Final exam

- **Monday, May 13 – Don't miss it!**
  - Open Book, Open Note
  - Exam covers full semester
  - Bring copies of the papers
- **Final grade in class determined by higher of:**
  - Average of midterm and final, Score on the final exam
- **Time for questions:**
  - Lecture will end early for review/questions
  - Office hours after class today
  - Question session Wednesday 4–5PM
  - Extra office hours Thursday 5–6PM
  - By appointment

Papers NOT on the exam

- **The following topics & papers will not be on the exam:**
  - Lecture 3 (forward-secure signature schemes)
  - Spencer – Flask/SElinux
  - Wagner – Detection of Buffer Overrun Vulnerabilities
  - Necula – Proof-carrying code
  - Castro – Byzantine fault tolerance

SSH overview

- **Widely-used secure remote login program**
- **MACs/encrypts all data sent over the network**
  - Version 2 of protocol basically gets this right
  - Open to man in the middle attack on first server access
- **Often sends password at start of session**
  - Gets sent encrypted in a single TCP packet
- **Assuming crypto secure (& no MiM), how to attack?**

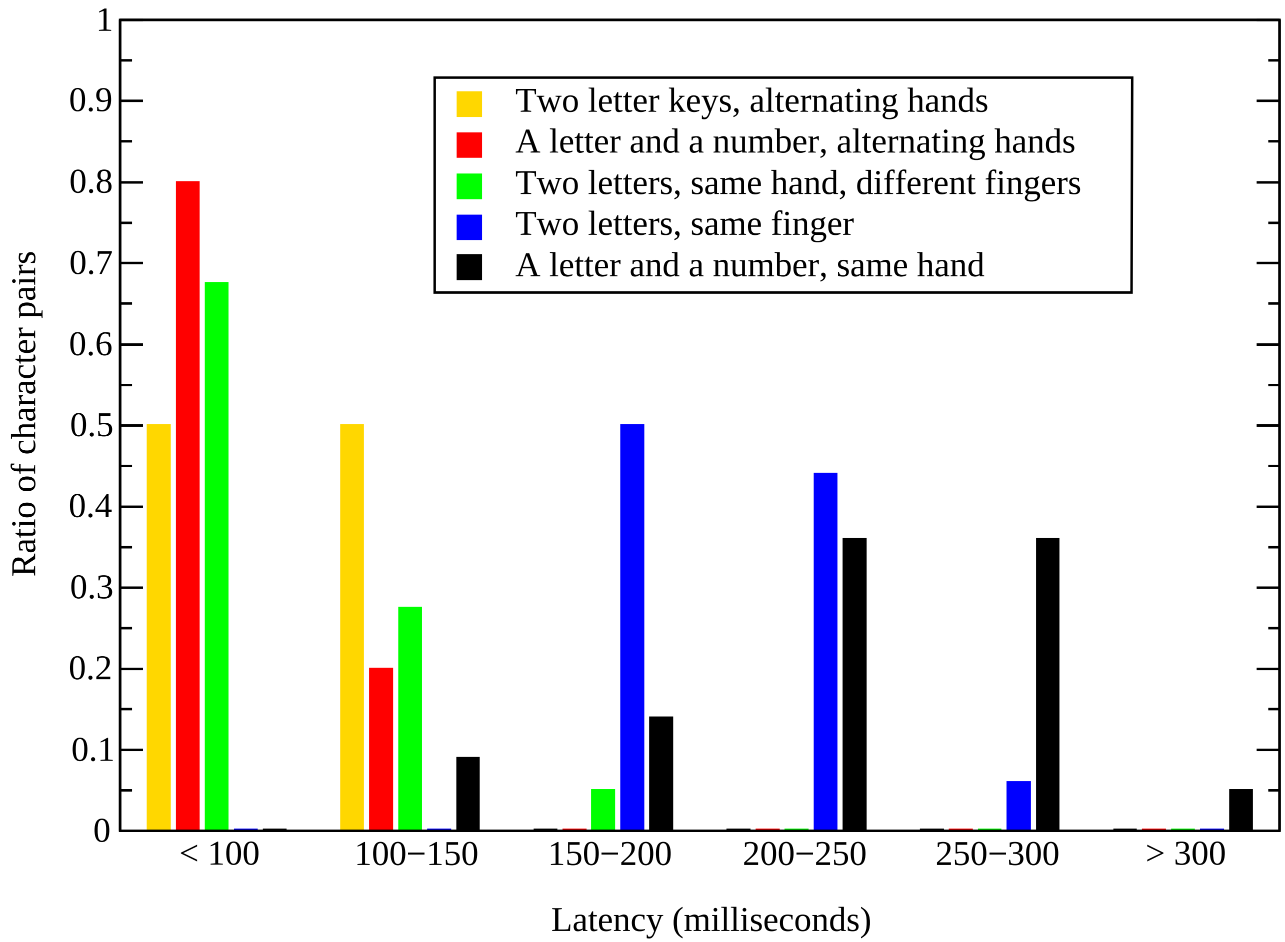
Packet size

- **Transmitted packets rounded to multiple of 8 bytes**
  - Version 1 even had exact packet-size in the clear
- **Can tell if user's password is less than 7 chars**
  - Password sent in one packet of initial exchange
- **Why do we care?**
  - Might tell you which account to try to crack

Inter-keystroke timings

- **Each character typed causes a packet to be sent**
  - Typical inter-character times 10–300 msec
  - Typical network round-trip time 10 of msec
  - Can get very accurate timing information by eavesdropping
- **What can you learn from this?**
  - Some character sequences harder to type than others
  - E.g., v–b is much slower to type than v–o
  - In general, characters with different hands faster
  - Two characters typed with same finger are much slower
  - Digits, special chars also slower
- **Idea: Use timing to learn about passwords**

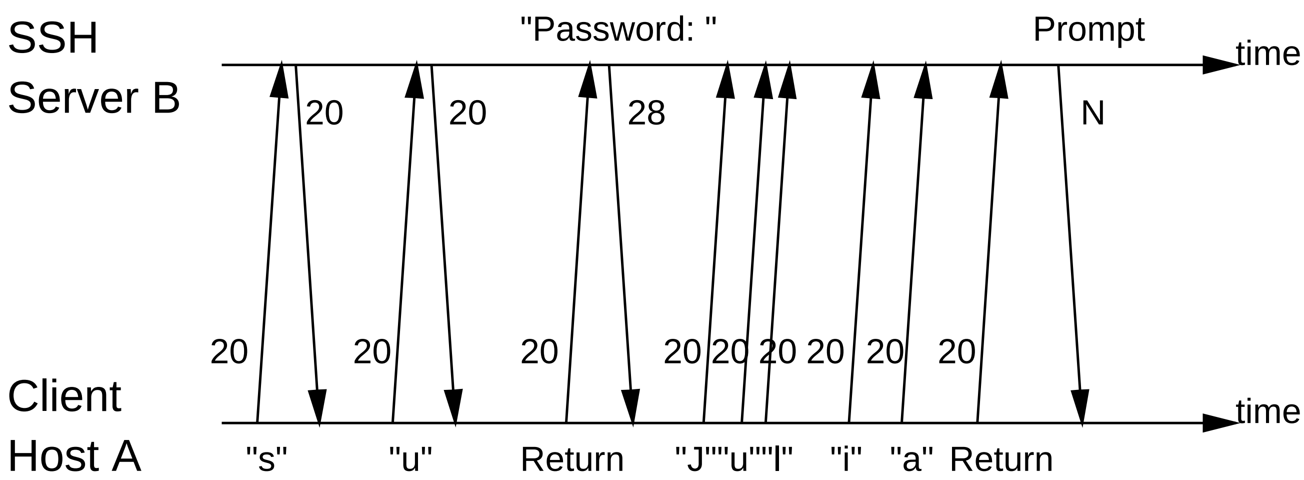
Character latency



How to know password is being typed

- **Traffic signature**
  - E.g., echo turned off when password typed
- **Multi-user attack**
  - E.g., run ps on machine to see when victim runs pgp
- **Nested ssh attack**
  - See remote host open SSH connection to another host

Example: su command



- **“Password:” prompt – 28 char packet**
- **Echo turned off for password, no return packets**

Modeling keystroke timings

- **Assume Gaussian-like distribution of timings**
  - For each key pair q, mean time μ_q, stdev σ_q
  - Prob. of timing y $\Pr[y|q] = \frac{1}{\sqrt{2\pi}\sigma_q} e^{-\frac{(y-\mu_q)^2}{2\sigma_q^2}}$
  - See figure 5 for example distributions
  - Significant but far from complete overlap between key pairs
- **Model keystrokes as HMM**
  - Each key pair is a state, timing an observation
  - AI techniques allow you to get n best choices

Results

- **Experiment: Assign users random passwords**
  - Picked from a reduced set of characters
  - Users practice typing the password before experiments
- **Train on users typing individual key pairs**
- **Ignore pause in the middle of passwords**
- **Output most likely password**
- **Bottom line:** $50\times$ **reduction in brute-force cracking**
  - Half the time password shows up in top 1% output

How to work around the problem

- **Send dummy packets when in echo mode**
  - Foils traffic signature detection of passwords
- **Adding random delays to packets?**
  - Latencies in 100s of msec, so need big random delays
  - Can still get info by averaging many sessions
  - Delay might get seriously annoying
- **Constant bit-rate traffic**
  - Practicel for *one session* over a modem

Discussion

- **How convincing is evaluation?**
  - Random passwords with reduced character sets
- **How serious is this vulnerability?**
  - Would this matter in a system like TAOS?
- **What else could this technique be applied to?**
- **Other possible solutions to the problem?**

Why cryptosystems fail

Review

- Cryptography and Protocols
- Key management
- Information flow
- Secure operating systems
- Software Checking
- Safety
- Intrusion detection and tolerance
- Network security
- Anonymity and privacy
- System failures