Consistency Challenges of Service Discovery in Mobile Ad Hoc Networks

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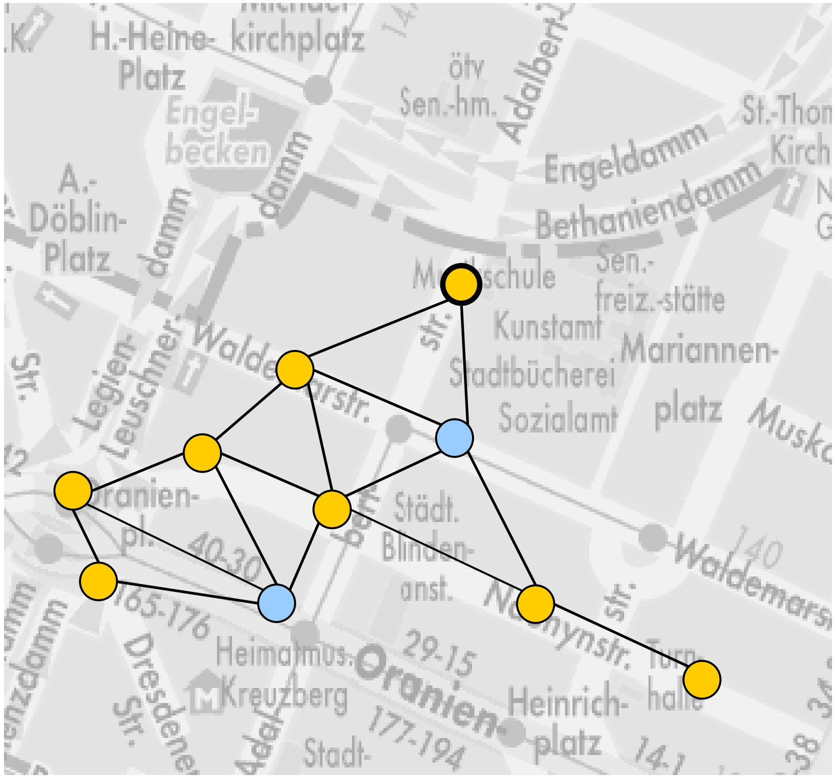
Scenario

- Users form ad-hoc network
- Usage scenarios:
  - Find nearest store
  - Hail taxi cab
  - Connect to access point
- Stores, cabs, etc. publish services on the network
- Clients perform “Service Discovery“



Requirements

- Service-Discovery
- Efficient at times of few requests
  - Only act on-demand (reactive)
  - No requests → no network traffic
- Efficient when requests frequent
  - Prepare information in advance (proactive)
- Completely independent of infrastructure
- Post-discovery routing

Design Goals

- Re-use routing functionality:
  - On-demand (reactive) routing and service discovery similar
    - Request
    - Reply
    - Caching
    - Expanding ring search
- Extendable architecture
  - Exchangeable routing component

Related Work

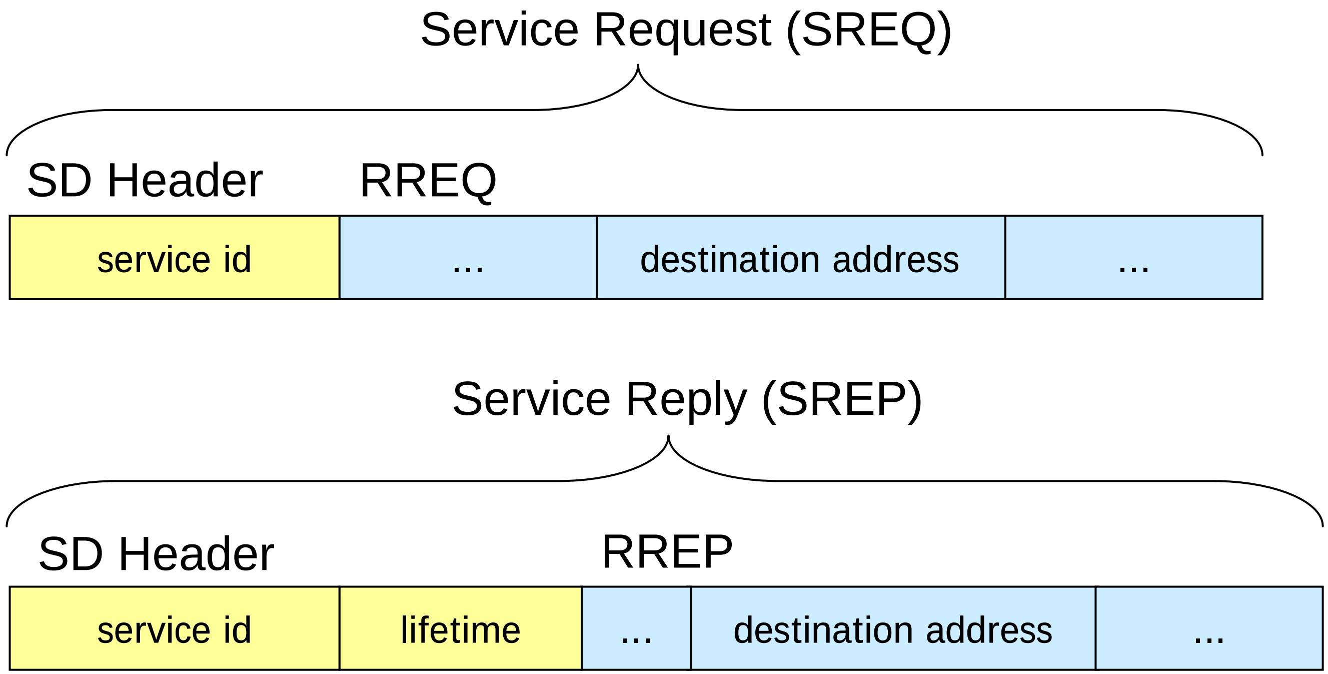
- Managed Networks
  - Service Location Protocol
  - UPnP
  - Jini Lookup Service
  - Intentional Naming Service (INS)
- Ad Hoc Networks
  - Multicast trees (e.g., L. Cheng, CSCW'02)
  - Integration with routing (Koodli, Perkins, *Internet Draft* '02)

Outline

- Introduction
- **Design / Implementation**
- Model
- Results
- Conclusion

Approach [kp02]

- Based on reactive ad-hoc network routing
- Attach service discovery headers to routing messages



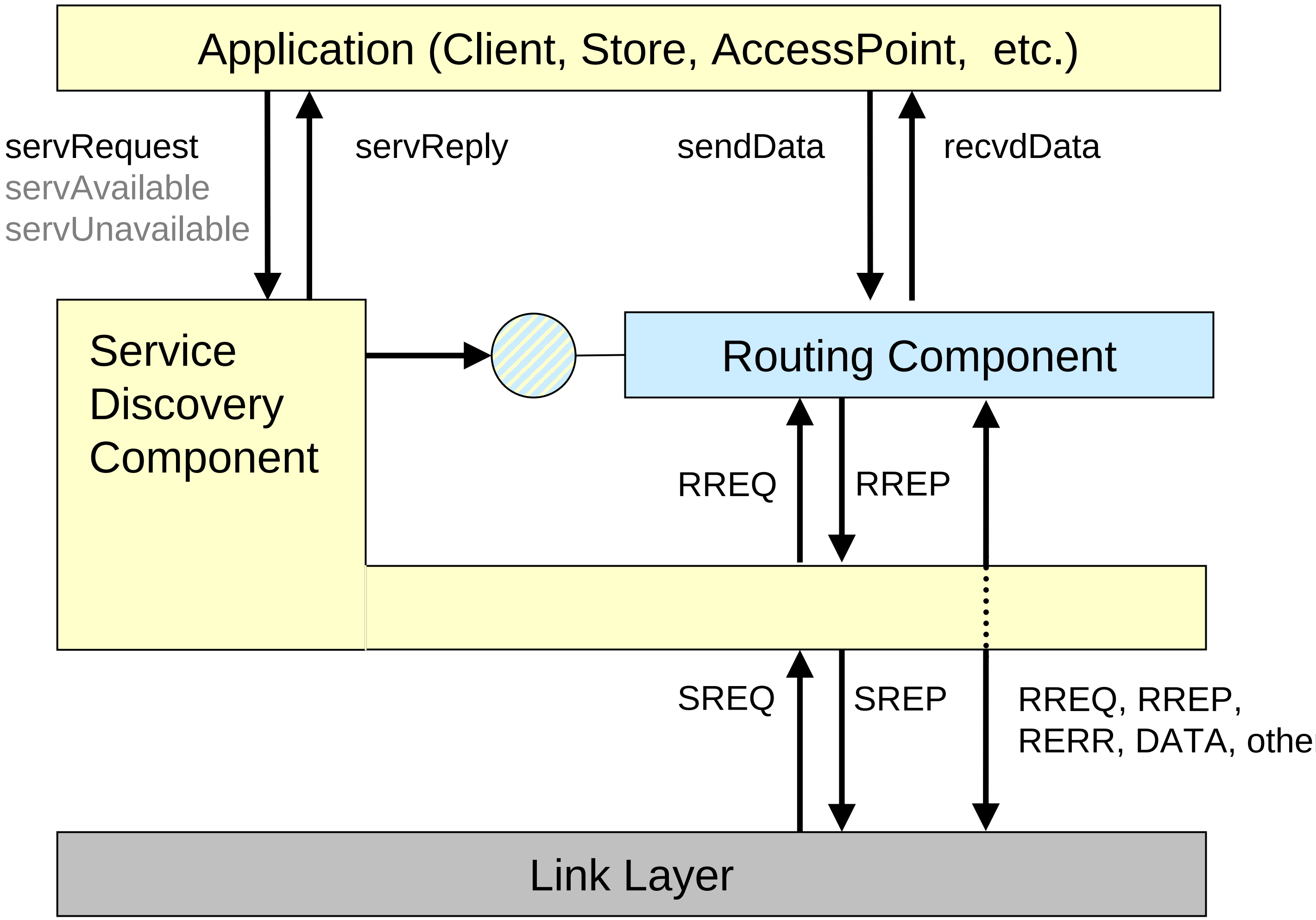
Approach [kp02]

- Each node maintains service bindings:

service-id	lifetime	provider
x	...	c
y	...	e
y	...	f

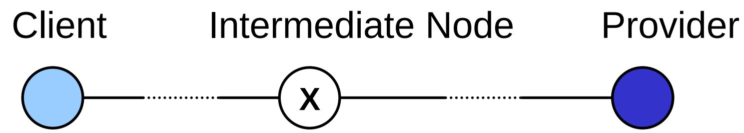
- SREQ flood
  - Destination in RREQ message is initially empty
- If node has binding for sought service
  - insert *provider* as *destination* and forward
- Nodes storing a route to destination will reply SREP
- Client receives SREP
  - Client knows provider and route to provider

Architecture

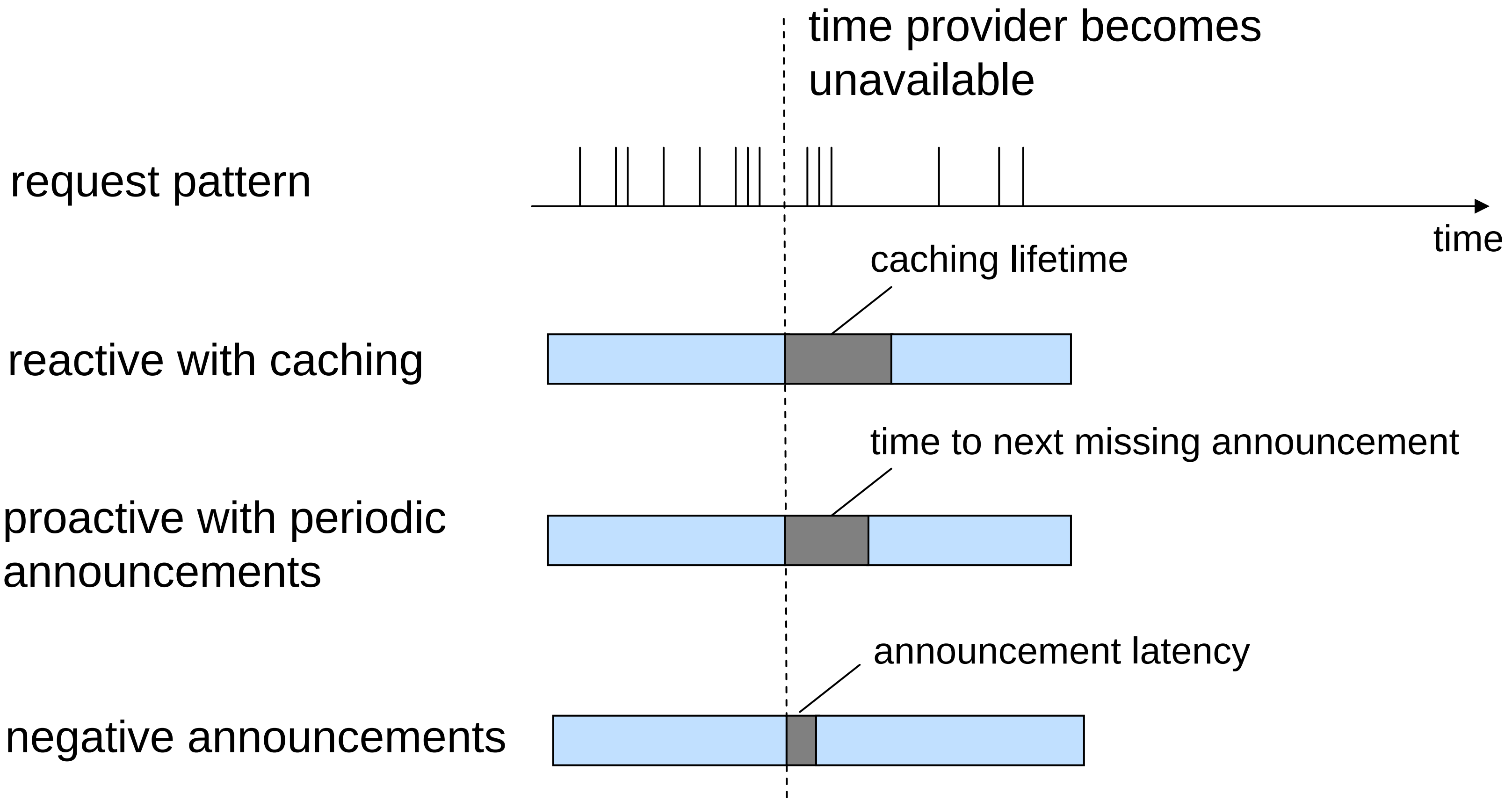


Proactive Elements?

- Be more efficient for frequent requests
- Periodic Announcements?
  - Caching enough with frequent requests
- Negative Announcements?
  - Good when providers become **actively** unavailable

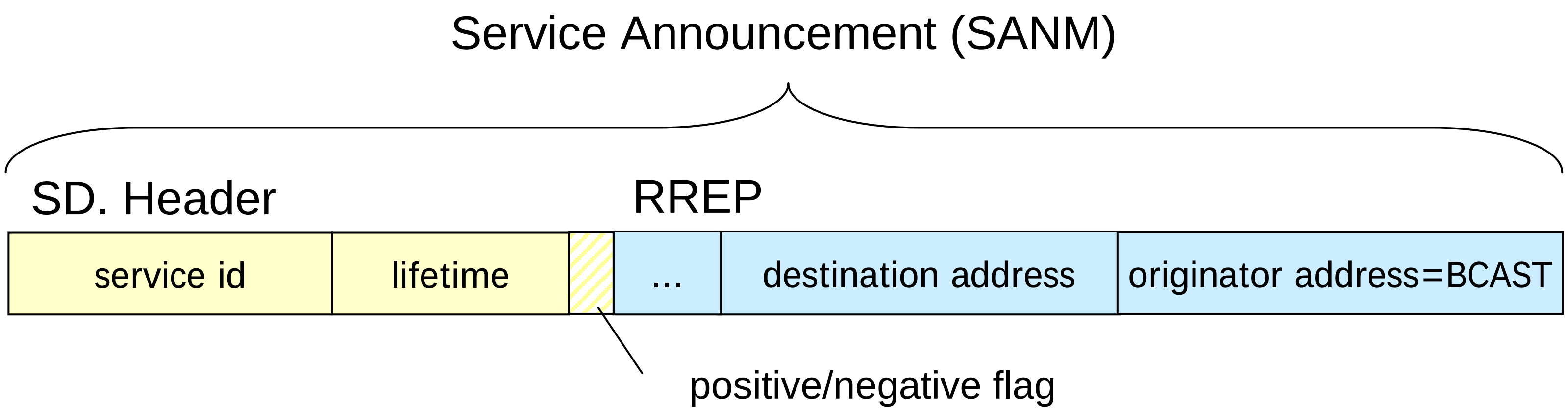


Provider Unavailable



- Benefit grows with #requests

Announcement Message



- Very similar to SREP
- Provider initiates SANM flood:
  - Service disc. header adds / removes service binding
  - RREP part creates route
- Nodes only forward if own decision is affected

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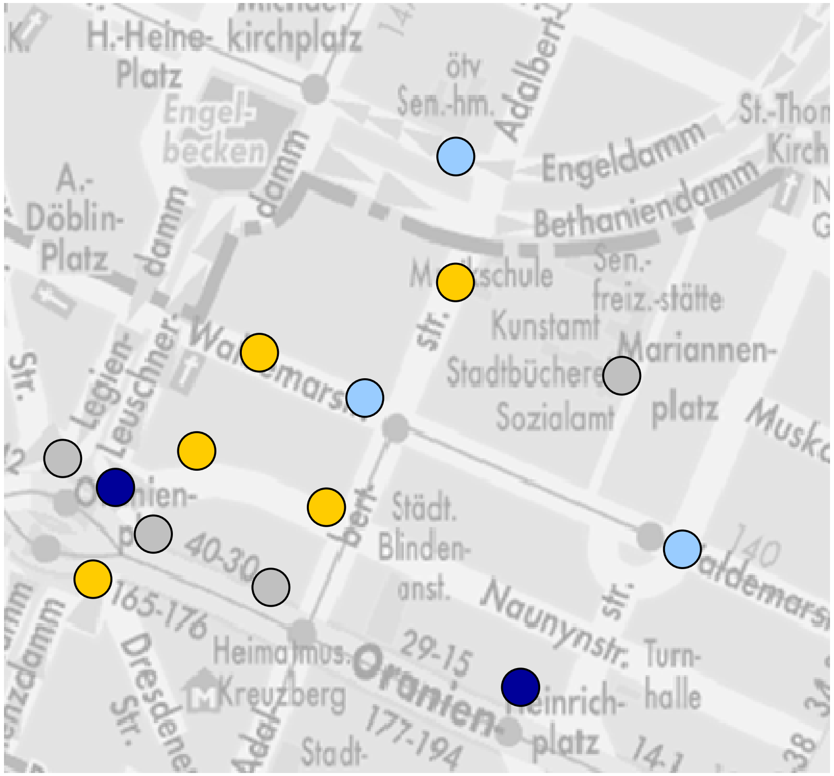
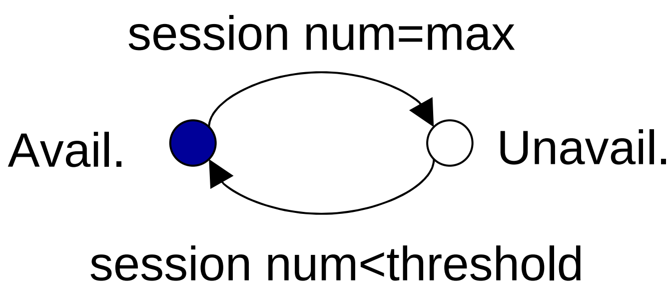
Model: Applications

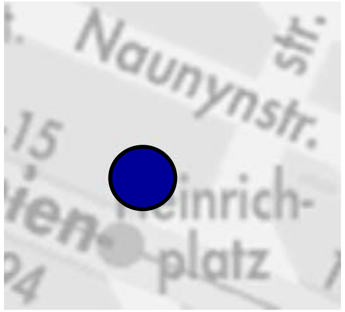
- **Clients**
  - Inter-request time ~ exponential
  - Mobile
- Stores, institutions
  - Constant service availability
- Cabs, bike couriers
  - Very volatile service availability
- **Internet access points**



Access Point Providers

- Clients are engaged in sessions
- Provider becomes unavailable if max. capacity is reached

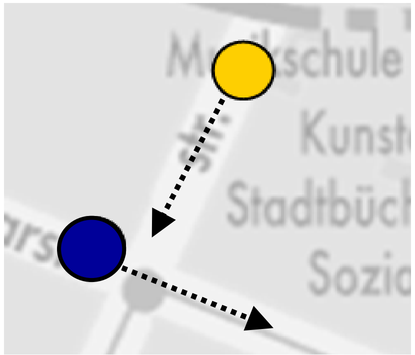




- Becomes available if capacity free (threshold)
- Session length ~ gamma(α,1)
- Traffic during session

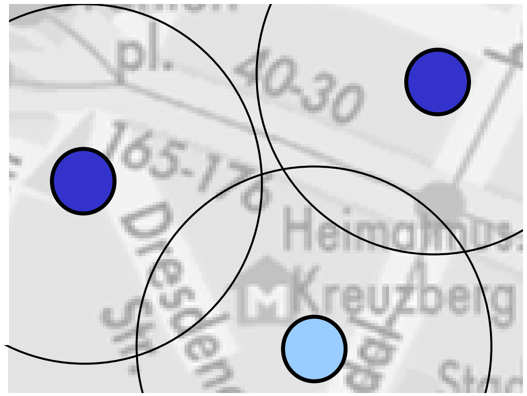
Model: Mobility

- Variant of Random Waypoint Model
- Participants travel to random destination
  - Speed ~ normal(μ, σ)
  - Different μ, σ for provider types
- Minimum speed



Model: Network

- Physical Layer
  - Simple path loss → radius
- Link Layer
  - Broadcast and unicast message delivery
  - Latency based on message length
  - MAC modelled by random delay



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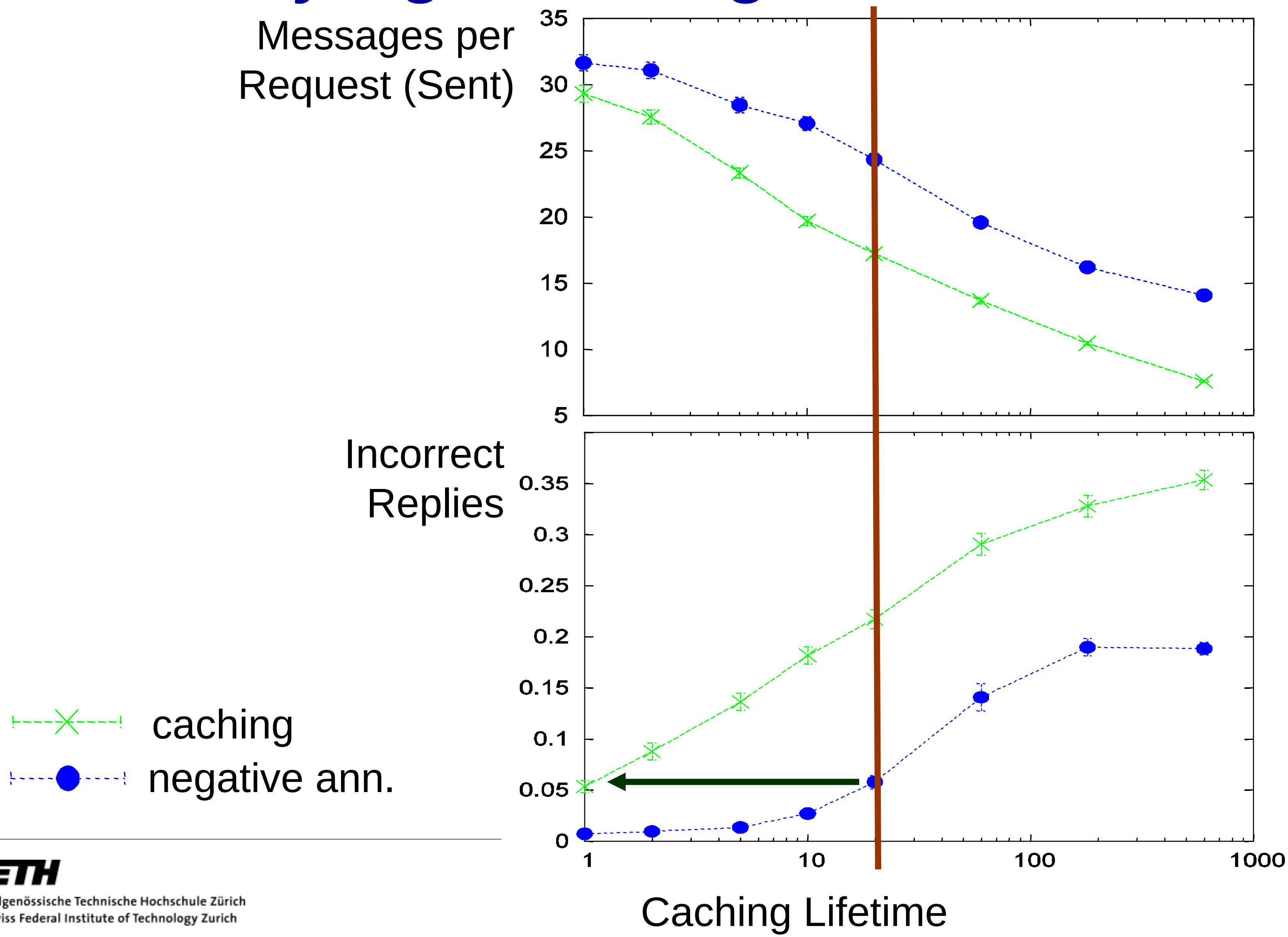
Simulation: Access Point Providers

- Study protocol behaviour with AP
- 800m x 800m area (see paper f. parameters)
- AODV as routing component
- Prominent metrics:
  - Messages per request
  - Ratio of incorrect replies
- Runs:
  - Increase **cache lifetime** (under high load: 50 clients and 5 AP)
  - Increase **number of requests** (with a given lifetime)

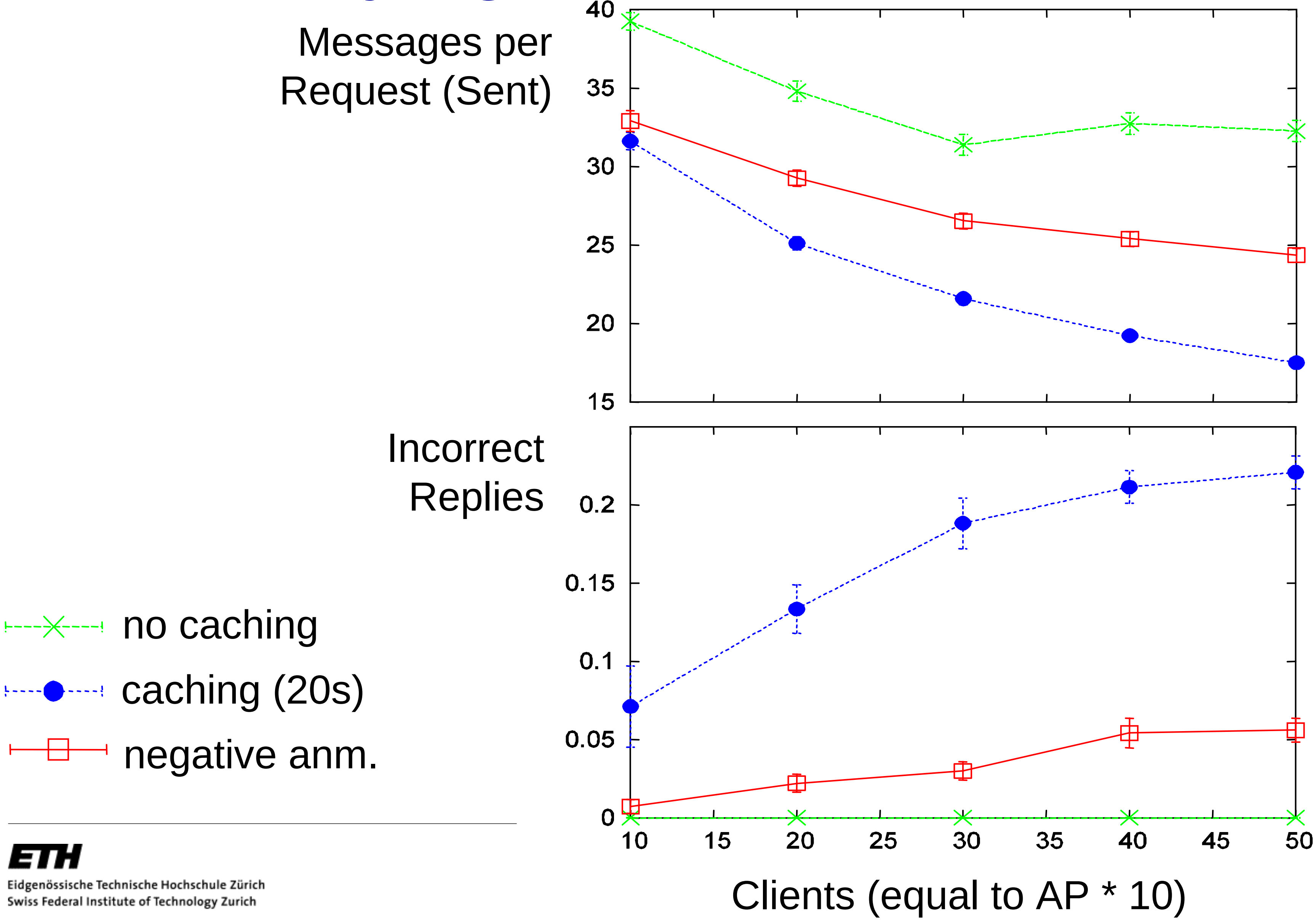
Method

- Implementation in C++
  - Discrete Event Simulator (Omnet++)
  - TKN Mobility Framework
- Transient removal with Akaroa
- Parallel runs until reaching:
  - confidence level of 95%
  - 5% precision (or 0.05)

Varying Caching Lifetime



Varying Network Load



Results

- Reactive without caching:
  - Most consistent
  - Least performant
- Reactive with caching:
  - Least consistent
  - Most performant
- **Negative Announcements**
  - Good balance
  - Better than customized lifetime

Conclusion

- Implemented and evaluated Internet Draft [kp02]
- Modular architecture for integration of routing and discovery
- Negative announcements perform well:
  - Make no difference for **`STORE`** providers
  - Provide consistency for **`CAB`** providers
  - Balance between performance and consistency for **`ACCESS POINT`** providers
- Explicitly removing cached entries is well-invested effort

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Thank you!
Questions?

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