Securing the Tor Network

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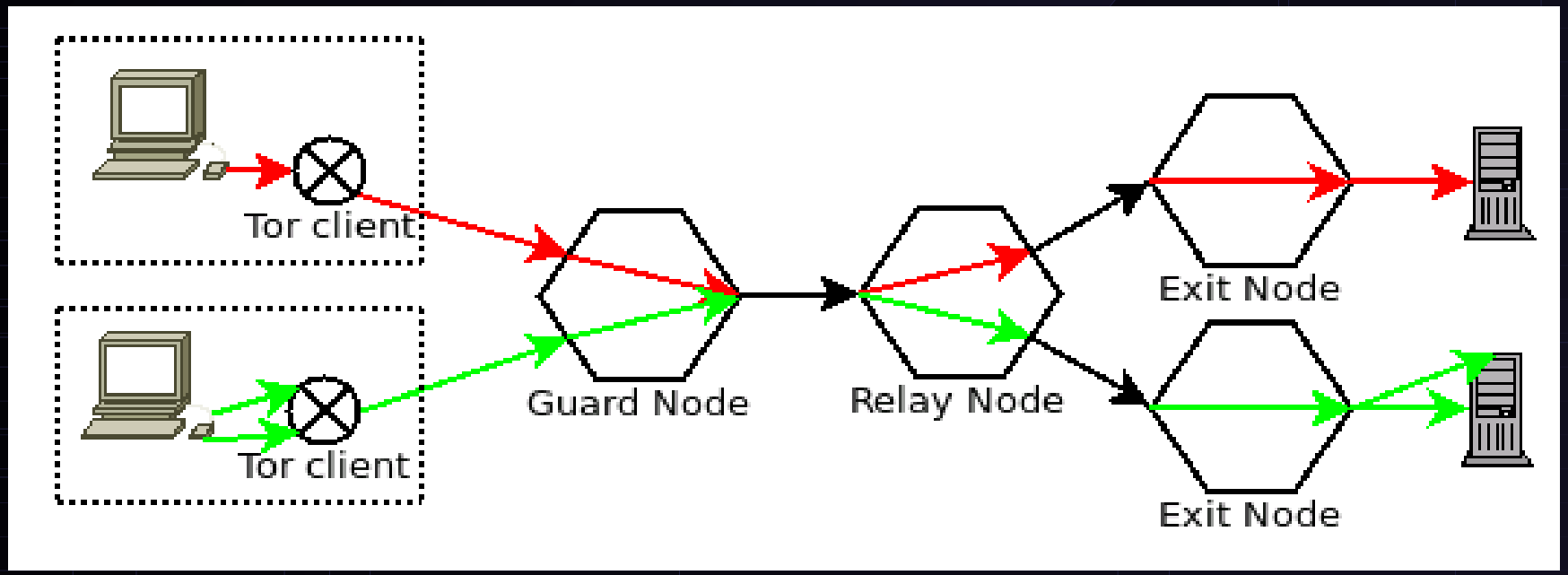
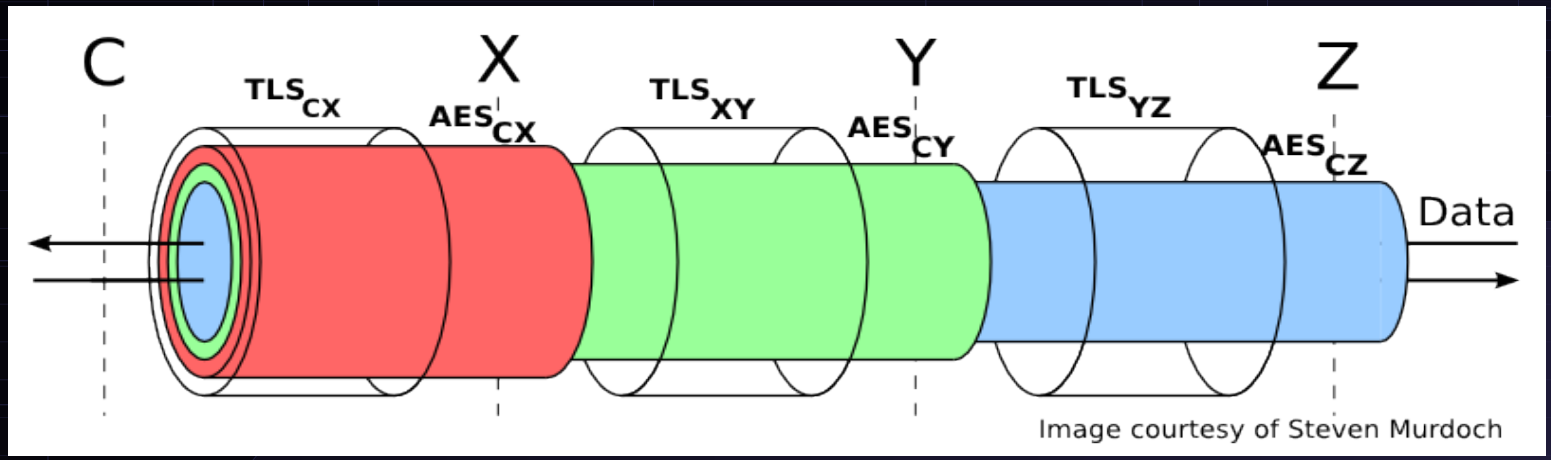
What is Tor?

- Volunteer run relay network designed for privacy, anonymity, and censorship resistance.
- Tor relays TCP connections (“streams”)
  - Multiplexed on encrypted paths (“circuits”)
- Nodes connected by TLS/SSL
- Circuits route through 3 nodes
  - “Guard”, “relay”, “exit”

Tor Routing


Tor client
Tor client
Guard Node
Relay Node
Exit Node
Exit Node


C
X
Y
Z
TLS CX
AES CX
TLS XY
AES CY
TLS YZ
AES CZ
Data
Image courtesy of Steven Murdoch

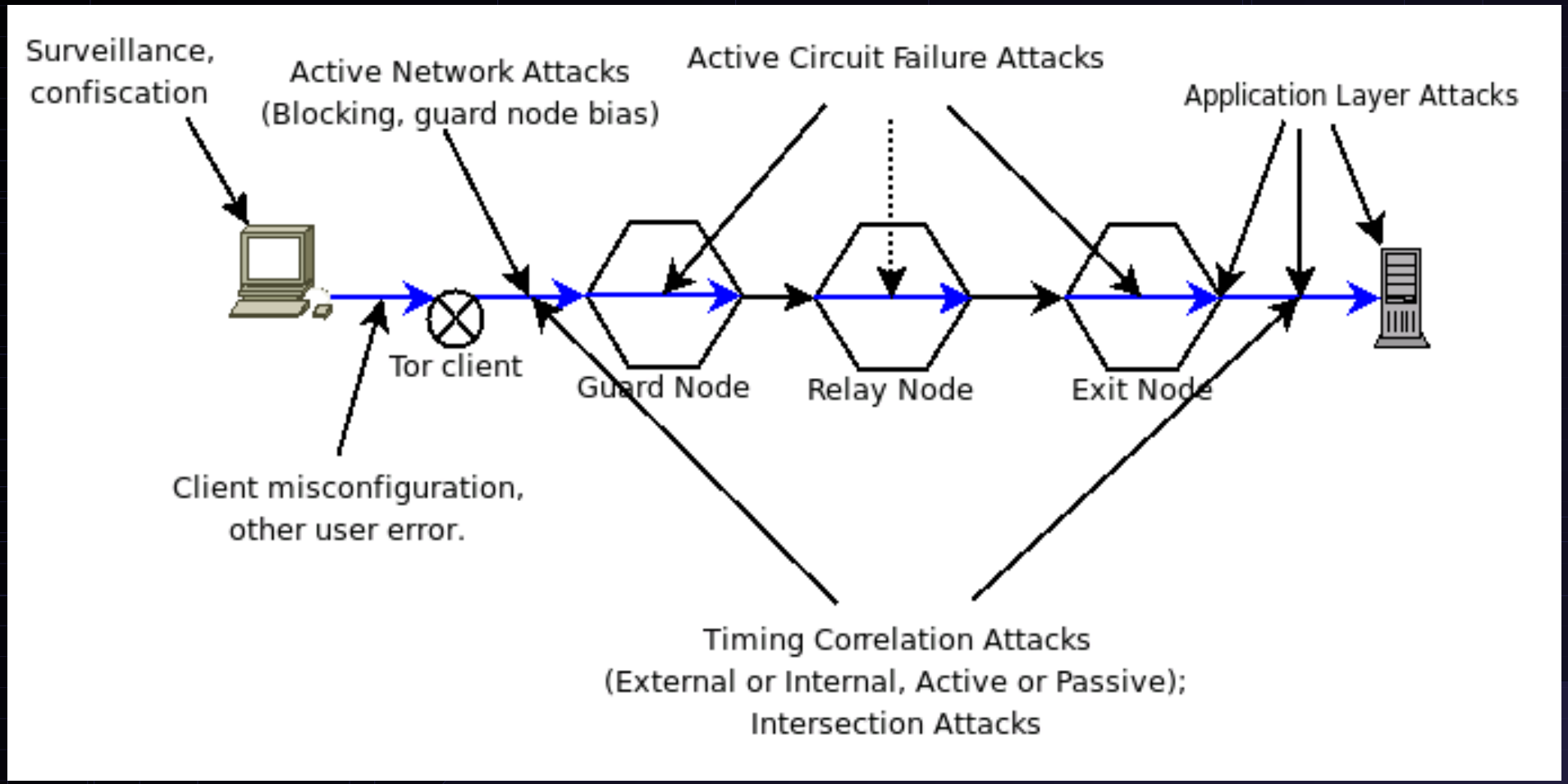
Classes of Attack

- Passive attacks
  - Packet and connection timing correlation
  - Fingerprinting of traffic/usage patterns
  - “Intersection Attacks” of multiple attributes of users
- Active attacks
  - Lying about bandwidth to get more traffic
  - Failing circuits to bias node selection
  - Modifying application layer traffic at exit

Position of Attack

- Internal
  - Node operator
  - Can differentiate circuits at guard and relay.
  - Able to differentiate streams per circuit at exit
- External
  - ISP or Echelon-style adversary
  - Assumed to be unable to see inside TLS streams
  - Likely frustrated to a large degree by running Tor as both node and client

Attack Points



Approaches to Security

- Verify node operators (Ha!)
- Path selection hacks
- Scan nodes for modification/reliability
- “Tor up from the floor up”
- Secure the applications (different threat model)
- Improve network speed and usability

Path Selection Hacks

- /16 hack: No two nodes from same /16 netmask
  - Many ISPs have disjoint IP ranges..
- Guard nodes
  - Essentially a time-tradeoff of risk
    - Difficult to do right. Typically still rotate
  - Avoids long-term fingerprinting
  - Without rotation, can deter intimidation attacks
  - Foil “repetitive fetch” application layer attacks

Tor Routers and LiveCDs

- JanusVM, Anonym.OS, others
  - “Tor up from the floor up”
  - Addresses application-level attacks to bypass Tor
  - Blocks UDP
- Major flaw: Circuit reuse -> app correlation
  - Windows update, other ID-based software updates
  - AIM, ssh, email usage of different “nyms”
  - Media players checking recommended music, etc etc

Centralized Network Scanning

- Tor control port is fun stuff
- Snakes on a Tor and TorFlow
  - Verifies md5 sums of googled URLs
  - Also verifies node reliability+bandwidth
- Works against incompetent+blanket adversaries
  - Actually found some broken+malicious nodes
- Does not work against targeted adversaries
- Vulnerable to detection

Decentralized Network Scanning

- Client-based:
  - Use reliability averages from TorFlow
  - Alert user if guard node fails more than X% circuits
  - Measure observed bandwidth/latency of nodes
- Node-based:
  - Gather statistics on average capacity and queue lengths to peers, compare to node rankings
  - Report major deviations or use as balancing feedback loop.

Securing the Application Layer

- Tor has a superset of the threat model most applications are written for.
  - No UDP!
  - Unique identifiers are bad
  - Proxy settings must be sacrosanct
  - Location information must not be transmitted
  - Updates are dangerous. Hostile network.

Tor's Web Attack Profile

1. Bypassing proxy settings
2. Correlation of Tor vs Non-Tor
3. History disclosure
4. Location information
5. Misc Anonymity set reduction
6. History records

Solution: Improved TorButton

- Disable plugins while Tor is enabled
- Isolate dynamic content per Tor load state
- Cookie jars/cookie clearing
- Cache management
- History management
- User agent spoofing during Tor
- Javascript Hooking

TorButton Demo

- http://gemal.dk/browserspy/basic.html
- http://gemal.dk/browserspy/css.html
- http://gemal.dk/browserspy/date.html
- http://gemal.dk/browserspy/plugins.html
- http://ha.ckers.org/weird/CSS-history-hack.html
- http://ha.ckers.org/weird/CSS-history.cgi
- http://www.tjkdesign.com/articles/css%20pop%2(

Interesting Technical Details

- Context issues
- Tab tagging
- XPCOM hooking and XPCOM policies
- Javascript hooking

Improving Speed and Usability

- Key component of Tor security: Large userbase
- Users want speed and ease of use
  - Many do not need as much anonymity
  - Two hop proposal (semi-controversial)
  - Intelligent path selection
- Tor network is unbalanced
  - Guard node issues (bug #440)
  - Exit selection issues

Final Thoughts

- Tor security != Internet security
  - Superset, actually
  - Adversary has different goals
  - Many apps do not consider privacy vulnerabilities as real vulnerabilities

Credits+Contributions

Scott Squires (Original TorButton Author)

Collin Jackson (History blocking+Cookie jars)

Johannes Renner (TorFlow contributions+research)

Nick & Roger (Advice, Tor in general)

Dave, Nitin G, Thom (Advice, moral support)

“What can I do to help Tor?”

- Extra bandwidth? Run a node!
  - See conference CD for Linux 'tc' prioritization script
  - No need to impact your own traffic flows
- Post patches/plugins to your favorite apps to protect against info disclosure.
  - Work to raise awareness that privacy issues should be considered as part of security measures