Distributed Information Retrieval: an approach based on harvesting

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outline

- Problem Domain
  - content-based wide-area distributed Information Retrieval
- Approach
  - from distributed retrieval to index harvesting via metadata harvesting
- Design Strategies
  - expanding the OAI-PMH infrastructure: protocol applications and protocol extensions
- Conclusions
  - where next?

problem domain

- Information Retrieval (IR)
  - primary content, not metadata
  - unstructured content and queries
  - queries evaluated probabilistically, not deterministically
- Distributed IR (DIR)
  - content is distributed across mutually remote collections
- Wide-Area DIR
  - content collections are widely dispersed
    - latencies, bandwidth fluctuations, network failures, connectivity issues
  - content collections are autonomously managed
    - disparity of strength and motivations

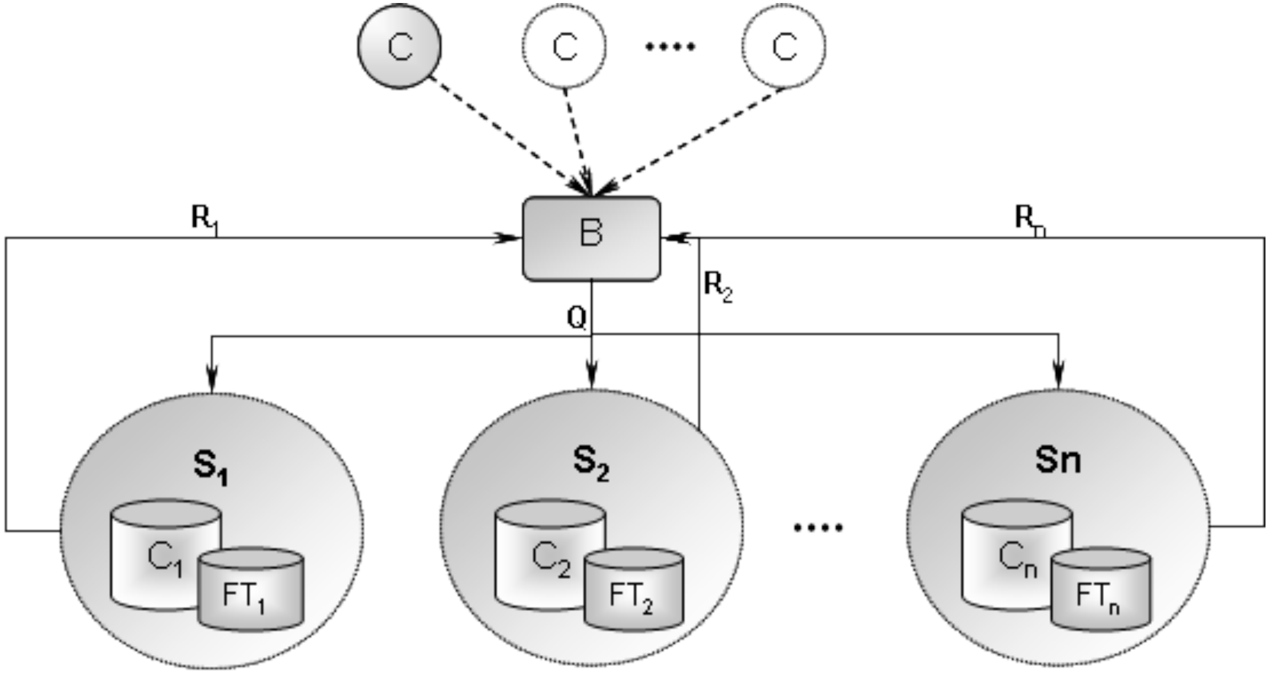
distributed retrieval contd.

- strategy
  1. distribute process across its inputs
     - ‘push’ queries towards collections
  2. centralise remotely produced outputs
     - ‘pull’ results of local query executions

- two phases
  - synchronous
  - real-time wrt user interaction

- common assumptions
  - brokered client/server architectures
  - textual content

distributed retrieval contd.



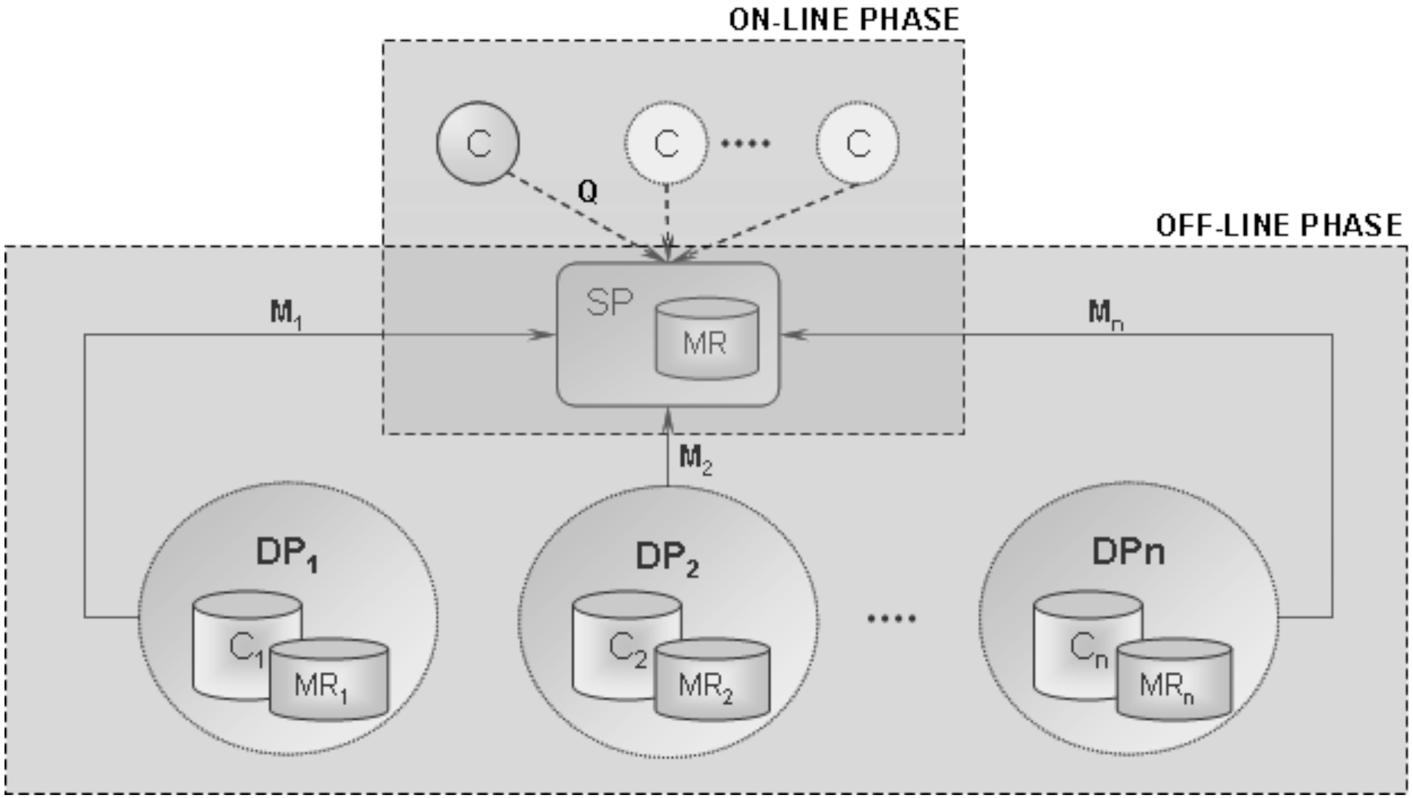
distributed retrieval contd.

- considerable amount of research
  - collection description, collection selection, result fusion
    - cooperative and uncooperative techniques
  - test-beds & evaluation
- hot areas
  - from client/server to peer-to-peer architectures
    - hybrid, multi-tiered
  - from textual to multi-media content
    - cf. MIND and PENG Projects
  - from ad-hoc to GRID-enabled infrastructures
    - cf. the DILIGENT Project
- applications
  - metasearch engines on the Web
  - Federated Digital Libraries

metadata harvesting

- from Z39.50…to the OAI-PMH
- strategy
  - centralise input in advance of process execution
    - incrementally and iteratively
  - execute process against its input
    - locally
- two phases
  - asynchronous
  - one batch, one real-time wrt user interaction
- common assumptions
  - *input*: manually authored, descriptive metadata records
  - *queries*: fielded and deterministically evaluated

metadata harvesting contd.



metadata harvesting contd.

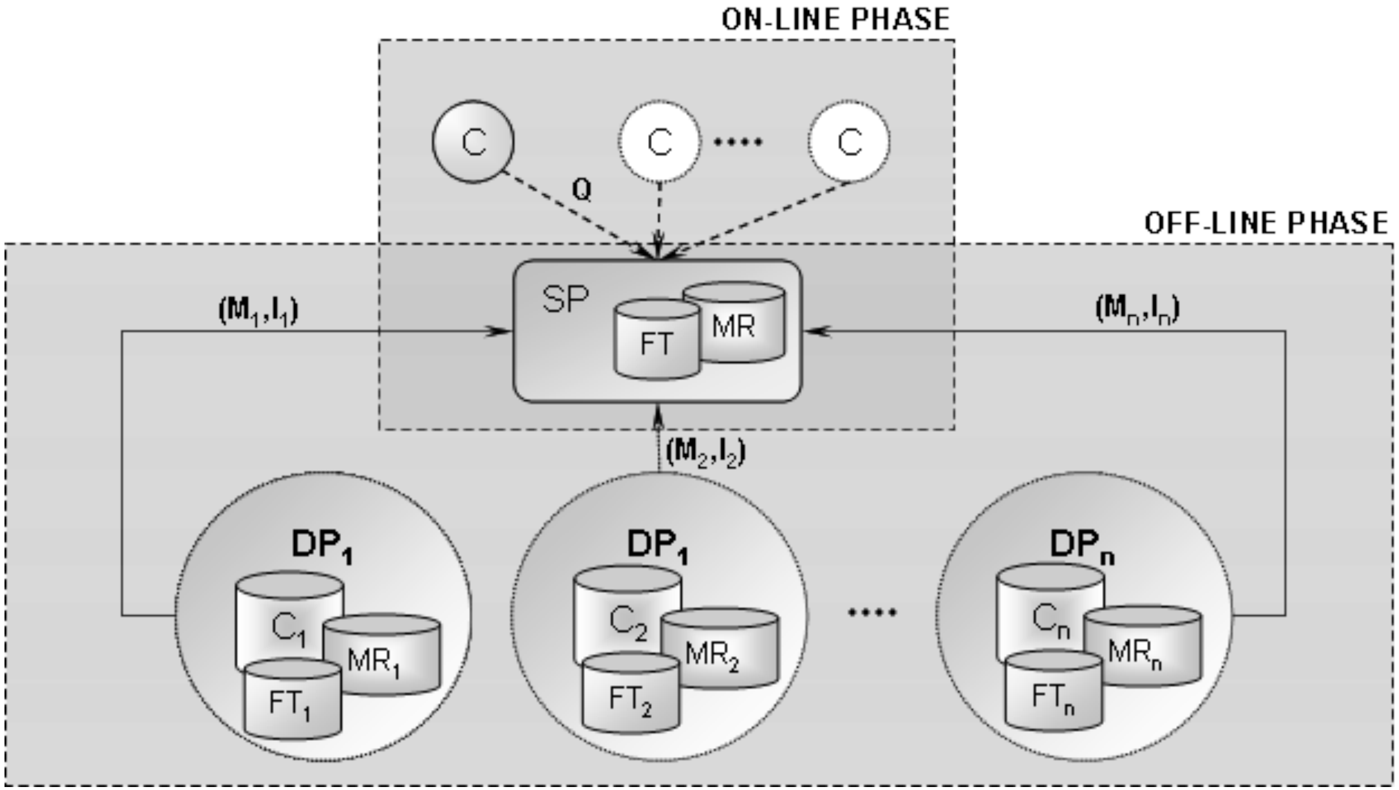
- technical advantages:
  - wide-area not observable during service provision
    - consistency, reliability, responsiveness, effectiveness, generality, simplicity
    - encourages medium, medium-large scalability
- sociological advantages:
  - *data providers*: greater visibility
    - without cost of full service provision
    - even for sensitive and dynamically published data
  - *service providers*: wider reach
- disadvantages:
  - minimal cooperation required
  - input potentially stale

  - …and yet a common assumption in large-scale DL developments

index harvesting

- strategy
  - centralise content statistics automatically generated at data providers…
    - e.g. term histograms
    - possibly filtered (e.g. stopword removal)
    - possibly normalised (e.g. stemming)
    - incrementally and iteratively
    - according to some exchange model
  - …as well as descriptive metadata records
    - according to some exchange model
  - ingest both into local index at service provider
    - possibly normalising statistics wrt to current index statistics
    - possibly enhancing/normalising metadata records
  - execute queries at service provider
    - against local index of remote collections
    - using the harvested metadata to present query results

index harvesting contd.



index harvesting contd.

- between distributed retrieval and content crawling
  - some process is distributed…but indexing not retrieval
    - reap benefits of metadata harvesting
  - some data is centralised…but content statistics not content
    - more efficient bandwidth consumption
    - reduced load at data and service providers
- expand scope of content-based DIR research
  - content distribution need no longer imply distribution of retrieval or centralisation of content
- complement existing harvesting-based DL services
  - from metadata-based services to content-based services
  - leveraging the OAI-PMH infrastructure
    - a protocol application
    - a protocol extension

OAI-PMH recap

- client/server protocol for exchange of self-describing data
- 6 requests available to clients
  - 3 auxiliary requests, to discover server capabilities (`Identiy, ListMetadataFormats, ListSets`)
  - 2 primary requests, to solicit data according to capabilities (`GetRecord, ListRecords, ListIdentifiers`)
- support for incremental harvesting
  - based on data time-stamping
- support for selective harvesting
  - based on hierarchies of potentially overlapping datasets
- support large data transfers in the face of transaction failures
  - simple session management mechanism based on resumption tokens

OAI-PMH recap contd.

- infrastructural issues outside protocol semantics
  - authentication, load balancing, compression, etc. resolved in a broader scope (e.g. at HTTP level)
- abstract data model
  - servers maintain repositories of *resources*
  - resources have 1^+ abstract descriptions, or *items* (basic unit of identification)
  - descriptions have 1^+ format-specific instantiations, of *records* (basic unit of exchange and time-stamping)
    - support for Dublin Core mandatory

applying the OAI-PMH

- application strategy
  - extended data model
    - resources have at least one digital and text-based manifestation
    - one such manifestation, the *primary manifestation*, represents the resource content for harvesting purposes
  - dedicated format
    - for manually authored metadata *and* content statistics
    - statistics extracted from primary manifestation
- appealing solution…
  - no change to protocol and its development infrastructure
  - may serve immediately specific communities
- …but ad-hoc
  - different format for any combination of metadata and content statistics formats
  - need more modular, infrastructural approach

extending the OAI-PMH

- extension strategy
  - retain extended data model
  - identify metadata and content statistics independently
    - a record has now both a ‘metadata part’ and an ‘index part’
  - requests specify desired formats for both parts
- extension elements
  - extra auxiliary request `ListIndexFormats`
    - mirrors `ListMetadataFormats`
  - extra primary request parameter `indexPrefix`
    - mirrors `metadataPrefix`
  - extra `<index>` element to server responses
    - follows `<metadata>` element
  - sample format `tf_basic` for the index part
    - captures name and frequency of occurrence of indexing terms

evaluation

- proof-of-concept prototype
  - extensive testing
  - release of extended PMH to the OAI community
- testing
  - used the Aquaint TREC corpus across two institutions in different countries
    - tested the emulated heterogeneity of collections
    - tested the behaviour of incremental and periodical harvesting
  - efficiency
    - very small difference in resources required to index the global collection wrt index the harvested index data
  - effectiveness
    - same level of effectiveness of the global collection

conclusions

- main points
  - the harvesting model may be profitably applied to content-based retrieval
    - or there exists appealing middle ground between distributed retrieval and content crawling
  - the OAI-PMH infrastructure may be profitably leveraged for the purpose
    - immediately, via a protocol application
    - flexibly, via a protocol extension
- future work
  - exploit 2-phase model for asynchronous resource discovery in mobile and context-aware computing

question?

- more detailed presentation
  - F. Simeoni, M. Yakici, S. Neely and F. Crestani. Metadata Harvesting for Content-based Distributed Information Retrieval. *Journal of the American Society for Information Science and Technology*, 59(1):12-24, 2008