How Low Can You Go: Balancing Performance with Anonymity in Tor'

DC-Area Anonymity,Privacy, and Security Seminar

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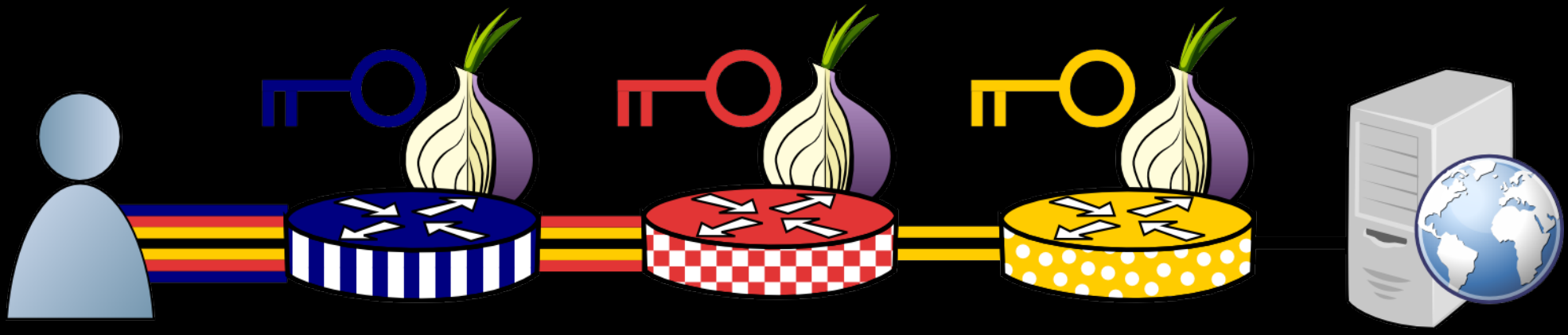
'PETS 2013, joint w/ John Geddes and Nick Hopper, U of Minnesota

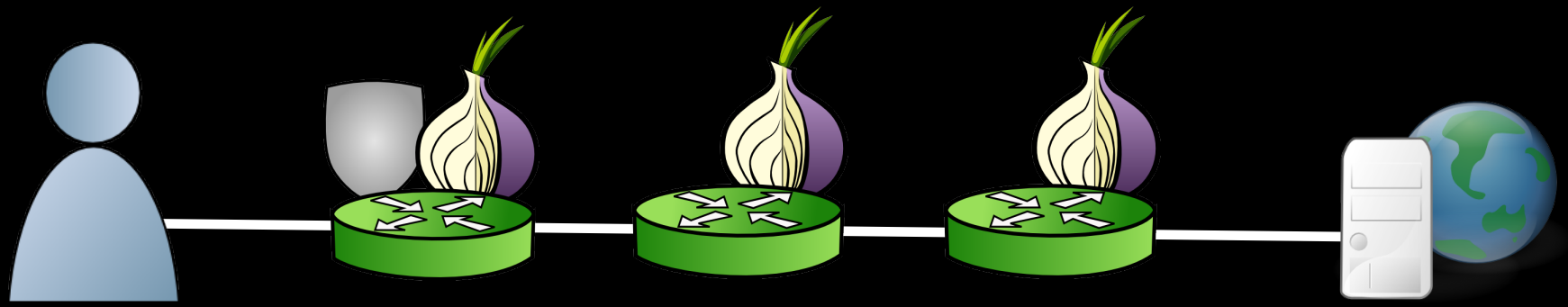
This Talk in a Nutshell

- New class of induced throttling attacks
  - Drastically improves traffic correlation via "stealthy throughput" style attacks
  - Analyze attacks against
    - Traffic admission control algorithms
    - Congestion control algorithms

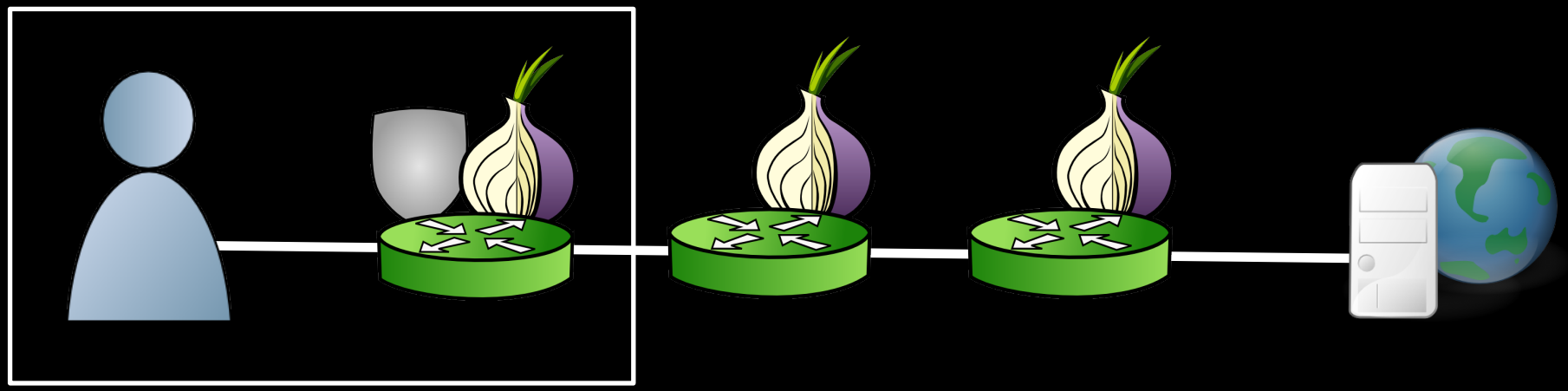
Anonymity with Onion Routing



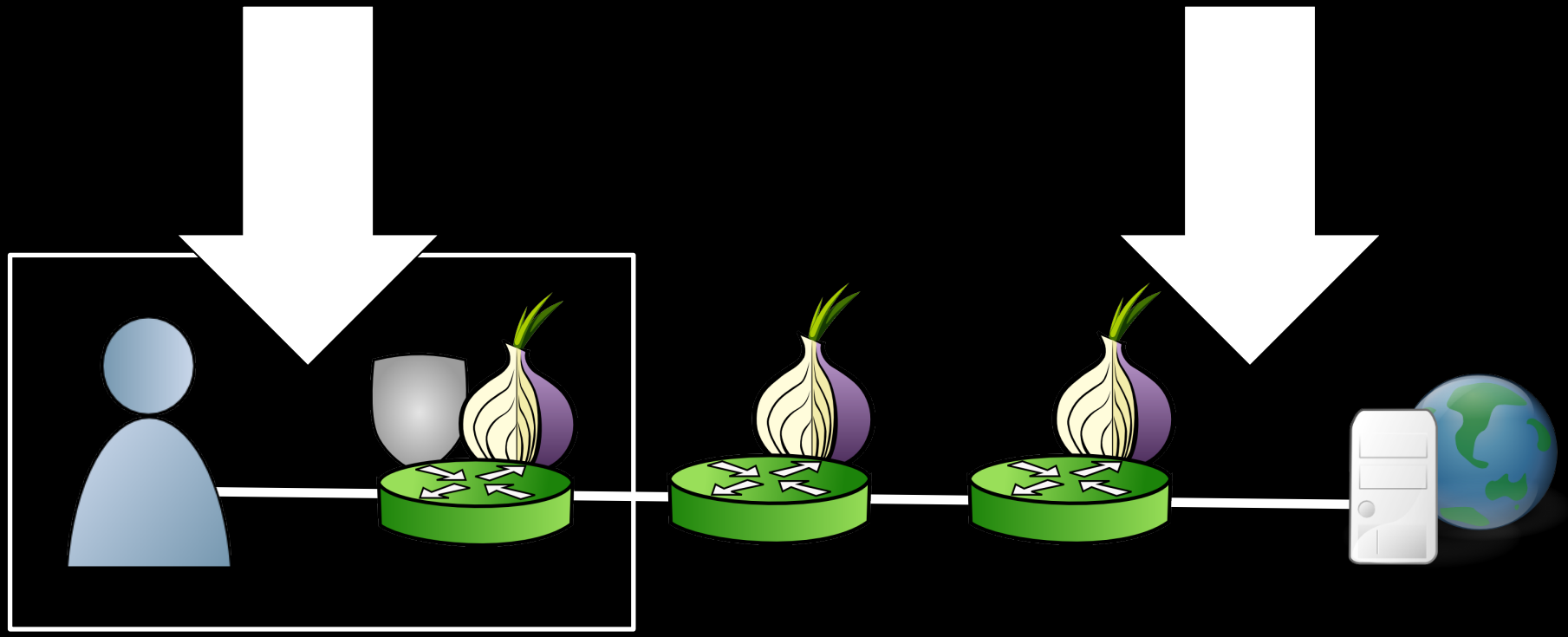
Traffic Correlation



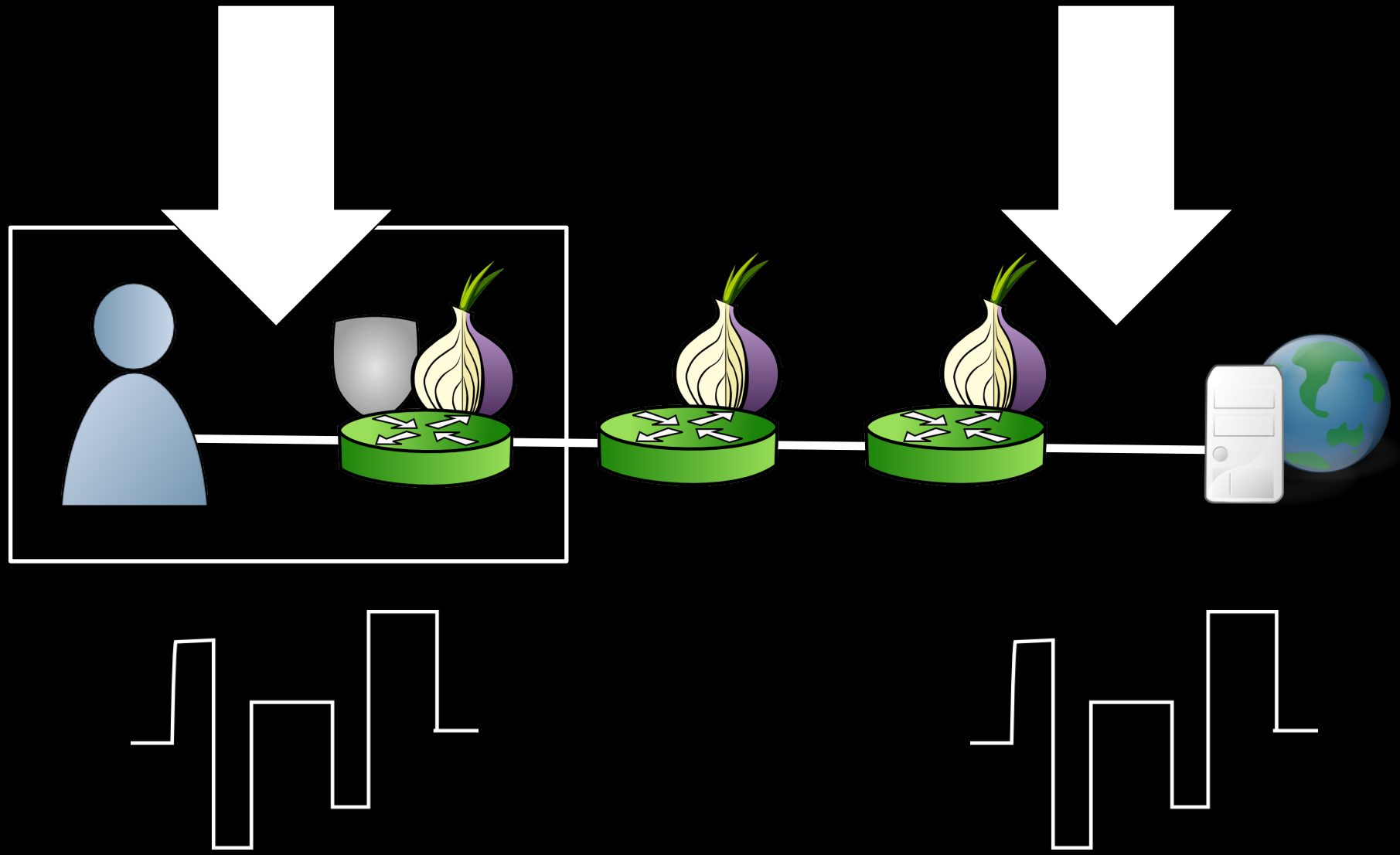
Traffic Correlation



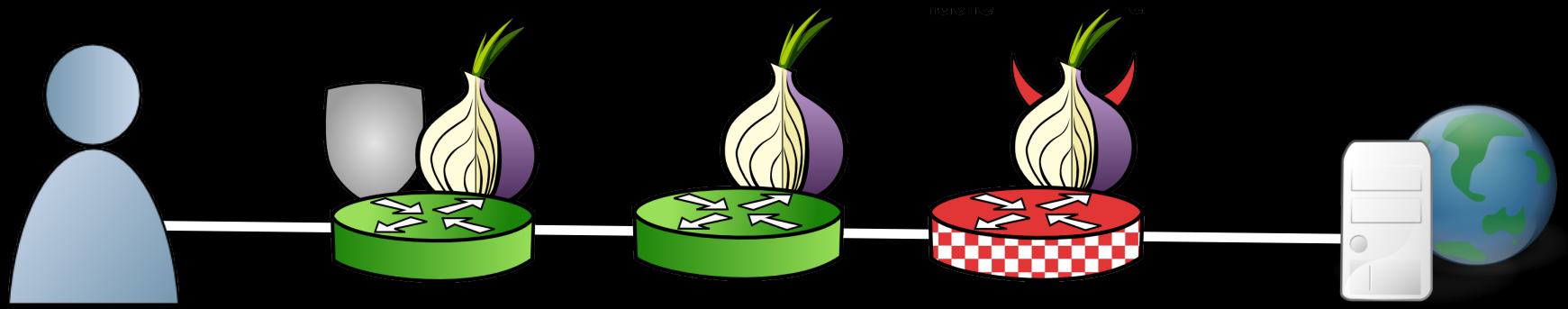
Traffic Correlation



Traffic Correlation



Traffic Correlation: Throughput



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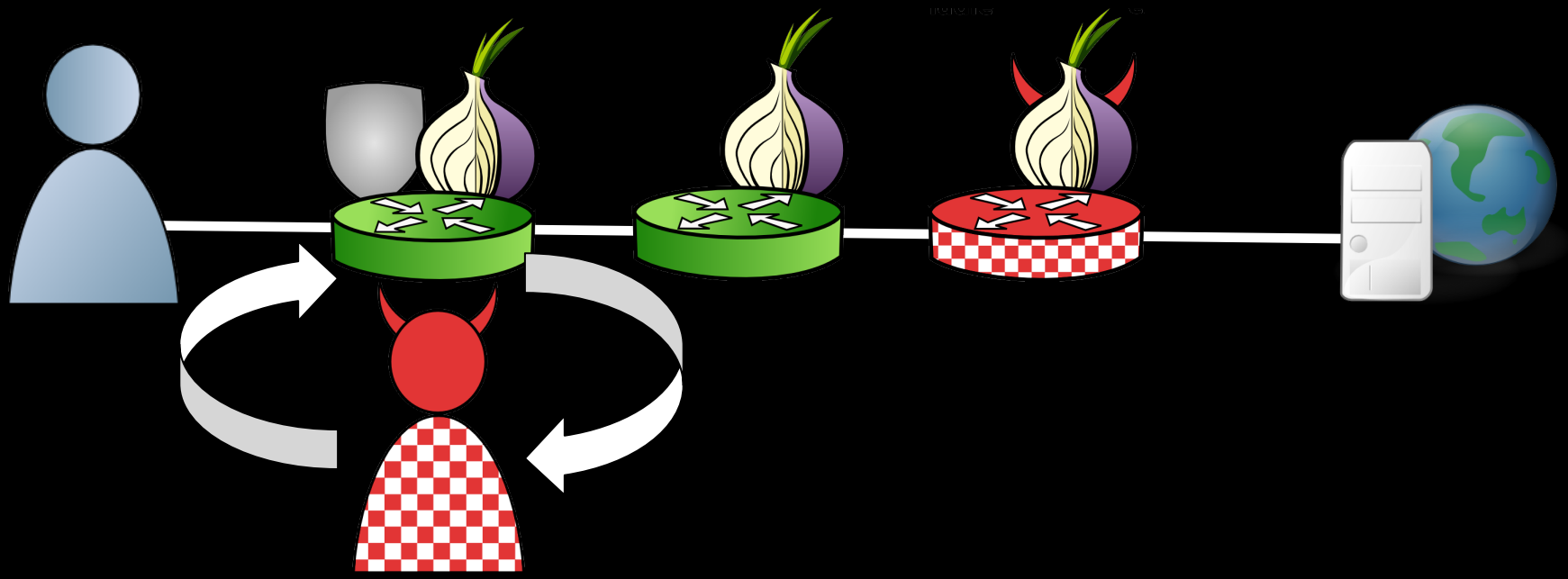
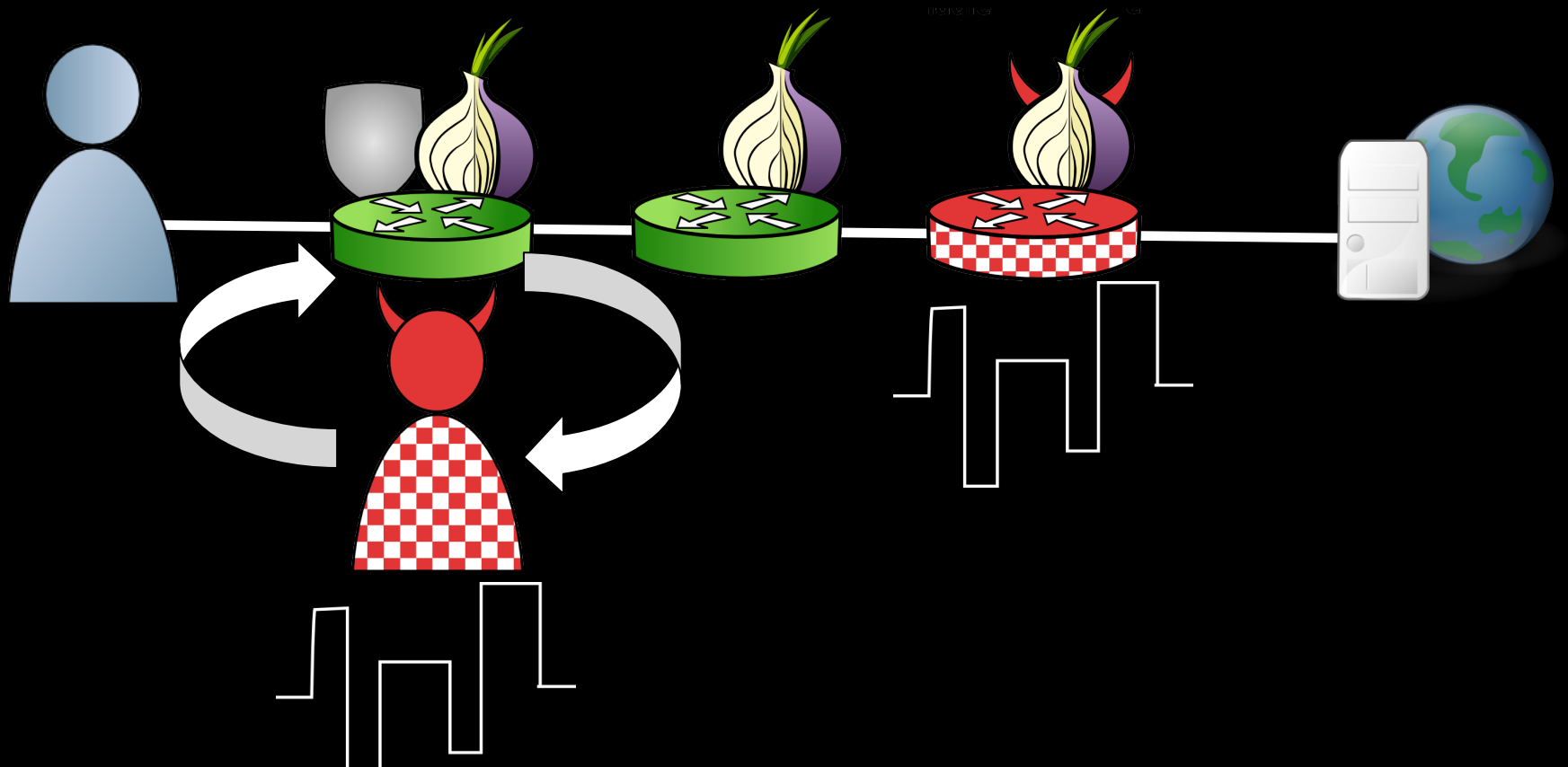
Traffic Correlation: Throughput



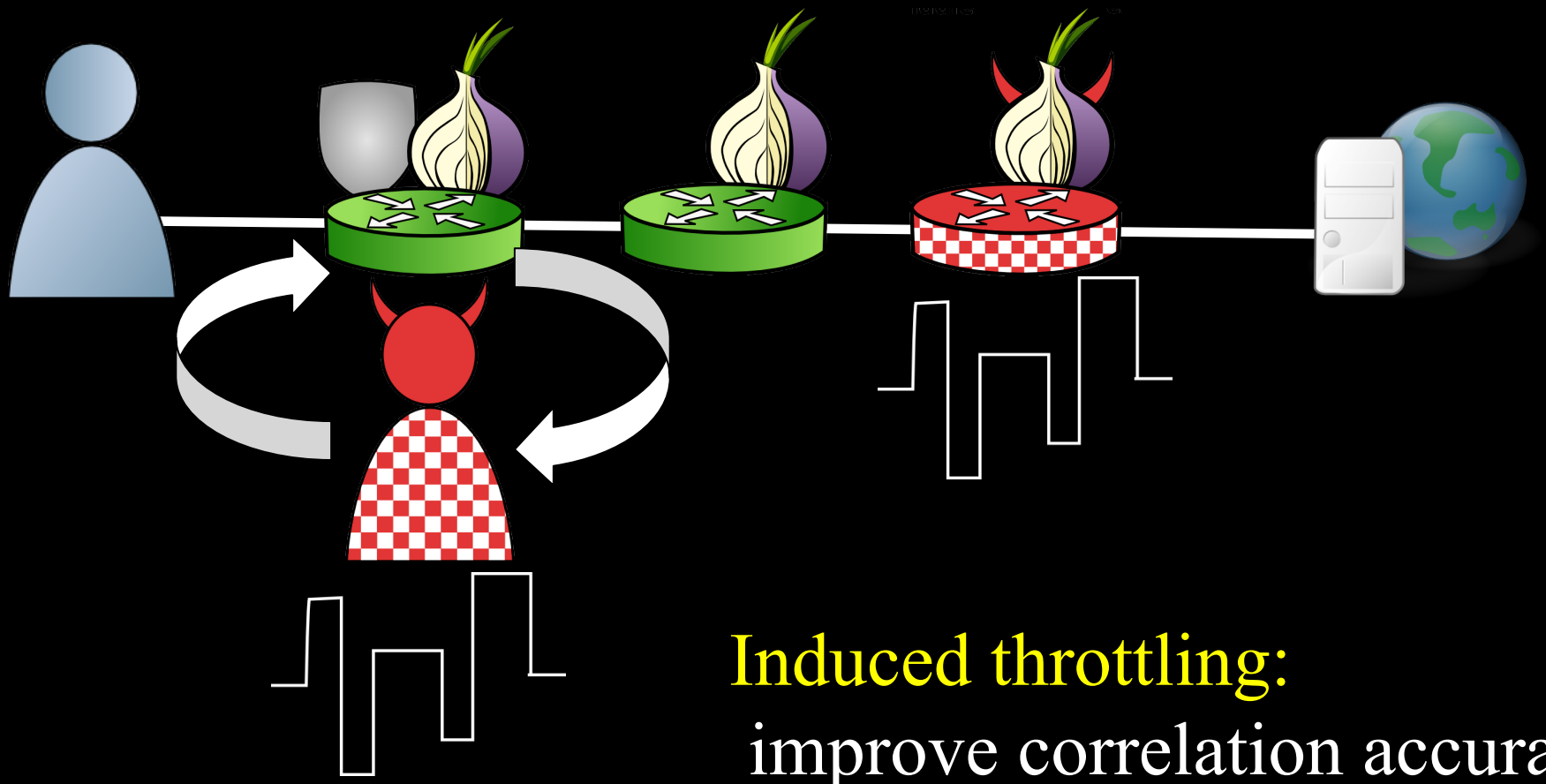
Mittal et.al. CCS'11

Traffic Correlation: Throughput



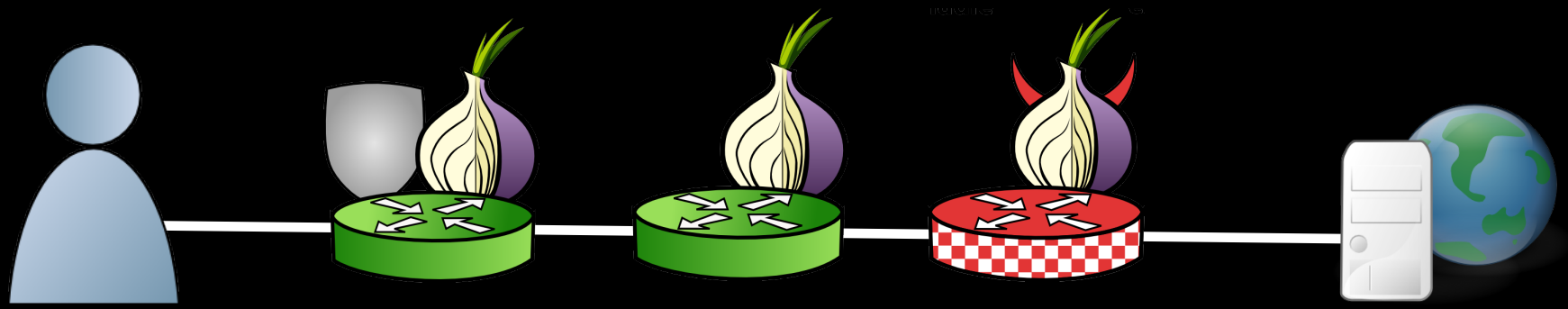
Mittal et.al. CCS'11

Traffic Correlation: Throughput



Induced throttling:
improve correlation accuracy

Traffic Correlation: Latency



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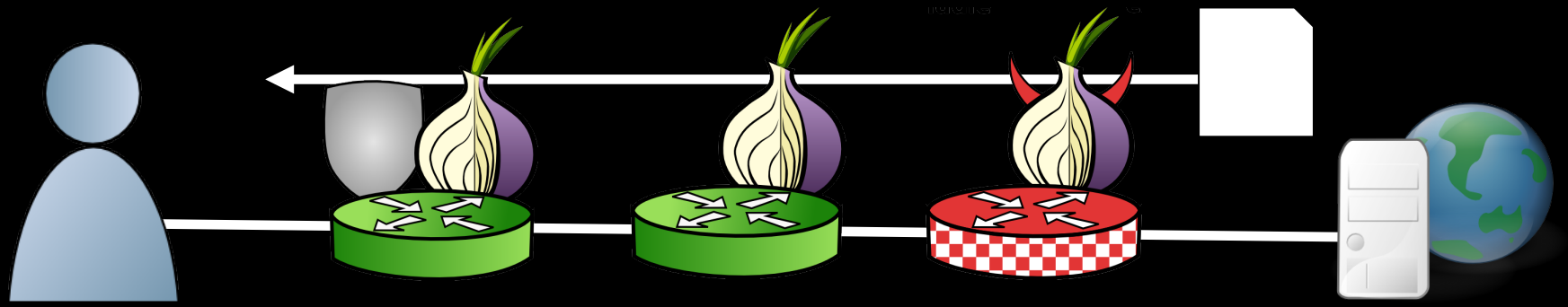
Traffic Correlation: Latency



- Inject redirect or javascript
- Start timer

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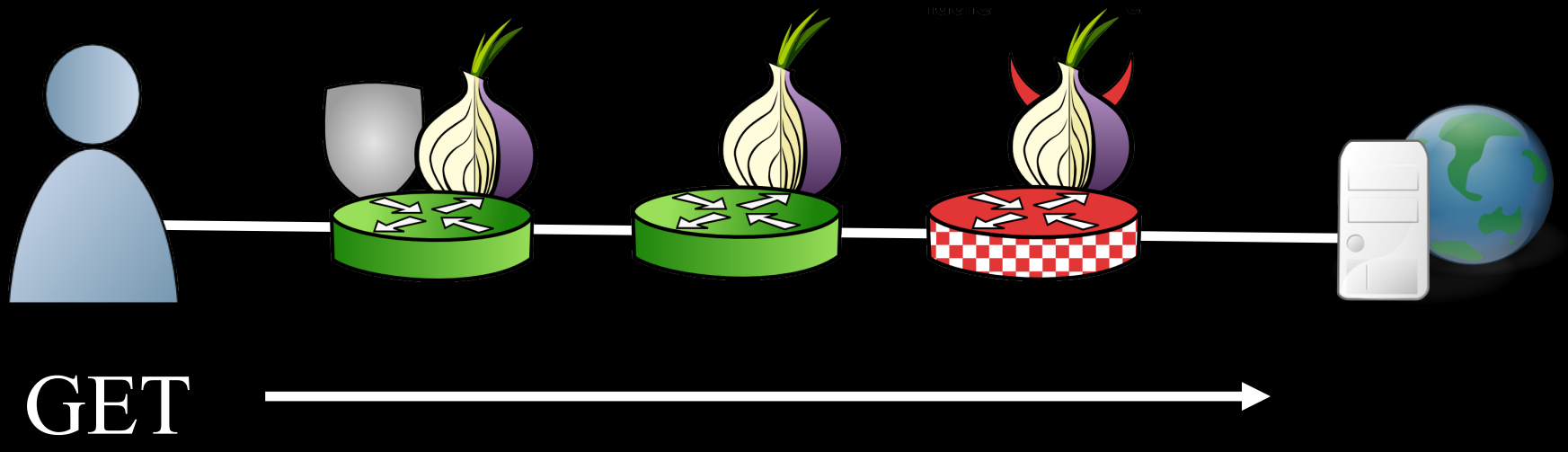
Traffic Correlation: Latency



- Request redirected page

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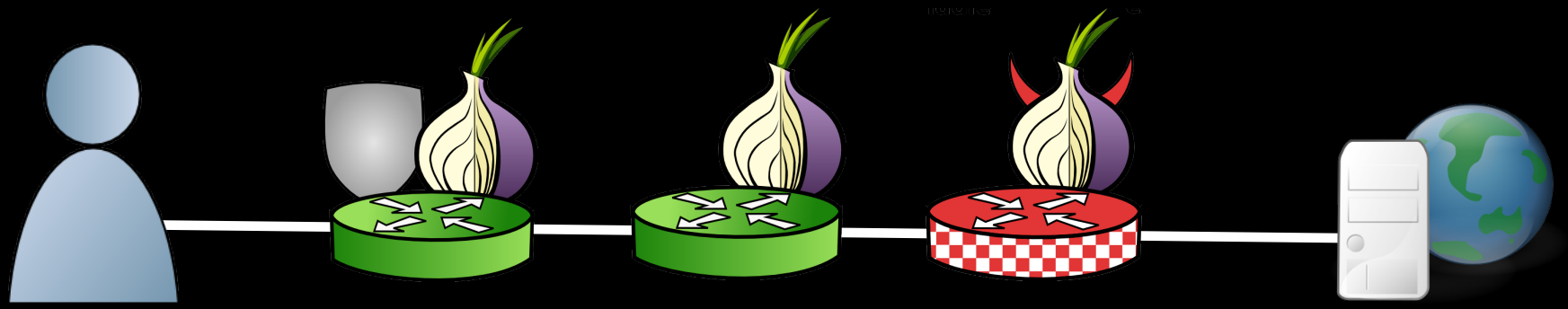
Traffic Correlation: Latency



- Stop timer
- Estimate latency

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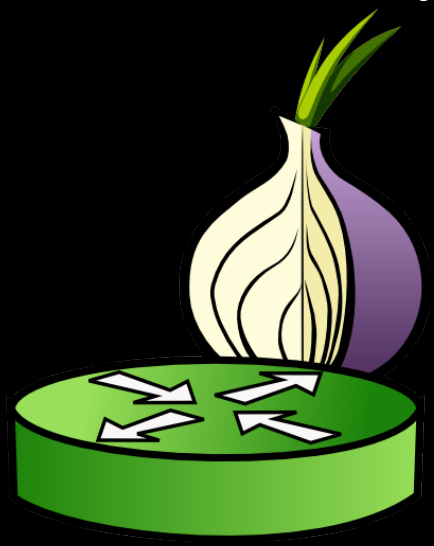
Outline

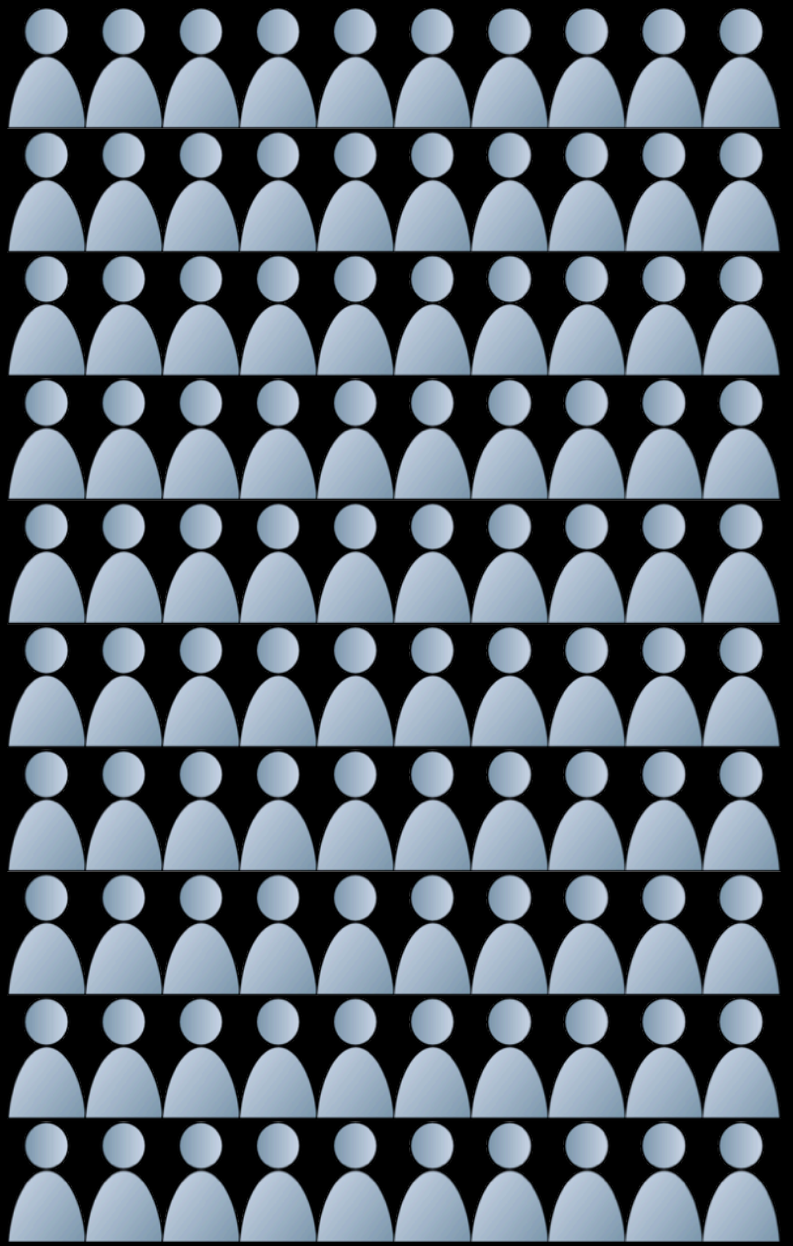
- ~~Tor intro, traffic correlation~~
- Why Tor is slow
- Traffic admission control
  - Induced throttling attack
  - Effects of throughput vs induced throttling
- Congestion control
  - Induced throttling attack
  - Effects of throughput vs induced throttling

Tor's Current Status

~3000 relays

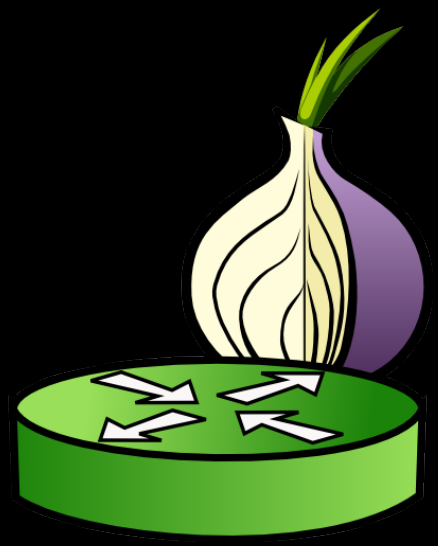


~500,000 clients

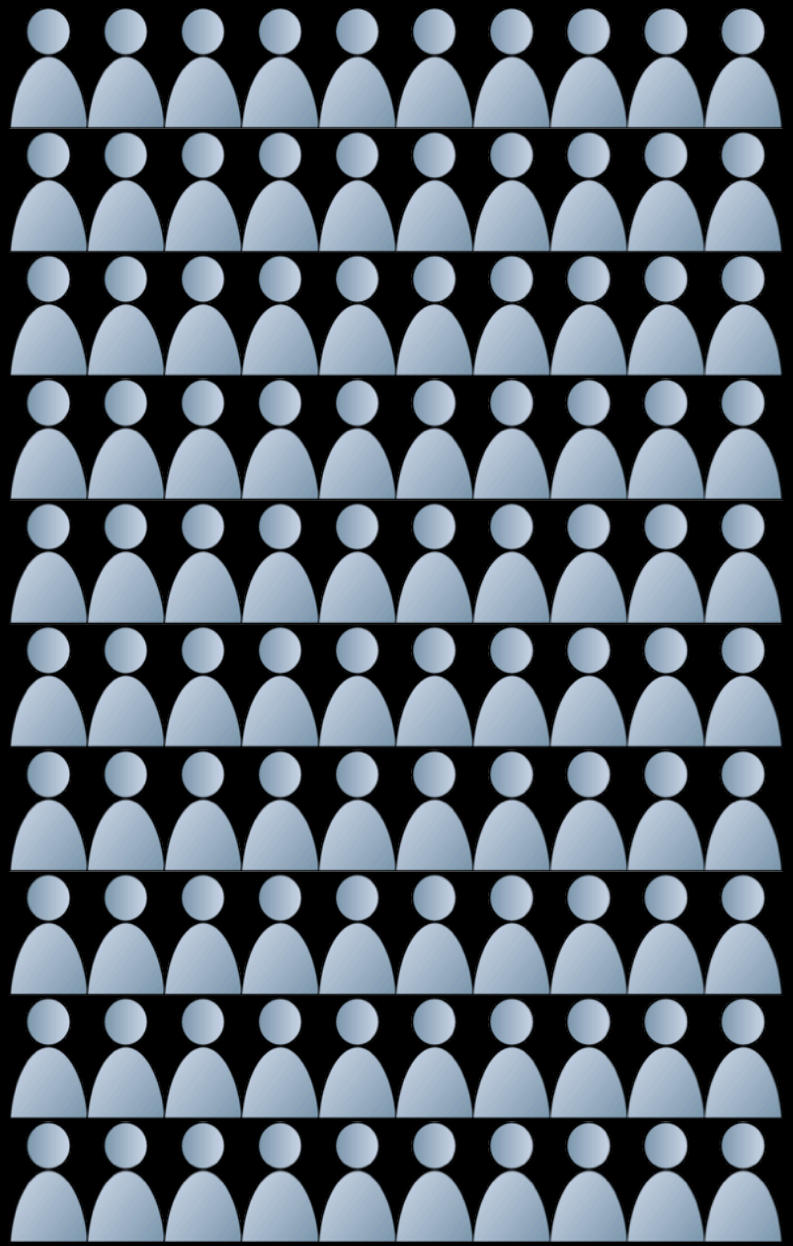


Tor's Current Status

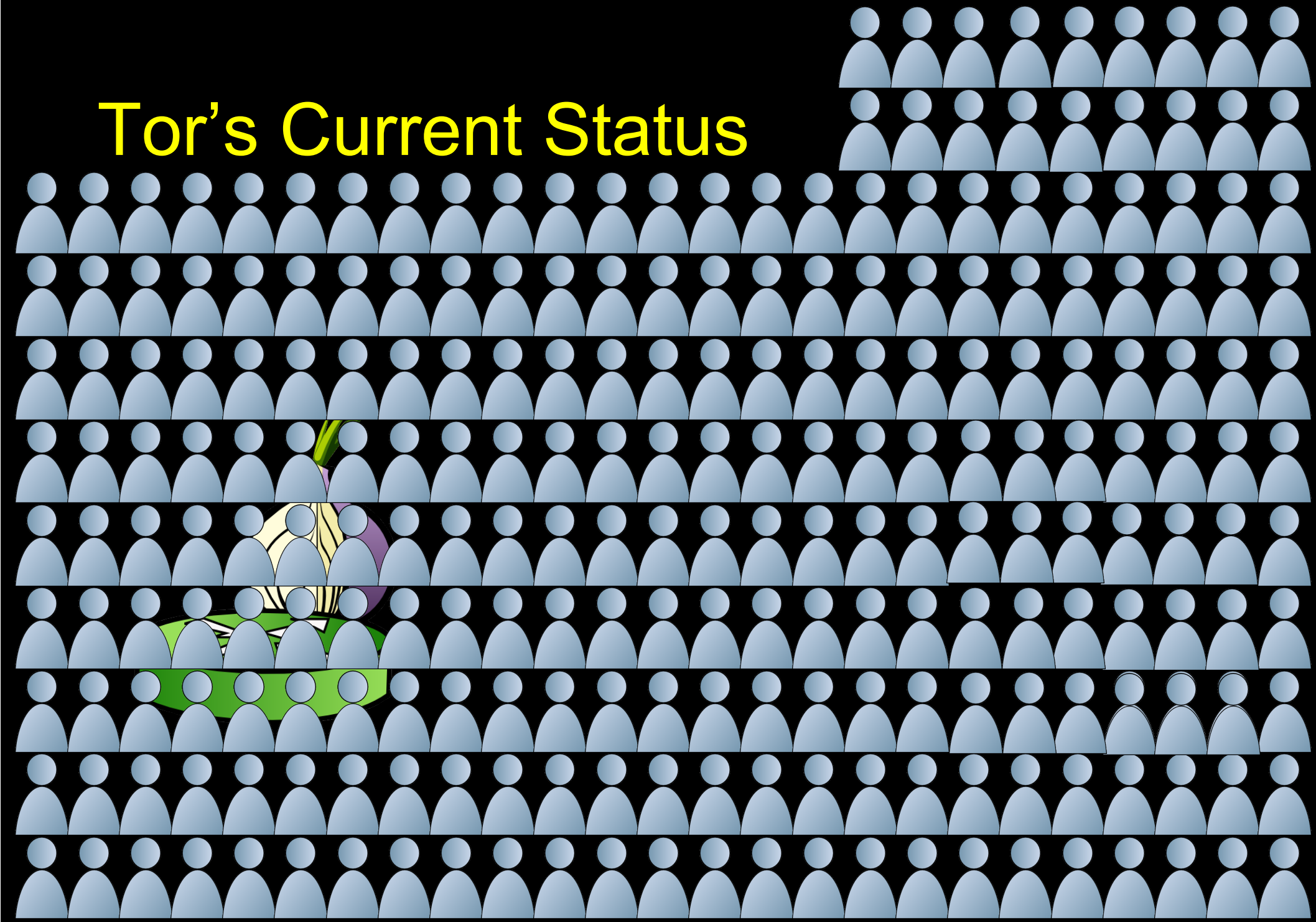
~~3000~~ 1200 relays

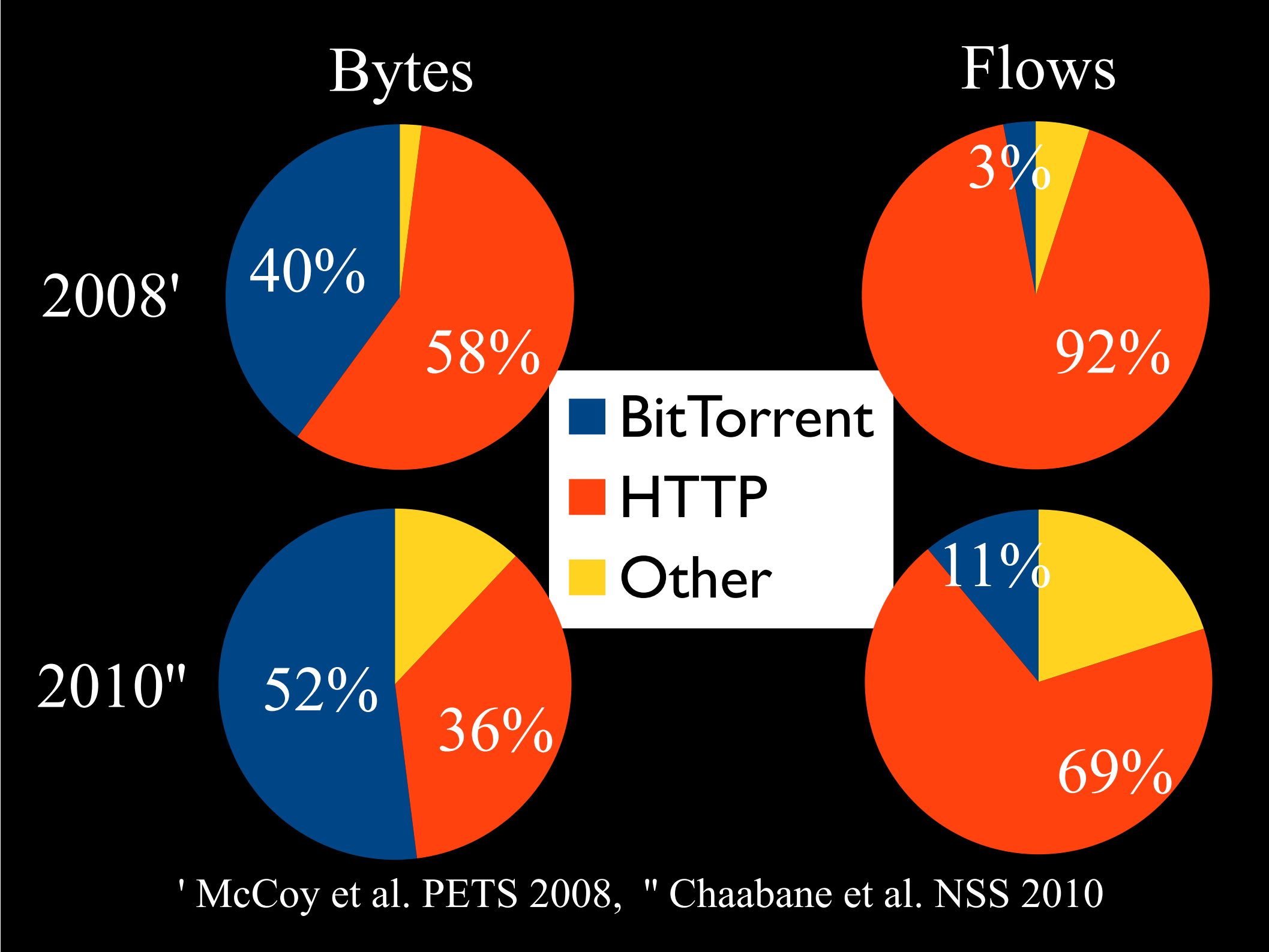


~500,000 clients



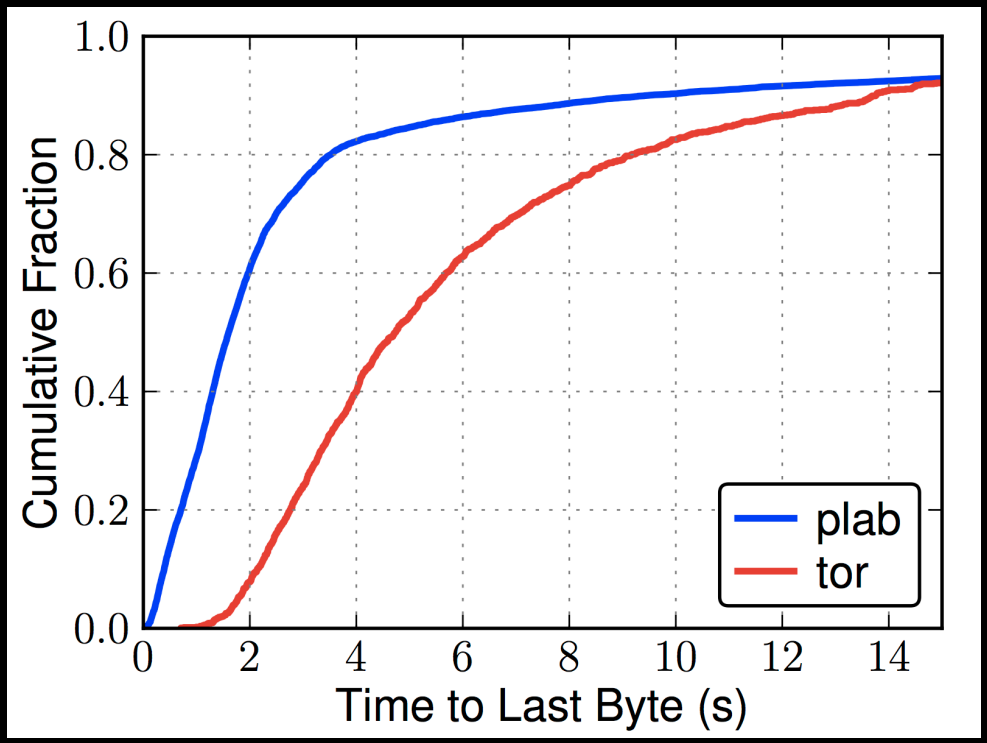
Tor's Current Status



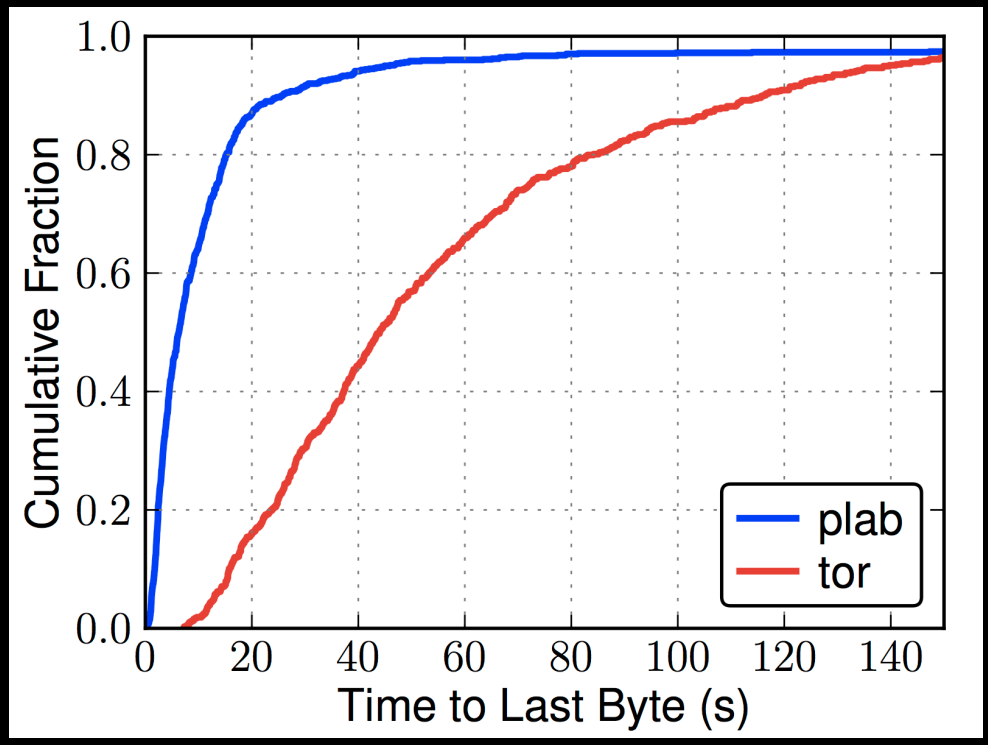

Bytes
Flows
2008'
2010"
40%
58%
3%
92%
52%
36%
11%
69%
BitTorrent
HTTP
Other
' McCoy et al. PETS 2008, " Chaabane et al. NSS 2010

Tor is Slow[er]

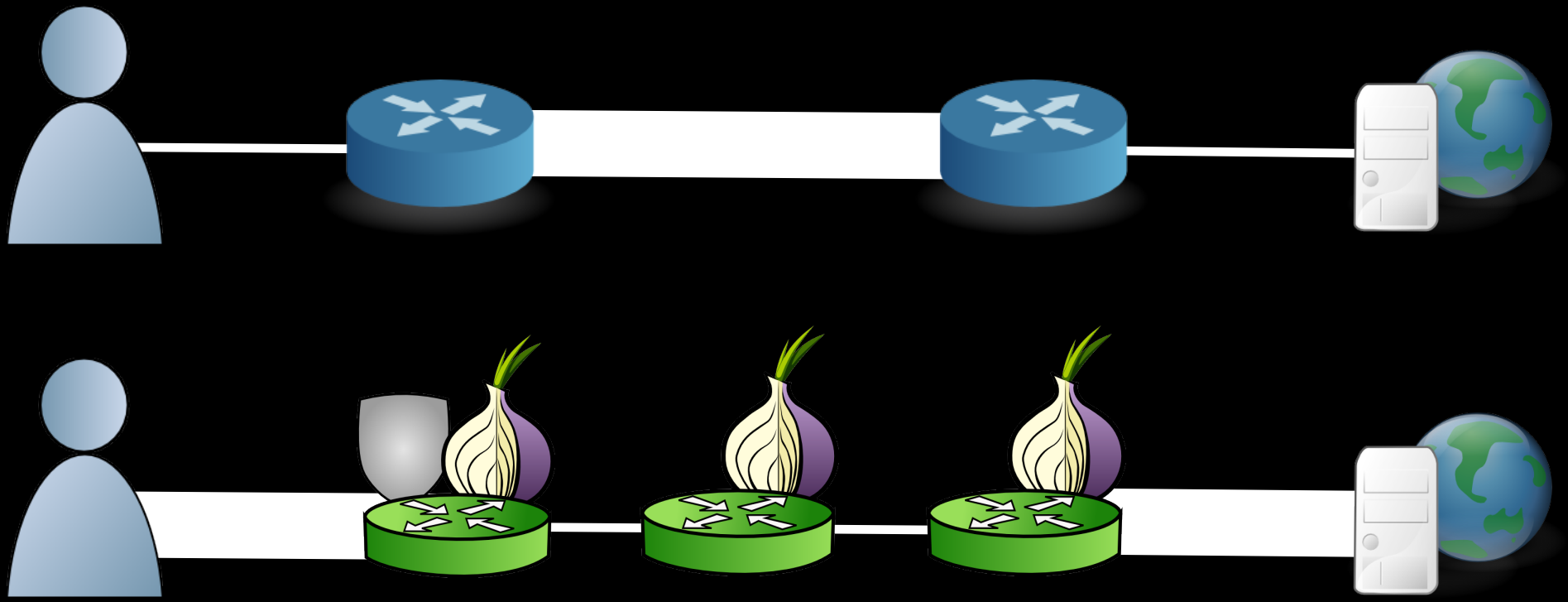
Web (320 KiB)



Bulk (5 MiB)



Tor != Internet

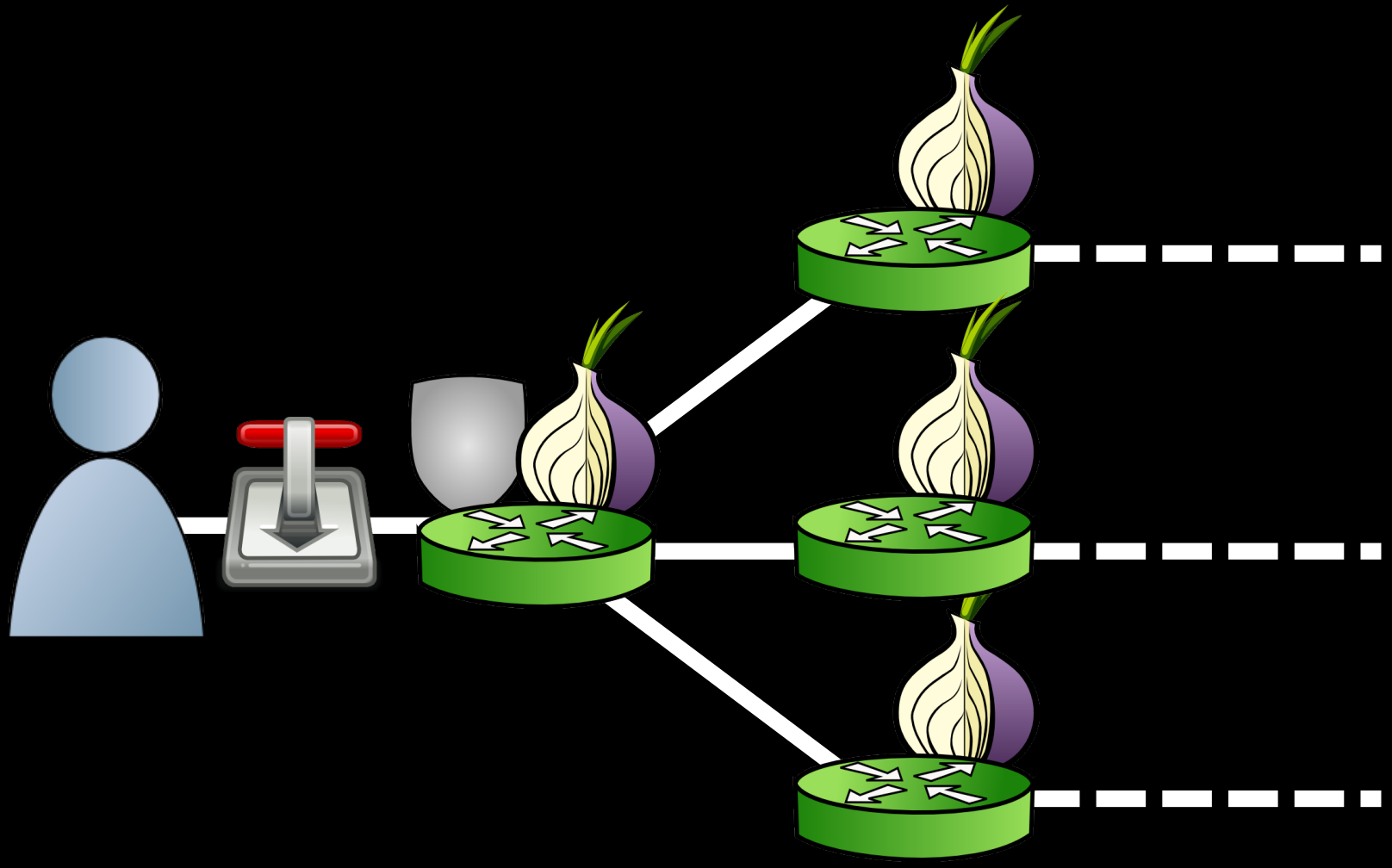


- Specialized Tor performance enhancements
  - Reducing load: traffic admission control
  - Reducing load, improving utilization: congestion control

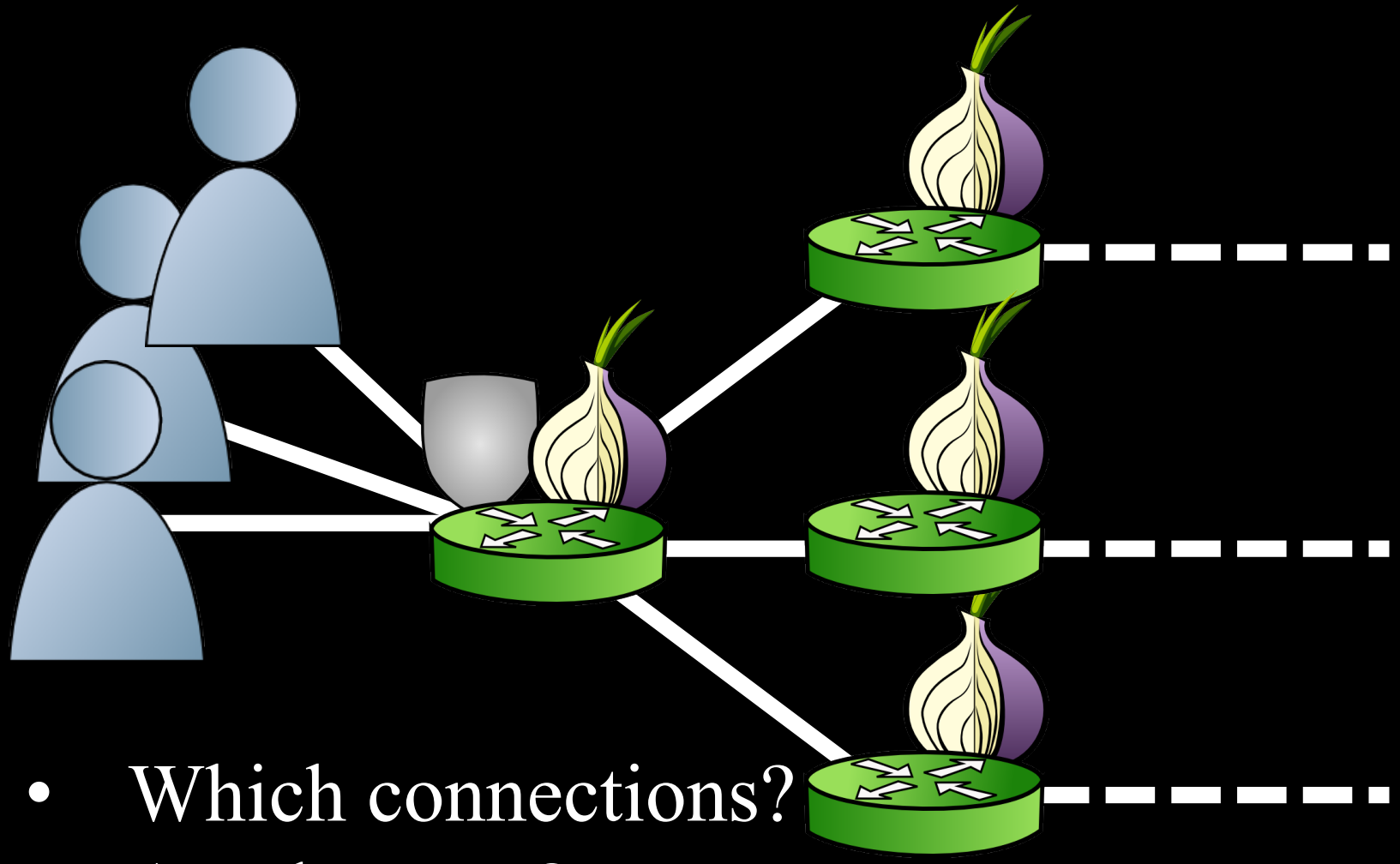
Outline

- ~~Tor intro, traffic correlation~~
- ~~Why Tor is slow~~
- Traffic admission control
  - Induced throttling attack
  - Effects of throughput vs induced throttling
- Congestion control
  - Induced throttling attack
  - Effects of throughput vs induced throttling

Traffic Admission Control

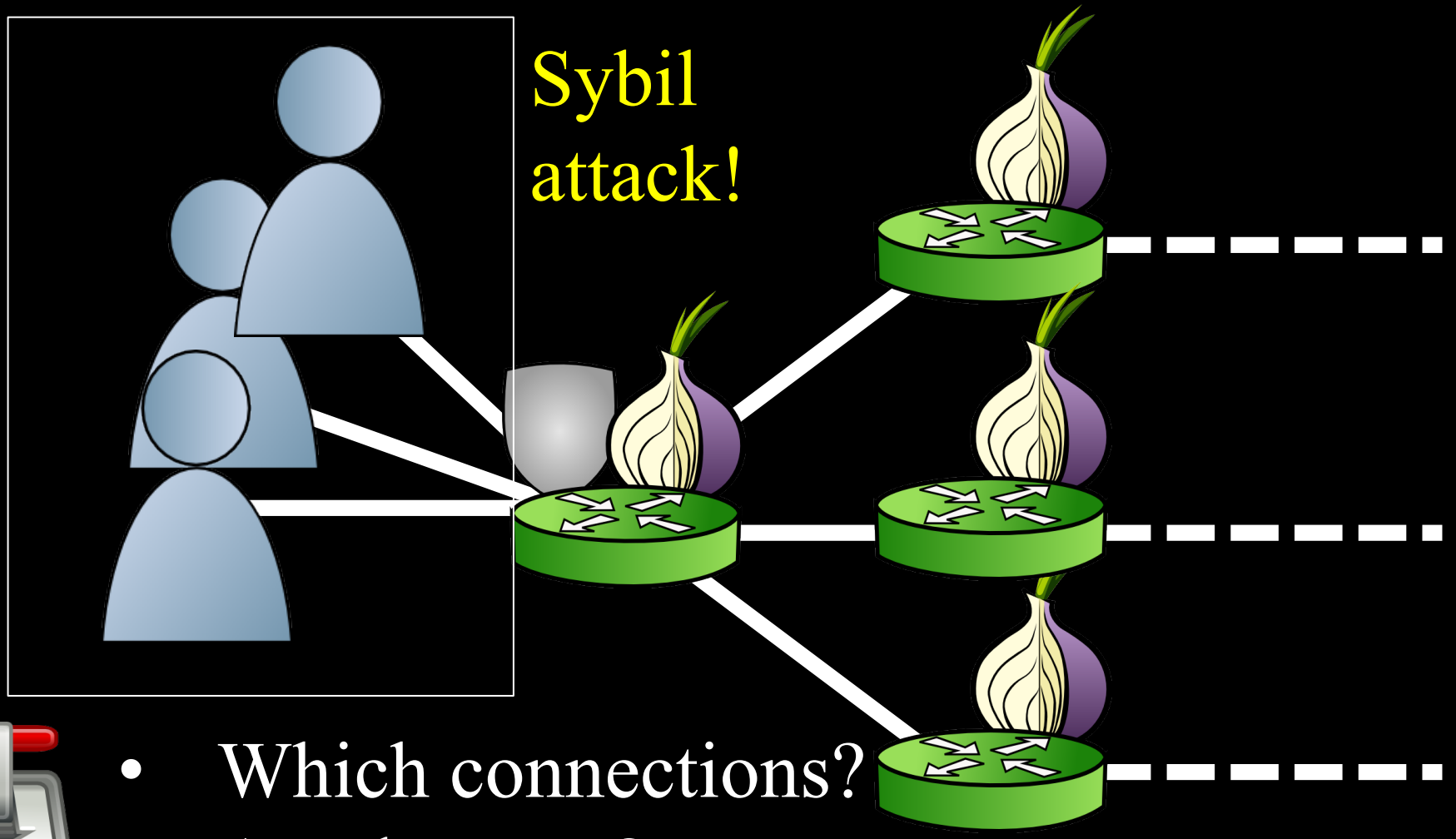


Traffic Admission Control



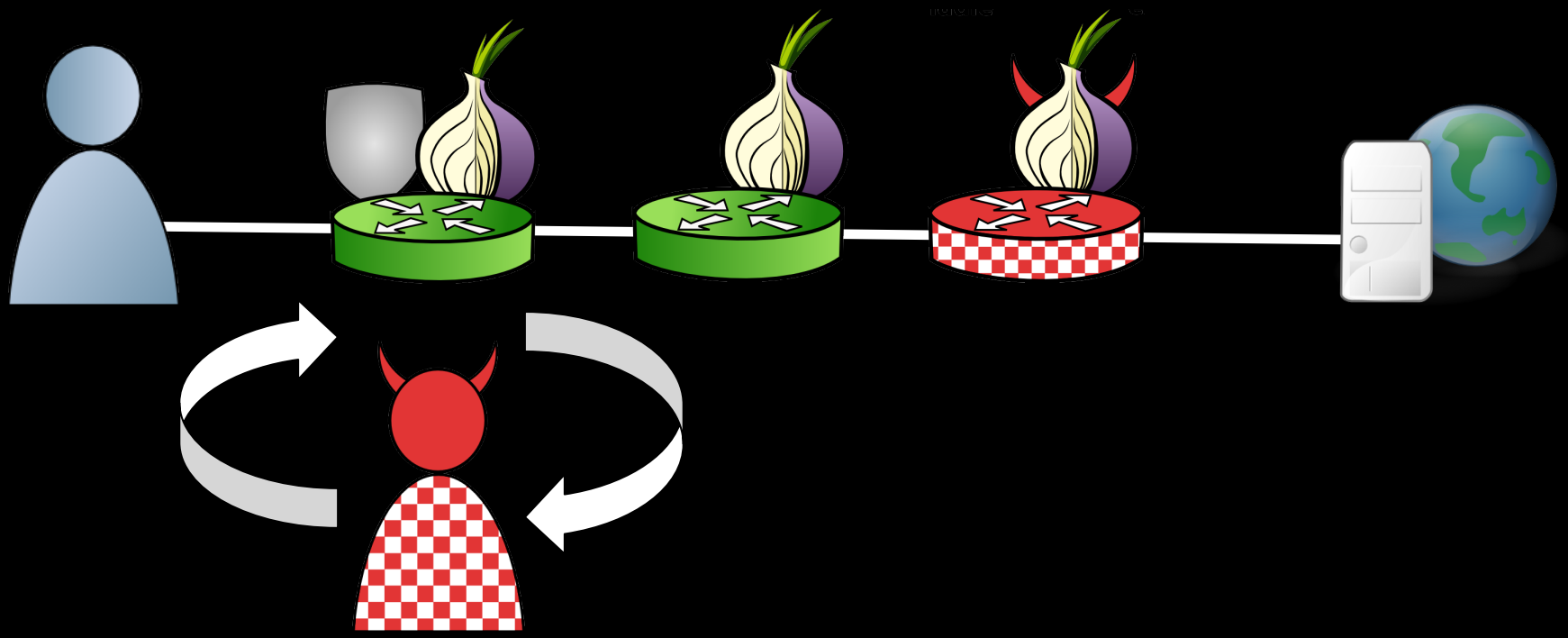
- Which connections?
- At what rate?

Traffic Admission Control



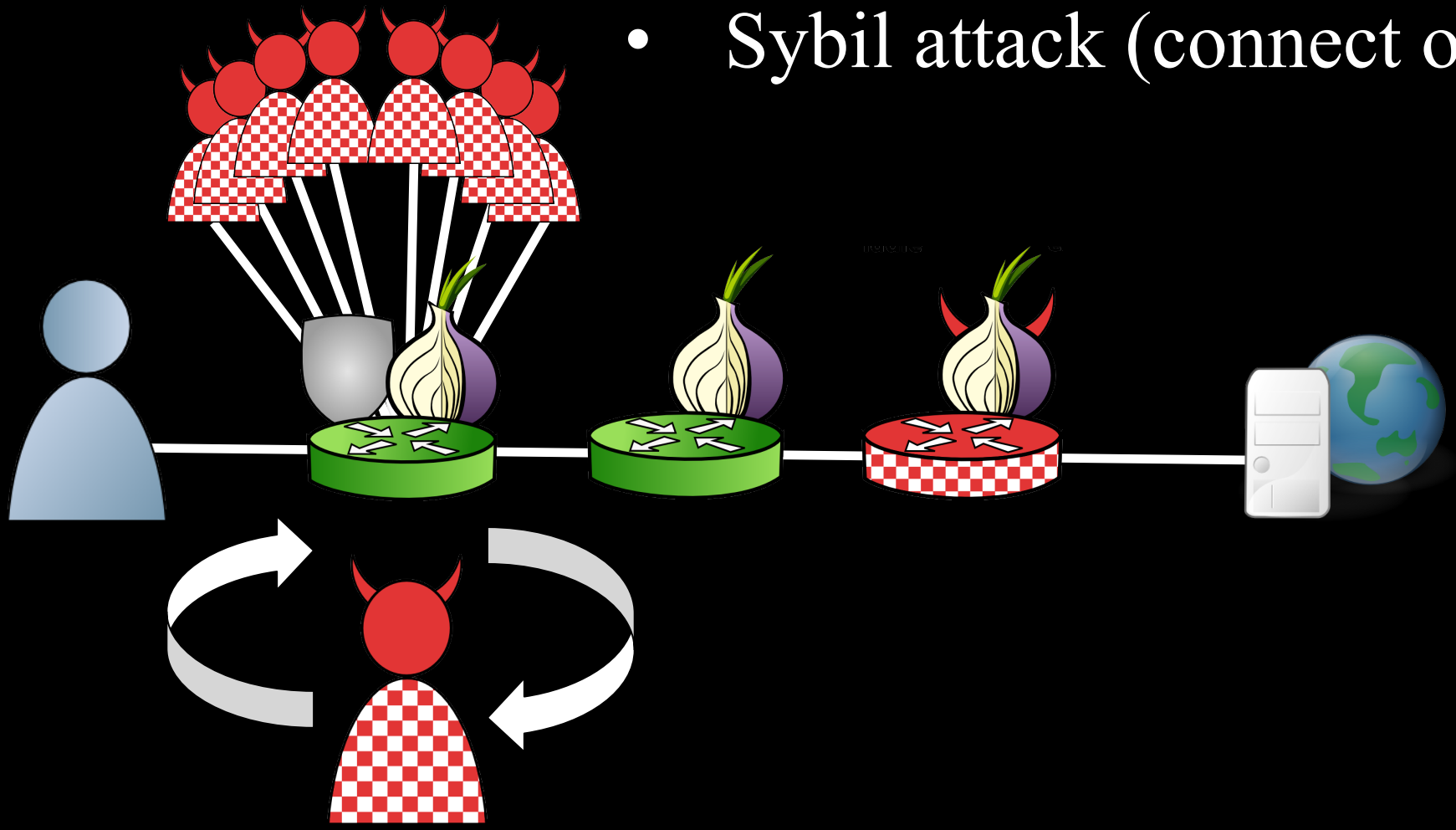
- Which connections?
- At what rate?

Traffic Admission Control

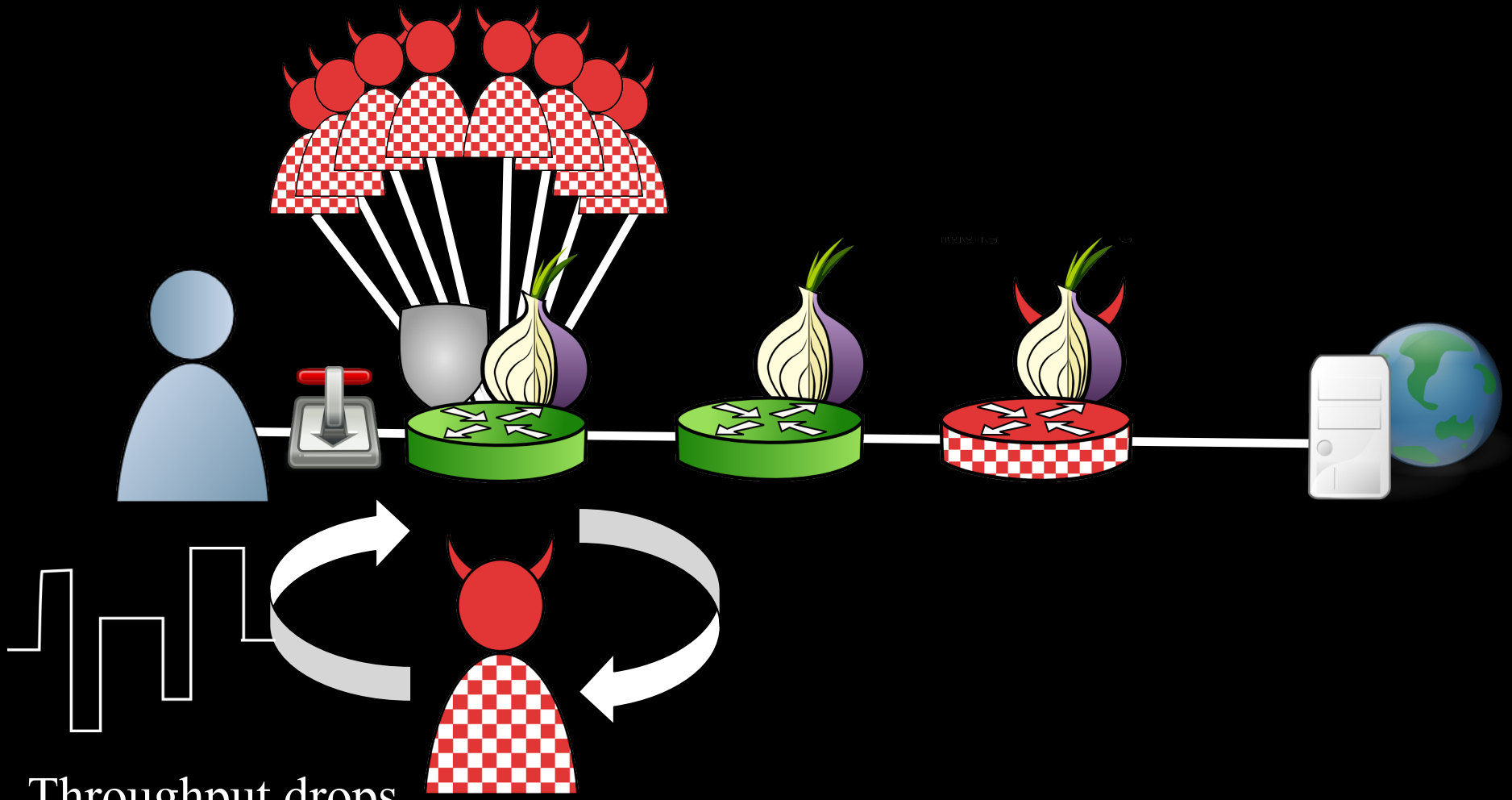


Traffic Admission Control

- Sybil attack (connect only)



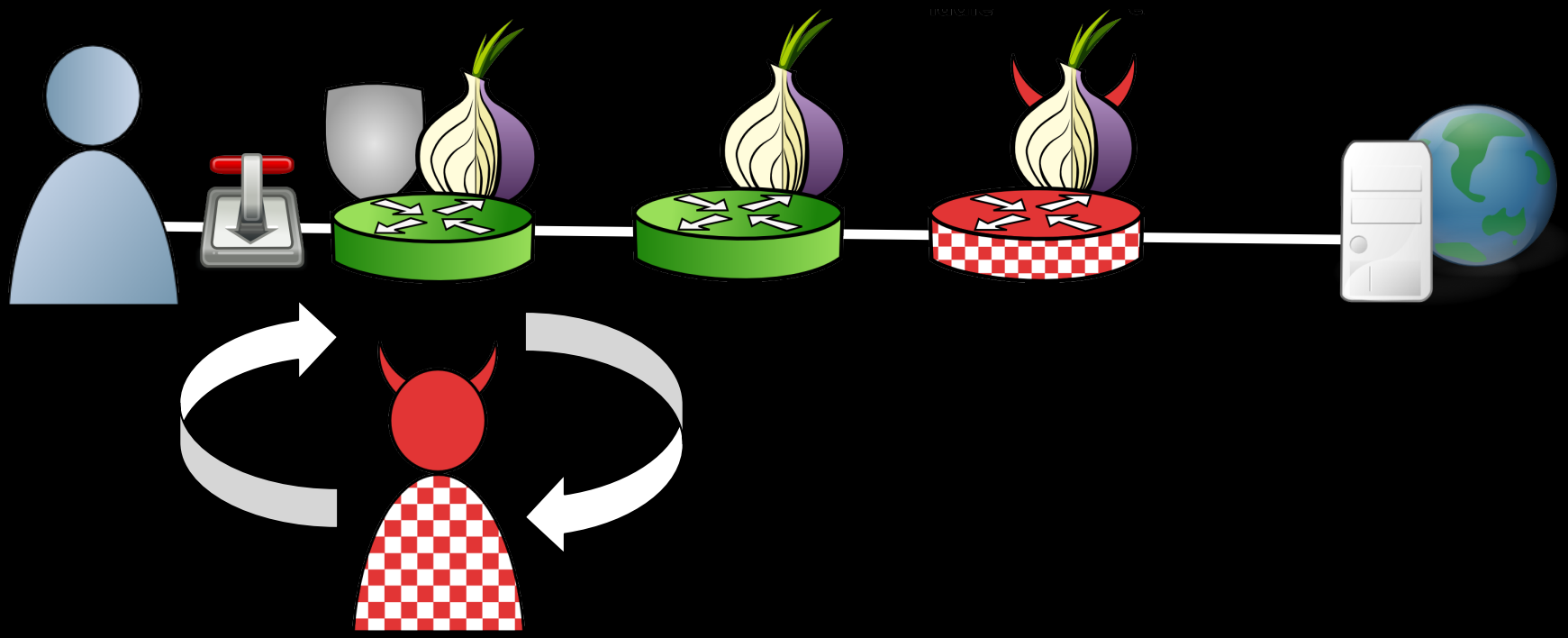
Traffic Admission Control



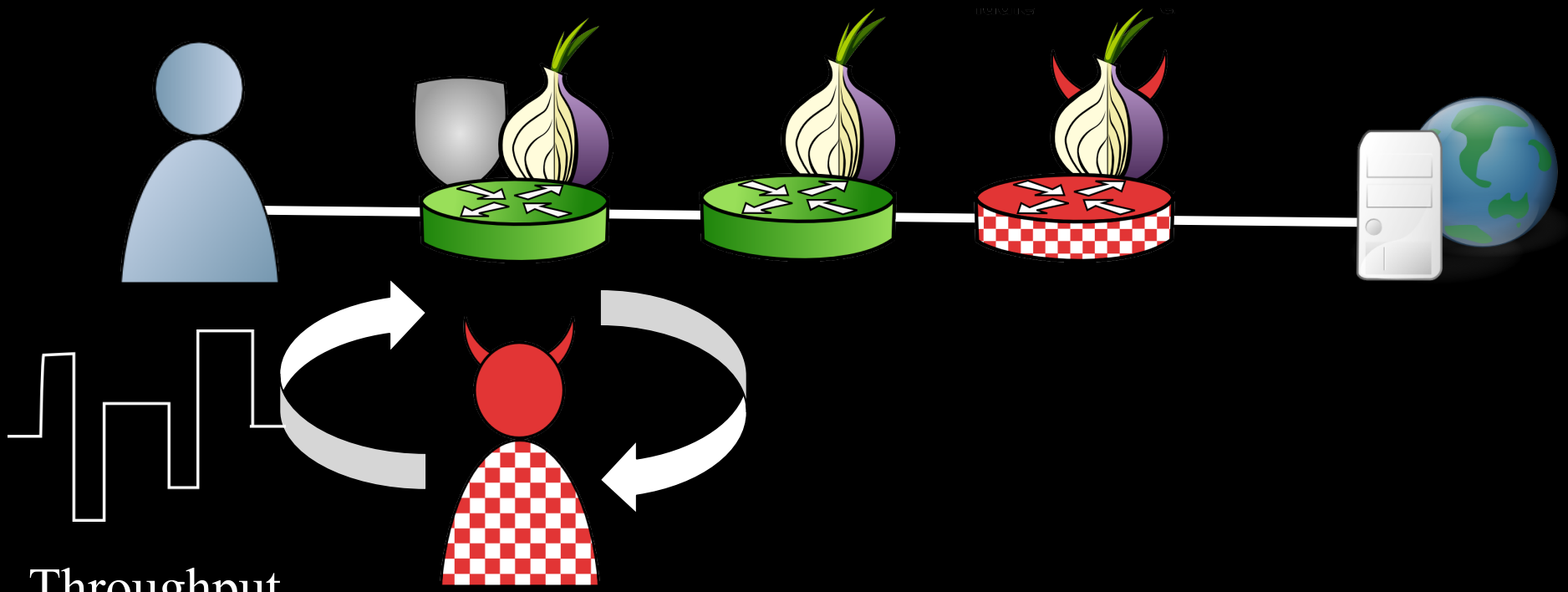
Throughput drops
to throttle rate

Traffic Admission Control

- Disconnect sybils

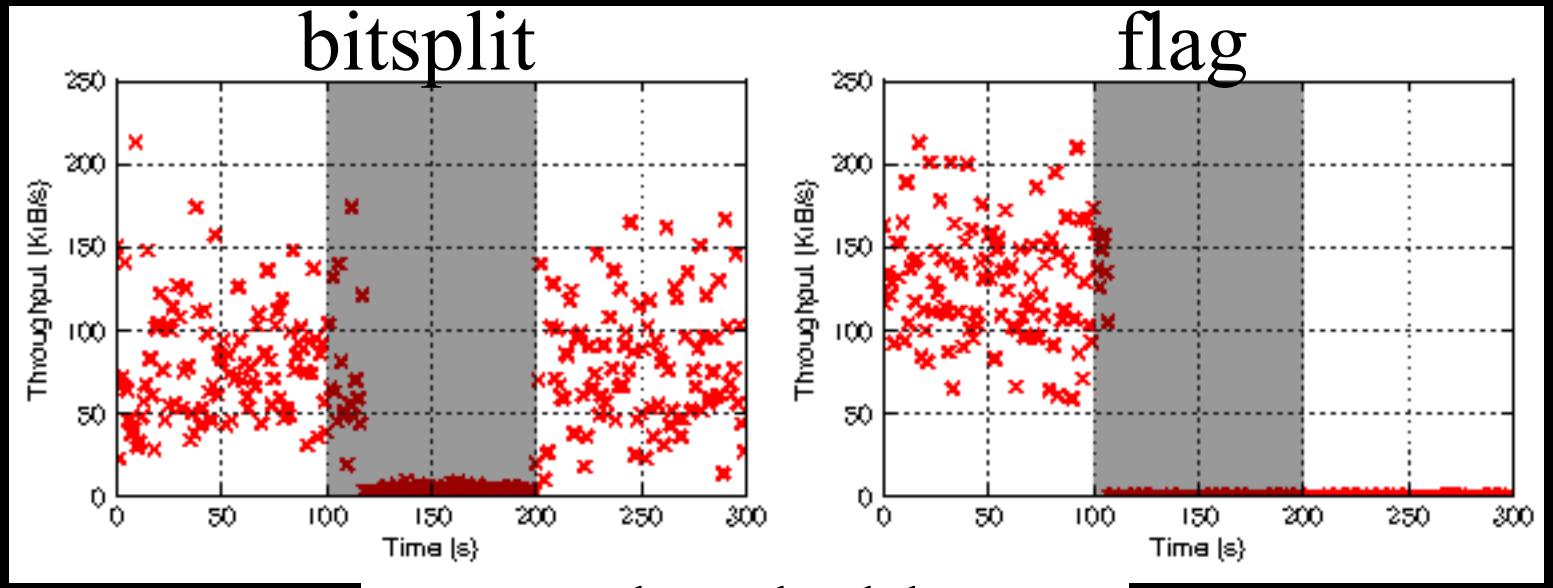


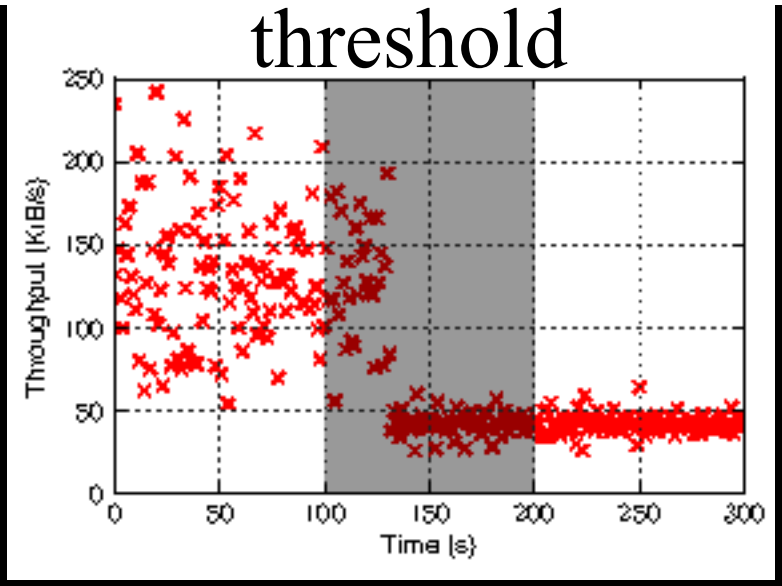
Traffic Admission Control



Throughput increases

Induced Throttling Prototype





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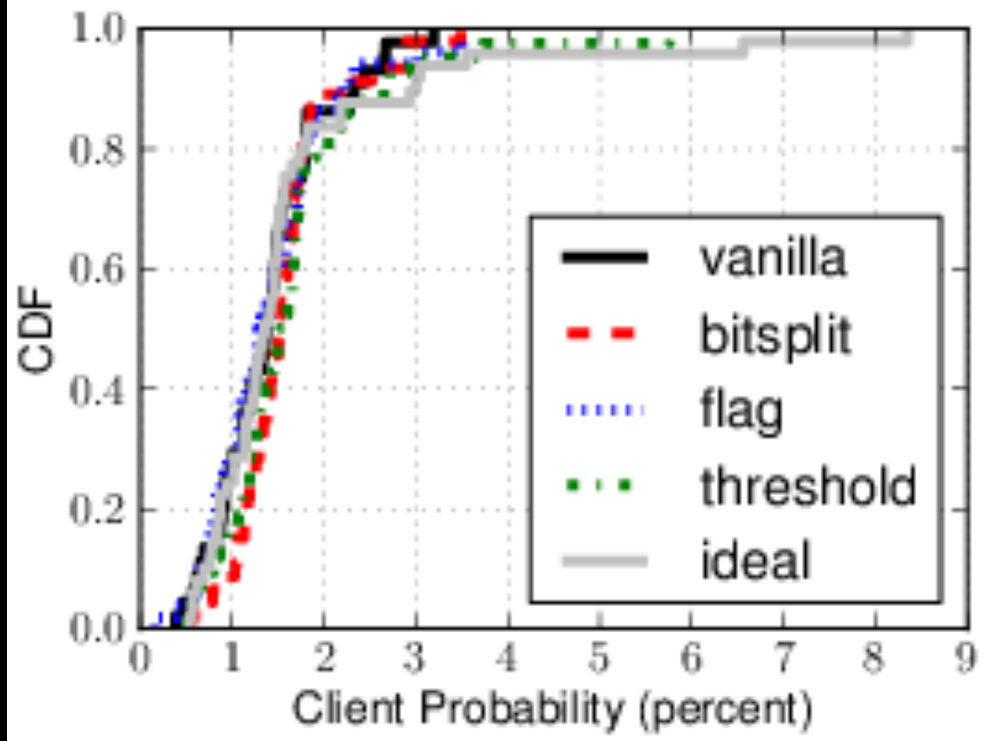
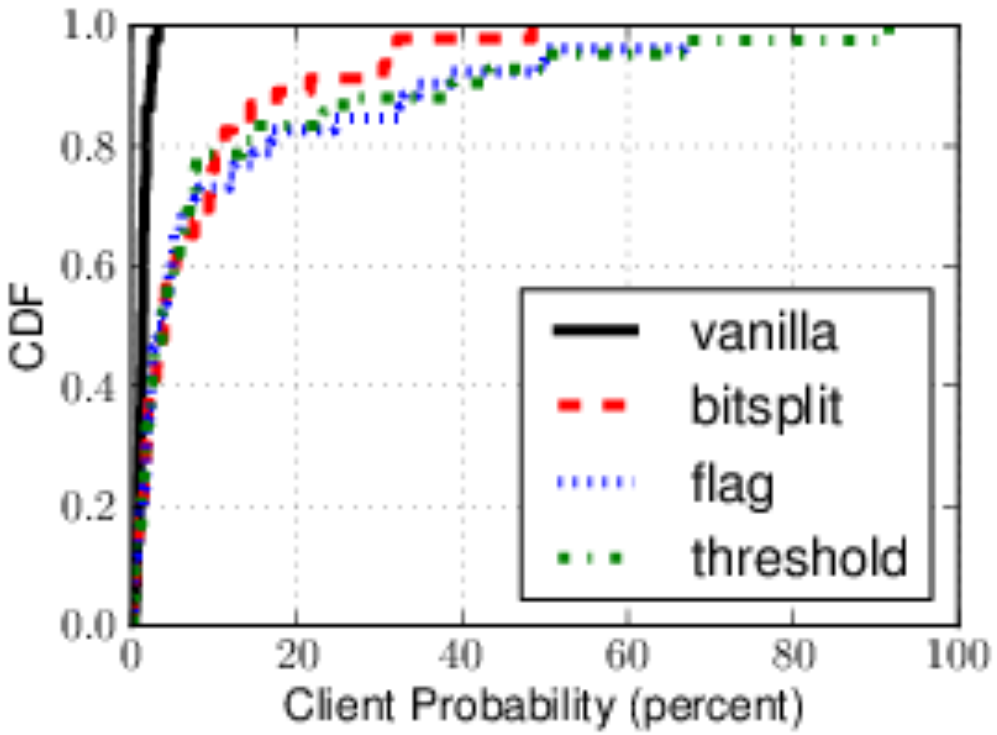
Induced Throttling Results

$$P[V = C_i] = \sum_j P[V = C_i \mid R_j] P[G = R_j]$$





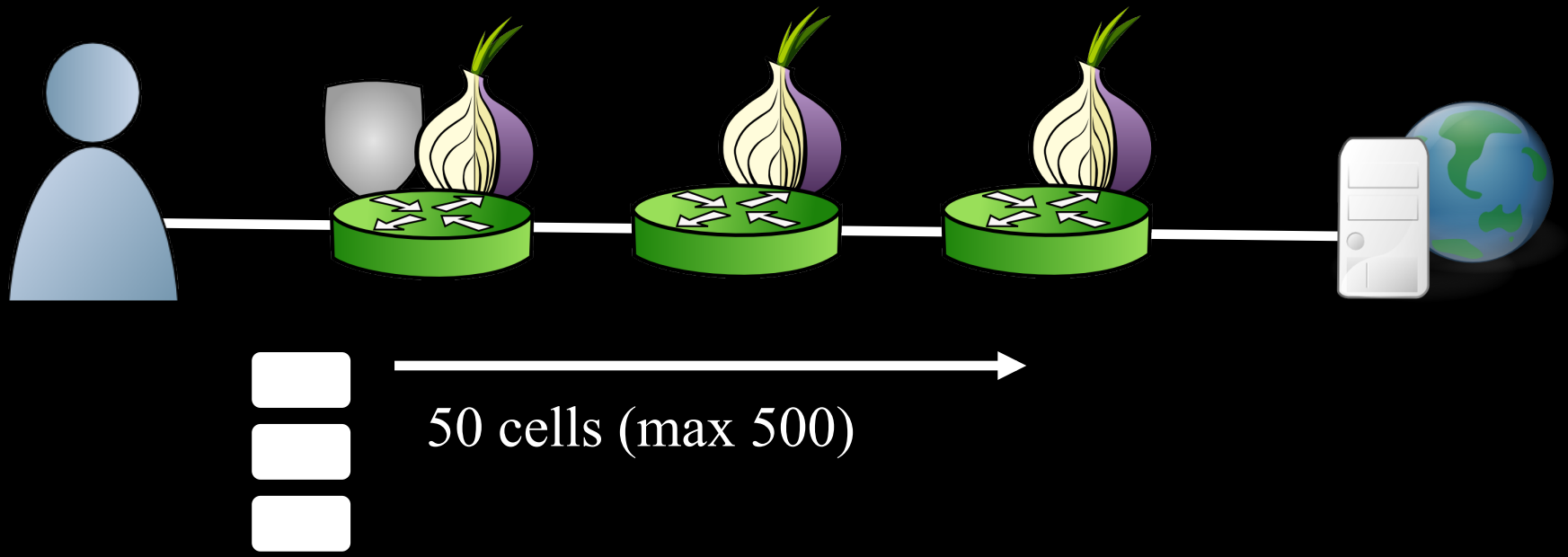
Throughput Attack

Induced Throttling Attack

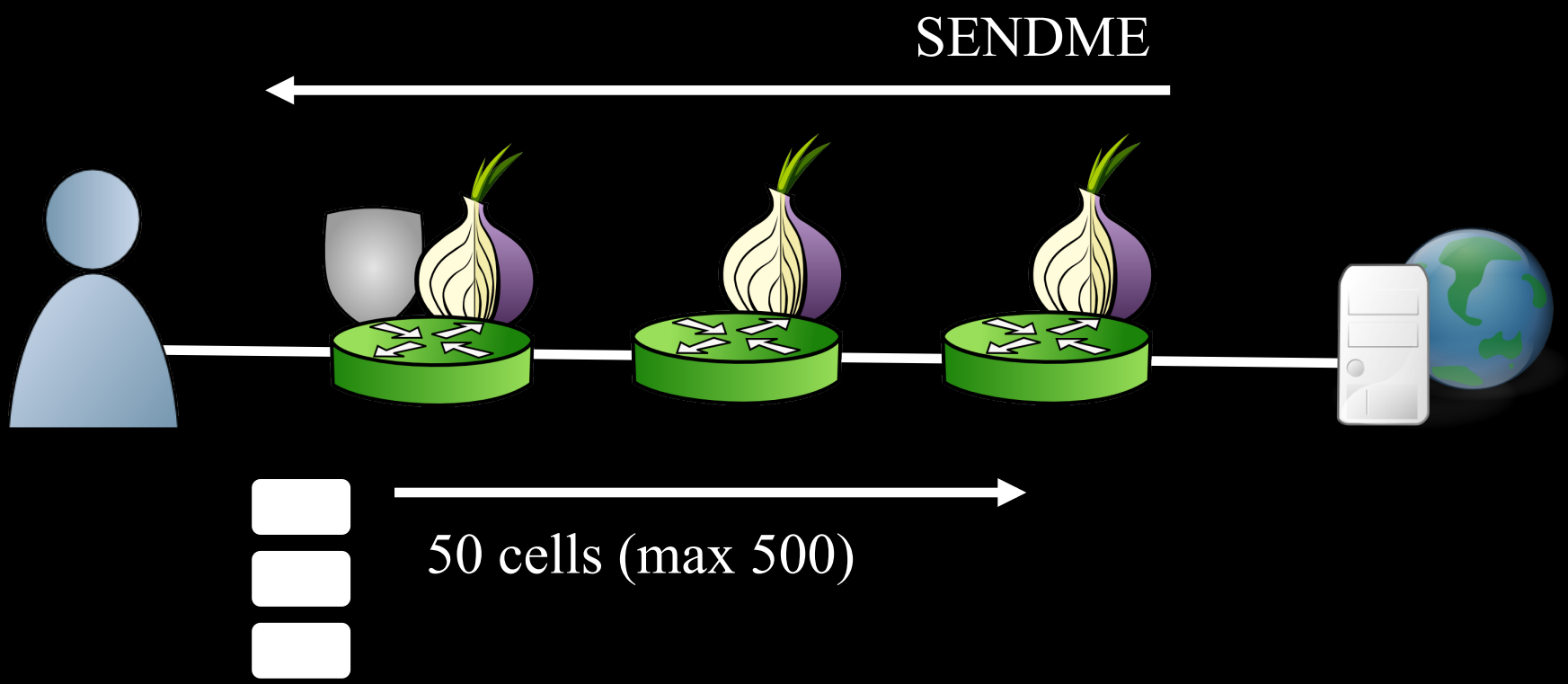
Outline

- ~~Tor intro, traffic correlation~~
- ~~Why Tor is slow~~
- ~~Traffic admission control~~
  - ~~Induced throttling attack~~
  - ~~Effects of throughput vs induced throttling~~
- Congestion control
  - Induced throttling attack
  - Effects of throughput vs induced throttling

Congestion Control



Congestion Control



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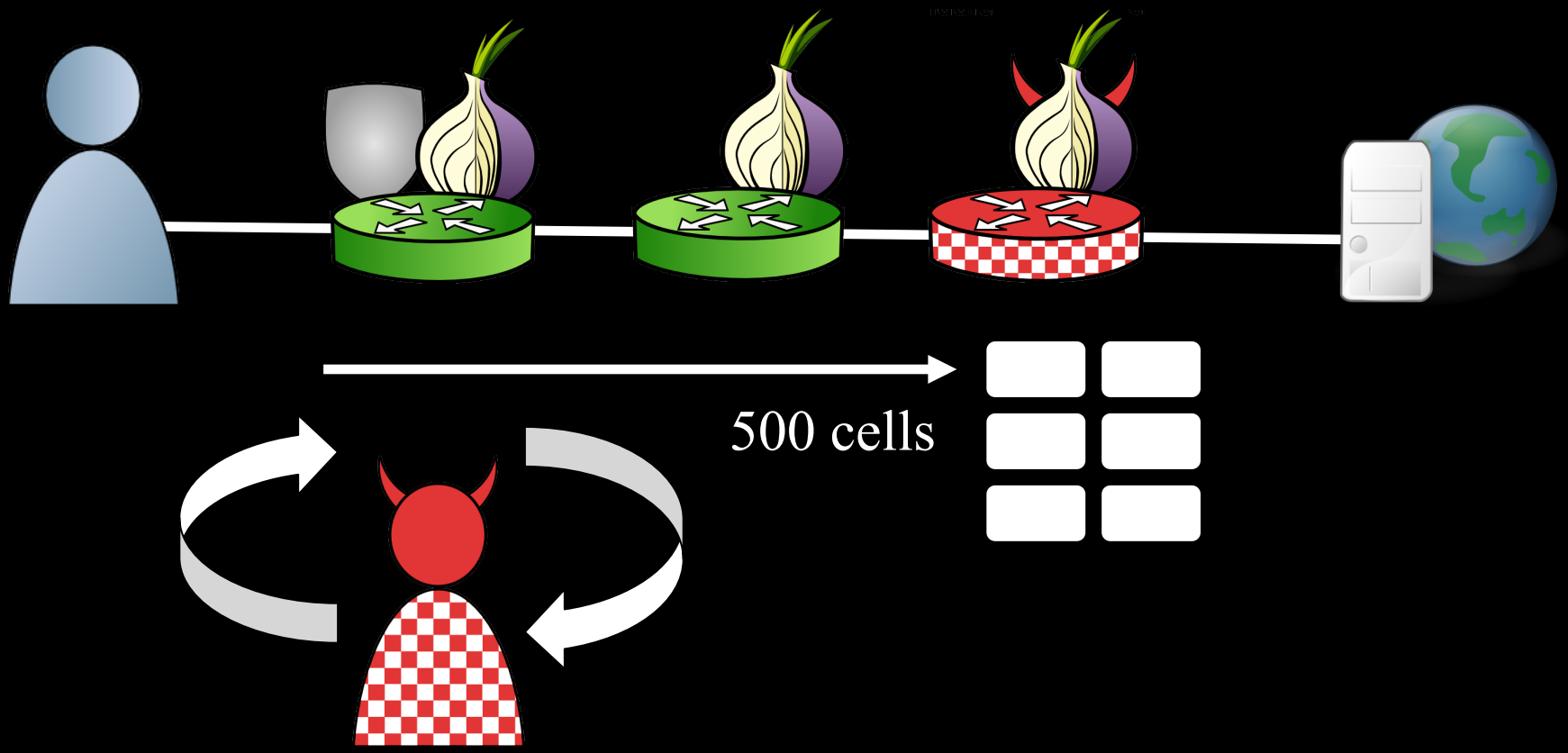
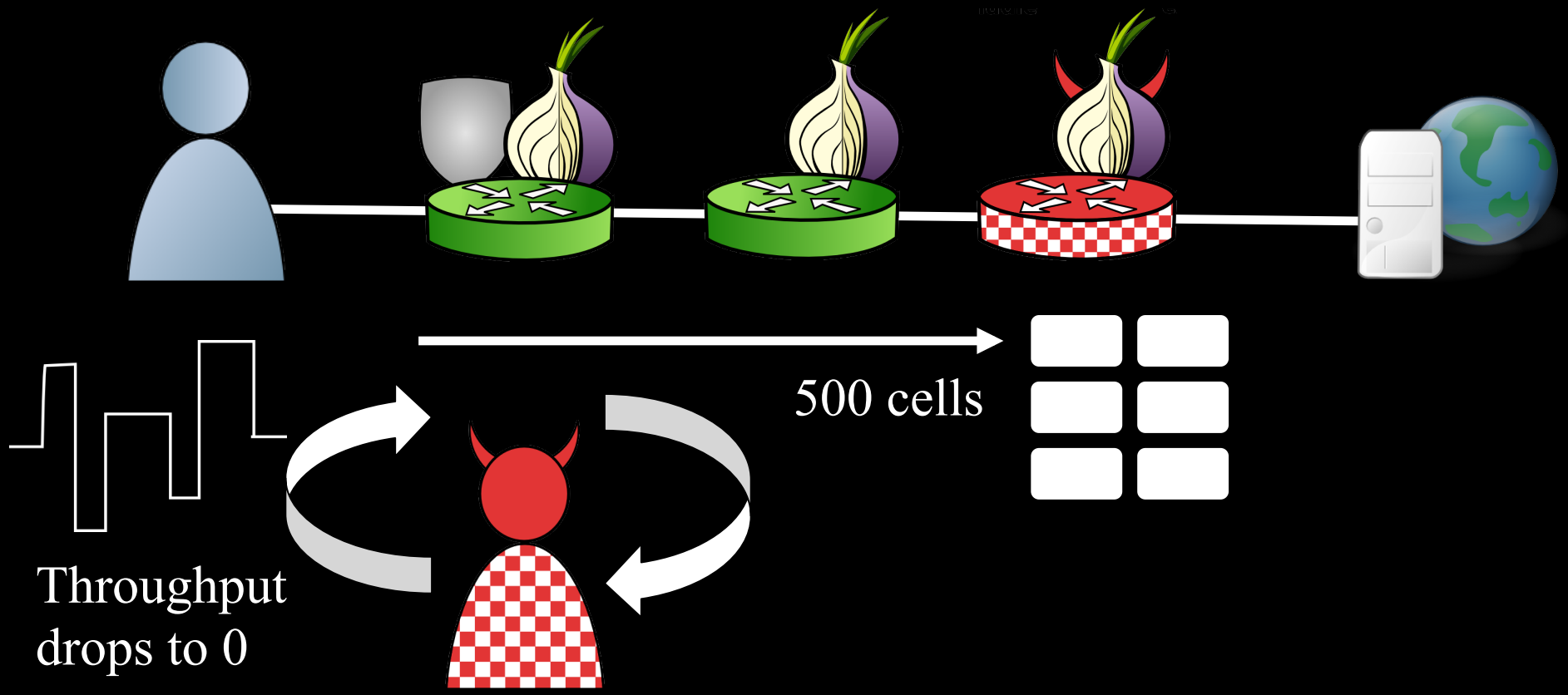
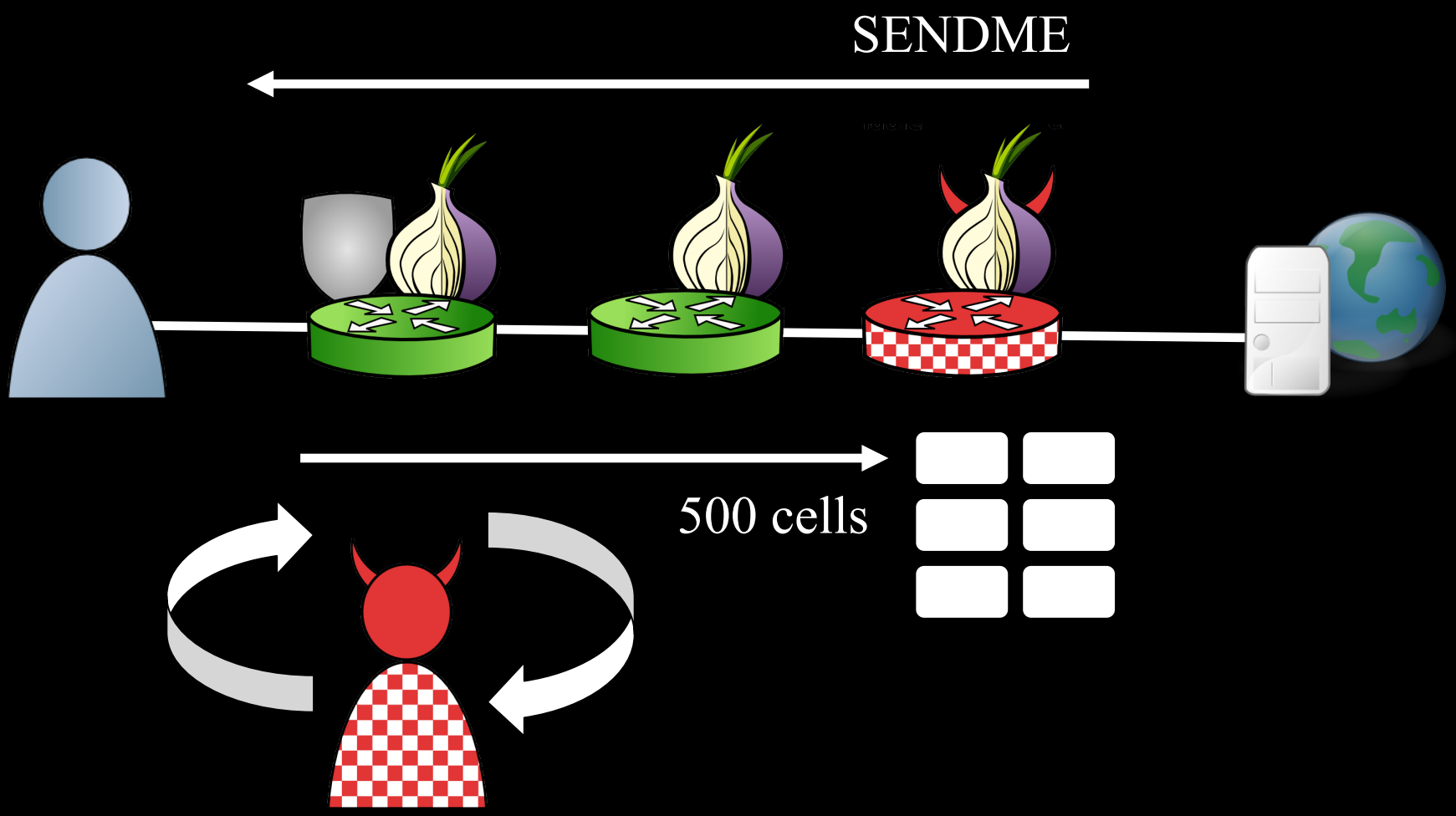


Congestion Control



Congestion Control



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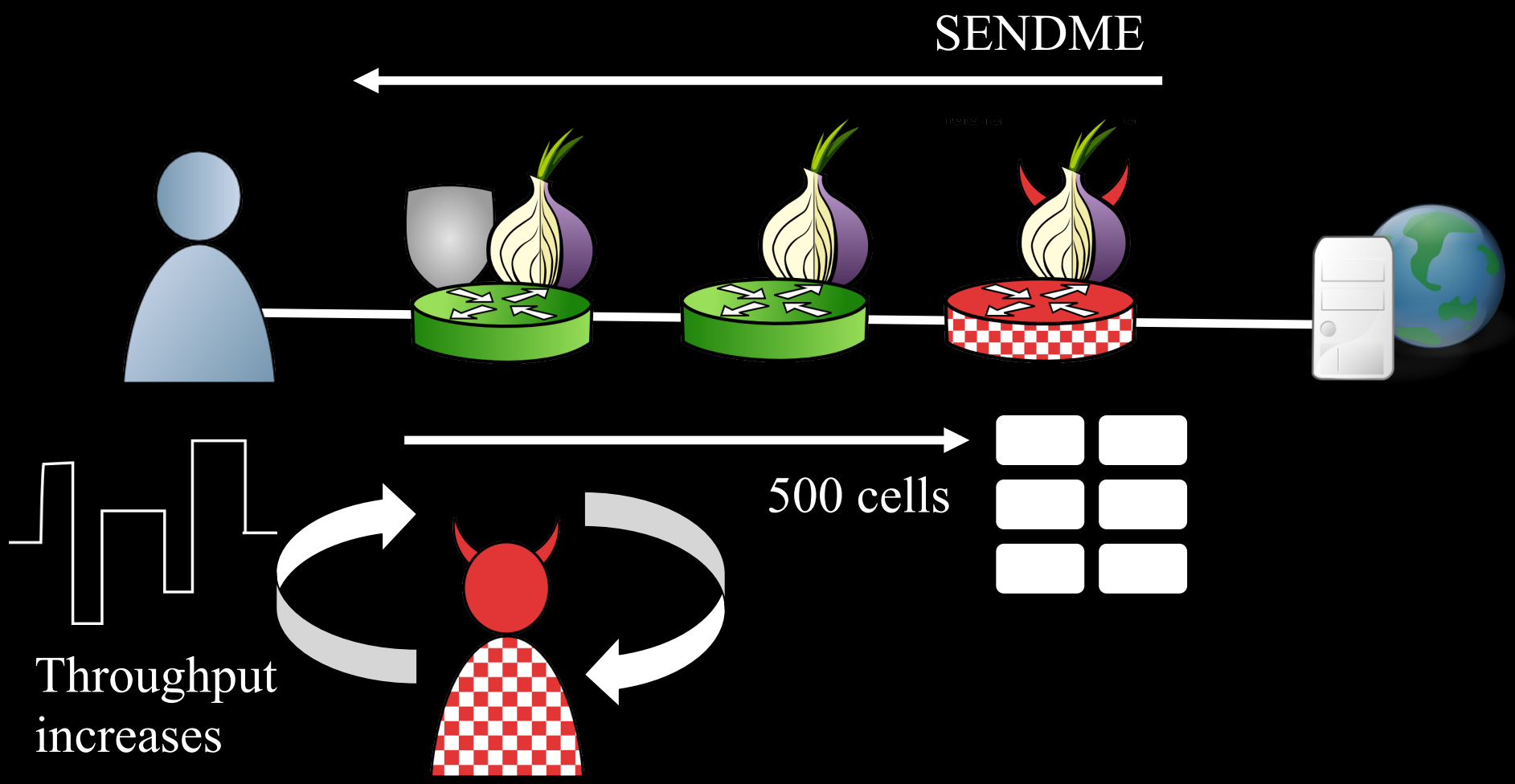
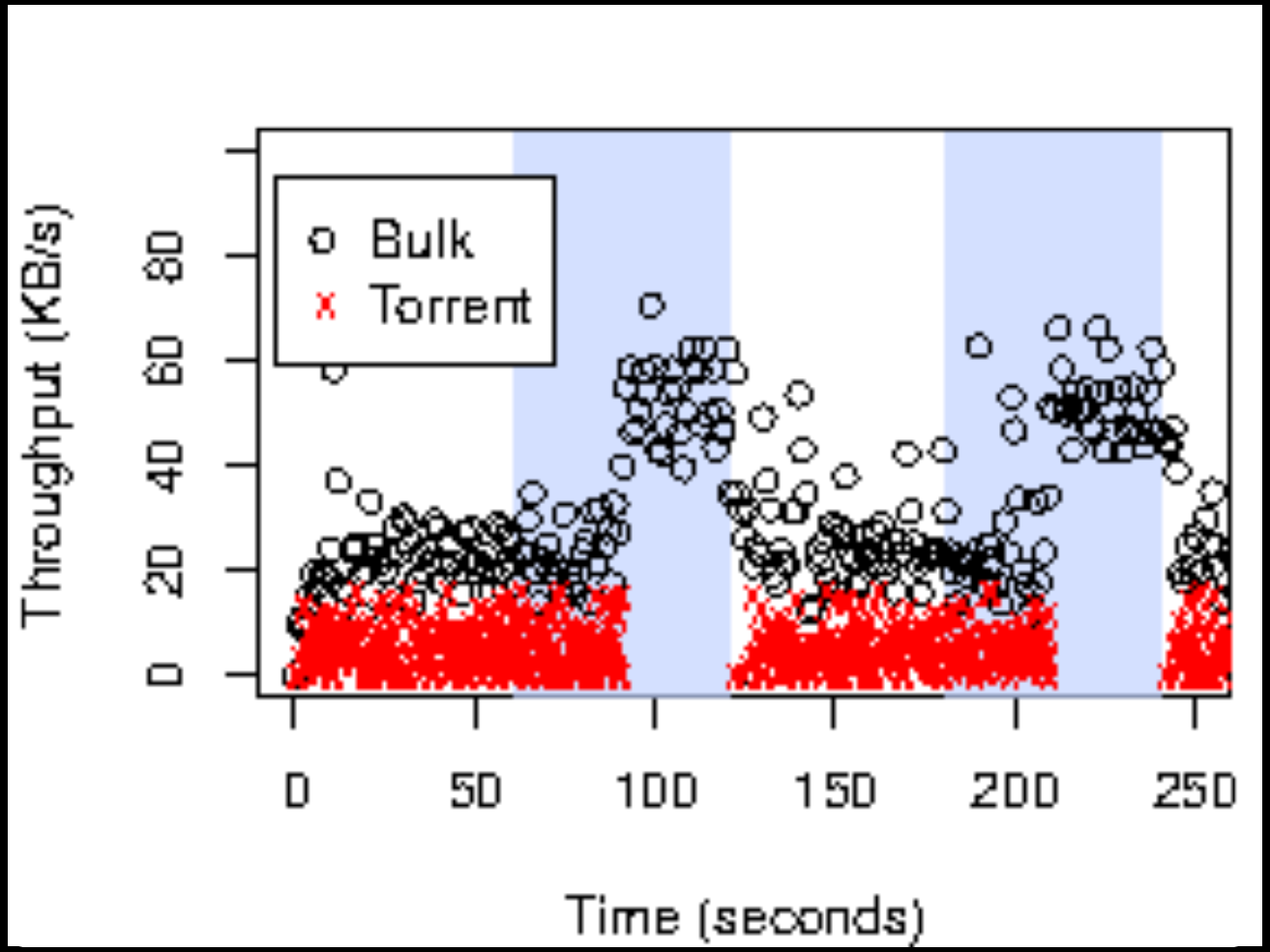
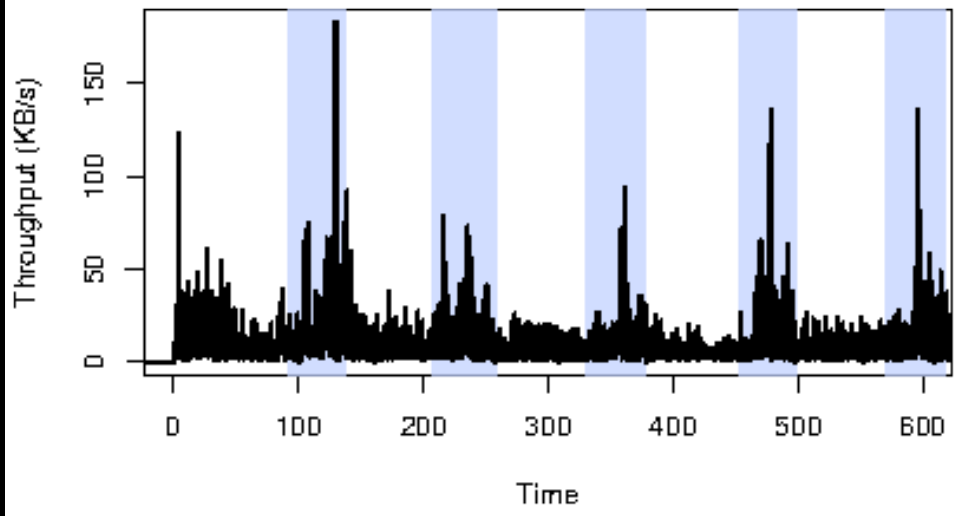


Induced Throttling Prototype

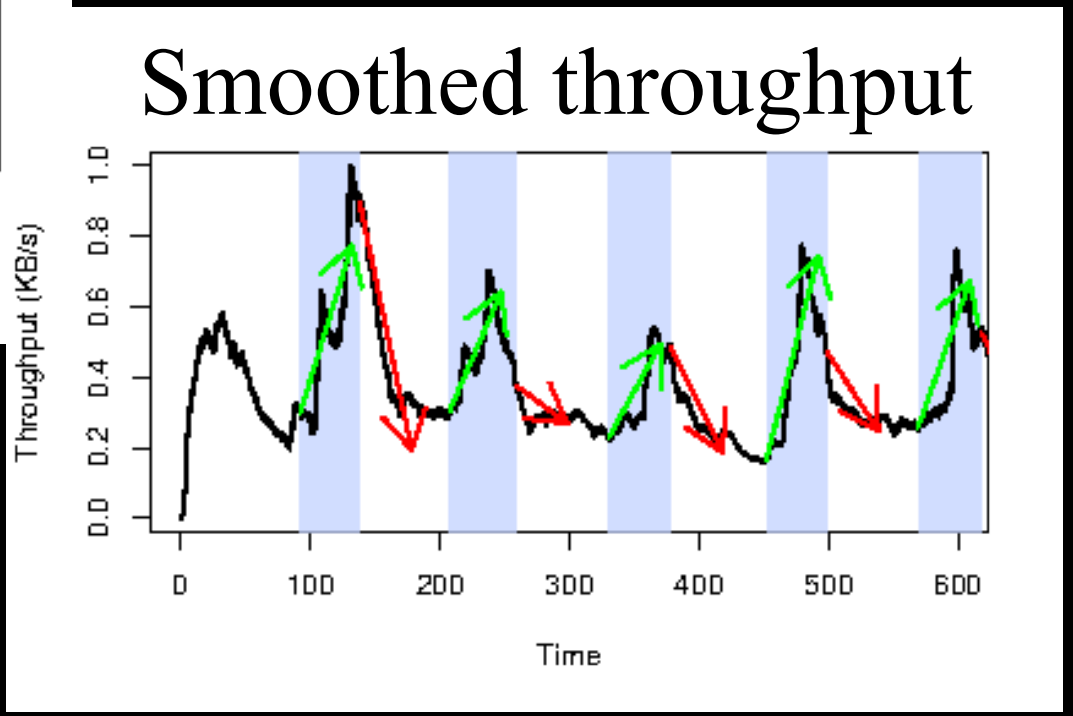


Induced Throttling Results

Raw throughput



Smoothed throughput



Induced Throttling Results

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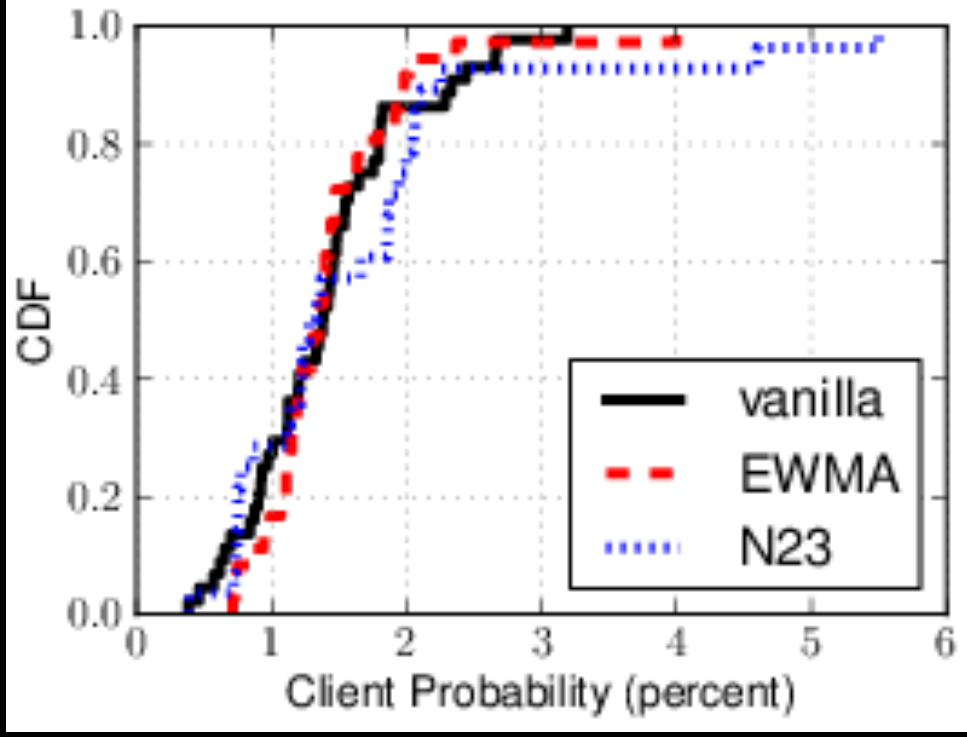

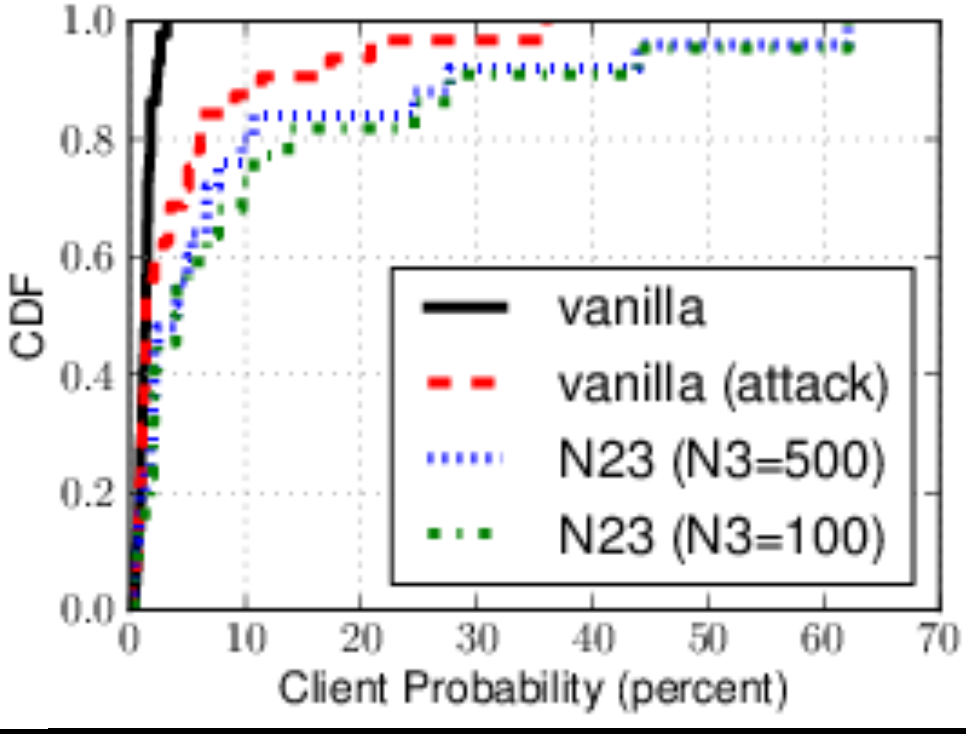

Throughput Attack

Induced Throttling Attack

Questions?

rob.g.jansen@nrl.navy.mil