
SHARKFEST '13
Wireshark Developer and User Conference
I Can Hear You Tunneling
Alex Weber

About me

- Software developer at Tenable Network Security
- I fixed a typo in a comment in the FreeBSD kernel
- Contact info:
  - Twitter: **@AlexWebr**
  - Email: **AlexWebr@gmail.com**
  - FreeNode and Efnet: **AlexWebr**
  - I'm **AlexWebr** pretty much everywhere

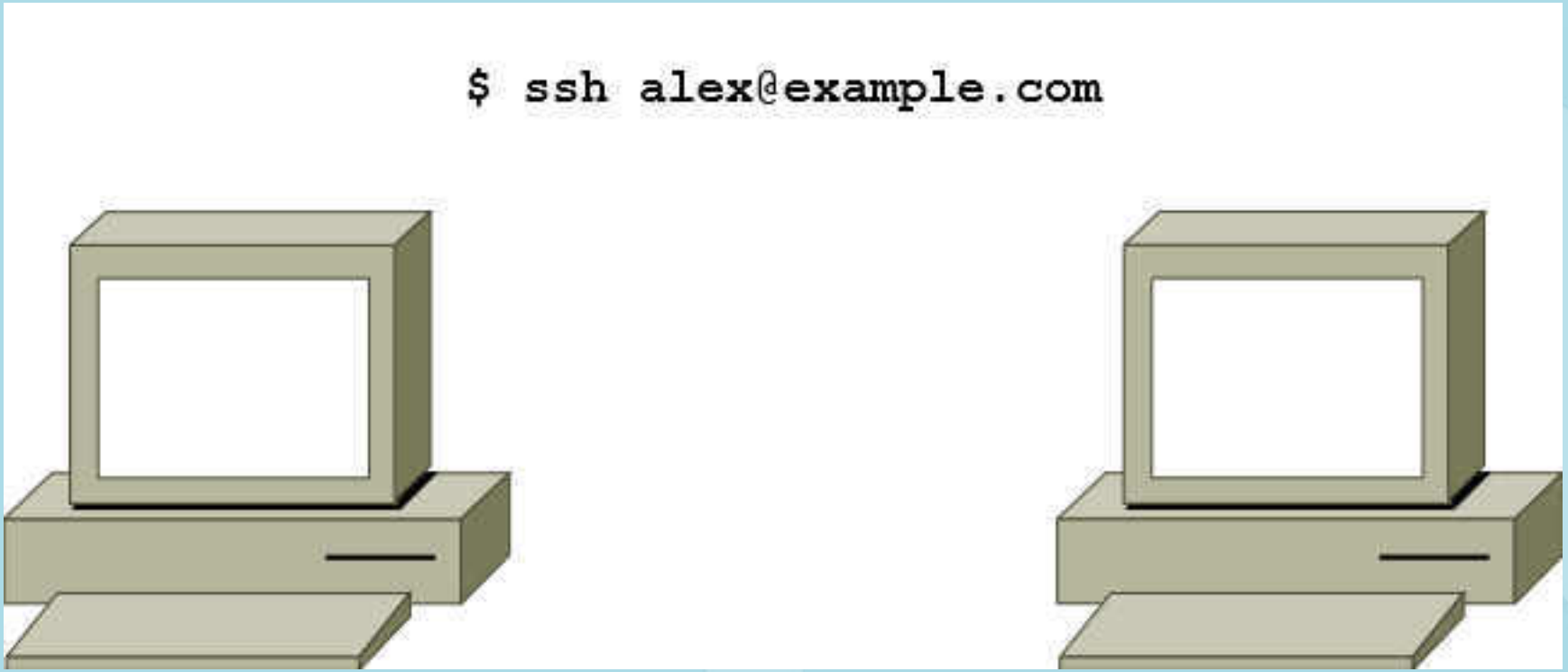
Forewarning

- I'm not here to show you how to break SSH
- SSH2 has a *really good* track record
- Warning: meandering ahead
- I intend to:
  - Explain what SSH is and convince you that it rocks
  - Explain why it can be dangerous
  - Bring you up to speed on previous research and current tools

What is SSH?

- Originally designed as a secure replacement for the infamous “r” commands (rsh, rexec, etc.)
- Uses strong encryption
- Allows for multiplexing many *channels* over a single encrypted TCP session
- The most popular implementation is OpenSSH
- PuTTY is a popular choice for Windows PCs

SSH Channels



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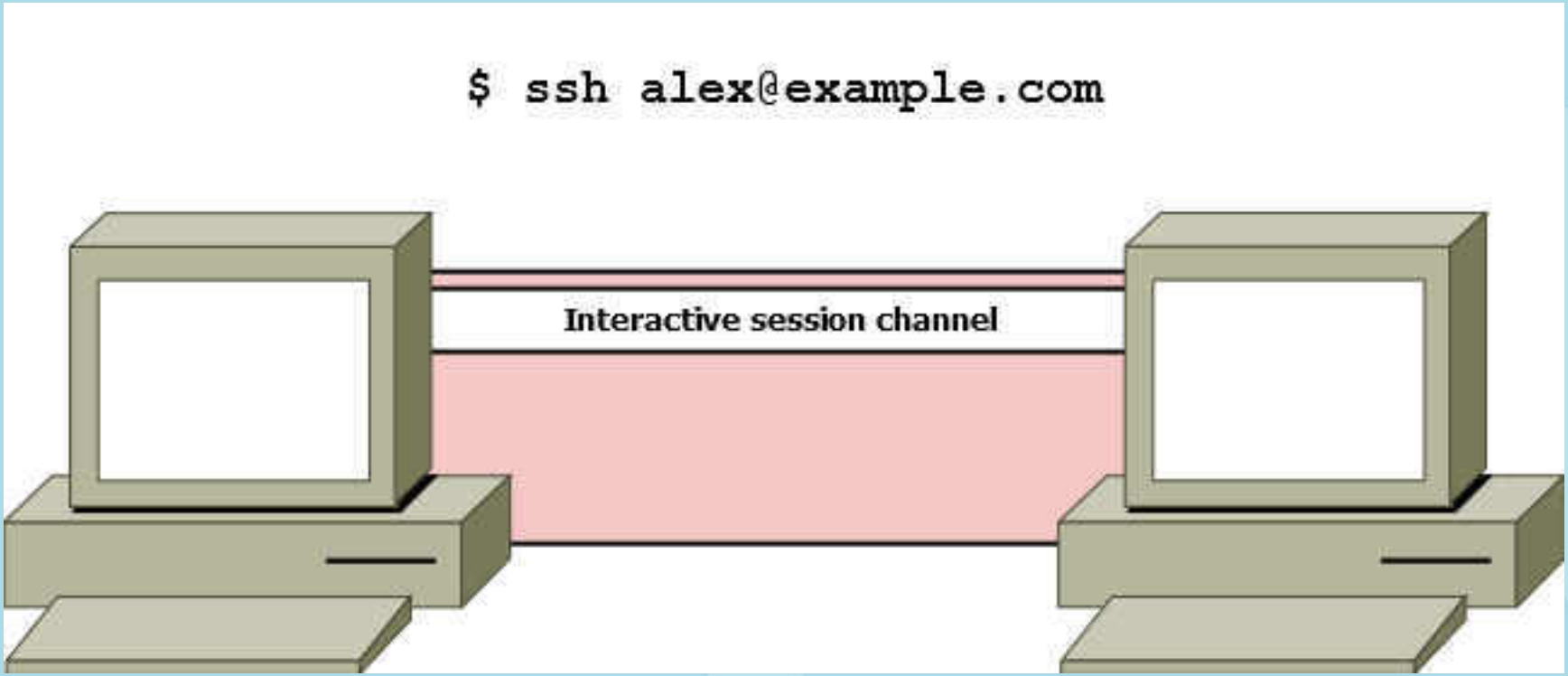

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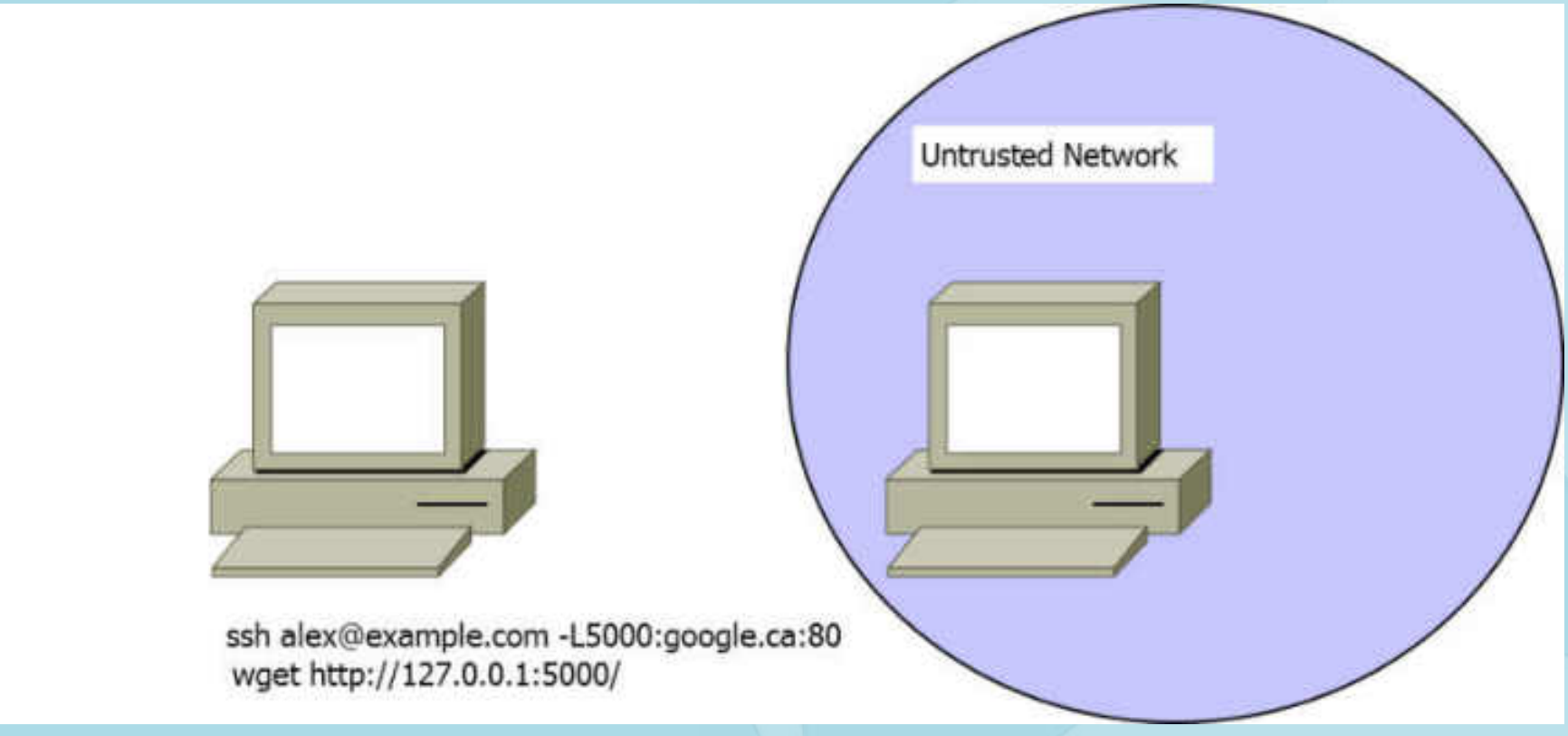

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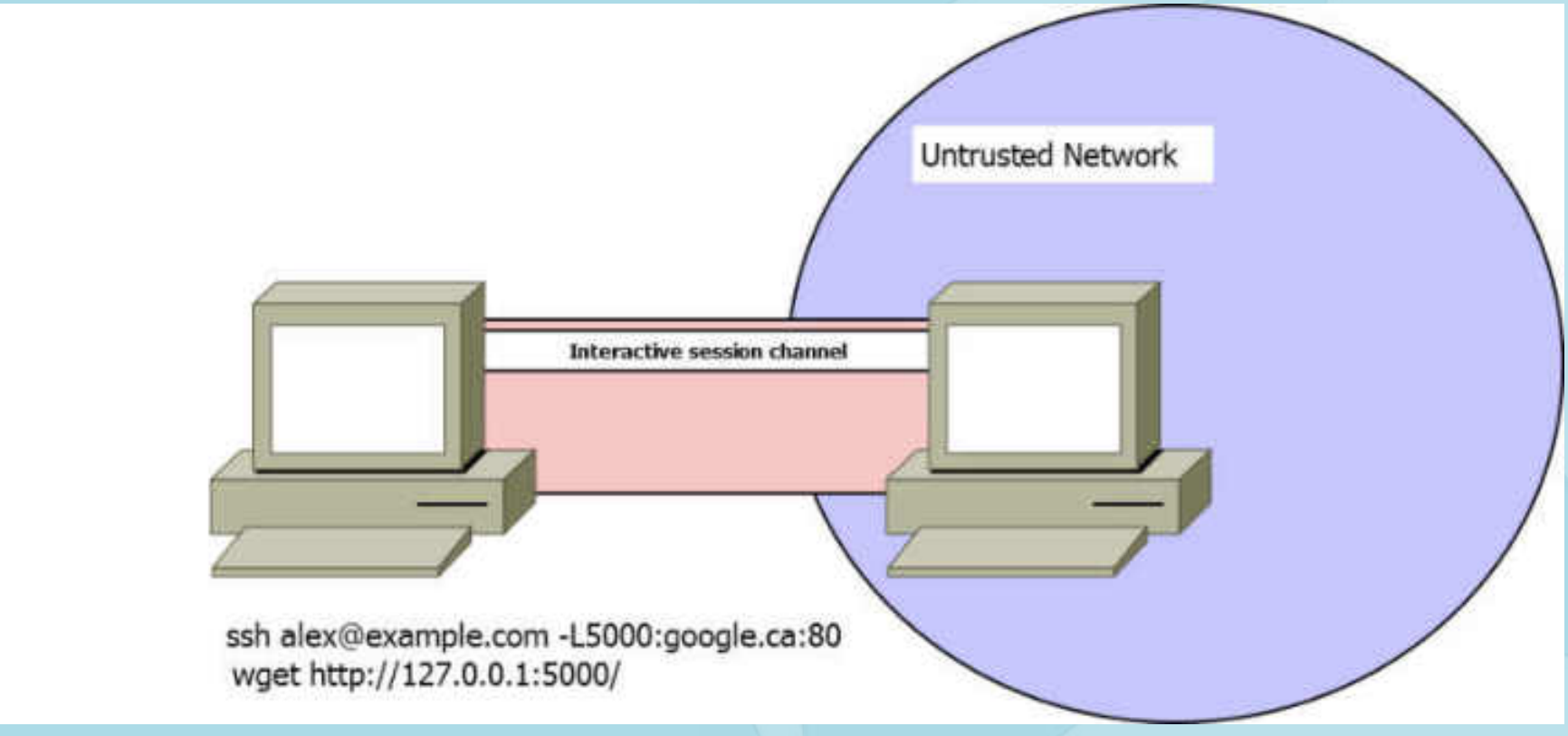

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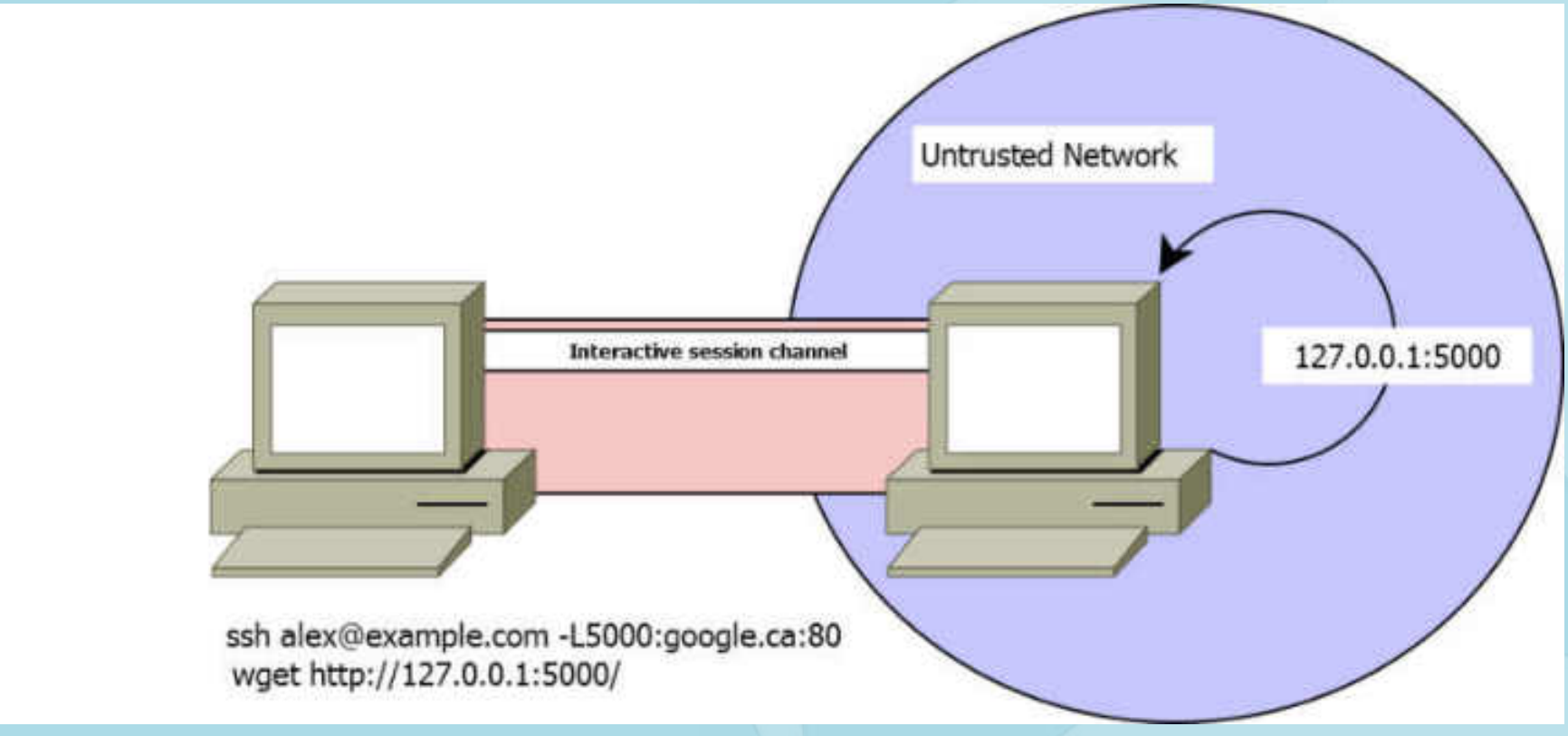

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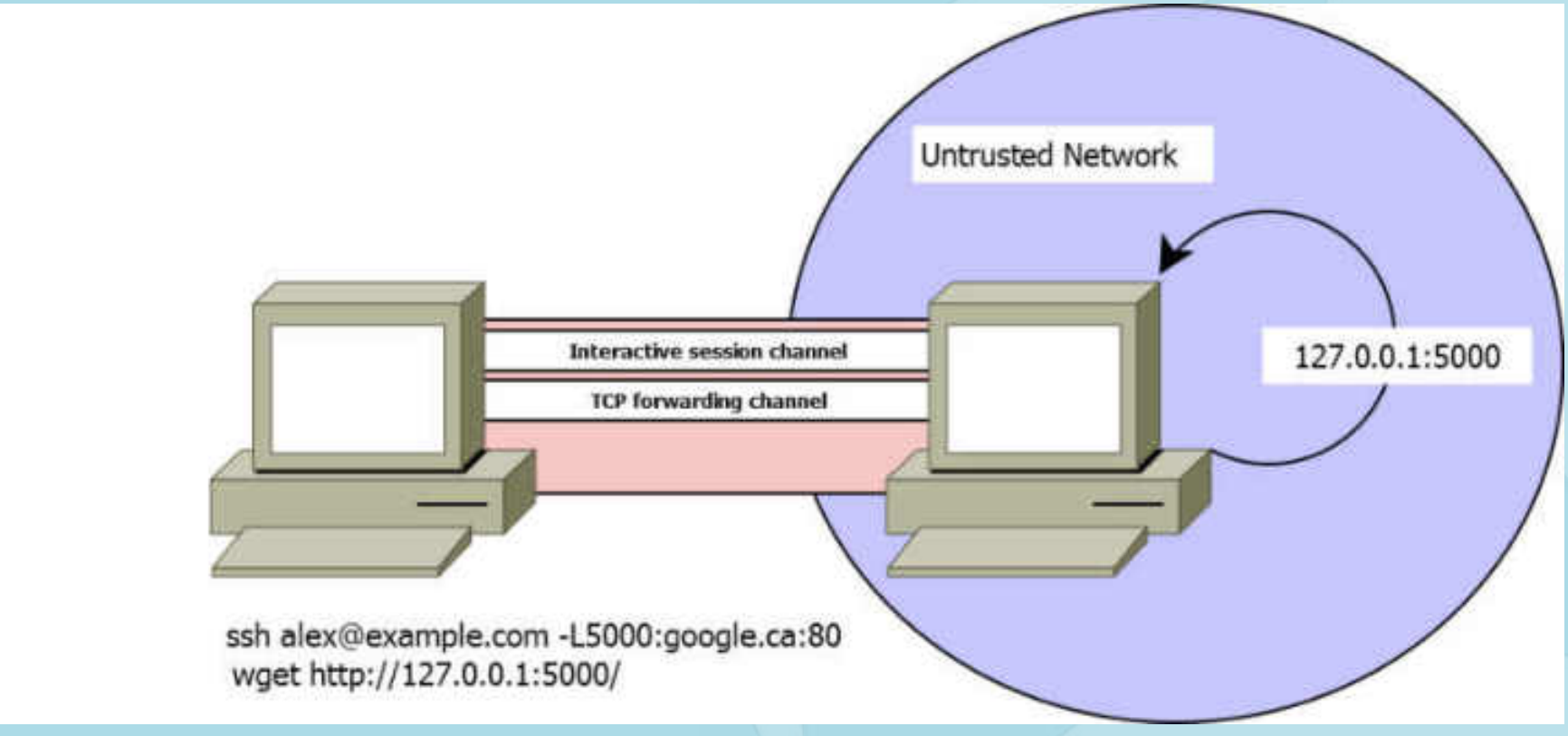

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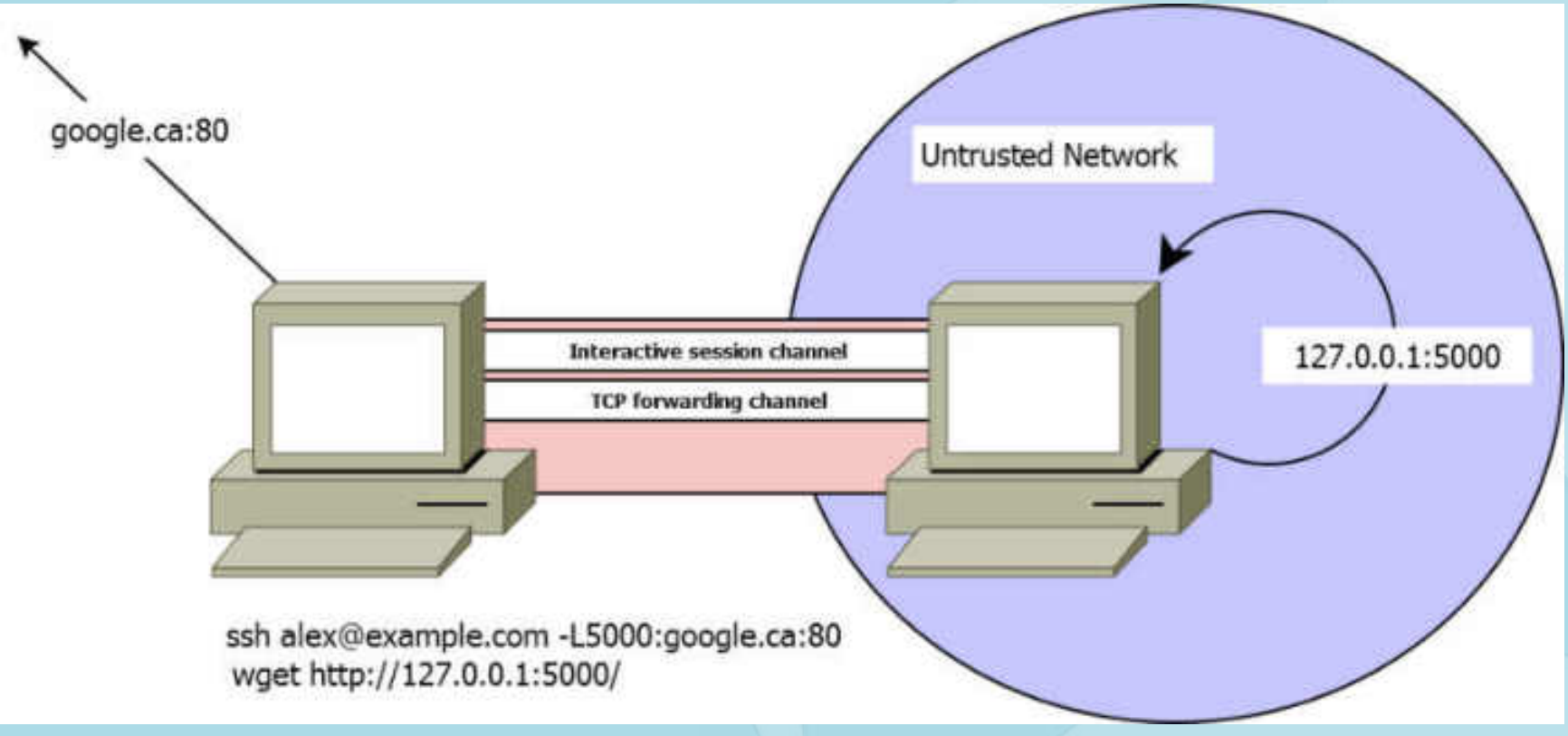
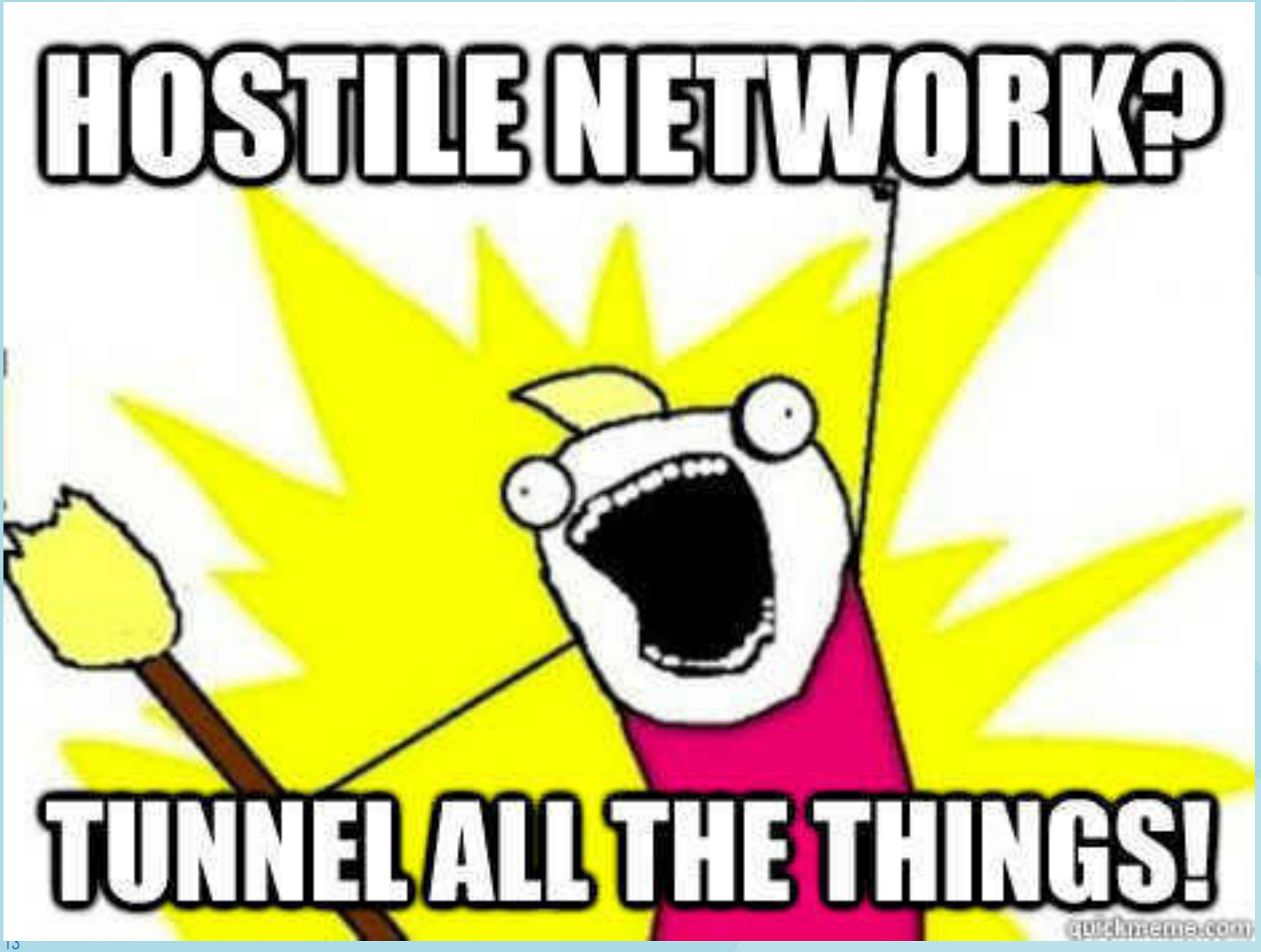


SSH can do some awesome stuff

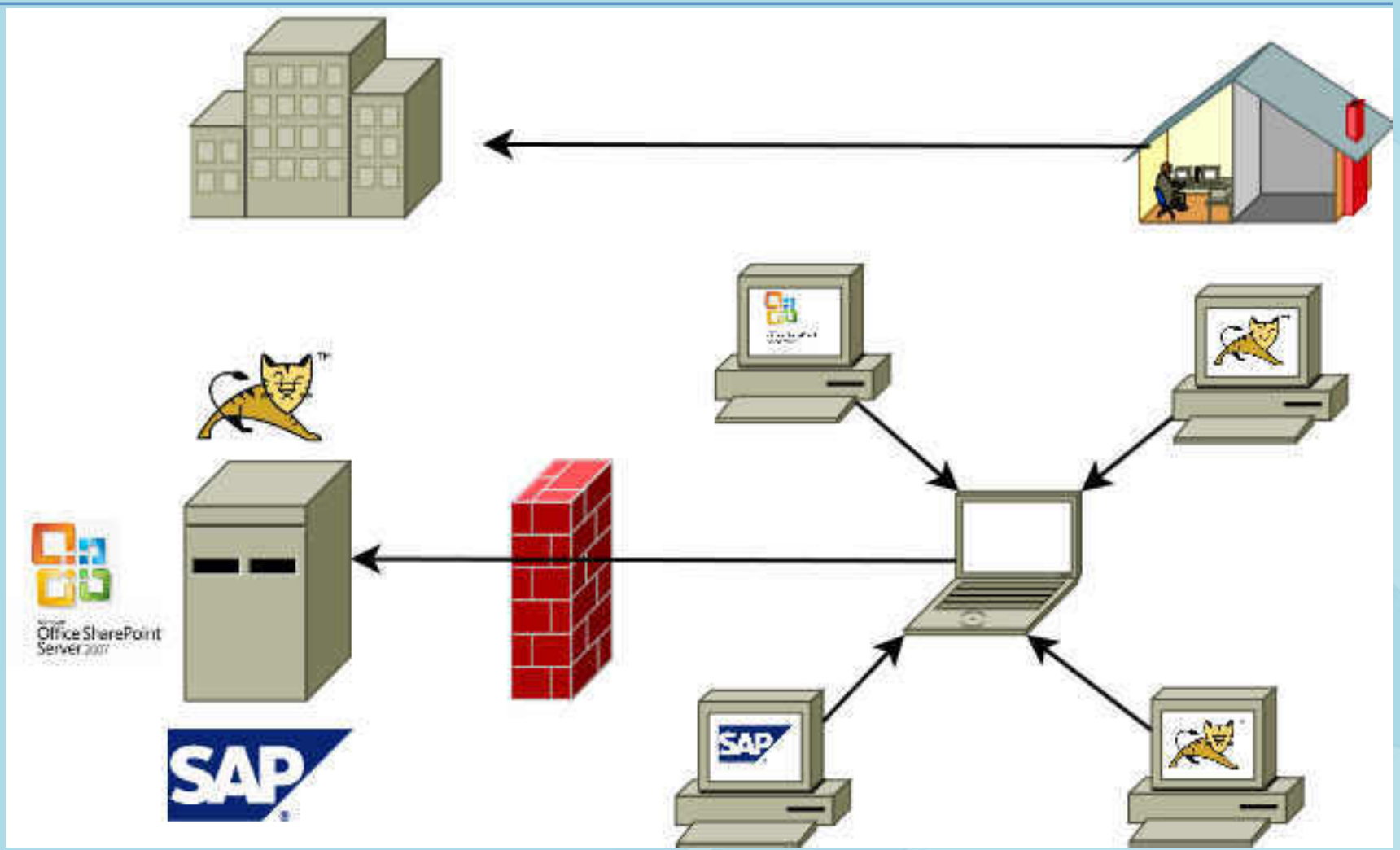
- Allows remote shell access to servers
- Choose-your-own authentication
- Permits file copies to and from a server
  File system access (SSHFS)
  Built-in compression
- Integrates with X11 – instant thin client!
- Can offer a SOCKS proxy (Firefox, Pidgin, etc.)
- Layer 3 and layer 2 VPN using **tun** devices


HOSTILE NETWORK?
TUNNEL ALL THE THINGS!

SSH can be dangerous!

- If you allow SSH traffic to travel all over the place, you are going to have a bad time
- We talked about channels already:
  The client can forward ports to the server
  The client can request that remote server ports be forwarded back to the client
  Both remote- and local-forwarded ports can listen on external interfaces
- Let's look at a few examples…

SSH can be dangerous!



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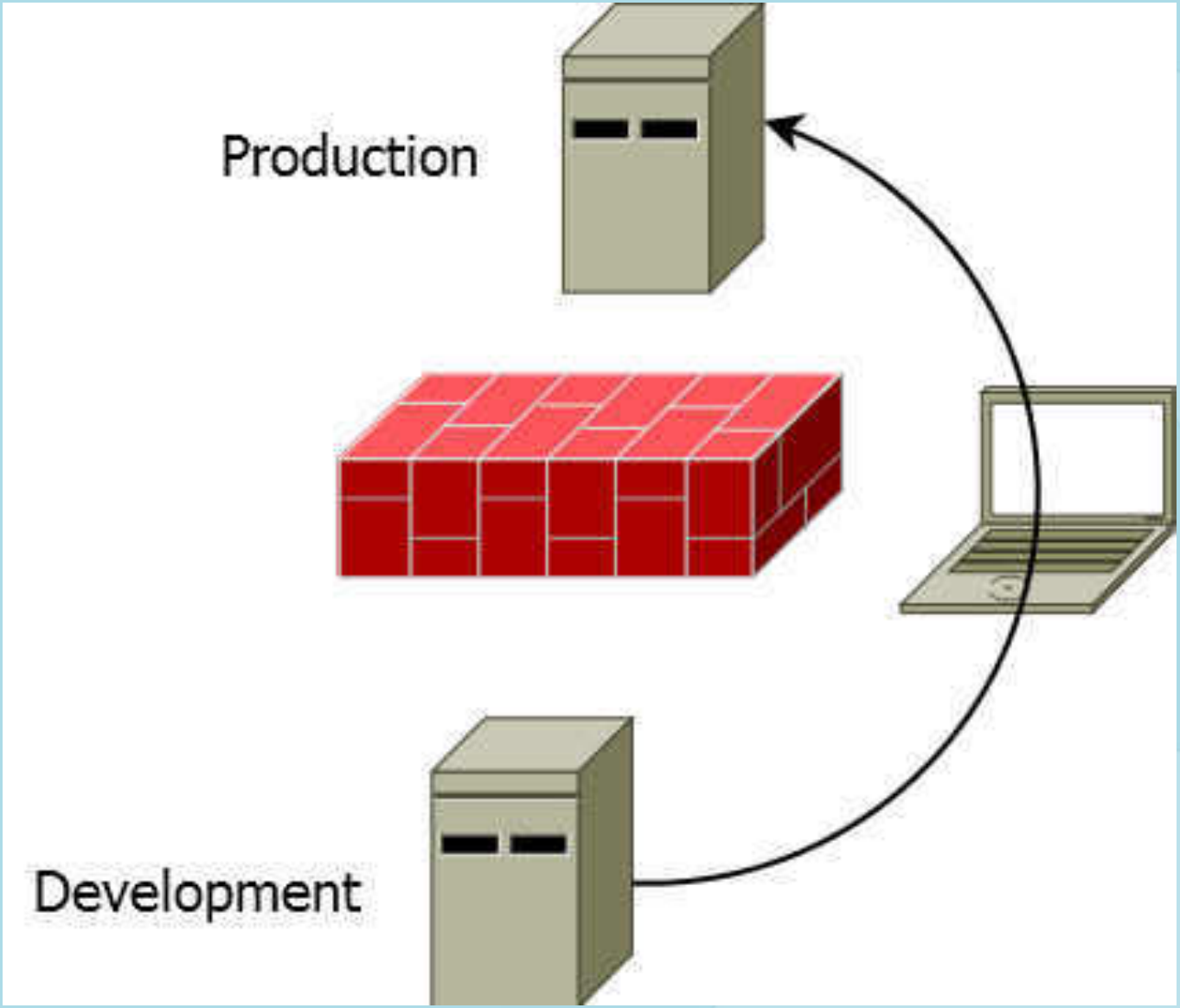

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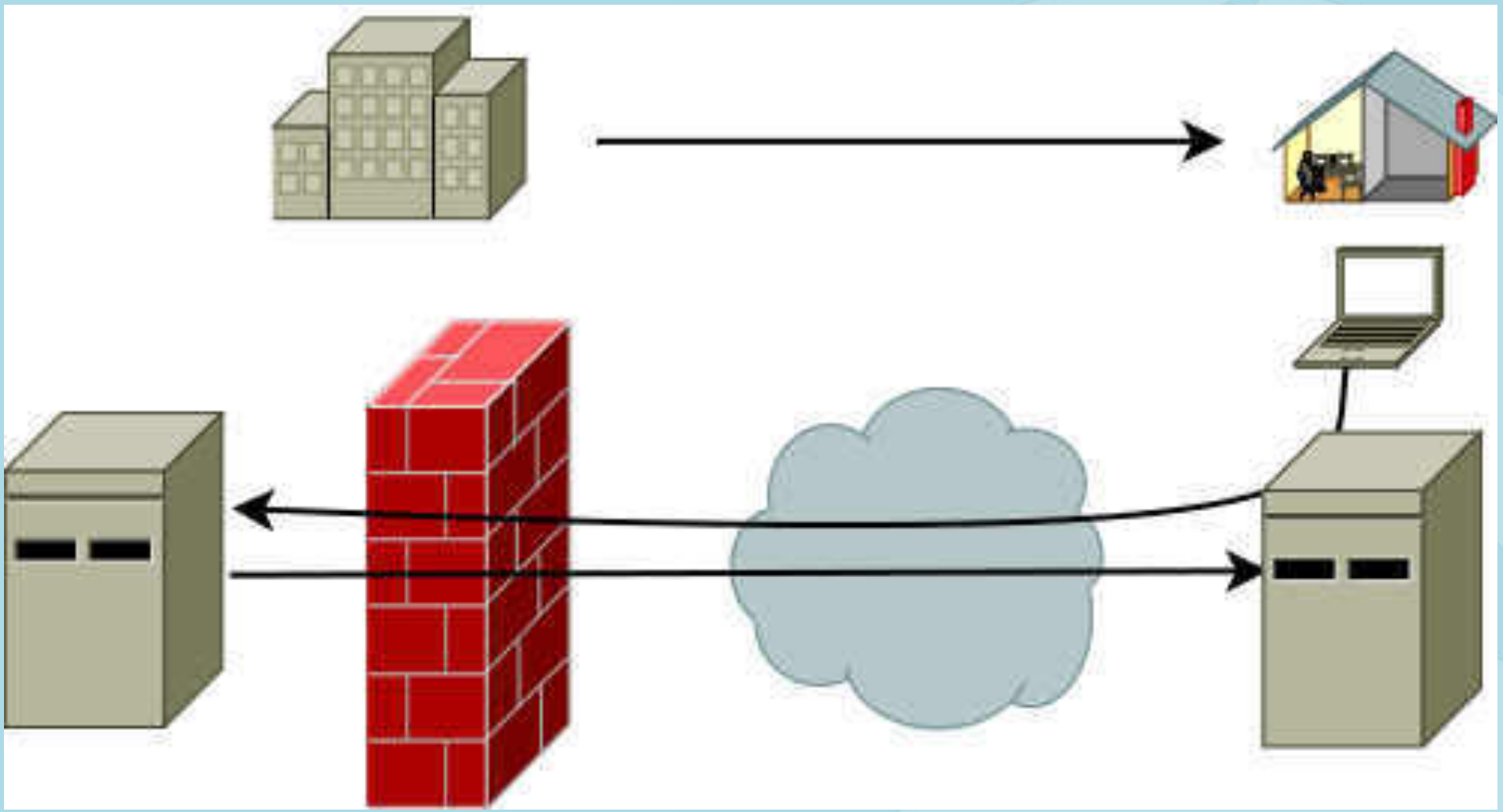
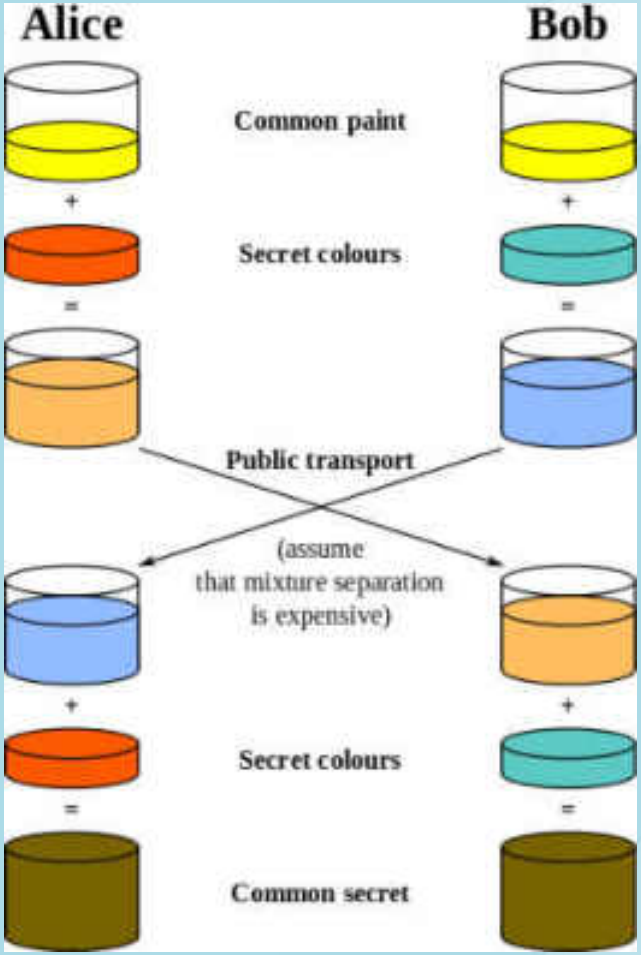


What's a network admin to do?

- SSH is hard to man-in-the-middle out of the box
- No X.509 certificate chain to transparently exploit

What's a network admin to do?

- Uses Diffie-Hellman (perfect forward secrecy)

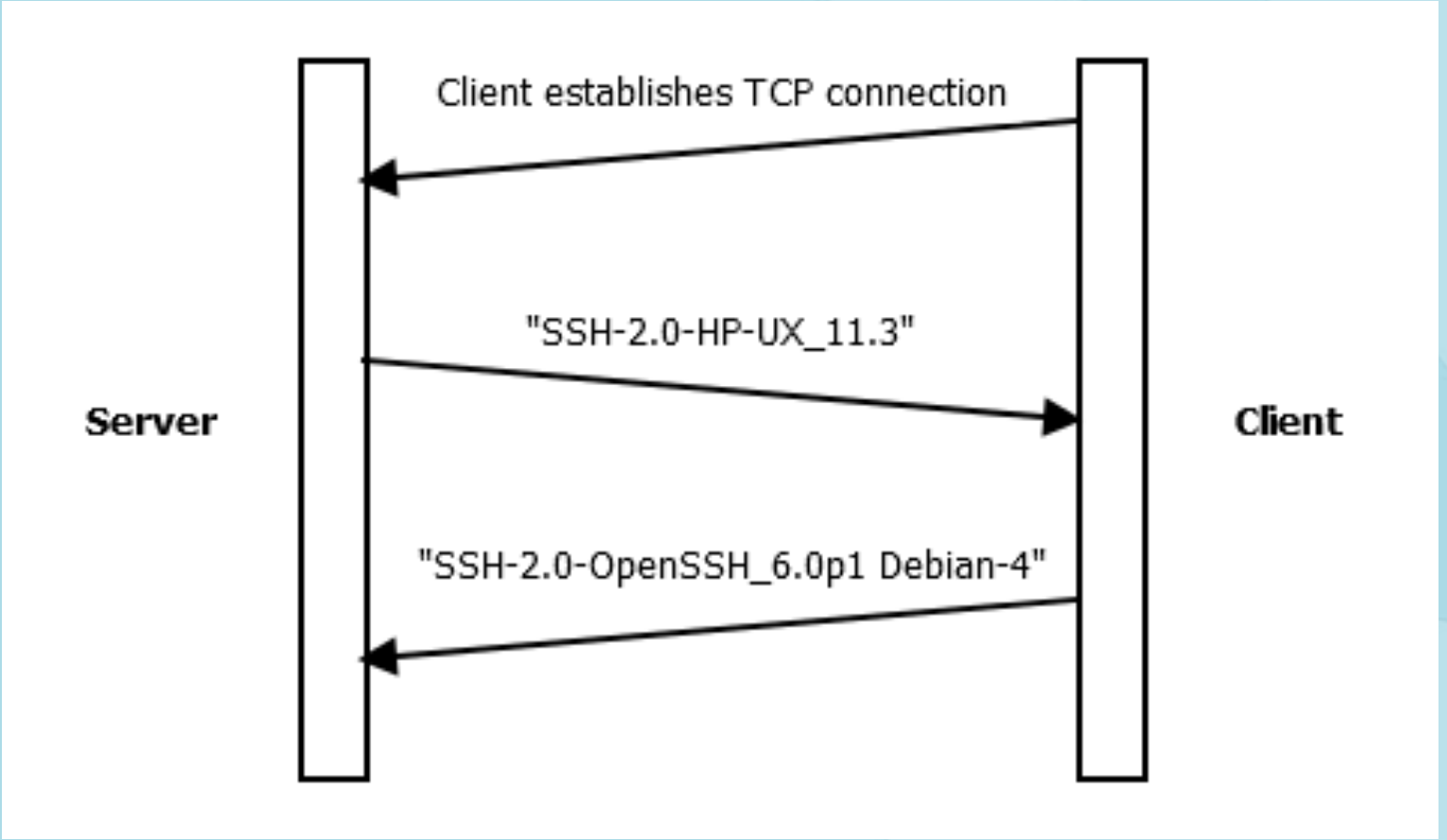


What's a network admin to do?

- In the real world, force all traffic through an SSH proxy - anything that doesn't cross the proxy is a policy violation
  But, the real world is boring!

Analyzing the Handshake

- Let's look at the SSH handshake…



Analyzing the Handshake

- Look at version strings exchanged in the handshake because they can give away the operating system!
- Remember that a lack of explicit OS name is also information: likely **not** Debian, FreeBSD, etc.
- Examples:
  SSH-2.0-OpenSSH_5.9p1 Debian-5ubuntu1
  SSH-2.0-OpenSSH_6.0p1 Debian-4
  SSH-2.0-OpenSSH_5.5p1 Debian-6+squeeze2
  SSH-2.0-HP-UX_11.3
  SSH-2.0-OpenSSH_5.8p2_hpn13v11 FreeBSD-20110503

Analyzing the Handshake

- Look at negotiated cipher suites – can give away patch level if the version number is not present
- UMAC-64 support was added in 4.7
- CBC preferred before 5.2, CTR afterwards
- Elliptic Curve DSA support was added in 5.7
- Truncated SHA2 support added in 5.9 and removed in 6.1
- AES-GCM supported added in 6.2

Analyzing the Handshake

- Why should we care about version numbers?
- We can correlate operating system information with what's expected on the network:
  "Why is there an Ubuntu machine on our network?"
- Can be used to look for vulnerabilities:
  Tenable's Passive Vulnerability Scanner has over 90 passive checks that connect SSH version numbers to exploitable vulnerabilities

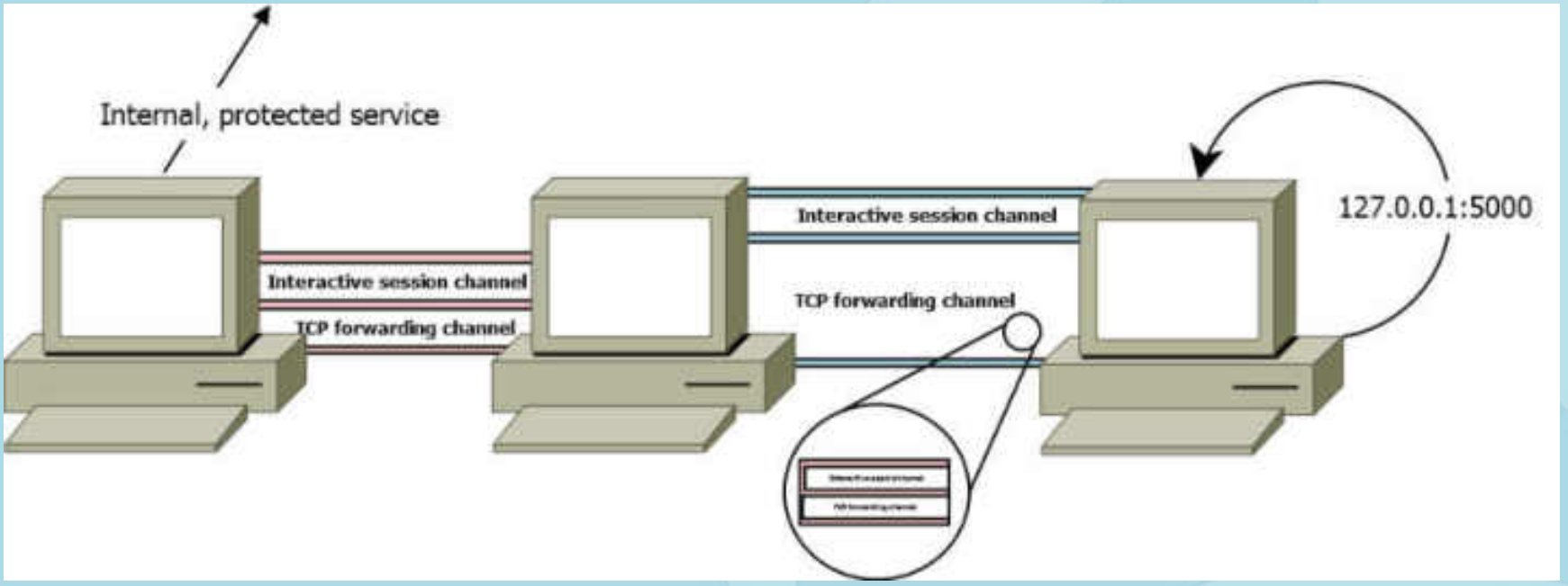
Detecting pivots

- Ingress and egress rules may be different depending on the network segment a device is in
- A user may route their traffic through one or more hops, so that their traffic is treated more favorably
- Penetration testers call this “pivoting”
- I’ve always wished I was cool enough to be a penetration tester, so I’ll call it pivoting too

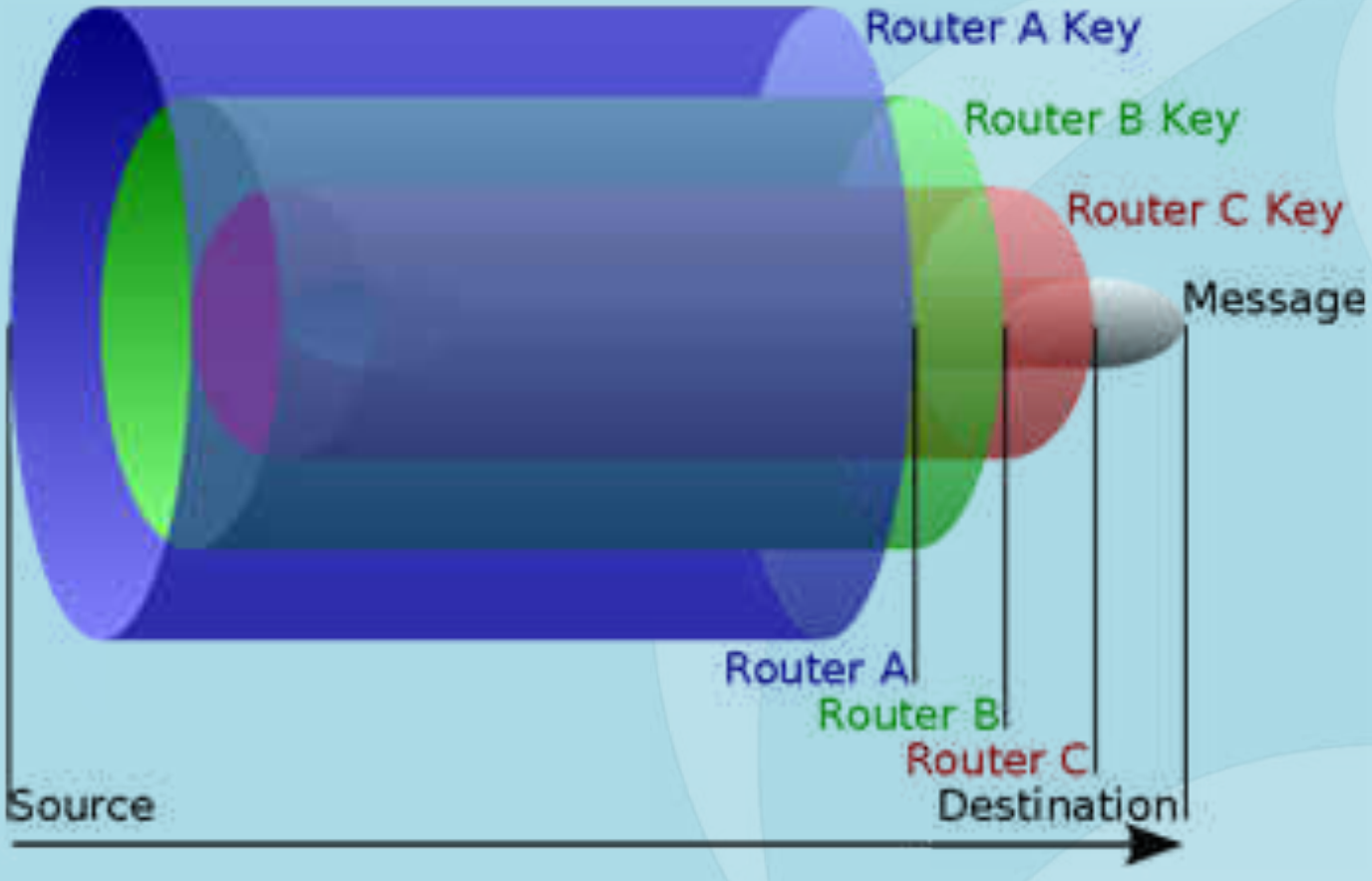
Detecting pivots

- The two kinds of pivots we'll talk about today:
  - Nesting SSH sessions
  - Using netcat, Ncat, or similar to relay

Detecting Nested SSH Sessions



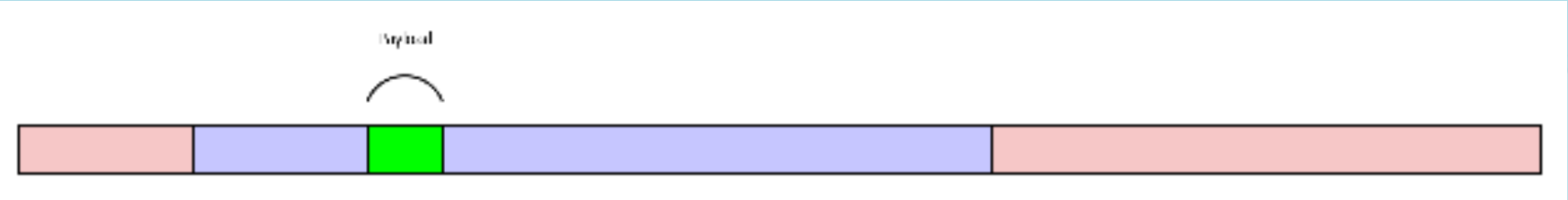
Detecting Nested SSH Sessions

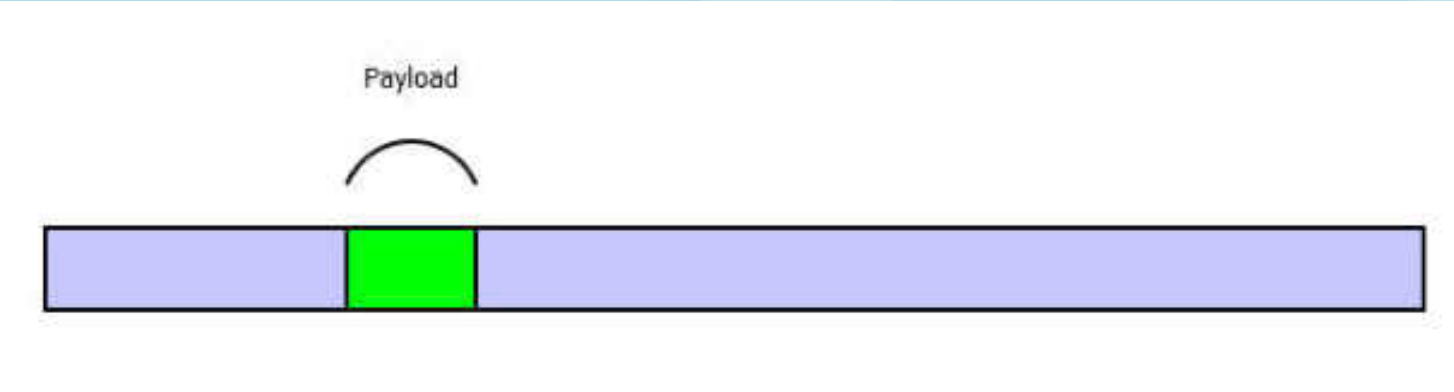


Detecting Nested SSH Sessions

- In the case of nested tunnels, it's pretty easy to follow the flow through the network
- Look for SSH connections where the smallest packet is double/triple/etc. the size of the smallest possible packet for the chosen ciphersuite
- To find the next hop, look for packets egressing from the middle host that are "one layer smaller"

Detecting Nested SSH Sessions

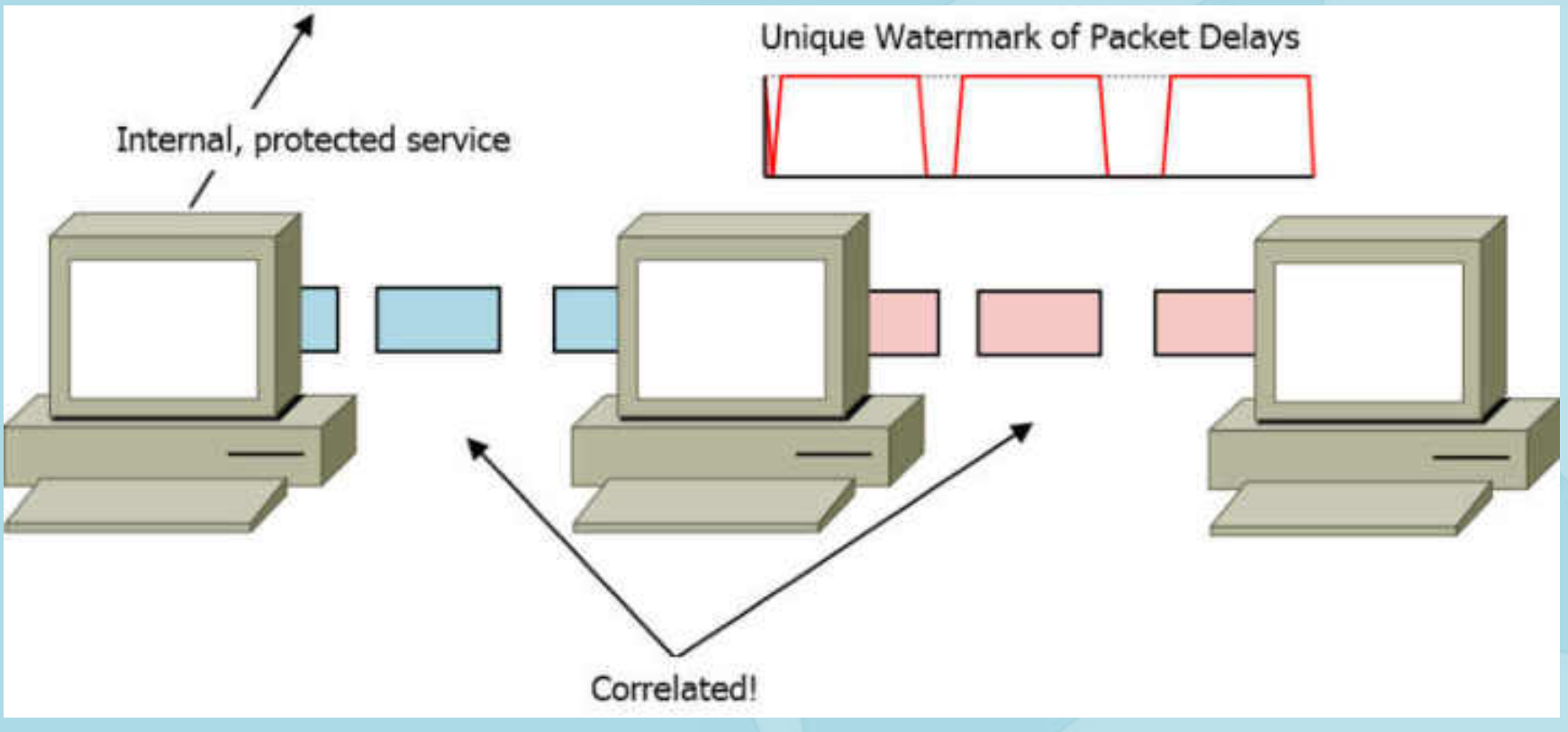




Detecting netcat / Ncat relays

- "Active Timing-Based Correlation of Perturbed Traffic Flows with Chaff Packets"
  Pai Peng, Peng Ning, Douglas S. Reeves, Xinyuan Wang
  North Carolina State U, George Mason U
- Not strictly passive, and not SSH, but interesting
- Watermark packets by introducing small, unique inter-packet delays
  Any connection downstream with same inter-packet delay is likely 'fed' by the watermarked upstream connection

Detecting Pivots



Side Channel Attacks

- Definition: a side channel attack is any attack based on information gained from the physical implementation of a cryptosystem, rather than brute force or theoretical weaknesses in the algorithms (compare cryptanalysis)

  - Wikipedia

Side Channel Attacks

- **Protocol for Securely Recording Information**
  - Write information down on a pad of paper
  - Don’t allow anyone to see the paper
  - Easy!

Side Channel Attacks

- The act of writing requires visible movement
  - Can we reconstruct the text by monitoring movement of the arm, the eyes, or the pencil? How about all together?
- Writing causes friction heat in the writing surface
  - Can a thermal imaging camera reproduce the text by viewing the writing surface, post-recording?
- The act of writing generates noise
  - If recorded, can we determine the movement of the pencil?
  - What if there are many microphones?

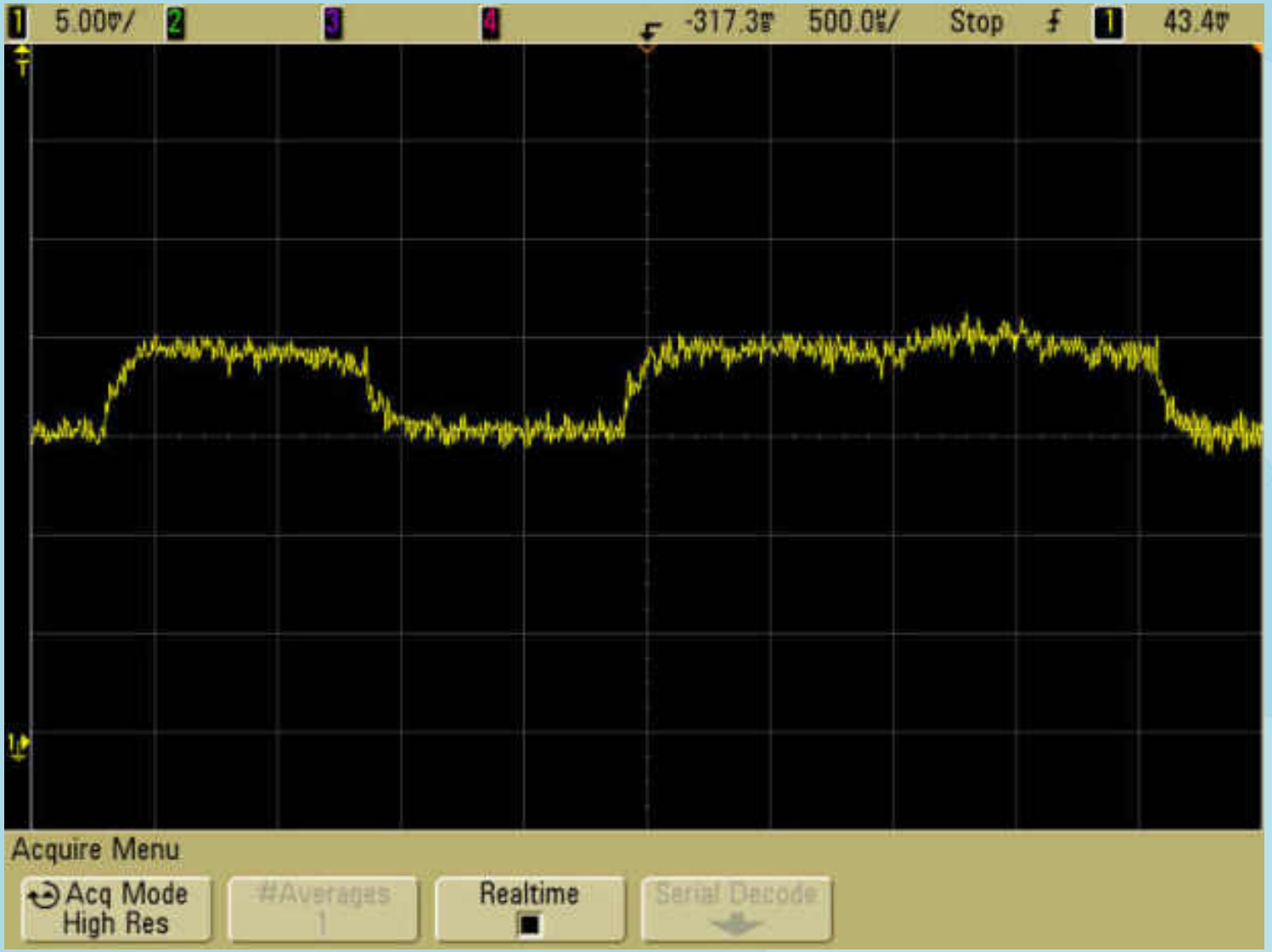
Side Channel Attacks – Real World

- Observable movement
  - Real-world equivalent: traffic flow analysis
- Residual heat in the writing surface
  - Real-world equivalent: cold-boot attacks
- Recordable noise from the writing process
  - Real-world equivalent: acoustic and power analysis
- Writing activity does not match information density
  - Real-world equivalent: CRIME (compression attacks)

Power Analysis

- Introduced by Cryptography Research in 1998
- Exactly what it sounds like:
  Measuring the power consumption of a device as it performs a cryptographic operation
- Simple and Differential power analysis (SPA/DPA)
- FIPS 140-2 doesn't require SPA or DPA resistance

Power Analysis



Cold Boot Attacks

- Pioneered by J. Alex Halderman, Seth D. Schoen, Nadia Heninger, William Clarkson, William Paul, Joseph A. Calandrino, Ariel J. Feldman, Jacob Appelbaum, and Edward W. Felten
- Contrary to popular assumption, RAM retains information for seconds to minutes after power is lost

Cold Boot Attacks

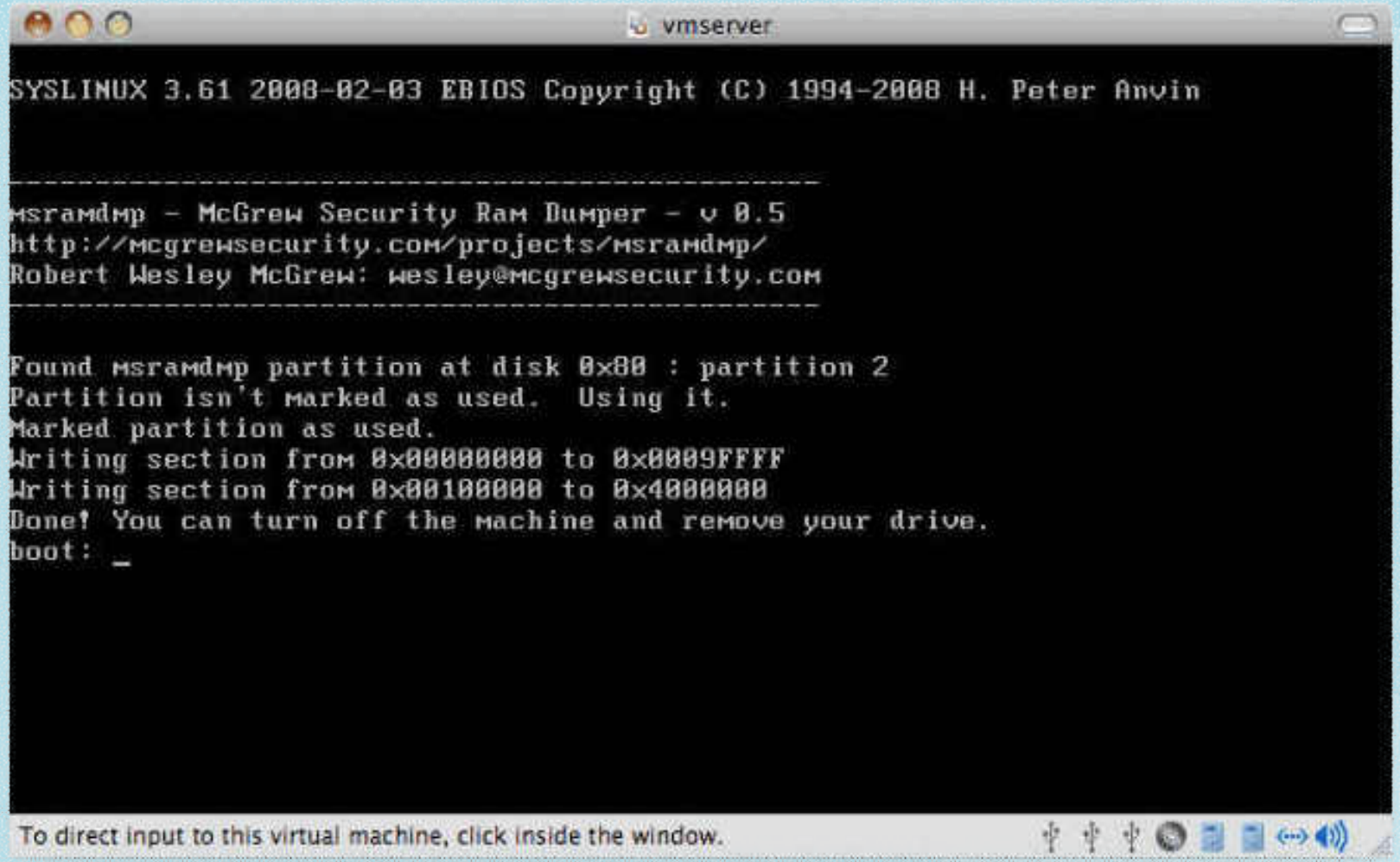
- Attack scenario:
  - Your laptop uses full-disk encryption
  - Your laptop is powered on, but locked
  - Your laptop is stolen
- If the attacker removes the harddrive, they get nothing
- We assume the lock screen cannot be bypassed (not always true, see “Inception” against Mac OS X)

Cold Boot Attacks

- Cryptographic keys must stay in RAM
- RAM retains information for seconds to minutes after power loss
- As RAM is cooled, it retains information for longer
- Cool the RAM, hard reset, and dump all memory
- Apply a tool like **findaes** to the dumped memory to locate cryptographic keys

Cold Boot Attacks

Cold Boot Attacks



Side Channels and SSH

- Let's look at the previous information leaks SSH has had and how others have exploited them

Previous Research

- "Passive Analysis of SSH Traffic"
  Solar Designer and Dug Song
  March 19th, 2001
- Applies to SSH1, primarily
- Wrote a tool that:
  - Detects password length (login and sudo)
  - Detects RSA or DSA authentication
  - Determine the length of shell commands and in some cases, the commands themselves
  - If you have old Cisco devices with SSHv1, you're still vulnerable!

Previous Research

- **sshkeydata**
  Tool written by Brendan Gregg
  Compares a packet capture from an SSH session and a Telnet session of the same user
  Looks for timing similarities to guess commands

- 92% accuracy in an SSH session where 20 commands were executed

Previous Research

- First and foremost, SSH should protect the privacy of data being exchanged
- Ideally, SSH should also keep the user's behavior confidential.
- "A Preliminary Look at the Privacy of SSH Tunnels"
- "Tunnel Hunter: Detecting Application-Layer Tunnels with Statistical Fingerprinting"
- Uses big words like Gaussian Mixture Models and Hidden Markov Models

SSHFlow

- Written in Python, uses the dpkt library
- Examines a PCAP for SSH traffic
- Guesses what is being tunneled based on most common packet sizes
- Can distinguish file copies from X11 from interactive sessions
- Can detect nested tunnels
- It's not pretty – it's just a proof-of-concept

SSHFlow Demo 1

- I am going to demo using ASCII.IO
- If you have a smartphone or a laptop in front of you, you can watch this “asciicast” by browsing to this address:

ascii.io/a/3442

SSHFlow Demo 2

- I am going to demo using ASCII.IO
- If you have a smartphone or a laptop in front of you, you can watch this “asciicast” by browsing to this address:

ascii.io/a/3443

Recommended Reading

- Silence on the Wire
  Michal Zalewski
- Cryptography Engineering
  Ferguson, Schneier, Kohno

Hacker CTFs and Wargames

- PlaidCTF
- Ghost in the Shellcode
- Defcon Qualifiers
- PHDays
- PoliCTF
- Over the Wire
- Smash the Stack

Recap

- What SSH and why you should use it
- Why you should **not** let your users use SSH without careful monitoring
- Some pie-in-the-sky and some more practical techniques for following pivots through the network
- What side channel attacks are and how they affect SSHv1 with regards to password authentication

Recap

- SSHFlow, a proof-of-concept tool to detect the protocols being tunneled by an SSH connection
- Recommended reading
- CTF challenges and http://ctftime.org
- Recap
  - Recap
    - Recap
      - Recap
        - Oh my god what's going on!?!?!?

Thanks!

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  - FreeNode and Efnet IRC: **AlexWebr**
- Demos: **ascii.io/~AlexWebr**
- https://github.com/AlexWebr/sshflow