Large Scale Internet Search at Ask.com

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InfoScale 2006

Outline

- **Overview of the company and products**
- **Core techniques for page ranking**
  - ExpertRank
- **Challenges in building scalable search services**
  - Neptune clustering middleware.
  - Fault detection and isolation.

Ask.com: Focused on Delivering a Better Search Experience

- **Innovative search technologies.**
- **#6 U.S. Web Property; #8 Global in terms of user coverage**
  - 28.5% reach - Active North American Audience with 48.8 million unique users
  - 133 million global unique users for ASK worldwide sites: USA, UK, Germany, France, Italy, Japan, Spain, Netherlands.
- **A Division of IAC Search and Media (Formally Ask Jeeves)**

Ask.com

IAC Search & Media

Sectors of IAC (InterActiveCorp)

•Retailing	HSN.com, Cornerstone Brands, Inc., HSE24, America's Store, Shoebuy.com
•Services	ticketmaster, RealEstate.com inventing a better way, PRC, LendingTree When banks compete, you win, ServiceMagic
•Media & Advertising	Ask.com, Citysearch, evite
•Membership & Subscriptions	Interval International, match.com, entertainment
•Emerging Businesses	gifts.com, Quiz.tv, pronto, iBuy

Ask.com

IAC (InterActiveCorp)

- Fortune 500 company
  - •Create, acquire and build businesses with leading positions in interactive markets.

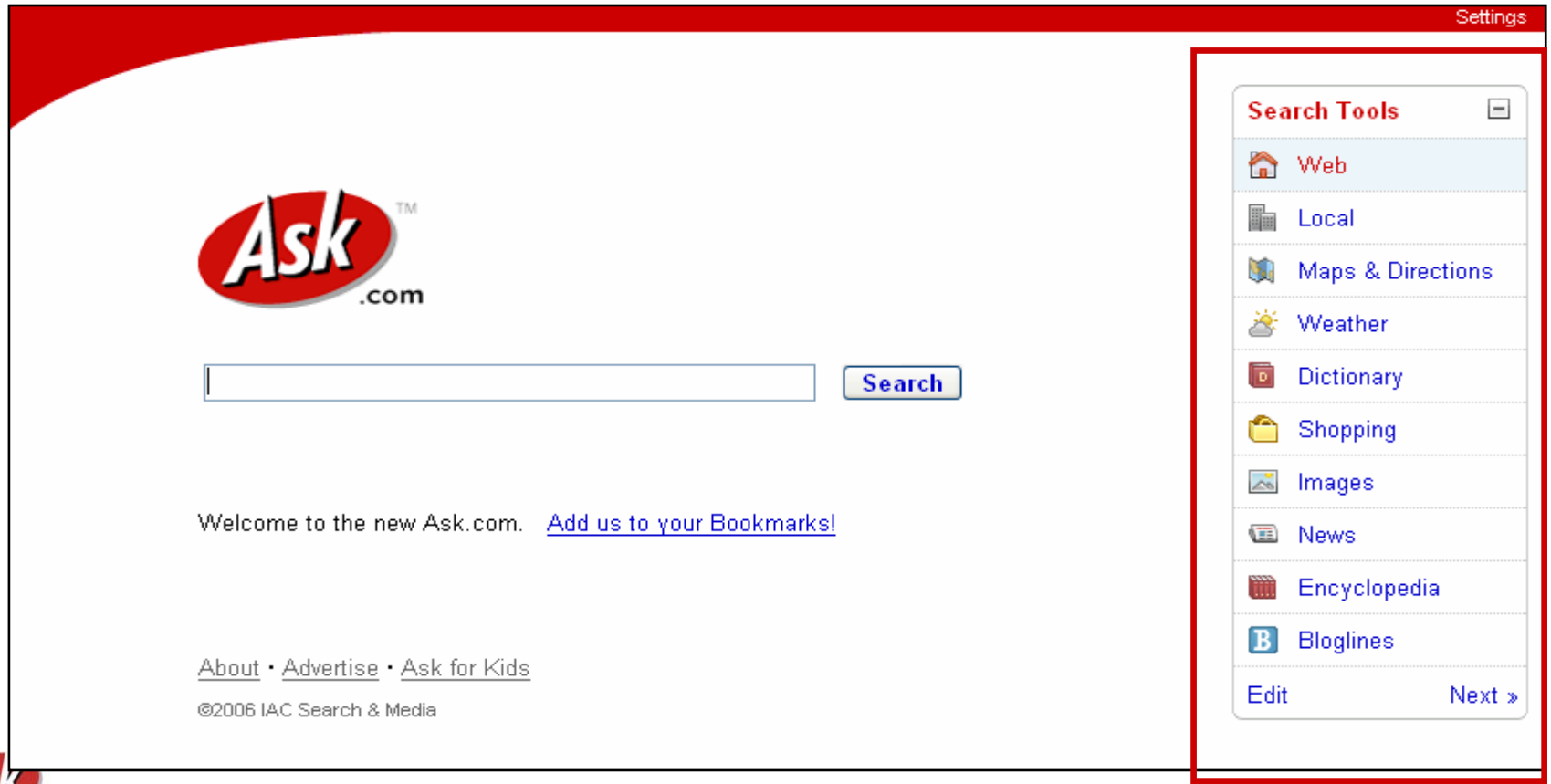
- 60 specialized & global brands
- 28K+ employees
- $5.8 billion – 2005 Revenue
- $668 million – 2005 OIBA (Profit)
- $1.5 billion net cash

IAC / InterActiveCorp

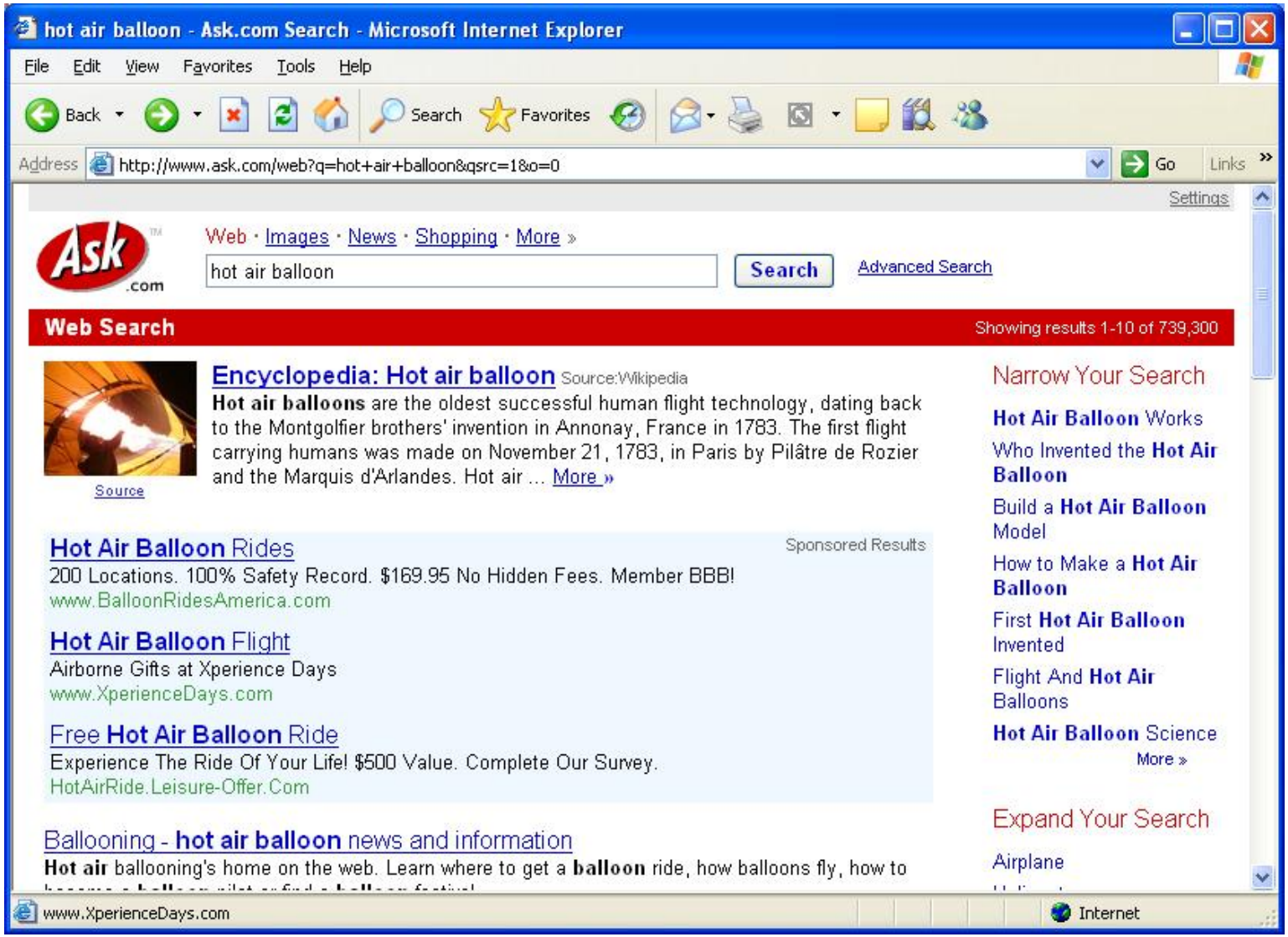
Ask.com

Ask.com Site Relaunching and branding in Q1 2006

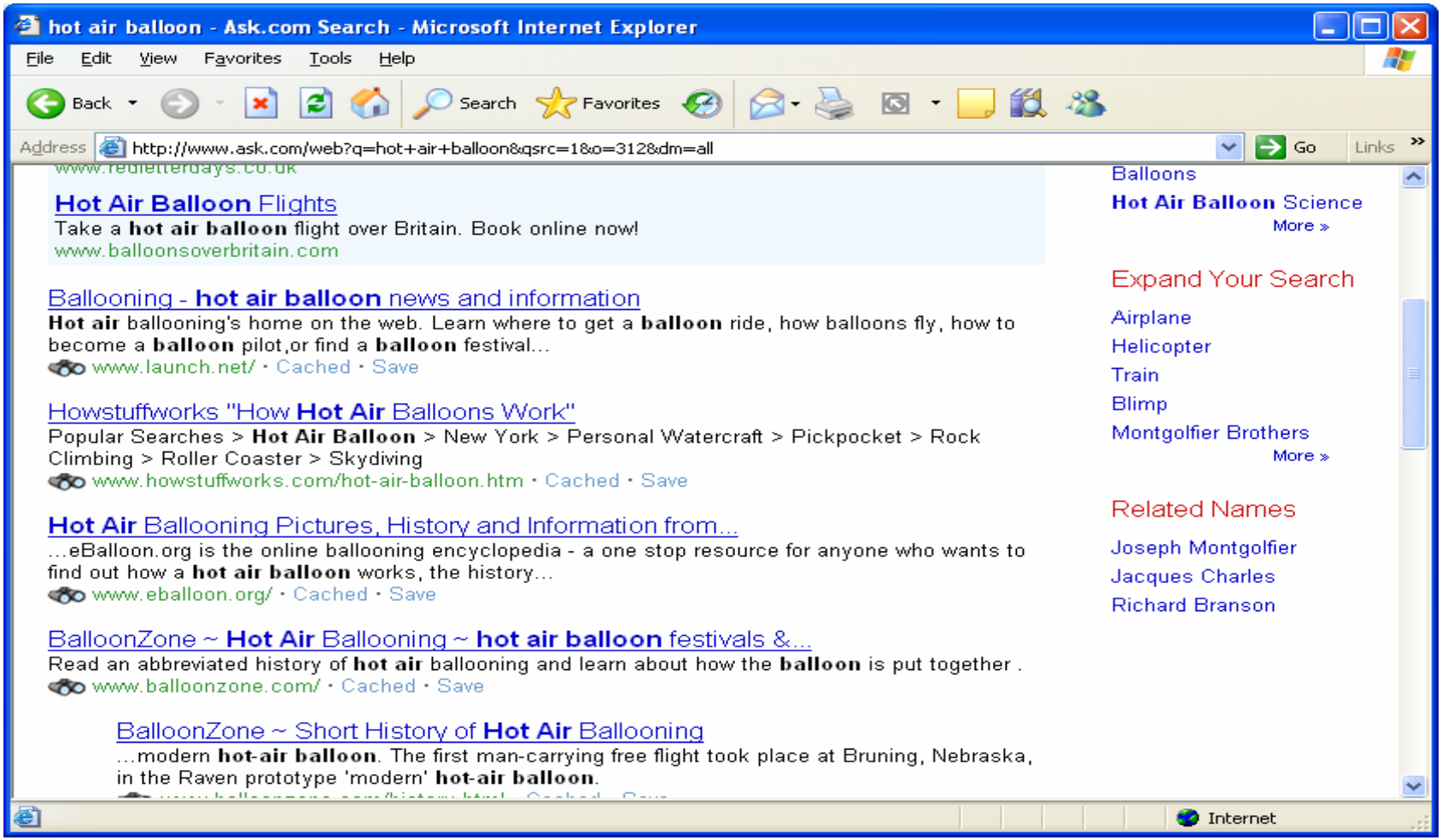
- **Cleaner interface with a list of search tools**



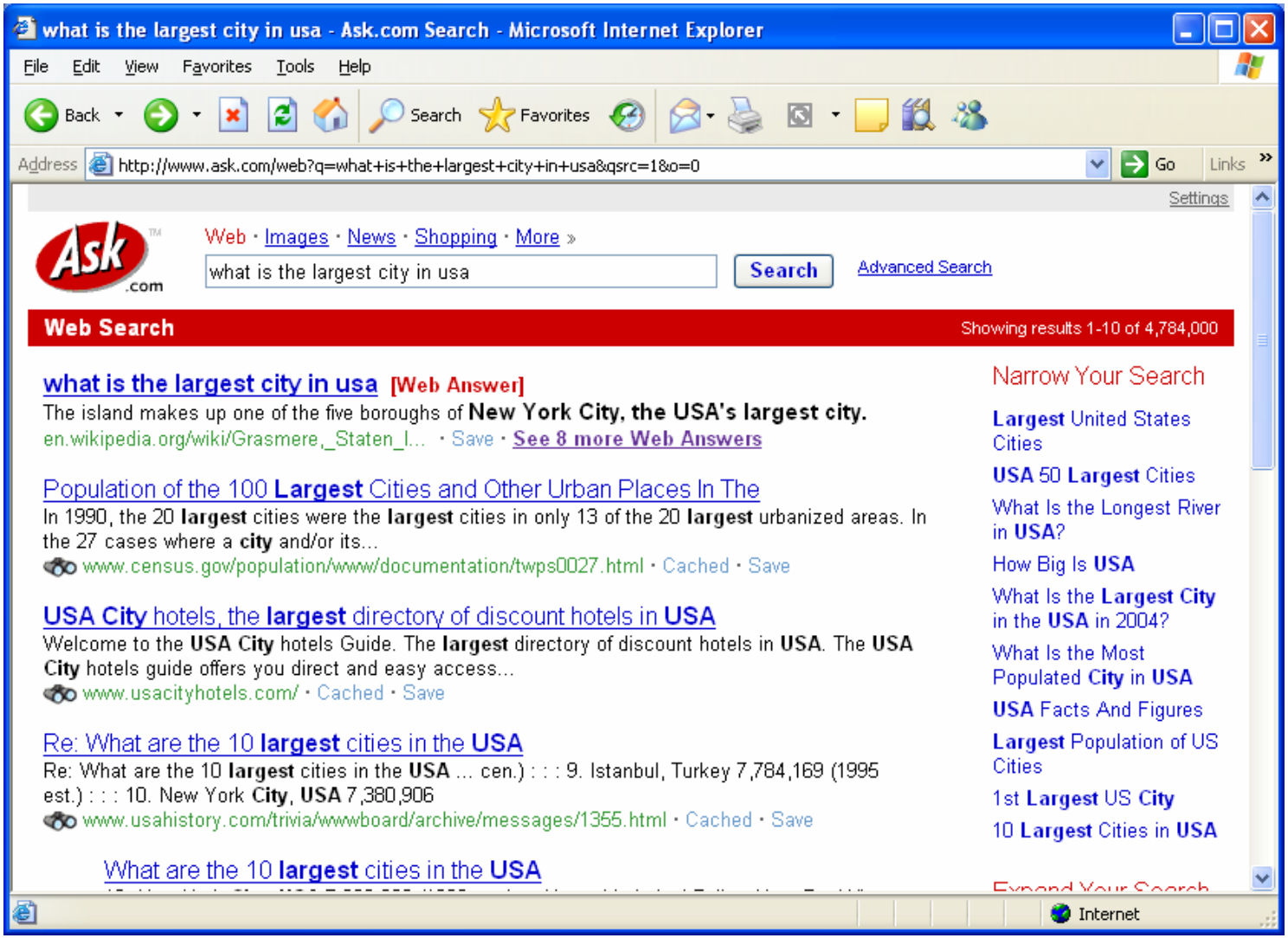
Site Features: Smart Answer



Topic Zooming with Search Suggestions



Site Feature: Web Direct Answer



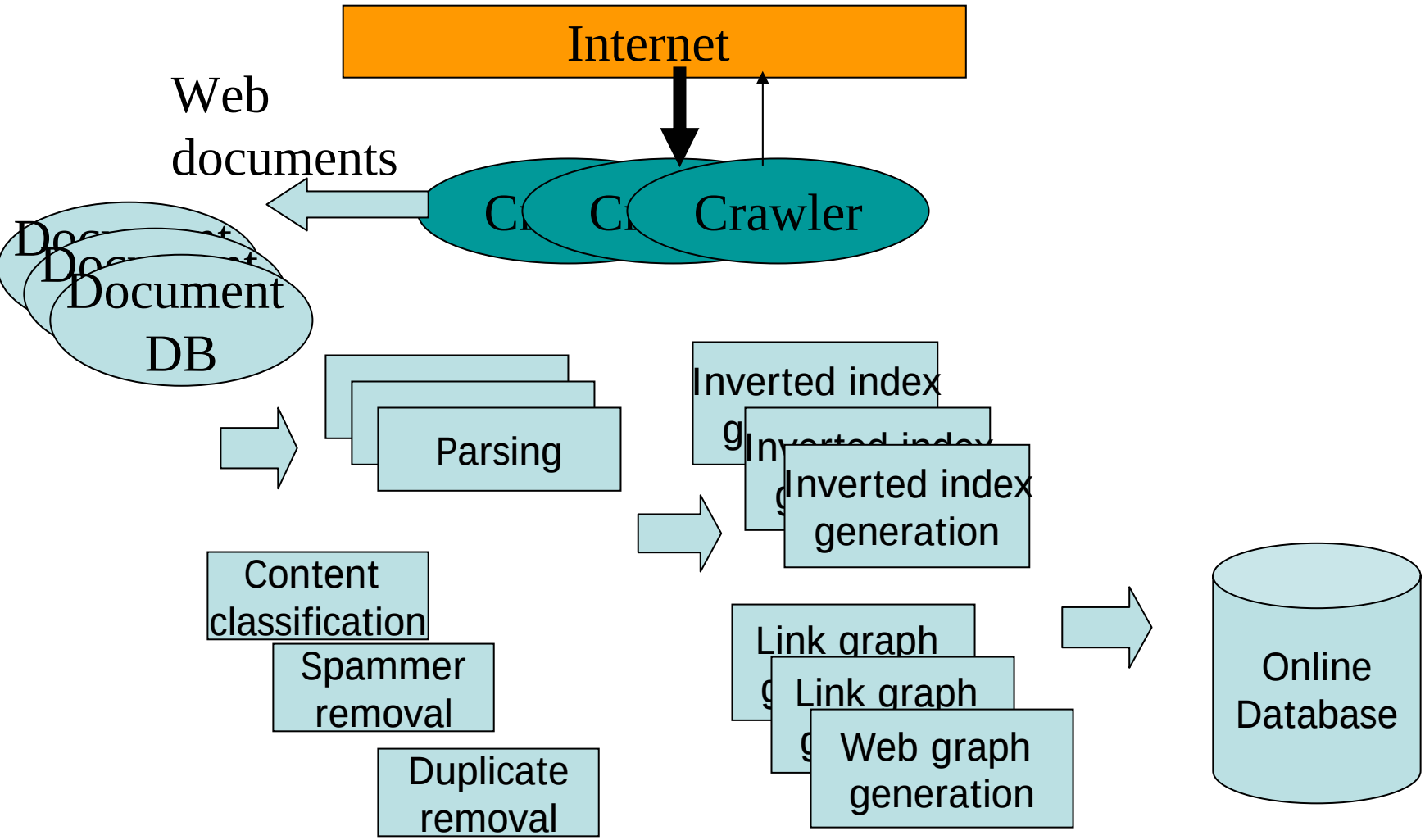
More Site Features - Binoculars

- **Our Binoculars tool lets you see what a site looks like before clicking to visit it**

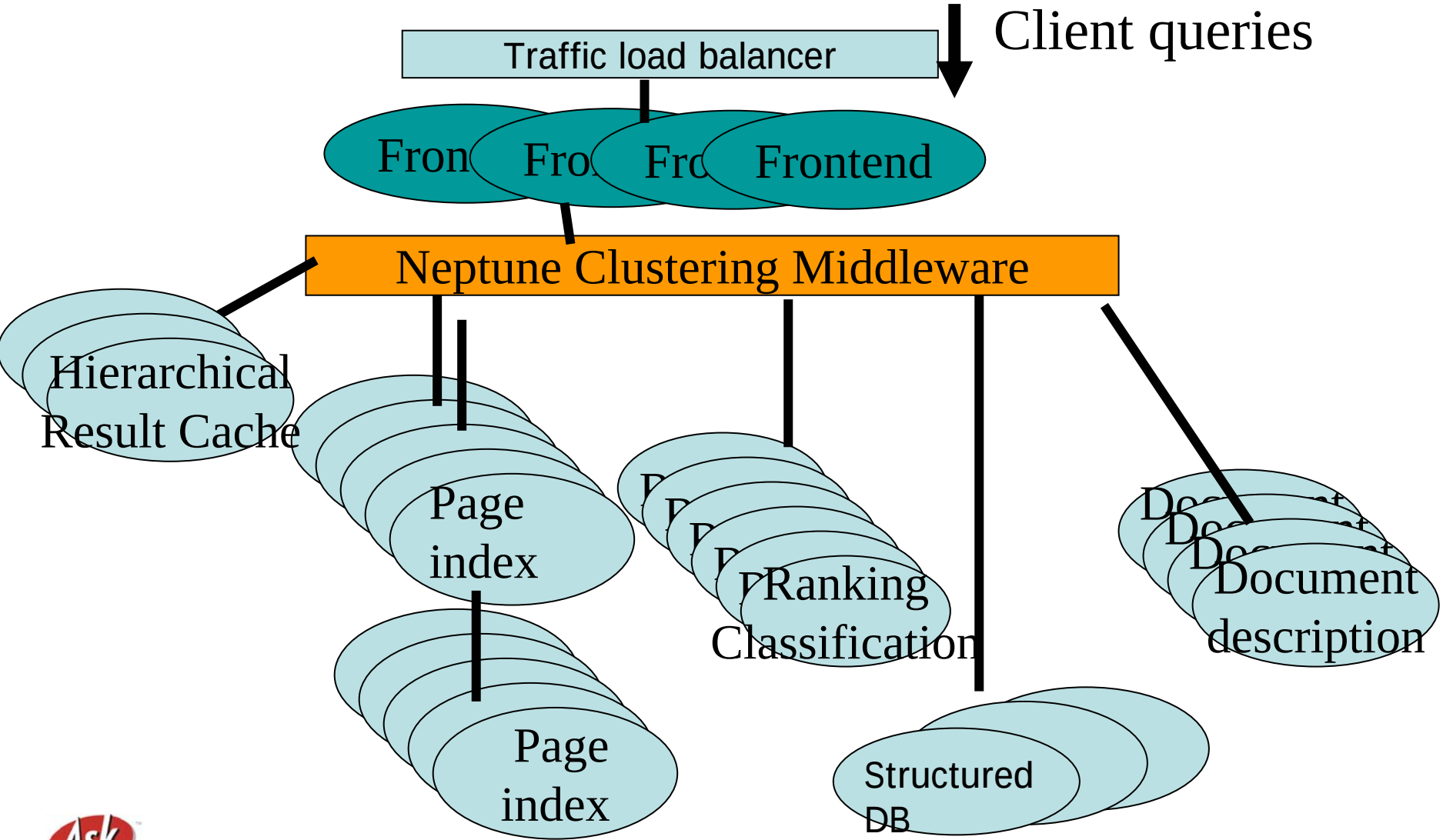
Ask Competitive Strengths

- Deeper topic view of the Internet
  - Query-specific link and text analysis with behavior analysis
  - Differentiated clustering technology
- Natural Language Processing
  - Better understanding/analysis of queries and user behavior
- Integration of structured data with web search.
  - Smart answers

Behind Ask.com: Data Indexing and Mining

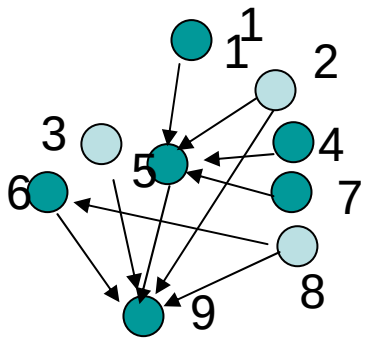


Engine Architecture



Concept: Link-based Popularity for Ranking

- **A is a connectivity matrix among web pages. A(i,j)=1 for edge from i to j.**



	1	2	3	4	5	6	7	8	9
1					1				
2					1				1
3									1
4					1				
5									1
6									1
7					1				
8						1			1

- **Query-independent popularity.**
- **Query-specific popularity**

Approaches for Page Ranking

- **PageRank:[Brin/Page'98]** offline computation of query-independent popularity iteratively.
- **HITS:[Kleinberg'98, IBM Clever]**
  - Build a query-based connectivity matrix on the fly. H, R are hub and authority weights of pages.
  - Repeat until H, R converge.
    - R=A' H= A'A R;
    - Normalize H, R.
- **ExpertRank:** Compute query-specific communities and ranking in real time.
  - Started from Teoma and evolved at Ask.com

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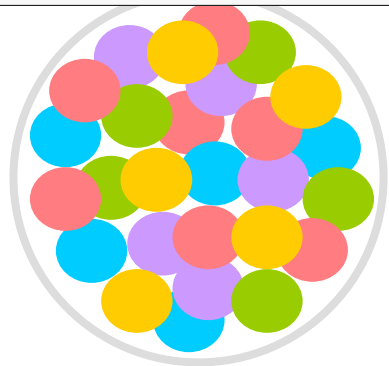
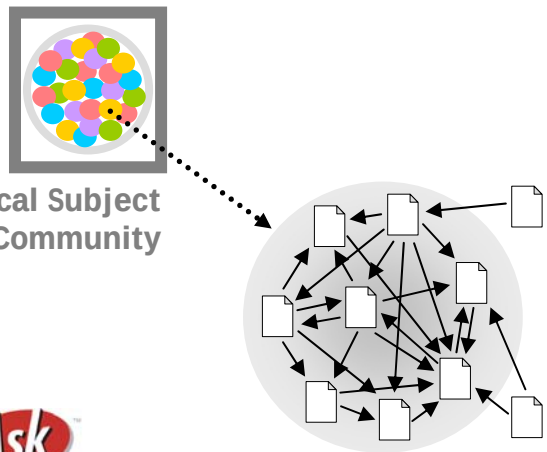
Steps of ExpertRank at Ask.com

1 Search the index for a query

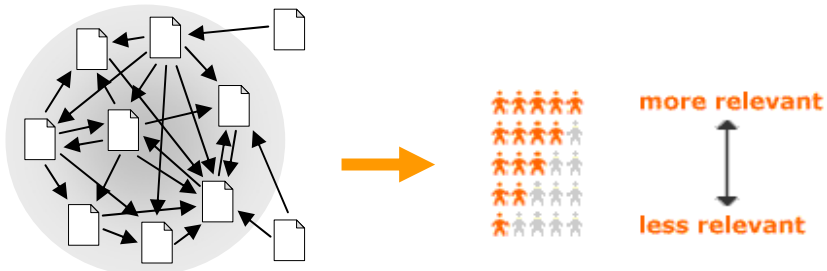
2 Clustering for subject communities for matched results



3 local subject-specific mining

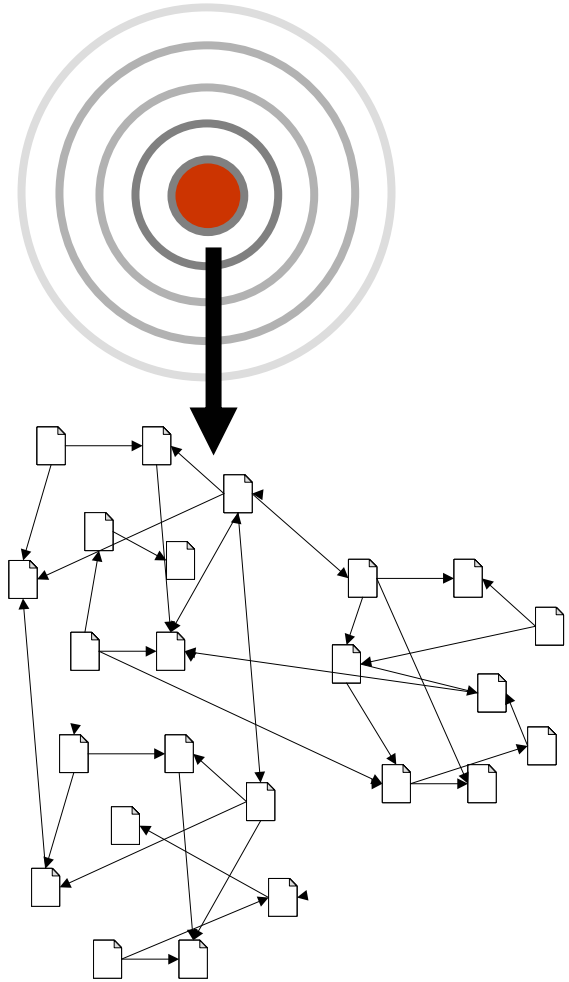


4 Ranking with knowledge and classification



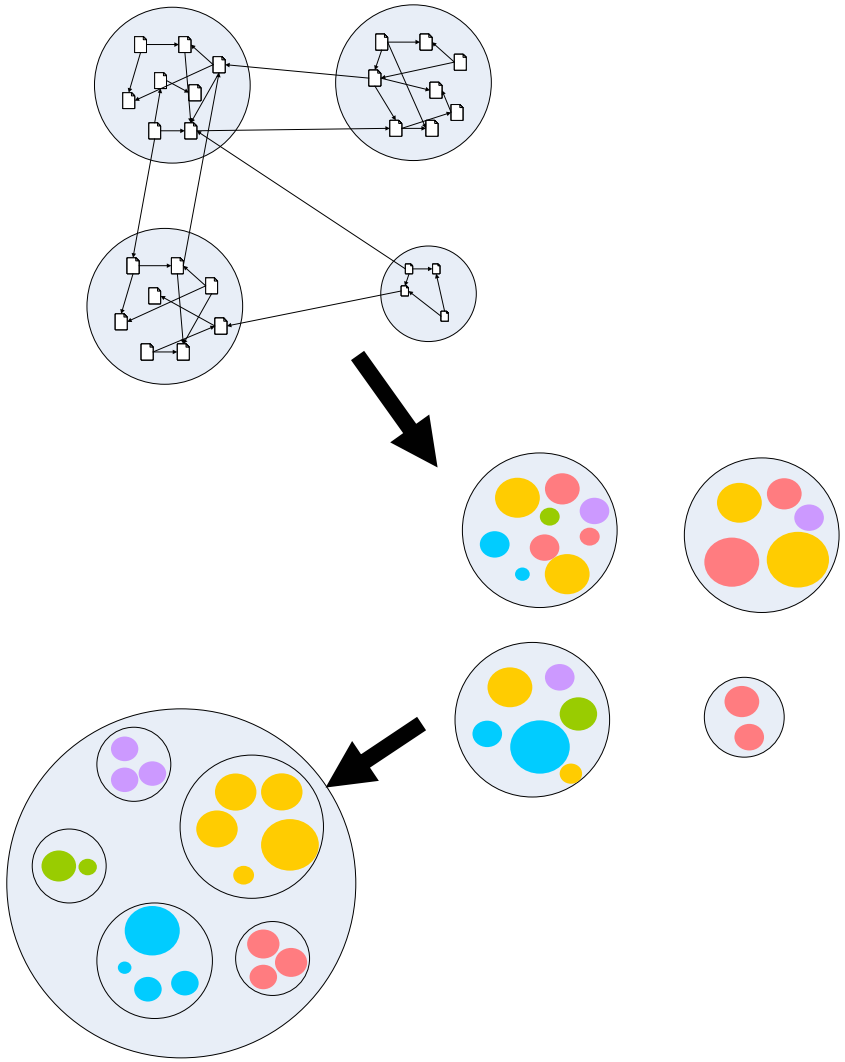
1 Index search and web graph generation

- **Search the index and identify relevant candidates for a given query.**
  - Relevant pages, high quality pages, fresh pages.
- **Generate a query-specific link graph dynamically.**



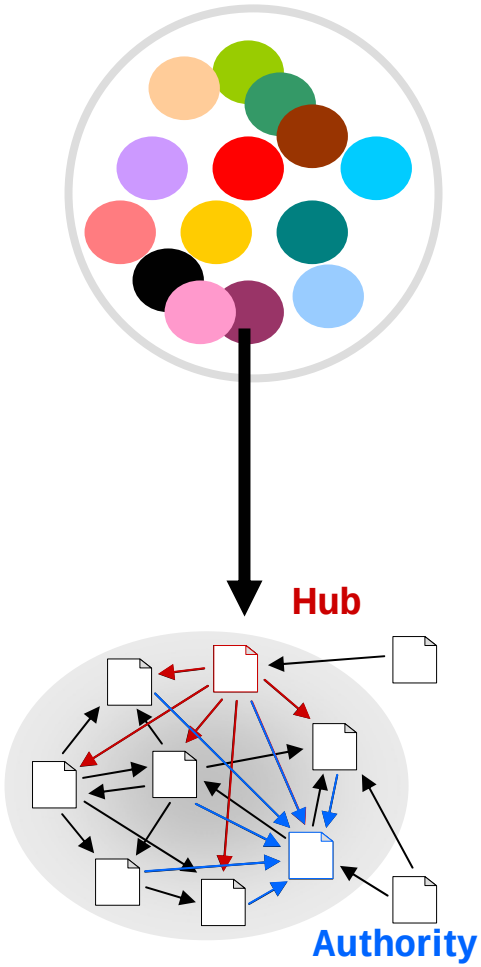
2 Multi-stage Cluster Refinement with Integrated Link/Topic Analysis

- **Link-guided page clustering**
- **Cluster refinement with content analysis and topic purification**
  - Text classification and NLP
  - Similarity and overlapping analysis



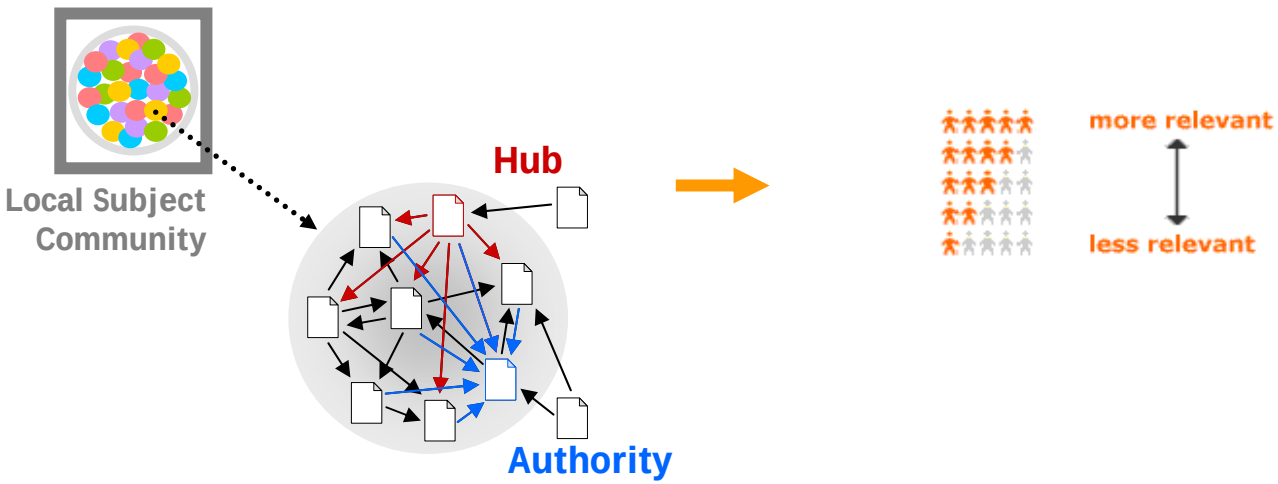
3 Subject-specific ranking

- **Example**
  - "bat", flying mammals vs. baseball bat.
- **For each topic group, identify experts for page recommendation, and remove spamming links.**
- **Derive local ranking scores**



4 Integrated Ranking with User Intention Analysis

- **Score weighting from multiple topic groups.**
  - Authoritativeness and freshness assessment.
  - User intention analysis.
  - Result diversification.



Scalability Challenges

- **Data scalability:**
  - From millions of pages to billions of pages.
  - Clean vs. datasets with lots of noise.
- **Infrastructure scalability:**
  - Tens of thousands of machines.
  - Tens of Millions of users
  - Impact on response time, throughput, &availability,
  - data center power/space/networking.
- **People scalability:** From few persons to many engineers with non-uniform experience.

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Downtime Costs (per Hour)

• Brokerage operations	$6,450,000
• Credit card authorization	$2,600,000
• Ebay (1 outage 22 hours)	$225,000
• Amazon.com	$180,000
• Package shipping services	$150,000
• Home shopping channel	$113,000
• Catalog sales center	$90,000
• Airline reservation center	$89,000
• Cellular service activation	$41,000
• On-line network fees	$25,000
• ATM service fees	$14,000

Source: **InternetWeek 4/3/2000 +** ***Fibre Channel: A Comprehensive Introduction*****, R. Kembel 2000, p.8. "...based on a survey done by Contingency Planning Research."**

Examples of Scalability Problems

- Mining question answers from web.
- Large-scale spammer detection.
- Computing with irregular data. On-chip cache.
- Large-scale memory management: 32 bits vs. 64 bits.
- Incremental cluster expansion and topology mgmt.
- High throughput write/read traffic. Reliability.
- Fast and reliable data propagation across networks.
- Architecture optimization for low power consumption.
- Update large software & data on a live platform.
- Distributed debugging thousands of machines.

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Some of Lessons Learned

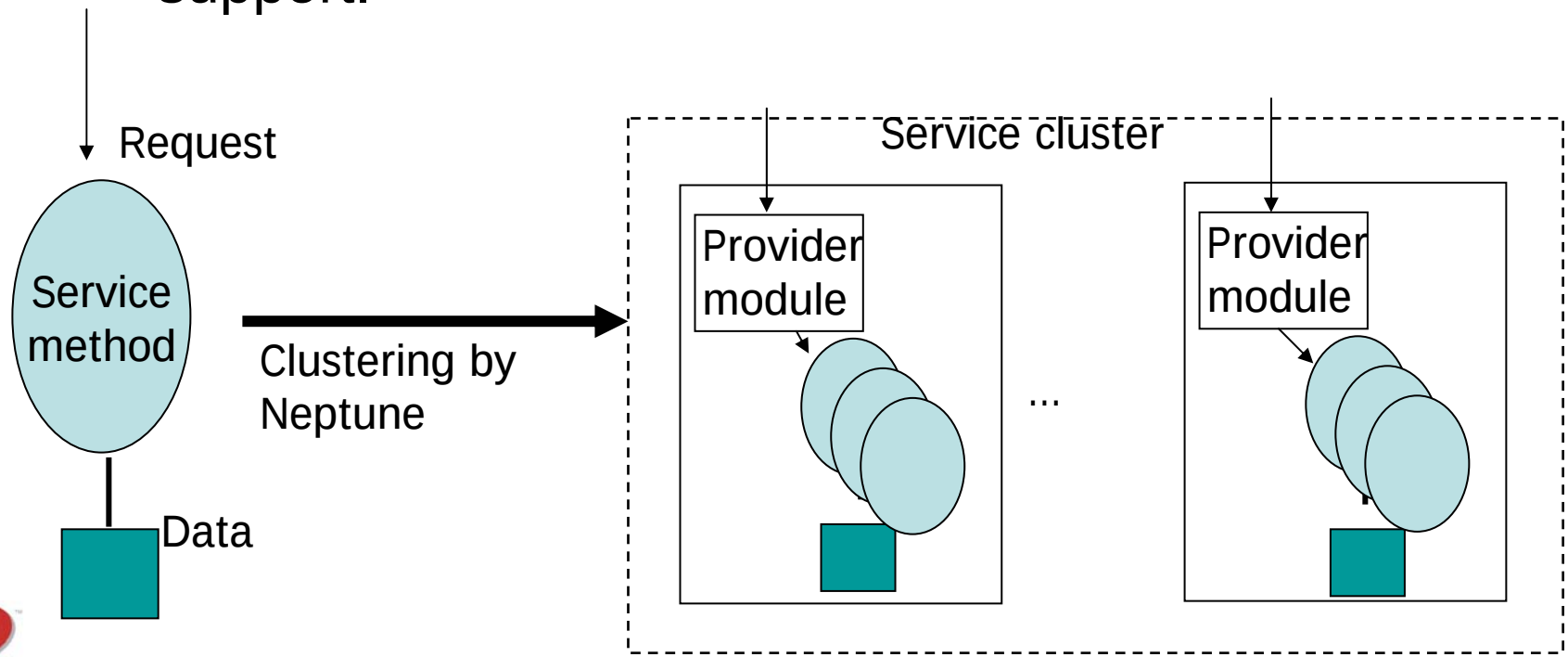
- **Data**
  - Data methods can behave differently with different data sizes/noise levels.
  - Data-driven approaches with iterative refinement.
- **Architecture & Software**
  - Distributed service-oriented architectures
  - Middleware support.
- **Product:**
  - Monitoring is as critical as others.
  - Simplicity

The Neptune Clustering Middleware

- **A simple/flexible programming model**
  - Aggregating and replicating application modules with persistent data.
  - Shielding complexity of service discovery, load balancing, consistency, and failover management
  - Providing inter-service communication.
  - Providing quality-aware request scheduling for service differentiation
- **Started at UCSB. Evolved with Teoma, Ask.com.**

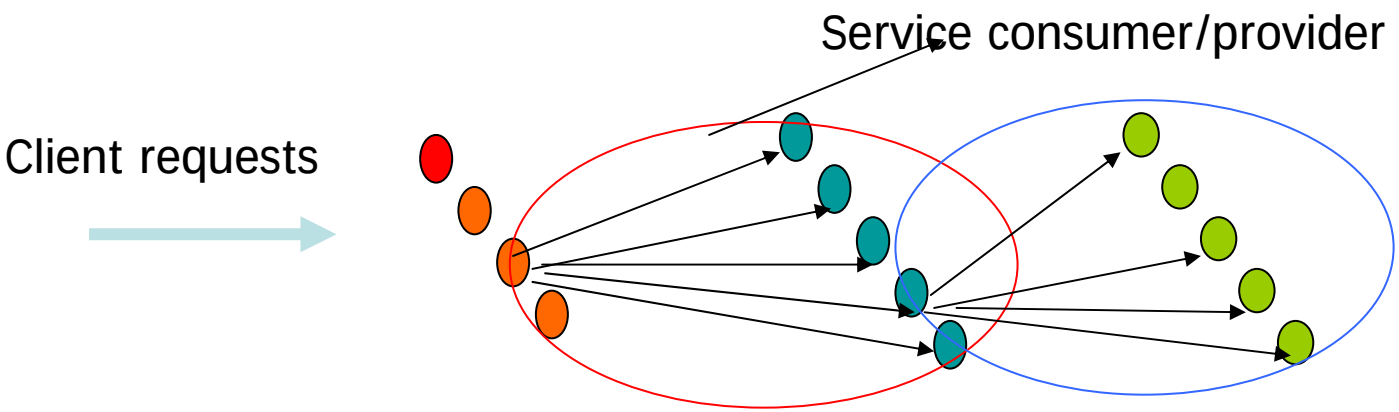
Programming Model and Cluster-level Parallelism/Redudancy in Neptune

- Request-driven processing model.
- SPMD model (single program/multiple data) while large data sets are partitioned and replicated.
- Location-transparent service access with consistency support.

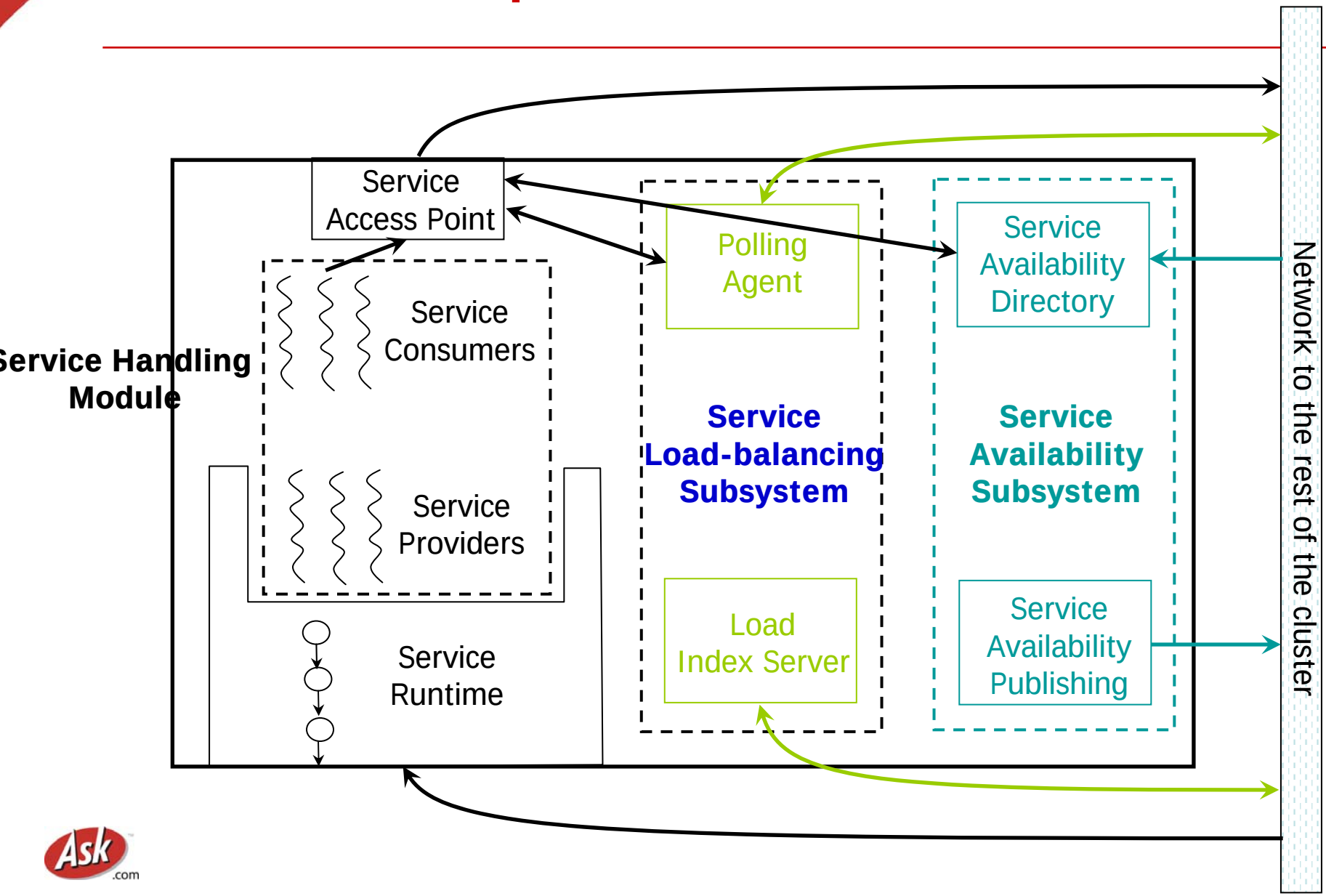


Neptune architecture for cluster-based services

- Symmetric and decentralized:
  - Each node can host multiple services, acting as a service provider.
  - Each node can also subscribe internal services from other nodes, acting as a consumer.
    - *Support multi-tier or nested service architecture*

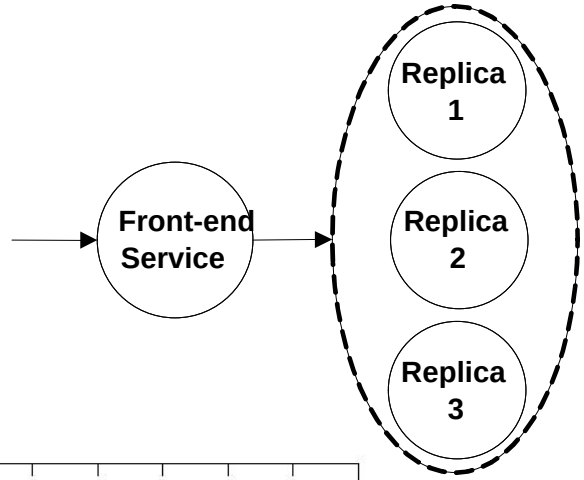


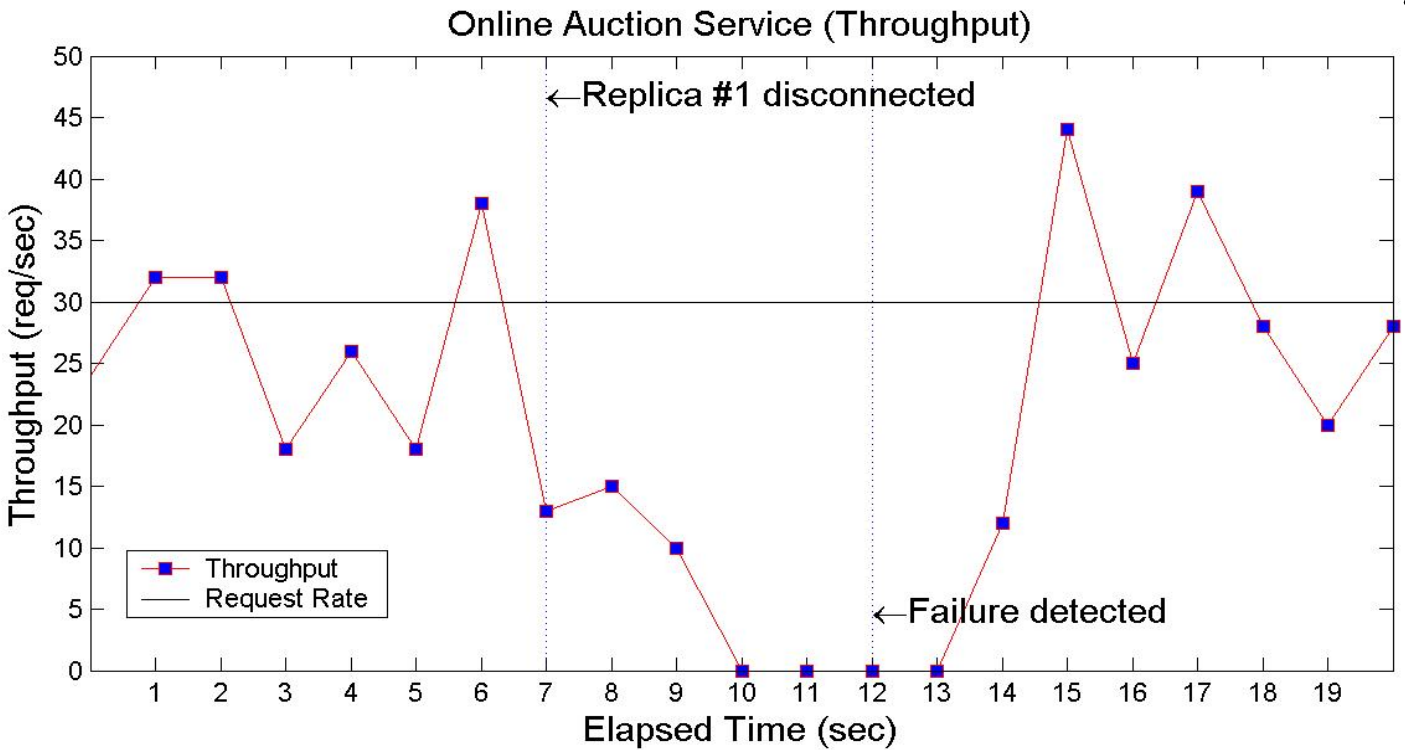
Inside a Neptune Server Node



Impact of Component Failure in Multi-tier services

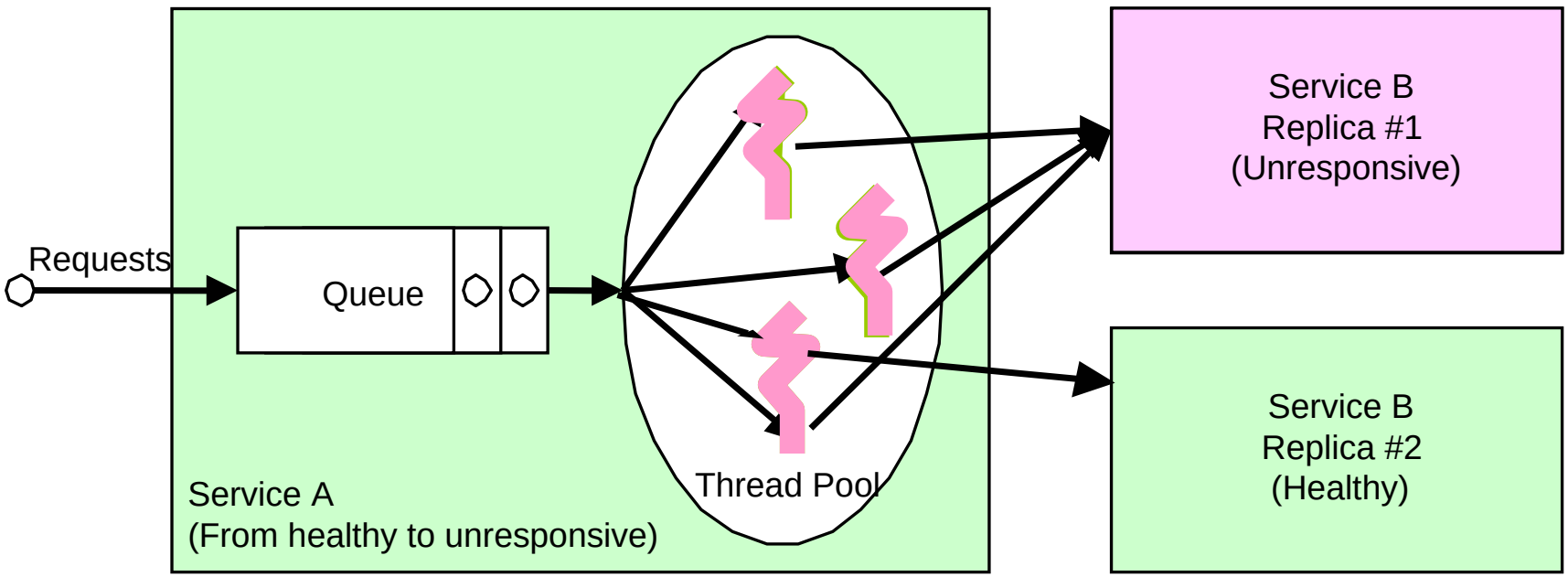
- **Failure of one replica: 7s - 12s**
- **Service unavailable: 10s - 13s**





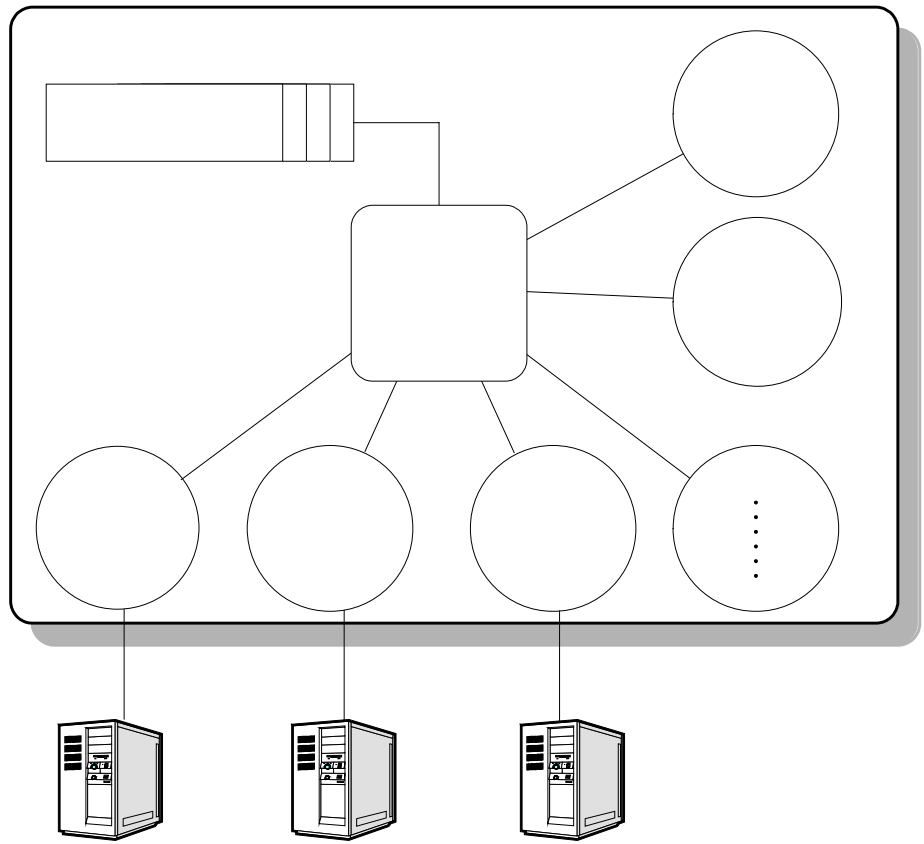
Problems that affect availability

- Threads are blocked with slow service dependency.
- Fault detection speed.



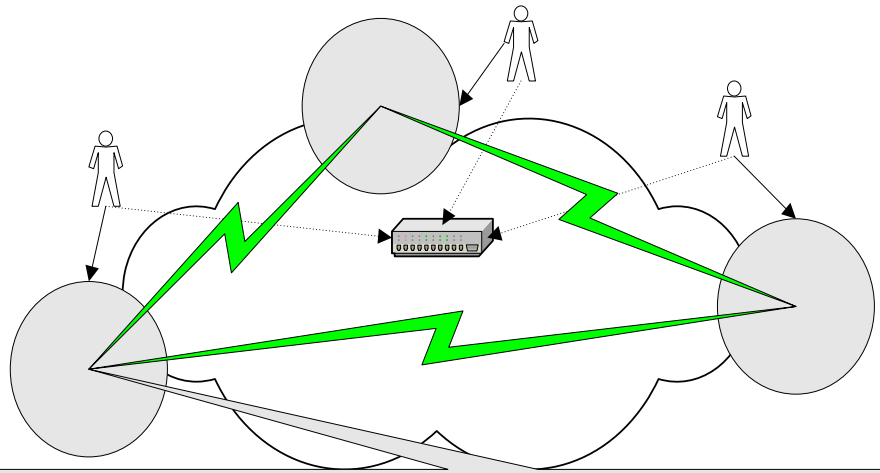
Dependency Isolation

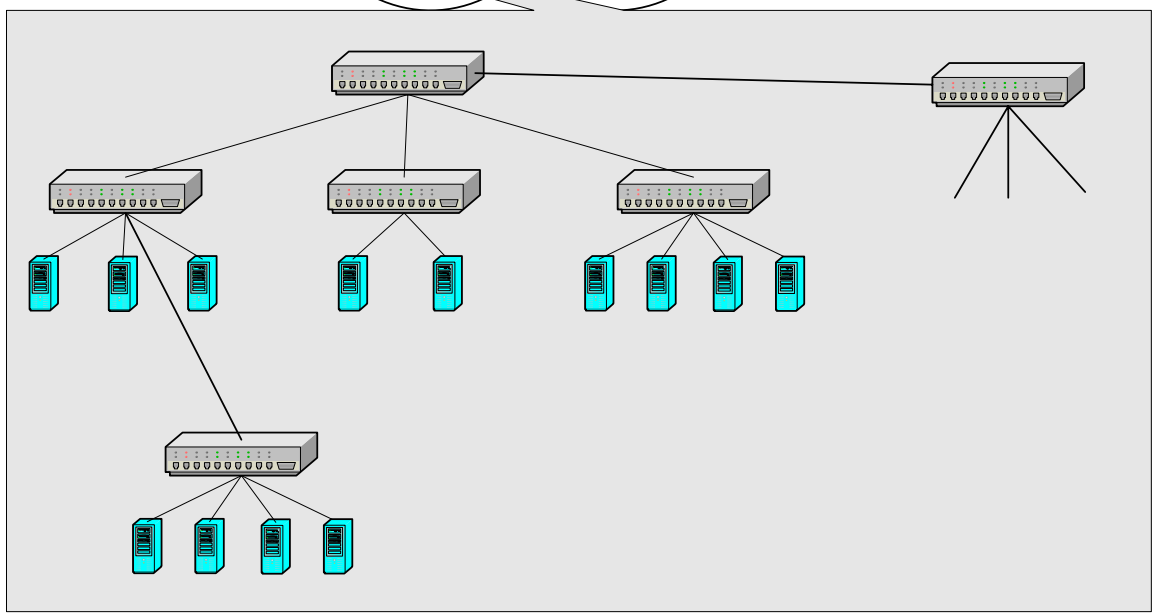
- **Per-dependency management with capsules.**
  - Isolate their performance impact.
  - maintain dependency-specific feedback information for QoS control.
- **Programming support with automatic recognition of dependency states.**



Fast Fault Detection and Information Propagation for Large-Scale Cluster-Based Services

- **Complex 24x7 network topology in service clusters.**
- **Frequent events: failures, structure changes, and new services.**
  - Yellowpage directory
  - discovery of services and their attributes
  - Server aliveness





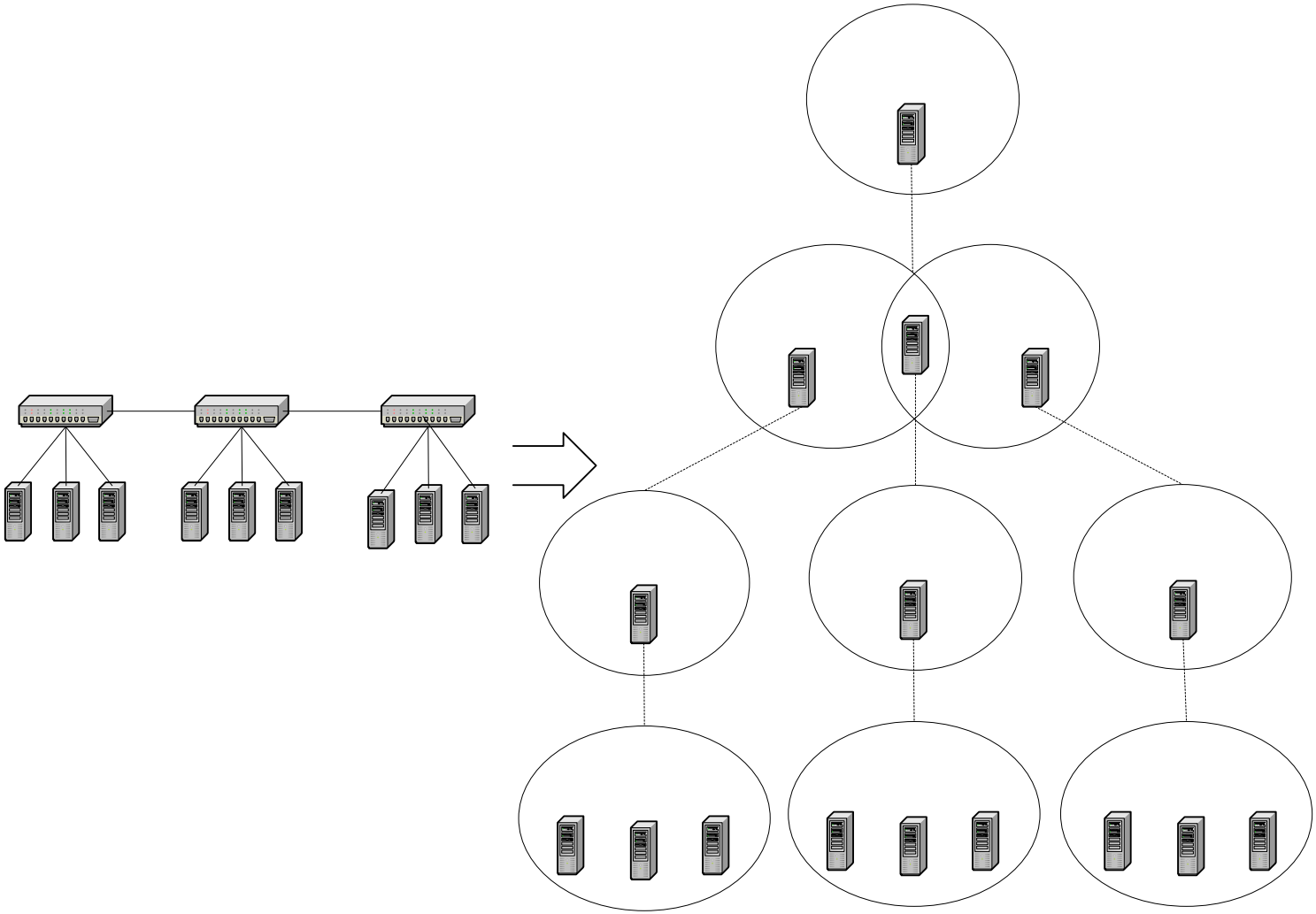
TAMP: Topology-Adaptive Membership Protocol

- **Highly Efficient: Optimize bandwidth, # of packets**
- **Topology-aware:**
  - Form a hierarchical tree according to network topology
  - Localize traffic within switches and adaptive to changes of switch architecture.
- **Topology-adaptive:**
  - Network changes: switches
- **Scalable: scale to tens of thousands of nodes. Easy to operate.**

Hierarchical Tree Formation Algorithm

- Exploiting TTL count in IP packet for topology-adaptive design.
- Each multicast group with a fixed TLL value performs an election;
- Group leaders form higher level groups with larger TTL values;
- Stop when max. TTL value is reached; otherwise, goto *Step 2*.

An Example of Hiearchical Tree Formation



Scalability Analysis

- **Basic performance factors**
  - Failure detection time (T_{fail_detect})
  - View convergence time ($T_{converge}$)
  - Communication cost in terms of bandwidth (B)
- **Two metrics**
  - $BDP = B * T_{fail_detect}$, lower failure detection time with low bandwidth is desired
  - $BCP = B * T_{converge}$, lower convergence time with low bandwidth is desired

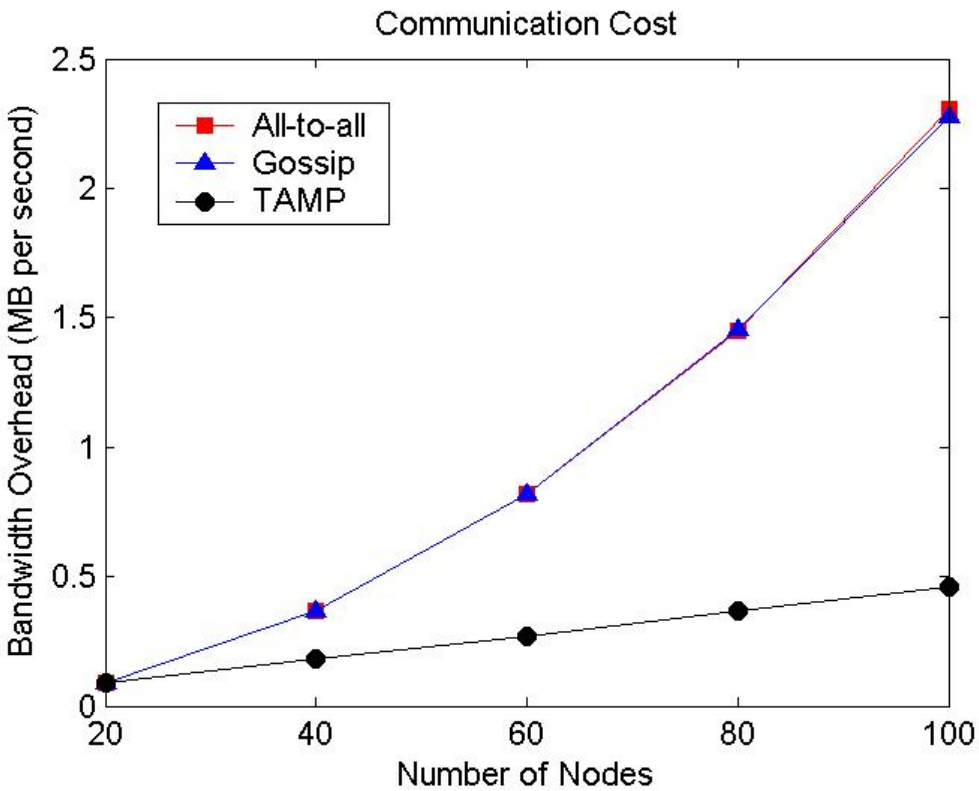
A scalability comparison of three methods

	Failure Detection Time x Bandwidth	*Convergence Time x Bandwidth required*
All-to-all	**$O(n^2)$**	**$O(n^2)$**
Gossip	**$O(n^2 \log n)$**	**$O(n^2 \log n)$**
TAMP	**$O(n)$**	**$O(n \log_k n)$**

n: total # of nodes

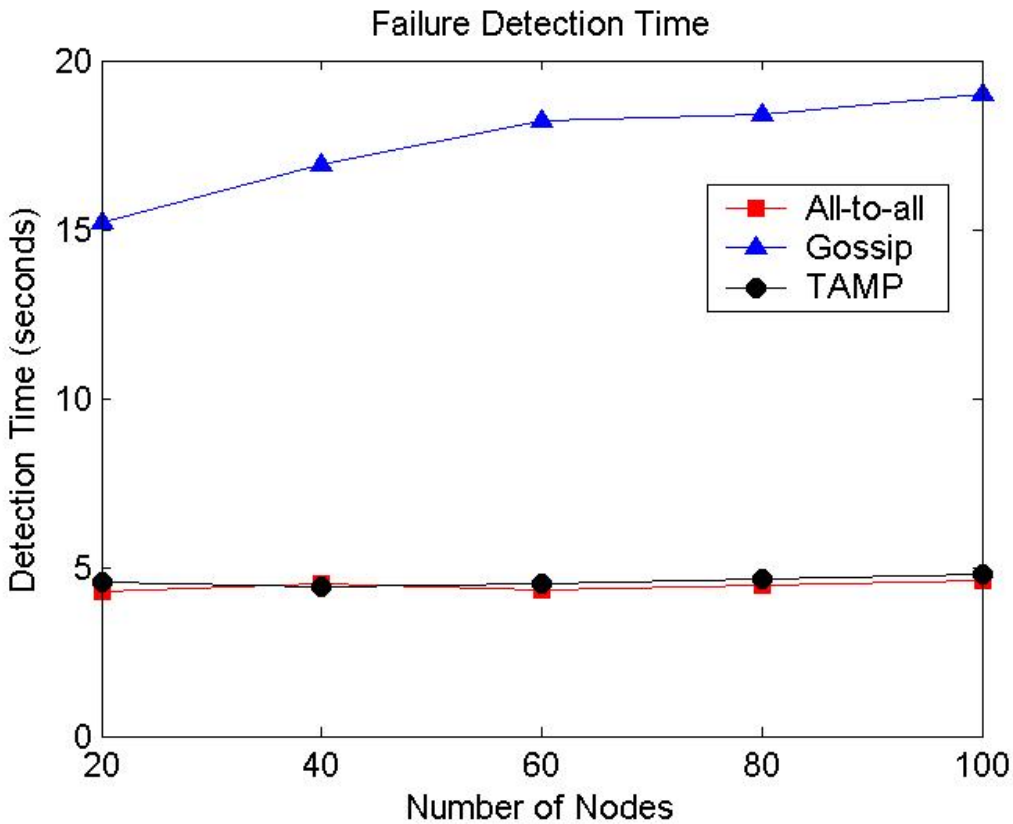
k: each group size, a constant

Bandwidth Consumption



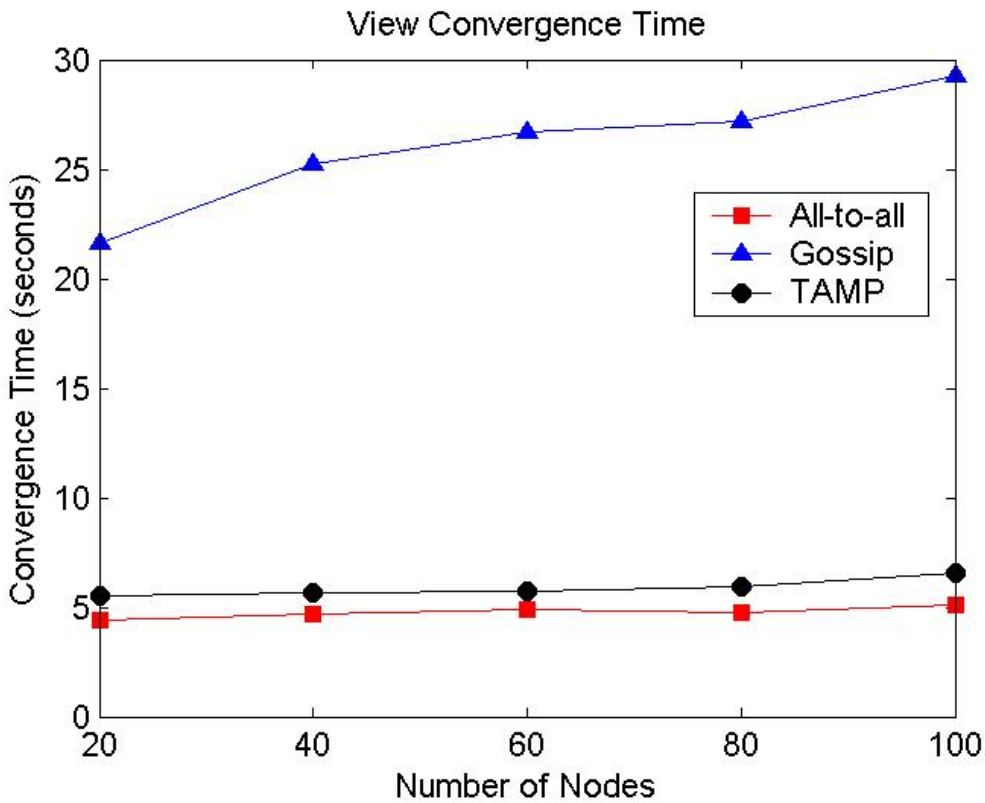
- **All-to-All & Gossip: quadratic increase**
- **TAMP: close to linear**

Failure Detection Time



- **Gossip: log(N) increase**
- **All-to-All & TAMP: constant**

View Convergence Time



- **Gossip: log(N) increase**
- **All-to-All & TAMP: constant**

References

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- K. Shen, H. Tang, T. Yang, and L. Chu, Integrated Resource Management for Cluster-based Internet Services. In *Proc. of Fifth USENIX Sym. on Operating Systems Design and Implementation (OSDI '02)* , pp 225-238, Boston, 2002.
- L. Chu, T. Yang, J. Zhou, Topology-Centric Resource Management for Large Scale Service Clusters, 2005 (Pending patent application).
- L. Chu, K. Shen, H.Tang, T. Yang, and J. Zhou. Dependency Isolation for Thread-based Multi-tier Internet Services. In Proc. of IEEE INFOCOM 2005, Miami FL, March, 2005

Concluding Remarks

- **Ask.com is focused on leading-edge technology for Internet search.**
- **Many open/challenging problems for information retrieval, mining, and system scalability.**
- **Interested in joining Ask.com? recruiting@ask.com**