SHA512 Algorithm
Cryptography – Lab 7

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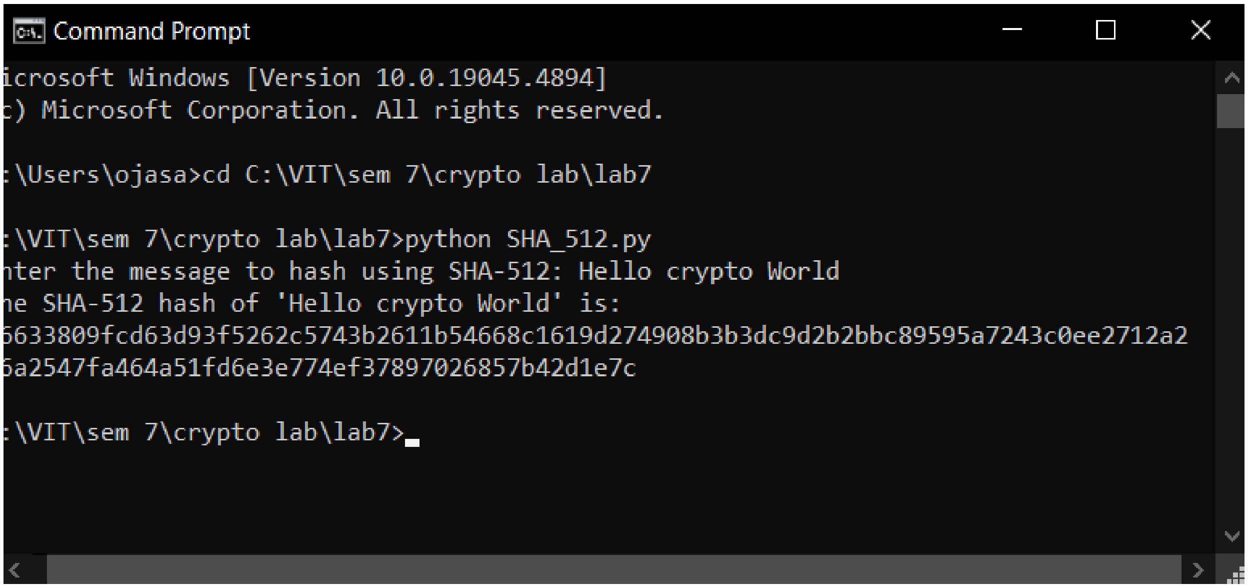
Task

To Develop a Python-based SHA512 Algorithm implementation.

SHA512 Algorithm - Definition

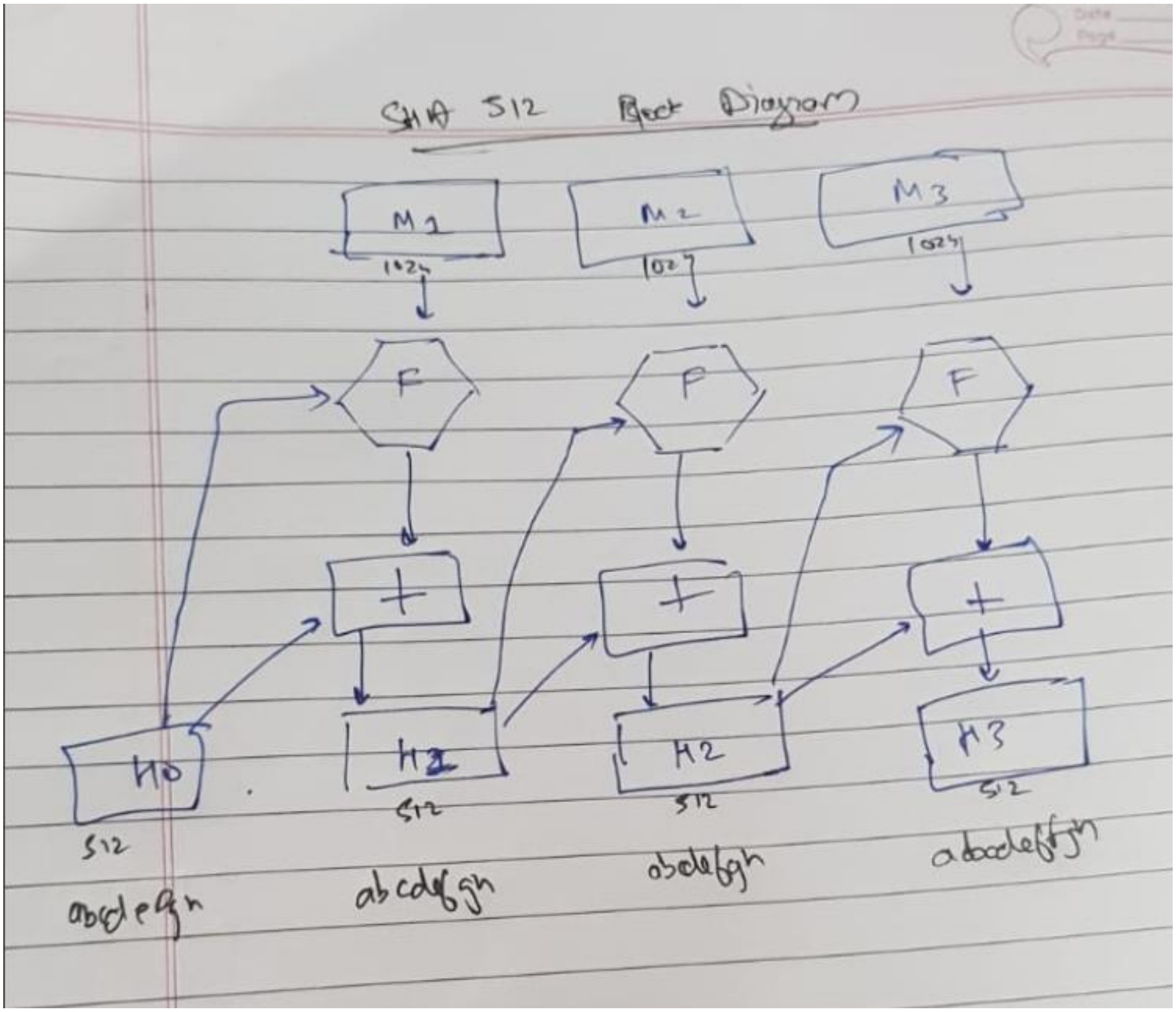
The SHA-512 hashing algorithm generates a 512-bit hash (digest) from an input string. It processes the input in 1024-bit blocks, applying a series of logical functions and bitwise operations to produce a unique fixed-length hash. This algorithm is a part of the SHA-2 family and is widely used for cryptographic security, including verifying data integrity and securing digital signatures.

SHA512 Algorithm - Output Snapshot

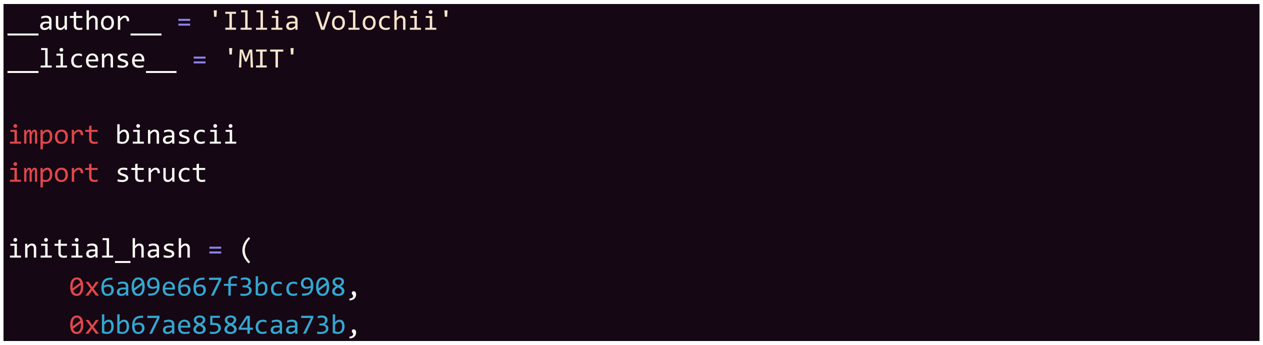


```
icrosoft Windows [Version 10.0.19045.4894]
c) Microsoft Corporation. All rights reserved.

:\Users\ojasa>cd C:\VIT\sem 7\crypto lab\lab7

:\VIT\sem 7\crypto lab\lab7>python SHA_512.py
nter the message to hash using SHA-512: Hello crypto World
he SHA-512 hash of 'Hello crypto World' is:
5633809fcd63d93f5262c5743b2611b54668c1619d274908b3b3dc9d2b2bbc89595a7243c0ee2712a2
5a2547fa464a51fd6e3e774ef37897026857b42d1e7c

:\VIT\sem 7\crypto lab\lab7>
```

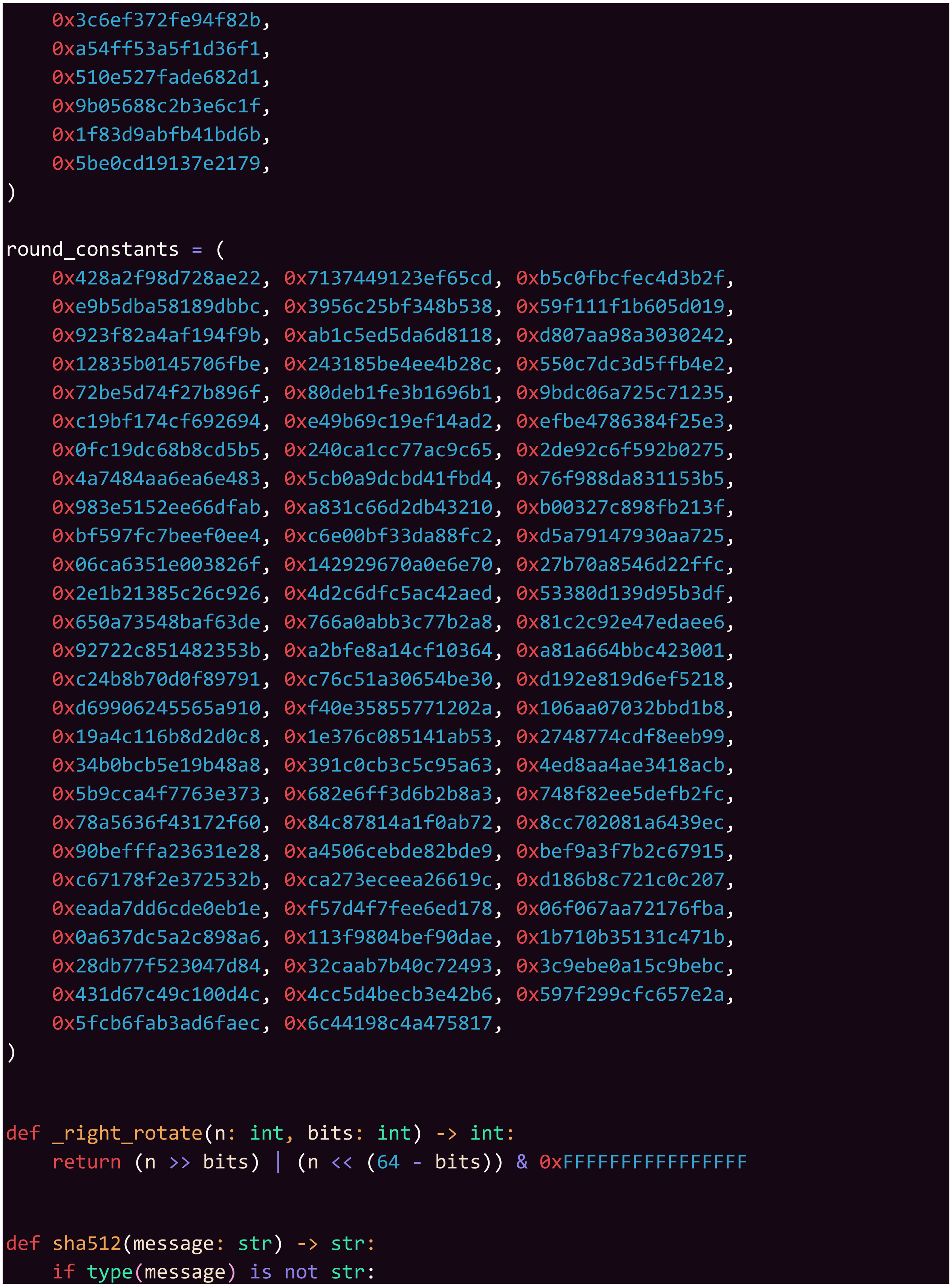
SHA512 - Diagram



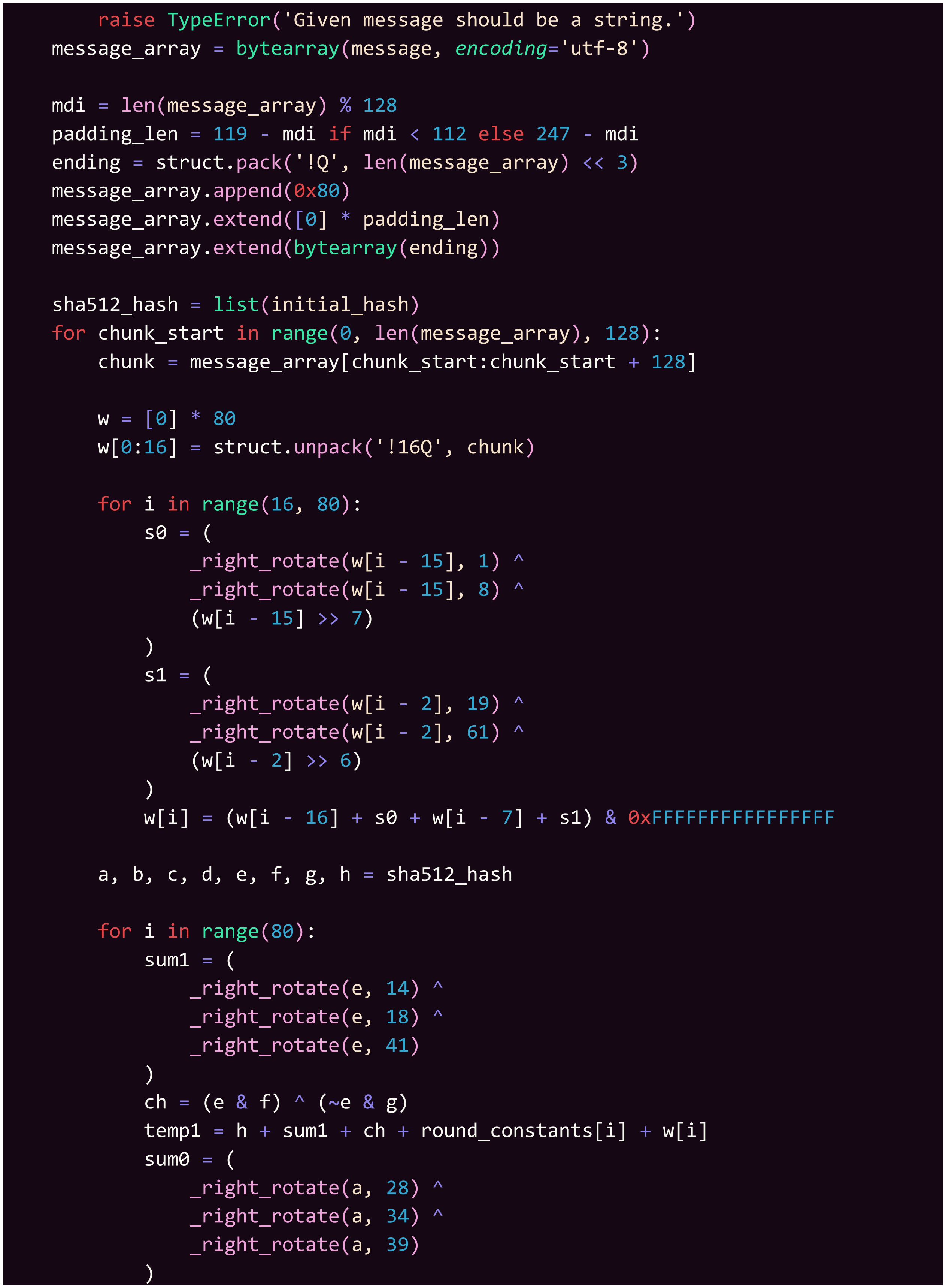
Source Code



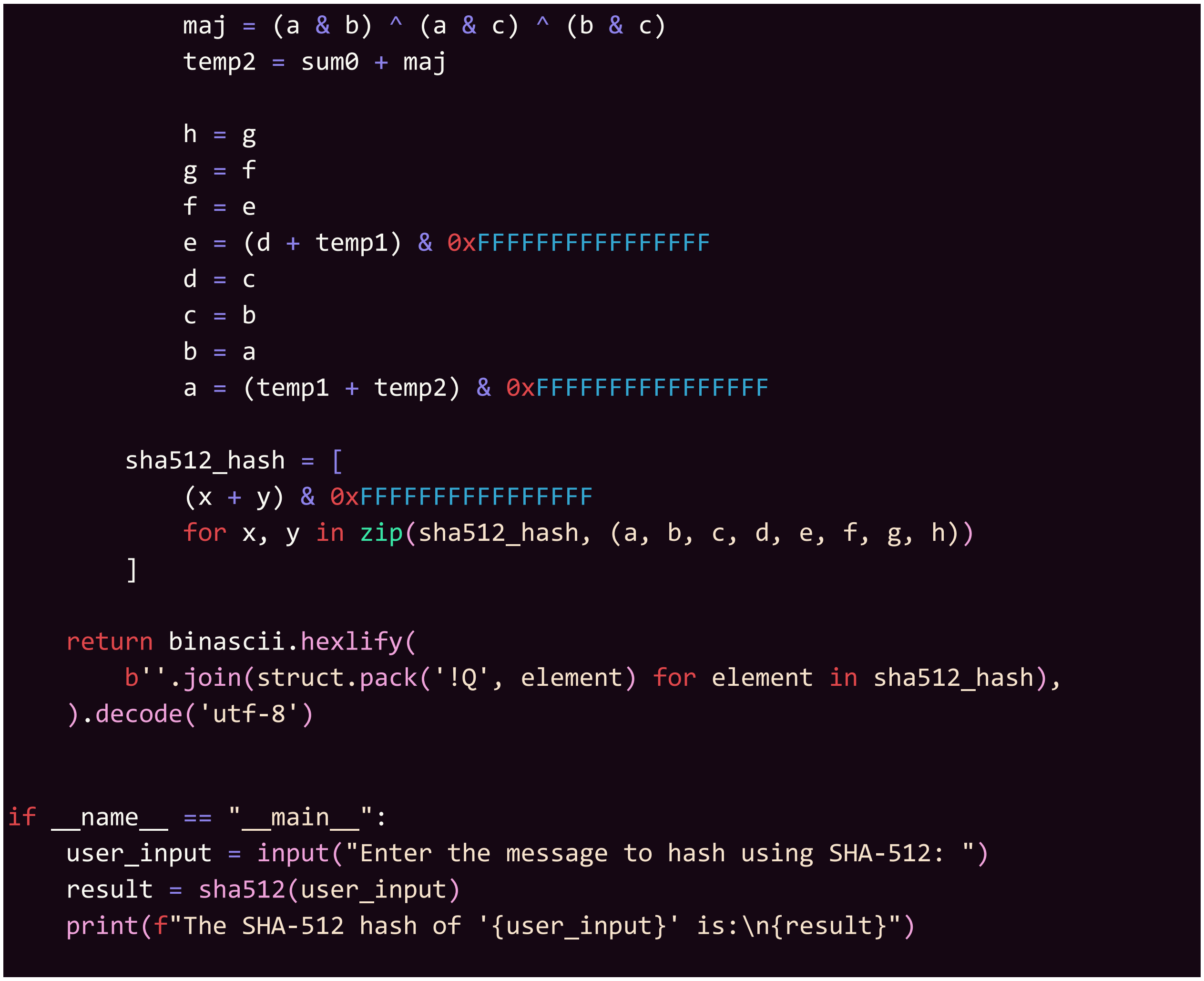
```
__author__ = 'Illia Volochii'
__license__ = 'MIT'

import binascii
import struct

initial_hash = (
    0x6a09e667f3bcc908,
    0xbb67ae8584caa73b,
```



```
    0x3c6ef372fe94f82b,
    0xa54ff53a5f1d36f1,
    0x510e527fade682d1,
    0x9b05688c2b3e6c1f,
    0x1f83d9abfb41bd6b,
    0x5be0cd19137e2179,
)

round_constants = (
    0x428a2f98d728ae22, 0x7137449123ef65cd, 0xb5c0fbcfec4d3b2f,
    0xe9b5dba58189dbbc, 0x3956c25bf348b538, 0x59f111f1b605d019,
    0x923f82a4af194f9b, 0xab1c5ed5da6d8118, 0xd807aa98a3030242,
    0x12835b0145706fbe, 0x243185be4ee4b28c, 0x550c7dc3d5ffb4e2,
    0x72be5d74f27b896f, 0x80deb1fe3b1696b1, 0x9bdc06a725c71235,
    0xc19bf174cf692694, 0xe49b69c19ef14ad2, 0xefbe4786384f25e3,
    0x0fc19dc68b8cd5b5, 0x240ca1cc77ac9c65, 0x2de92c6f592b0275,
    0x4a7484aa6ea6e483, 0x5cb0a9dcbd41fbd4, 0x76f988da831153b5,
    0x983e5152ee66dfab, 0xa831c66d2db43210, 0xb00327c898fb213f,
    0xbf597fc7beef0ee4, 0xc6e00bf33da88fc2, 0xd5a79147930aa725,
    0x06ca6351e003826f, 0x142929670a0e6e70, 0x27b70a8546d22ffc,
    0x2e1b21385c26c926, 0x4d2c6dfc5ac42aed, 0x53380d139d95b3df,
    0x650a73548baf63de, 0x766a0abb3c77b2a8, 0x81c2c92e47edaee6,
    0x92722c851482353b, 0xa2bfe8a14cf10364, 0xa81a664bbc423001,
    0xc24b8b70d0f89791, 0xc76c51a30654be30, 0xd192e819d6ef5218,
    0xd69906245565a910, 0xf40e35855771202a, 0x106aa07032bbd1b8,
    0x19a4c116b8d2d0c8, 0x1e376c085141ab53, 0x2748774cdf8eeb99,
    0x34b0bcb5e19b48a8, 0x391c0cb3c5c95a63, 0x4ed8aa4ae3418acb,
    0x5b9cca4f7763e373, 0x682e6ff3d6b2b8a3, 0x748f82ee5defb2fc,
    0x78a5636f43172f60, 0x84c87814a1f0ab72, 0x8cc702081a6439ec,
    0x90befffa23631e28, 0xa4506cebde82bde9, 0xbef9a3f7b2c67915,
    0xc67178f2e372532b, 0xca273eceea26619c, 0xd186b8c721c0c207,
    0xeada7dd6cde0eb1e, 0xf57d4f7fee6ed178, 0x06f067aa72176fba,
    0x0a637dc5a2c898a6, 0x113f9804bef90dae, 0x1b710b35131c471b,
    0x28db77f523047d84, 0x32caab7b40c72493, 0x3c9ebe0a15c9bebc,
    0x431d67c49c100d4c, 0x4cc5d4becb3e42b6, 0x597f299cfc657e2a,
    0x5fcb6fab3ad6faec, 0x6c44198c4a475817,
)


def _right_rotate(n: int, bits: int) -> int:
    return (n >> bits) | (n << (64 - bits)) & 0xFFFFFFFFFFFFFFFF


def sha512(message: str) -> str:
    if type(message) is not str:
```



```
        raise TypeError('Given message should be a string.')
    message_array = bytearray(message, encoding='utf-8')

    mdi = len(message_array) % 128
    padding_len = 119 - mdi if mdi < 112 else 247 - mdi
    ending = struct.pack('!Q', len(message_array) << 3)
    message_array.append(0x80)
    message_array.extend([0] * padding_len)
    message_array.extend(bytearray(ending))

    sha512_hash = list(initial_hash)
    for chunk_start in range(0, len(message_array), 128):
        chunk = message_array[chunk_start:chunk_start + 128]

        w = [0] * 80
        w[0:16] = struct.unpack('!16Q', chunk)

        for i in range(16, 80):
            s0 = (
                _right_rotate(w[i - 15], 1) ^
                _right_rotate(w[i - 15], 8) ^
                (w[i - 15] >> 7)
            )
            s1 = (
                _right_rotate(w[i - 2], 19) ^
                _right_rotate(w[i - 2], 61) ^
                (w[i - 2] >> 6)
            )
            w[i] = (w[i - 16] + s0 + w[i - 7] + s1) & 0xFFFFFFFFFFFFFFFF

        a, b, c, d, e, f, g, h = sha512_hash

        for i in range(80):
            sum1 = (
                _right_rotate(e, 14) ^
                _right_rotate(e, 18) ^
                _right_rotate(e, 41)
            )
            ch = (e & f) ^ (~e & g)
            temp1 = h + sum1 + ch + round_constants[i] + w[i]
            sum0 = (
                _right_rotate(a, 28) ^
                _right_rotate(a, 34) ^
                _right_rotate(a, 39)
            )
```



```python
            maj = (a & b) ^ (a & c) ^ (b & c)
            temp2 = sum0 + maj

            h = g
            g = f
            f = e
            e = (d + temp1) & 0xFFFFFFFFFFFFFFFF
            d = c
            c = b
            b = a
            a = (temp1 + temp2) & 0xFFFFFFFFFFFFFFFF

        sha512_hash = [
            (x + y) & 0xFFFFFFFFFFFFFFFF
            for x, y in zip(sha512_hash, (a, b, c, d, e, f, g, h))
        ]

    return binascii.hexlify(
        b''.join(struct.pack('!Q', element) for element in sha512_hash),
    ).decode('utf-8')


if __name__ == "__main__":
    user_input = input("Enter the message to hash using SHA-512: ")
    result = sha512(user_input)
    print(f"The SHA-512 hash of '{user_input}' is:\n{result}")
```

Conclusion

The implementation of the SHA-512 algorithm in Python effectively demonstrates its core components, offering a deeper understanding of how SHA-512 generates fixed-length, 512-bit hashes. Its role in maintaining data integrity, security, and authentication is crucial, particularly in cryptographic applications requiring higher security than earlier algorithms like MD5.