

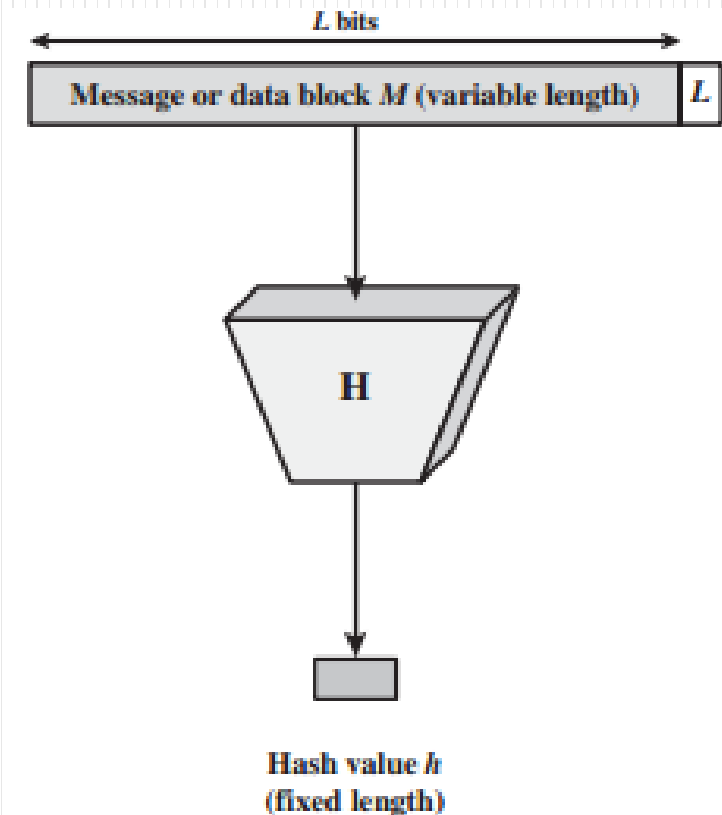
CRYPTOGRAPHIC HASH FUNCTIONS

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1. Hash function

- A hash function maps a variable-length message into a fixed-length hash value, or message digest: $h = H(M)$



1. Cryptographic hash function.

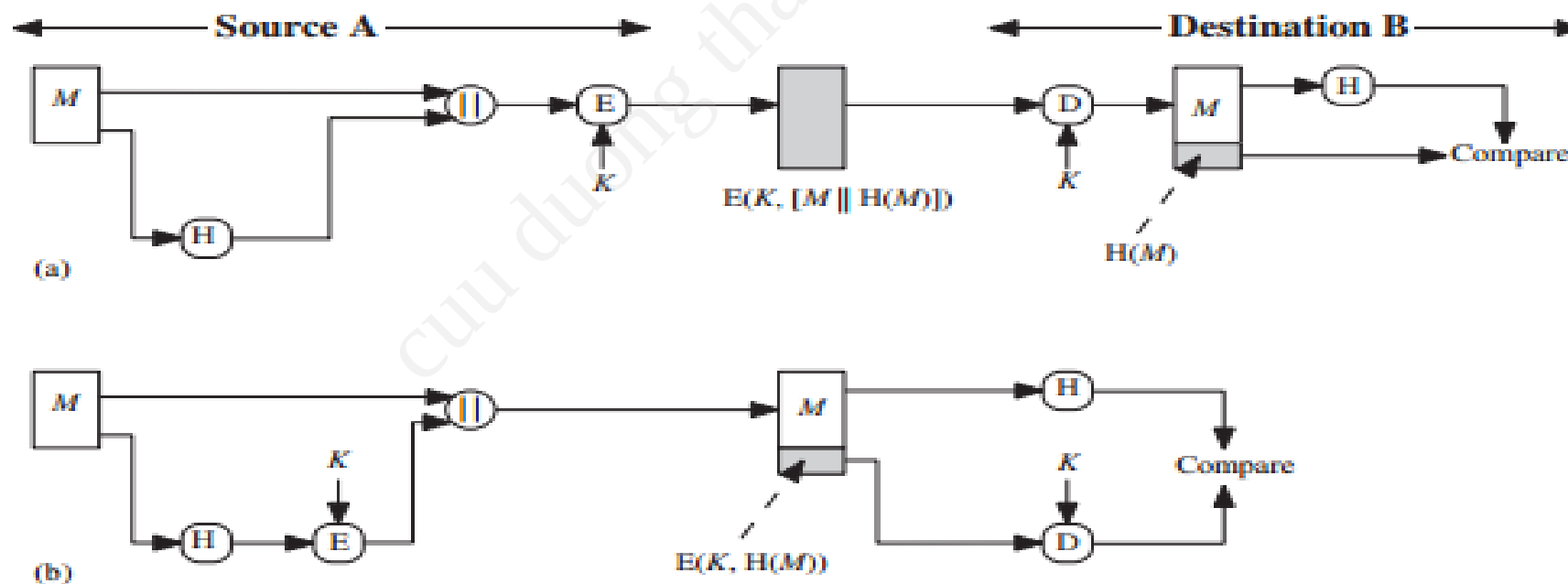
- A cryptographic hash function is an algorithm for which it is computationally infeasible to find either a data object that maps to a pre-specified hash result or two data objects that map to the same hash result

2. Applications Of Cryptographic Hash Functions

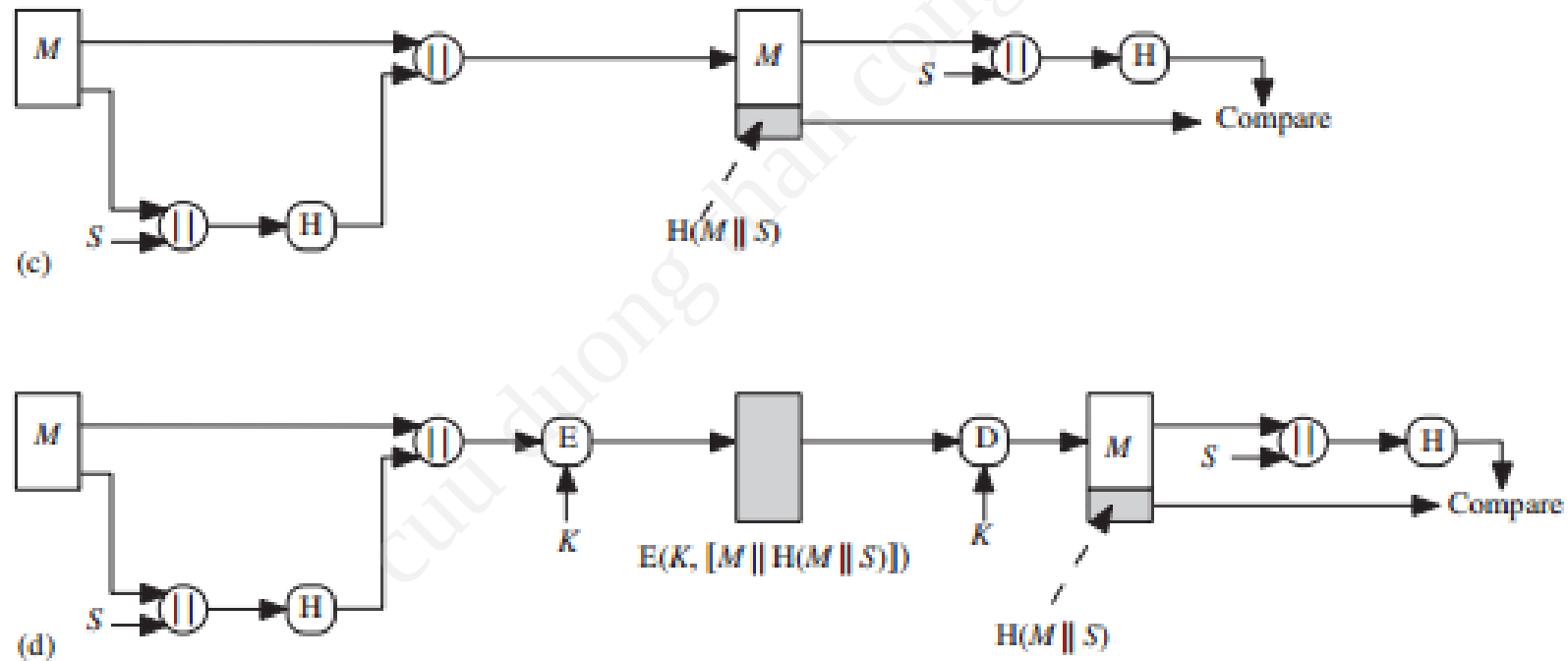
- Message Authentication
- Digital signature

Message Authentication

- Message authentication is a mechanism or service used to verify the integrity of a message. Message authentication assures that data received are exactly as sent



Message Authentication

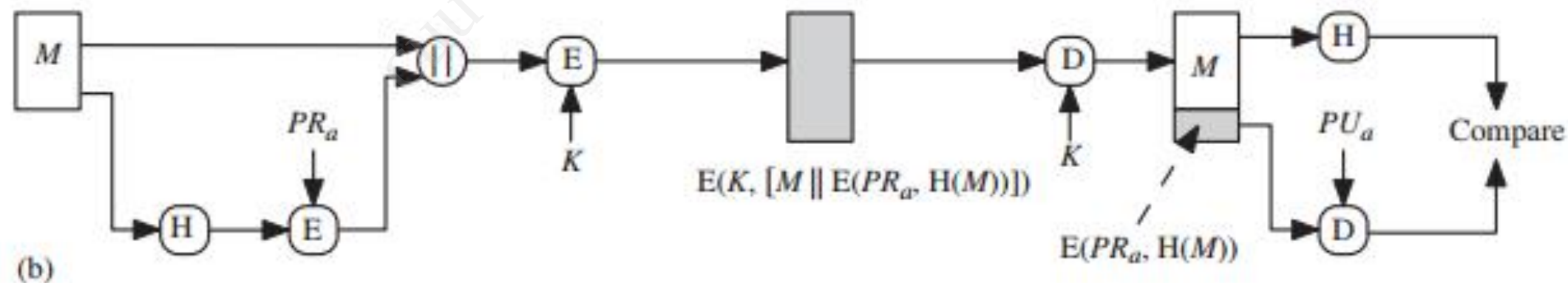
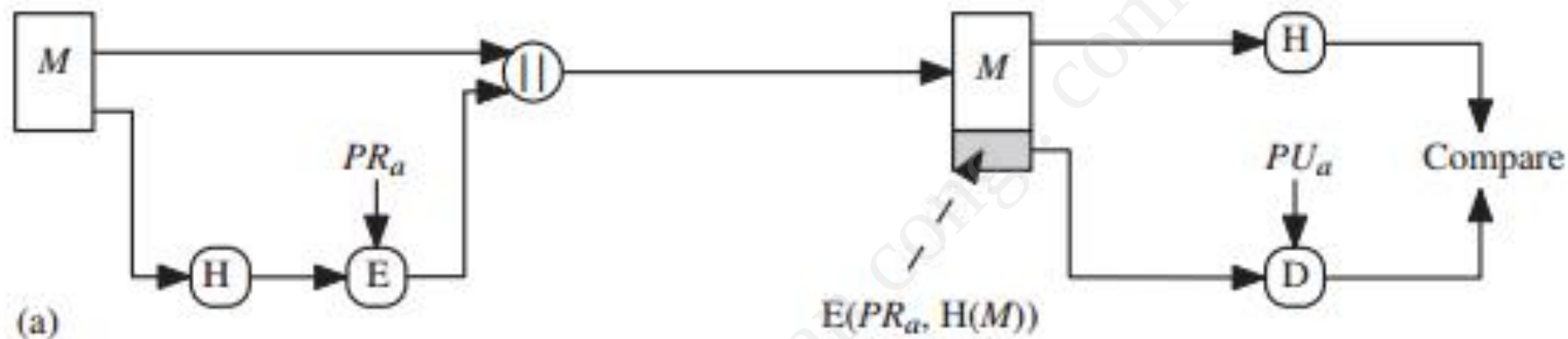


Digital signature

- The hash value of a message is encrypted with a user's private key.
- Anyone who knows the user's public key can verify the integrity of the message that is associated with the digital signature

← Source A →

← Destination B →



Other Applications

- Hash functions are commonly used to create a one-way password file
- Hash functions can be used for intrusion detection and virus detection

3. Simple Hash Functions

- Input (message, file, etc.) is viewed as a sequence of n -bit blocks
- One of the simplest hash functions is the bit-by-bit exclusive-OR (XOR) of every block. This can be expressed as:

$$C_i = b_{i1} \oplus b_{i2} \oplus \dots \oplus b_{im}$$

where

C_i = i th bit of the hash code, $1 \leq i \leq n$

m = number of n -bit blocks in the input

b_{ij} = i th bit in j th block

$\oplus$ = XOR operation

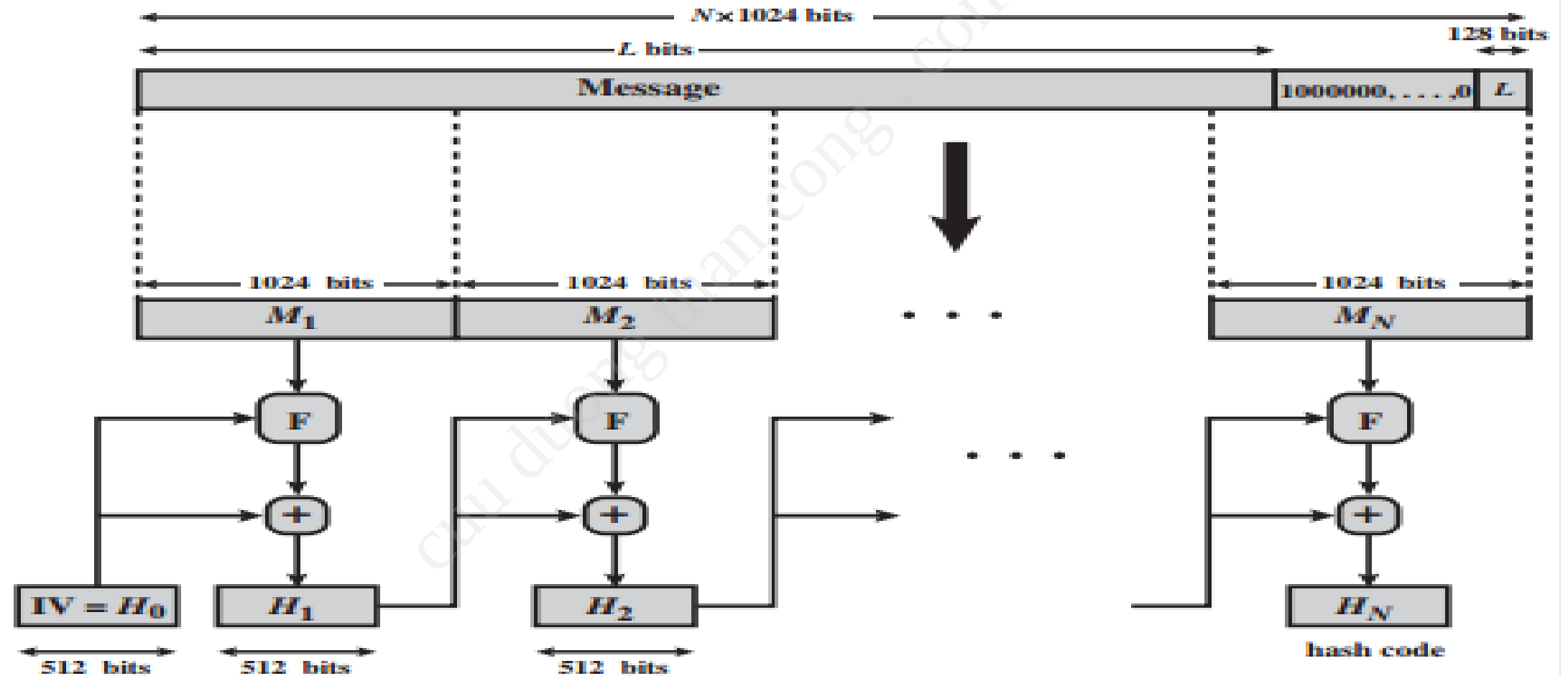
4. Requirements And Security

Requirement	Description
Variable input size	H can be applied to a block of data of any size.
Fixed output size	H produces a fixed-length output.
Efficiency	$H(x)$ is relatively easy to compute for any given x , making both hardware and software implementations practical.
Preimage resistant (one-way property)	For any given hash value h , it is computationally infeasible to find y such that $H(y) = h$.
Second preimage resistant (weak collision resistant)	For any given block x , it is computationally infeasible to find $y \neq x$ with $H(y) = H(x)$.
Collision resistant (strong collision resistant)	It is computationally infeasible to find any pair (x, y) such that $H(x) = H(y)$.
Pseudorandomness	Output of H meets standard tests for pseudorandomness.

5. Secure Hash Algorithm (SHA)

	SHA-1	SHA-224	SHA-256	SHA-384	SHA-512
Message Digest Size	160	224	256	384	512
Message Size	$< 2^{64}$	$< 2^{64}$	$< 2^{64}$	$< 2^{128}$	$< 2^{128}$
Block Size	512	512	512	1024	1024
Word Size	32	32	32	64	64
Number of Steps	80	64	64	80	80

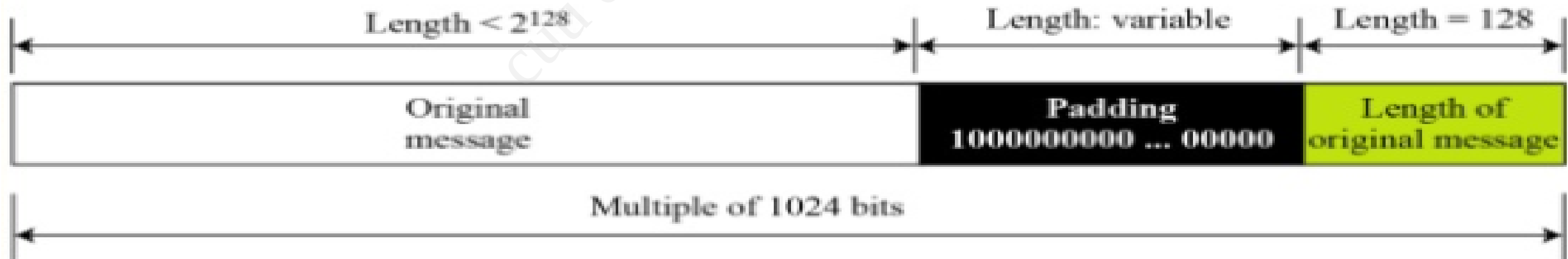
SHA-512



$+$ = word-by-word addition mod 2^{64}

SHA-512

- **Step 1** Append padding bits: The padding consists of a single 1 bit followed by the necessary number of 0 bits
- **Step 2** Append length: A block of 128 bits is appended to the message. This block is treated as an unsigned 128-bit integer and contains the length of the original message (before the padding).



SHA-512

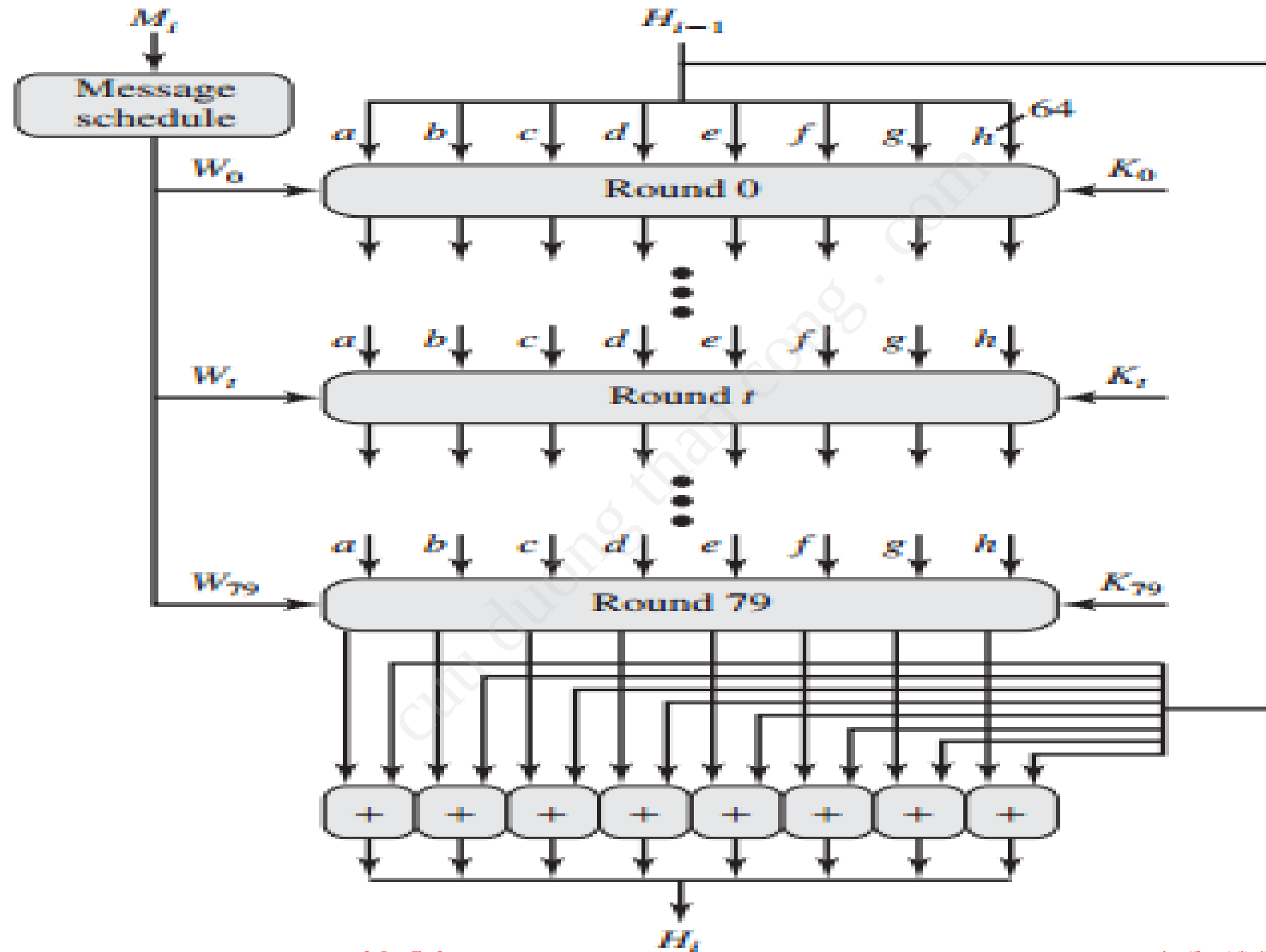
- **Step 3** Initialize hash buffer: A 512-bit buffer is used to hold intermediate and final results of the hash function. The buffer can be represented as eight 64-bit registers (a, b, c, d, e, f, g, h). These registers are initialized to the following 64-bit integers (hexadecimal values):

a = 6A09E667F3BCC908 e = 510E527FADE682D1

b = BB67AE8584CAA73B f = 9B05688C2B3E6C1F

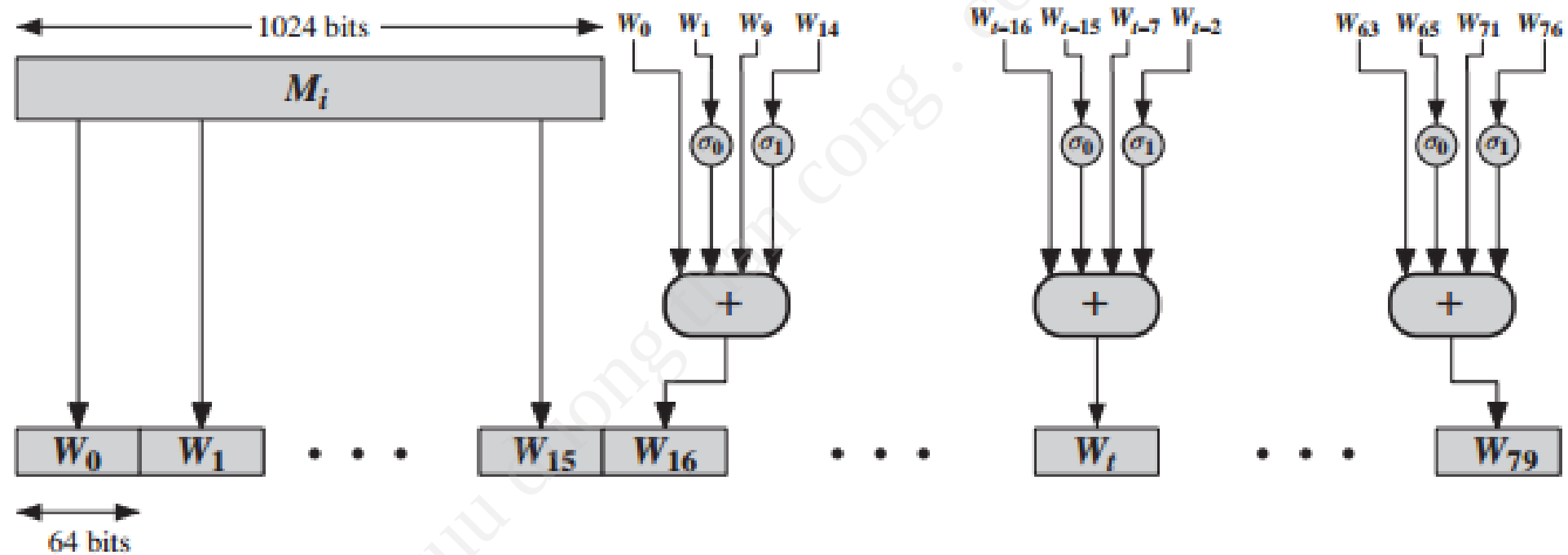
c = 3C6EF372FE94F82B g = 1F83D9ABFB41BD6B

d = A54FF53A5F1D36F1 h = 5BE0CD19137E2179

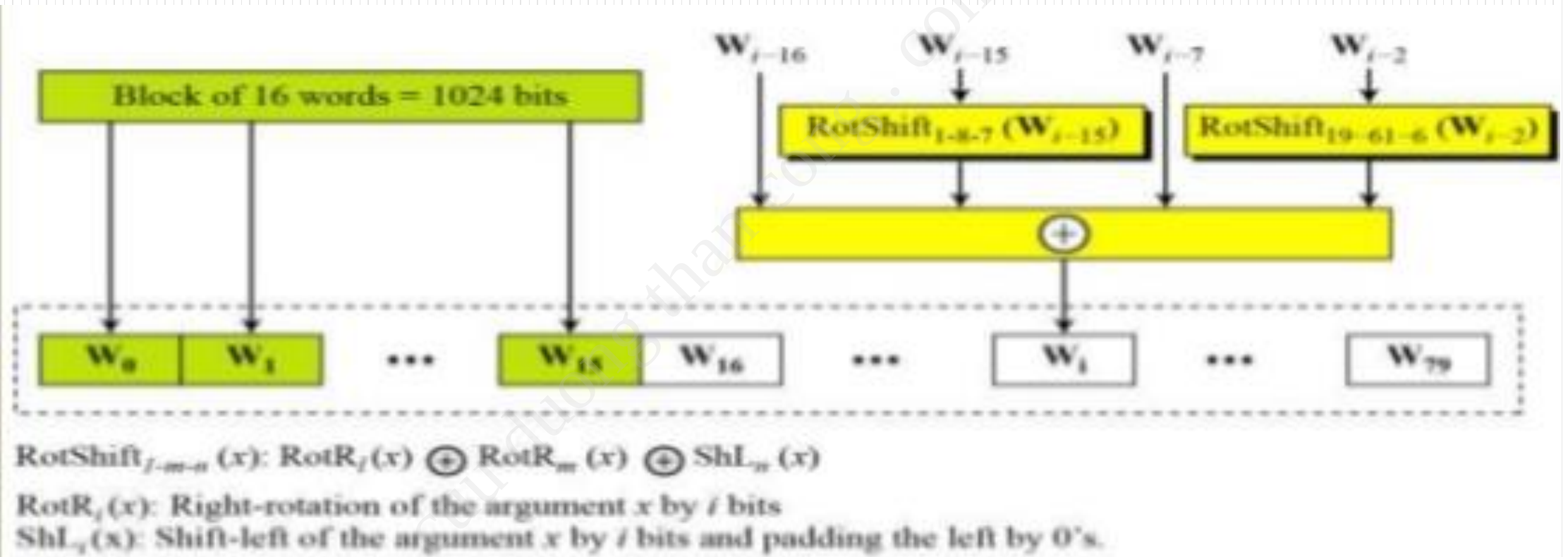


428a2f98d728ae22	7137449123ef65cd	b5c0fbcfec4d3b2f	e9b5dba58189dbbc
3956c25bf348b538	59f111f1b605d019	923f82a4af194f9b	ab1c5ed5da6d8118
d807aa98a3030242	12835b0145706fbe	243185be4ee4b28c	550c7dc3d5ffb4e2
72be5d74f27b896f	80deb1fe3b1696b1	9bdc06a725c71235	c19bf174cf692694
e49b69c19ef14ad2	efbe4786384f25e3	0fc19dc68b8cd5b5	240ca1cc77ac9c65
2de92c6f592b0275	4a7484aa6ea6e483	5cb0a9dcbbd41fbd4	76f988da831153b5
983e5152ee66dfab	a831c66d2db43210	b00327c898fb213f	bf597fc7beef0ee4
c6e00bf33da88fc2	d5a79147930aa725	06ca6351e003826f	142929670a0e6e70
27b70a8546d22ffc	2e1b21385c26c926	4d2c6dfc5ac42aed	53380d139d95b3df
650a73548baf63de	766a0abb3c77b2a8	81c2c92e47edaaee6	92722c851482353b
a2bfe8a14cf10364	a81a664bbc423001	c24b8b70d0f89791	c76c51a30654be30
d192e819d6ef5218	d69906245565a910	f40e35855771202a	106aa07032bbd1b8
19a4c116b8d2d0c8	1e376c085141ab53	2748774cdf8eeb99	34b0bcb5e19b48a8
391c0cb3c5c95a63	4ed8aa4ae3418acb	5b9cca4f7763e373	682e6fff3d6b2b8a3
748f82ee5defb2fc	78a5636f43172f60	84c87814a1f0ab72	8cc702081a6439ec
90befffa23631e28	a4506cebbe82bde9	bef9a3f7b2c67915	c67178f2e372532b
ca273eceeaa26619c	d186b8c721c0c207	eada7dd6cde0eb1e	f57d4f7fee6ed178
06f067aa72176fba	0a637dc5a2c898a6	113f9804bef90dae	1b710b35131c471b
28db77f523047d84	32caab7b40c72493	3c9ebe0a15c9bebc	431d67c49c100d4c
4cc5d4becb3e42b6	597f299cfc657e2a	5fcb6fab3ad6faec	6c44198c4a475817

SHA-512



SHA-512: Word Expansion



SHA-512

- **Step 5 Output:** After all 1024-bit blocks have been processed, the output from the Nth stage is the 512-bit message digest.

Thanks