Large Scale Simulation of Tor: Stream Correlation Attacks

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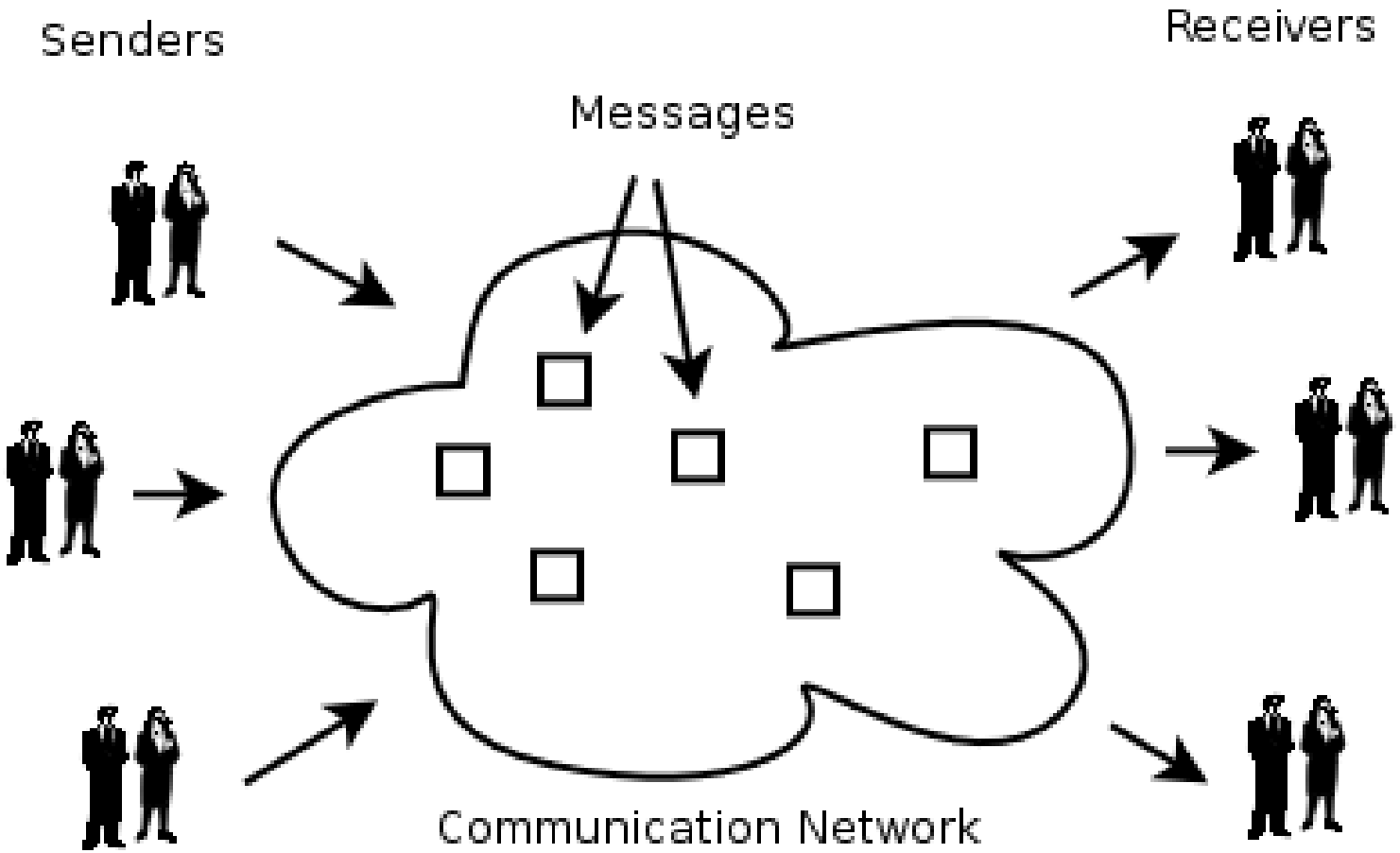
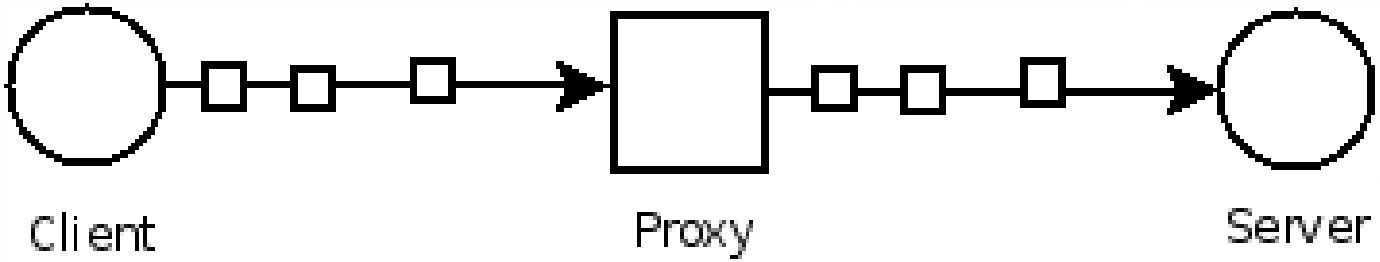
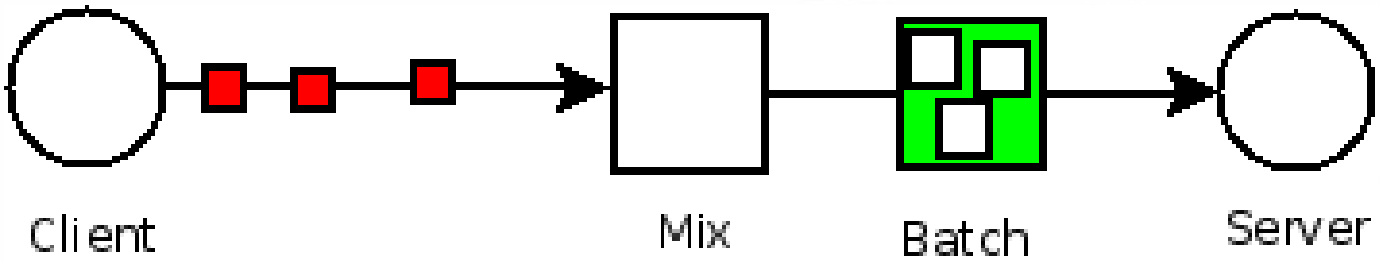
Anonymous networks



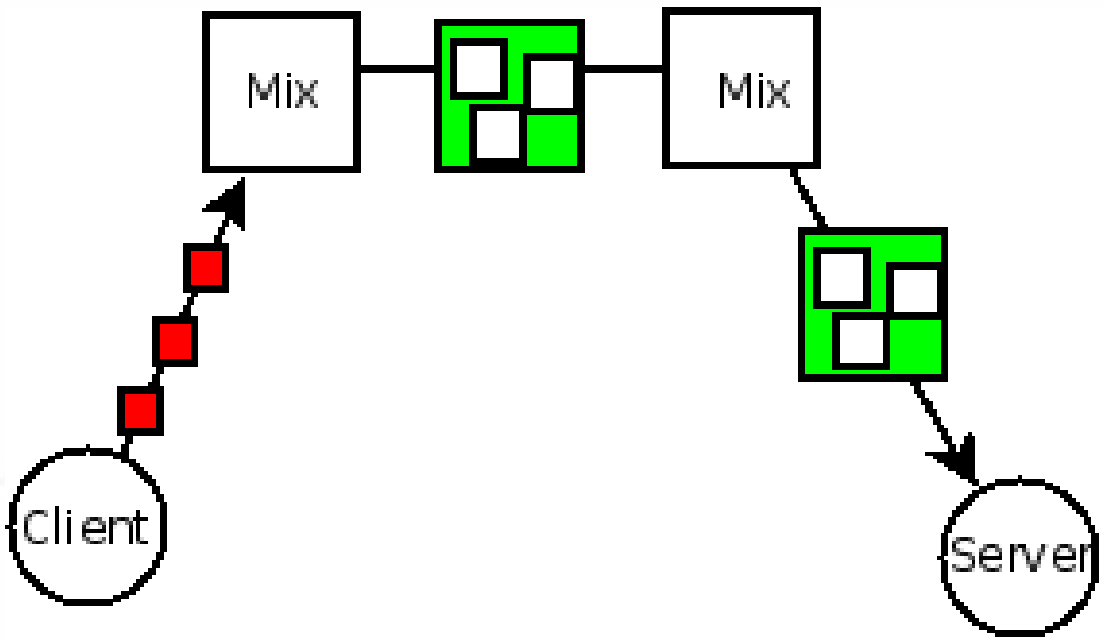
Proxy



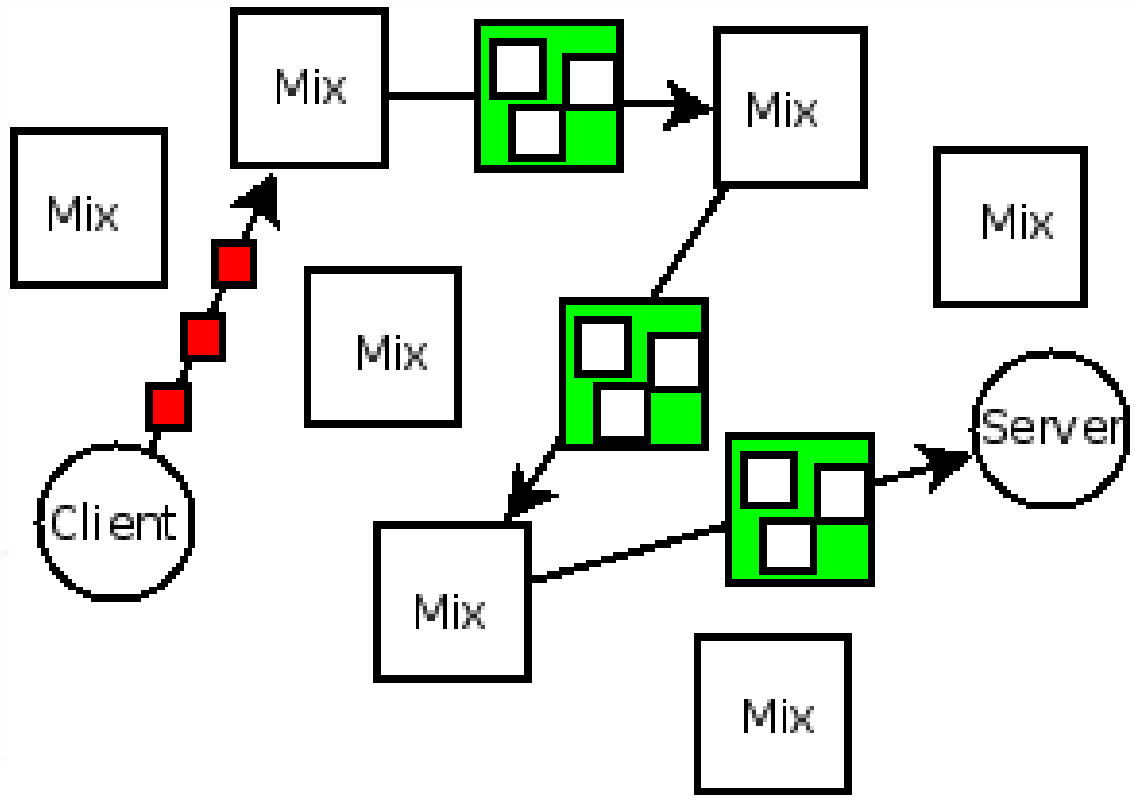
Simple Mix



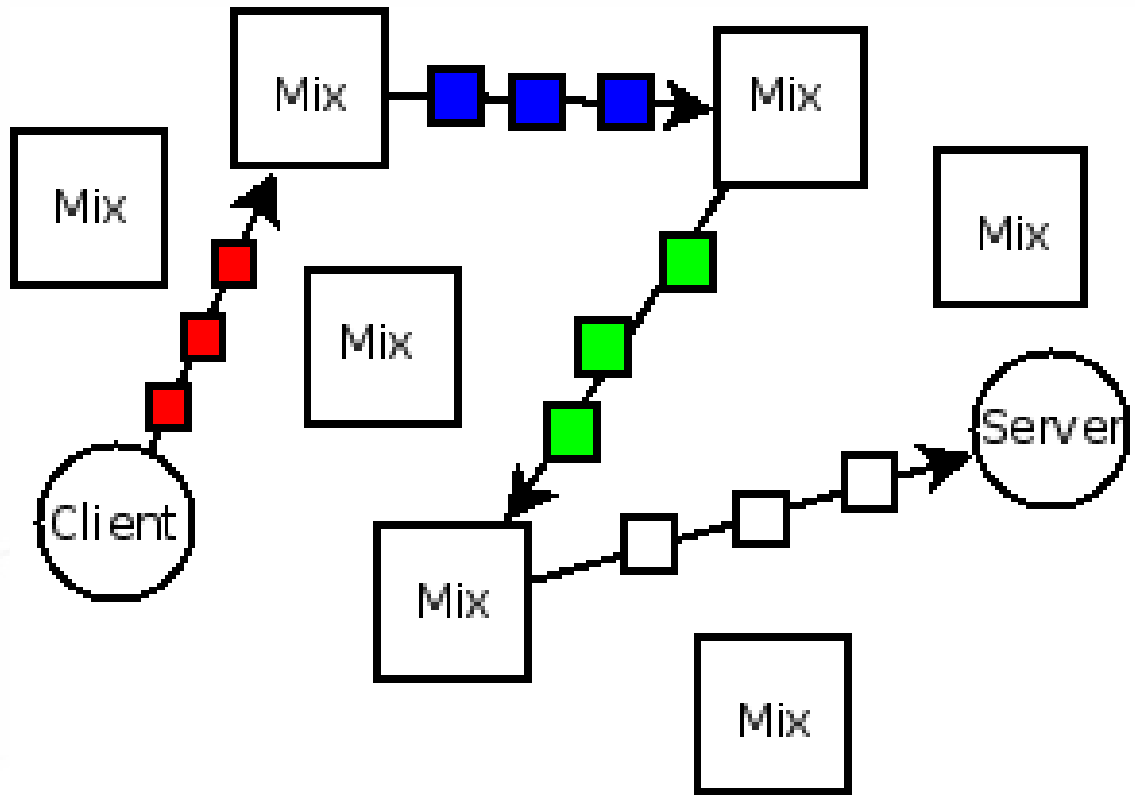
Cascade Mix



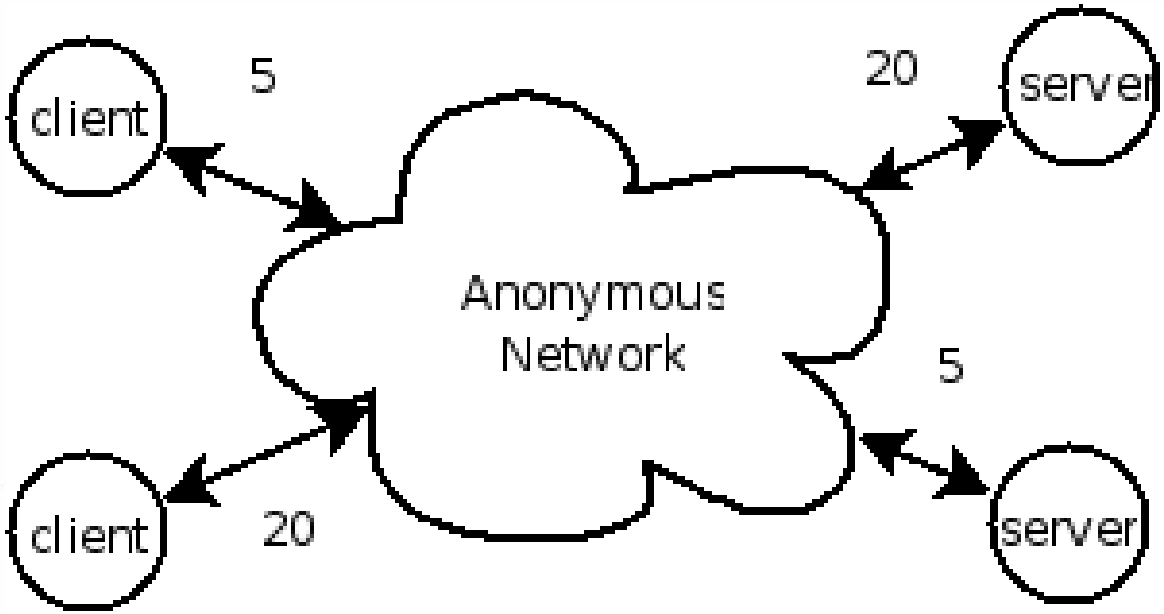
Free Cascade Mix



Low latency network



Traffic Analysis



Currently deployed anonymous networks

- Over 1500 nodes
- Over 100 countries
- Hundreds of thousands on connections through the network
- Theorized traffic analysis attacks

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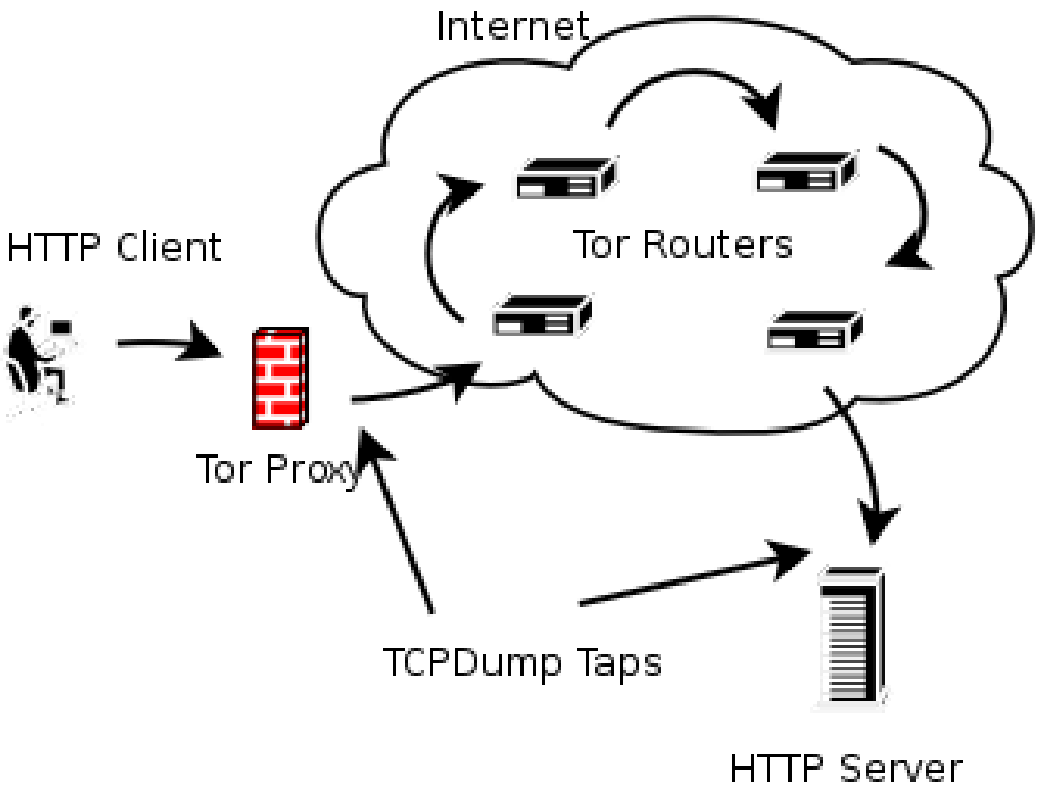
- Over 1500 nodes
- Over 100 countries
- Hundreds of thousands on connections through the network
- Theorized traffic analysis attacks
- How anonymous is a user ?

SSFNet

- Scalable Simulation Framework Network (SSFNet)
- Simulate TCP/IP, Ethernet, Socket interfaces
- Has HTTP/TCP generators.
- TCPDump compatible output

- Simulated Tor circuits, routing, traffic fragmentation
- US ISP Topology
- 6,000 nodes
- Run the simulation for 1060 seconds to settle and then 60 for data

Tor Simulation Process



Results

- Probability of correctly identifying streams entering the network with streams exiting the network
- Several attacks used
  - Start and End timing
  - Packet counting
  - Cross-Correlation - Pearson Function
- Run the attacks with increasing numbers of streams
- Don't know the transit time, so have to test

Start & End stream timing

- Compare the start and end times of streams
- 98% to 94% of streams filtered

Packet counting

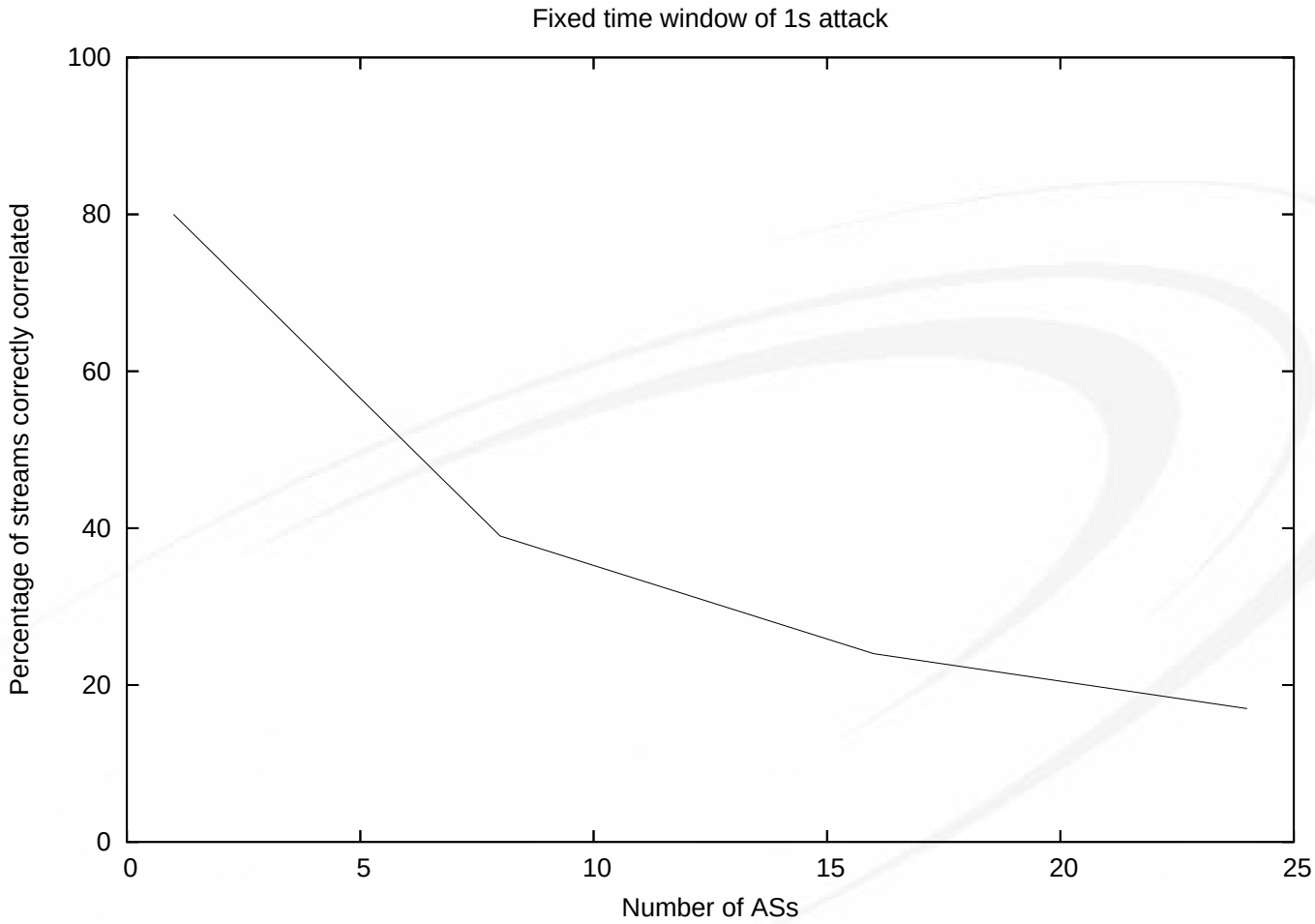
- Count the number of cells in a stream
- 5% to 15% of streams are removed.

Cross-Correlation

$$r(d) = \frac{\sum_i ((x_i - \mu)(x'_{i+d} - \mu'))}{\sqrt{\sum_i (x_i - \mu)^2} \sqrt{\sum_i (x'_{i+d} - \mu')^2}}$$

- Set a windows size W and count the number of packets received
- x_i is the ith packet count of stream x
- x'_i is the ith packet count of stream x'
- μ is the average of packet counts in stream x
- d is the variable delay value

Cross-Correlation



Conclusion

- Initial results show promise
- Future work the simulation will allow us to:
  - Introduce delay and measure QoS & Anonymity
  - Test active attacks
  - Modify Tor protocol to account for specific attacks scenarios

Thank you!

- Thanks for listening and thanks to Science Foundation Ireland

Any questions ?