

Topology Management for Unstructured Overlay Networks

João Leitão

September 5th, 2012

Roadmap

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

1 Introduction

2 Overview

3 CellFarm

4 X-BOT

5 Thicket

6 OpenFire

7 Conclusions

Introduction

P2P Systems

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

Peer-to-Peer model:

- Promise to overcome the limitations of the client-server model.
- Fault-Tolerance: There is no single point of failure.
- Inherent Scalability: All nodes contribute with their resources.

Popular Examples:

- File Sharing: Napster, Emule, Gnutella, Bittorrent.
- VOIP: Skype.
- IPTV: PPLive.
- Internet Anonymity: TOR.

Introduction

P2P Systems

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

Peer-to-Peer model:

- Promise to overcome the limitations of the client-server model.
- Fault-Tolerance: There is no single point of failure.
- Inherent Scalability: All nodes contribute with their resources.

Popular Examples:

- File Sharing: Napster, Emule, Gnutella, Bittorrent.
- VOIP: Skype.
- IPTV: PPLive.
- Internet Anonymity: TOR.

Introduction

P2P Global Membership

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

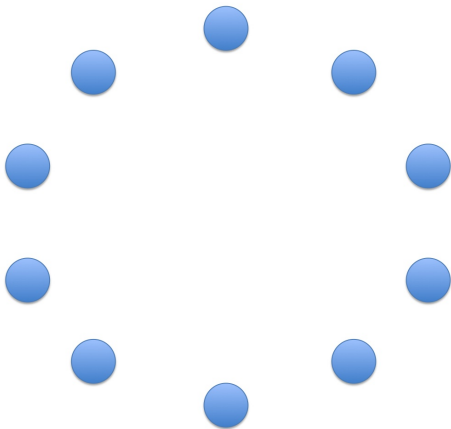
X-BOT

Thicket

OpenFire

Conclusions

Publications



Introduction

P2P Global Membership

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

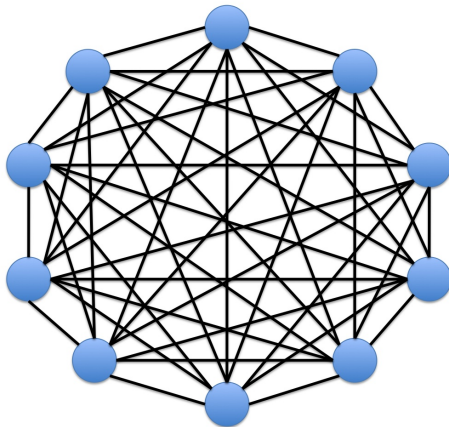
X-BOT

Thicket

OpenFire

Conclusions

Publications



Introduction

P2P Global Membership

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

- Global Membership:
 - Limits scalability.
 - High maintenance cost under high membership changes (e.g., churn).
- Alternative is to rely on a (distributed) membership service:
 - Offers a partial view to each participant.

Introduction

P2P Global Membership

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

- Global Membership:
 - Limits scalability.
 - High maintenance cost under high membership changes (e.g., churn).
- Alternative is to rely on a (distributed) membership service:
 - Offers a partial view to each participant.

Introduction

Partial Views

Partial Views:

- Encodes neighboring relations across participants.
- Their closure establishes an *overlay network*.

Topology properties can affect P2P services performance:

- Efficiency.
- Fault-tolerance.
- Convergence.
- Latency.

Introduction

Partial Views

Partial Views:

- Encodes neighboring relations across participants.
- Their closure establishes an *overlay network*.

Topology properties can affect P2P services performance:

- Efficiency.
- Fault-tolerance.
- Convergence.
- Latency.

Introduction

Overlay Networks

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

Two types of overlay networks:

- Structured Overlay Networks (e.g., DHTs)
- Unstructured Overlay Networks (i.e., random overlays).

Introduction

Structured Overlay Networks

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

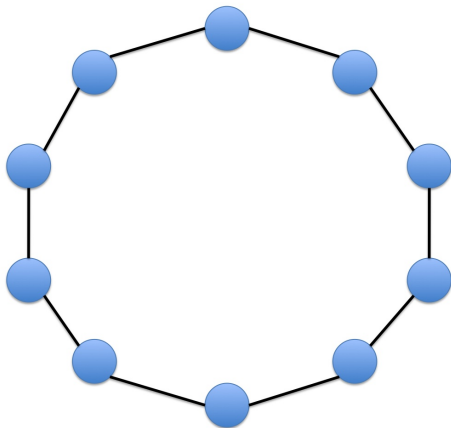
X-BOT

Thicket

OpenFire

Conclusions

Publications



Introduction

Structured Overlay Networks

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

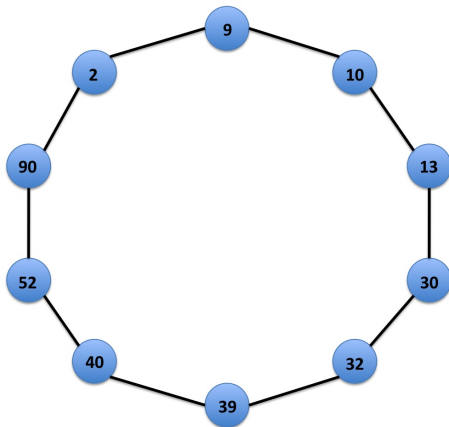
X-BOT

Thicket

OpenFire

Conclusions

Publications



Introduction

Unstructured Overlay Networks

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

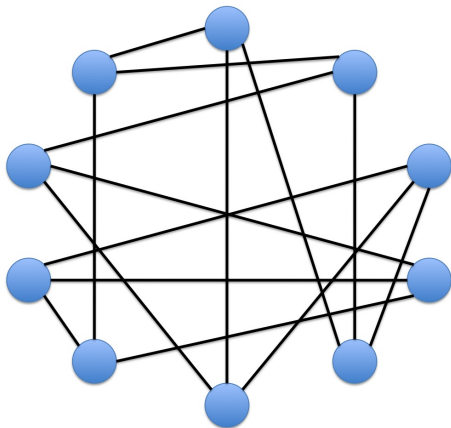
X-BOT

Thicket

OpenFire

Conclusions

Publications



Introduction

Overlay Networks

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

Structured Overlay Networks

- Can (easily) offer additional functionality to services.
- Complex construction and maintenance.
- More susceptible to (high) membership dynamics.

Unstructured Overlay Networks

- Lower construction and maintenance costs.
- More robust to (high) membership dynamics.
- Natural redundancy.
- Topology cannot be easily leveraged by services.

Introduction

Overlay Networks

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

Structured Overlay Networks

- Can (easily) offer additional functionality to services.
- **Complex construction and maintenance.**
- **More susceptible to (high) membership dynamics.**

Unstructured Overlay Networks

- Lower construction and maintenance costs.
- More robust to (high) membership dynamics.
- **Natural redundancy.**
- **Topology cannot be easily leveraged by services.**

Introduction

Overlay Networks

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

Structured Overlay Networks

- Can (easily) offer additional functionality to services.
- **Complex construction and maintenance.**
- **More susceptible to (high) membership dynamics.**

Unstructured Overlay Networks

- Lower construction and maintenance costs.
- More robust to (high) membership dynamics.
- **Natural redundancy.**
- **Topology cannot be easily leveraged by services.**

Introduction

Overlay Networks

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

Structured Overlay Networks

- Can (easily) offer additional functionality to services.
- **Complex construction and maintenance.**
- **More susceptible to (high) membership dynamics.**

Unstructured Overlay Networks

- Lower construction and maintenance costs.
- More robust to (high) membership dynamics.
- **Natural redundancy.**
- **Topology cannot be easily leveraged by services.**

Introduction

Problem Statement

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

Motivation:

Get the best of both worlds by imbuing some form of relaxed structure over unstructured overlay networks.

- Retain the simplicity, flexibility, and robustness of unstructured overlays.
- Offer some topology properties that can benefit and be leveraged by P2P services and applications.

Introduction

Problem Statement

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

Motivation:

Get the best of both worlds by imbuing some form of relaxed structure over unstructured overlay networks.

- Retain the simplicity, flexibility, and robustness of unstructured overlays.
- Offer some topology properties that can benefit and be leveraged by P2P services and applications.

Introduction

Problem Statement

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

Motivation:

Get the best of both worlds by imbuing some form of relaxed structure over unstructured overlay networks.

- Retain the simplicity, flexibility, and robustness of unstructured overlays.
- Offer some topology properties that can benefit and be leveraged by P2P services and applications.

Roadmap

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

1 Introduction

2 Overview

3 CellFarm

4 X-BOT

5 Thicket

6 OpenFire

7 Conclusions

Overview

P2P Typical Architecture

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

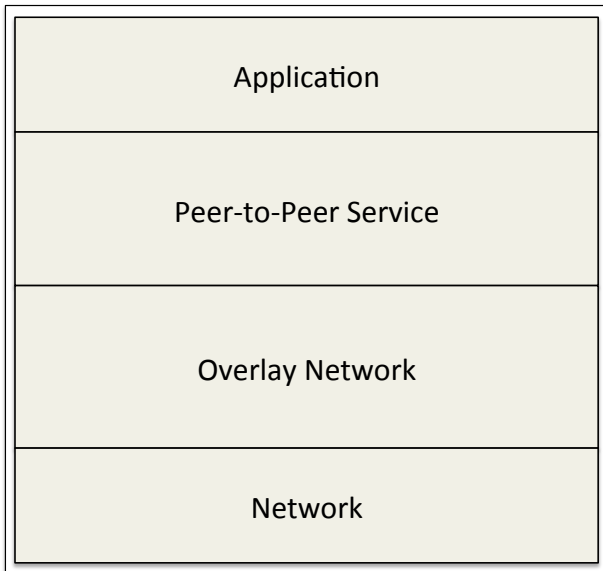
X-BOT

Thicket

OpenFire

Conclusions

Publications



Overview

Control Technique

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

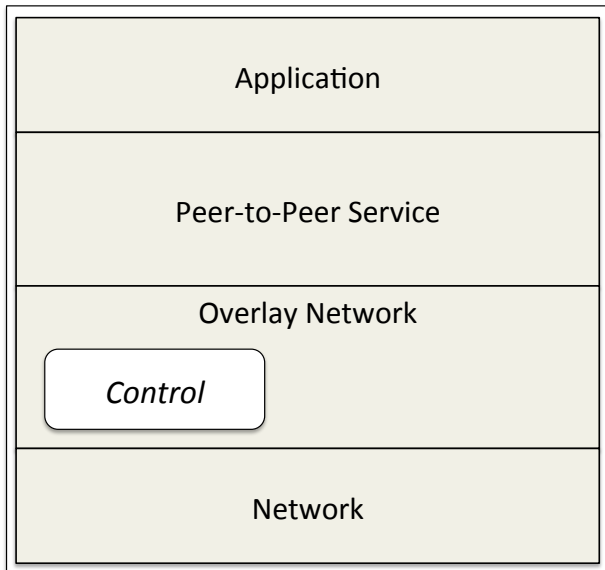
X-BOT

Thicket

OpenFire

Conclusions

Publications



Overview

Control Technique

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

- Soft-constraints over neighboring relations.
 - Enforce topological properties.
 - During the construction of the overlay.
- Maintain high level of randomness:
 - Overlay is flexible to deal with churn.
 - Keep maintenance overhead low.

Example:

Generate dynamic cliques of nodes that can be exploited to support replication and load balancing.

Overview

Control Technique

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

- Soft-constraints over neighboring relations.
 - Enforce topological properties.
 - During the construction of the overlay.
- Maintain high level of randomness:
 - Overlay is flexible to deal with churn.
 - Keep maintenance overhead low.

Example:

Generate dynamic cliques of nodes that can be exploited to support replication and load balancing.

Overview

Control Technique

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

- Soft-constraints over neighboring relations.
 - Enforce topological properties.
 - During the construction of the overlay.
- Maintain high level of randomness:
 - Overlay is flexible to deal with churn.
 - Keep maintenance overhead low.

Example:

Generate dynamic cliques of nodes that can be exploited to support replication and load balancing.

Overview

Bias Technique

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

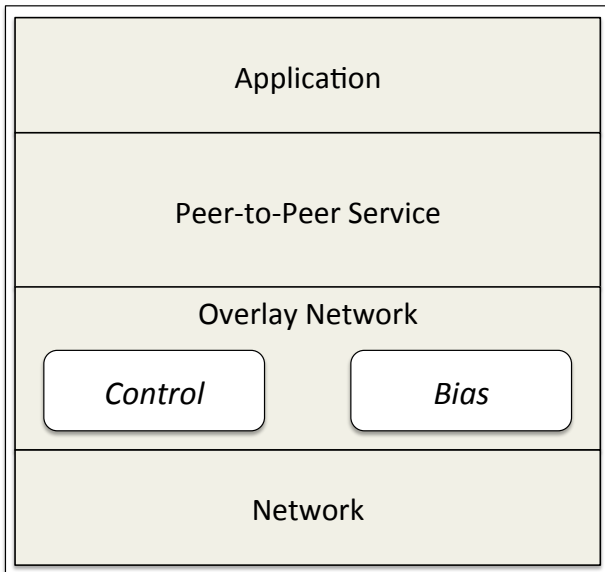
X-BOT

Thicket

OpenFire

Conclusions

Publications



Overview

Bias Technique

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

- Build an random overlay network.
- Iteratively:
 - Swap some existing overlay links by other links that are *better*.
 - Consider a particular performance criteria (e.g., latency).
- Resulting overlay:
 - Random in nature.
 - Optimized to benefit the operation of a P2P service.

Example:

Promote low-latency overlay links to improve the latency of an application-level broadcast service.

Overview

Bias Technique

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

- Build an random overlay network.
- Iteratively:
 - Swap some existing overlay links by other links that are *better*.
 - Consider a particular performance criteria (e.g., latency).
- Resulting overlay:
 - Random in nature.
 - Optimized to benefit the operation of a P2P service.

Example:

Promote low-latency overlay links to improve the latency of an application-level broadcast service.

Overview

Bias Technique

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

- Build an random overlay network.
- Iteratively:
 - Swap some existing overlay links by other links that are *better*.
 - Consider a particular performance criteria (e.g., latency).
- Resulting overlay:
 - Random in nature.
 - Optimized to benefit the operation of a P2P service.

Example:

Promote low-latency overlay links to improve the latency of an application-level broadcast service.

Overview

Embed Technique

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

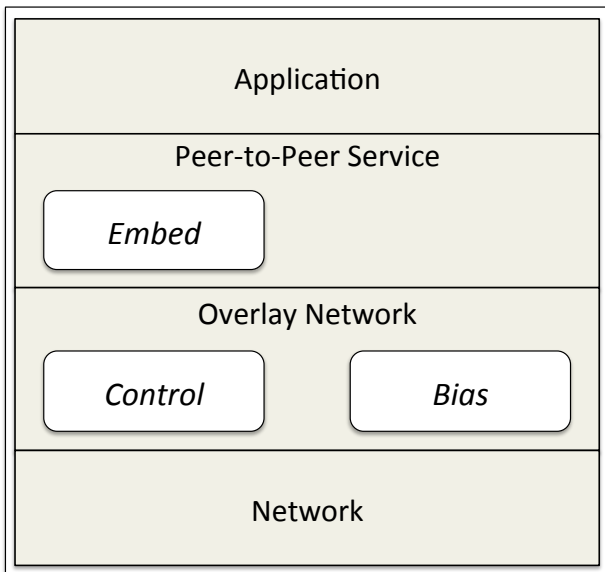
X-BOT

Thicket

OpenFire

Conclusions

Publications



Overview

Embed Technique

- Considering feedback from a P2P service.
- Embed a secondary topology over a pure unstructured overlay network:
 - Secondary topology can be leveraged by the service.
- Remaining overlay links can be used to transmit control information:
 - Recover secondary topology in face of failures.
 - Fallback if secondary topology becomes compromised.

Example

Embed spanning trees over an unstructured overlay to support multimedia streaming.

Overview

Embed Technique

- Considering feedback from a P2P service.
- Embed a secondary topology over a pure unstructured overlay network:
 - Secondary topology can be leveraged by the service.
- Remaining overlay links can be used to transmit control information:
 - Recover secondary topology in face of failures.
 - Fallback if secondary topology becomes compromised.

Example

Embed spanning trees over an unstructured overlay to support multimedia streaming.

Overview

Embed Technique

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

- Considering feedback from a P2P service.
- Embed a secondary topology over a pure unstructured overlay network:
 - Secondary topology can be leveraged by the service.
- Remaining overlay links can be used to transmit control information:
 - Recover secondary topology in face of failures.
 - Fallback if secondary topology becomes compromised.

Example

Embed spanning trees over an unstructured overlay to support multimedia streaming.

Overview

Enrich Technique

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

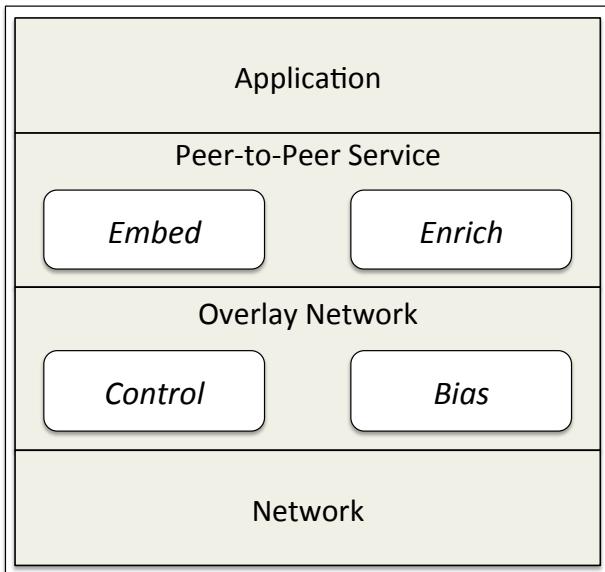
X-BOT

Thicket

OpenFire

Conclusions

Publications



Overview

Enrich Technique

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

- Considering feedback from a P2P service.
- Create temporary overlay links at the P2P service layer:
 - Temporary links are outside the logic of the unstructured overlay.
 - Enable the service to contact peers that could not be available through the overlay.

Example

Create temporary overlay links that enable one to circumvent Firewalls and NAT boxes.

Overview

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

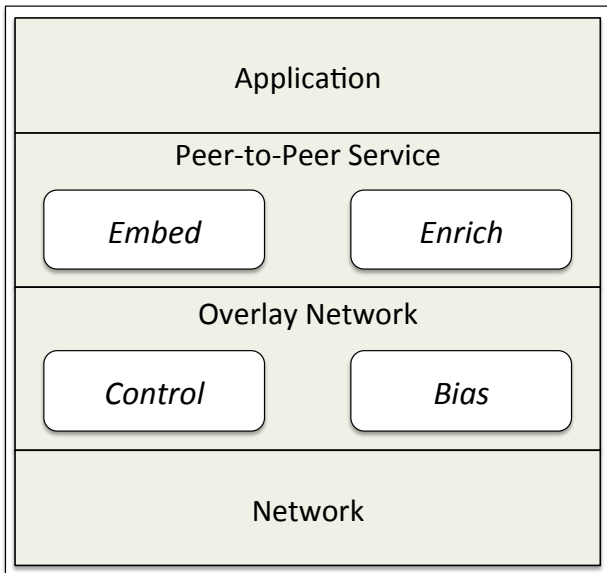
X-BOT

Thicket

OpenFire

Conclusions

Publications



Overview

CellFarm

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

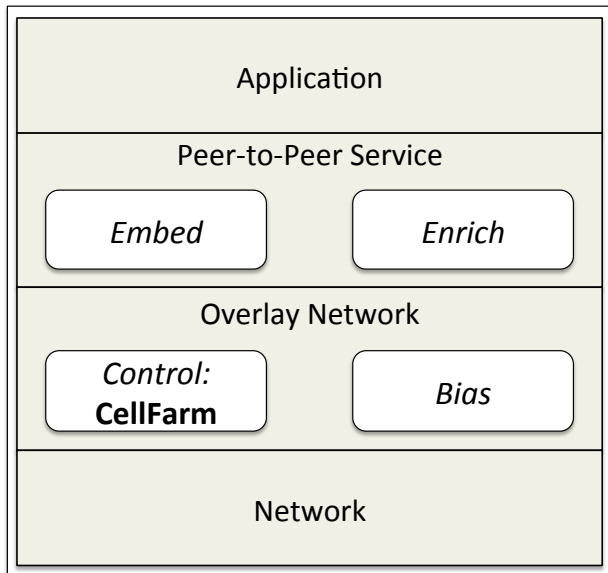
X-BOT

Thicket

OpenFire

Conclusions

Publications



Overview

X-BOT

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

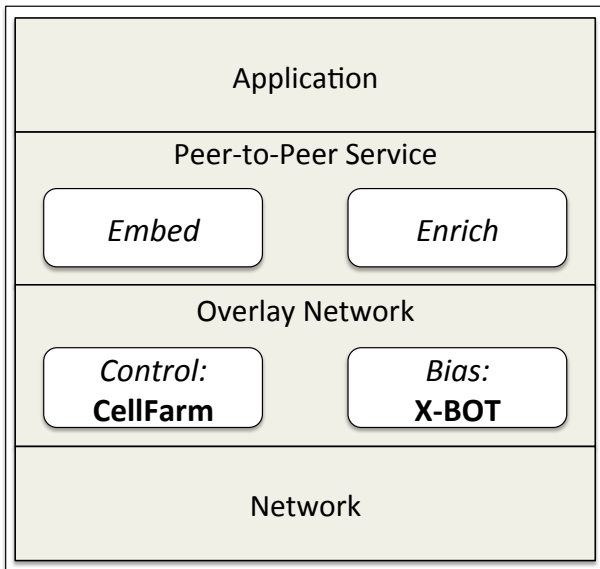
X-BOT

Thicket

OpenFire

Conclusions

Publications



Overview

Thicket

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

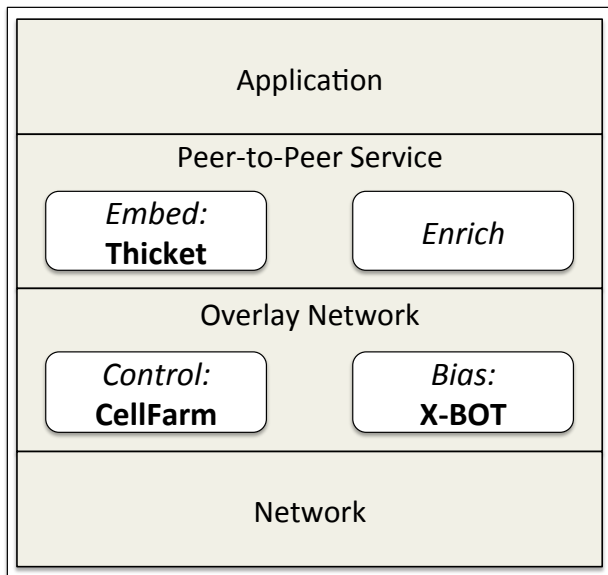
X-BOT

Thicket

OpenFire

Conclusions

Publications



Overview

OpenFire

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

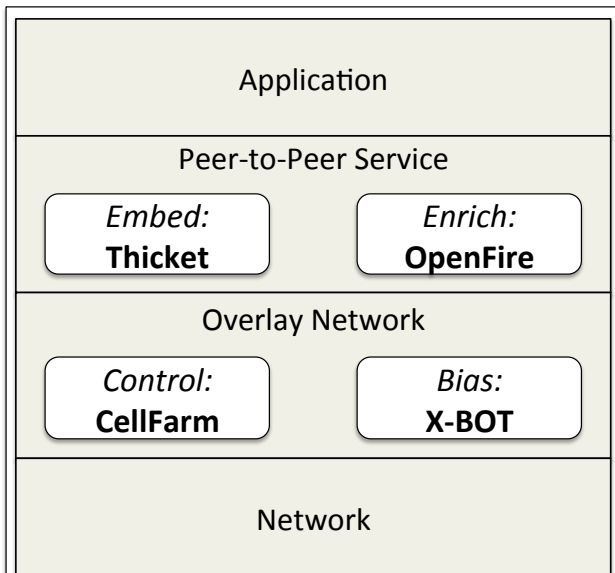
X-BOT

Thicket

OpenFire

Conclusions

Publications



Overview

Topology Management for Unstructured Overlay Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

- Very briefly motivate the problem and solution.
- Present some relevant results.

Overview

Topology Management for Unstructured Overlay Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

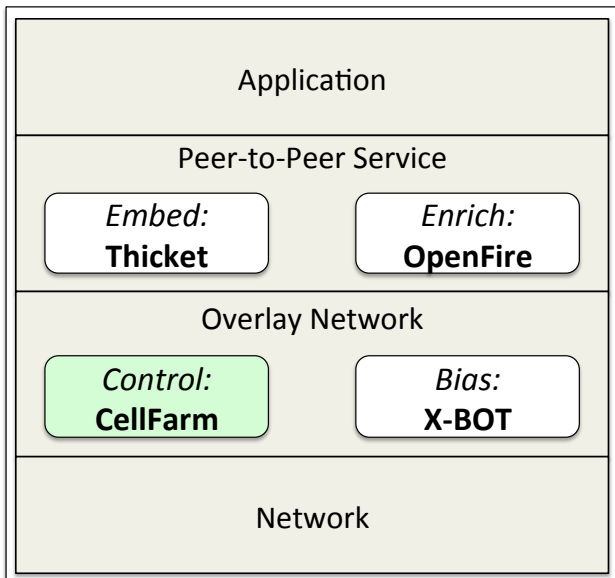
OpenFire

Conclusions

Publications

- Very briefly motivate the problem and solution.
- Present some relevant results.

Control the Topology



Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

- Goal: Offer support to replication and load balancing:
 - Process groups.
- This can be achieved by manipulating the topology:
 - Nodes self-organize in (fully connected) *cliques*.
 - Cliques are used as a replication and load balancing unit.
 - Cliques are highly connected among them.

- Goal: Offer support to replication and load balancing:
 - Process groups.
- This can be achieved by manipulating the topology:
 - Nodes self-organize in (fully connected) *cliques*.
 - Cliques are used as a replication and load balancing unit.
 - Cliques are highly connected among them.

- Employed technique: **Control**.
- Flexibility is essential:
 - Enable the overlay to cope with churn.
 - Clique size governed by three parameters: target size; minimum size; maximum size;

- Employed technique: **Control**.
- Flexibility is essential:
 - Enable the overlay to cope with churn.
 - Clique size governed by three parameters: target size; minimum size; maximum size;

CellFarm

Main Results: Cell Size Distribution

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

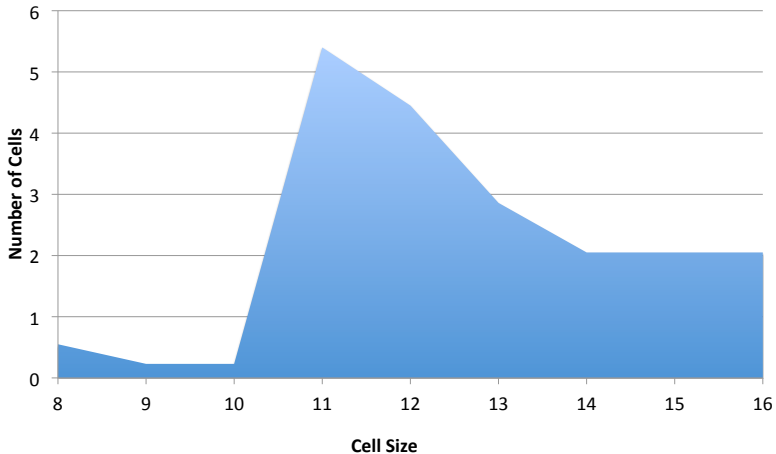
X-BOT

Thicket

OpenFire

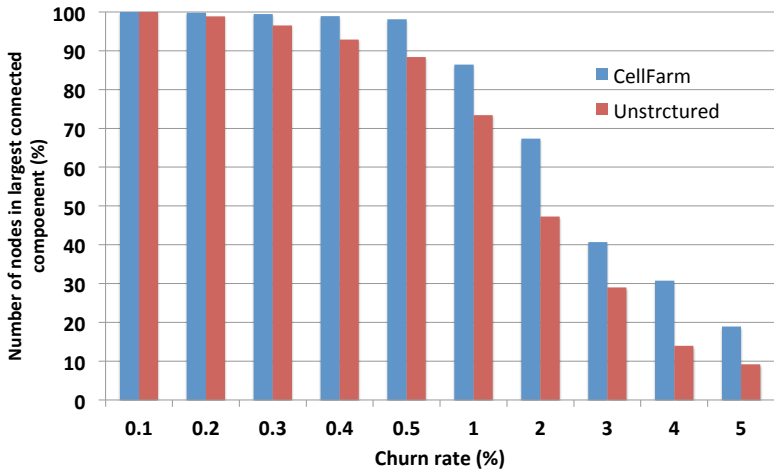
Conclusions

Publications



CellFarm

Main Results: Robustness to Churn



CellFarm

Summary

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

- CellFarm, based on the control technique operating at the overlay network layer.
- Control technique allows to build and maintain robust and flexible overlays with pre-determined topological properties.
- Benefit the operation of P2P resource location systems based on unstructured overlays and one-hop replication.

CellFarm

Summary

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

- CellFarm, based on the control technique operating at the overlay network layer.
- Control technique allows to build and maintain robust and flexible overlays with pre-determined topological properties.
- Benefit the operation of P2P resource location systems based on unstructured overlays and one-hop replication.

Overview

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

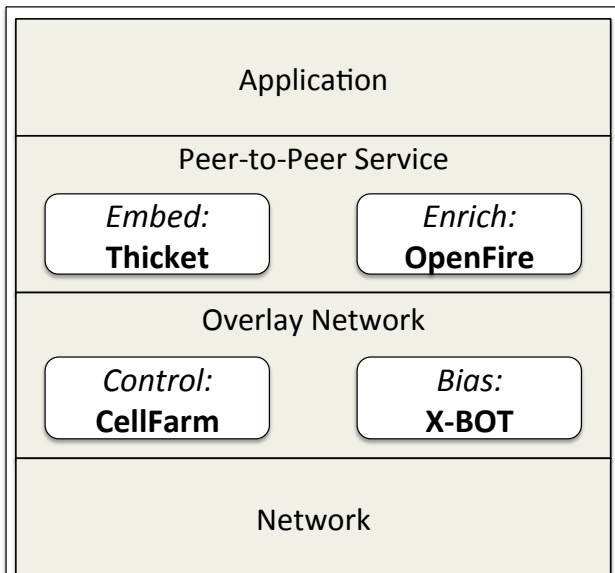
X-BOT

Thicket

OpenFire

Conclusions

Publications



Bias the Topology

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

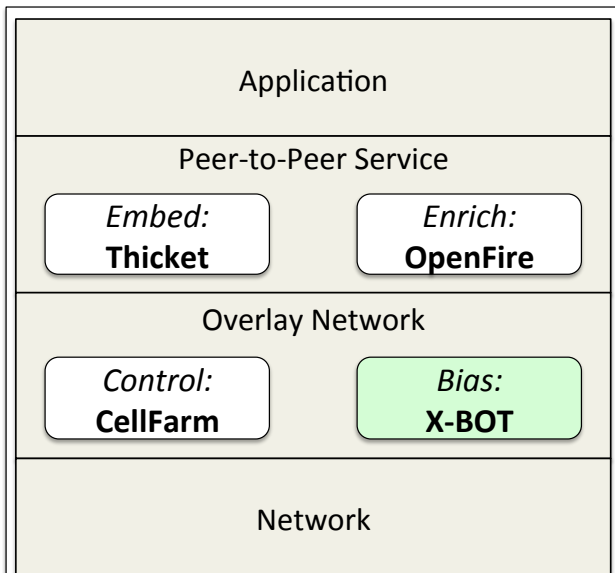
X-BOT

Thicket

OpenFire

Conclusions

Publications



- Goal: Deal with the topology mismatch problem:
 - Random topology means that many links may be sub-optimal.
- This can be achieved by manipulating the topology:
 - Cannot employ control technique.
 - New nodes may offer new opportunities to improve the overlay topology.
 - Allow nodes to replace sub-optimal links by better links.
 - Approach can be used to improve the overlay for different criteria.

- Goal: Deal with the topology mismatch problem:
 - Random topology means that many links may be sub-optimal.
- This can be achieved by manipulating the topology:
 - Cannot employ control technique.
 - New nodes may offer new opportunities to improve the overlay topology.
 - Allow nodes to replace sub-optimal links by better links.
 - Approach can be used to improve the overlay for different criteria.

- Employed technique: **Bias**.
- Generic approach: Companion oracle tags overlay links with *costs*.
- X-BOT strives to minimize the overlay cost.
- Some minimal coordination is essential:
 - Protect relevant properties of an unstructured overlay (e.g., connectivity).
 - Rely on 4-node coordination technique to bias the overlay.
 - X-BOT also includes other mechanisms to protect relevant overlay properties.

X-BOT

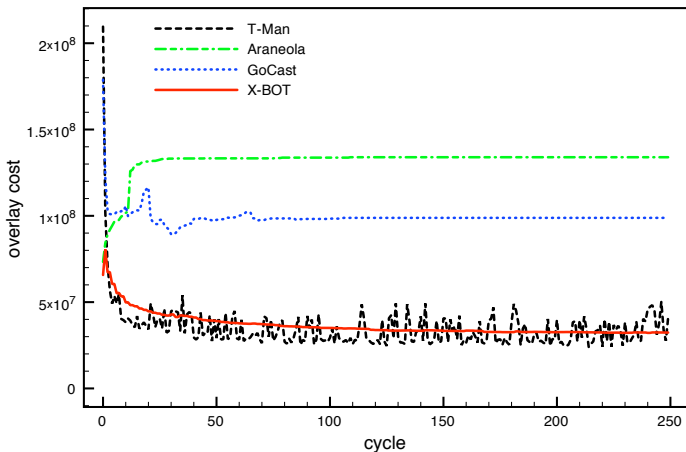
- Employed technique: **Bias**.
- Generic approach: Companion oracle tags overlay links with *costs*.
- X-BOT strives to minimize the overlay cost.
- Some minimal coordination is essential:
 - Protect relevant properties of an unstructured overlay (e.g., connectivity).
 - Rely on 4-node coordination technique to bias the overlay.
 - X-BOT also includes other mechanisms to protect relevant overlay properties.

X-BOT

- Employed technique: **Bias**.
- Generic approach: Companion oracle tags overlay links with *costs*.
- X-BOT strives to minimize the overlay cost.
- Some minimal coordination is essential:
 - Protect relevant properties of an unstructured overlay (e.g., connectivity).
 - Rely on 4-node coordination technique to bias the overlay.
 - X-BOT also includes other mechanisms to protect relevant overlay properties.

X-BOT

Main Results: Overlay Cost



X-BOT

Main Results: Broadcast Latency & Reliability

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

	Gossip-based Broadcast	
	Latency (ms)	Reliability (%)
Araneola	3517.0	100.00000
GoCast	2108.00	99,99996
T-Man	2545.2	13.80600
X-BOT	1879.8	100.00000

X-BOT

Main Results: Broadcast Latency

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

	Inet-3.0 Scenario	
	Latency (ms)	Reliability (%)
Araneola	3517.0	100.00000
GoCast	2108.00	99,99996
T-Man	2545.2	13.80600
X-BOT	1879.8	100.00000

X-BOT

Summary

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

- X-BOT, based on the bias technique operating at the overlay network layer.
- Bias technique allows to achieve improved overlay topologies that can better match the requirements of services executing on top of them.
- If a minimal amount of coordination exists among nodes, biasing can be achieved without compromising relevant overlay properties.

X-BOT

Summary

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

- X-BOT, based on the bias technique operating at the overlay network layer.
- Bias technique allows to achieve improved overlay topologies that can better match the requirements of services executing on top of them.
- If a minimal amount of coordination exists among nodes, biasing can be achieved without compromising relevant overlay properties.

Bias the Topology

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

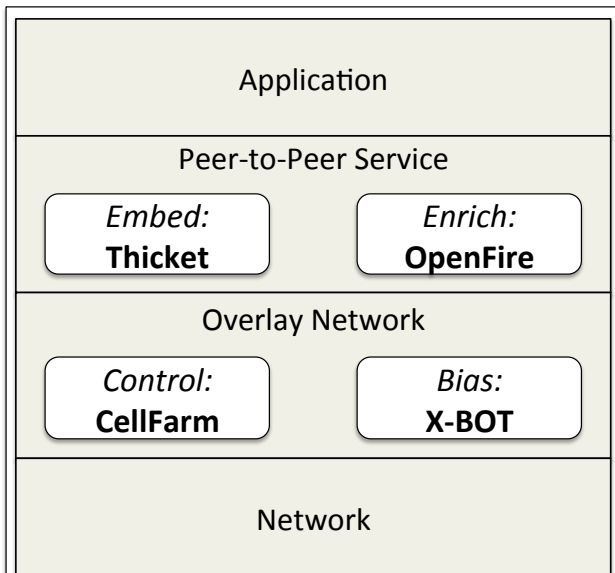
X-BOT

Thicket

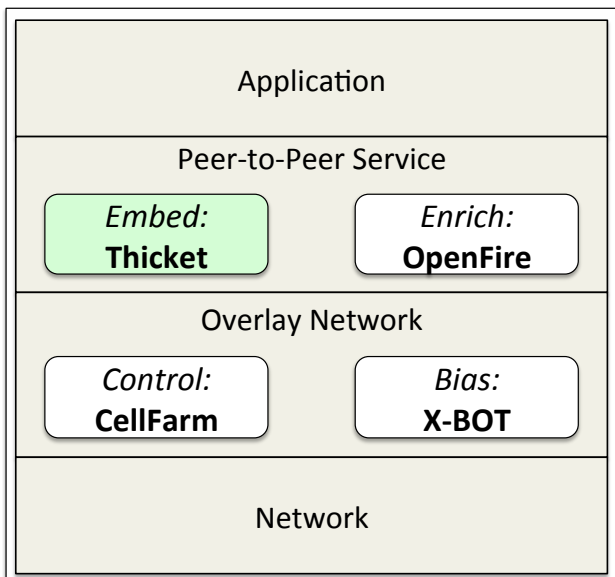
OpenFire

Conclusions

Publications



Embed the Topology



Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

Thicket

- Goal: Support efficient and robust data streaming:
 - Efficient: Rely on spanning tree.
 - Robust: Multiple spanning trees.
 - Load distribution: Multiple interior-node disjoint trees.
- Efficient spanning tree topologies should consider feedback of streaming service:
 - Cannot employ a technique at the overlay layer.
 - Building independent trees is not an option.
 - Use a single unstructured overlay networks as a base.
 - Embed several spanning trees over that overlay in a coordinated fashion.

Thicket

- Goal: Support efficient and robust data streaming:
 - Efficient: Rely on spanning tree.
 - Robust: Multiple spanning trees.
 - Load distribution: Multiple interior-node disjoint trees.
- Efficient spanning tree topologies should consider feedback of streaming service:
 - Cannot employ a technique at the overlay layer.
 - Building independent trees is not an option.
 - Use a single unstructured overlay networks as a base.
 - Embed several spanning trees over that overlay in a coordinated fashion.

- Employed technique: **Embed**.
- Coordination is essential.
 - Overlay links used to embed a tree should consider the existence of other trees.
 - Trees should be able to recover from partitions efficiently.
 - The maximum forwarding load imposed over nodes should be limited.
- Multiples trees allow to transmit redundant data:
 - e.g., Network coding techniques.
 - Sustain the data stream even if one tree becomes temporarily partitioned.

Thicket

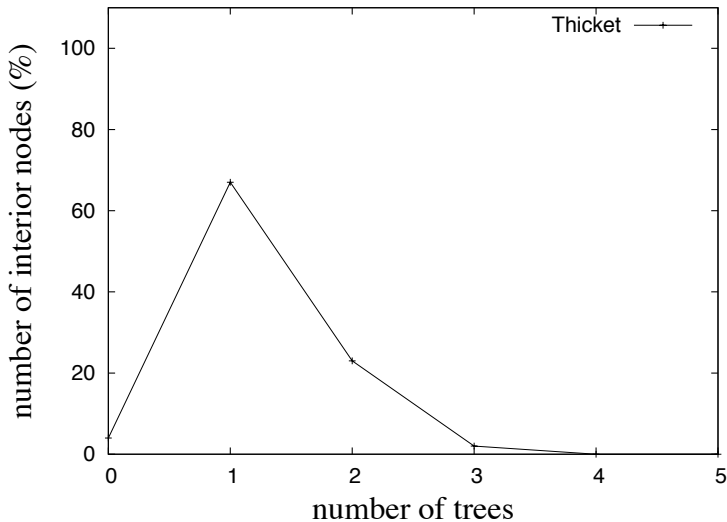
- Employed technique: **Embed**.
- Coordination is essential.
 - Overlay links used to embed a tree should consider the existence of other trees.
 - Trees should be able to recover from partitions efficiently.
 - The maximum forwarding load imposed over nodes should be limited.
- Multiples trees allow to transmit redundant data:
 - e.g., Network coding techniques.
 - Sustain the data stream even if one tree becomes temporarily partitioned.

Thicket

- Employed technique: **Embed**.
- Coordination is essential.
 - Overlay links used to embed a tree should consider the existence of other trees.
 - Trees should be able to recover from partitions efficiently.
 - The maximum forwarding load imposed over nodes should be limited.
- Multiples trees allow to transmit redundant data:
 - e.g., Network coding techniques.
 - Sustain the data stream even if one tree becomes temporarily partitioned.

Thicket

Main Results: K-interior node distribution (PlanetLab)



Thicket

Main Results: Streaming service robustness in face of targeted node failures

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

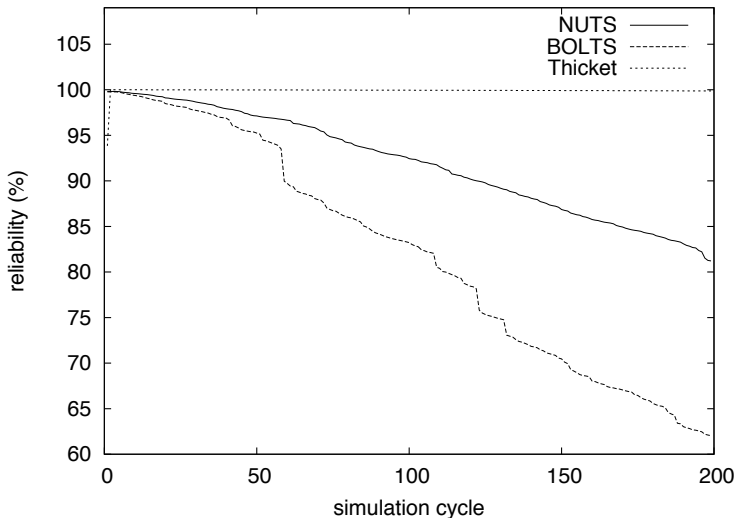
X-BOT

Thicket

OpenFire

Conclusions

Publications



Thicket

Summary

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

- Thicket, based on the embed technique operating at the peer-to-peer service layer.
- Embed technique allows to efficiently embed interior-node disjoint trees over a single unstructured overlay.
- Combines the best of gossip-based and tree-based dissemination approaches.
- Improved the usage of available resources when compared with existing solutions.

Thicket

Summary

- Thicket, based on the embed technique operating at the peer-to-peer service layer.
- Embed technique allows to efficiently embed interior-node disjoint trees over a single unstructured overlay.
- Combines the best of gossip-based and tree-based dissemination approaches.
- Improved the usage of available resources when compared with existing solutions.

Embed the Topology

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

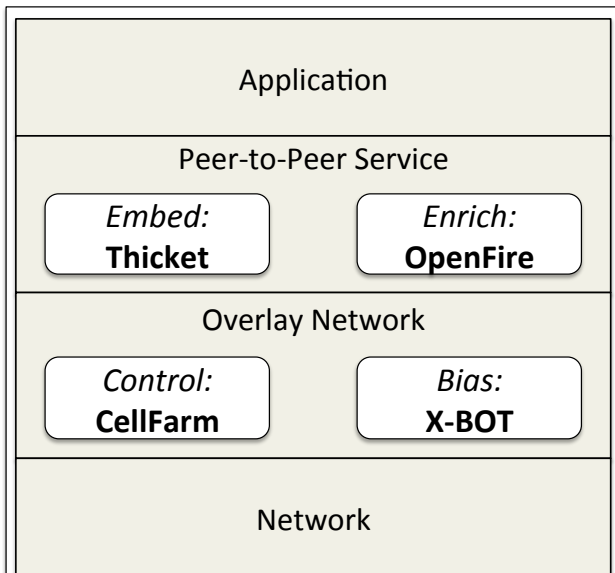
X-BOT

Thicket

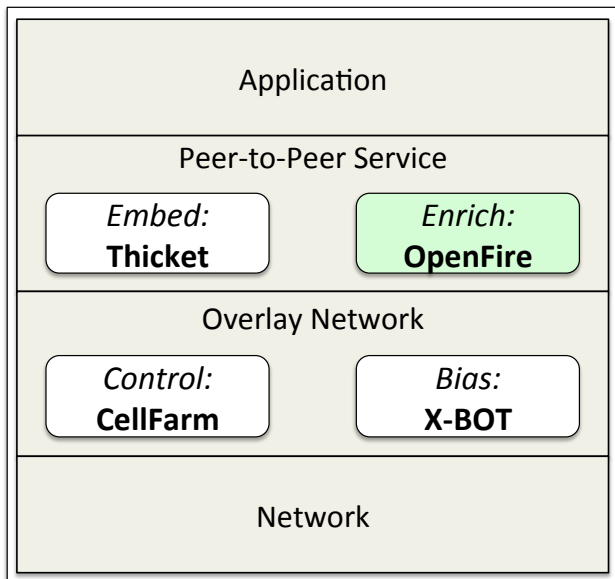
OpenFire

Conclusions

Publications



Enrich the Topology



- Goal: Deal with the presence of Firewalls and NAT boxes.
 - Firewalls and NAT boxes make nodes unreachable.
 - This can produce an unbalanced behavior in P2P services (e.g, rumor mongering protocols).
 - Most nodes interact only with public nodes in the Internet.
 - Those nodes can easily become resource exhausted.
- Circumvent Firewalls and NAT boxes:
 - Taking into consideration communication patterns at the P2P service layer.
 - Keep connections established by *confined* nodes open to be used later.

- Goal: Deal with the presence of Firewalls and NAT boxes.
 - Firewalls and NAT boxes make nodes unreachable.
 - This can produce an unbalanced behavior in P2P services (e.g, rumor mongering protocols).
 - Most nodes interact only with public nodes in the Internet.
 - Those nodes can easily become resource exhausted.
- Circumvent Firewalls and NAT boxes:
 - Taking into consideration communication patterns at the P2P service layer.
 - Keep connections established by *confined* nodes open to be used later.

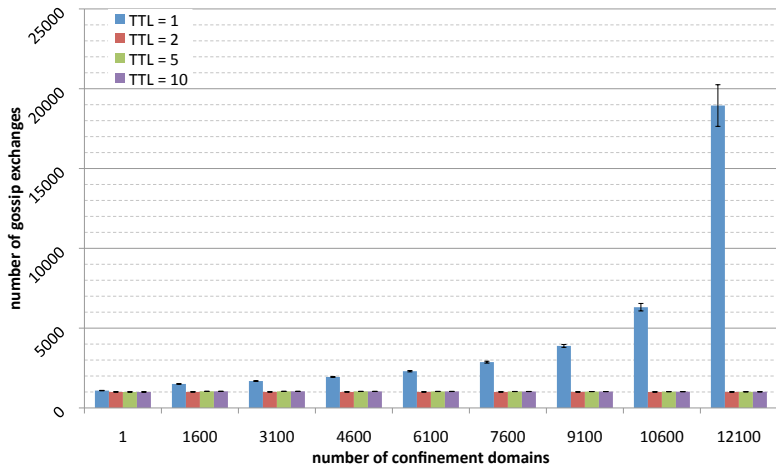
- Employed technique: **Enrich**.
- Use a single temporary overlay link.
 - Whenever a node receives a request from a peer it updates its temporary overlay link.
 - Nodes only process a (rumor mongering) request for each request they sent themselves.
 - Additional received requests are forwarded across the temporary connection.
- This solution is interesting:
 - Can easily ensure balanced processing of messages.
 - Nodes are not required to be aware of Firewalls and NATs explicitly.

- Employed technique: **Enrich**.
- Use a single temporary overlay link.
 - Whenever a node receives a request from a peer it updates its temporary overlay link.
 - Nodes only process a (rumor mongering) request for each request they sent themselves.
 - Additional received requests are forwarded across the temporary connection.
- This solution is interesting:
 - Can easily ensure balanced processing of messages.
 - Nodes are not required to be aware of Firewalls and NATs explicitly.

- Employed technique: **Enrich**.
- Use a single temporary overlay link.
 - Whenever a node receives a request from a peer it updates its temporary overlay link.
 - Nodes only process a (rumor mongering) request for each request they sent themselves.
 - Additional received requests are forwarded across the temporary connection.
- This solution is interesting:
 - Can easily ensure balanced processing of messages.
 - Nodes are not required to be aware of Firewalls and NATs explicitly.

OpenFire

Main Results: Maximum gossip exchanges per node



OpenFire

Main Results: Maximum latency

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

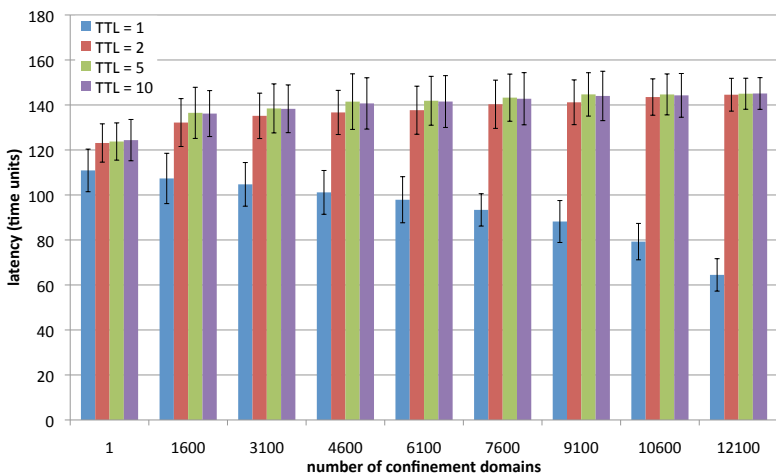
X-BOT

Thicket

OpenFire

Conclusions

Publications



OpenFire

Summary

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

- OpenFire, based on the enrich technique operating at the peer-to-peer service layer.
- Enrich technique allows to overcome some of the challenges introduced by Firewalls and NAT boxes.

OpenFire

Summary

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

- OpenFire, based on the enrich technique operating at the peer-to-peer service layer.
- Enrich technique allows to overcome some of the challenges introduced by Firewalls and NAT boxes.

Roadmap

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

1 Introduction

2 Overview

3 CellFarm

4 X-BOT

5 Thicket

6 OpenFire

7 Conclusions

Conclusions & Future Research Directions

Conclusions

- 4 techniques to manage the topology of unstructured overlay networks.
- Imbuing some relaxed form of structure.
- Protecting the relevant properties of unstructured overlays:
 - Low overhead.
 - Robustness to churn scenarios.

Conclusions & Future Research Directions

Conclusions

- 4 techniques to manage the topology of unstructured overlay networks.
- Imbuing some relaxed form of structure.
- Protecting the relevant properties of unstructured overlays:
 - Low overhead.
 - Robustness to churn scenarios.

Conclusions & Future Research Directions

Conclusions

- At the overlay network layer:
 - Control (CellFarm).
 - Bias (X-BOT).
- At the peer-to-peer service layer:
 - Embed (Thicket).
 - Enrich (OpenFire).

Conclusions & Future Research Directions

Conclusions

- In the thesis:
 - Discusses the design of each solution in detail.
 - Validates all proposed solutions.
 - Experimentally evaluate their impact over particular case studies.
- Summary: *The thesis has show and studied how to add some form structure to unstructured overlay benefiting the operation of peer-to-peer services.*

Conclusions & Future Research Directions

Conclusions

- In the thesis:
 - Discusses the design of each solution in detail.
 - Validates all proposed solutions.
 - Experimentally evaluate their impact over particular case studies.
- Summary: *The thesis has show and studied how to add some form structure to unstructured overlay benefiting the operation of peer-to-peer services.*

Conclusions & Future Research Directions

Future Research Directions

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

Improving volunteer parallel computing platforms

- New decentralized volunteer computing infrastructures:
 - For instance based in solutions similar to CellFarm and X-BOT.
 - Offer the opportunity to support more complex parallel programming models (e.g, MapReduce).
- Devise a new class of robust and flexible DHT overlay networks based on the X-BOT design.

Conclusions & Future Research Directions

Future Research Directions

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

Improving volunteer parallel computing platforms

- New decentralized volunteer computing infrastructures:
 - For instance based in solutions similar to CellFarm and X-BOT.
 - Offer the opportunity to support more complex parallel programming models (e.g, MapReduce).
- Devise a new class of robust and flexible DHT overlay networks based on the X-BOT design.

Conclusions & Future Research Directions

Future Research Directions

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

User-centric platform for social applications

- Offer a decentralized platform to support a persistent and dynamic social network.
- Providing the mechanisms for designing new collaborative applications over the social network that can operate in a more decentralized fashion.

Conclusions & Future Research Directions

Future Research Directions

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

User-centric platform for social applications

- Offer a decentralized platform to support a persistent and dynamic social network.
- Providing the mechanisms for designing new collaborative applications over the social network that can operate in a more decentralized fashion.

On the Structure of Unstructured Overlay Networks (fast abstract). *J. Leitão, J. Pereira and L. Rodrigues. In Supplement of the 38th Annual IEEE/IFIP International Conference on Dependable Systems and Networks, Anchorage, Alaska, USA, June, 2008.*

Overnesia: a Robust Overlay Network for Virtual Super-Peers.
João Leitão and Luís Rodrigues. Technical Report 36/2009, INESC-ID, July 2009 (Available in: <http://www.inesc-id.pt/ficheiros/publicacoes/5510.pdf>).

X-BOT: A Protocol for Resilient Optimization of Unstructured Overlays. *J. Leitão, J. P. Marques, J. Pereira and L. Rodrigues. Proceedings of the 28th IEEE International Symposium on Reliable Distributed Systems, Niagara Falls, New York, U.S.A., Sep, 2009. pp. 236–245.*

On Adding Structure to Unstructured Overlay Networks. *J. Leitão, N. Carvalho, J. Pereira, R. Oliveira, and L. Rodrigues. In Handbook of Peer-to-Peer Networking, X. Shen, H. Yu, J. Buford, M. Akon (Eds.), Springer 2010. pp. 327-365. ISBN: 978-0-387-09750-3.*

Balancing Gossip Exchanges in Networks with Firewalls. *J. Leitão, R. van Renesse and L. Rodrigues. Proceedings of the 9th International Workshop on Peer-to-Peer Systems (IPTPS '10), San Jose, CA, USA, 27 April, 2010.*

Thicket: A Protocol for Building and Maintaining Multiple Trees in a P2P Overlay. *M. Ferreira, J. Leitão, and L. Rodrigues. Proceedings of the 29th IEEE Symposium on Reliable Distributed Systems (SRDS), New Delhi, India, 31 October-3 November 2010.*

X-BOT: A Protocol for Resilient Optimization of Unstructured Overlay Networks. *J. Leitão, J. P. Marques, J. Pereira, and L. Rodrigues. IEEE Transactions on Parallel and Distributed Systems (Published online January 2012).*

Gossip-based Interior-Node-Disjoint Trees. *J. Leitão, M. Ferreira, J. Pereira, and L. Rodrigues. IEEE Transactions on Parallel and Distributed Systems (Submitted).*

Topology
Management
for
Unstructured
Overlay
Networks

João Leitão

Introduction

Overview

CellFarm

X-BOT

Thicket

OpenFire

Conclusions

Publications

Thanks for your attention.