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

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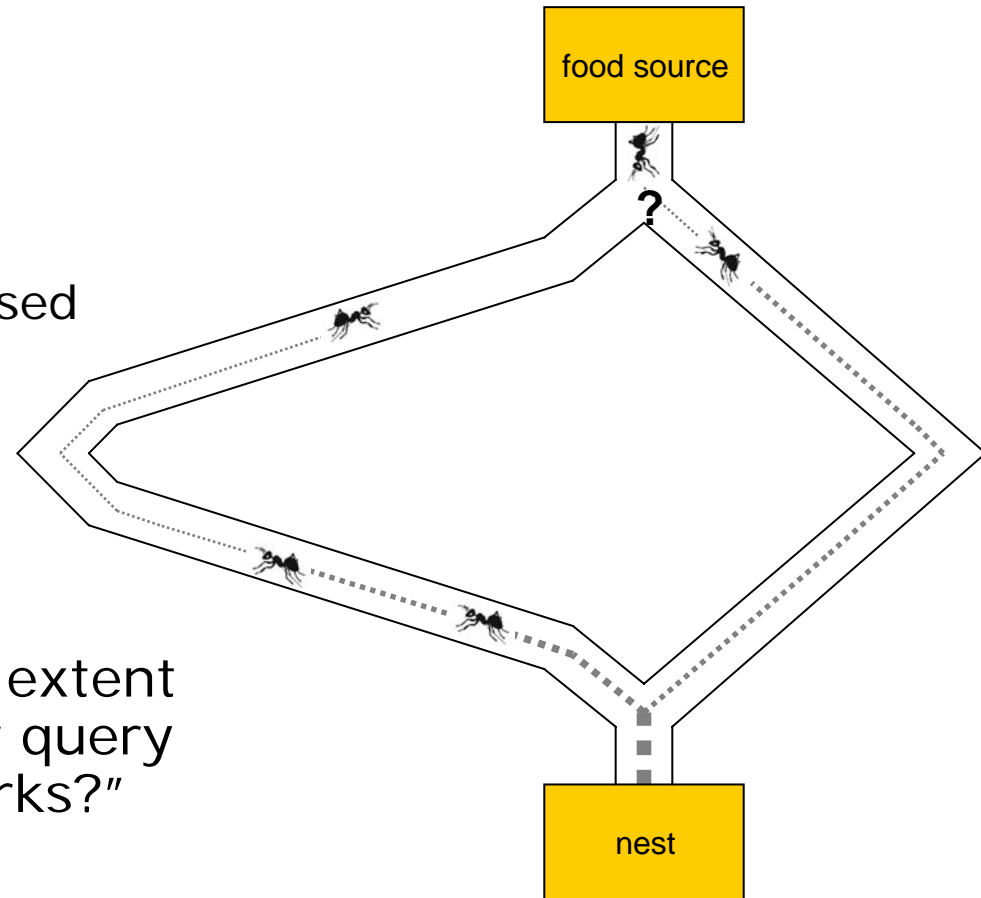
<http://wit.tuwien.ac.at/people/michlmayr>

# 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)

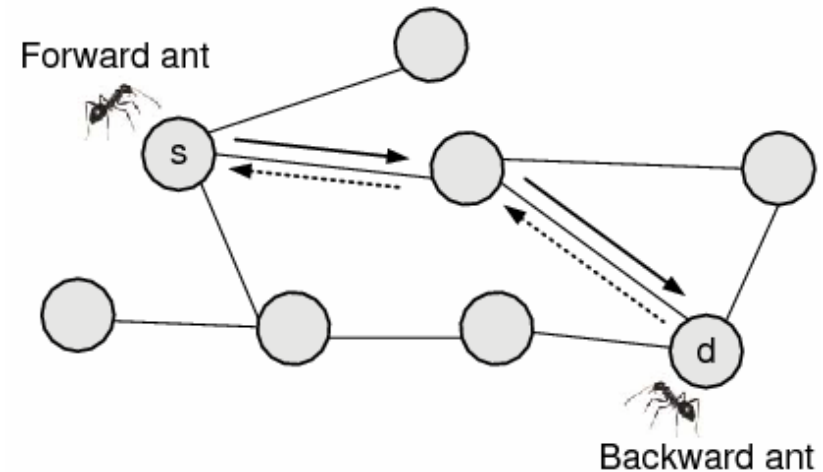


# Search in peer-to-peer networks

- 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

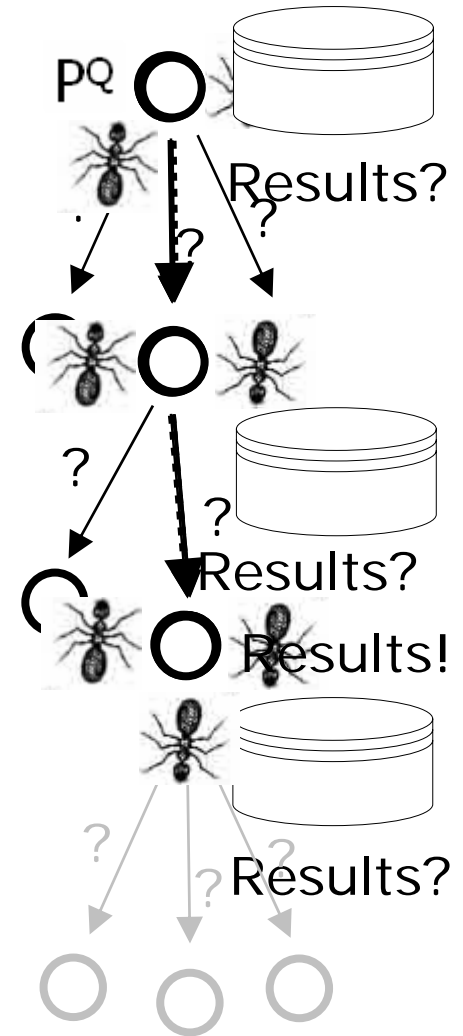
- Combines adapted features from
  - AntNet
  - Ant Colony System
- Queries are ants
  - No additional traffic
- Pheromone trails
  - Multiple types of pheromone
  - Probabilistic routing tables
    - One row for each neighbouring peer
    - One column for each keyword
    - Initialize entries with small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



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

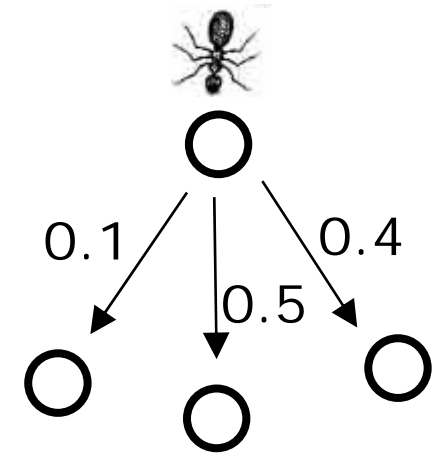
# SemAnt: If a query is issued at peer $P^Q$ ...

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

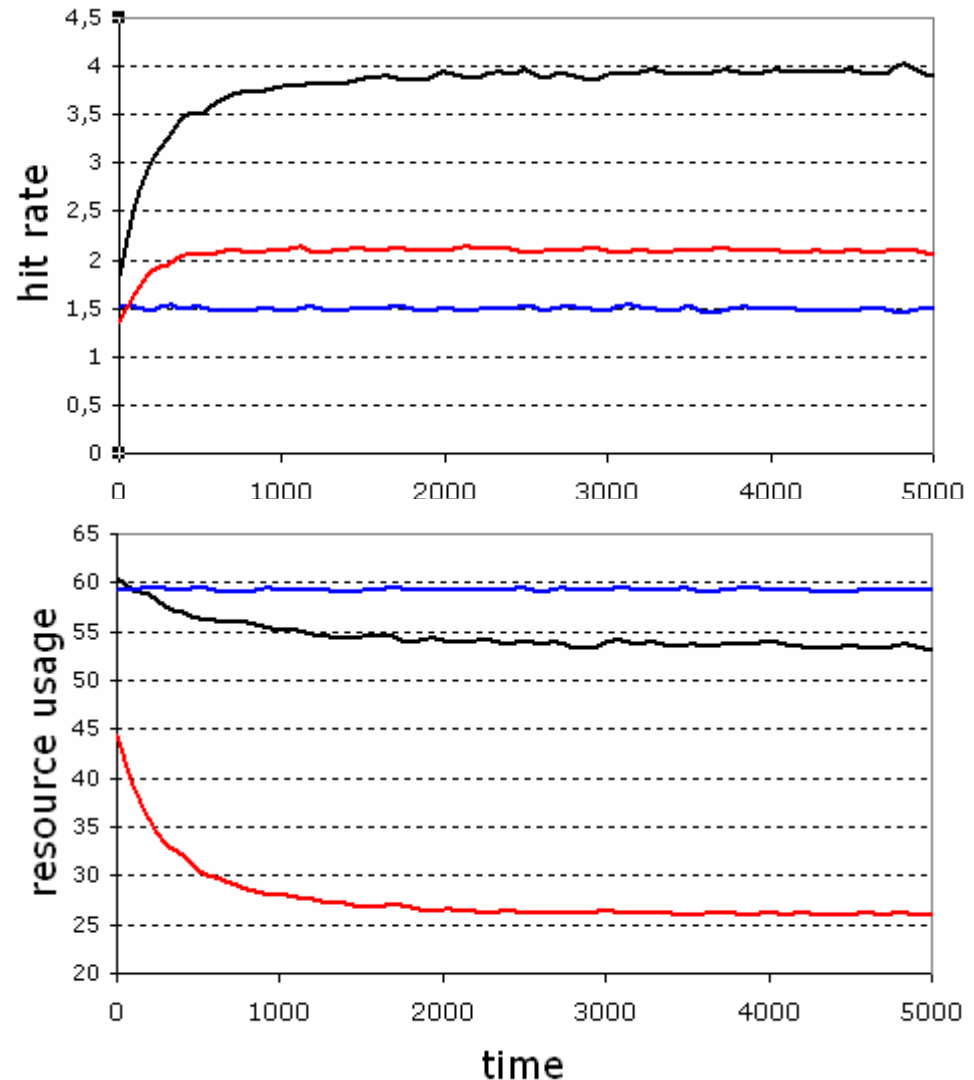
- Hit rate
- Resource usage

## ■ 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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