Experimental Responsiveness Evaluation of Decentralized Service Discovery

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Introduction

- Trends of the 21st century
  - Rapid convergence of computing and communication infrastructures
  - Ubiquitous connectivity creates heterogeneous networks
  - Internet of things
- Challenges
  - Unified architecture to connect all devices and leverage their provided functionality
  - Maintain dependability with ever-growing complexity

Service Networks

- Service networks approach challenges by promising to master complexity with encapsulation

- Service
  - Abstract functionality, provided over the network
  - Leveraged by using the methods of an interface on a concrete service instance providing that service in the network
- Service-oriented computing
  - Defines layers of service usage
  - Defines standardized protocols and interfaces for service networks
  - **What about dependability properties in SoC ?**

Service Discovery

- Service Discovery
  - Key concept in service-oriented computing
  - Provides service instance enumeration for a given service type
  - Provides basic service description, the mapping of instances to
    - network addresses, port and protocol
    - more specific information for service usage

- If a service instance cannot be discovered …
  - Instance remains unknown and clients cannot use it
  - Instance unavailable for the client
  - **Dependable service discovery is a prerequisite for dependable service networks**

Service Discovery Systems Today

- Several technologies have been developed in the last decade
  - SLP, UPnP, Jini, Zeroconf, …
- Technologies remain incompatible, no unified service network architecture exists
- Several technologies have been developed with ad-hoc scenarios in mind
  - However, their dependability in such unreliable environments has never been proven

- **Goal of this paper:** Examine dependability of exemplary ad-hoc service network under influence of packet loss

Service Discovery Architectures

- Decentralized: 2-party
  - Service provider and user
  - All communication is done directly between provider and user
- Centralized: 3-party
  - Service provider, user and registry
  - Communication is done between provider and registry and between user and registry
- Adaptive
  - Switches between 2-party and 3-party architecture under certain conditions

- **Focus here:** Decentralized service discovery using 2-party architecture

Service Discovery Responsiveness

- Various metrics can be used to evaluate dependability of service discovery
  - Efficiency
  - Latency
  - (Update) Effectiveness

- Responsiveness (general)
  - *The probability of successful operation within deadlines, even in the presence of faults*
- **Responsiveness of Service Discovery**
  - *The probability that a given discovery operation finishes successfully before deadline t_D in the presence of faults*

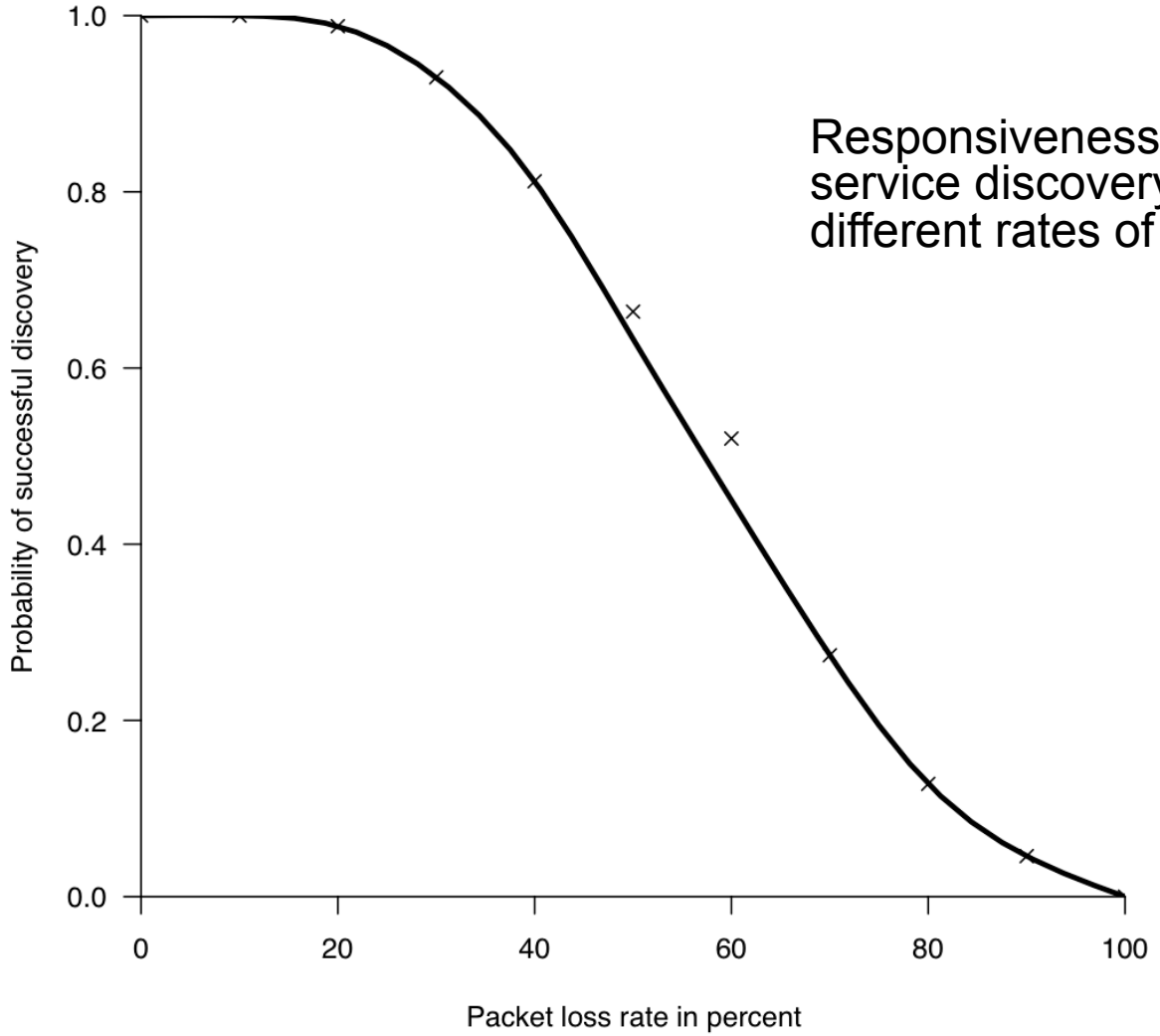
Simulation Model

- What is the probability to discover *m* out of *n* service instances within time t_D in a given network with packet loss rate *L*?
  - To date, no analytical models exist to evaluate responsiveness in auto-configuring networks
  - Today, we provide results from simulation experiments
- Simulation Setup
  - Service network realized in Xen virtualized environment
    - Nodes run minimal Debian Linux
    - Avahi used for network auto-configuration and service discovery
    - Fully connected star topology
    - Up to 100 instances, number constant in each experiment
    - Up to 90% packet loss probability, constant in each experiment
    - Discovery is successful when *m/n* of instances have been discovered
    - Recovery happening on MAC and discovery layer

Simulation Scenarios

- **Scenario 1:** Find single service within deadline
  - 1 client, 1 provider, variable packet loss, deadline t_D = 10s
  - Common scenario with lax requirements, can be considered as the baseline
- **Scenario 2:** Discover all services as fast as possible
  - 1 client, *n* providers, variable packet loss
  - Measure increase of responsiveness with time in networks with different number of service instances
- **Scenario 3:** Discover all services within deadline
  - 1 client, *n* providers, variable packet loss, deadline t_D = 20s
  - Measure change of responsiveness with number of service instances in the network

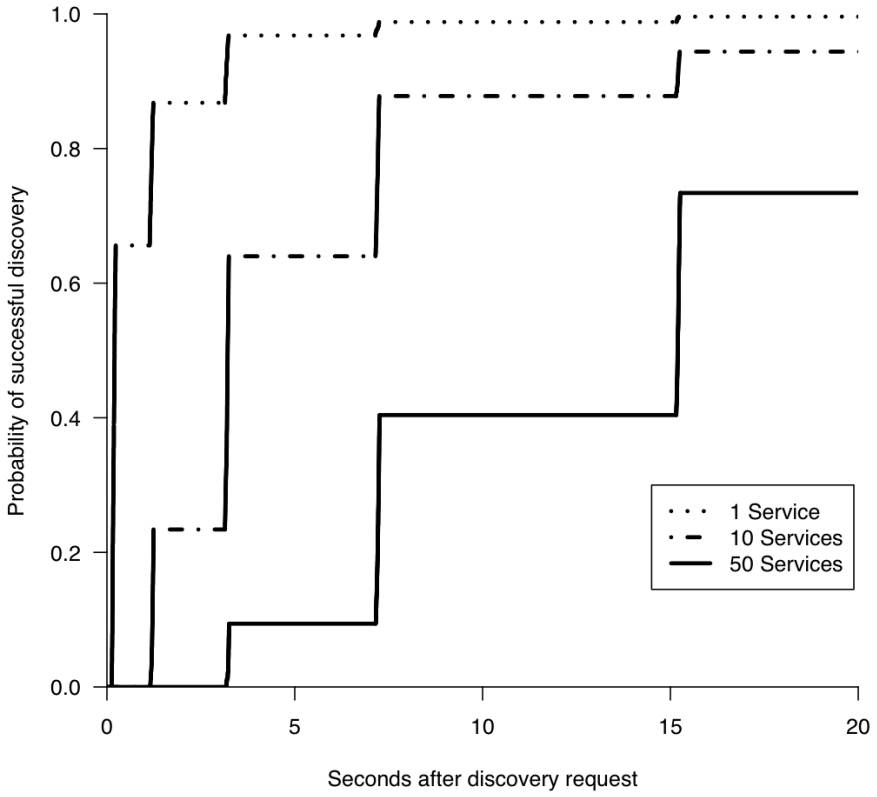
Simulation Results – Scenario 1



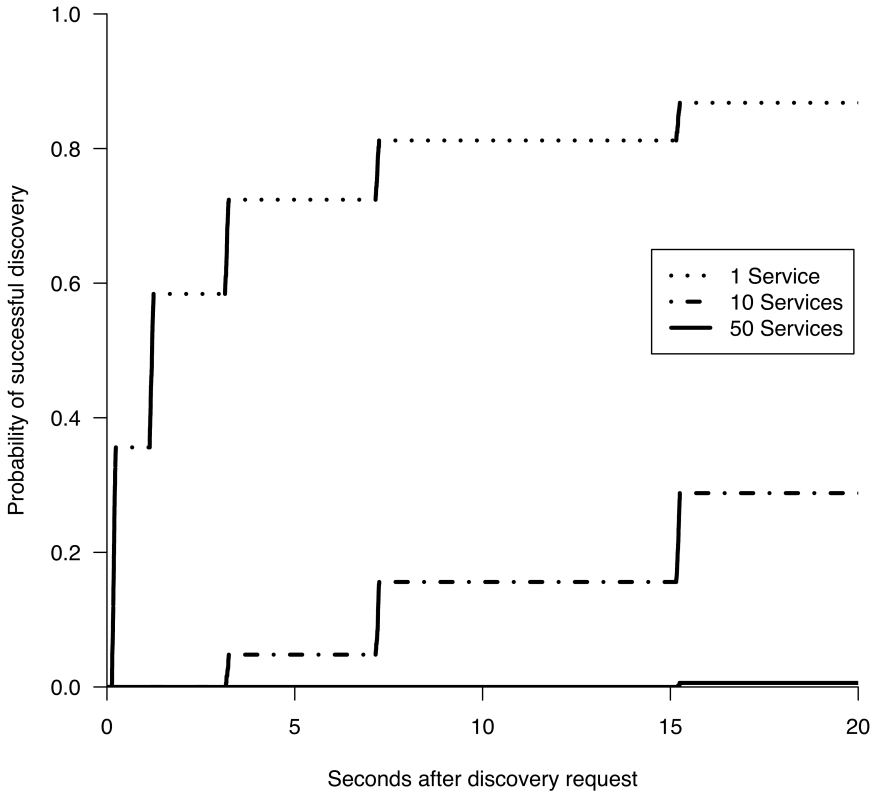
Responsiveness of single service discovery at different rates of packet loss

Simulation Results – Scenario 2

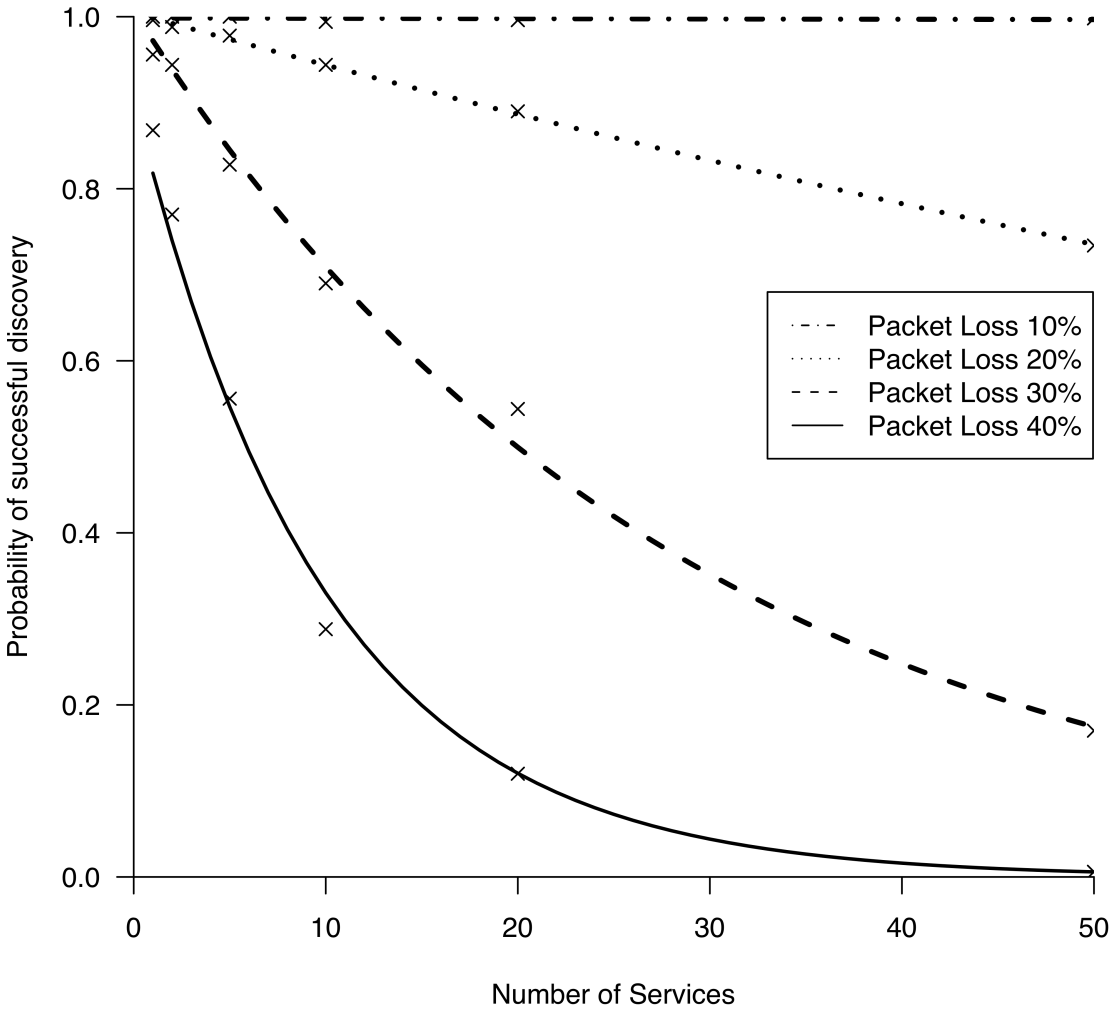
Responsiveness of service discovery with 20% packet loss



Responsiveness of service discovery with 40% packet loss



Simulation Results – Scenario 3



Responsiveness of multiple service discovery at different rates of packet loss

Conclusions

- Dependable service discovery is the precondition for a service network to operate correctly and for the services to be available.
- Dependability aspects of decentralized service discovery have been examined in simulated unreliable networks
  - Simulation of three realistic scenarios
  - Focus on responsiveness, since discovery is a time-critical operation
- Empirical results demonstrate
  - Responsiveness decreases dramatically with moderate packet loss
  - Responsiveness decreases further the more service instances need to be discovered
  - At high packet loss rates the decrease becomes exponential with the number of nodes such that discovery becomes practically impossible
- Distributed service discovery has to be used with caution, especially in scenarios where packet loss cannot be neglected

Thank you for your attention.

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