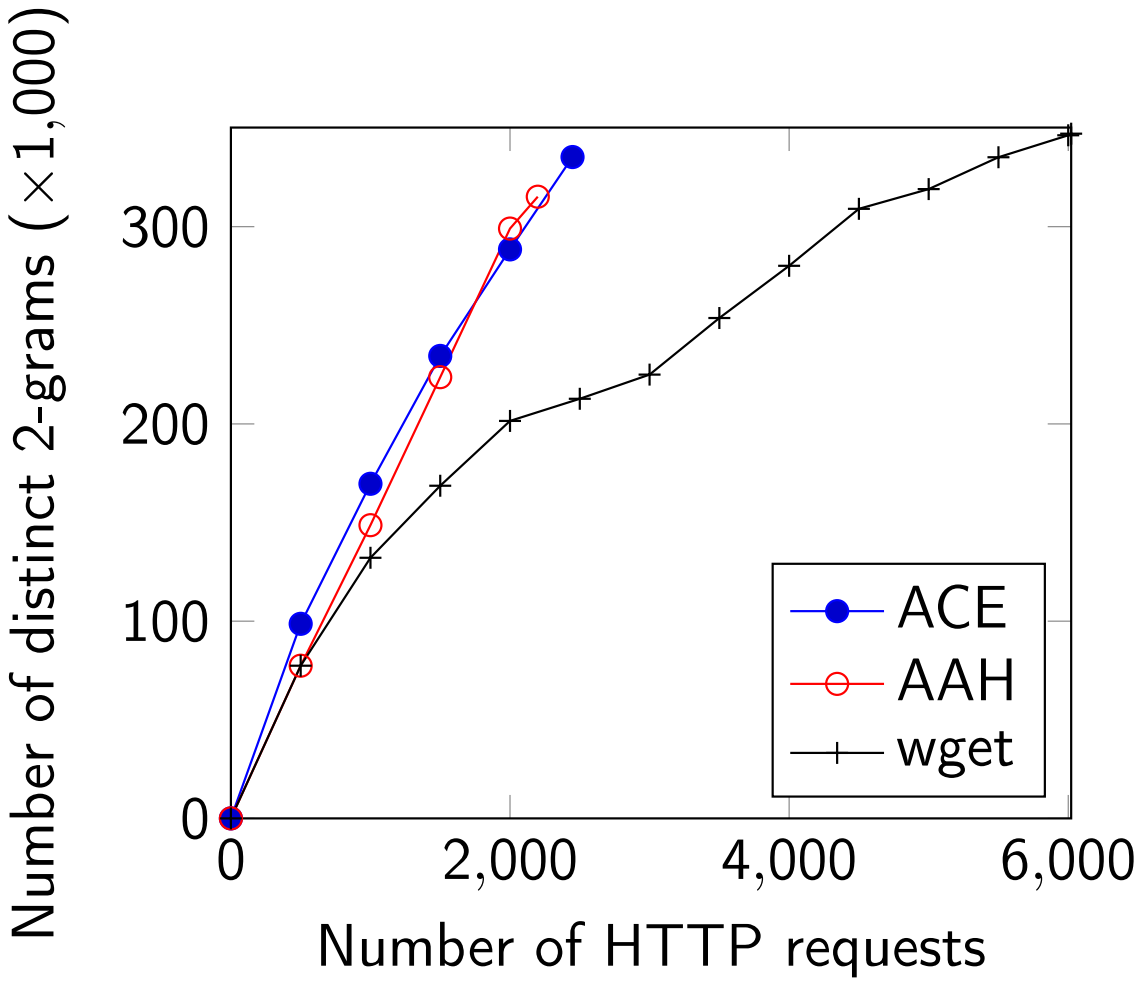
Crawl efficiency



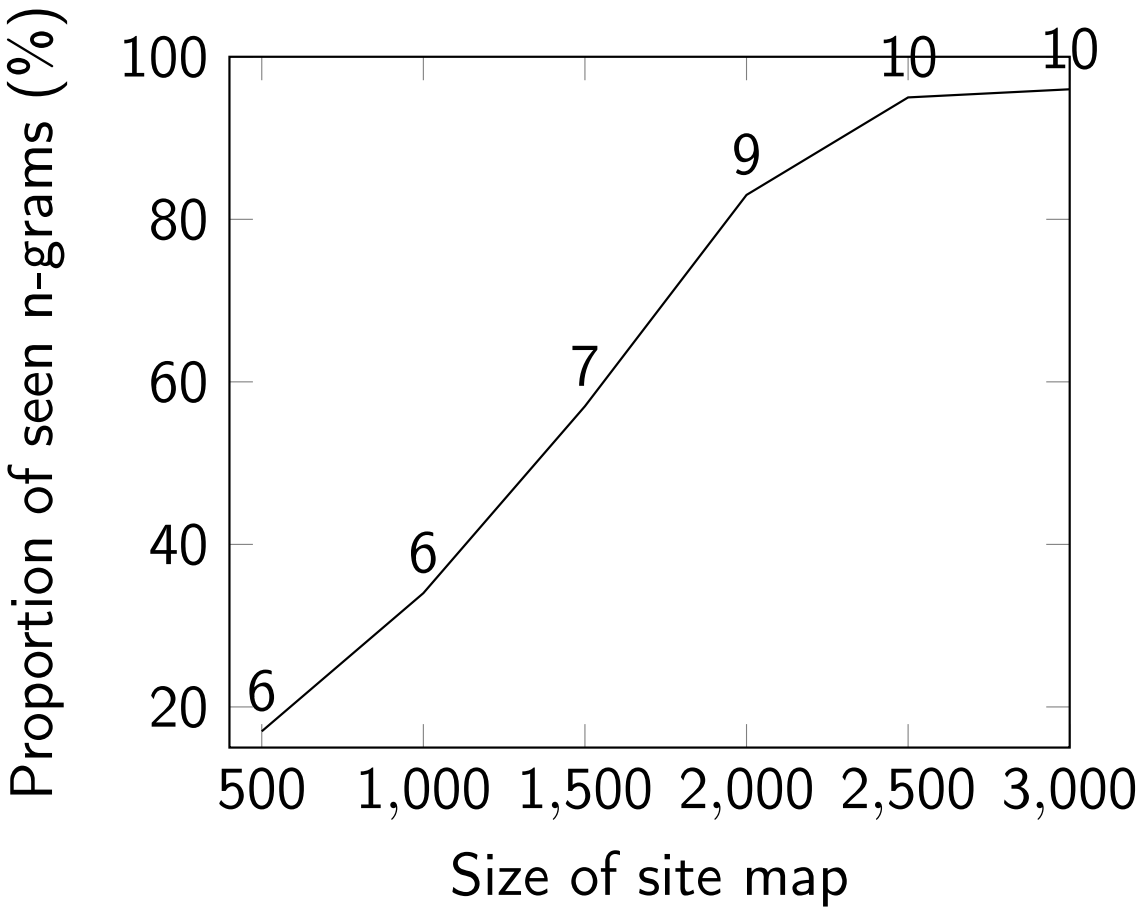
Navigation pattern efficiency



Crawling a particular Web site



Impact of the sitemap size



(Labels are the number of navigation patterns learned.)

Outline

Conclusion

In brief:

- It is possible to retrieve the significant content of a Web site much more efficiently than by crawling it whole
- Comparable results between fully automatic approach and approach relying on hand-written knowledge base
- Sample, learn, apply to whole Web site

Main open direction:

- More adaptive selection of sitemap size – adapt to the size of the Web site

Conclusion

In brief:

- It is possible to retrieve the significant content of a Web site much more efficiently than by crawling it whole
- Comparable results between fully automatic approach and approach relying on hand-written knowledge base
- Sample, learn, apply to whole Web site

Main open direction:

- More adaptive selection of sitemap size – adapt to the size of the Web site

Merci !