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Ant Algorithms for Search in Unstructured Peer-to-Peer Networks

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Outline

- Motivation
 - Ant algorithms
 - Research question
 - Search in peer-to-peer networks

- The SemAnt algorithm
 - Design
 - Evaluation

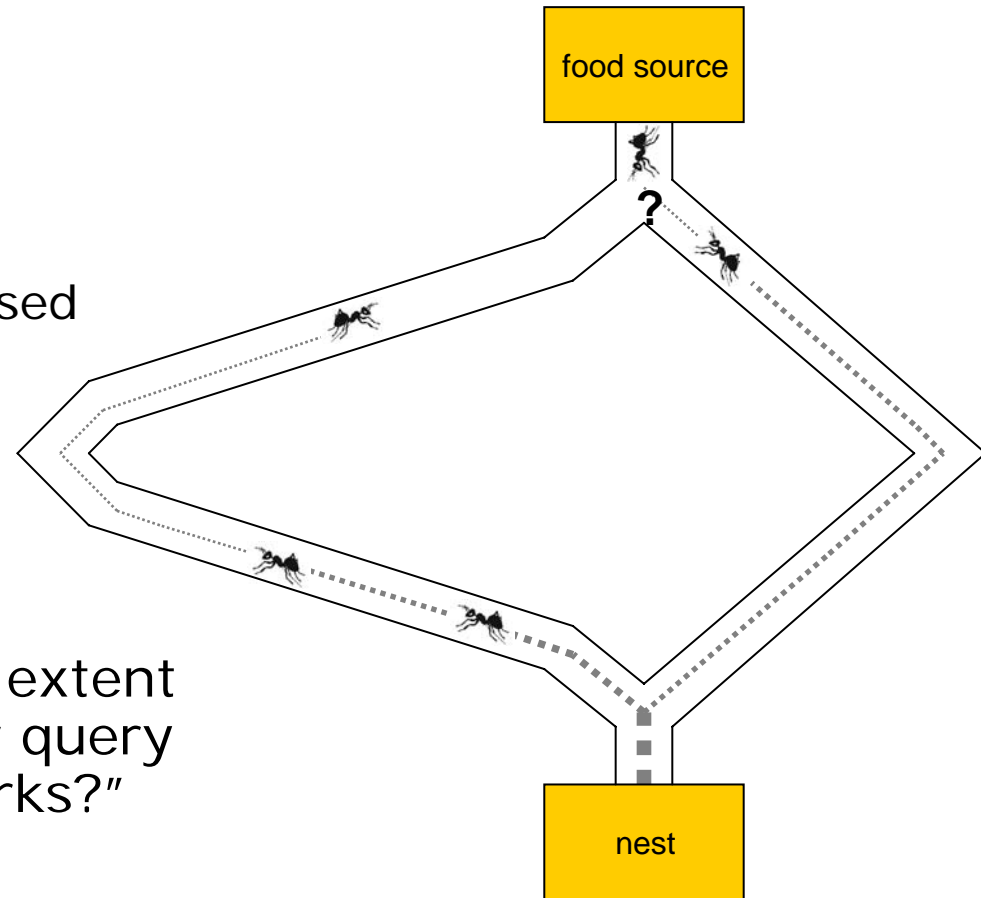
- Contributions and future work

Ant algorithms

- Pheromone for indirect communication
 - Trail-laying and trail-following
 - Evaporation

- Ant Colony Optimization
 - Ant Colony System: graph-based optimization problems
 - AntNet: adaptive routing in communication networks

- Research question: "To which extent are ant algorithms feasible for query routing in peer-to-peer networks?"
 - Self-adaptation to changes in network topology (churn)



Search in peer-to-peer networks

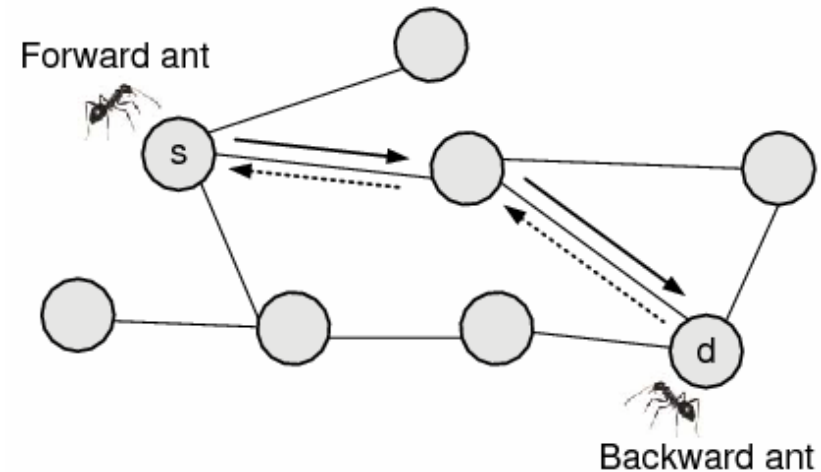
- Can be viewed as an optimization problem
 - Maximize number of search results
 - Minimize hop count

- Structured networks
 - Efficient lookup by key
 - Key space is distributed among peers
 - Resource is relocated to the peer responsible for its key

- Unstructured networks
 - Store information about queries in the past
 - Use it to predict which peer can answer a query
 - Based on the keywords of the query

The SemAnt algorithm

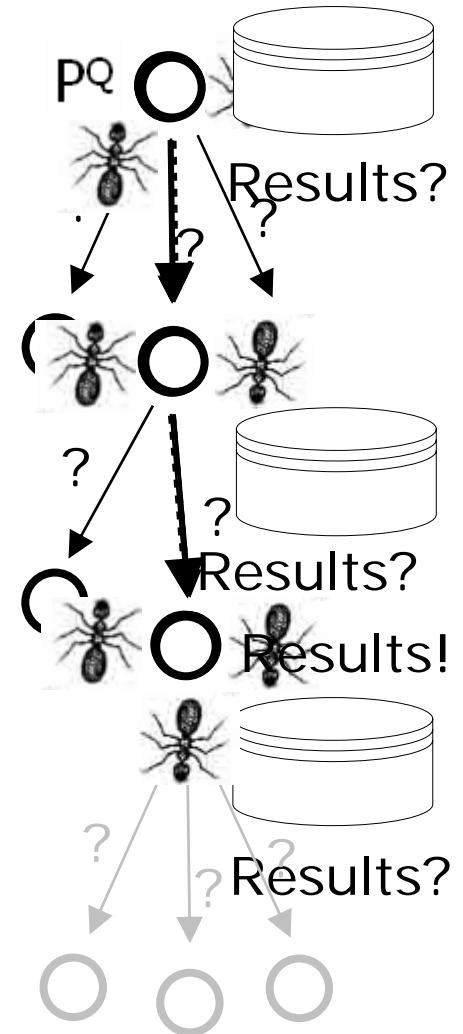
- Combines adapted features from
 - AntNet
 - Ant Colony System
- Queries are ants
 - No additional traffic
- Pheromone trails
 - Multiple types of pheromone
 - Probabilistic routing tables
 - One row for each neighbouring peer
 - One column for each keyword
 - Initialize entries with small value
 - Evaporation



		Keywords	
Outgoing links	T_{11}	...	T_{c1}
	\vdots	...	\vdots
	T_{1u}	...	T_{cu}

SemAnt: If a query is issued at peer P^Q ...

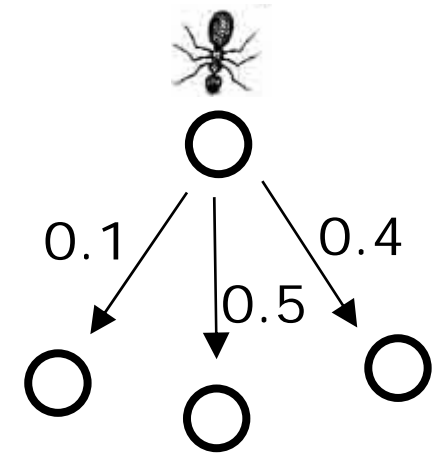
1. Check P^Q 's repository
2. Create forward ant with a certain TTL
3. Select next peer
4. Go to peer and check repository
5. If results are found:
 - Create backward ant
 - Terminate forward ant?
 - Minimizes resource usage
 - Backward ant travels back hop-by-hop to P^Q
 - Drops pheromone at each intermediate peer
6. Add peer to stack of already visited peers
7. If TTL not reached: continue at 3
Else: terminate



Trail following and trail laying

- How to select the next peer?
 - Exploiting strategy
 - Select best link
 - Exploring strategy
 - Derive goodness value p_j for each link
 - Compute random value $q \in [0, 1]$
 - Select link if $q \leq p_j$

- How to update pheromone trails?
 - Amount depends on
 - Number of results found
 - Number of hops
 - Compared to “optimal” values



Evaluation

- Application scenario
 - Metadata-based search
 - Resources annotated with leaf concepts of ACM CCS taxonomy
 - Small-world network with 1024 peers
 - Static network topology and content distribution

- Content distribution
 - Peer is an expert in one research area
 - 60% of its resources
 - 20% belong to another research area
 - 20% are resources about random topics

- Query distribution
 - Probability that a peer issues a query is 0.1 per time unit
 - One keyword per query

Experimental results

■ Metrics

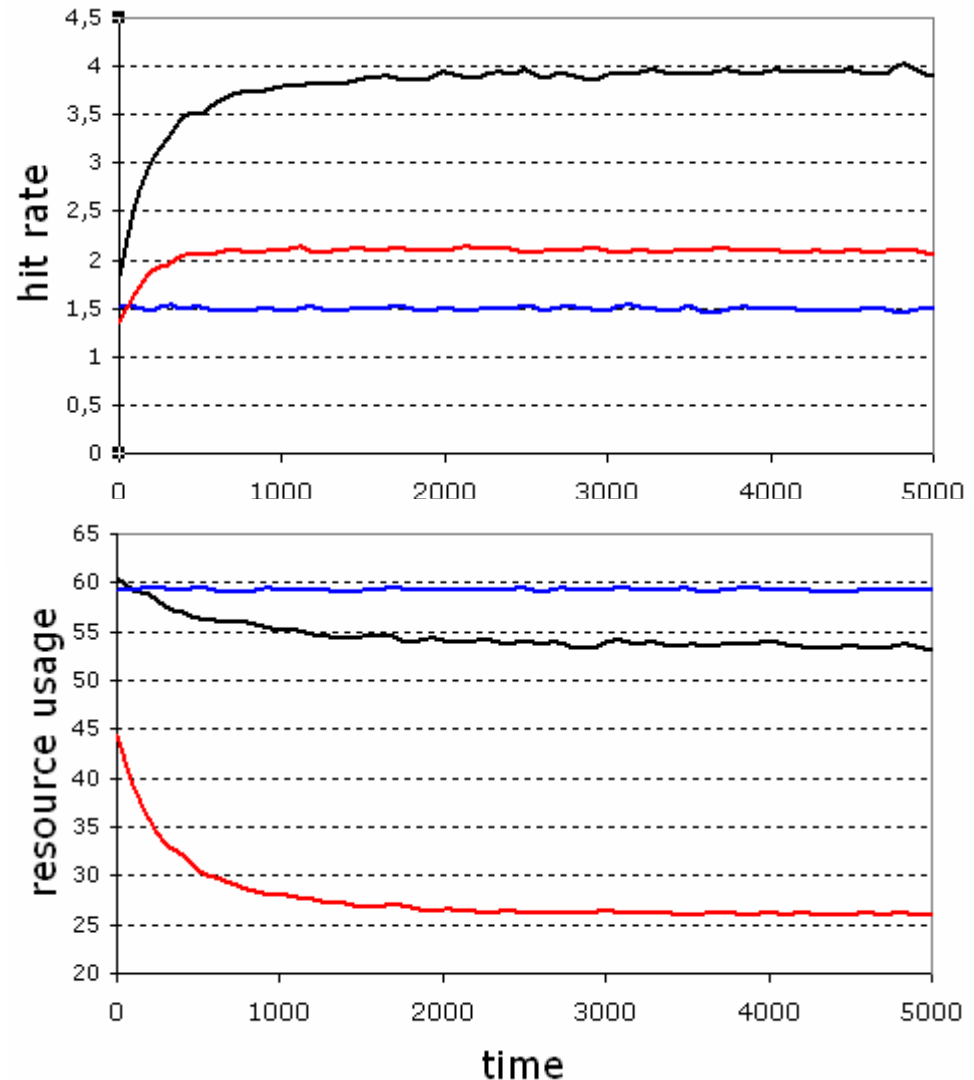
- Hit rate
- Resource usage

■ Parameter settings

- 85% exploiting strategy
- TTL of 25

■ Comparison of

- **k-random walker**
- SemAnt maxResults
 - Use maximum TTL
- **SemAnt minResources**
 - Stop after first result



Contributions and future work

■ SemAnt algorithm

- Content-based query routing in unstructured peer-to-peer networks
- Based on the ant metaphor
 - Successful queries leave small traces in the network
 - Heuristics use traces to direct subsequent queries



■ Self-adaptation to dynamic network topologies

- Evaporation built-in
- Converged phase reached fast
- Trails reflect content distribution

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