

## Homework 4: Denial of Service

This homework is due **Monday, April 20 at 6 p.m.** and counts for 5% of your course grade. Late submissions will be penalized by 10% plus an additional 10% every 5 hours until received. Late work will not be accepted after 20.5 hours past the deadline. If you have a conflict due to travel, interviews, etc., please plan accordingly and turn in your homework early.

We encourage you to discuss the problems and your general approach with other students in the class. However, the answers you turn in must be your own original work, and you are bound by the Student Code. Solutions should be submitted electronically via SVN in plain text format by completing the template at the end of this document.

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Concisely answer the following questions. (Limit yourself to at most 80 words per subquestion.)

1. **Client puzzles.** Denial-of-service (DoS) attacks attempt to overwhelm a server with a huge volume of requests. Researchers have proposed a defense against DoS attacks called *client puzzles*: For each request, the server sends the client a freshly generated random challenge  $r$  and a difficulty parameter  $n$ , and the client has to produce a solution  $s$  such that  $\text{HMAC}_r(s)$  ends in  $n$  zero bits. Clients must present a valid solution to receive service.
  - (a) What is the expected number of HMAC computations for the client to compute the solution? How many HMAC computations does it take for the server to check the solution?
  - (b) Suppose a “unit of work” is equivalent to the difficulty of computing one HMAC. If an attacker enjoys an *amplification factor* of 64 (i.e., the attacker can cause the server to do 64 units of work by expending one unit of work), what should  $n$  be to negate this advantage using client puzzles?
  - (c) Some denial-of-service attacks employ a large number of malicious clients to overwhelm the server. Briefly, how can the system adjust the puzzles to ensure that legitimate clients receive service during such attacks without requiring them to do excessive work solving puzzles when the system is not under attack? Hint: think about the scenario in terms of supply and demand.
2. **Distributed denial-of-service.** A popular attack tool among novice hackers recently has been the Low Orbit Ion Cannon (LOIC), which features a user-friendly GUI as well as an option to voluntarily add yourself to a botnet controlled via an IRC channel. *We do not recommend installing or using LOIC!*

- (a) LOIC is a fairly simple program. The source file at <http://goo.gl/iFeHk2> contains the primary attack mechanism. Briefly, how does this mechanism work?
- (b) The LOIC command and control system (“Hive Mind mode”) is also fairly simple. It is described in the README file at <http://goo.gl/mpu9ZU>. Briefly, how does this mechanism work?
- (c) Other than client puzzles, what are some things a website could do to defend itself against a LOIC Hive Mind attack? If the attack involves thousands of bots, how can the server distinguish them from legitimate clients?
- (d) Briefly, what was Operation Payback?
- (e) Who is Christopher Wayne Cooper? What was he charged with when he was indicted?
- (f) Briefly, compare and contrast LOIC Hive Mind mode to a typical botnet.
- (g) Briefly, compare and contrast LOIC Hive Mind mode to a political protest. □

## Submission Template

Make sure each answer is formatted as a single line, and that the file you submit is in plain text format. You may use LaTeX-style math syntax if you wish.

# Problem 1

1a. [Answer ...]

1b. [Answer ...]

1c. [Answer ...]

# Problem 2

2a. [Answer ...]

2b. [Answer ...]

2c. [Answer ...]

2d. [Answer ...]

2e. [Answer ...]

2f. [Answer ...]

2g. [Answer ...]