Tor:

Anonymous Communications for the Dept of Defense...and you.

Roger Dingledine
Free Haven Project
Electronic Frontier Foundation

http://tor.eff.org/

17 September 2005

Talk Outline

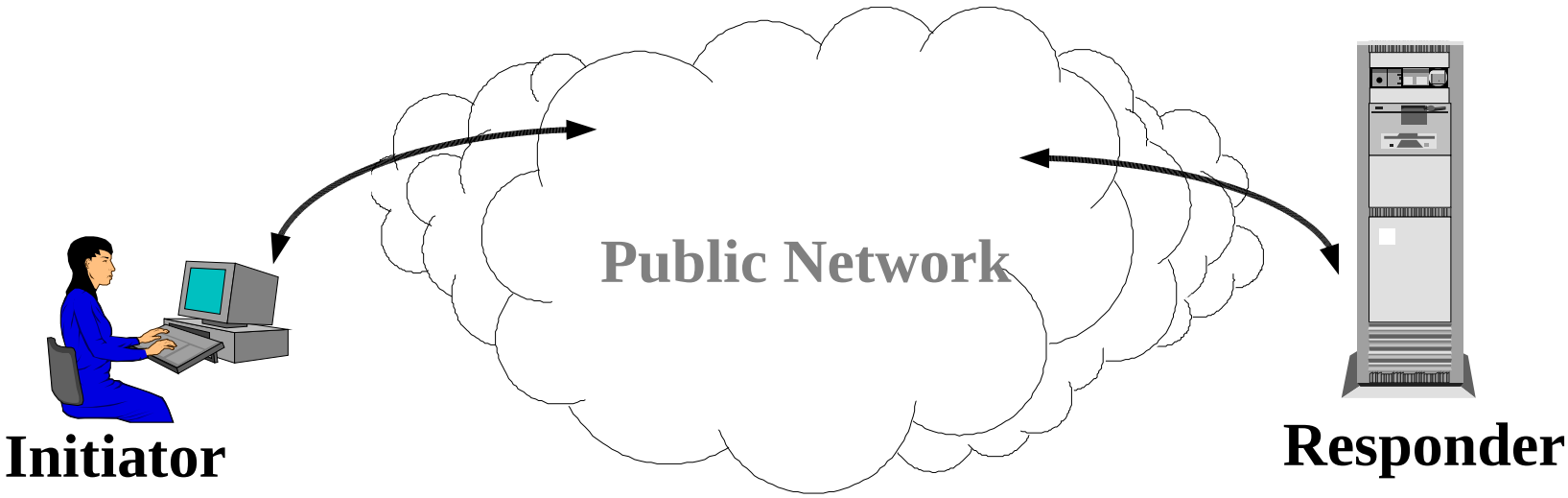
- Motivation: Why anonymous communication?
  - Myth 1: This is only for privacy nuts.
  - Myth 2: This stuff enables criminals.
- Tor design overview
- Hidden servers and rendezvous points
- Policy issues raised
- Open technical issues and hard problems

Bad people are doing great

- Trojans, viruses, 'sploits
- Botnets, zombies
- Phishing -> funding
- Collect user information -> spam better
- Corporate espionage -> extortion -> funding

Public Networks are Vulnerable to Traffic Analysis

- In a Public Network (Internet):
- Packet (message) headers identify recipients
- Packet routes can be tracked



Encryption does *not* hide routing information.

Who Needs Anonymity?

- Journalists, Dissidents, Whistleblowers (Indymedia, bloggers, Iran, Tibet)
- Censorship resistant publishers/readers (libraries)
- Socially sensitive communicants:
  - Chat rooms and web forums for abuse survivors, people with illnesses

Who Needs Anonymity?

- You:
  - Where are you sending email (who is emailing you)
  - What web sites are you browsing
  - Where do you work, where are you from
  - What do you buy, what kind of physicians do you visit, what books do you read, ...

Who Needs Anonymity?

- Corporations: (Google, Wal-Mart, ...)
  - Who's talking to the company lawyers? Are your employees looking at monster.com?
  - Hiding procurement suppliers or patterns
  - Competitive analysis
- Law Enforcement: (In-q-tel, Nye Kripos)
  - Anonymous tips or crime reporting
  - Surveillance and honeypots (sting operations)

Who Needs Anonymity?

- Government

Government Needs Anonymity? Yes, for...

- Open source intelligence gathering
  - Hiding individual analysts is not enough
  - That a query was from a govt. source may be sensitive
- Defense in depth on open and *classified* networks
  - Networks with only cleared users (but a million of them)
- Dynamic and semitrusted international coalitions
  - Network can be shared without revealing existence or amount of communication between all parties
- Elections and voting

Anonymity Loves Company

- You can't be anonymous by yourself.
  - *Can* have confidentiality by yourself.
- A network that protects only DoD network users won't hide that connections from that network are from DoD.
- You must carry traffic for others to protect yourself.
- But those others don't want to trust their traffic to just one entity either. Network needs *distributed trust*.
- Security depends on diversity and dispersal of network.

Who Needs Anonymity?

- And yes criminals

Who Needs Anonymity?

- And yes criminals

But they already have it.

We need to protect everyone else.

Privacy and Criminals

- Criminals have privacy
  - Motivation to learn
  - Motivation to buy
  - Identity theft
- Normal People, Companies, Governments, Police don't
- The worst of all possible worlds

Privacy and Crackers

- Crackers have privacy
  - Break into system
  - Destroy the logs
  - Repeat as needed
  - They don’t use or need our software
- Normal People, Companies, Governments, Police don’t
- The worst of all possible worlds

Anonymous From Whom?
Adversary Model

- Recipient of your message
- Sender of your message

=> Need Channel and Data Anonymity

- Observer of network from outside
- Network Infrastructure (Insider)

=> Need Channel Anonymity

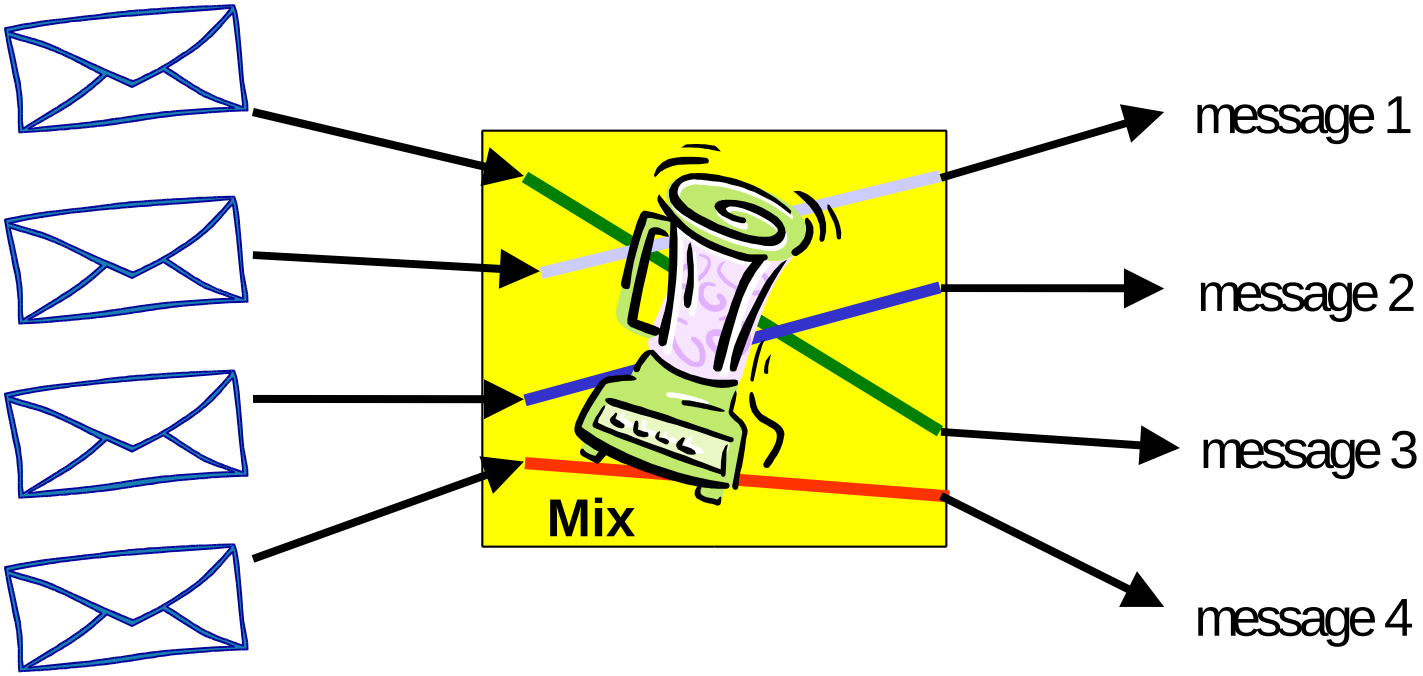
- Note: Anonymous authenticated communication makes perfect sense
- Communicant identification should be inside the basic channel, not a property of the channel

Focus of Tor is anonymity of the communication pipe,
not what goes through it

How Do You Get Communication Anonymity?

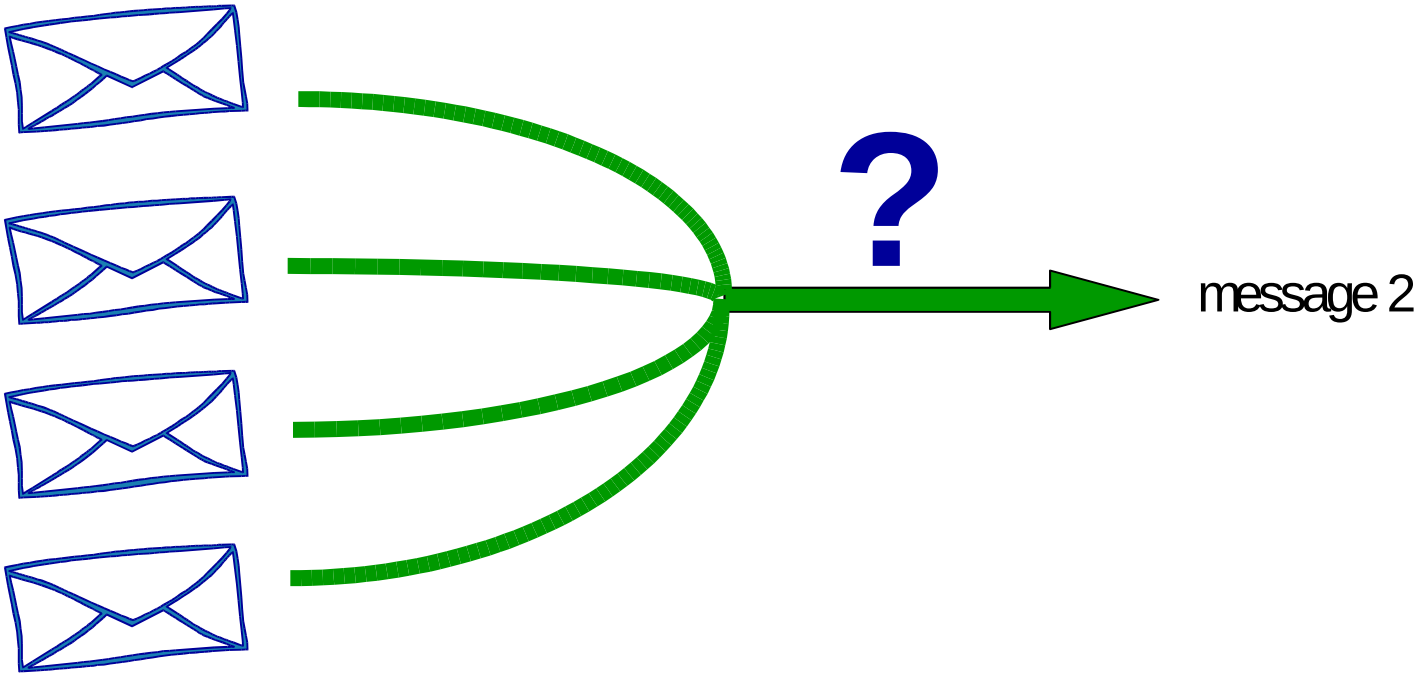
- Many technical approaches
- Overview of two extensively used approaches
  - Mixes
  - Proxies

What does a mix do?



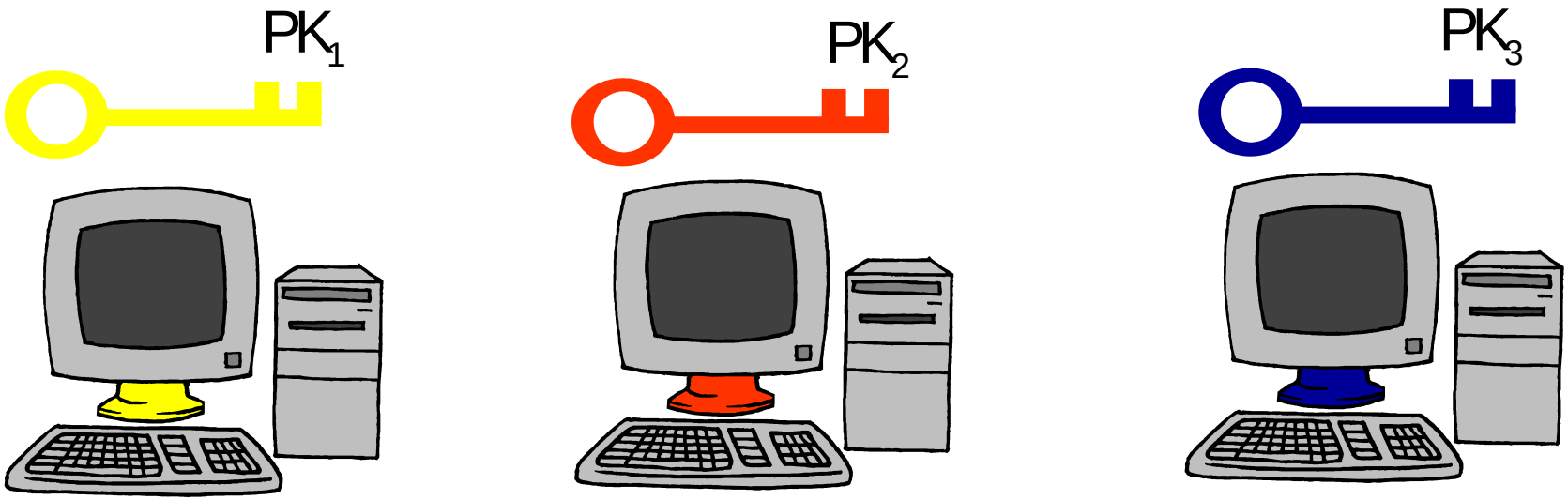
Randomly permutes and decrypts inputs

What does a mix do?

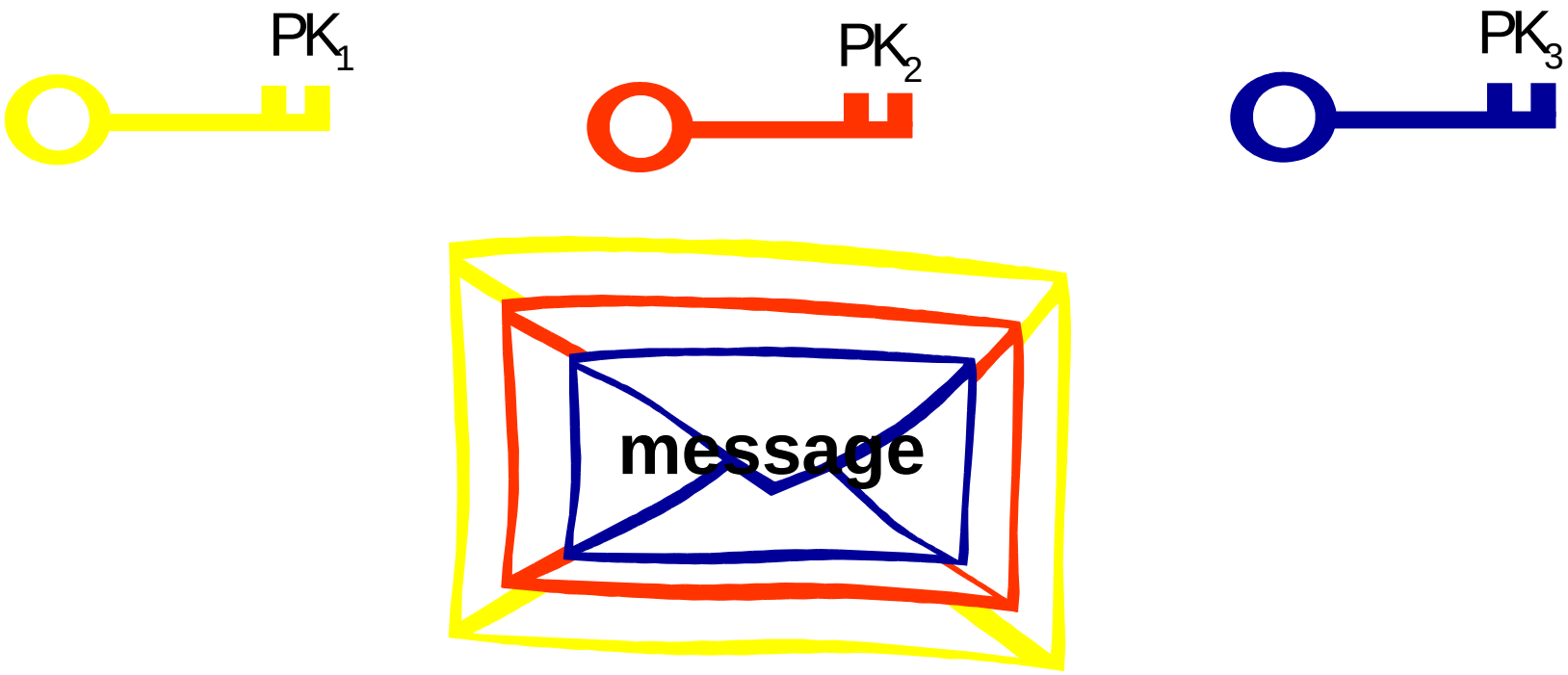


Key property: Adversary can't tell which ciphertext corresponds to a given message

Basic Mix (Chaum '81)

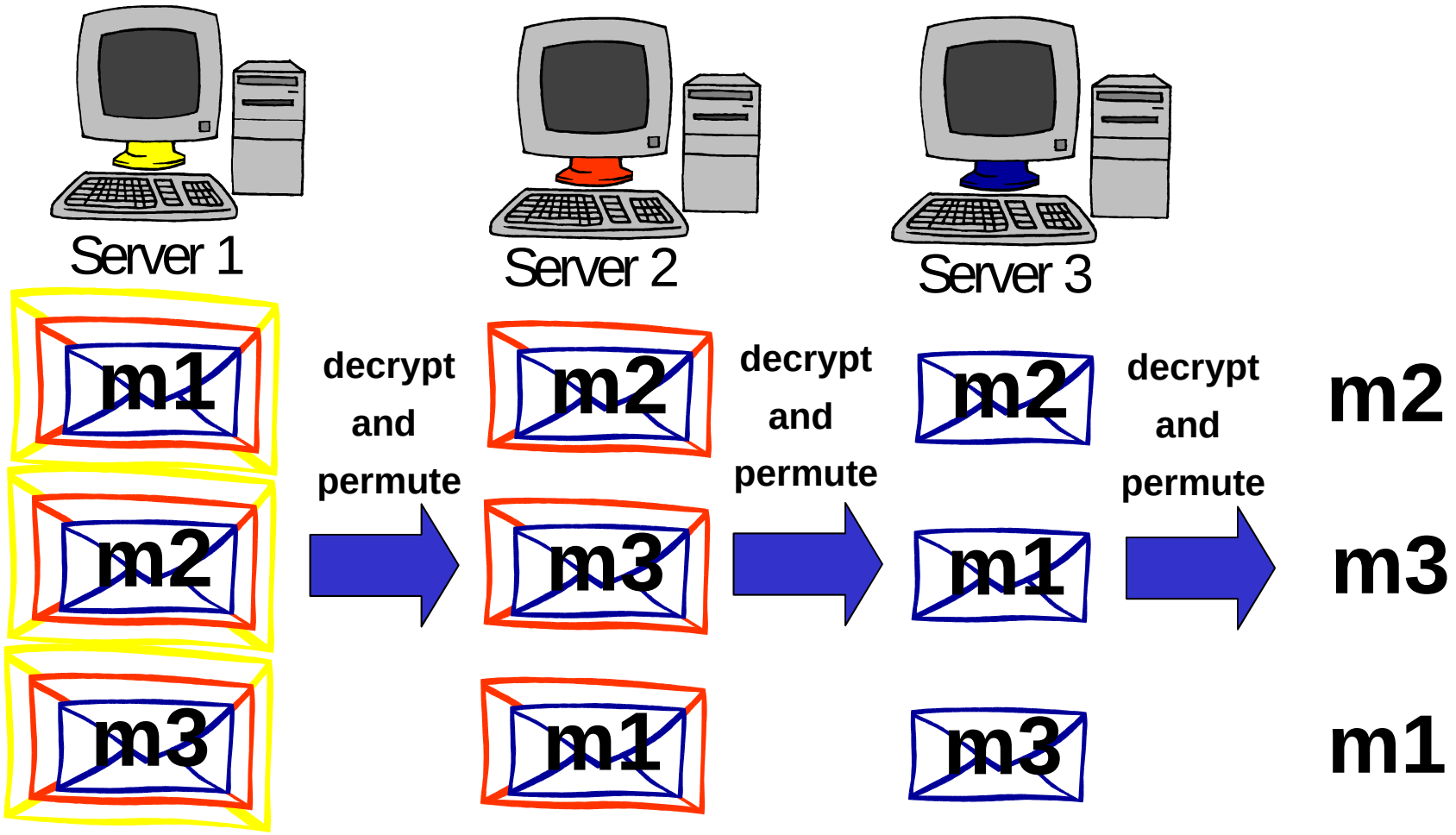


Encryption of Message

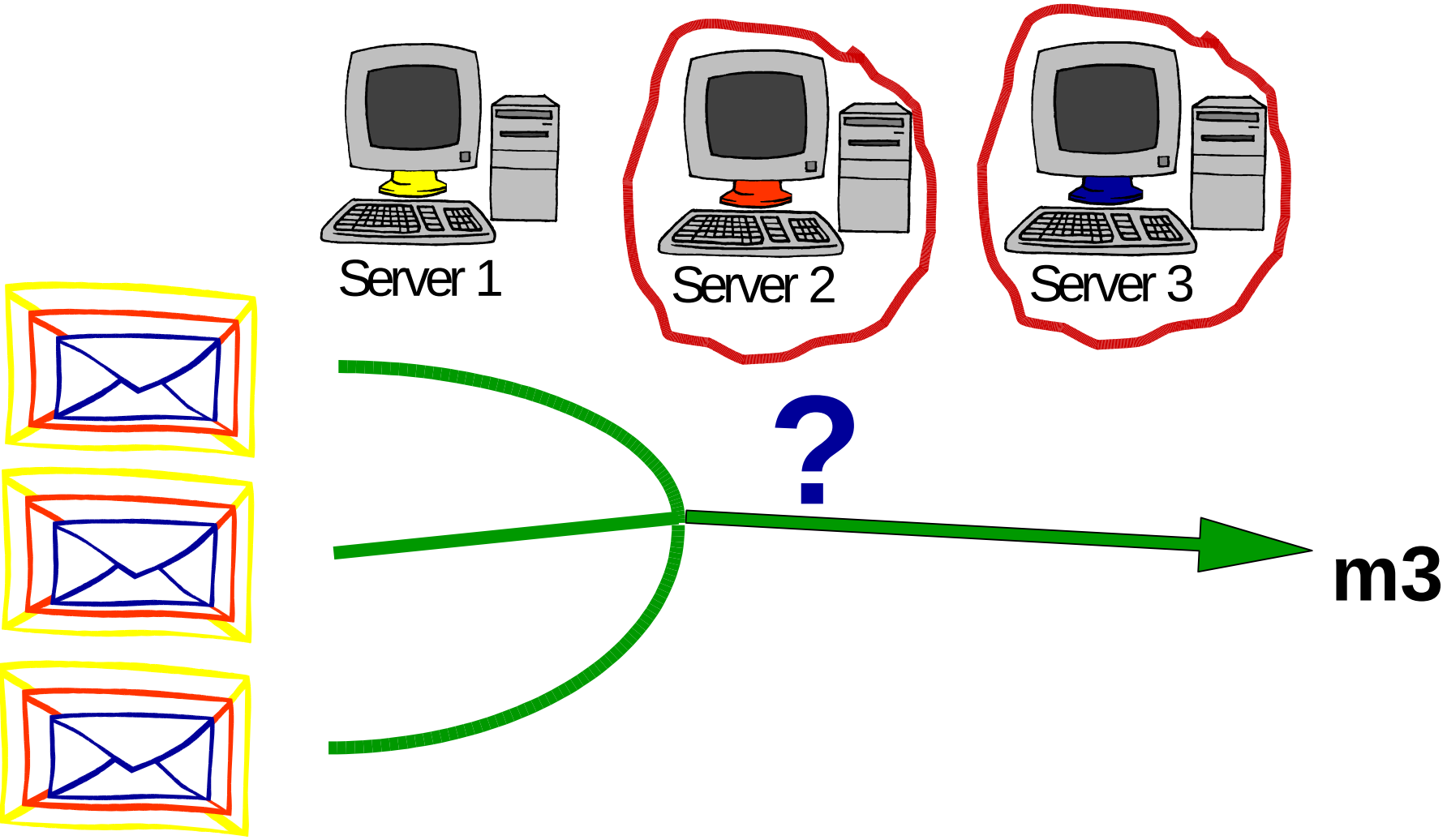


$$Ciphertext = E_{PK1}[E_{PK2}[E_{PK3}[message]]]$$

Basic Chaum-type Mix

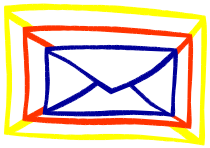


One honest server preserves privacy

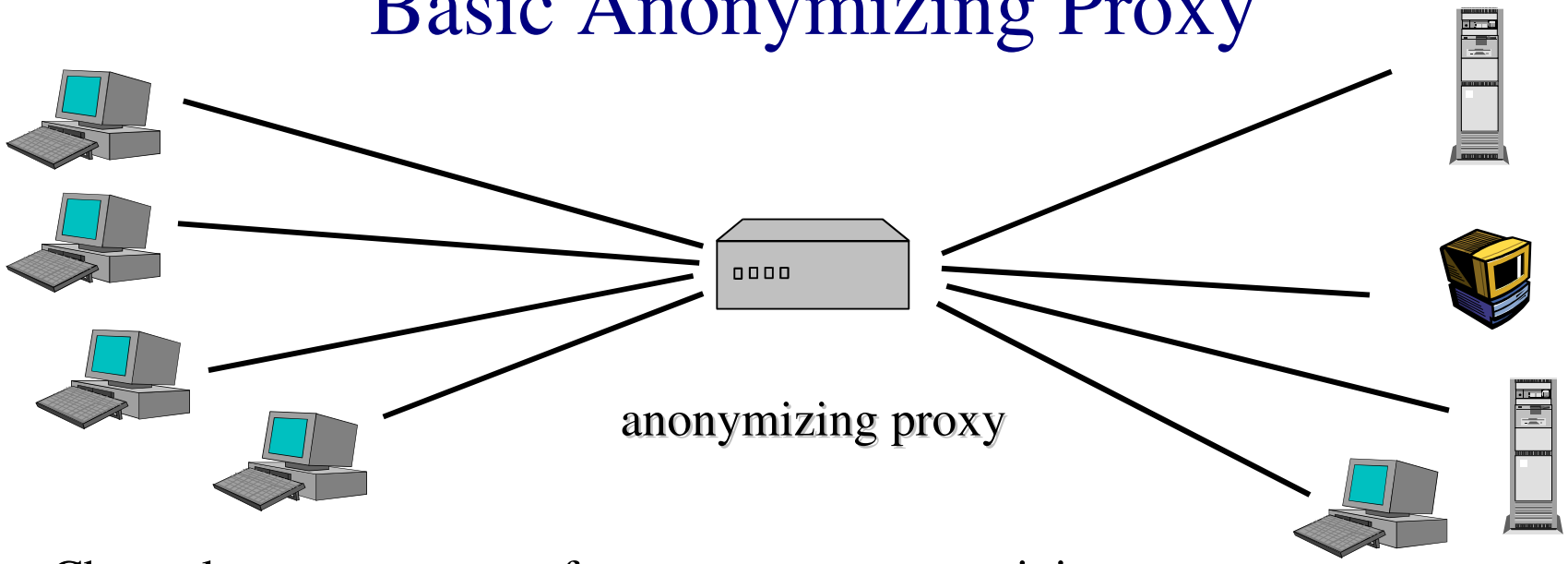


What if you need quick interaction?

- Web browsing, Remote login, Chat, etc.
- Mixnets introduced for email and other high latency apps
- Each layer of message requires expensive public-key crypto



Basic Anonymizing Proxy



- Channels appear to come from proxy, not true originator
- Appropriate for Web connections, etc.:
  SSL, TLS, SSH (lower cost symmetric encryption)
- Examples: The Anonymizer
- Advantages: Simple, Focuses lots of traffic for more anonymity
- Main Disadvantage: Single point of failure, compromise, attack

Onion Routing
Traffic Analysis Resistant Infrastructure

- Main Idea: Combine Advantages of mixes and proxies
- Use (expensive) public-key crypto to establish circuits
- Use (cheaper) symmetric-key crypto to move data
  - Like SSL/TLS based proxies
- Distributed trust like mixes
- Related Work (some implemented, some just designs):
  - ISDN Mixes
  - Crowds, JAP Webmixes, Freedom Network
  - Tarzan, Morphmix

Tor

Tor

The Onion Router

Tor

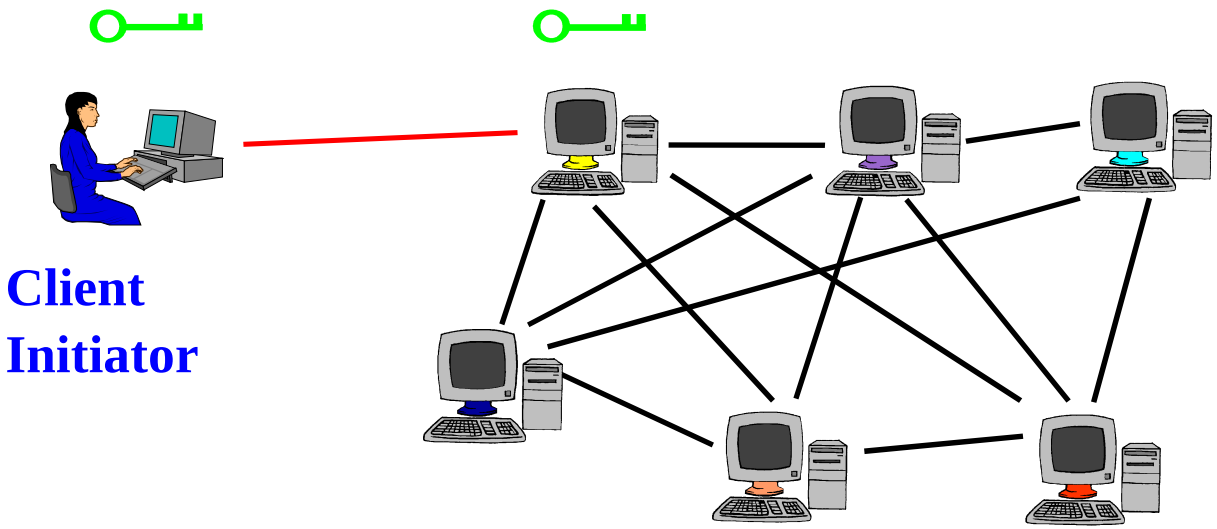
Tor's Onion Routing

Numbers and Performance

- Running since October 2003
- 250 nodes on six continents
- Volunteer-based infrastructure
- Fifty thousand+ (?) users
- Nodes process 1-100 GB / day application cells
- Network has never been down

Tor Circuit Setup

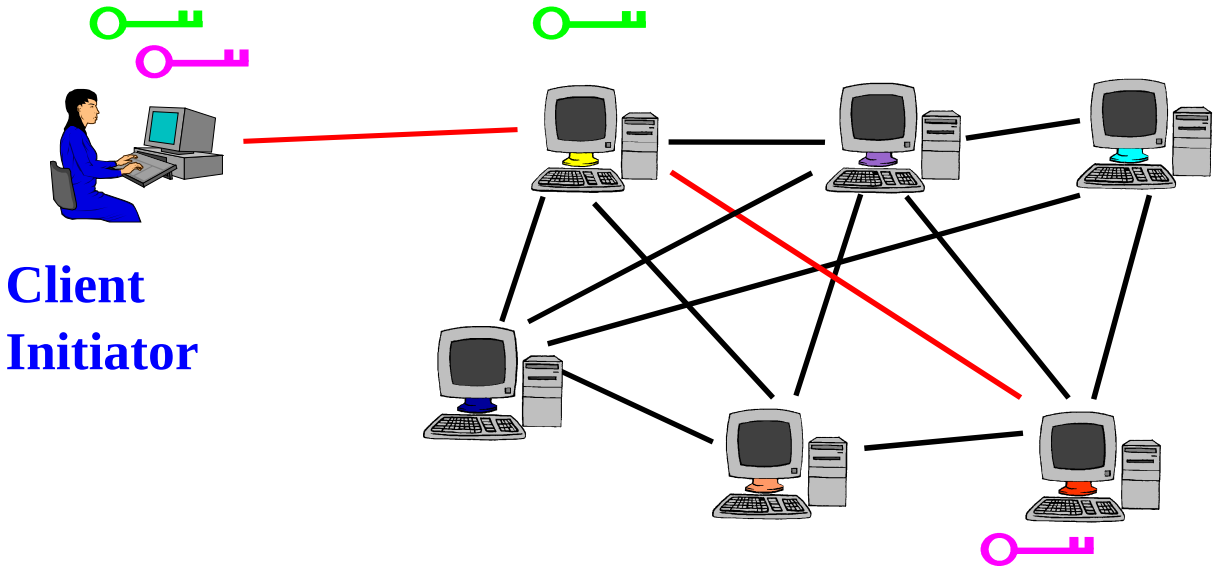
- Client Proxy establishes session key + circuit w/ Onion Router 1



Client Initiator

Tor Circuit Setup

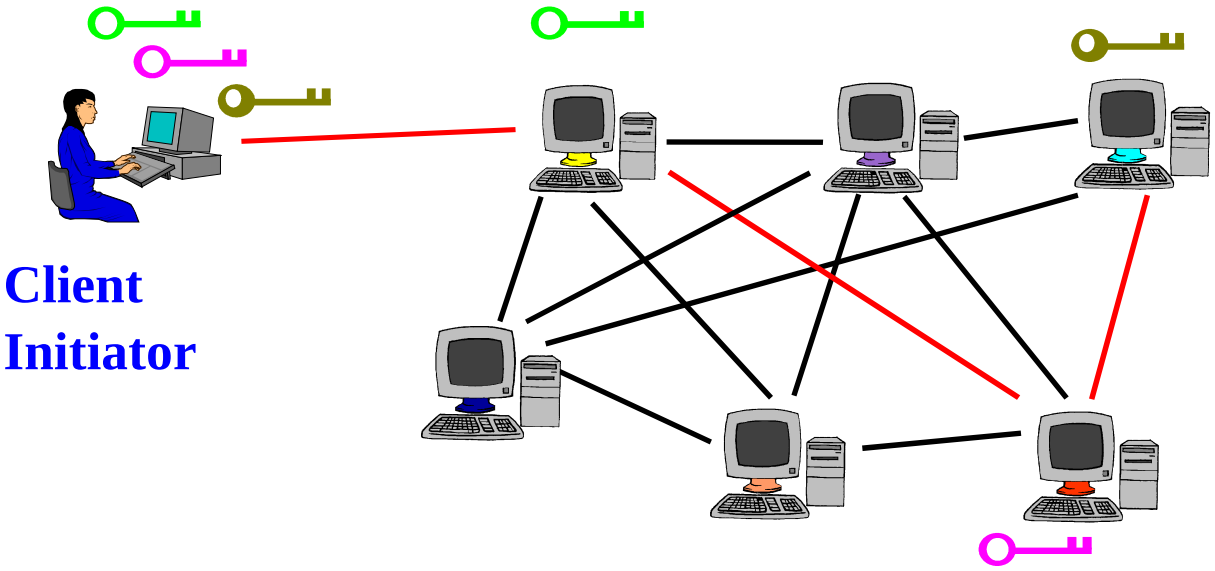
- Client Proxy establishes session key + circuit w/ Onion Router 1
- Proxy tunnels through that circuit to extend to Onion Router 2



Client Initiator

Tor Circuit Setup

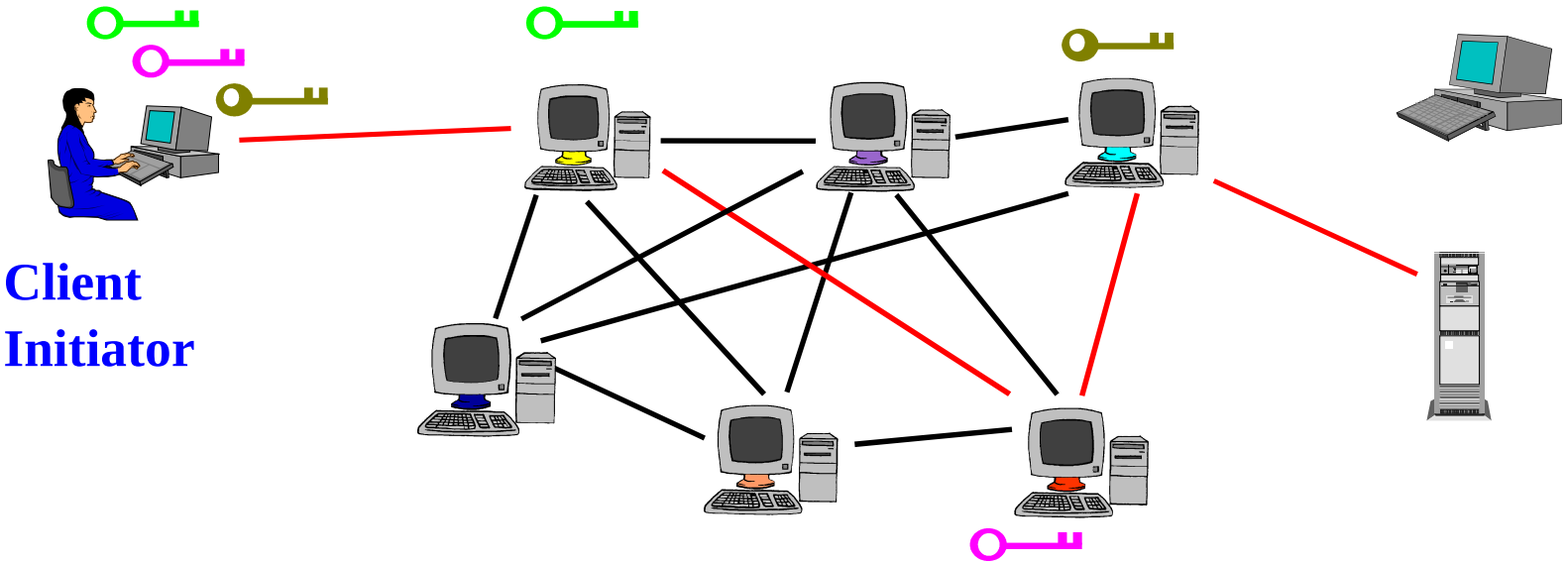
- Client Proxy establishes session key + circuit w/ Onion Router 1
- Proxy tunnels through that circuit to extend to Onion Router 2
- Etc



Client Initiator

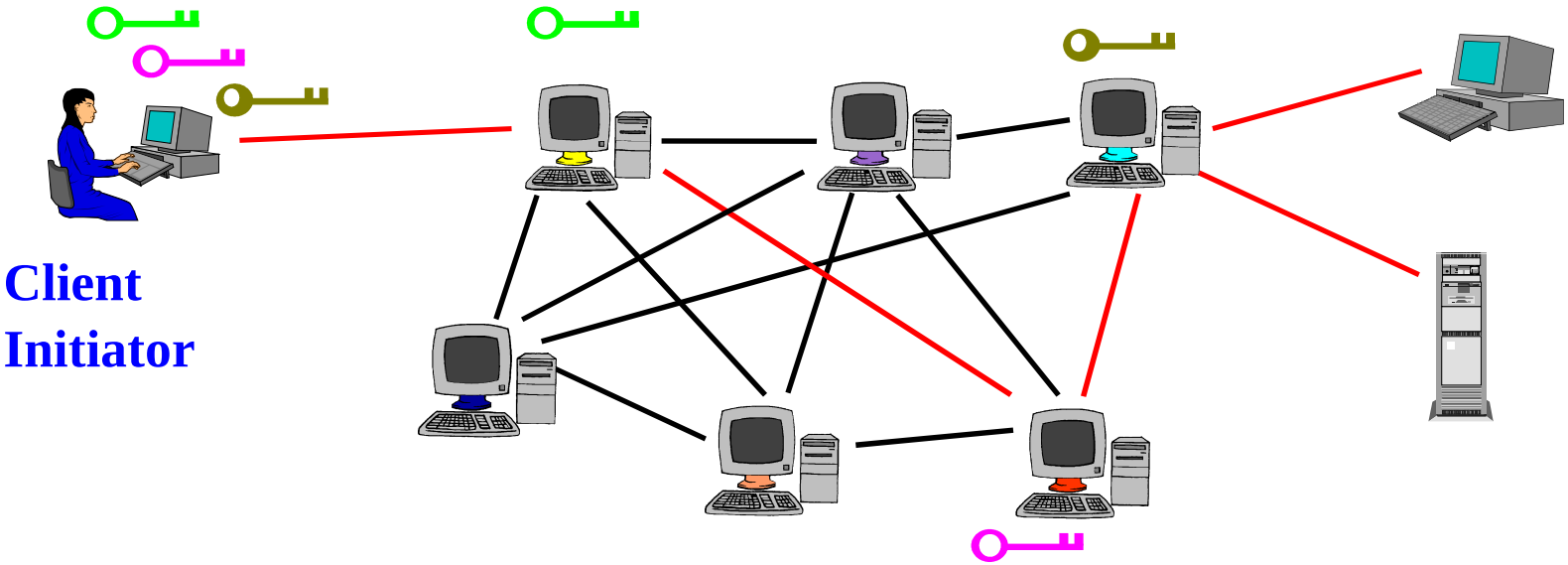
Tor Circuit Usage

- Client Proxy establishes session key + circuit w/ Onion Router 1
- Proxy tunnels through that circuit to extend to Onion Router 2
- Etc
- Client applications connect and communicate over Tor circuit



Tor Circuit Usage

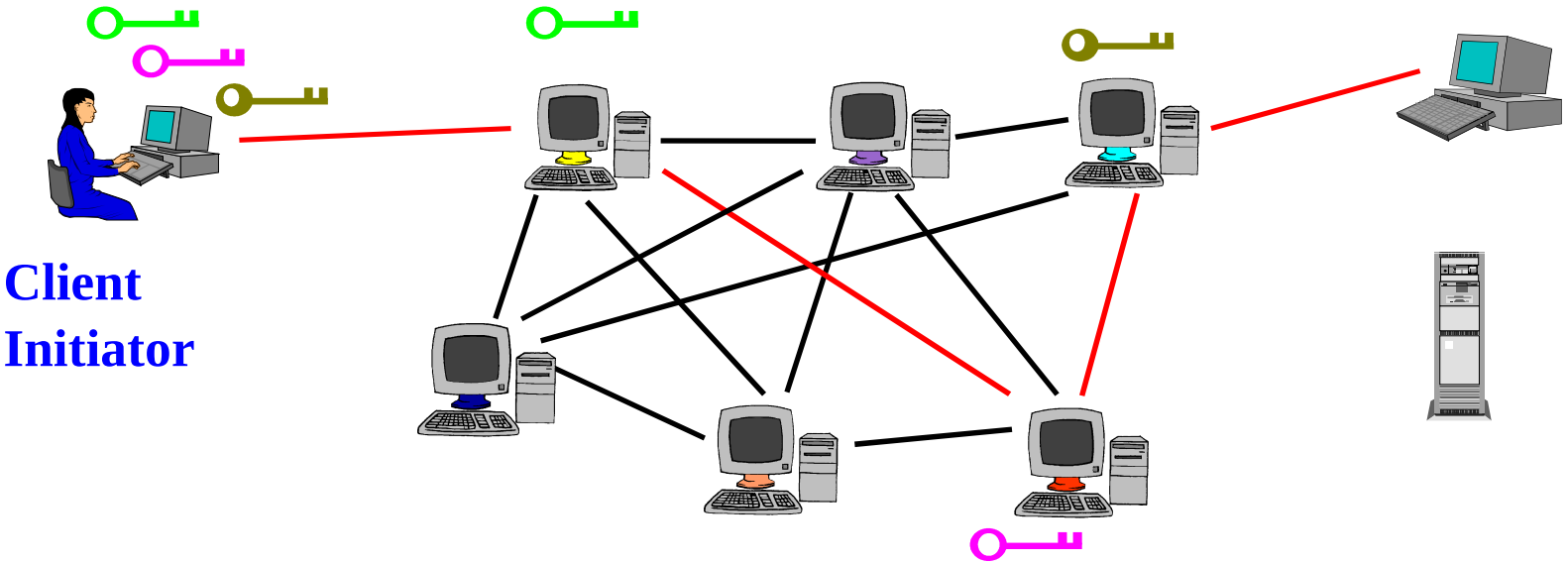
- Client Proxy establishes session key + circuit w/ Onion Router 1
- Proxy tunnels through that circuit to extend to Onion Router 2
- Etc
- Client applications connect and communicate over Tor circuit



Client Initiator

Tor Circuit Usage

- Client Proxy establishes session key + circuit w/ Onion Router 1
- Proxy tunnels through that circuit to extend to Onion Router 2
- Etc
- Client applications connect and communicate over Tor circuit



Client Initiator

Where do I go to connect to the network?

- Directory Servers
  - Maintain list of which onion routers are up, their locations, current keys, exit policies, etc.
  - Directory server keys ship with the code
  - Control which nodes can join network
    - Important to guard against “Sybil attack” and related problems
  - These directories are cached and served by other servers, to reduce bottlenecks
  - Need to decentralize, get humans out of the loop, without letting attackers sign up 100,000 nodes.

Some Tor Properties

- Simple modular design, restricted ambitions.
  - ~40K lines of C code
  - Even servers run in user space, no need to be root
  - Flexible exit policies, each node chooses what applications/destinations can emerge from it
  - Server usability is key to adoption. Without a network, we are nothing.

Some Tor Properties

- Simple modular design, restricted ambitions.
  - Just anonymize the pipe
    - Can use, e.g., privoxy as front end if desired to anonymize data
  - SOCKS compliant TCP: includes Web, remote login, mail, chat, more
    - No need to build proxies for every application

Some Tor Properties

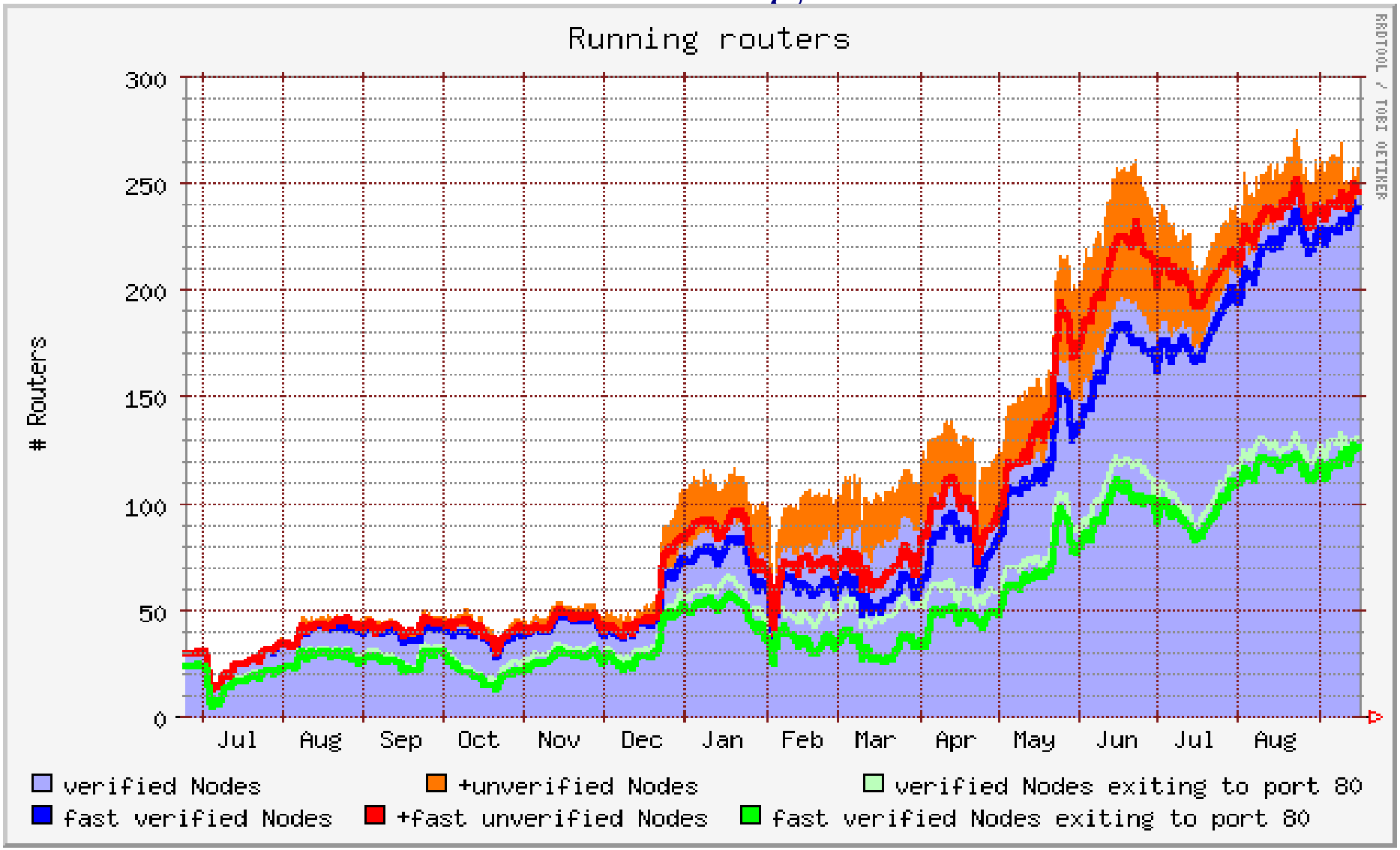
- Lots of supported platforms:

  Linux, BSD, MacOS X, Solaris, Windows, ...

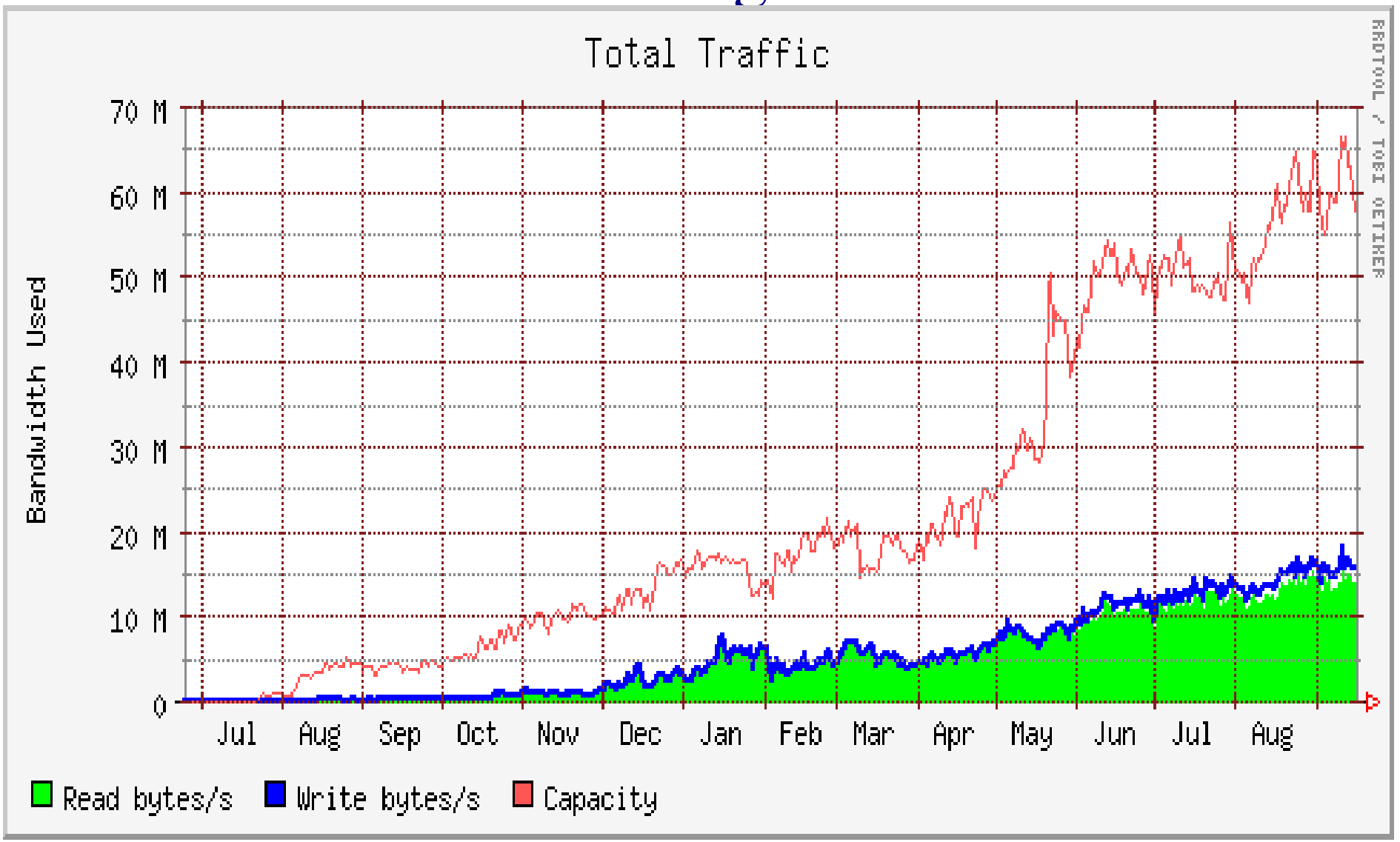
(Tor servers on xbox, linksys wireless routers.)

- Deployment paradigm:
  - Volunteer server operators
  - No payments, not proprietary
  - Moving to a P2P incentives model

Number of running Tor servers



Total traffic through Tor network



Location Hidden Servers

- Alice can connect to Bob's server without knowing where it is or possibly who he is
- Can provide servers that
  - Are accessible from anywhere
  - Resist censorship
  - Require minimal redundancy for resilience in denial of service (DoS) attack
  - Can survive to provide selected service even during full blown distributed DoS attack
  - Resistant to physical attack (you can't find them)

Policy issues

- Attacks we've seen:
  - Ransom note via Hotmail
  - Spam via Google Groups
  - IRC jerks --> DDoS on Tor server
  - Vin Diesel movies
- Wikipedia, Slashdot
- SORBS / spam blacklists

Design Tradeoffs

- Low-latency (Tor) vs. high-latency (Mixminion)
- Packet-level vs stream-level capture
  - IP packets reveal OS characteristics
  - Need application-level scrubbing; and DNS requests to local servers still leak info.
  - Exit policies turn into IDS policies?!
- Padding vs. no padding (mixing, traffic shaping)
- UI vs. no UI (Contest!)
- AS-level paths and proximity issues

Design Tradeoffs

- Enclave-level onion routers / proxies / helper nodes
- Path length? (3 hops, don't reuse nodes)
- China?
- P2P network vs. static network

Get the Code, Run a Node!
(or just surf the web anonymously)

- Current code freely available (free software license)
- Comes with a specification – the JAP team in Dresden implemented a compatible Tor client in Java
- Chosen as the anonymity layer for EU PRIME project
- Design paper, system spec, code, see the list of current nodes, etc.
- http://tor.eff.org/