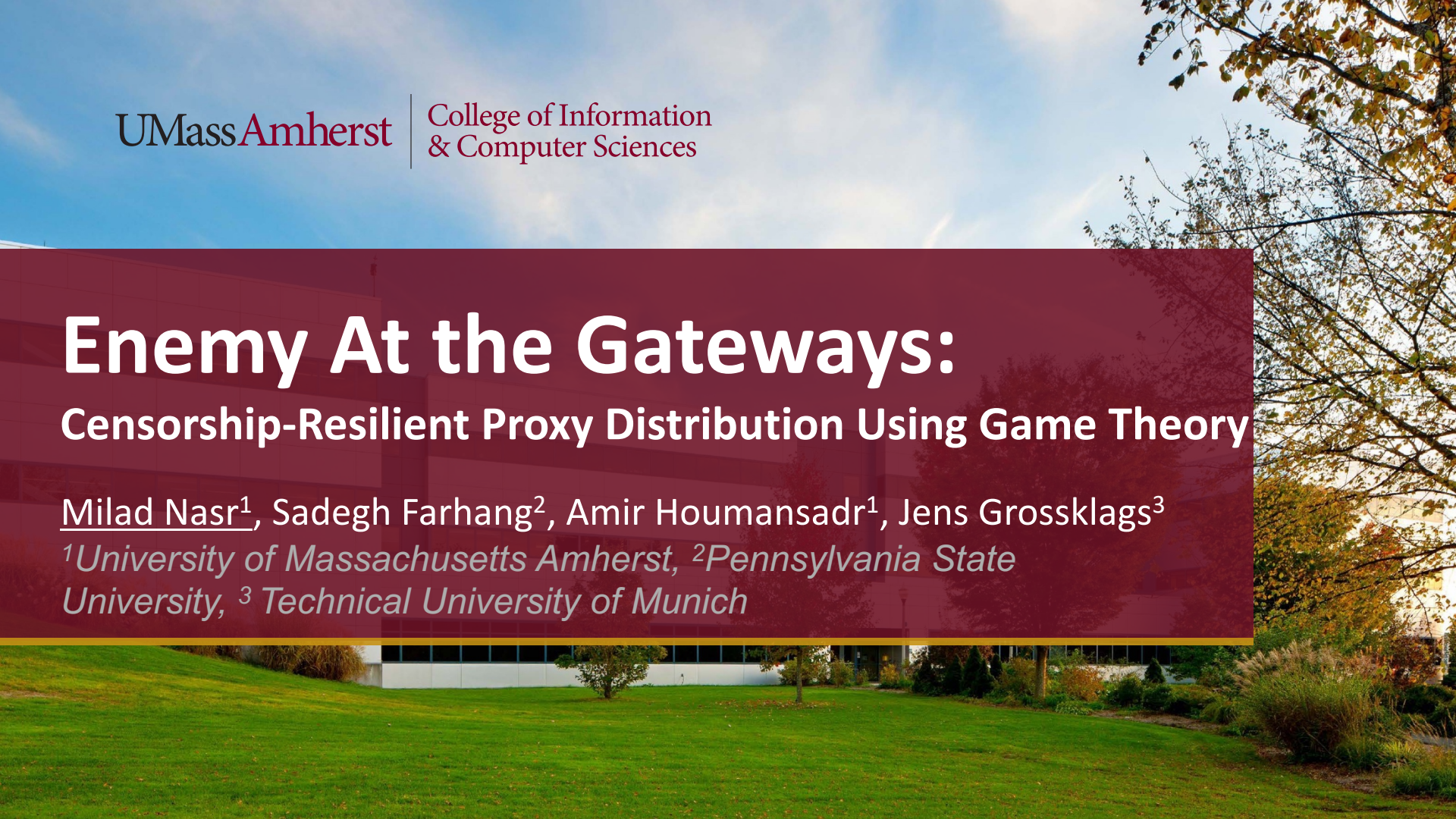

Enemy At the Gateways:

Censorship-Resilient Proxy Distribution Using Game Theory

Milad Nasr[1], Sadegh Farhang[2], Amir Houmansadr[1], Jens Grossklags[3]

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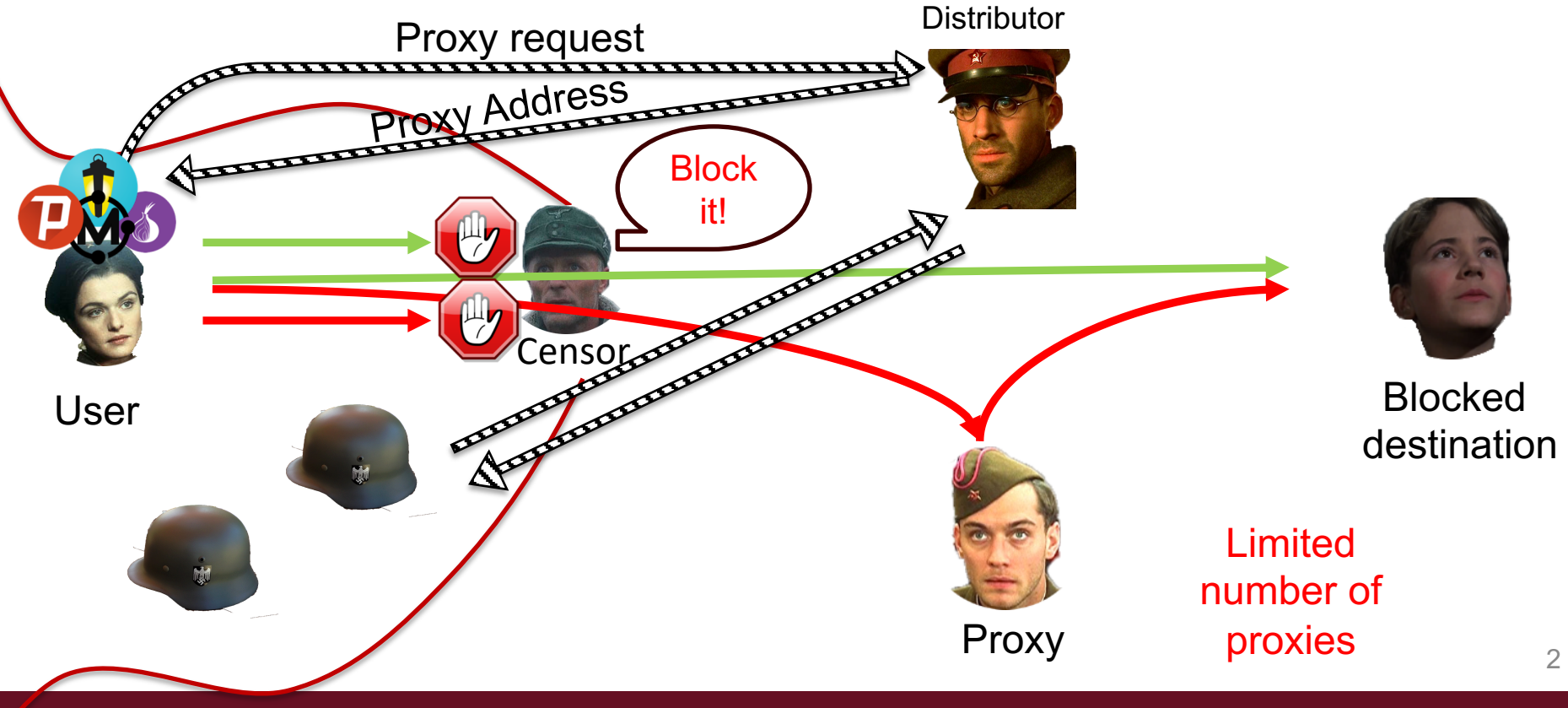
Internet Censorship

- Oppression regimes try to stop flow of information by censoring contents, specifically in Internet censorship
- There are a lot of censorship circumvention tools to help the users of such countries
- Proxies are the core technique for circumventions

Censorship Circumvention



Tor Is Blocked in Most Censoring Countries

Proxy distribution is an open challenge in censorship circumvention tools

Our goal:

Find the optimal assignment between clients and proxies

Existing Approaches

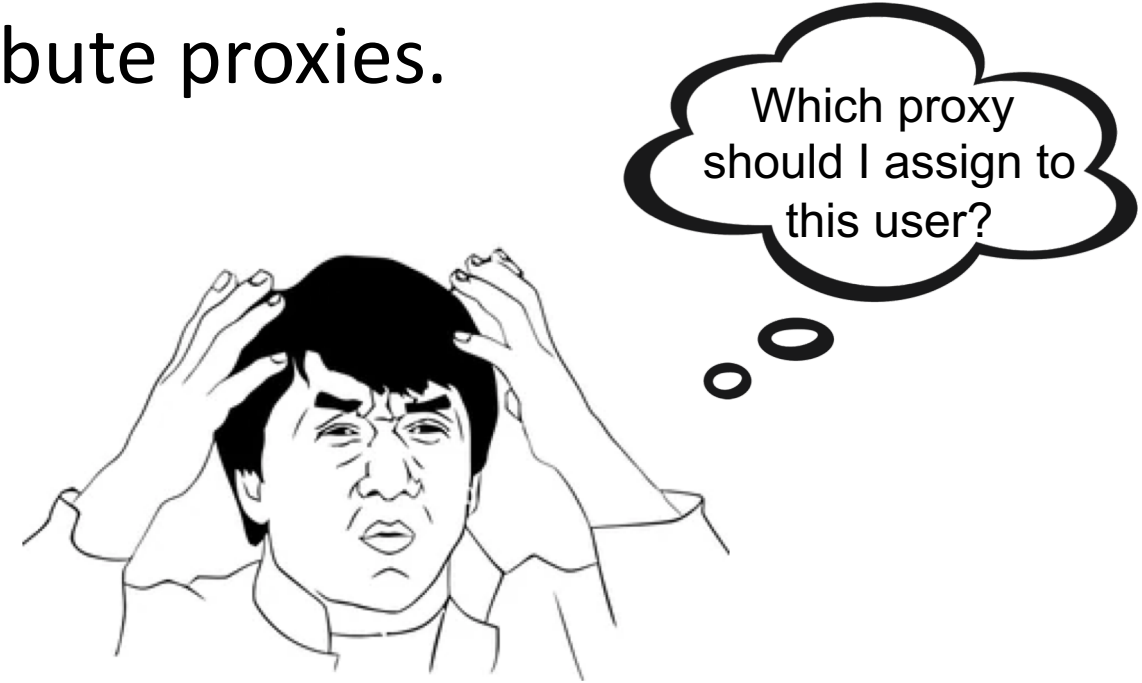
- Social networks:
  - Proximax [FC 11], Pass it on [*IPTPS* 10]
- Solving puzzles:
  - CAPTCHA, Feamster et al. [PETS 03]
- Theoretical modeling:
  - rBridge[NDSS 13], Mahdian [*Fun with Algorithms*.2010]

Not scalable

Orthogonal with our work

Existing Approaches (Cont.)

- None of existing methods define how to distribute proxies.

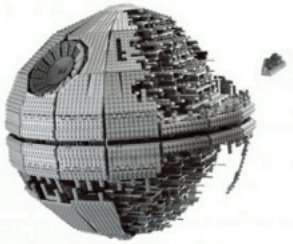


Existing Approaches (Cont.)

- Only consider the simple censoring strategies.

What we consider as a censoring strategy

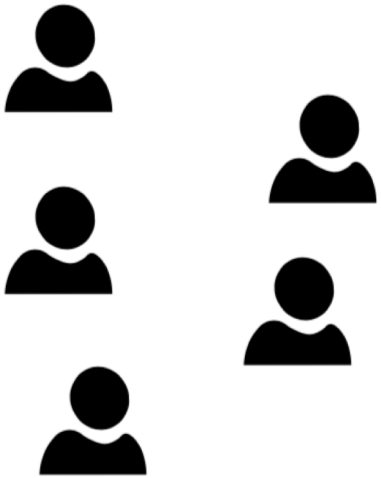
But actually…



Our approach

- A generic framework which can be applied on different censorship circumvention tools
- We use game theory to model the problem and find the best solution
- We model the optimal censoring strategy and evaluate our model against it

How Does It Work?

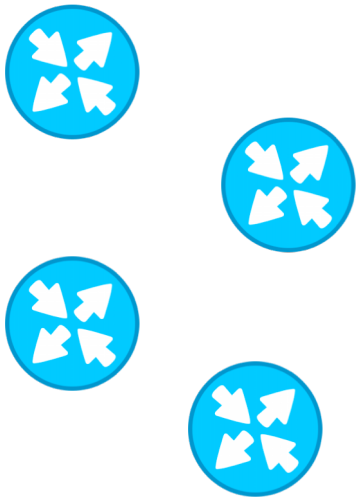


Users

We want a stable assignment such that:

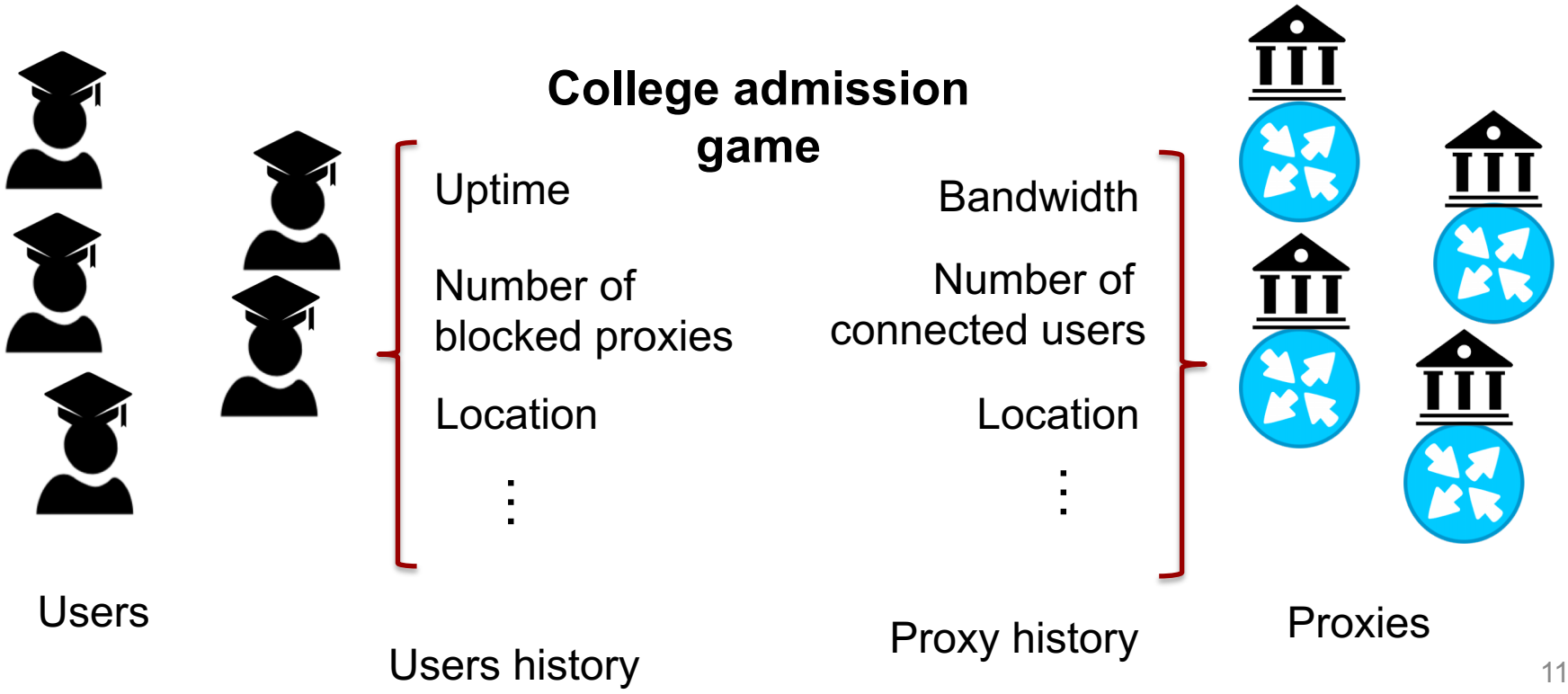
Each user gets the most desirable proxies

No any **two** users want to change their proxies and they get the best proxy under this condition



Proxies

How Does It Work? (Cont.)



How Does It Work? (Cont.)

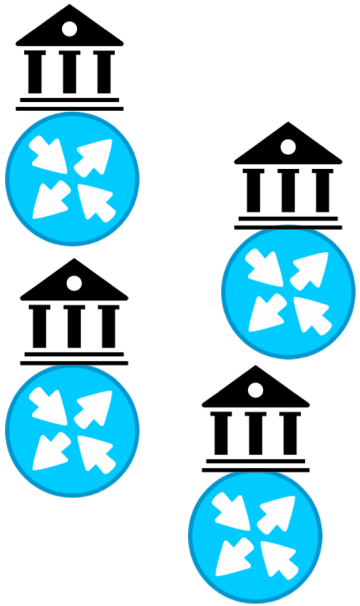
Users

College admission game

User (i) utility function for each proxy (x) : $U^t_{a_i}(p_x)$

Proxy (x) utility function for each user (i) : $U^t_{p_x}(a_i)$

We use a customized Gale-Shapley algorithm to find equilibrium assignment between proxies and users



Proxies

Suggested metrics

- Proxy (β):
  - Number of users who know the proxy
  - Number of users connected to the proxy
  - Total time utilization of the proxy
  - Distance from user
- User (α):
  - Proxy utilization
  - Blocked proxy usage
  - Number of requests for new proxy addresses
  - Number of blocked proxies that a user knows
  - Distance from proxy

Distributor Type	α_1	α_2	α_3	α_4	α_5	β_1	β_2	β_3	β_4
Strict - Balanced distribution	L	M	H	H	M	L	M	M	M
Strict - Sparse distribution	L	M	H	H	H	H	L	M	H
Kind - Balanced distribution	H	M	M	M	M	L	M	M	M
Kind - Sparse distribution	H	M	M	M	H	H	L	M	H

Optimal Censoring Strategy

- Censor decides based on the collective information from the agents
- Optimal censor increases its users' utility while blocking maximum number of proxies:

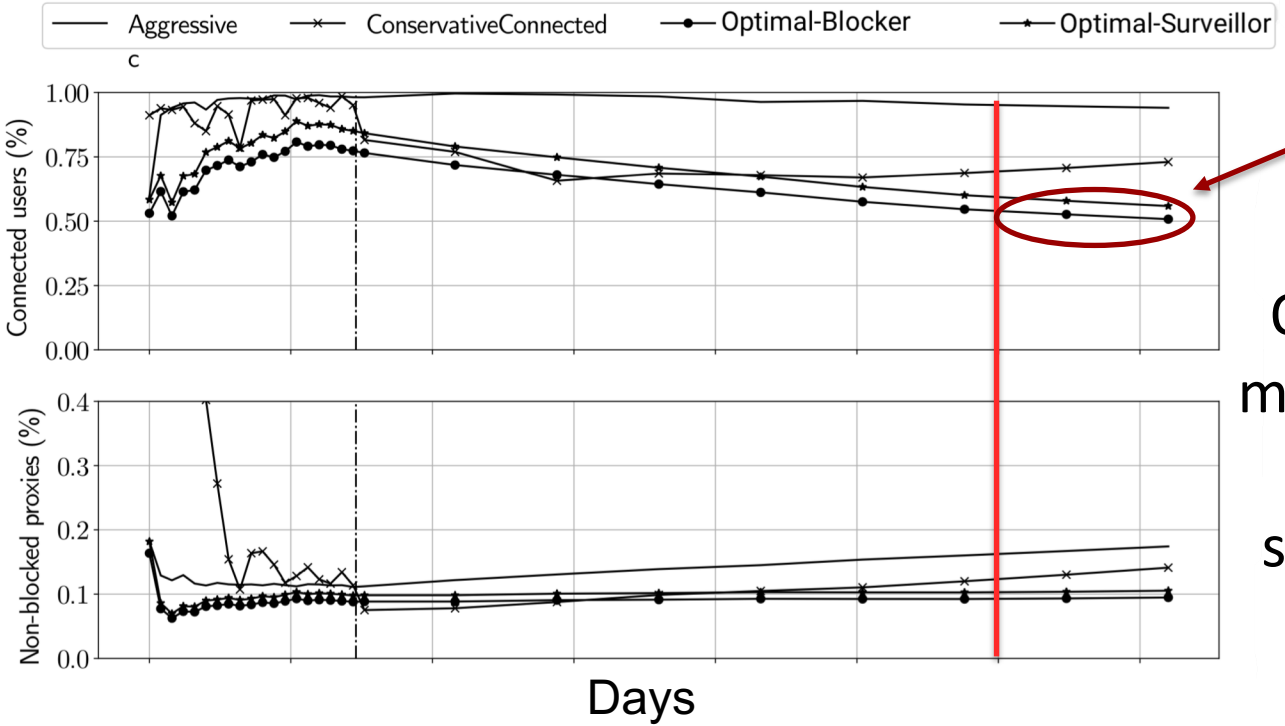
$$U_C^t = \omega \sum_{a_i \in \mathbb{J}} U_C^t(a_i) + r_{Blocked}$$

Experiments

Experimental Setup

- We implemented a proxy distribution simulator
- The proxy distributor assigns new proxies at the end of each epoch
- We simulated each experiment for 5 years
- We used different rates of proxies and users

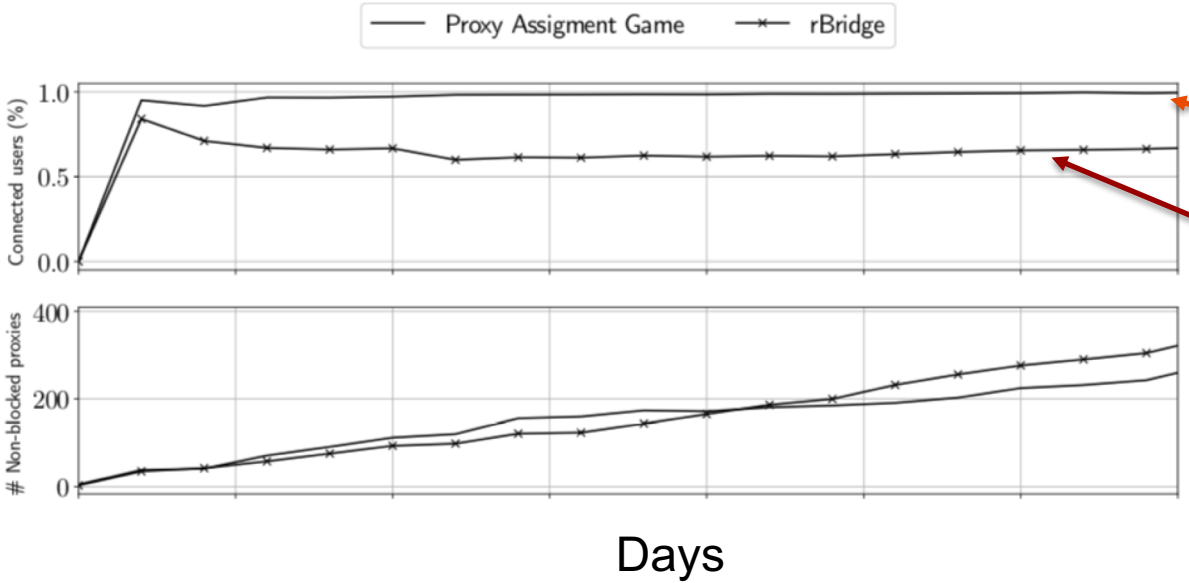
Our Optimal Censor Is More Powerful



Optimal Censor

Our optimal censor is much stronger than any other censoring strategy mentioned in the previous works

Comparison to Previous Works



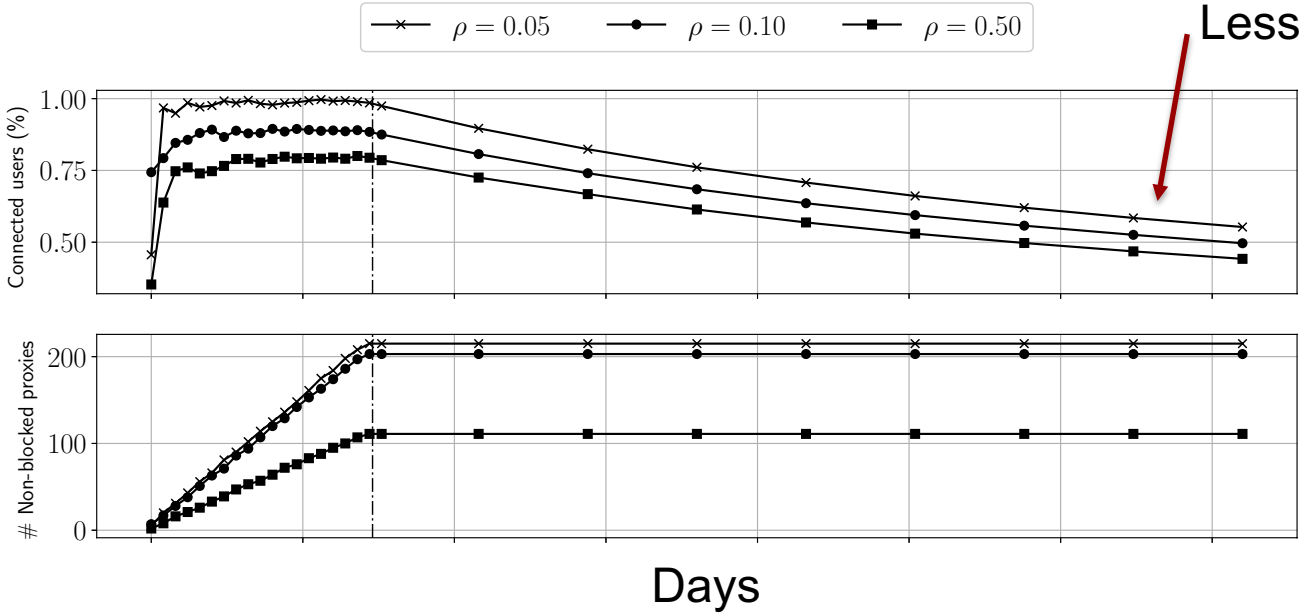
Our approach

rBridge [NDSS' 13]

We get better performance against The same censoring strategy

[NDSS' 13] "rBridge: User Reputation based Tor Bridge Distribution with Privacy Preservation."

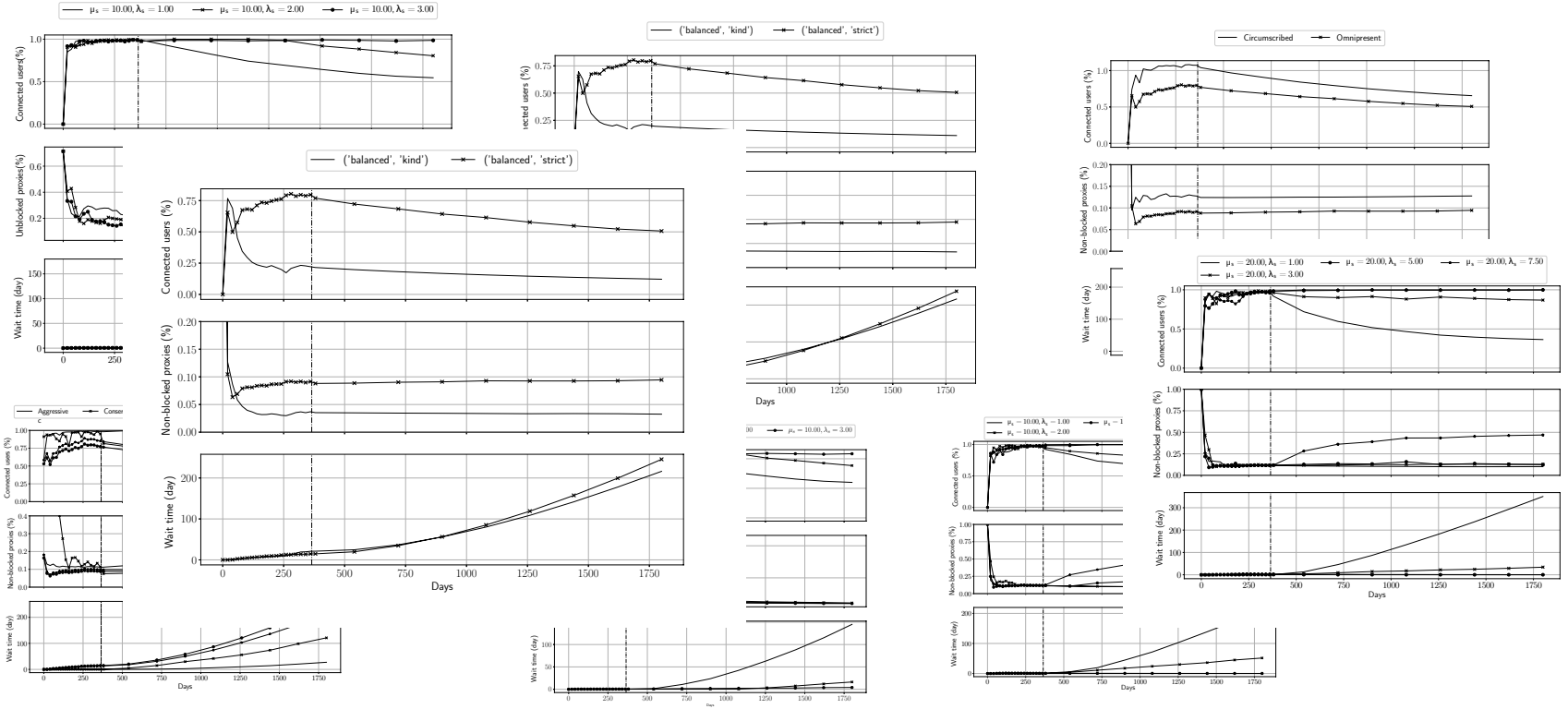
Static Proxy Distribution System



Less censoring agents

No matter how dumb is the censor we should always add new proxies to the system.

Different Settings and Scenarios



Summary

- Proxy distribution is a core problem in censorship circumvention tools
- We used game theory to model the problem and derive the optimal answers
- We show the performance of the system against the optimal censoring strategy

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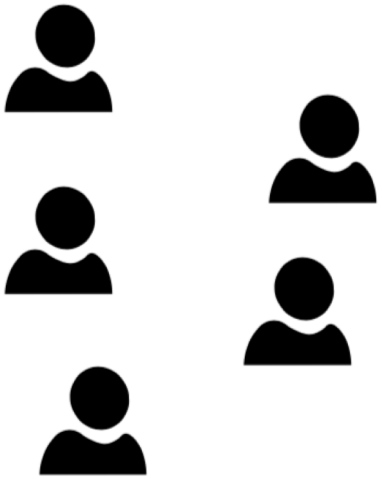
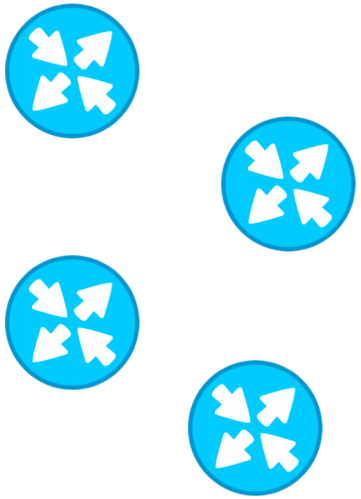
How Does It Work? (Cont.)



Users



Proxies