# CS 556 – Computer Security
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Dr. Indrajit Ray
Email: indrajit@cs.colostate.edu

Department of Computer Science
Colorado State University
Fort Collins, CO 80523, USA

# Password Based Authentication

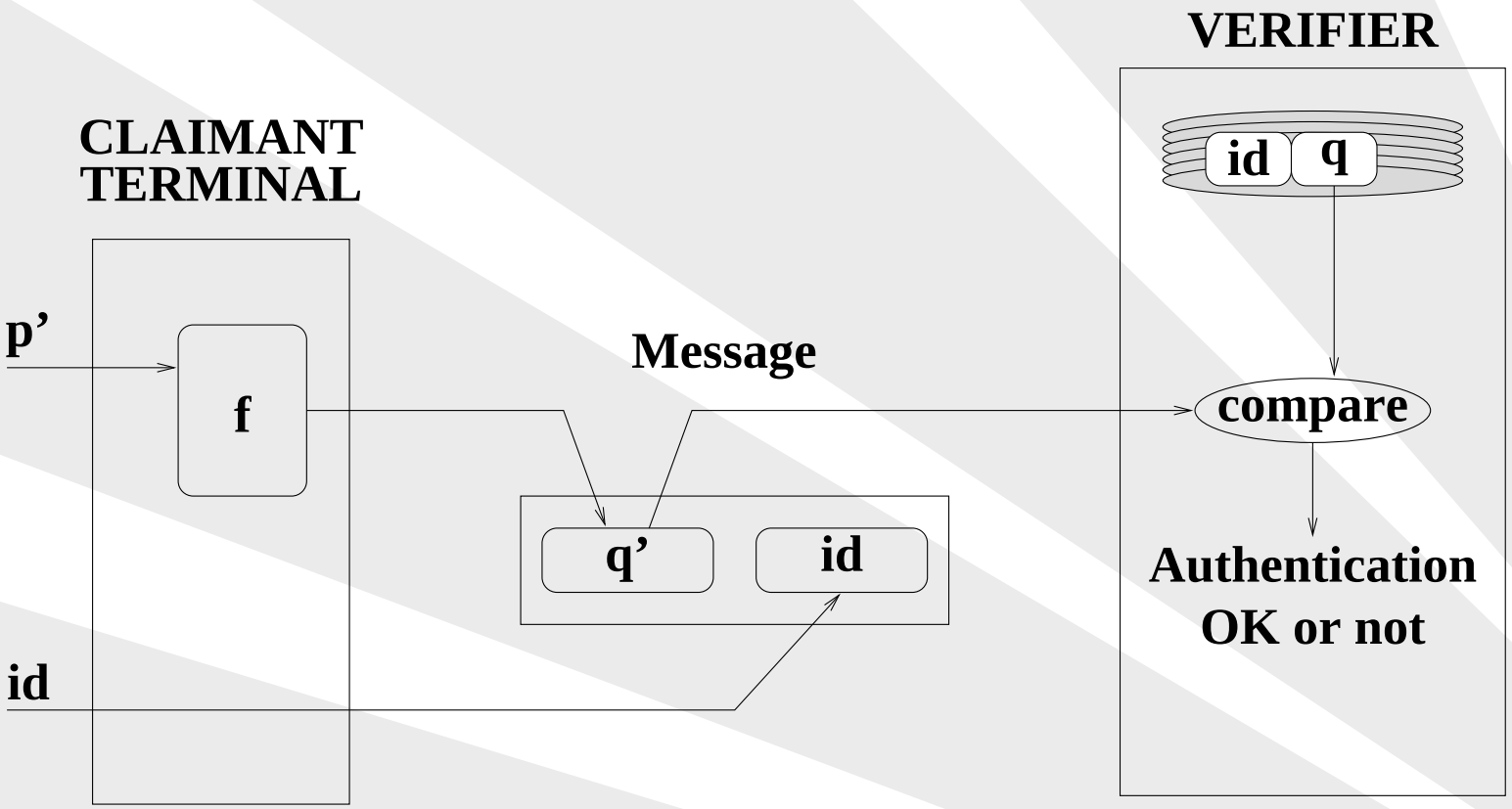
# Passwords



- Commonly used method
- For each user, system stores in a password file $< User\ name,\ F(password) >$, where F is some transformation
  - F(password) is easy to compute
  - From F(password), password is difficult (ideally) to compute
- When a user enters the password, system computes F(password); A match provides proof of identity

# Simple Password Scheme





# Choice of Passwords



- Suppose passwords can be from 1 to 8 characters in length
  - Lower case English alphabets used
- Possible choices for passwords $= 26^1 + 26^2 + \ldots + 26^8 = 1.5 \times 10^{12}$
- At the rate of 1 password per millisecond, it will take about 150 years to test all passwords

**We don't need to try all possible passwords – only many probable ones ☹**

# Probable Passwords



- In a Bell Labs study (Morris & Thompson 1979), 3,289 passwords were examined
  - 15 single ASCII characters
  - 72 two ASCII characters
  - 464 three ASCII characters
  - 477 four alphanumeric character
  - 706 five letters (all lower or all upper case)
  - 605 six letters all lower case
  - 492 weak passwords (dictionary words spelled backwords, first names, last names etc)
- Summary: 2831 passwords (86%) were weak, that is they were too easily predictable, or were too short

# Dictionary Attacks on Passwords



- The statistics haven't changed much in later studies
- To improve upon the expected probability of success of an exhaustive search, an attacker may search the space of all possible passwords in order of decreasing probability
- Note that these attacks work only with strong passwords

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# Dictionary Attack on Simple Password Scheme



- Attacker constructs a table of values of $q$ to values of $p$ ensuring, especially, that the table contains the most likely expected values for $p$
- Passively monitor large numbers of authentication attempts
  - Can obtain with high degree of probability some passwords for some user

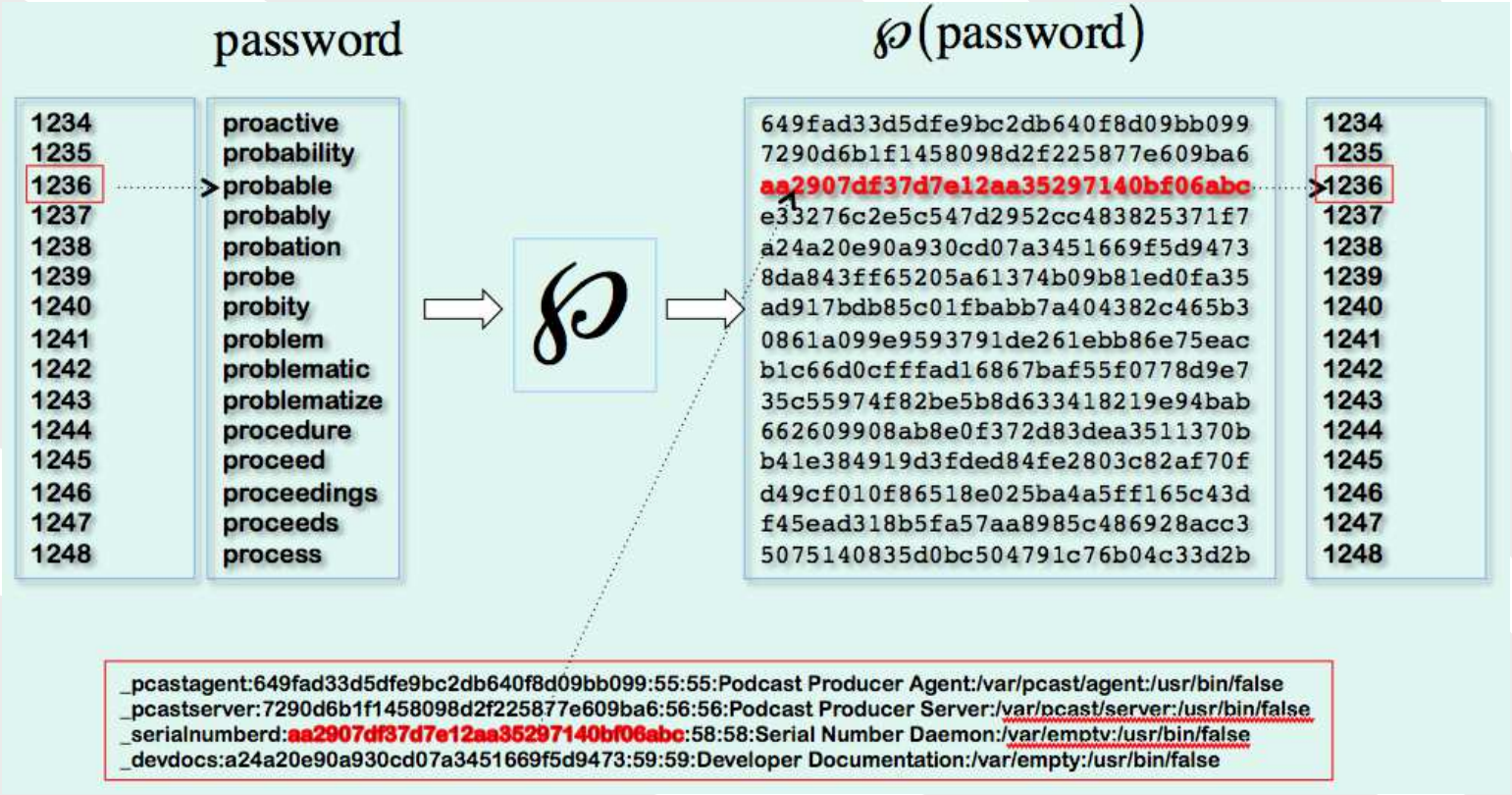
# Dictionary Attack (Case 1)



- Create a dictionary of common words and names and their simple transformation
  - For example: **indrajit** $\longrightarrow$ **jndaitr**
- Use these to guess the password

# Dictionary Attack (Case 2 – known $\mathcal{F}$)

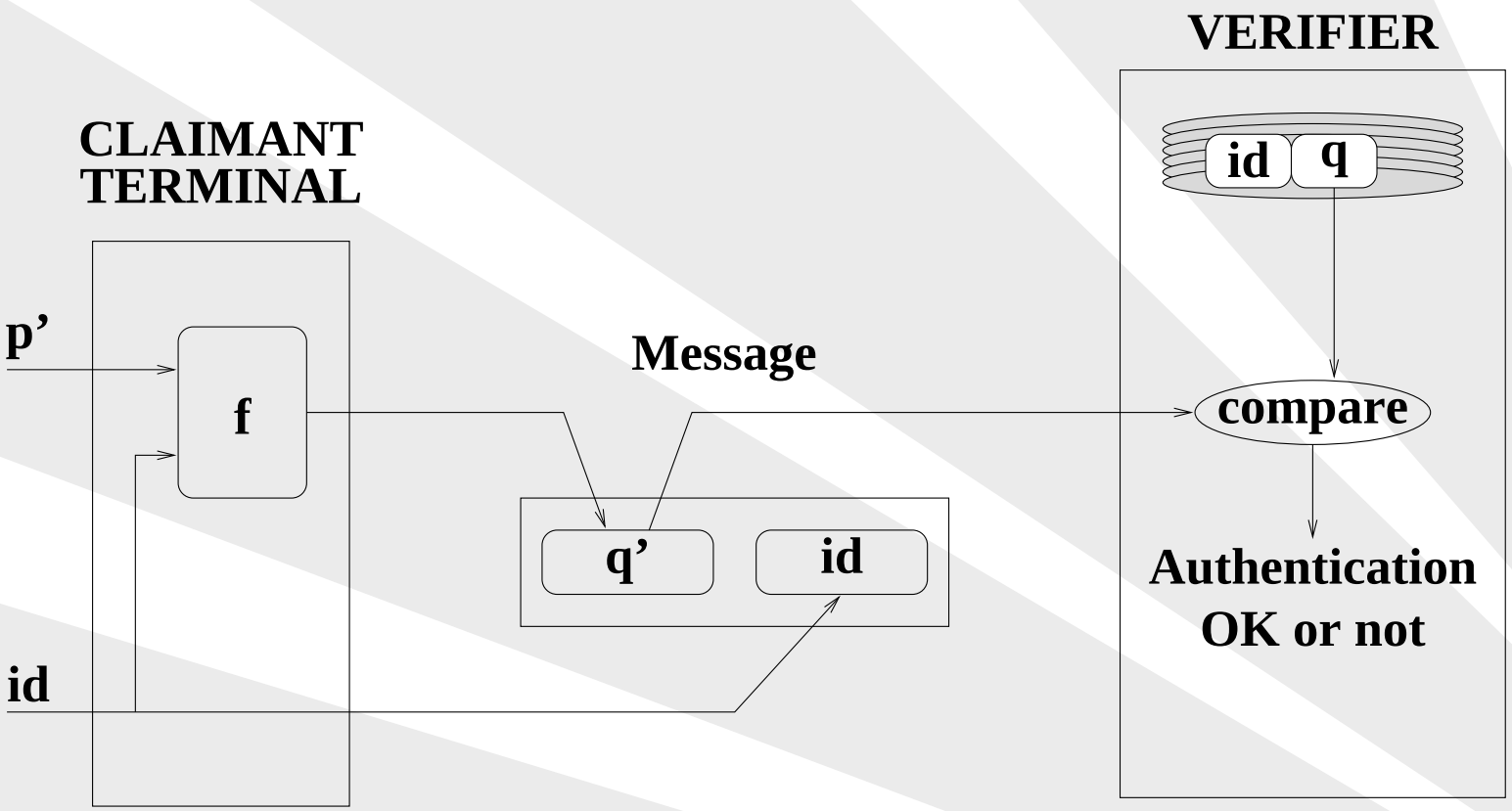




# Password Authentication Models

# Improved Password Scheme (#2)





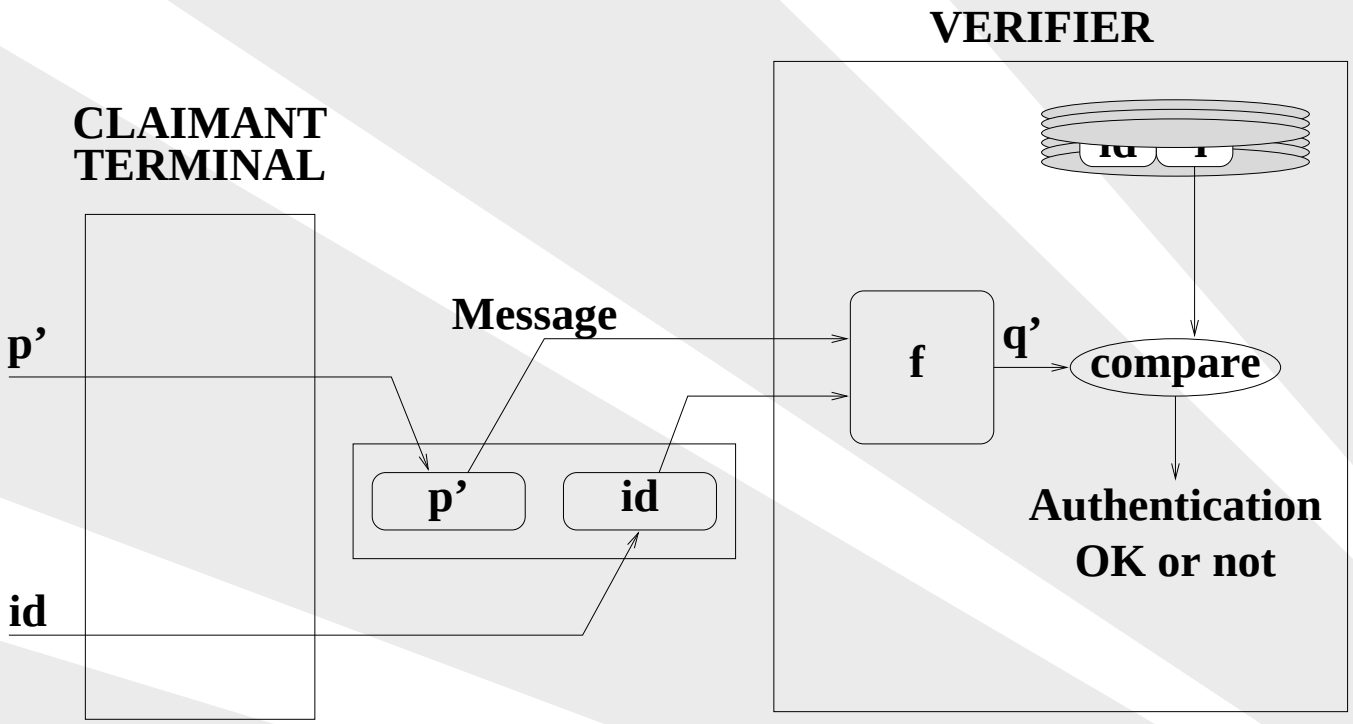
# Attack on Scheme #2



- Now we have stored password q $= \mathcal{F}$(p,id)
- It is still possible to prepare the table of q values for password values but now only for one particular id.
- Suffers from verifier compromise
  - attacker gets $< id, q >$ pair and attacker generating an authentication message request on the wire.

# Improved Scheme #3





# UNIX Password Authentication

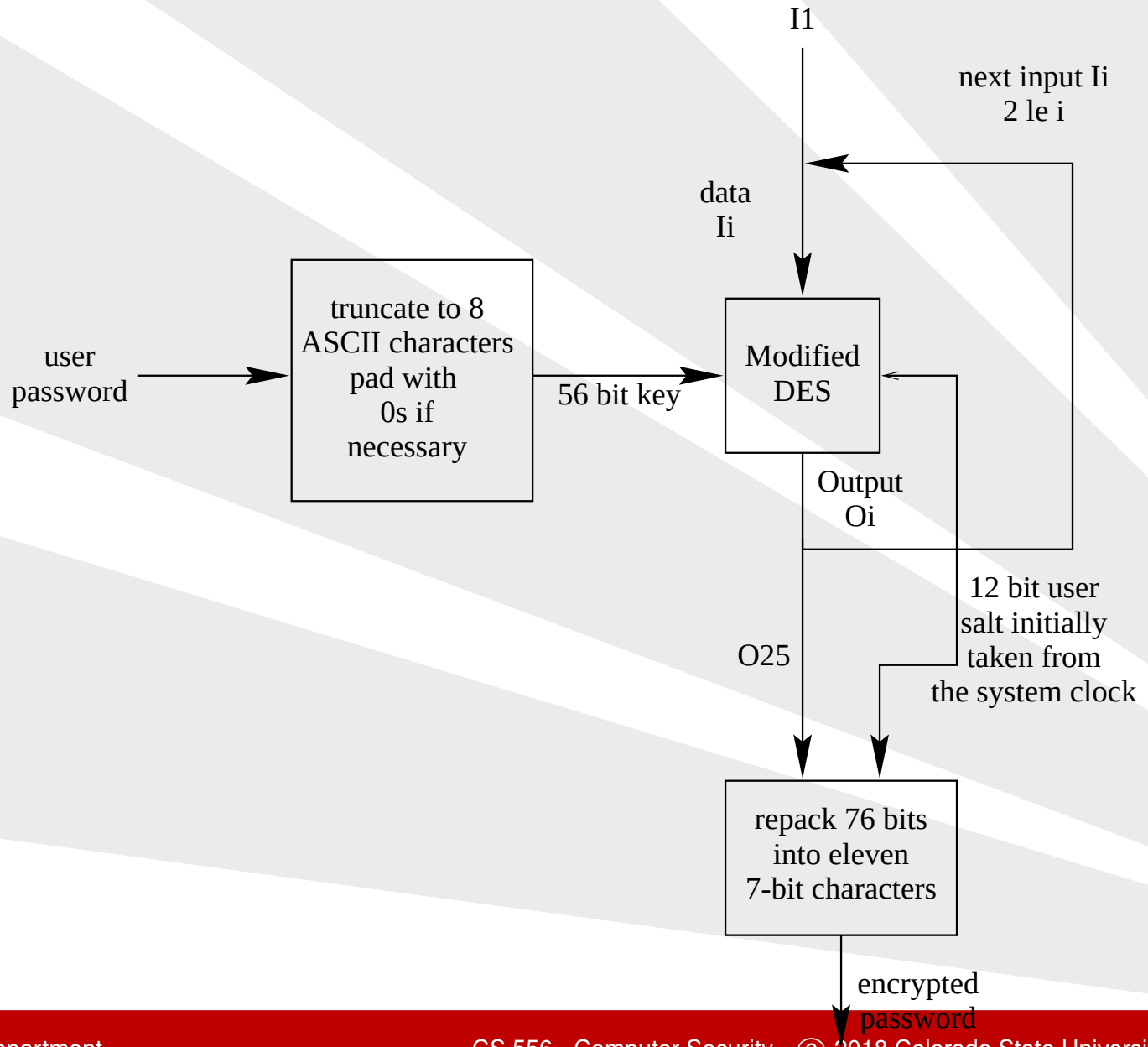
# Scheme #3 ≡ UNIX Password



- Designed by Bob Morris and Ken Thomson to encrypt passwords in Unix
- Uses an extended DES algorithm for the password function $\mathcal{F}$
- User password and salt is used as encryption key to encrypt
- Process is repeated 25 times
  - $i^{th}$ encrypted block used as the plaintext for the $(i+1)^{th}$ round

# Unix Crypt Algorithm





# Password Salt



- Salt is used to make dictionary attack a bit more difficult
- Salt is a 12 bit number between 0 and 4095
- It is derived from the system clock and the process identifier
- Rather than computing f(password), compute f(password + salt); both salt and f(passwd + salt) is stored in the table
- With salt the same password can result in 4096 different values stored in the table.

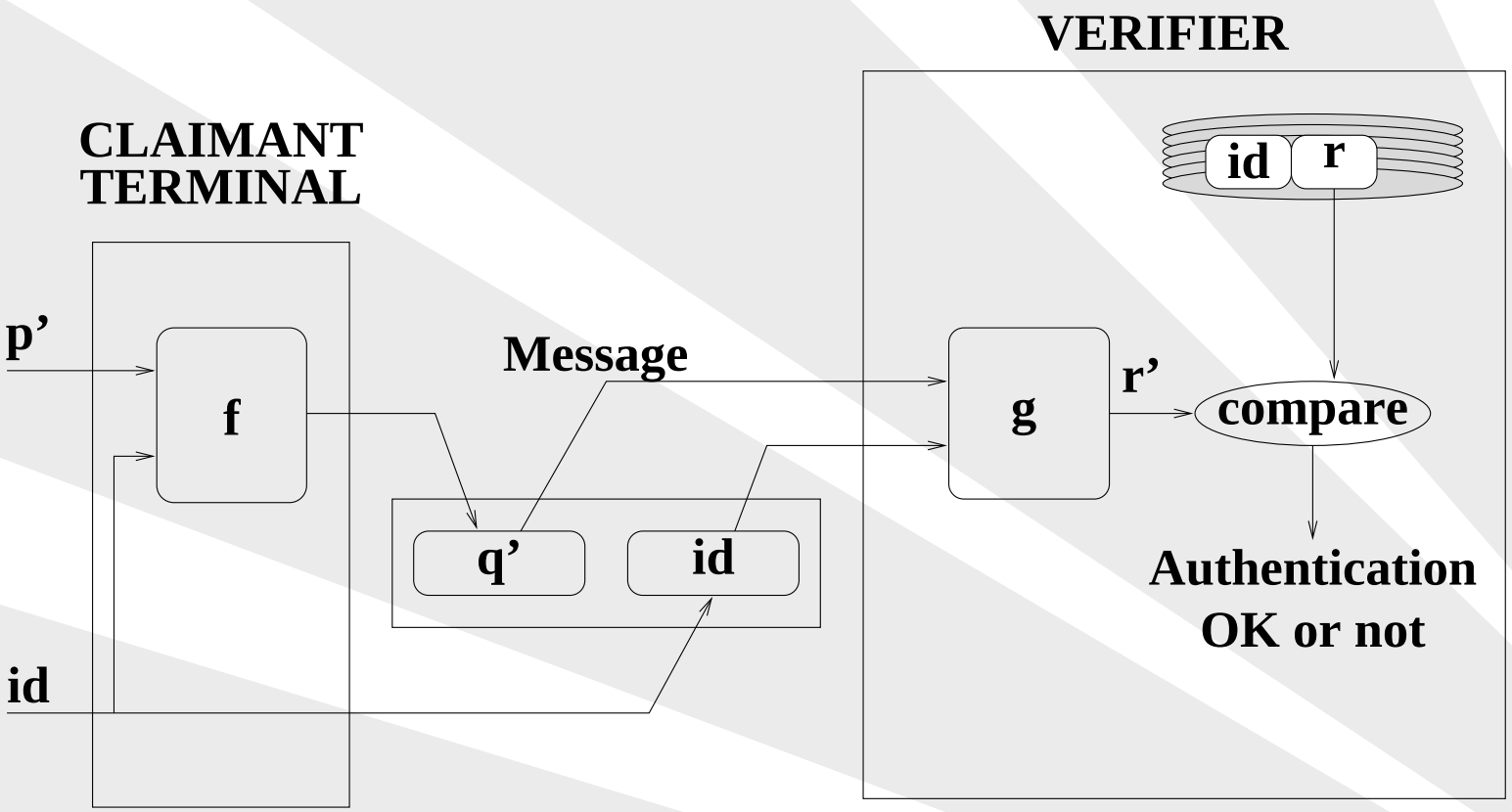
# Attack on Scheme #3



- Password on the clear in the network
  - Vulnerable to eavesdropping
    - Serious concern on any network
  - Also susceptible to replay attacks
    - Attacker eavesdrops on the communication channel and intercepts a legitimate authentication exchange
    - Attacker later replays the authentication exchange
    - Serious on interconnected networks

# Improved Password Scheme #4





# Password Management

# Policy and Procedure



- Educate users to make better choices
  - Does not work if user population is large or novice
- Define rules for good password selection and ask users to follow them
  - Rules serve as guidelines for attackers
- Ask or force users to change their passwords periodically

# Policy and Procedure



- Force users to use machine generated passwords
  - Random passwords are difficult to memorize
  - Password generator may become known to the attacker through analysis
- Actively attempt to break user's passwords; force users to change those that are broken
- Screen password choices; if a choice is weak force user to make a different choice