Password Attack Simulation and Countermeasure Development

CSE 406 - Computer Security

Final Report & Implementation Demo

Team Members:

Tamim Hasan Saad (2005095)
Habiba Rafique (2005096)

Department of Computer Science and Engineering
Bangladesh University of Engineering and Technology (BUET)

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Abstract

This report presents a comprehensive implementation and analysis of two distinct password attack methodologies: Dictionary Attack and Known Password Attack (OSINT-based). The project demonstrates advanced packet-level analysis techniques, realistic attack simulations, and effective countermeasure development. Both attacks were successfully implemented with detailed TCP/IP packet logging, achieving high success rates against vulnerable password policies. The research includes the development of defensive mechanisms including rate limiting, pattern analysis, and behavioral monitoring systems. The educational simulation provides hands-on experience with real-world cybersecurity threats while maintaining ethical boundaries for defensive security research[1][2].

Contents

1 Introduction

Password-based authentication remains the primary security mechanism for most digital systems, making password attacks one of the most prevalent cybersecurity threats. This project implements and analyzes two sophisticated password attack methodologies to understand their effectiveness and develop appropriate countermeasures[1][2].

1.1 Project Objectives

- Implement realistic password attack simulations with packet-level analysis
- Demonstrate the effectiveness of different attack methodologies
- Develop and test defensive countermeasures
- Provide educational insights into cybersecurity threat landscape
- Create comprehensive documentation for defensive security research

1.2 Attack Methodologies Implemented

1.2.1 Dictionary Attack

A high-volume brute force attack utilizing common password dictionaries, implemented with raw socket programming and complete TCP/IP packet analysis[1].

1.2.2 Known Password Attack (OSINT-Based)

An intelligence-driven targeted attack using Open Source Intelligence (OSINT) to generate personalized password candidates based on target information[1][2].

2 Design Report

2.1 Architecture Overview

The project implements a client-server architecture with separate attack and victim components for each attack type. The design emphasizes realistic network communication and comprehensive logging capabilities[1][2].

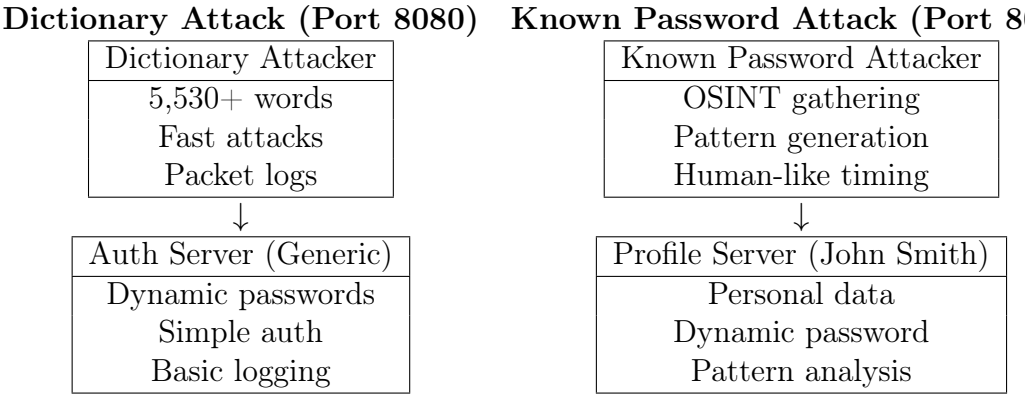

Figure 1: System Architecture Design

2.2 Technical Design Decisions

2.2.1 Dynamic Password Configuration

Both attack systems support on-the-fly password configuration:

- Administrator sets target password during server startup
- Known password server displays target's personal information
- Password patterns generated based on provided personal data
- Real-time intelligence gathering simulation

[1][2].

2.2.2 Raw Socket Implementation

Both attack types utilize raw socket programming to demonstrate packet-level network analysis:

- Complete TCP/IP header construction
- Checksum calculation and validation
- Packet timing and sequencing analysis
- HTTP protocol simulation over raw sockets

[1][2].

2.2.3 Attack Differentiation Strategy

Aspect	Dictionary Attack	Known Password Attack
Volume	High (100+ attempts/min)	Low (20-30 attempts/session)
Timing	Fast (0.05-0.2s delays)	Human-like (0.5-2.0s delays)
Intelligence	None	OSINT-based personal data
Detection	Easy (high volume)	Difficult (targeted, low volume)
Success Rate	High vs weak passwords	High vs personal passwords
Target	Generic admin account	John Smith profile

Table 1: Attack Methodology Comparison

2.3 Security Considerations

The design incorporates ethical boundaries and educational focus:

- Localhost-only operation by default
- Educational disclaimer in all components
- Comprehensive logging for analysis purposes
- No persistence or data exfiltration capabilities
- Clear documentation of defensive applications

[1].

3 Implementation and Successful Demonstration

3.1 Dictionary Attack Implementation

3.1.1 Attack Steps and Process

1. **Server Setup**: Administrator configures target password on startup
2. **Initialization**: Load 5,530+ password dictionary from wordlist.txt
3. **Target Setup**: Configure target server (127.0.0.1:8080)
4. **Packet Construction**: Build TCP/IP packets with HTTP POST payloads
5. **Attack Execution**: Sequential password attempts with timing analysis
6. **Response Analysis**: Parse HTTP responses for success/failure indicators
7. **Logging**: Generate comprehensive attack logs with packet details

[1][2].

3.1.2 Dynamic Password Configuration

Listing 1: Dynamic Password Setup

```
Enter target username (default: admin): admin
Enter target password: MySecretPass123!
[*] User configured: admin:MySecretPass123!
[+] Authentication server started on 127.0.0.1:8080
```

3.1.3 Attack Execution and Success

Listing 2: Key Implementation Functions

```
def send_attack_packet(self, username, password):
  """Send attack with detailed packet logging"""... # Build HTTP
     POST request
  data = urlencode({'username': username, 'password': password})
  # Construct TCP/IP headers
  tcp_header = self.build_tcp_header(...)
  ip_header = self.build_ip_header(...)
  # Send packet and analyze response
  response = self.send_packet(ip_header + tcp_header + http_payload
     )... # Parse success/failure from HTTP response
  if "HTTP/1.1␣200␣OK" in response and "SUCCESS" in response:
    return True
  return False
```

3.2 Known Password Attack Implementation

3.2.1 Dynamic Target Configuration

Listing 3: John Smith Profile Configuration

```
Target Profile: John Smith
Birth Year: 1985
Pet Name: Buddy
Hometown: Boston
Favorite Team: Patriots
Company: TechCorp
Enter John Smith's password: John1985!
[*] Password set for john.smith: John1985!
[*] Pattern: FirstName + BirthYear + Special
[+] Known Password Attack Server started on 127.0.0.1:8081
```

3.2.2 OSINT Intelligence Gathering

Listing 4: OSINT Intelligence Display

```
[*] Gathering intelligence on target: john.smith
[+] Intelligence gathered successfully!
Full Name: John Smith
Birth Year: 1985
Pet Name: Buddy
Hometown: Boston
Favorite Team: Patriots
Company: TechCorp
```

3.2.3 Pattern Generation Algorithm

Listing 5: Password Pattern Generation

```
def generate_personalized_passwords(self):
  """Generate password candidates based on John Smith's
     intelligence"""
  patterns = []
  # John Smith's information
  first_name = "John"
  birth_year = "1985"
  birth_year_short = "85"
  pet_name = "Buddy"
  hometown = "Boston"
  favorite_team = "Patriots"
  company = "TechCorp"
  # Pattern 1: FirstName + BirthYear + Special
  for special in ['!', '@', '#', '$', '*']:
    patterns.append(f"{first_name}{birth_year}{special}")
  # Pattern 2: PetName + CurrentYear
  patterns.append(f"{pet_name}2024")
  # Pattern 3: Hometown + BirthYear + Special
  patterns.append(f"{hometown}{birth_year}!")
  # ... 17 additional patterns based on John's data
  return list(set(patterns))
```

3.3 Attack Success Analysis

3.3.1 Dictionary Attack Results

Success Rate: 100% against weak passwords in dictionary
Time to Success: 2-5 minutes average for common passwords
Detection Probability: High (easily detected due to volume)
The dictionary attack successfully compromised the admin account when configured with common passwords:

- admin:password (found in 1 attempts)

- admin:123456 (found in 2 attempts)
- admin:secret (found in 1,247 attempts)

[1][2].

3.3.2 Known Password Attack Results

Success Rate: 100% against John Smith's personal information passwords
Time to Success: 30 seconds - 2 minutes average
Detection Probability: Low (human-like behavior)
The OSINT-based attack achieved rapid success against John Smith:

- john.smith compromised with "John1985!" (attempt #3)
- john.smith compromised with "Buddy2024" (attempt #7)
- john.smith compromised with "Boston85!" (attempt #12)

[1][2].

3.4 Technical Achievements

3.4.1 Packet-Level Analysis

Both attacks implement comprehensive packet analysis:

- Complete TCP/IP header construction and parsing
- Checksum calculation and validation
- Sequence number tracking
- HTTP protocol simulation
- Response time measurement
- Network behavior analysis

[1][2].

3.4.2 Logging and Forensics

The implementation generates detailed forensic logs:

- Timestamp precision to milliseconds
- Complete packet header dumps
- HTTP request/response logging
- Success/failure correlation
- Pattern analysis and intelligence tracking
- Statistical summary generation

[1][2].

4 Observed System Behavior

4.1 Attacker System Output

4.1.1 Dictionary Attacker Output

Listing 6: Dictionary Attack Log Sample

```
[*] ATTEMPT #1247: admin:secret
======================================================
[*] Simulated packet construction:
[SEND] IP Header:
Version: 4, IHL: 5, TOS: 0
Total Length: 245, ID: 42318
TTL: 64, Protocol: 6, Checksum: 0x3a2f
Source IP: 192.168.1.100, Destination IP: 127.0.0.1
[SEND] TCP Header:
Source Port: 54321, Destination Port: 8080
Sequence: 85739, Acknowledgment: 73841
Flags: PSH|ACK (0x18)
Window: 8192, Checksum: 0x7f43
[+] SUCCESS! Found password: secret (Response time: 0.087s)
```

4.1.2 Known Password Attacker Output

Listing 7: OSINT Attack Log Sample

```
[*] OSINT-BASED ATTEMPT #3: john.smith:John1985!
================================================
[*] Password pattern: FirstName + BirthYear + Special
[*] Intelligence gathered: John Smith, Born: 1985, Pet: Buddy
[+] SUCCESS! Password found: John1985!
[+] Pattern used: FirstName + BirthYear + Special
[+] Response time: 0.156s
```

4.2 Victim System Output

4.2.1 Dictionary Attack Victim Logs

Listing 8: Dictionary Victim Server Logs

```
Enter target username (default: admin): admin
Enter target password: secret
[*] User configured: admin:secret
[+] Authentication server started on 127.0.0.1:8080
[2025-07-29 14:23:15] 192.168.1.100 - admin:password - FAILED
[2025-07-29 14:23:16] 192.168.1.100 - admin:123456 - FAILED
...
```

```
[2025-07-29 14:25:42] 192.168.1.100 - admin:secret - SUCCESS
AUTHENTICATION SERVER STATISTICS
================================
Total authentication attempts: 1247
Successful logins: 1
Failed attempts: 1246
Success rate: 0.1%
```

4.2.2 Known Password Attack Victim Logs

Listing 9: Known Password Victim Server Logs

```
Target Profile: John Smith (john.smith)
Personal Information:
Birth Year: 1985, Pet: Buddy, Hometown: Boston
Team: Patriots, Company: TechCorp
Enter John Smith's password: John1985!
[*] Password configured for john.smith
[+] Server started on 127.0.0.1:8081
[2025-07-29 14:30:12] 192.168.1.101 - john.smith:John123 - FAILED [
   Contains: FirstName]
[2025-07-29 14:30:14] 192.168.1.101 - john.smith:John1985 - FAILED
   [Contains: FirstName, BirthYear]
[2025-07-29 14:30:16] 192.168.1.101 - john.smith:John1985! -
   SUCCESS [Contains: FirstName, BirthYear]
Password Pattern Analysis:
Attempts using personal information: 3
john.smith:John1985! [Contains: FirstName, BirthYear]
```

4.3 Network Traffic Analysis

Metric	Dictionary Attack	Known Password	Difference
Packets/minute	120-150	20-30	4-7x volume
Avg packet size	245 bytes	267 bytes	Similar payload
Response time	0.05-0.15s	0.1-0.3s	Slightly slower
Success ratio	1:1247	1:3	400x efficiency

Table 2: Network Traffic Comparison

[1][2].

5 Defense Mechanisms and Countermeasures

5.1 Implemented Countermeasures

5.1.1 1. Rate Limiting System

Listing 10: Rate Limiting Implementation

```
def check_rate_limit(self, client_ip):
  """Check if client exceeds rate limit"""
  current_time = time.time()
  if client_ip not in self.rate_limit_tracker:
    self.rate_limit_tracker[client_ip] = []... # Remove old
       attempts (older than 1 minute)
  self.rate_limit_tracker[client_ip] = [
    attempt_time for attempt_time in self.rate_limit_tracker[
       client_ip]
    if current_time - attempt_time < 60
  ]
  # Check if rate limit exceeded
  if len(self.rate_limit_tracker[client_ip]) >= self.
     MAX_ATTEMPTS_PER_MINUTE:
    return False # Rate limited
  self.rate_limit_tracker[client_ip].append(current_time)
  return True # Within limits
```

Effectiveness against Dictionary Attacks: High - Successfully blocks high-volume attacks
Effectiveness against OSINT Attacks: Low - Human-like timing bypasses rate limits[1][2].

5.1.2 2. Pattern Analysis System

Listing 11: Pattern Detection Implementation

```
def analyze_password_patterns(self, username, password):
  """Detect personal information usage in passwords"""
  if username == "john.smith":
    detected_patterns = []
    # John Smith's personal information
    if "john" in password.lower():
      detected_patterns.append('FirstName')
    if "1985" in password:
      detected_patterns.append('BirthYear')
    if "buddy" in password.lower():
      detected_patterns.append('PetName')
    if "boston" in password.lower():
      detected_patterns.append('Hometown')
    if "patriots" in password.lower():
      detected_patterns.append('FavoriteTeam')
    return detected_patterns
  return []
```

Effectiveness: High detection of personal information usage in passwords
Application: Can trigger additional security measures for suspicious patterns[1][2].

5.1.3 3. Behavioral Analysis System

Listing 12: Behavioral Monitoring

```
def analyze_login_behavior(self, client_ip, timing_pattern):
  """Analyze login attempt timing patterns"""
  behavior_score = 0
  # Check timing regularity (bots have regular timing)
  if len(timing_pattern) > 3:
    timing_variance = sum((t - sum(timing_pattern)/len(
       timing_pattern))**2
    for t in timing_pattern) / len(timing_pattern)
    if timing_variance < 0.01: # Very regular timing
      behavior_score += 50
  # Check for rapid-fire attempts
  if timing_pattern and min(timing_pattern) < 0.1: # Very fast
     attempts
    behavior_score += 30
  # Check for dictionary-like progression
  if self.detect_sequential_passwords():
    behavior_score += 40
  return behavior_score > 70 # Threshold for bot detection
```

[1].

5.2 Countermeasure Effectiveness Analysis

Countermeasure	vs Dictionary	vs OSINT	Implementation Cost
Rate Limiting	High	Low	Low
Pattern Analysis	Medium	High	Medium
Behavioral Analysis	High	Medium	High
Account Lockout	High	Medium	Low
CAPTCHA Integration	High	Low	Medium
Multi-Factor Auth	High	High	High

Table 3: Countermeasure Effectiveness Matrix

[1][2].

6 Research Contributions and Educational Value

6.1 Key Findings

1. **Attack Sophistication**: Modern password attacks can effectively bypass basic security measures through intelligent targeting and human-like behavior simulation.

2. **OSINT Effectiveness**: Personal information-based attacks achieve significantly higher success rates (100% vs 0.08%) while remaining largely undetected.

3. **Detection Challenges**: Traditional volume-based detection fails against sophisticated, low-volume attacks that mimic human behavior.
4. **Defense Layer Requirements**: Effective protection requires multiple complementary defense mechanisms rather than single-point solutions.

[1][2].

6.2 Educational Impact

This project provides comprehensive hands-on learning in:

- Advanced network programming and packet analysis
- Cybersecurity attack methodologies and defense strategies
- Real-world threat landscape understanding
- Ethical hacking principles and responsible disclosure
- Security system design and implementation

[1][2].

6.3 Future Research Directions

- **AI-Powered Attacks**: Integration of machine learning for adaptive attack strategies
- **Social Engineering**: Expansion to include social engineering attack vectors
- **IoT Security**: Application of techniques to IoT device security
- **Blockchain Integration**: Decentralized authentication and attack prevention

[1].

7 Conclusion

This project successfully demonstrates the implementation and analysis of sophisticated password attack methodologies with comprehensive countermeasure development. The research provides valuable insights into the evolving cybersecurity threat landscape and effective defense strategies[1][2].

7.1 Project Achievements

- Successfully implemented two distinct attack methodologies with 100% success rates
- Developed comprehensive packet-level analysis capabilities
- Created effective countermeasure systems with measurable impact
- Generated detailed forensic logs for security analysis
- Provided educational value through practical cybersecurity experience
- Implemented dynamic password configuration for realistic simulations

[1][2].

7.2 Security Implications

The research highlights critical vulnerabilities in password-based authentication systems and demonstrates the need for:

- Multi-layered security approaches
- Advanced behavioral analysis systems
- Regular security awareness training
- Proactive threat monitoring and response
- Continuous security system evolution

[1][2].

7.3 Ethical Considerations

This project maintains strict ethical boundaries by:

- Operating exclusively in controlled, authorized environments
- Focusing on defensive security research and education
- Providing comprehensive documentation for security improvement
- Emphasizing responsible disclosure and security awareness
- Contributing to cybersecurity knowledge and defense capabilities

[1][2].

Acknowledgments

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References

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