Assignment 2

Learning Outcome: The student will gain experience using memory and bit-shifting in a real-world application.

Description:

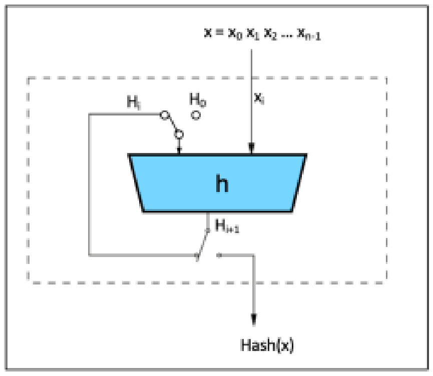
Your task is to construct a 40-bit cryptographic hash function named SHA_40 and investigate its security properties.

A hash function is any function that can be used to map data of arbitrary size to fixed-size values. Hash functions play an important role in cryptography. They have been used for establishing data integrity and authentication. The value returned by a hash function is called a **digest** which can be considered as a fingerprint of the input message. A secure hash function possesses the following properties:

- Randomness – Two similar inputs must produce two seemingly unrelated random looking outputs.
- Onewayness – It should be easy to compute hash digest for a given input, whereas it should be hard to compute an input message that produces a given output.
- Collision resistance – It should be hard to find two different messages that result in the same hash digest.

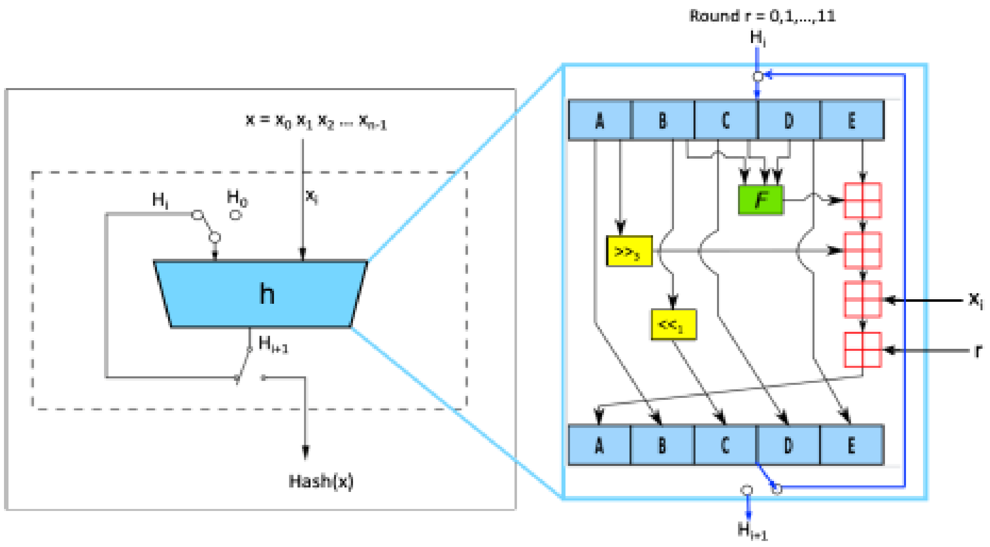
How can hash functions process an arbitrary-length message and produce a fixed length output? In practice, this is achieved by segmenting the input into a series of **blocks of equal size**. These blocks are processed iteratively by a function called compression function, denoted as **h** in the diagram below.

The current output of the compression function is *then used as input in the next iteration.* This iterative design is known as Merkle–Damgard construction which is in fact used by many cryptographic hash functions, including the SHA family and the one you are going to implement here.



<Merkle–Damgard construction>

In SHA_40, each block x_i of message x is a byte and hash output is 40 bits, a sequence of 5 bytes. The compression function **h** takes a byte $\mathbf{x_i}$ and the previous output $\mathbf{H_i}$ as input and produces 40 bits output $\mathbf{H_{i+1}}$, for each i = 0, 1, …,n-1,



<Internal Structure of SHA_40>

• SHA_40 can process an arbitrary-length message and produces a 40-bit output.

• **x is the input** - denotes a sequence of *bytes* (unsigned characters) $x_0x_1\ldots x_{n-1}$. These bytes are processed sequentially by the **h** function. The function consists of 12 rounds, each of which performs identical operations. More precisely, i-th round takes x_i and Hi as input and generates a sequence of 5 bytes H_{i+1}. Each H_i comprises five bytes, denoted by A, B, C, D, and E.

• The hash digest, SHA_40(**x**), is then defined as the output of the last iteration of the **h** functions.

  • H_0 is the initial seed value. Let H_0 = {11, 22, 33, 44, 55}.

- $H_{i+1} = h(H_i, x_i)$, for i = 0, 1, …, n-1
- H_n = SHA_40(x)

- The **h** function uses bit shifting and Boolean operators to scramble the bits efficiently.
- **<<** and **>>** are bitwise shift left and shit right operators respectively.
- **F(**B, C, D) = (B & C) ^ D where **&** is a bitwise AND operator and **^** is a bit wise XOR operator.

FInally, the + boxes represent simple addition.

First, open **hash.h** file and read it. Create a file named hash.c and write the following functions:

- **SHA_40**, which takes a message of arbitrary length and generated a 40-bit hash value using the sha_40 algorithm
- **digest_equal**, which indicates whether or not two digests are equal
- **main**, which tests the functions above

The screenshots requested in the deliverables should contain the following information.

- The SHA-40 hash of the string "CSEC"
- The SHA-40 hash of your first name
- The result of digest_equal when given the SHA-40 hashes of "Rob" and "Rob"
- The result of digest_equal when given the SHA-40 hashes of "James" and "Ahmed"

You may use command line arguments to test your program with different input, or simply use string constants defined in the program.

Deliverables:

a. Submit a **PDF** containing screenshots of the output of your program. Submit your hash.c code on MyCourses. Do not include your entire VS solution files, just your source code.