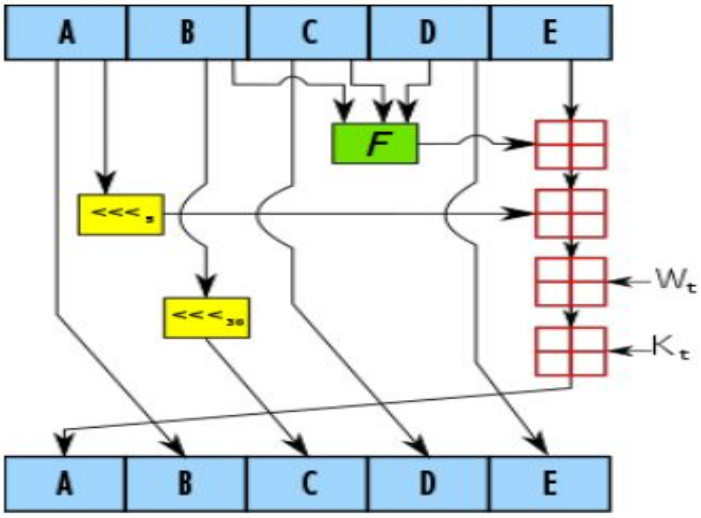
Experiment 9

Aim: Write a program to implement generation of hash by SHA1.

Theory: In computer cryptography, a popular message compress standard is utilized known as Secure Hash Algorithm (SHA). Its enhanced version is called SHA-1. It has the ability to compress a fairly lengthy message and create a short message abstract in response. The algorithm can be utilized along various protocols to ensure security of the applied algorithm, particularly for Digital Signature Standard (DSS). The algorithm offers five separate hash functions which were created by the National Security Agency (NSA) and were issued by the National Institute of Standards and Technology (NIST).



According to SHA-1 standard, a message digest is evaluated utilizing padded messages. The evaluation utilizes two buffers, each comprising five 32 bit words and a sequence of eighty 32 bit words. The words of the first five-word buffer are labelled as A, B, C, D and E. The words of the second five-word buffer are labelled as H0, H1, H2, H3 and H4. The words of the eighty-word sequence are labelled as W0, W1, W2 to W79. SHA1 operates blocks of 512 bits, when evaluating a message digest. The entire extent lengthwise of message digest shall be multiple of 512. A novel architecture of SHA-1 for enhanced throughput and decreased area, in which at the same time diverse acceleration techniques are exerted like pre-computation, loop unfolding and pipelining. Hash function requires a set of operations that are an input of diversifying length and creating a stable length string which is known as the hash value or message digest.

Pre-computation technique is utilized to produce definite intermediate signals of the critical path and reserve them in a register, which can be utilized in the computation of values of the next step. For a message possessing a maximum length of 264, SHA-1 constructs a 160 bit message digest. ` 160 bit dedicated hash function is incorporated in SHA-1 originate in the design

principle of MD4, which is an algorithm utilized to certify data integrity through the formation of a 128 bit message digest from data input that is declared to be as distinctive to that particular data as a fingerprint is to the particular individual.

The input message is padded and broken into 'k' 512 bit message blocks. At every iteration of the compression function 'h', a 160 bit chaining variable Ht is upgraded utilizing one message block Mt+1, that is **Ht+1 = h(Ht, Mt+1).**

The beginning value H0 is established in advance and Hk is the out-turn of the hash function. SHA-1 compression function is constructed upon the Davis Meyer construction. It utilizes a function 'E' as a block cipher with Ht for the message input and Mt+1 for the key input. The SHA-1 is implicit. It is as secure as anything in opposition to reimaged attacks, although it is effortless to calculate, which means it is uncomplicated to mount a brute force or dictionary attack. It is a well-known cryptographic primitive which ensures the integrity and reliability of original messages.

Source Code:

sha1.h

```
#ifndef SHA1_HPP
#define SHA1_HPP
#include <cstdint>
#include <iostream>
#include <string>
#include <stdint.h>
class SHA1
{
public:
 SHA1();
 void update(const std::string &s);
 void update(std::istream &is);
 std::string final();
 static std::string from_file(const std::string &filename);
private:
 uint32_t digest[5];
 std::string buffer;
 uint64_t transforms;
};
#endif
```

SHA.cpp

```
#include "sha1.h"
#include <sstream>
#include <iomanip>
#include <fstream>
static const size_t BLOCK_INTS = 16;
static const size_t BLOCK_BYTES = BLOCK_INTS * 4;
static void reset(uint32_t digest[], std::string &buffer, uint64_t &transforms)
{
 digest[0] = 0x67452301;
 digest[1] = 0xefcdab89;
 digest[2] = 0x98badcfe;
 digest[3] = 0x10325476;
 digest[4] = 0xc3d2e1f0;
  buffer = "";
 transforms = 0;
}
static uint32_t rol(const uint32_t value, const size_t bits)
{ return (value << bits) | (value >> (32 - bits));}
static uint32_t blk(const uint32_t block[BLOCK_INTS], const size_t i)
{  return rol(block[(i+13)&15] ^ block[(i+8)&15] ^ block[(i+2)&15] ^ block[i], 1); }

static void R0(const uint32_t block[BLOCK_INTS], const uint32_t v, uint32_t &w, const
uint32_t x, const uint32_t y, uint32_t &z, const size_t i)
{
 z += ((w&(x^y))^y) + block[i] + 0x5a827999 + rol(v, 5);
 w = rol(w, 30);
}
static void R1(uint32_t block[BLOCK_INTS], const uint32_t v, uint32_t &w, const uint32_t x,
const uint32_t y, uint32_t &z, const size_t i)
{
 block[i] = blk(block, i);
 z += ((w&(x^y))^y) + block[i] + 0x5a827999 + rol(v, 5);
 w = rol(w, 30);
}
static void R2(uint32_t block[BLOCK_INTS], const uint32_t v, uint32_t &w, const uint32_t x,
const uint32_t y, uint32_t &z, const size_t i)
{
 block[i] = blk(block, i);
```

```
 z += (w^x^y) + block[i] + 0x6ed9eba1 + rol(v, 5);
w = rol(w, 30);
}
static void R3(uint32_t block[BLOCK_INTS], const uint32_t v, uint32_t &w, const uint32_t x,
const uint32_t y, uint32_t &z, const size_t i)
{
 block[i] = blk(block, i);
 z += (((w|x)&y)|(w&x)) + block[i] + 0x8f1bbcdc + rol(v, 5);
 w = rol(w, 30);
}
static void R4(uint32_t block[BLOCK_INTS], const uint32_t v, uint32_t &w, const uint32_t x,
const uint32_t y, uint32_t &z, const size_t i)
{
 block[i] = blk(block, i);
 z += (w^x^y) + block[i] + 0xca62c1d6 + rol(v, 5);
 w = rol(w, 30);
}
static void transform(uint32_t digest[], uint32_t block[BLOCK_INTS], uint64_t &transforms)
{
 uint32_t a = digest[0];
 uint32_t b = digest[1];
 uint32_t c = digest[2];
 uint32_t d = digest[3];
 uint32_t e = digest[4];
 R0(block, a, b, c, d, e, 0);
 R0(block, e, a, b, c, d, 1);
 R0(block, d, e, a, b, c, 2);
 R0(block, c, d, e, a, b, 3);
 R0(block, b, c, d, e, a, 4);
 R0(block, a, b, c, d, e, 5);
 R0(block, e, a, b, c, d, 6);
 R0(block, d, e, a, b, c, 7);
 R0(block, c, d, e, a, b, 8);
 R0(block, b, c, d, e, a, 9);
 R0(block, a, b, c, d, e, 10);
 R0(block, e, a, b, c, d, 11);
 R0(block, d, e, a, b, c, 12);
 R0(block, c, d, e, a, b, 13);
 R0(block, b, c, d, e, a, 14);
```

```
R0(block, a, b, c, d, e, 15);
R1(block, e, a, b, c, d, 0);
R1(block, d, e, a, b, c, 1);
R1(block, c, d, e, a, b, 2);
R1(block, b, c, d, e, a, 3);
R2(block, a, b, c, d, e, 4);
R2(block, e, a, b, c, d, 5);
R2(block, d, e, a, b, c, 6);
R2(block, c, d, e, a, b, 7);
R2(block, b, c, d, e, a, 8);
R2(block, a, b, c, d, e, 9);
R2(block, e, a, b, c, d, 10);
R2(block, d, e, a, b, c, 11);
R2(block, c, d, e, a, b, 12);
R2(block, b, c, d, e, a, 13);
R2(block, a, b, c, d, e, 14);
R2(block, e, a, b, c, d, 15);
R2(block, d, e, a, b, c, 0);
R2(block, c, d, e, a, b, 1);
R2(block, b, c, d, e, a, 2);
R2(block, a, b, c, d, e, 3);
R2(block, e, a, b, c, d, 4);
R2(block, d, e, a, b, c, 5);
R2(block, c, d, e, a, b, 6);
R2(block, b, c, d, e, a, 7);
R3(block, a, b, c, d, e, 8);
R3(block, e, a, b, c, d, 9);
R3(block, d, e, a, b, c, 10);
R3(block, c, d, e, a, b, 11);
R3(block, b, c, d, e, a, 12);
R3(block, a, b, c, d, e, 13);
R3(block, e, a, b, c, d, 14);
R3(block, d, e, a, b, c, 15);
R3(block, c, d, e, a, b, 0);
R3(block, b, c, d, e, a, 1);
R3(block, a, b, c, d, e, 2);
R3(block, e, a, b, c, d, 3);
R3(block, d, e, a, b, c, 4);
R3(block, c, d, e, a, b, 5);
```

```
 R3(block, b, c, d, e, a, 6);
 R3(block, a, b, c, d, e, 7);
 R3(block, e, a, b, c, d, 8);
 R3(block, d, e, a, b, c, 9);
 R3(block, c, d, e, a, b, 10);
 R3(block, b, c, d, e, a, 11);
 R4(block, a, b, c, d, e, 12);
 R4(block, e, a, b, c, d, 13);
 R4(block, d, e, a, b, c, 14);
 R4(block, c, d, e, a, b, 15);
 R4(block, b, c, d, e, a, 0);
 R4(block, a, b, c, d, e, 1);
 R4(block, e, a, b, c, d, 2);
 R4(block, d, e, a, b, c, 3);
 R4(block, c, d, e, a, b, 4);
 R4(block, b, c, d, e, a, 5);
 R4(block, a, b, c, d, e, 6);
 R4(block, e, a, b, c, d, 7);
 R4(block, d, e, a, b, c, 8);
 R4(block, c, d, e, a, b, 9);
 R4(block, b, c, d, e, a, 10);
 R4(block, a, b, c, d, e, 11);
 R4(block, e, a, b, c, d, 12);
 R4(block, d, e, a, b, c, 13);
 R4(block, c, d, e, a, b, 14);
 R4(block, b, c, d, e, a, 15);
 digest[0] += a;
 digest[1] += b;
 digest[2] += c;
 digest[3] += d;
 digest[4] += e;
 transforms++;
}
static void buffer_to_block(const std::string &buffer, uint32_t block[BLOCK_INTS])
{
 for (size_t i = 0; i < BLOCK_INTS; i++)
 {
 block[i] = (buffer[4*i+3] & 0xff)
 | (buffer[4*i+2] & 0xff)<<8
```

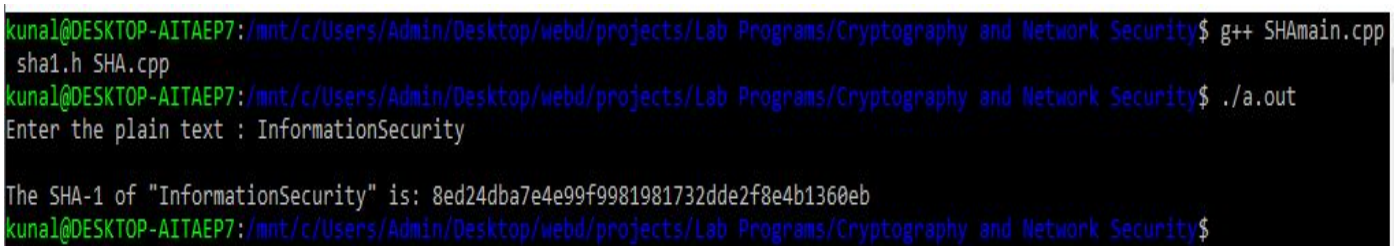
```
 | (buffer[4*i+1] & 0xff)<<16
 | (buffer[4*i+0] & 0xff)<<24;
 }
}
SHA1::SHA1()
{
 reset(digest, buffer, transforms);
}
void SHA1::update(const std::string &s)
{
 std::istringstream is(s);
 update(is);
}
void SHA1::update(std::istream &is)
{
 while (true)
 {
 char sbuf[BLOCK_BYTES];
 is.read(sbuf, BLOCK_BYTES - buffer.size());
 buffer.append(sbuf, (std::size_t)is.gcount());
 if (buffer.size() != BLOCK_BYTES)
 {return;}
 uint32_t block[BLOCK_INTS];
 buffer_to_block(buffer, block);
 transform(digest, block, transforms);
 buffer.clear();
 }
}
std::string SHA1::final()
{
uint64_t total_bits = (transforms*BLOCK_BYTES + buffer.size()) * 8;

 buffer += (char)0x80;
 size_t orig_size = buffer.size();
 while (buffer.size() < BLOCK_BYTES)
 {buffer += (char)0x00;}
 uint32_t block[BLOCK_INTS];
 buffer_to_block(buffer, block);
 if (orig_size > BLOCK_BYTES - 8)
```

```
 {
 transform(digest, block, transforms);
 for (size_t i = 0; i < BLOCK_INTS - 2; i++)
 { block[i] = 0;}
}
 block[BLOCK_INTS - 1] = (uint32_t)total_bits;
 block[BLOCK_INTS - 2] = (uint32_t)(total_bits >> 32);
 transform(digest, block, transforms);
 std::ostringstream result;
 for (size_t i = 0; i < sizeof(digest) / sizeof(digest[0]); i++)
 {result << std::hex << std::setfill('0') << std::setw(8);
 result << digest[i];
 }
 reset(digest, buffer, transforms);
 return result.str();
}
std::string SHA1::from_file(const std::string &filename)
{
 std::ifstream stream(filename.c_str(), std::ios::binary);
 SHA1 checksum;
 checksum.update(stream);
 return checksum.final();
}
```

SHAmain.cpp

```
#include "sha1.h"
#include <string>
#include <iostream>
using namespace std;
int main(int /* argc */, const char ** /* argv */)
{cout<<"Enter the plain text : ";
 string input;
 cin>>input;
 SHA1 checksum;
 checksum.update(input);
 const string hash = checksum.final();
 cout << "\nThe SHA-1 of \"" << input << "\" is: " << hash << endl;
 return 0;
}
```

Output:



Learning Outcomes:

SHA-1 is now considered insecure since 2005. Major tech giants browsers like Microsoft, Google, Apple and Mozilla have stopped accepting SHA-1 SSL certificates by 2017.

To calculate cryptographic hashing value in Java, MessageDigest Class is used, under the package java.security.MessagDigest Class provides following cryptographic hash function to find hash value of a text.