Lecture 24: Detection

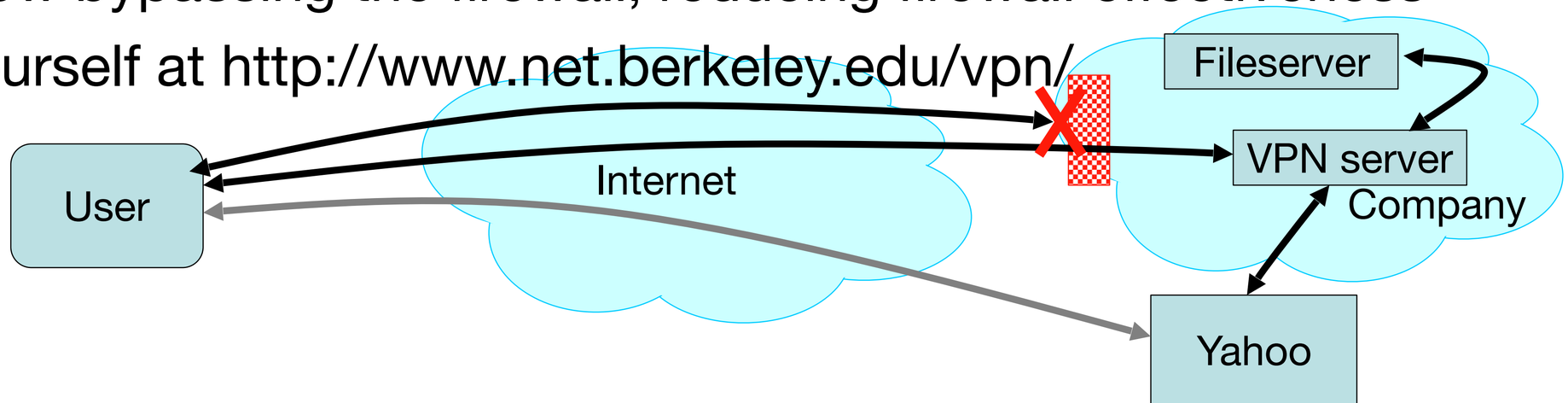
https://cs161.org

Announcements

Firewalls

Secure External Access to Inside Machines

- Often need to provide secure remote access to a network protected by a firewall
  - Remote access, telecommuting, branch offices, …
- Create secure channel (Virtual Private Network, or VPN) to tunnel traffic from outside host/network to inside network
  - May allow bypassing the firewall, reducing firewall effectiveness
  - Try it yourself at http://www.net.berkeley.edu/vpn/



Why Have Firewalls Been Successful?

- Central control – easy administration and update
  - Single point of control: update one config to change security policies
  - Potentially allows rapid response
- Easy to deploy – transparent to end users
  - Easy incremental/total deployment to protect 1000's
- Addresses an important problem
  - Security vulnerabilities in network services are rampant
  - Easier to use firewall than to directly secure code …

Think like an attacker

- Suppose you wanted to attack a company protected by a firewall. What attacks might you try?

- Share your ideas on chat (mark it visible to everyone)

Firewall Disadvantages

- Functionality loss – less connectivity, less risk
  - May reduce network's usefulness
  - Some applications don't work with firewalls
    - Two peer-to-peer users behind different firewalls
- The malicious insider problem
  - Assume insiders are trusted
    - Malicious insider (or anyone gaining control of internal machine) can wreak havoc
- Firewalls establish a security perimeter
  - Like Eskimo Pies: "hard crunchy exterior, soft creamy center"
  - Threat from travelers with laptops, cell phones, …

Lateral Movement

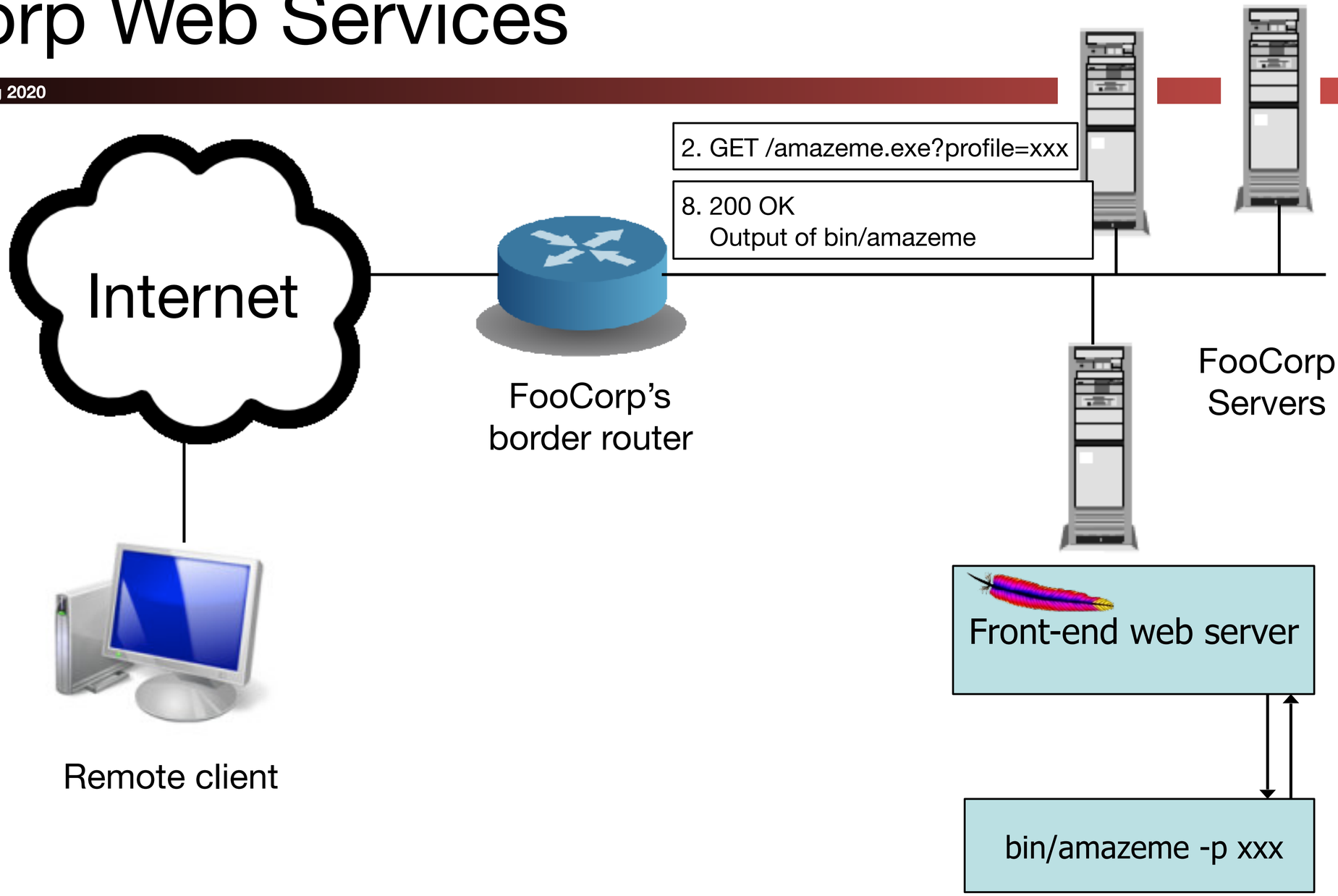
- Common attack: compromise an internal machine, then use that to attack other internal machines
- From there, you can now exploit internal systems directly
  - Bypassing the primary firewall
- That is the shortcoming of firewalls: A ***single*** breach of the perimeter by an attacker and you can no longer make ***any*** assertions about subsequent internal state

Takeaways on Firewalls

- Firewalls: Reference monitors and access control all over again, but at the network level
- Attack surface reduction
- Centralized control

Detection

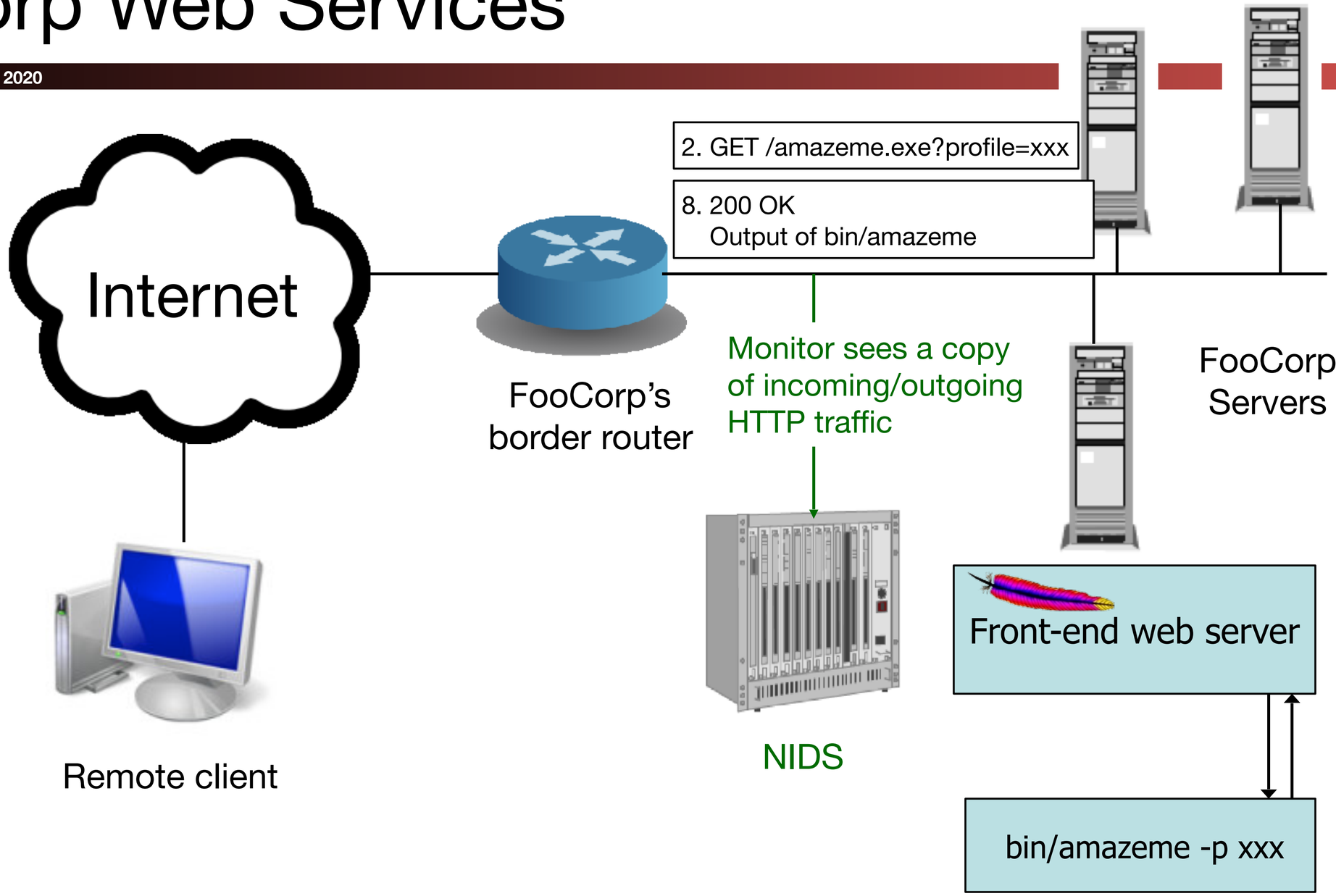
Structure of FooCorp Web Services



Network Intrusion Detection

- Approach #1: look at the network traffic
  - (a “NIDS”: rhymes with “kids”)
  - Scan HTTP requests
  - Look for “`/etc/passwd`” and/or “`../../`” in requests
    - Indicates attempts to get files that the web server shouldn't provide

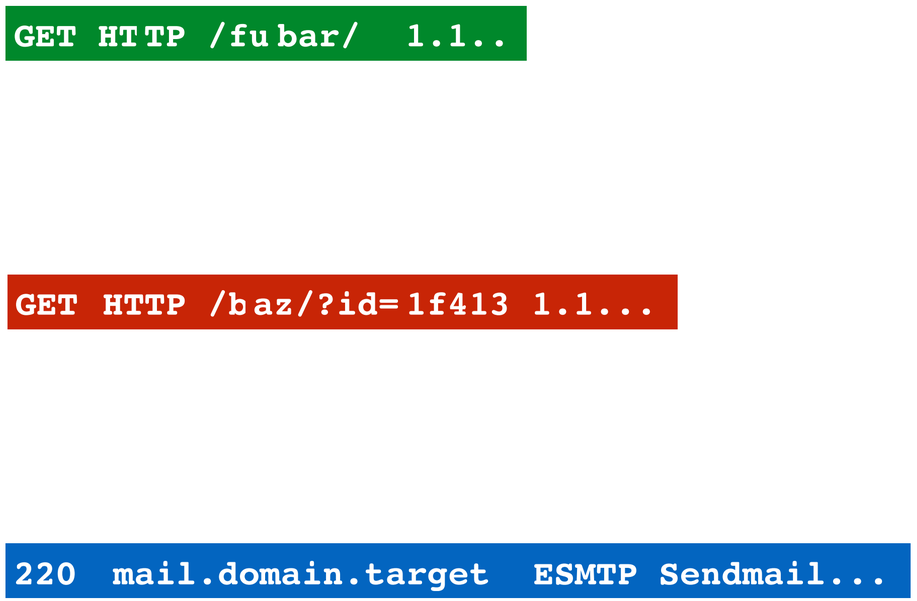
Structure of FooCorp Web Services



Network Intrusion Detection

- Approach #1: look at the network traffic
  - (a “NIDS”: rhymes with “kids”)
  - Scan HTTP requests
  - Look for “`/etc/passwd`” and/or “`../../`”
- Pros:
  - No need to touch or trust end systems
    - Can “bolt on” security
  - Cheap: cover many systems w/ single monitor
  - Cheap: centralized management

Inside the NIDS



HTTP Request
URL = /fubar/
Host = ...

HTTP Request
URL = /baz/?id=...
ID = 1f413

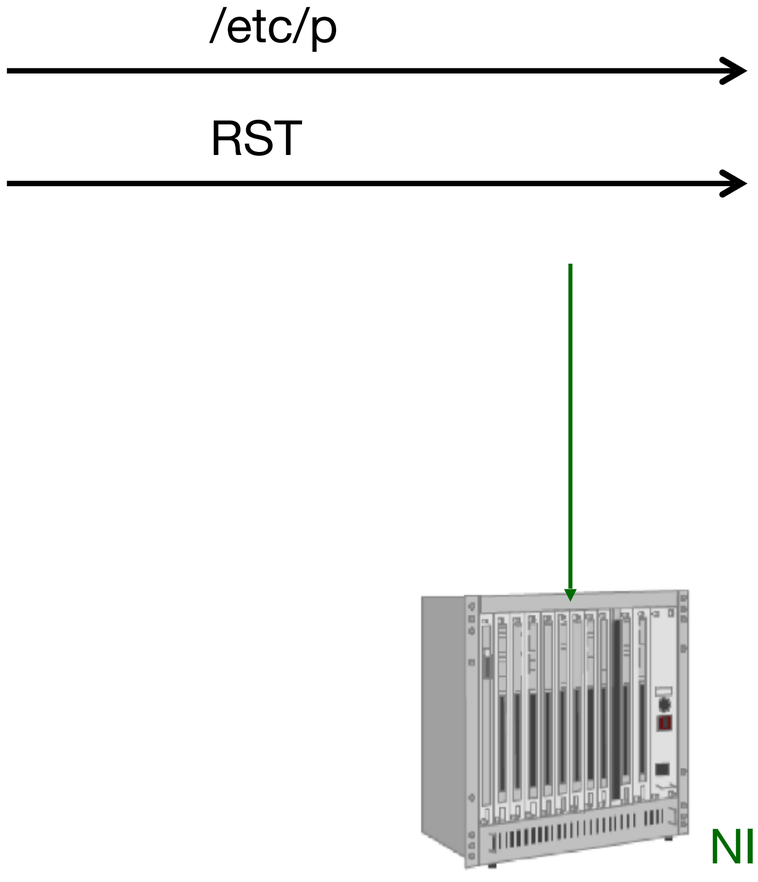
Sendmail
From = someguy@...
To = otherguy@...

Network Intrusion Detection (NIDS)

- NIDS has a table of all active connections, and maintains state for each
  - e.g., has it seen a partial match of /etc/passwd?
- What do you do when you see a new packet not associated with any known connection?
  - Create a new connection: when NIDS starts it doesn't know what connections might be existing
- New hotness: Network monitoring
  - Goal is not to detect attacks but just to understand everything.

Evasion

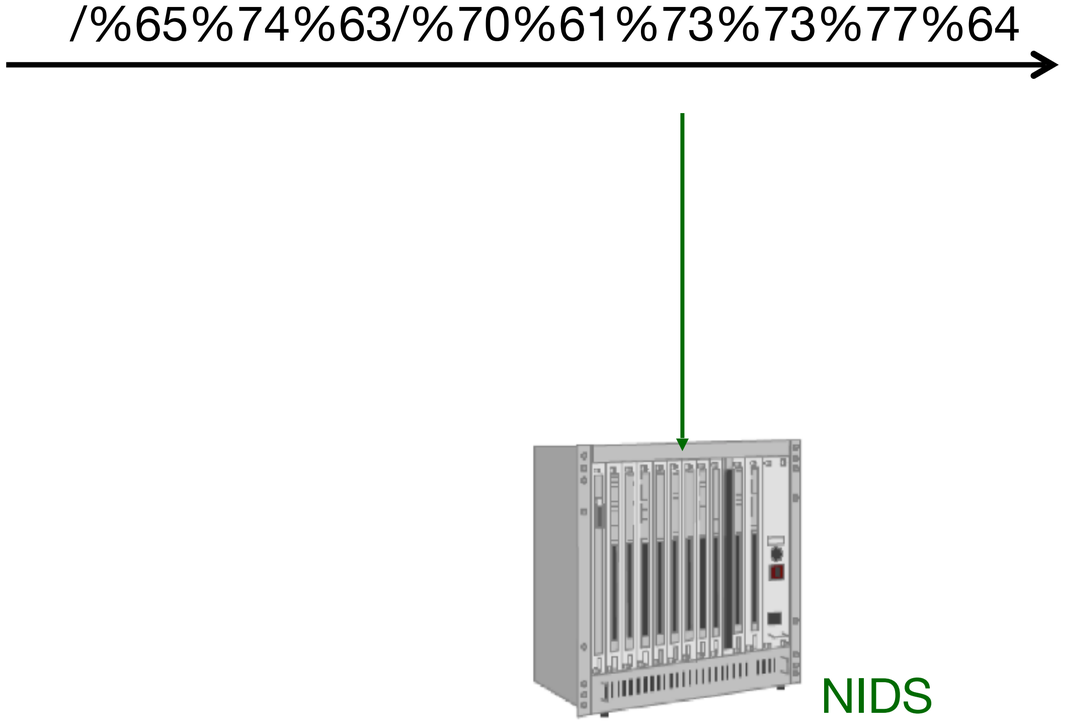
- What should NIDS do if it sees a RST packet?



- Assume RST will be received?
- Assume RST won't be received?
- Other (please specify)

Evasion

- What should NIDS do if it sees this?



- Alert – it's an attack
- No alert – it's all good
- Other (please specify)

Evasion

- Evasion attacks arise when you have “double parsing”
- ***Inconsistency*** - interpreted differently between the monitor and the end system
- ***Ambiguity*** - information needed to interpret correctly is missing

Evasion Attacks (High-Level View)

- Some evasions reflect incomplete analysis
  - In our FooCorp example, hex escapes or "`..////.//../`" alias
  - In principle, can deal with these with implementation care (make sure we fully understand the spec)
    - Of course, in practice things inevitably fall through the cracks!
- Some are due to imperfect observability
  - For instance, if what NIDS sees doesn't exactly match what arrives at the destination
  - E.g., two copies of the "same" packet, which are actually different and with different TTLs

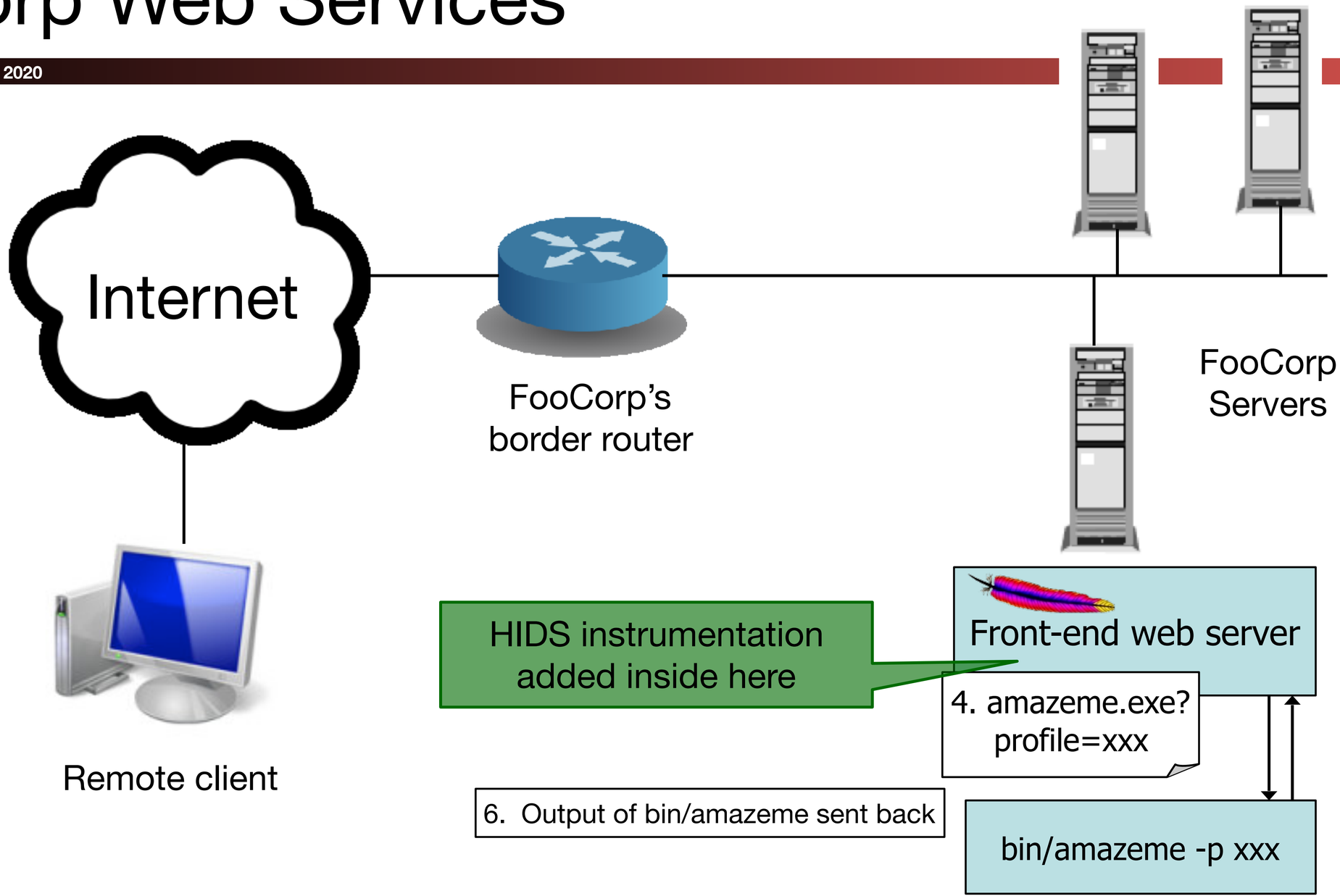
Network-Based Detection

- Issues:
  - Scan for "`/etc/passwd`"?
    - What about other sensitive files?
  - Scan for "`../../`"?
    - Sometimes seen in legit. requests (= false positive)
    - What about "`%2e%2e%2f%2e%2e%2f`"? (= evasion)
      - Okay, need to do full HTTP parsing
    - What about "`../////.////..////`"?
      - Okay, need to understand Unix filename semantics too!
  - What if it's HTTPS and not HTTP?
    - Need access to decrypted text / session key – yuck!

Host-based Intrusion Detection

- Approach #2: instrument the web server
  - Host-based IDS (sometimes called “HIDS”)
  - Scan ?arguments sent to back-end programs
    - Look for “`/etc/passwd`” and/or “`../../`”

Structure of FooCorp Web Services



Host-based Intrusion Detection

- Approach #2: instrument the web server
  - Host-based IDS (sometimes called “HIDS”)
  - Scan ?arguments sent to back-end programs
    - Look for “`/etc/passwd`” and/or “`../../`”
- Pros:
  - No problems with HTTP complexities like %-escapes
  - Works for encrypted HTTPS!
- Issues:
  - Have to add code to each (possibly different) web server
    - And that effort only helps with detecting web server attacks
  - Still have to consider Unix filename semantics (“`..////.//`”)
  - Still have to consider other sensitive files

Log Analysis

- Approach #3: each night, script runs to analyze log files generated by web servers
  - Again scan ?arguments sent to back-end programs

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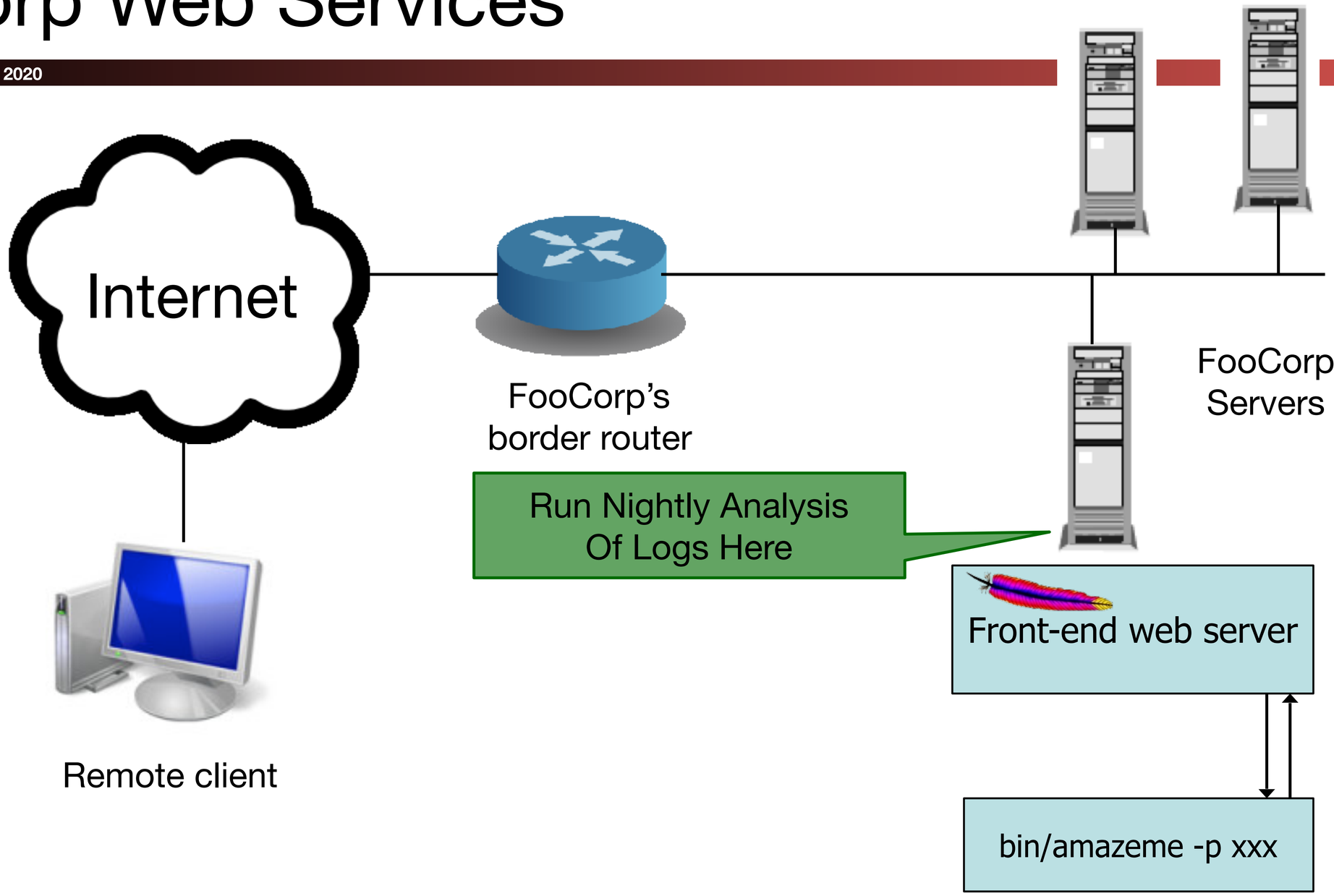

Log Analysis:
Aka "Log It All and let Splunk Sort It Out"

- Approach #3: each night, script runs to analyze log files generated by web servers
  - Again scan ?arguments sent to back-end programs
- Pros:
  - Cheap: web servers generally already have such logging facilities built into them
  - No problems like %-escapes, encrypted HTTPS
- Issues:
  - Again must consider filename tricks, other sensitive files
  - Can’t block attacks & prevent from happening
  - Detection delayed, so attack damage may compound
  - If the attack is a compromise, then malware might be able to alter the logs before they’re analyzed
    - (Not a problem for directory traversal information leak example)
    - Also can be mitigated by using a separate log server

System Call Monitoring (HIDS)

- Approach #4: monitor system call activity of backend processes
  - Look for access to **`/etc/passwd`**

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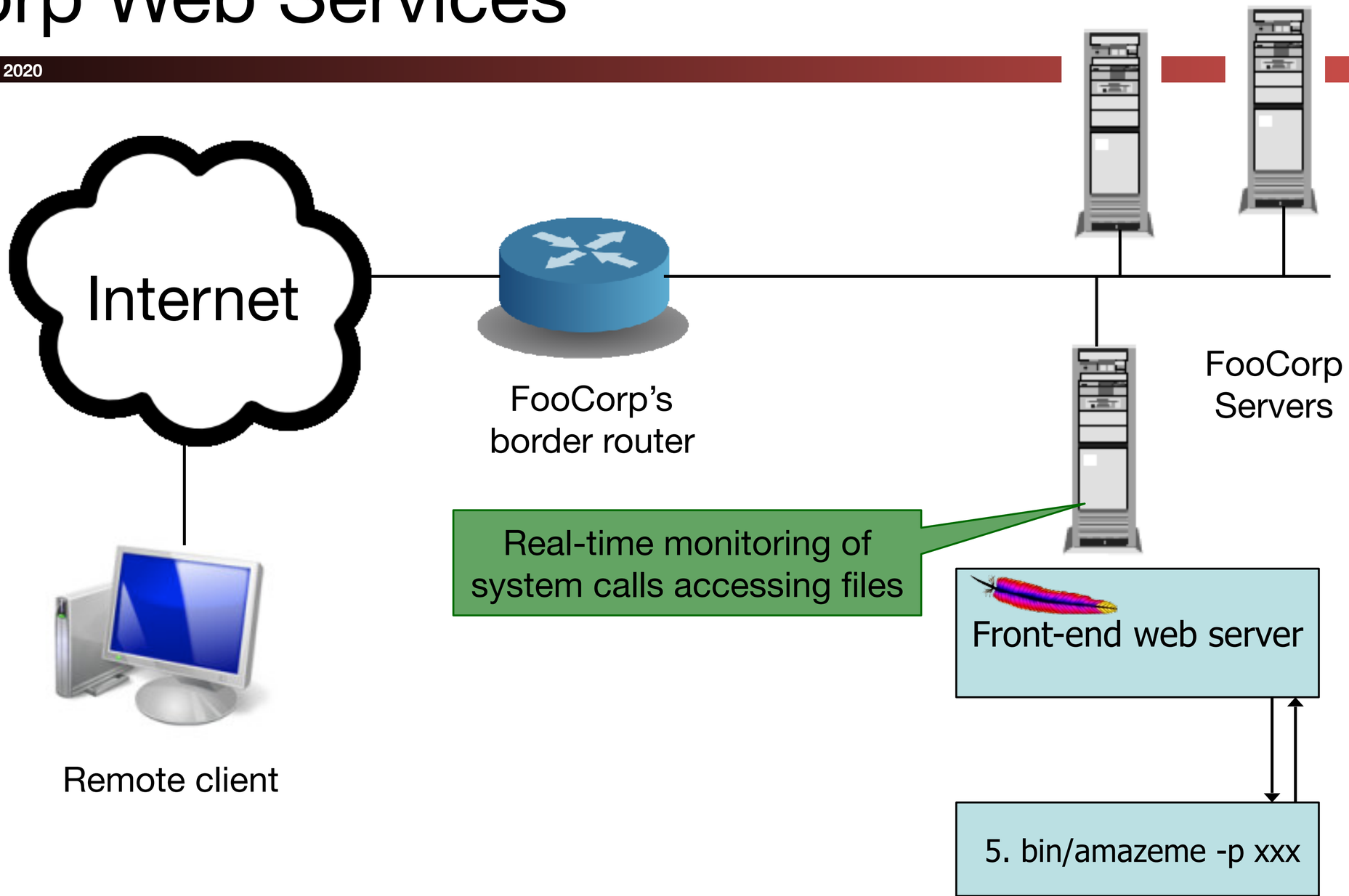

System Call Monitoring (HIDS)

- Approach #4: monitor system call activity of backend processes
  - Look for access to /etc/passwd
- Pros:
  - No issues with any HTTP complexities
  - May avoid issues with filename tricks
  - Attack only leads to an “alert” if attack succeeded
    - Sensitive file was indeed accessed
- Issues:
  - Maybe other processes make legit accesses to the sensitive files (false positives)
  - Maybe we’d like to detect attempts even if they fail?
    - “situational awareness”

Detection Accuracy

- Two types of detector errors:
  - False positive (FP): alerting about a problem when in fact there was no problem
  - False negative (FN): failing to alert about a problem when in fact there was a problem
- Detector accuracy is often assessed in terms of rates at which these occur:
  - Define I to be the event of an instance of intrusive behavior occurring (something we want to detect)
  - Define A to be the event of detector generating alarm
- Define:
  - False positive rate = $P[A|\neg I]$
  - False negative rate = $P[\neg A| I]$

Perfect Detection

- Is it possible to build a detector for our example with a false negative rate of 0%?
- Algorithm to detect bad URLs with 0% FN rate:

```
void my_detector_that_never_misses(char *URL)
{
    printf("yep, it's an attack!\n");
}
```

  - In fact, it works for detecting any bad activity with no false negatives! Woo-hoo!
- Wow, so what about a detector for bad URLs that has no false positives?
  - `printf("nope, not an attack\n");`