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Effective Acquaintance Management for Collaborative Intrusion Detection Networks

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Roadmap

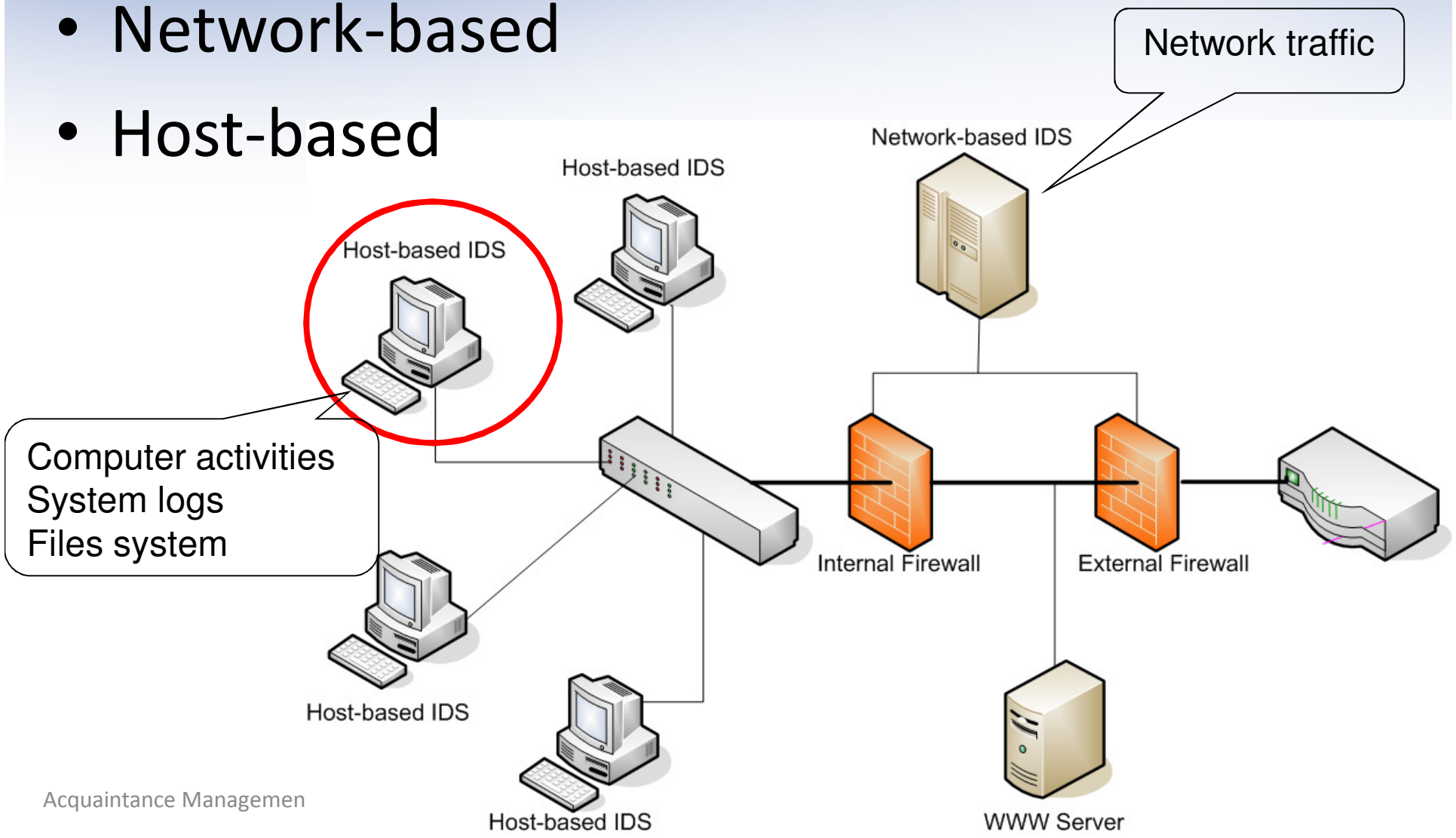
- Background
- Intrusion Detection and Collaboration
- Acquaintance Management
- Evaluation
- Conclusion

Network Intrusions

- Worms, Viruses, Malware
  - Storm worm (2007)
  - Conflicker (2008)
- Botnet
  - Zeus (2007-2010)
- Attack motivation
  - ID theft, Credit card , Privacy spying, Online account , Spamming, DoS, etc.

Intrusion Detection Systems

- Network-based
- Host-based

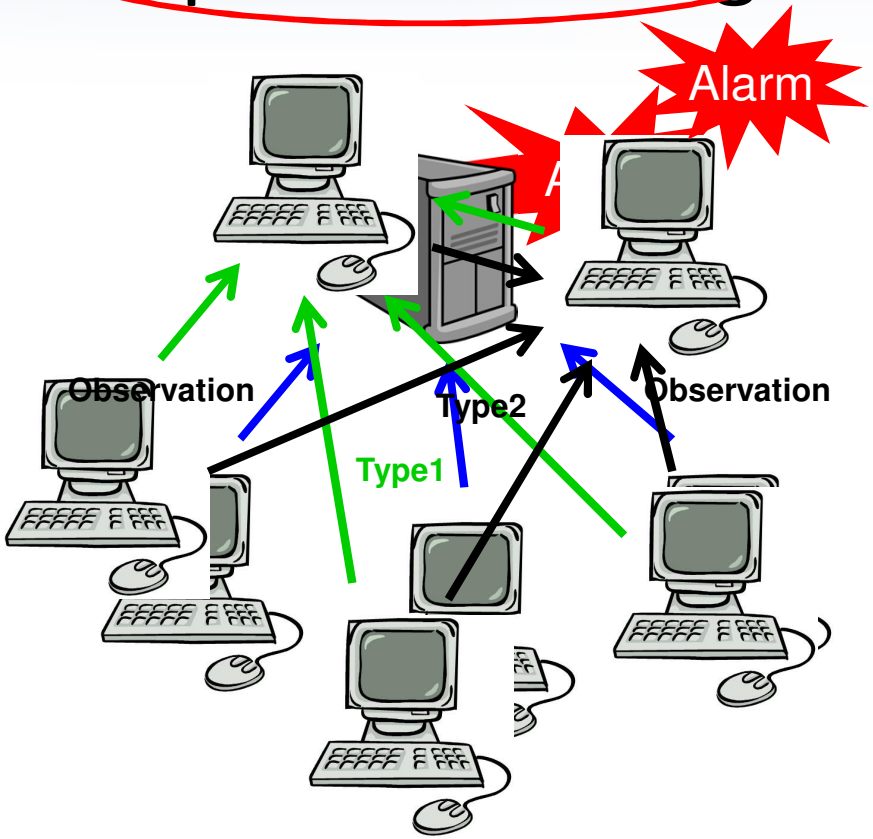


Host-based IDS (HIDS)

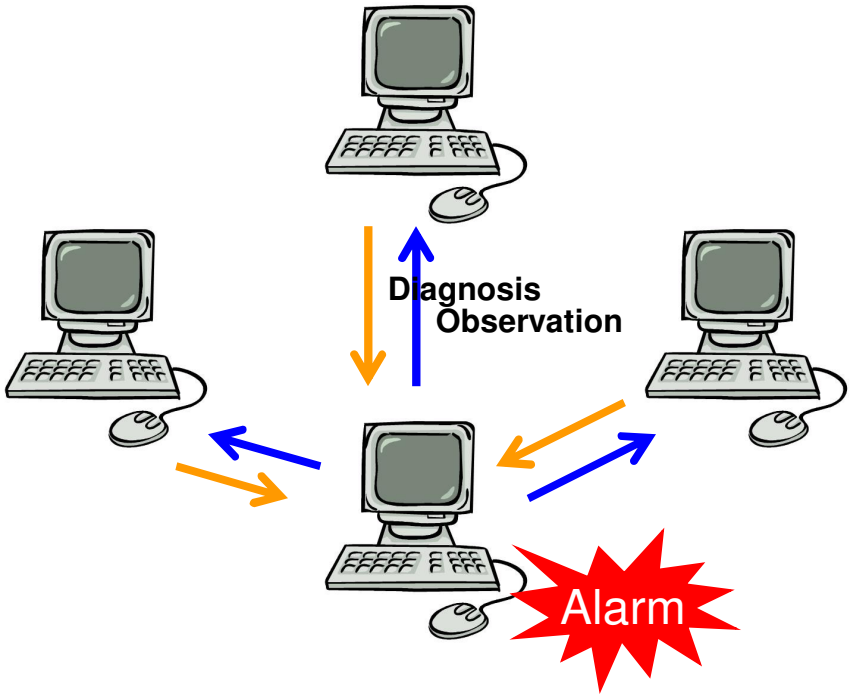
- Monitor computer activities, files, and compare against malicious patterns
  - Traditional HIDS such as OSSEC, Tripwire
  - Antivirus systems
- A single HIDS can be vulnerable to new attacks
  - Collaboration improves detection accuracy

Collaborative Intrusion Detection

- Information sharing (DShield, NetShield)
- Expertise sharing (Cloud-AV)



Information Sharing



Expertise Sharing

Who to collaborate with?

- Existing solutions
  - Fixed number
  - Fixed thresh-bar
- Our Contribution
  - An automatic acquaintance management
  - Cost efficient acquaintance selection

Our Approach

Step 1: Know your candidates

Step 2: Cost function modeling

Step 3: Consensus reaching

Know the Candidates

- Learn the quality of a candidate
  - False positive rate and True positive rate
  - Using test messages to gain experience
  - Bayesian learning

Cumulative evidences on false diagnosis

Cumulative evidences on true diagnosis

$$F \sim \frac{1}{B(\alpha,\beta)} x^{\alpha-1}(1-x)^{\beta-1}$$

Distribution of False Positive rate

Beta function

Cost Function Selection

- Cost on maintenance of collaborators
  - Increases with the number of collaborators
- Cost on false decisions
  - Cost of false positive and false negative decisions

$$C_{total} = M(\mathrm{A}) + R(\mathrm{A})$$

$$= C_m \mid \mathrm{A} \mid + \sum_{y \in \{0,1\}^{|\mathrm{A}|}} \min\{C_{fn}\pi_1 \prod_i T_i^{y_i}(1-T_i)^{1-y_i}, C_{fp}\pi_0 \prod_i F_i^{y_i}(1-F_i)^{1-y_i}\}$$

Maintenance cost

Cost on no alarm

Cost on raising alarm

Acquaintance Selection Algorithm

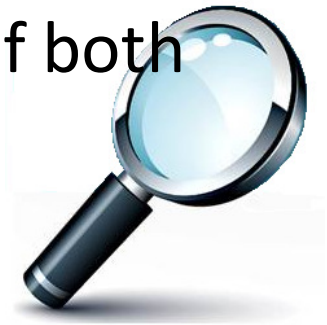
Algorithm1: Select the optimal acquaintance list with minimal cost

- Brute Force for a short candidate list and greedy for a long candidate list

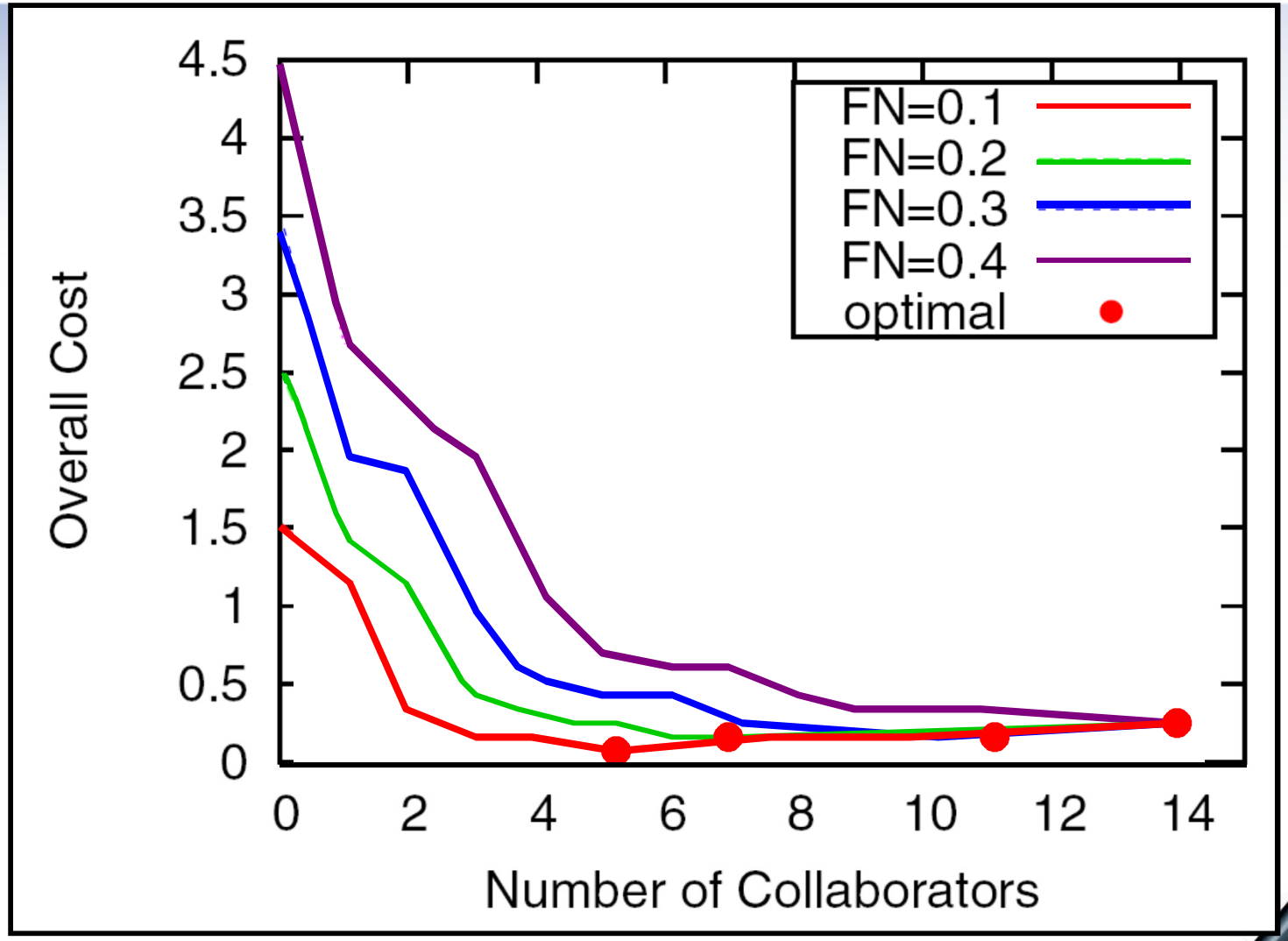
Algorithm2: Acquaintance management to find mutual agreement among nodes

- Probation period

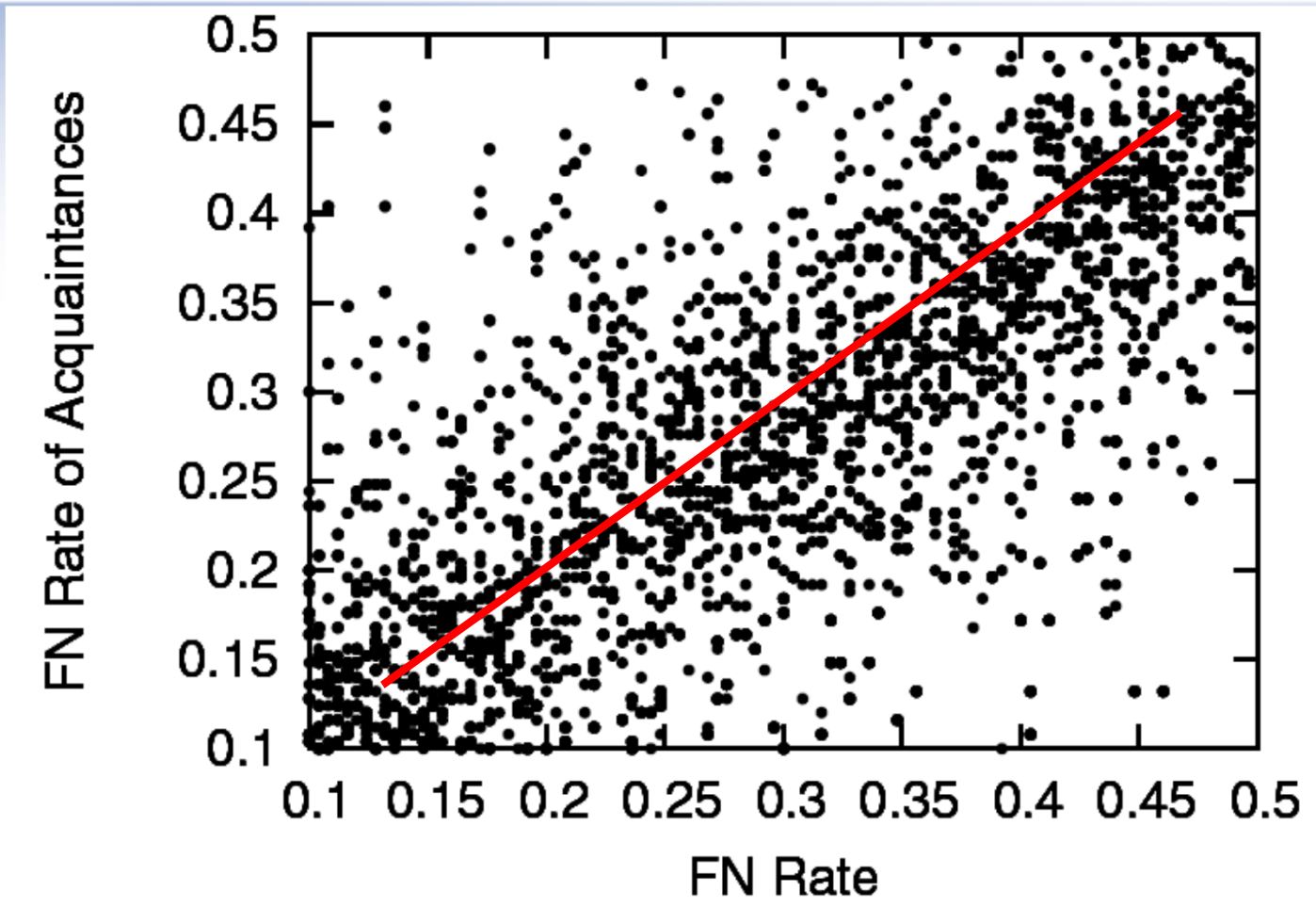
- Collaboration connection is established only if both peers select each other



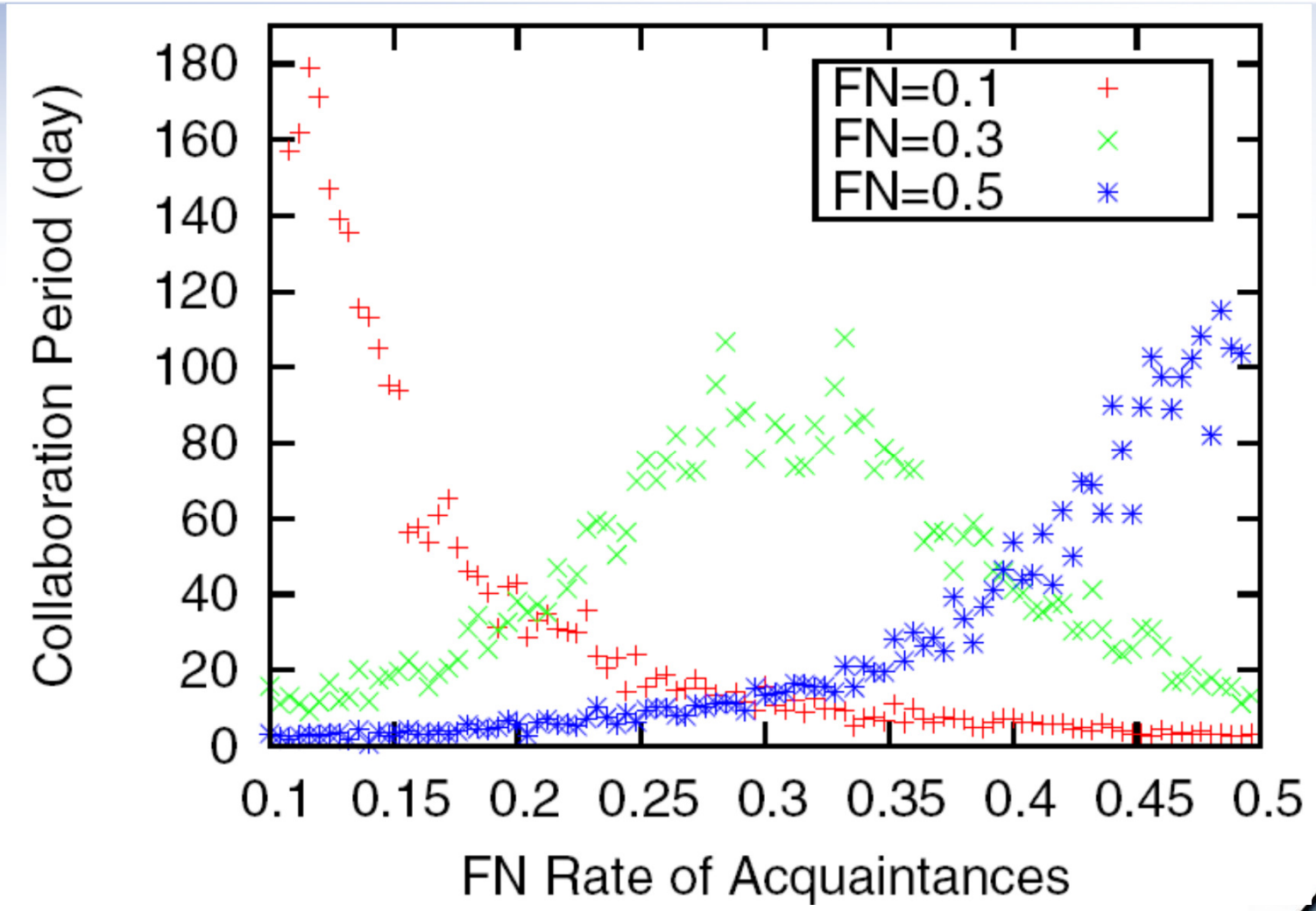
Evaluation - Cost Efficiency



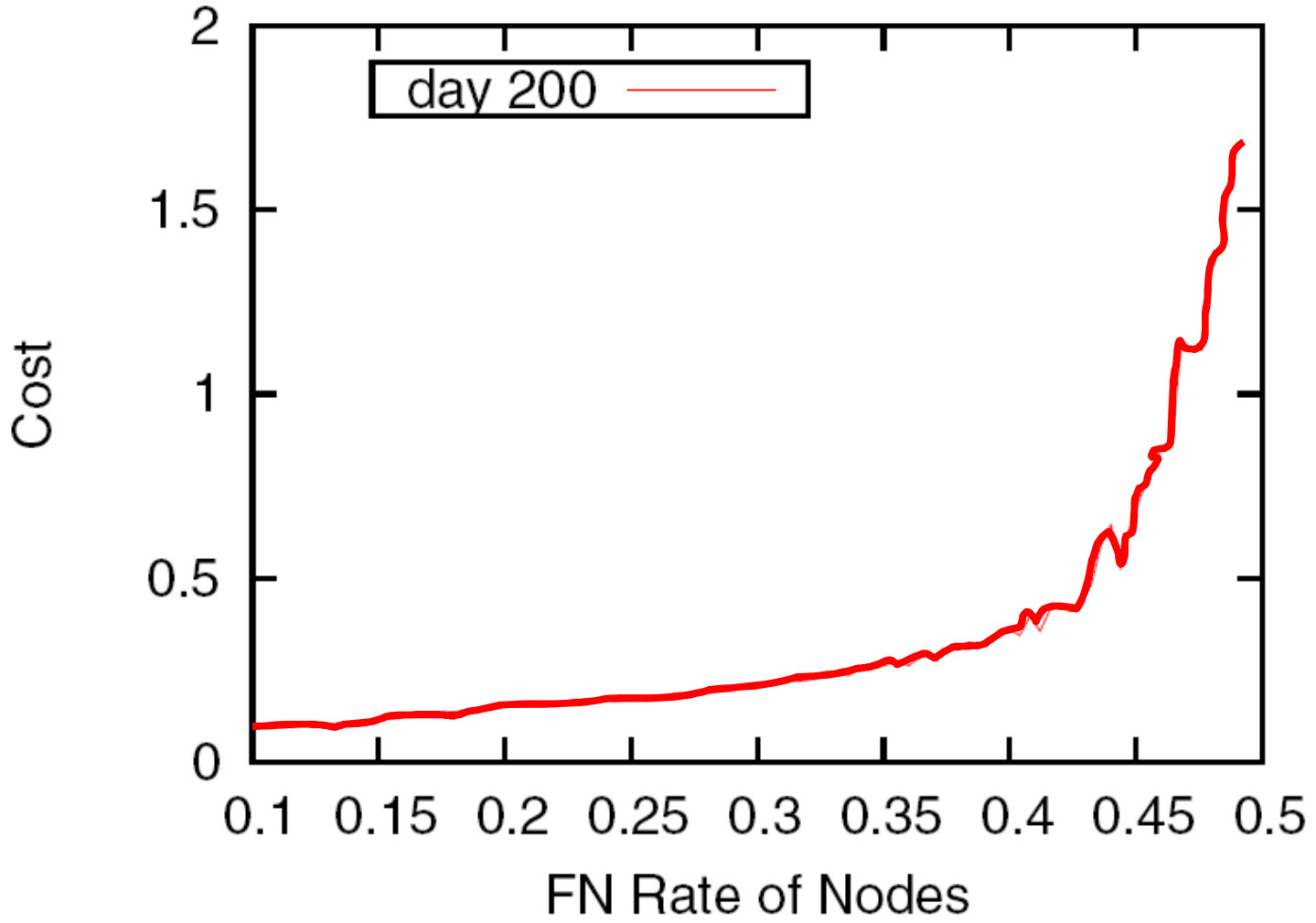
Evaluation - Convergence



Evaluation - Stability



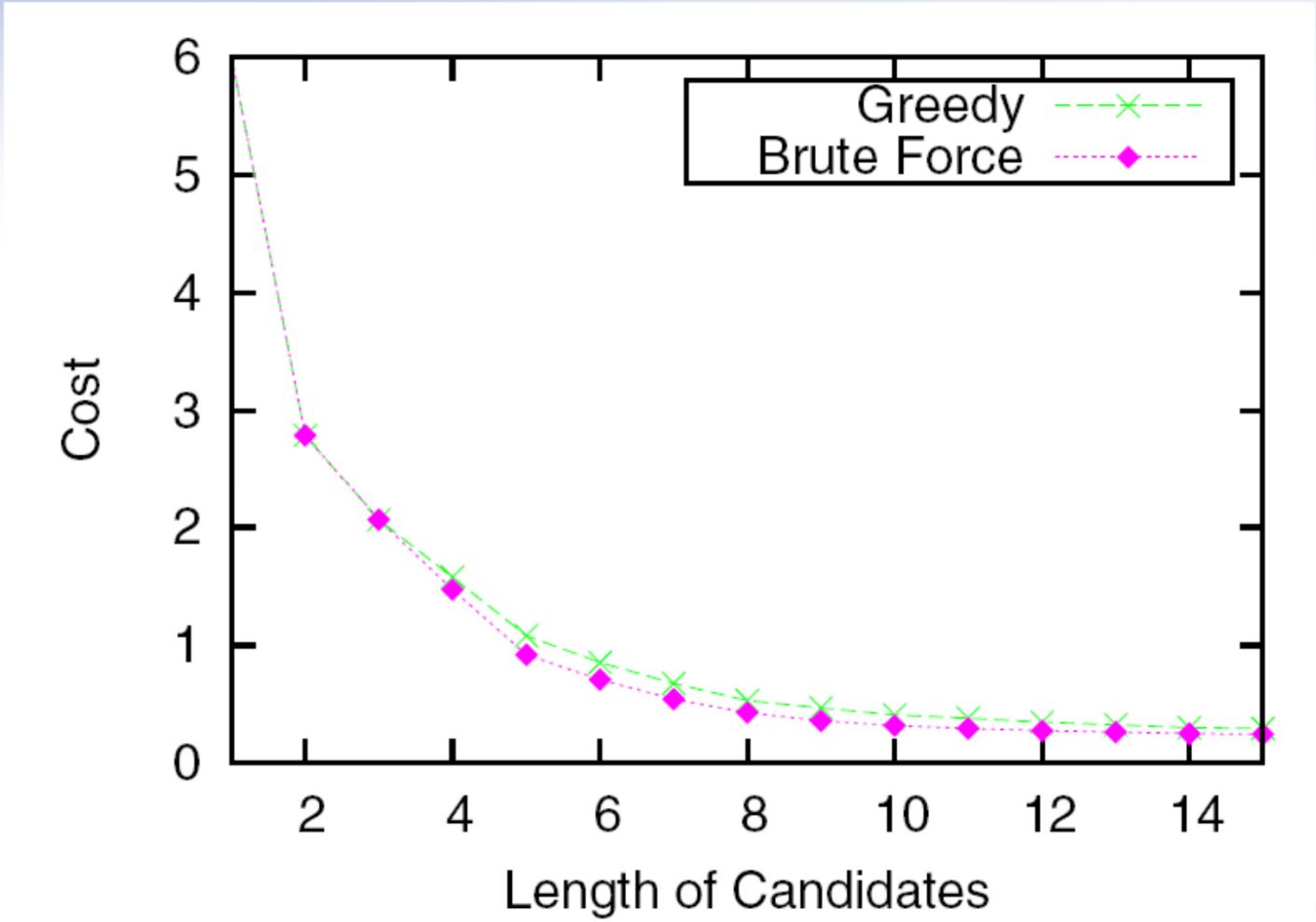
Evaluation – Incentive Compatibility

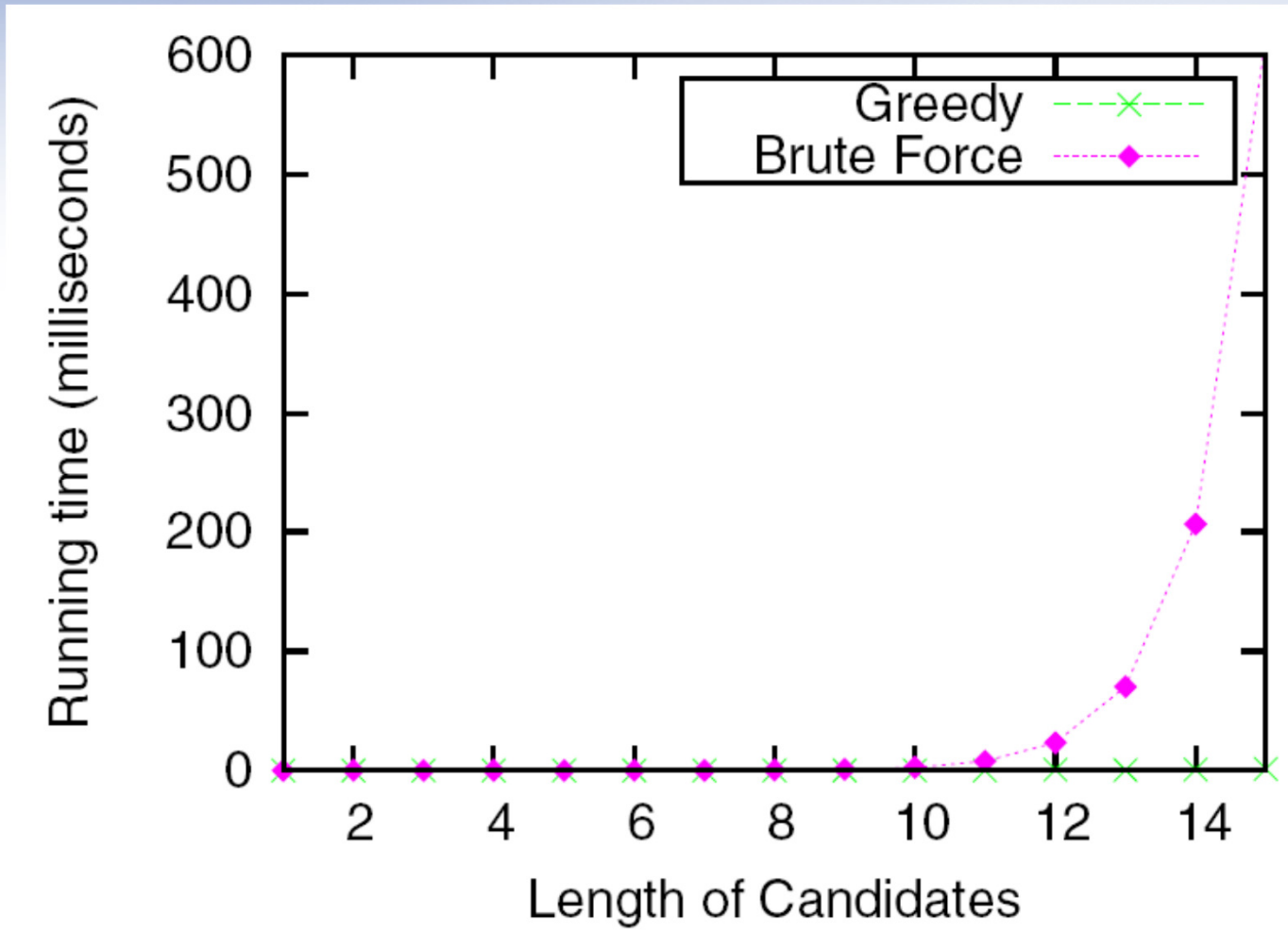


Conclusion

- Proposed an automatic acquaintance selection algorithm for collaborative intrusion detection networks
- Find optimal acquaintance list which leads to the minimum cost
- The acquaintance management algorithm holds the properties of efficiency, stability, and incentive-compatibility

Thank You


Greedy
Brute Force
Cost
Length of Candidates
0
1
2
3
4
5
6
2
4
6
8
10
12
14


Running time (milliseconds)
600
500
400
300
200
100
0
2
4
6
8
10
12
14
Length of Candidates
Greedy
Brute Force

Bayesian Learning

α: Cumulative evidences on false diagnosis
β: Cumulative evidences on true diagnosis