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C.S. 465

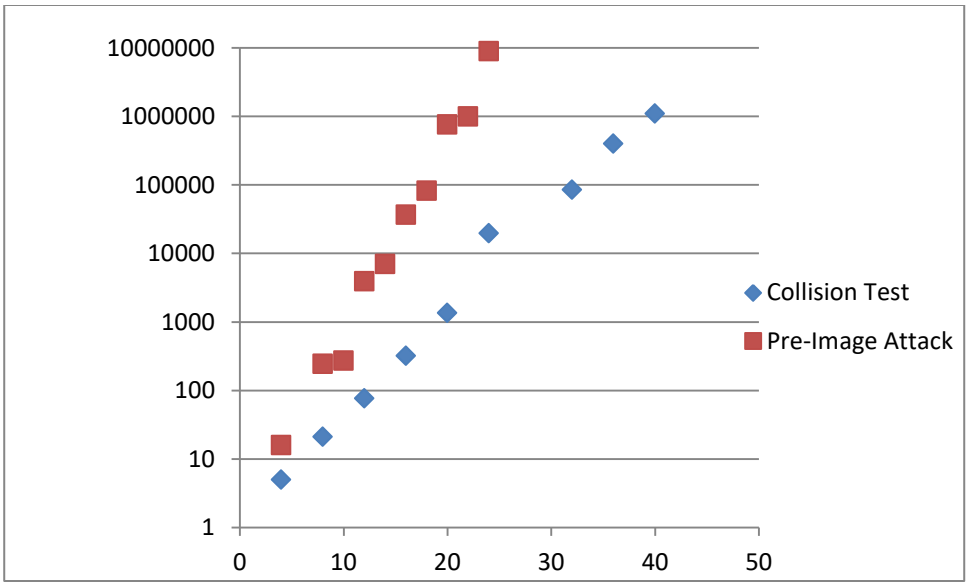
Hash Attack Technical Report

For my implementation of this Lab, I first studied the topic materials given to us in class and then began my project using the provided code. The first of the main functions I implemented was associated with collision attacks. To do so, it encrypted and truncated a given string and see if that value matched any if a Hash Map. If not, I would save it into that Hash Map and repeat the process till a match was found, therewith saving the number of times we had to loop through this process. This process I had repeat a number of times in order to get a good average number of times it took for any given n (where n is number of bits used as input).

What I found was that the number of times it took on average to find a matching hash was always a little bit more than what the expected values were. However, this difference was relatively small across every value, which led me to believe that there was a method in my code that took k*n time to complete (where k is some constant). In this case, I assumed that my random string generator was to blame. Other than this, it modeled the expected values quite closely.

Next, I implemented the function associated with second pre-image attacks. To do so, it used the same idea and functionality as the collision attacks implementation, but this function would not save any string other than the first. Each subsequent string that was encrypted and truncated was compared only against the first. Upon running the function with different values of n, I found that the results were very much smaller than the expected values. This result I can only assume occurred due to outliers in the data and comparing against the worst case scenarios derived from the expected values.

In conclusion, I feel that I learned a lot during the implementation of this project. I feel that I've gained a solid understanding of the algorithms used and, from comparing the results, realize just how hard a hash attack hacking attempt would be in the real world. Glad to know that hashing is a secure practice.



Hash Attack Lab Results

Results showing average number of iterations to find a match

Number of bits	4	8	10	12	14	16	18
Expected Collision Test	4	16	/	64	/	256	/
Collision Test	5	21	/	77	/	319	/
Expected Pre-Image Attack	16	256	1024	4096	16384	65536	262144
Pre-Image Attack	16	245	271	3928	7013	36902	82195

	20	22	24	28	32	36	40
	1024	/	4096	/	65536	262144	1048576
	1360	/	19666	/	85001	402021	1101942
	1048576	4194304	16777216	/	/	/	/
	760626	994267	8930441	/	/	/	/

```java
package Project2;

import java.util.*;

public class HashAttack
{
	final protected static char[] hexArray = "0123456789ABCDEF".toCharArray();

	public static void main(String[] args) throws Exception
	{
		//Do test for bit size = 4
		//preImageTestWrapper(4, 100);

		//Do test for bit size = 8
		//preImageTestWrapper(8, 100);

		//Do test for bit size = 10
		//preImageTestWrapper(10, 100);

		//Do test for bit size = 12
		//preImageTestWrapper(12, 100);

		//Do test for bit size = 14
		//preImageTestWrapper(14, 10);

		//Do test for bit size = 16
		preImageTestWrapper(16, 10);

		//Do test for bit size = 18
		//preImageTestWrapper(18, 10);

		//Do test for bit size = 20
		//preImageTestWrapper(20, 10);

		//Do test for bit size = 22
		//preImageTestWrapper(22, 10);

		//Do test for bit size = 24
		//preImageTestWrapper(24, 3);



		//Do test for bit size = 4
		//collisionTestWrapper(4, 100);

		//Do test for bit size = 8
		//collisionTestWrapper(8, 100);

		//Do test for bit size = 12
		//collisionTestWrapper(12, 100);

		//Do test for bit size = 16
		//collisionTestWrapper(16, 100);
```

```
		//Do test for bit size = 20
		//collisionTestWrapper(20, 100);

		//Do test for bit size = 24
		//collisionTestWrapper(24, 100);

		//Do test for bit size = 28
		//collisionTestWrapper(28, 100);

		//Do test for bit size = 32
		//collisionTestWrapper(32, 5);

		//Do test for bit size = 36
		//collisionTestWrapper(36, 5);

		//Do test for bit size = 40
		//collisionTestWrapper(40, 5);

	}

	//provided encryption code
	public static byte[] encrypt(String x) throws Exception
	{
		java.security.MessageDigest d = null;
		d = java.security.MessageDigest.getInstance("SHA-1");
		d.reset();
		d.update(x.getBytes());
		return d.digest();
	}

	//gets an average
	public static int getAverage(List<Integer> input)
	{
		int result = 0;
		for(Iterator<Integer> i = input.iterator(); i.hasNext();)
		{
			result += i.next();
		}
		return result / input.size();
	}

	//wrapper for preImage
	public static void preImageTestWrapper(int bitSize, int numRuns) throws
Exception
	{
		List<Integer> runs = new ArrayList<>();
		for(int i = 0; i < numRuns; i++)
		{
			runs.add(preImageAttack(bitSize));
		}
		int output = getAverage(runs);
		System.out.println("For bit size = " + bitSize + " with " + numRuns + "
runs: " + output);
	}
```

```
	//wrapper for collisionTest
	public static void collisionTestWrapper(int bitSize, int numRuns) throws
Exception
	{
		List<Integer> runs = new ArrayList<>();
		for(int i = 0; i < numRuns; i++)
		{
			runs.add(collisionAttack(bitSize));
		}
		int output = getAverage(runs);
		System.out.println("For bit size = " + bitSize + " with " + numRuns + "
runs: " + output);
	}

	//returns number of iterations to find a collision against a certain string
for the number of bits given (needs to be a multiple of 4!!!)
	public static int preImageAttack(int numBits) throws Exception
	{

		RandomString randomStringGen = new RandomString(10);
		int count = 0;
		HashMap<String, String> hashes = new HashMap<>();
		boolean found = false;
		boolean putIn= false;

		while(!found)
		{
			String str = randomStringGen.nextString();
			String truncHash = bytesToHex(encrypt(str)).substring(0, numBits
/ 4);
			if(hashes.get(truncHash) != null)
			{
				found = true;
				//System.out.println("Found collision with inputs: " + str
+ " & " + hashes.get(truncHash) + " at hash: " + truncHash);
			}
			else if(putIn == false)
			{
				hashes.put(truncHash, str);
				putIn = true;
			}
			count++;
		}
		return count;
	}

	//returns number of iterations to find a collision for a hash of the number of
bits given (needs to be a multiple of 4!!!)
	public static int collisionAttack(int numBits) throws Exception
	{
		RandomString randomStringGen = new RandomString(10);
		int count = 0;
		HashMap<String, String> hashes = new HashMap<>();
		boolean found = false;
```

```
		while(!found)
		{
			String str = randomStringGen.nextString();
			String truncHash = bytesToHex(encrypt(str)).substring(0, numBits
/ 4);
			if(hashes.get(truncHash) != null)
			{
				found = true;
				//System.out.println("Found collision with inputs: " + str
+ " & " + hashes.get(truncHash) + " at hash: " + truncHash);
			}
			else hashes.put(truncHash, str);
			count++;
		}
		return count;
	}

	public static String bytesToHex(byte[] bytes)
	{
		char[] hexChars = new char[bytes.length * 2];

		for ( int j = 0; j < bytes.length; j++ )
		{
			int pos = j * 2;
			int v = bytes[j] & 0xFF;//AND them with 0xFF, then shift 4
			hexChars[pos] = hexArray[v >>> 4];
			hexChars[pos + 1] = hexArray[v & 0x0F];
		}
		return new String(hexChars);
	}
}
```

```java
package Project2;

import java.util.Random;

public class RandomString {


	private static final char[] symbols;
	private final Random random = new Random();//random number
	private final char[] buf;//our buffer

	static {
		StringBuilder tmp = new StringBuilder();
		for (char ch = '0'; ch <= '9'; ++ch)
			tmp.append(ch);
		for (char ch = 'a'; ch <= 'z'; ++ch)
			tmp.append(ch);
		symbols = tmp.toString().toCharArray();
	}

	public String nextString()
	{
		for (int idx = 0; idx < buf.length; ++idx)//fill our predefined buffer
with a random symbol, which
			//will be our string
		{
			buf[idx] = symbols[random.nextInt(symbols.length)];
		}
		return new String(buf);
	}

	public RandomString(int length)
	{
		if (length < 1)
			throw new IllegalArgumentException("length < 1: " + length);
		buf = new char[length];
	}
}
```