Creating an Adaptive Network of Hubs Using Schelling's Model

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Contents

- **Peer-to-Peer**
- Schelling's Work
- Algorithm
- Case Study
- Simulations

Peer-to-Peer

- Distributed systems without any central control, where all the nodes are equivalent in functionality.
- Overlay Network Topology.
- Lack of central control makes it difficult to develop efficient algorithms for P2P networks.

Peer-to-Peer (cont'd)

- Suboptimal grouping of peers.
- Adapting topology to satisfy certain criteria when peers leave or join the network.
- Work presented is applicable for decentralized unstructured networks only.

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Schelling's Work

- Thomas Schelling is an American Economist.
- In 1960, he suggested that segregated neighborhood is an emergent behavior caused by the desire of people to have a very small percentage of similar neighbors.
- No central control.
- Lack of global picture.
- Variations possible.

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Algorithm

TopologyAdapter
#m_isNodeSatisfied: boolean
+manageTopology(): void ***#calculateSatisfaction(): boolean*** ***#executeAdaptation(): boolean*** ***+delayBeforeNextAdaptation(): int***

```
void manageTopology() {
  while (1) {
    m_isNodeSatisfied =
         calculateSatisfaction();
    if (!m_isNodeSatisfied)
    {
        m_adaptationResult =
              executeAdaptation();
    }
    sleep(delayBeforeNextAdaptation());
  }
}
```

• calculateSatisfaction() uses a **satisfaction criteria** to determine a peer’s satisfaction state.

• executeAdaptation is used to execute the **topology adaptation steps**.

Algorithm (cont'd)

Satisfaction Criteria	Topology Adaptation Steps
count(*same property*) * 100 / **count**(*all*) > PNSP where, PNSP is the desired percentage of neighbours with similar property.	*Step 1:* **drop**(**neighbour**(*different property*)) *Step 2:* **add**(**search**(*same bandwidth*))
Same as above	**drop**(**neighbour**(*different property*))

Two set of satisfaction criteria and topology adaptation steps that can be used to bring together peers with similar properties (e.g., bandwidth)

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An Adaptive Network of Hubs

- Super peers used to reduce bandwidth usage (e.g., KaZaA).
- Failure of super peers can be catastrophic.
- Ordinary peers are connected with each other and to more than one super-peer.

Adaptive Network of Hubs (cont'd)

Peer	Satisfaction Criteria	Topology Adaptation Steps

Hub	H_{max} > **count**(*hub*) and **count**(*hub*) != 0
	
	Where, H_{max} is the maximum number of hubs desired as neighbors.
		Step 1:
		if (**count**(*hub*) > H_{max})
		drop(**neighbor**(*hub*))
		Step 2:
		if (**count**(*hub*) == 0)
		add(**search**(*hub*))

Normal	**count**(*hubs*) > 0	*Step 1:* if (**count**(*all*) == *maxNeighbors*) **drop**(**neighbor**(*any*)) *Step 2:* **add**(**search**(*hub*))

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Simulations

```
Step 1:
   Peer p = newPeer(random() =< 0.9 ? “peer” : “hub”
Step 2:
   p.maxConnections = p.type == “hub” ? 20 : 5
Step 3:
  p.add(select(3))
```

- The algorithm on the left is used to create the random network on which the simulations are performed.
- Search operation is performed using a Depth First Search (DFS)

Simulations have been performed on :

- Static Overlay Network.
- Dynamic Overlay network with a a constant influx of peers.

Static Overlay Network

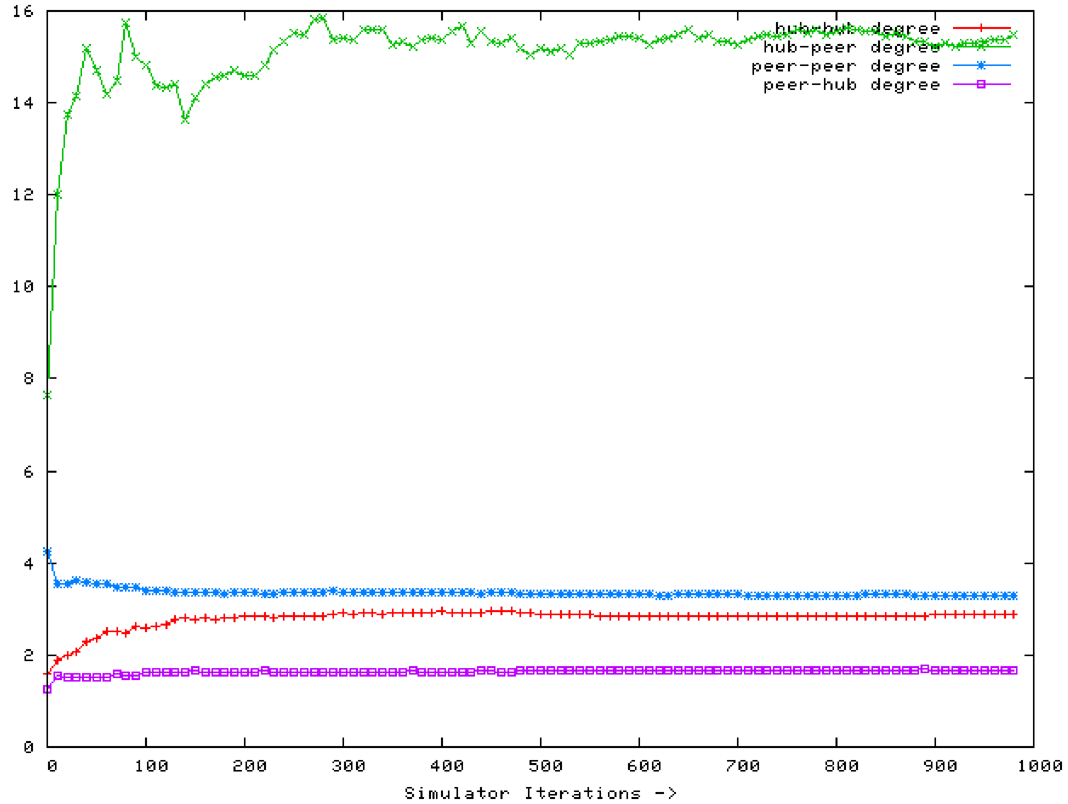
- Simulations done on four different random networks of 100, and 1000 peers each using H_{max} values from 1 and 10.
- A critical value of H max (called $H_{maxCritical}$) was observed below which all the peers are not satisfied.

Dynamic Overlay Network

- Simulations start with a small random network of 100 peers and 5 new peers are added every iteration till the number of nodes reaches 5000.

- Used a H_{max} value of 5.

Dynamic Overlay Network (cont'd)



H Set of hubs P Set of peers

$E_{H,H}$ Set of edges connecting two hubs

$E_{P,P}$ Set of edges connecting two peers

$E_{H,P}$ Set of edges connecting a hub and a peer

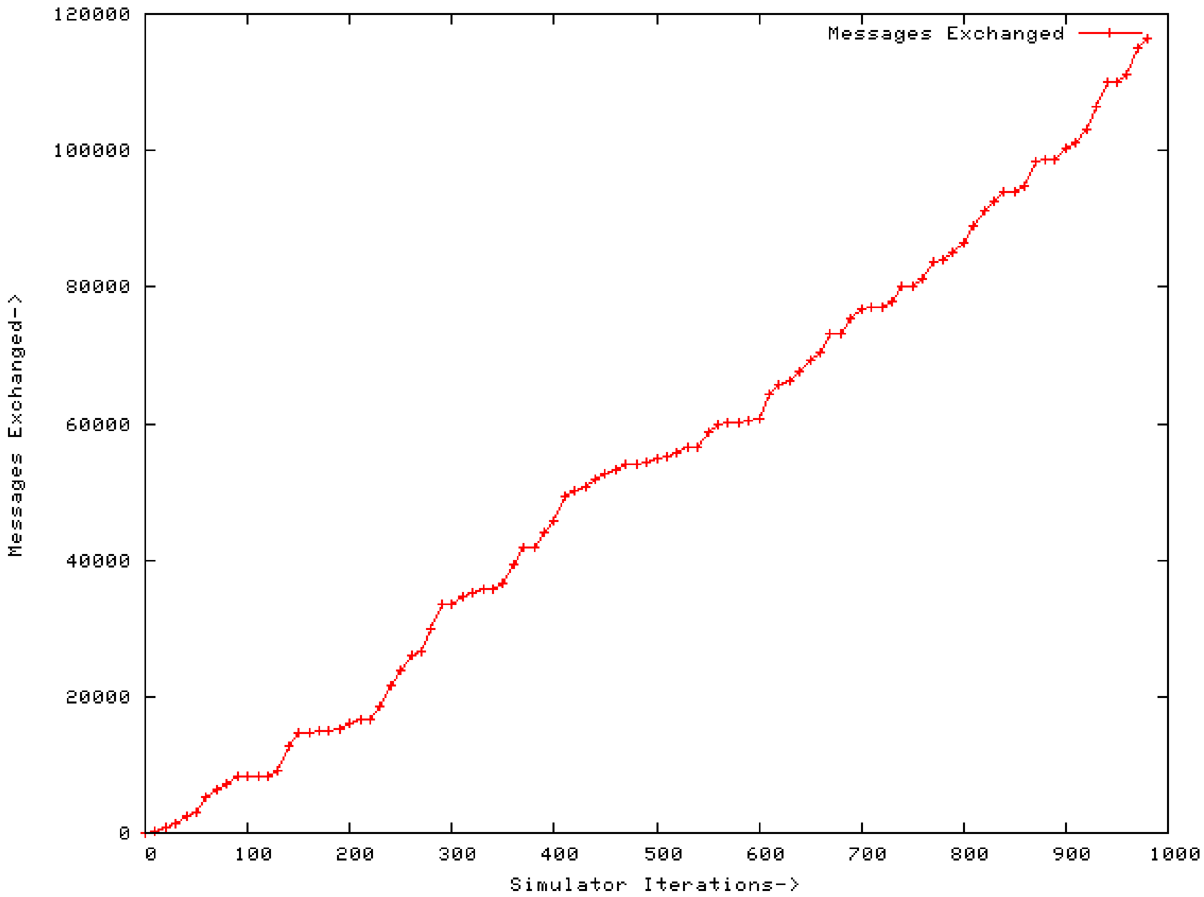
hub-hub degree = $|E_{H,H}| / |H|$

peer-peer degree = $|E_{P,P}| / |P|$

hub-peer degree = $|E_{H,P}| / |H|$

peer-hub degree = $|E_{H,P}| / |P|$

Dynamic Overlay Network (cont'd)



Conclusion

- Schelling’s Algorithm can be used for topology adaptation.

- An adaptive network of hubs can be created using a variation of the Schelling’s Algorithm.

Thank You!