Challenges in Experimenting *with* Botnet Detection Systems

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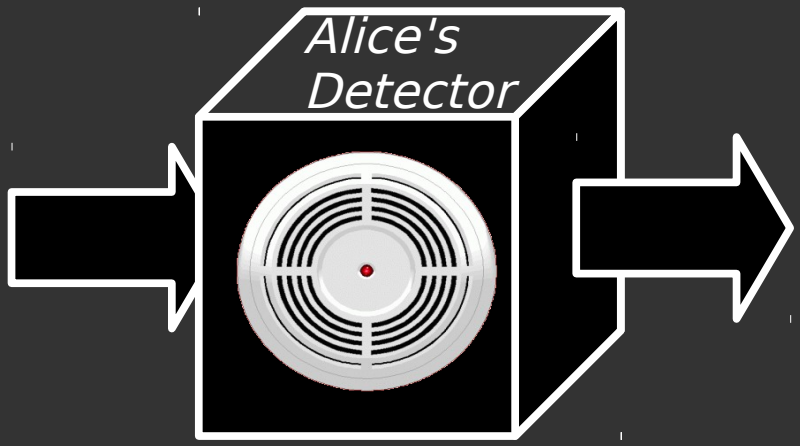
Alice has developed a new botnet detector!!!

What should the evaluation show?



Ideal

Alice deploys her detector live on her local network

- Alice is provided with a list of hosts that are botnet infected

Alice deploys her detector on various other networks

- Academic, Residential, Corporate, etc.

Alice records traces of each deployment

- Improve detector in the lab
- Readily available to other researchers

Realities

Production-ready deployment?

Ground truth of botnet infections?

Deployment on various networks?

Record trace and replay experiment?

Traces available to other researchers?

Taking a Step Back

so reporting performance statistics for the detector is very difficult.

As a result, researchers have relied on synthetic traces generated using an overlay methodology, where botnet traffic is mixed in with benign background traffic. This methodology can lead to a number of pitfalls, which could cause researchers to over- or underestimate the performance of their detector. A larger consequence of this methodology is that the background traces used in experiments are not easily shared due to privacy concerns, complicating basic scientific practices, such as performance comparisons and experimental reproducibility.

We observe that many of these issues are similar to those faced by researchers experimenting with large-scale distributed systems before the advent of PlanetLab. We propose a strawman system similar to PlanetLab that, through collaboration, could ameliorate many of the experimental challenges in botnet detection research. There are several research problems that would need to be addressed before such a system could become a reality, but there is evidence that these problems are solvable.

Acknowledgments

We thank Sean Peisert for shepherding this paper, and Jonathan Smith, Benjamin Pierce, Angelos Keromytis, Micah Sherr, and the anonymous reviewers for their helpful comments. This research was supported in part by ONR Grant N00014-09-1-0770 and by US National Science Foundation grants CNS-1054229 and CNS-1065060.

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Many Challenges

- Multiple Administrative Domains
- Network Heterogeneity
- Multimorbidity
- Privacy
- Controlled Environments
- Artifact Overfitting
- Botnet Overfitting
- Focus on Academic Networks
- Scale
- Mixing Artifacts
- False Postives & Negatives
- Repeatability
- Comparability
- Lack of Verification

privacy

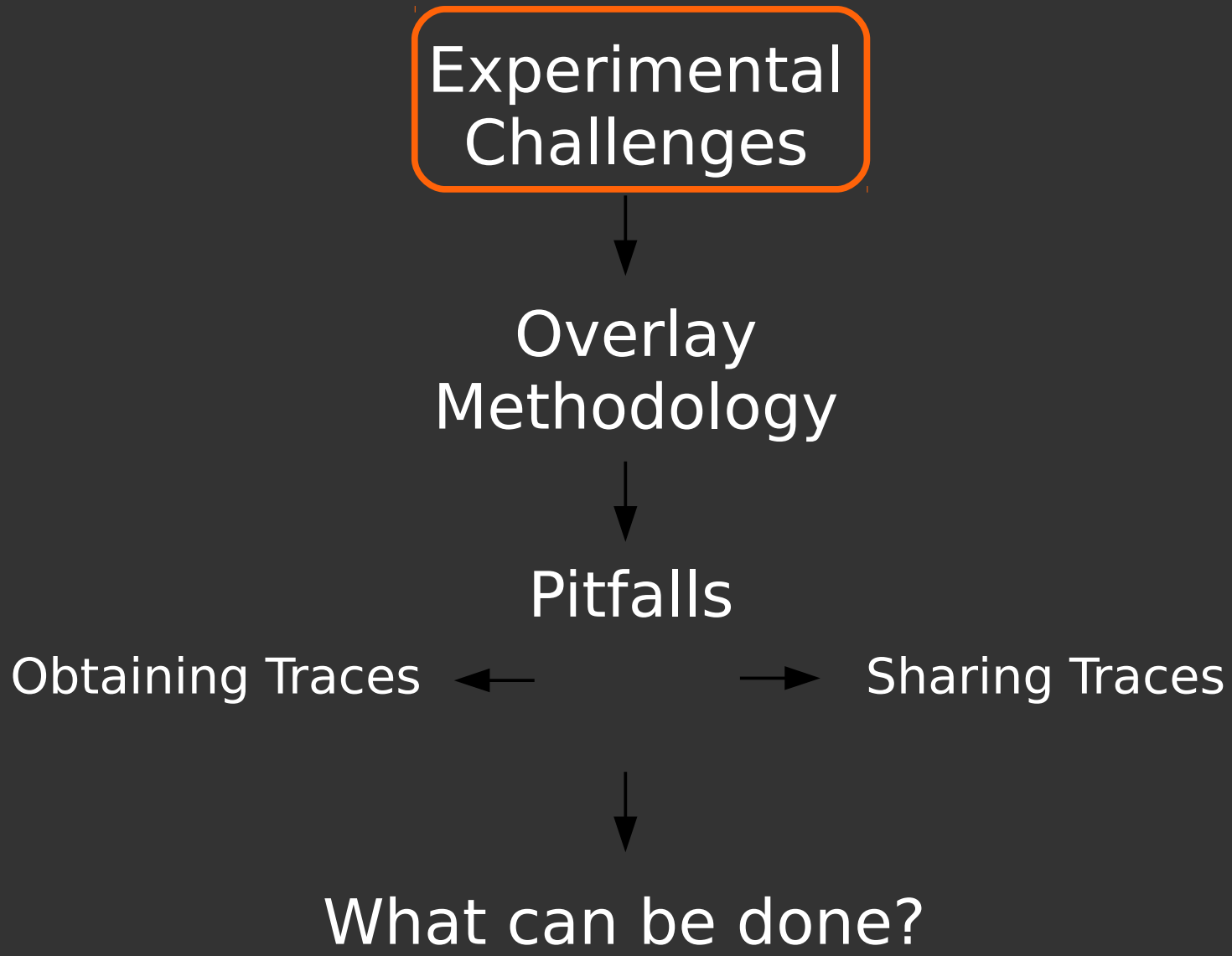
We have to worry about privacy, but the botnet authors don't!

Can we do better together?

Discussion/Topics/Questions

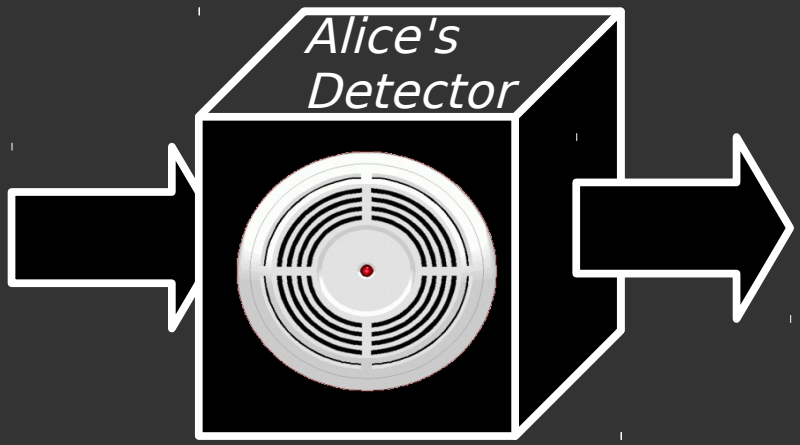
- Experimental Ideals vs. Realities
  - Not just botnet detectors ...
- Raw Materials of the Experiment
  - Sharing and Obtaining Traces
  - Botnet and Background Traces
- Can we do better via collaboration?

Presentation Outline



Alice has developed a new botnet detector!!!

What should the evaluation show?



Ideal vs. Reality

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- Alice is provided with list of hosts that are botnet infected

Production-ready deployment?

Ground truth of botnet infections?

Alice deploys her detector on other various networks

- Corporate, Residential, Corporate, etc.

Deployment on various networks?

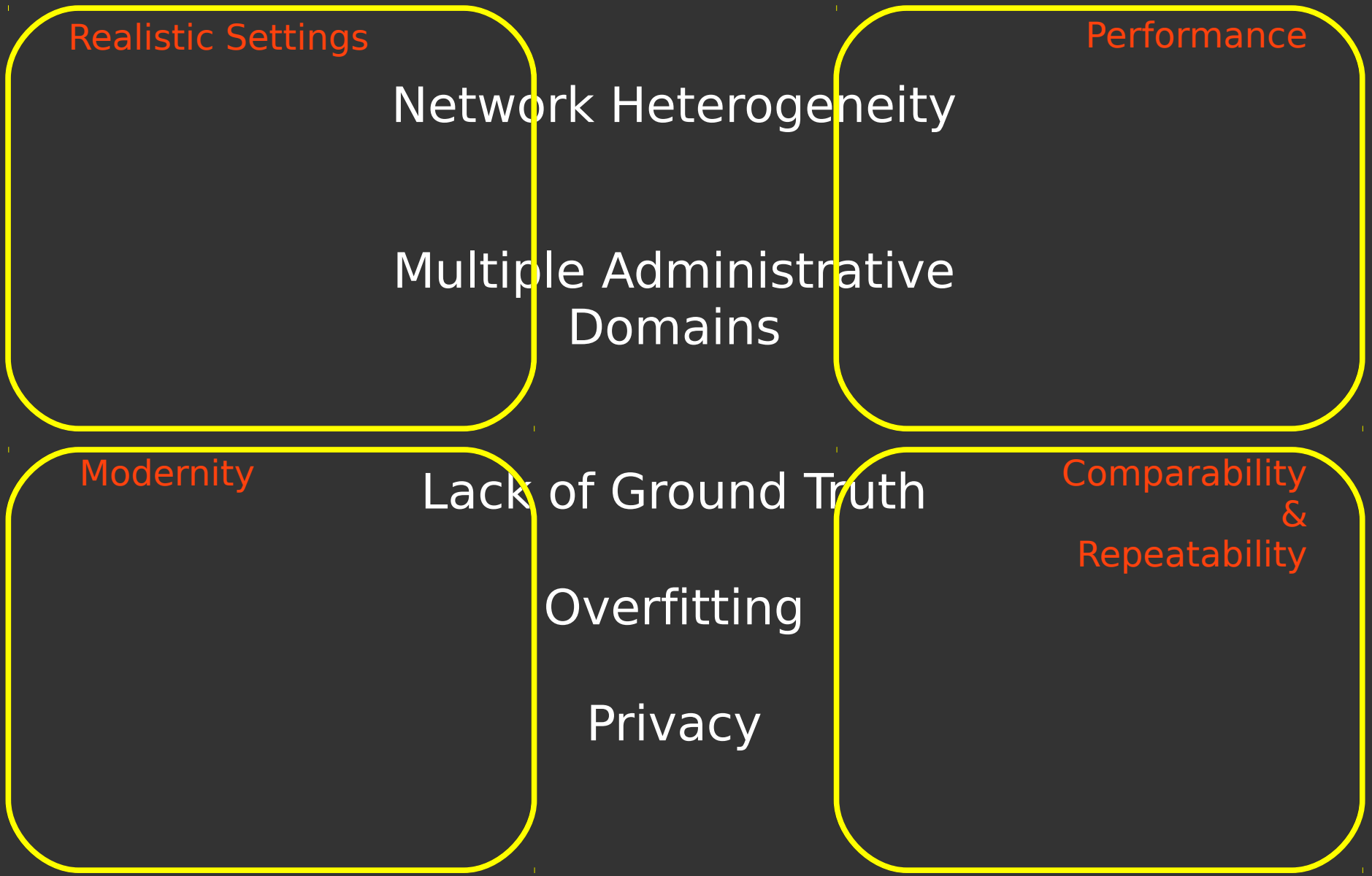
Alice records traces of each deployment

- Improve detector in the lab
- Readily available to other researchers

Record trace and replay experiment?

Traces available to other researchers?

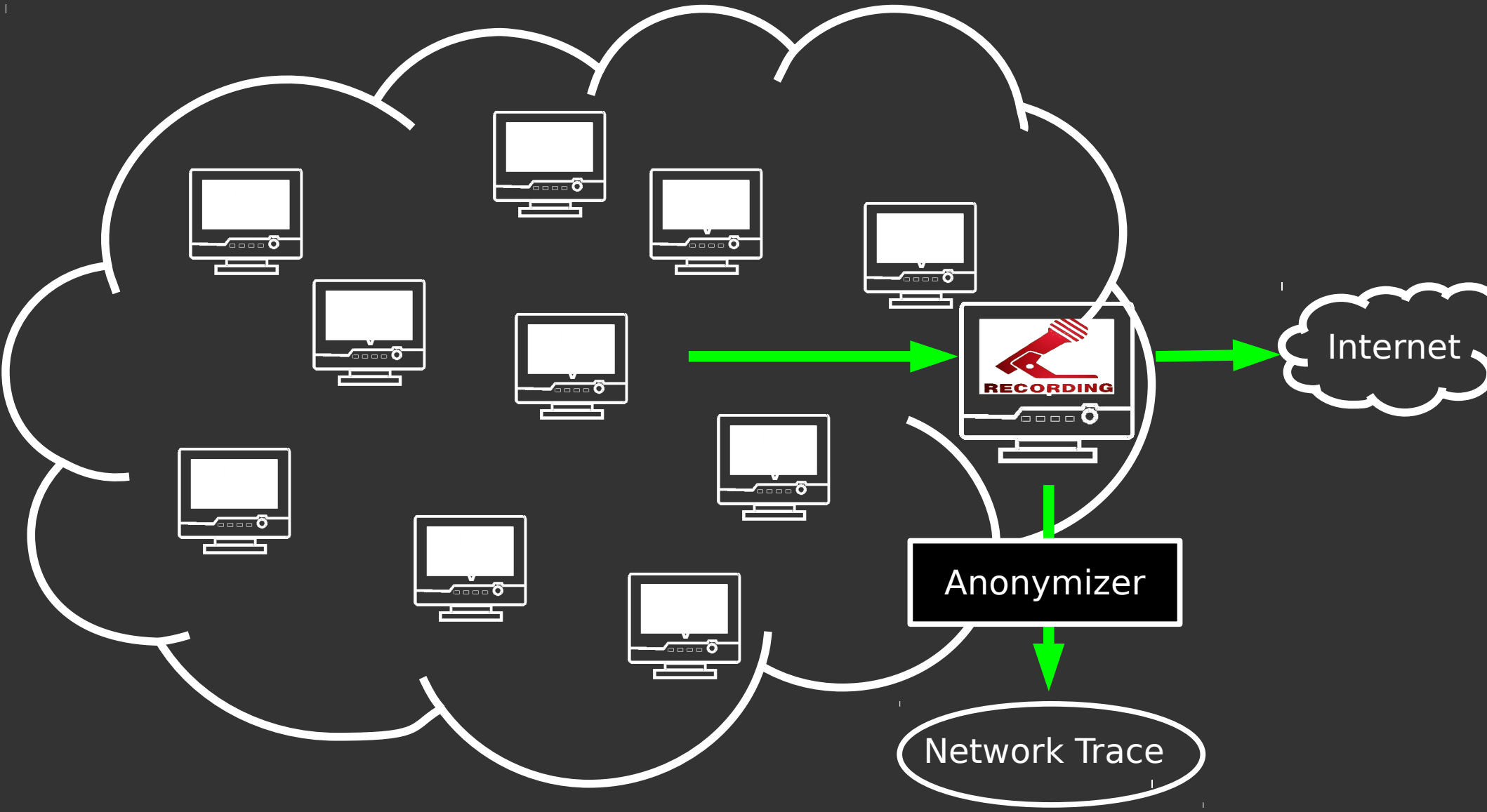
Evaluation Realities



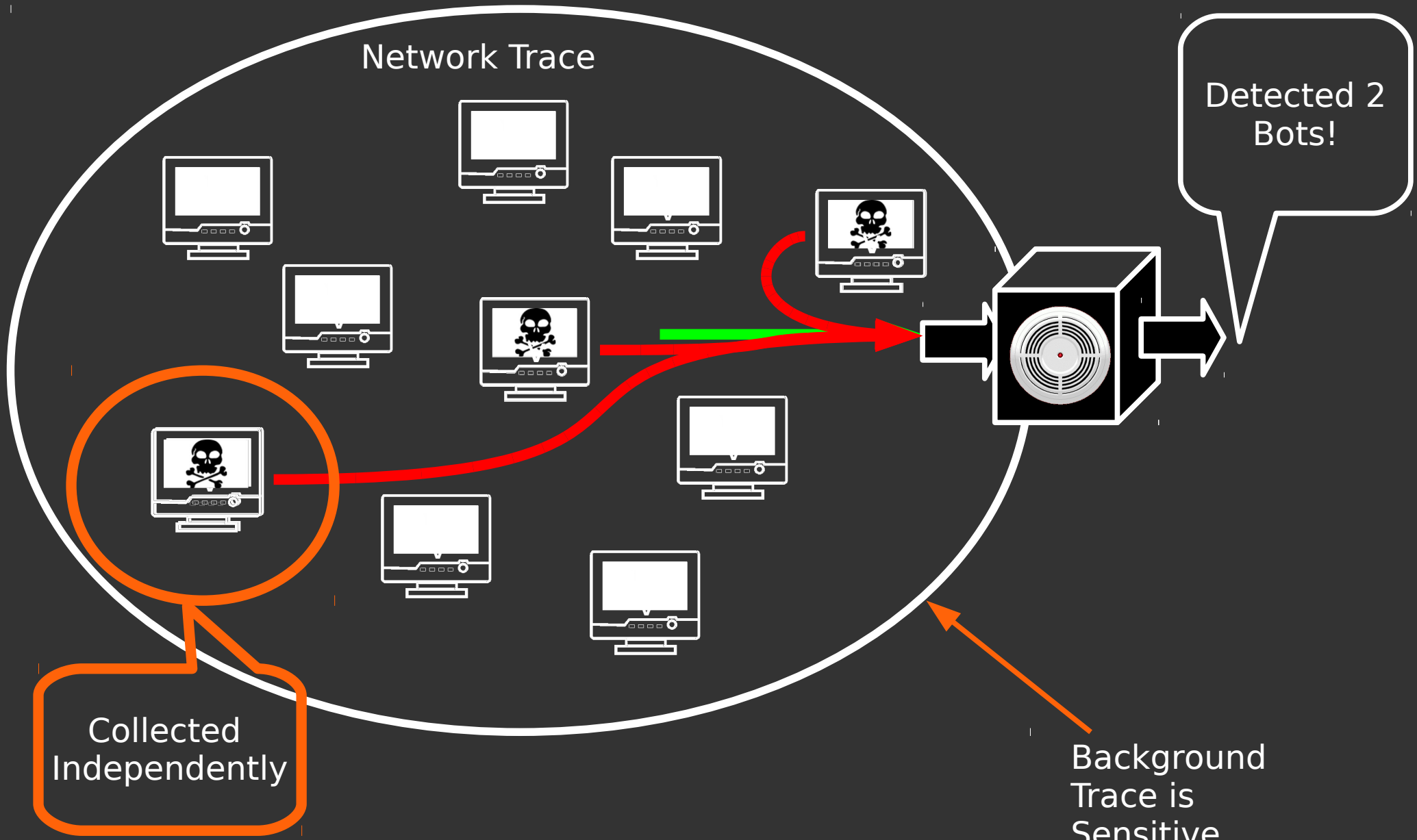
Pitfalls


Experimental Challenges
Overlay Methodology
Pitfalls
Obtaining Traces
Sharing Traces
What can be done?

Overlay Methodology



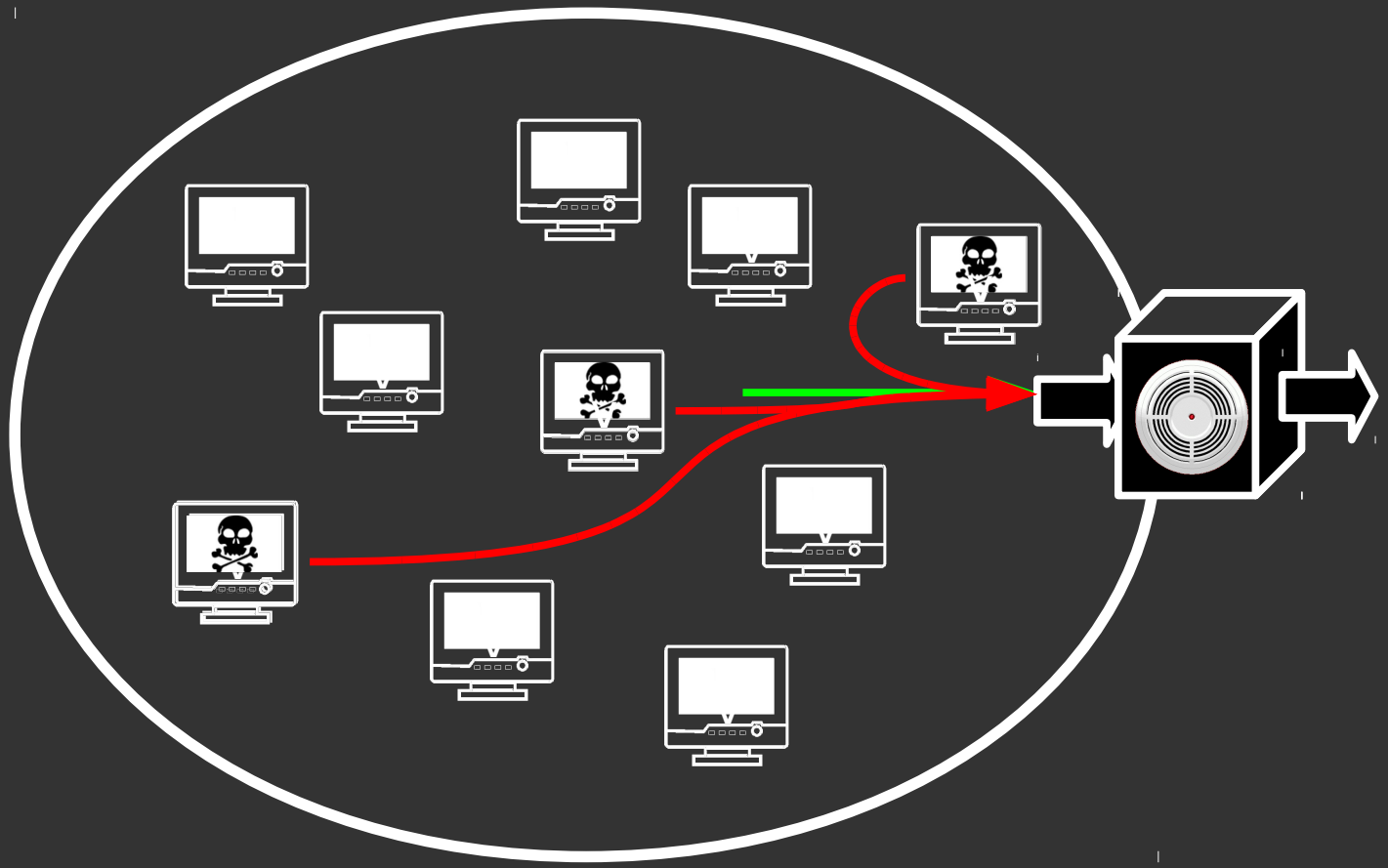
Replay and Evaluate



Prevalence in the Literature

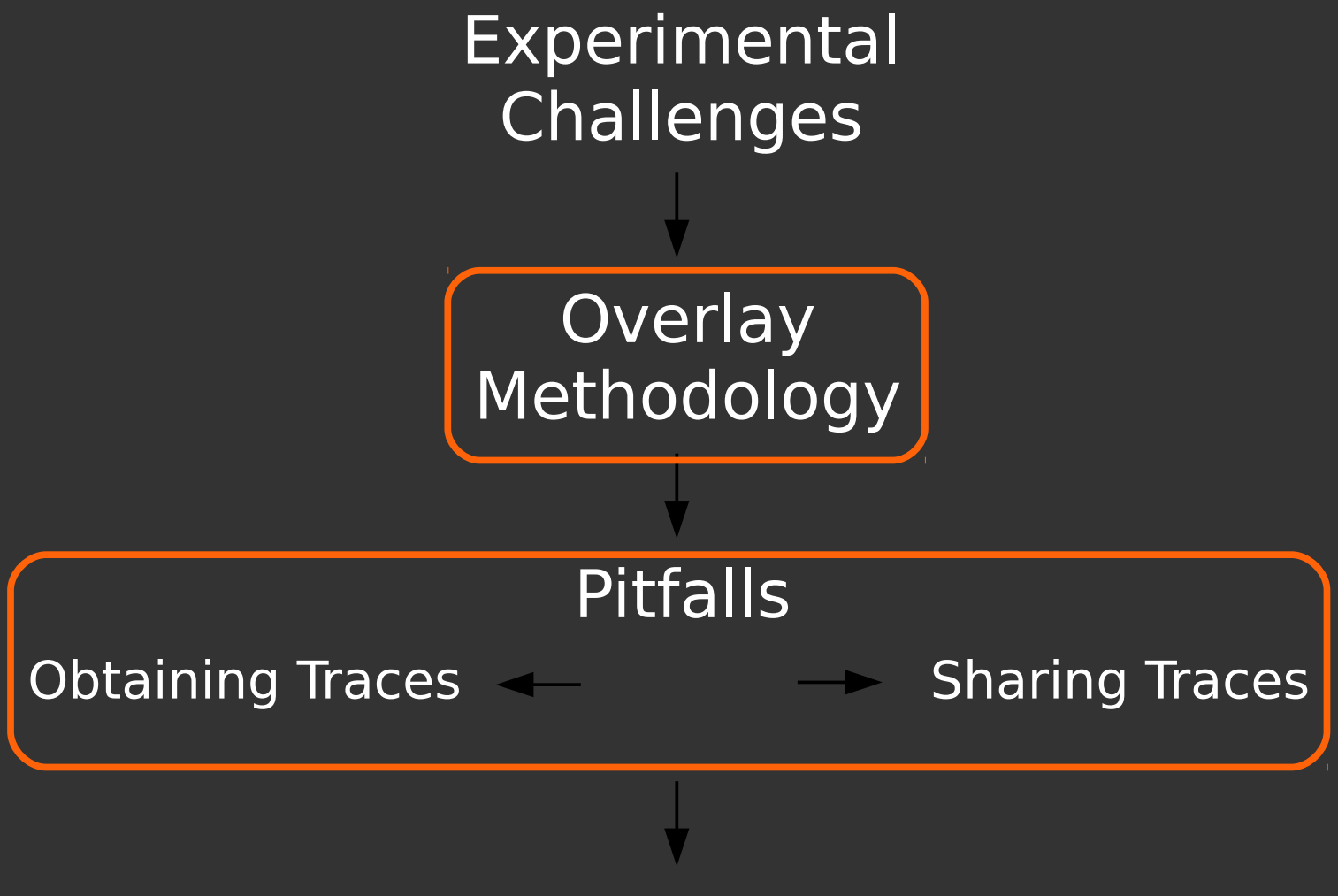
* See paper for references.

Advantages of Overlay Methodology



Ground Truth

Pitfalls

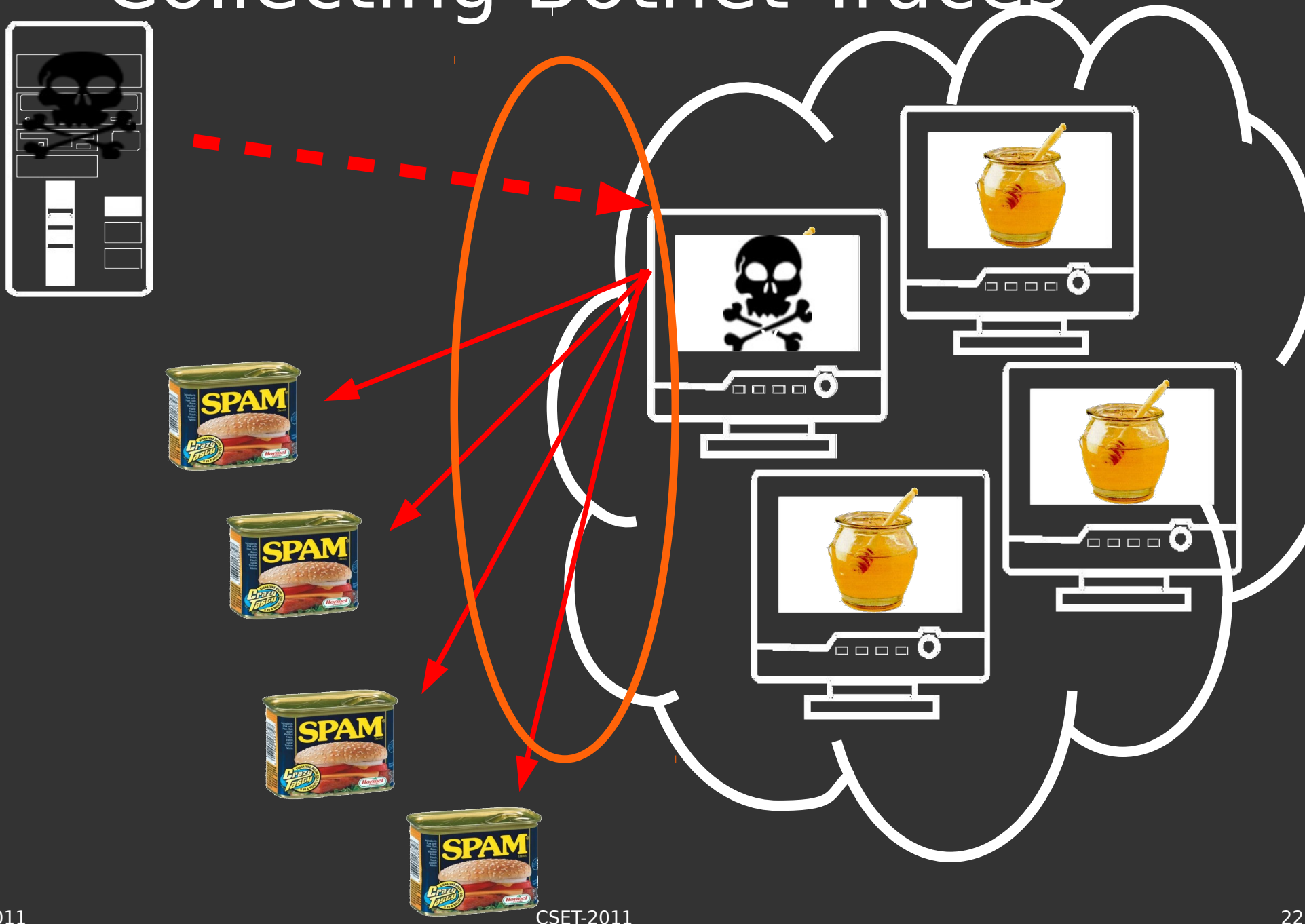

Experimental Challenges
Overlay Methodology
Pitfalls
Obtaining Traces
Sharing Traces
What can be done?

Obtaining Traces

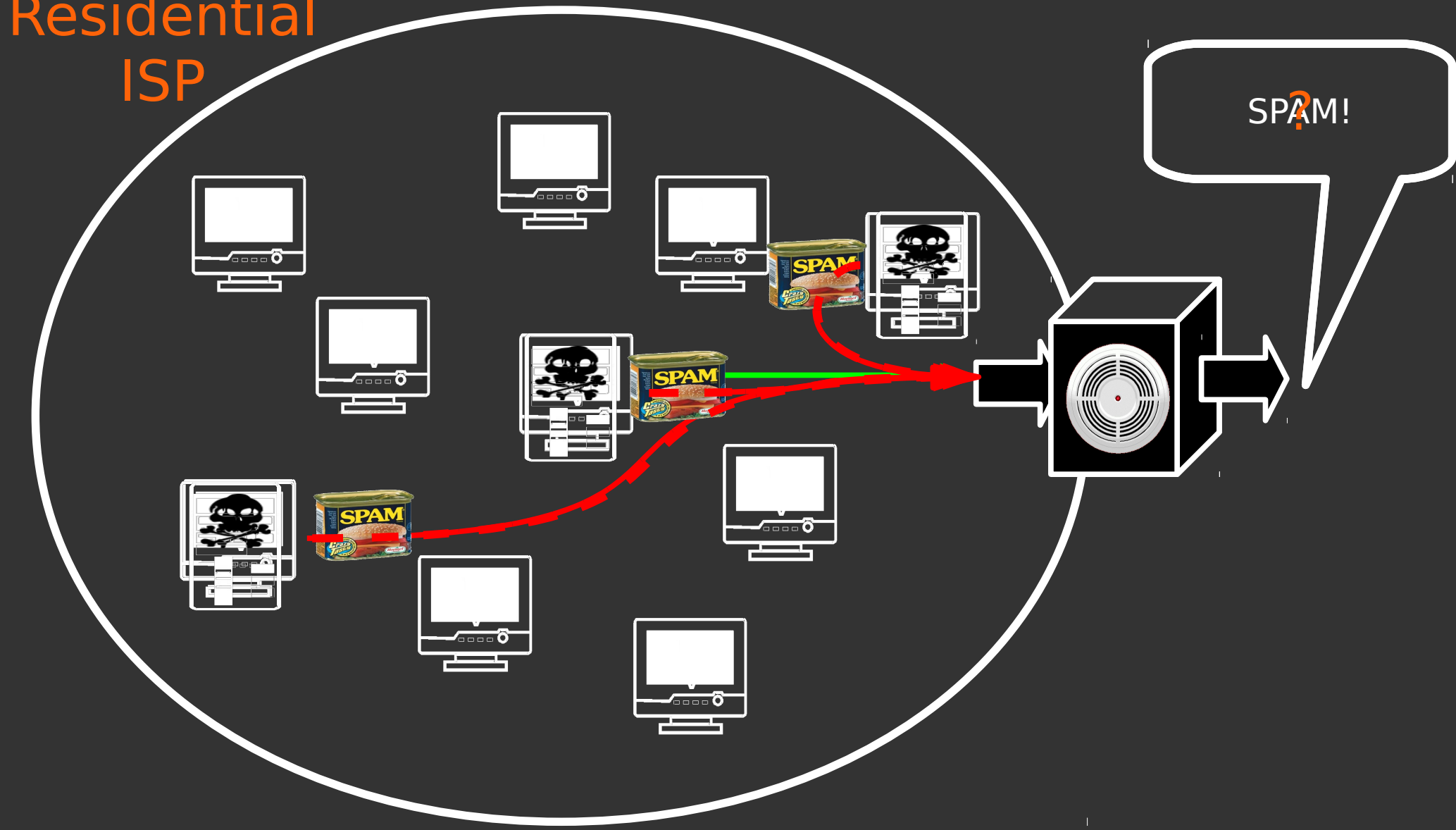
Realism

Merging of Botnet and Background trace should be realistic

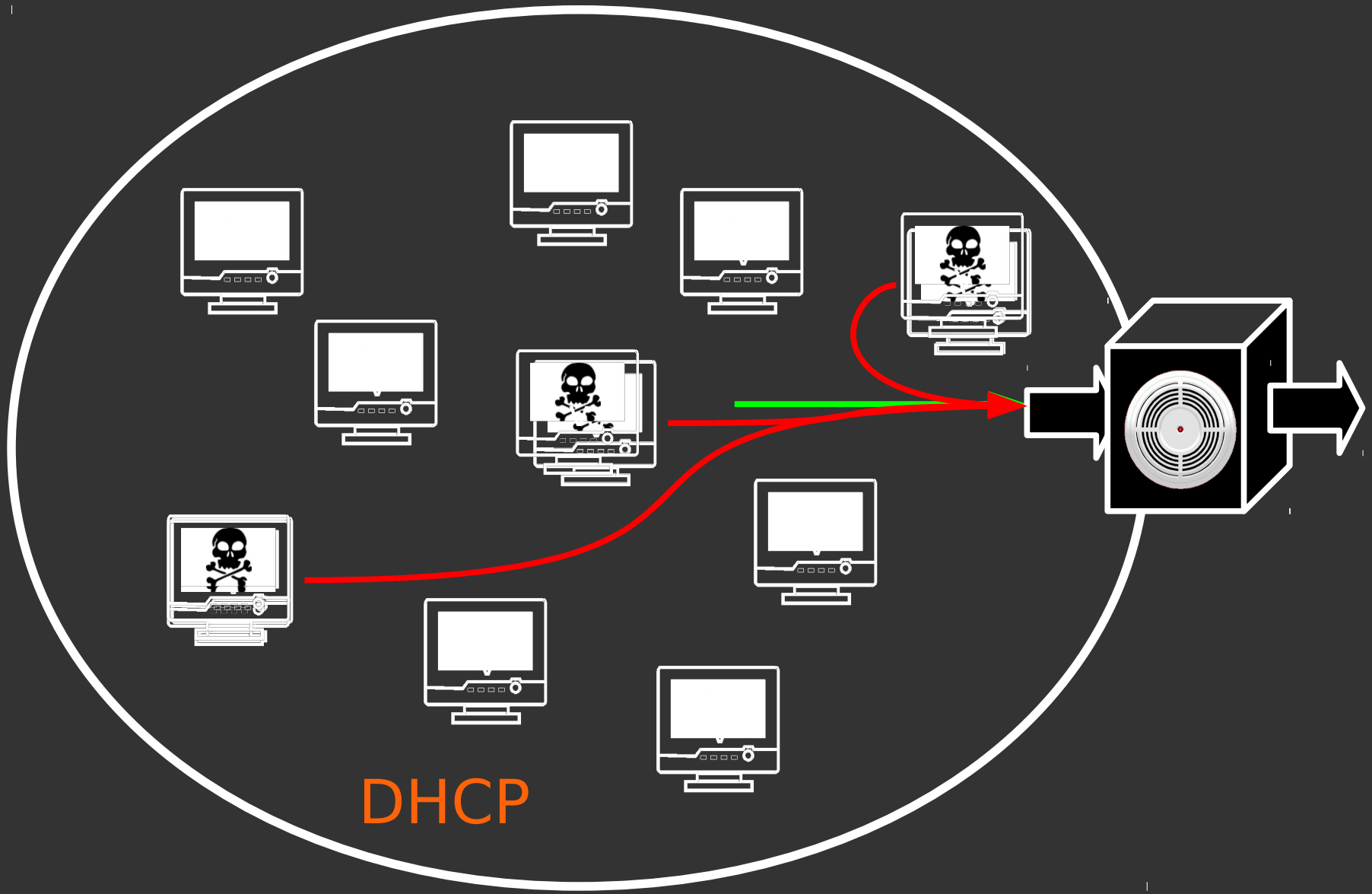
Collecting Botnet Traces



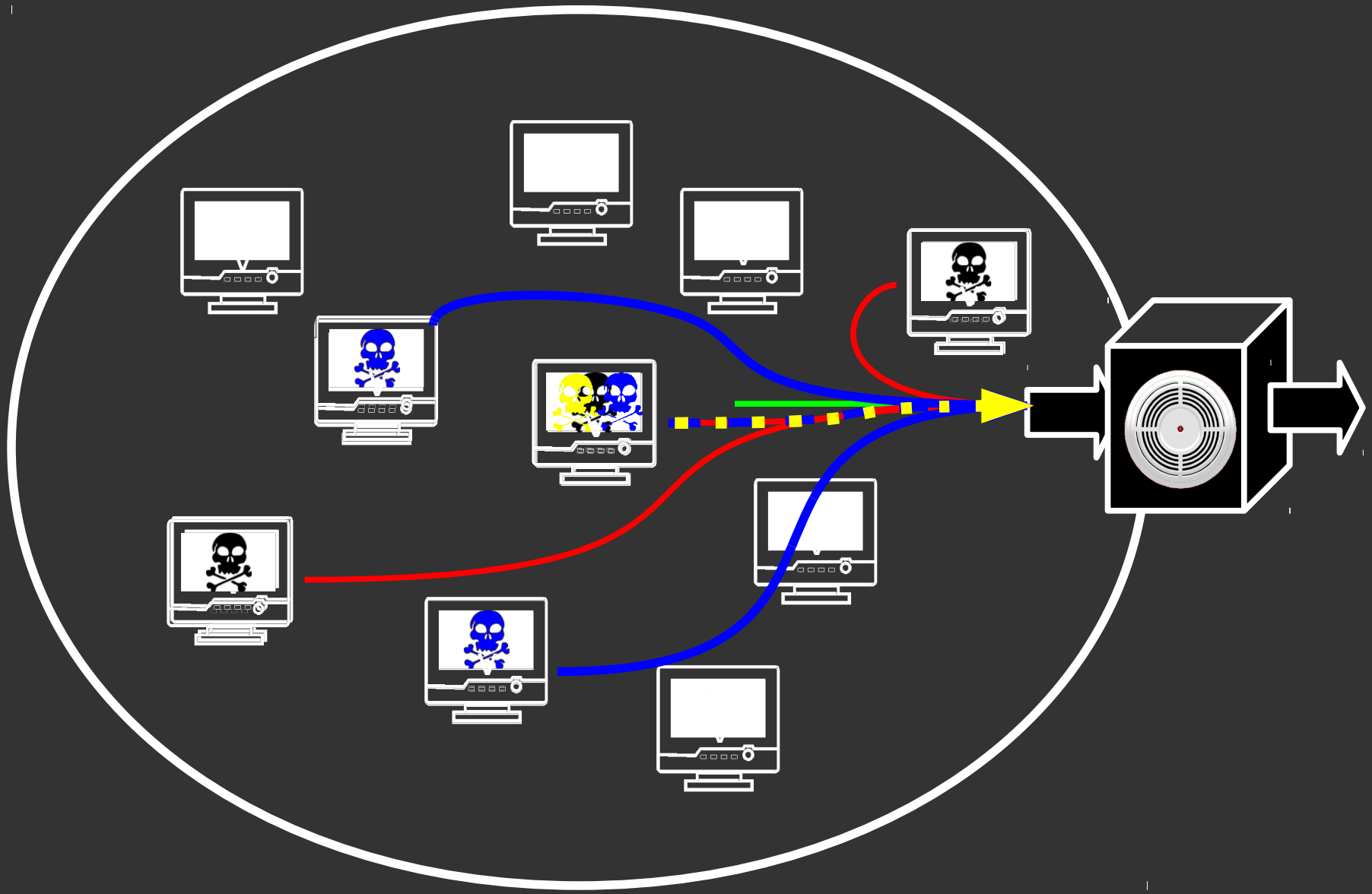
Realistic Embedding



Mixing Artifacts



Multimorbidity



Obtaining Traces

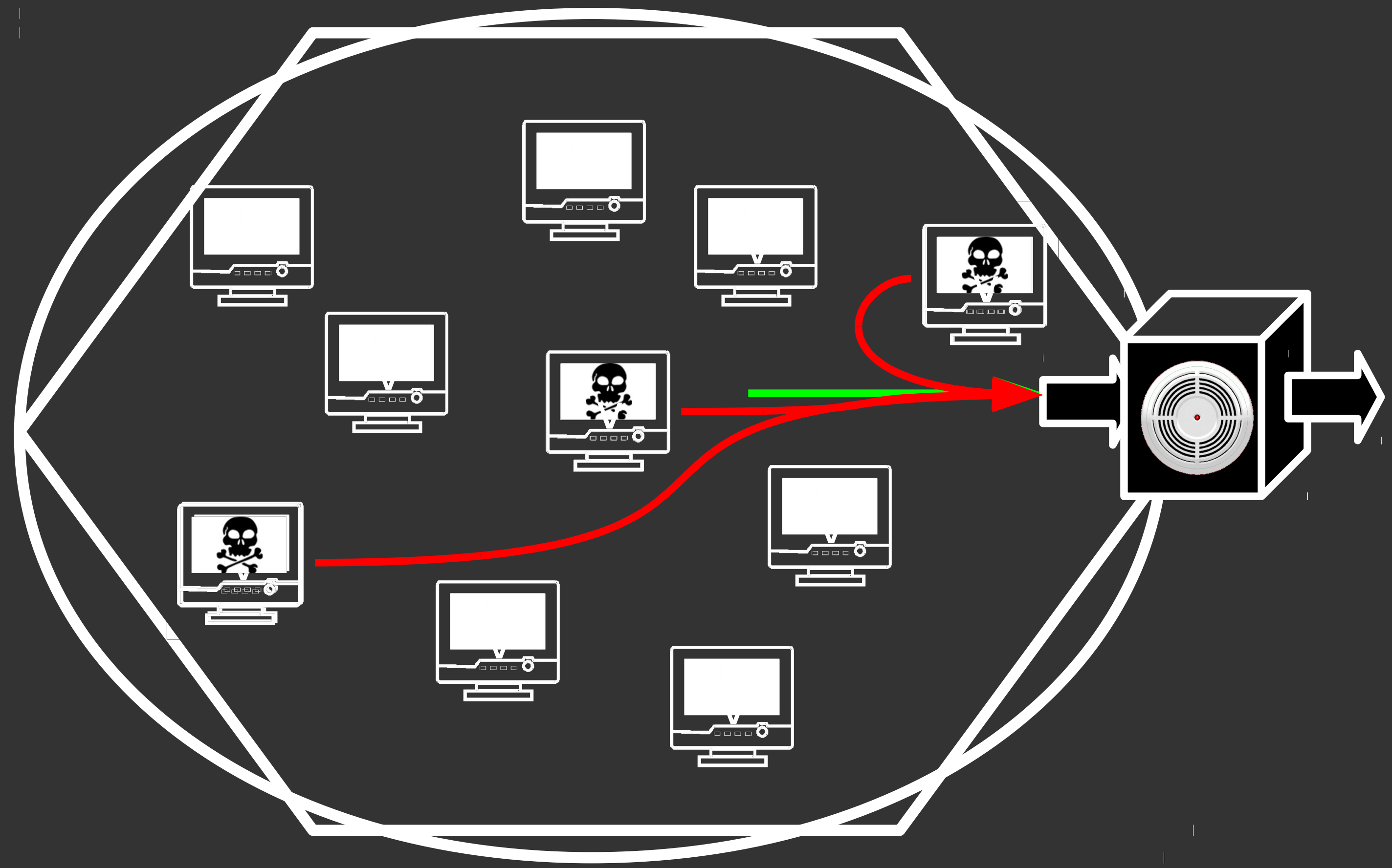
Realism

Merging of Botnet and Background trace should be realistic

Representativeness

Reflect diversity in network scenarios

Focus on Academic Networks



Corporate Business

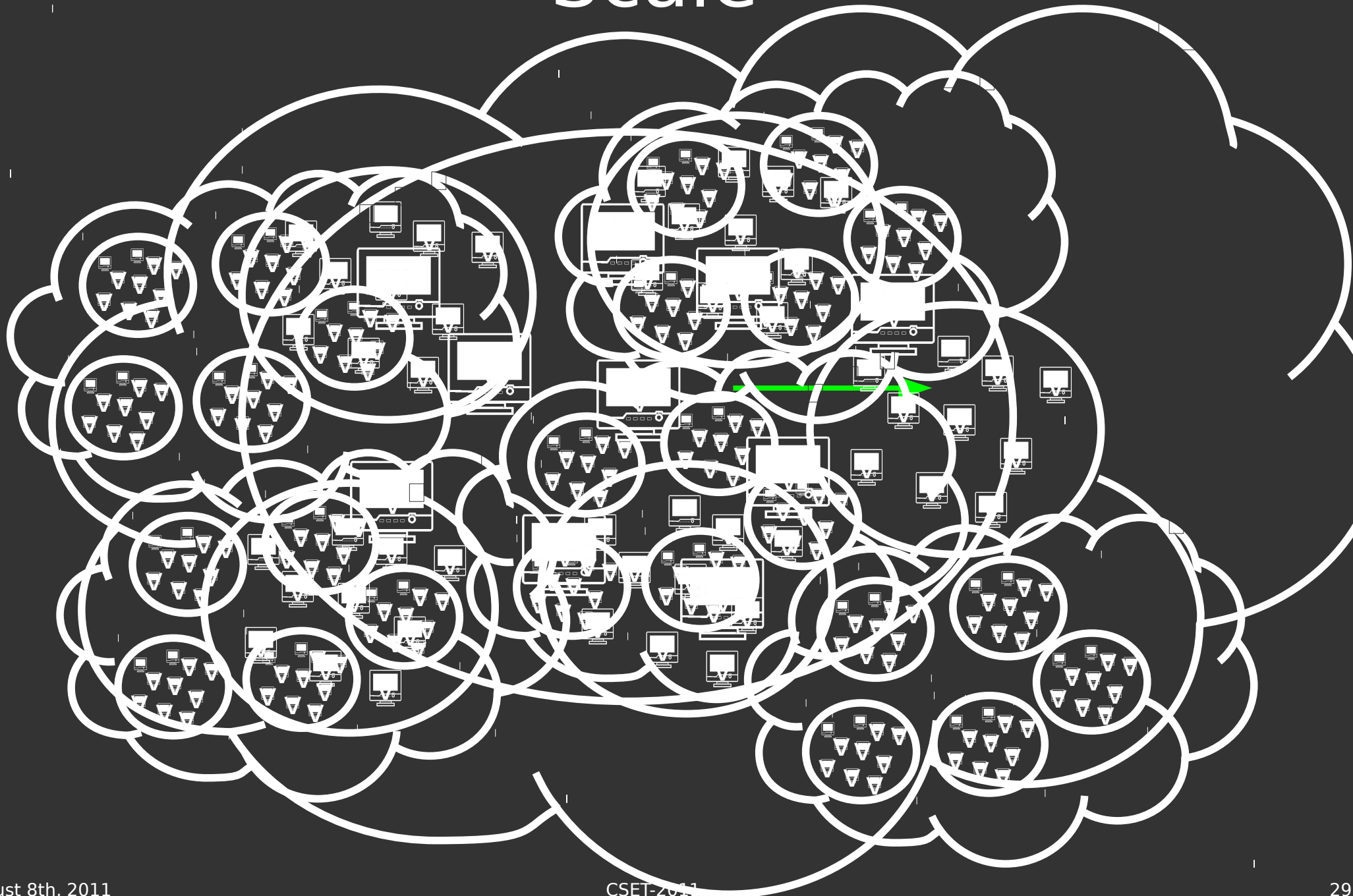
State Universities

Prevalence in the Literature

	Academic Traces	At Least One Other Trace
Overlay Methodology	[13] [49] [15] [36] [46] [47] [41] [23] [6] [7]	[28] [25] [24] [14]
Other Methodology	[36] [11] [5]	[20] [14] [45]

* See paper for references.

Scale



Obtaining Traces

Realism

- Merging of Botnet and Background trace should be realistic

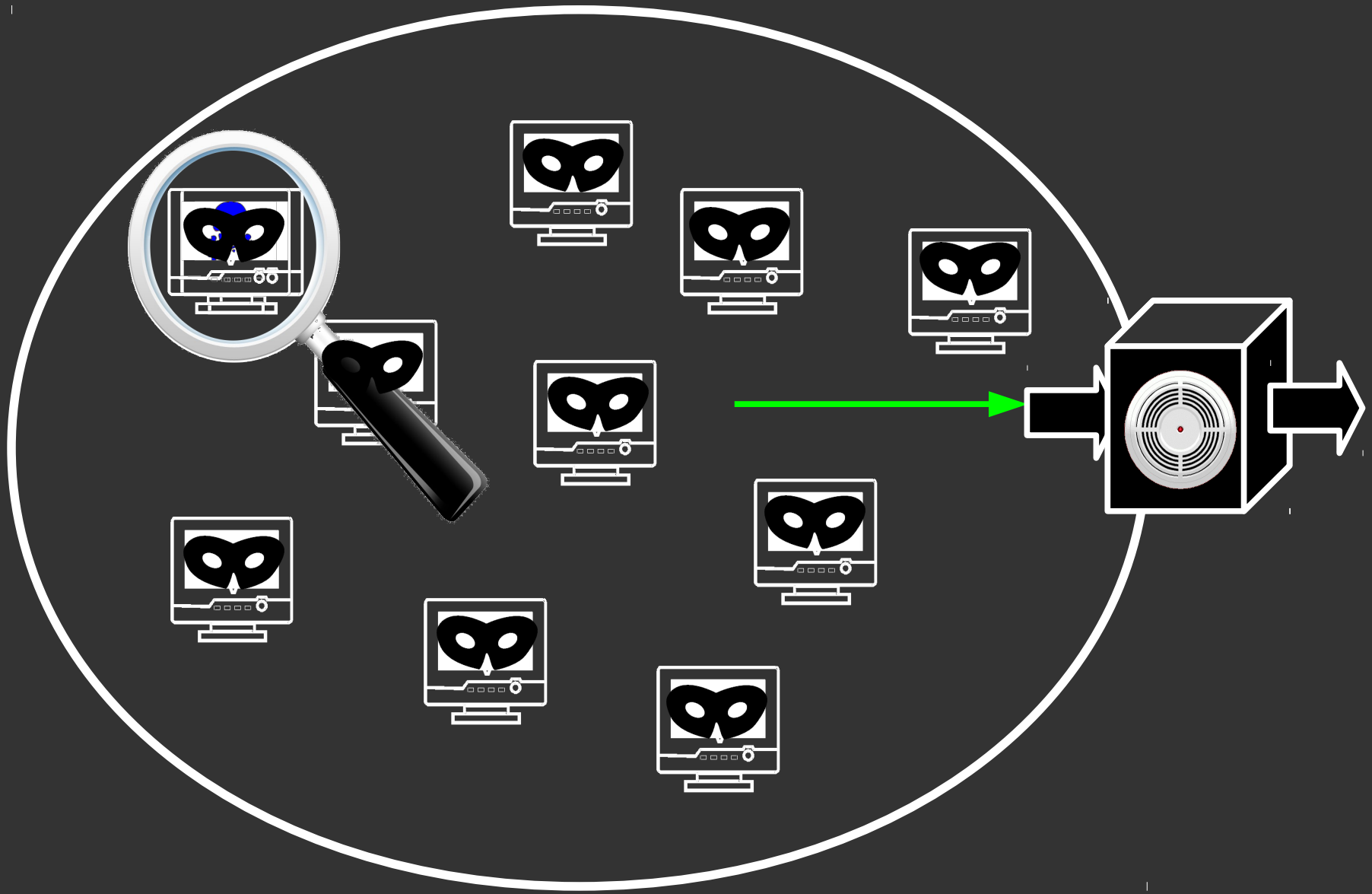
Representativeness

- Reflect diversity in network scenarios

Performance

- False postives and negatives

Lack of Verification

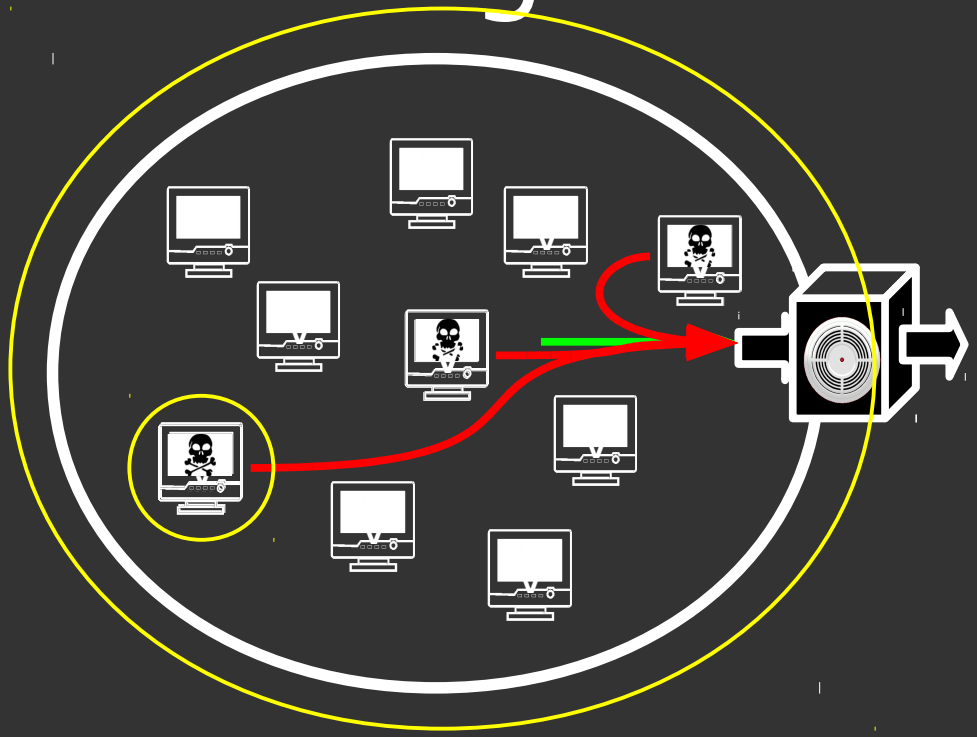


Example From the Literature
TaMD

“We suspect that the reason not every bot in the botnet was detected is due to the randomness in our choice of selected internal hosts to which the malware traffic was assigned, such that a selected internal host that was also contacting other suspicious subnets (not relevant to the botnet) is likely to bias the dimension reduction and clustering algorithm.”

privacy

Sharing Traces



Is the experiment independently repeatable?

Can we do apples to apples comparison?

What can be done?

Observations

Much of these challenges stem from difficulties in *sharing and obtaining* realistic data sets.

Similar to problems faced by researchers studying large scale distributed systems

---> PlanetLab

Can we do better together?

A PlanetLab for Botnet Detection?

Strawman

Distributed Evaluation

- PlanetLab-like nodes on participating networks
- Cannot communicate network traces outside of network

Researchers Deploy Detector Code on Nodes

- Reports are reviewed and declassified by sys-admins
- Researcher can test and debug on local node

Incentives

- Sys-Admins gain access to bleeding edge detectors, for FREE!
- Researchers gain insight into usefulness of reports or “ground truth”

Address Challenges

Realistic Settings

Network Heterogeneity

Multiple Administrative Domains

Performance

Lack of Ground Truth

Modernity

Overfitting

Comparability & Repeatability

Privacy

Huge Deployment Challenges

Privacy

Accountability

Conclusions

Taking a step back

- Literature Review
- Ideal is hard

Ideal vs. Reality

- Privacy!
- *Sharing* and *Obtaining* realistic traces

Overlay Methodology

- And, its pitfalls

Can we do better together?

- PlanetLab for Botnet detectors?

Backup