# Secure Hash Algo (SHA-1)

- Algo takes as i/p a msg with max length less than $2^{64}$ bits
- produces o/p of 160-bit msg digest.
- The i/p is processed in 512 bit blocks.
- follows structure of MD5.

**Step 1** : Append padding bits

- msg is padded so its length is congruent to 448 modulo 512
- padding is always added, even if msg is of desired length.
- no. of padding bits are 1 to 512.
- padding consists of a sing 1 followed by necessary 0's

**Step :2** : Append length

- block of 64 bit is appended to msg.
- This block is treated as unsigned 64 bit int. (most significant byte first)
- contains length of original msg (before padding)

## Step 3 Initialize MD buffer.

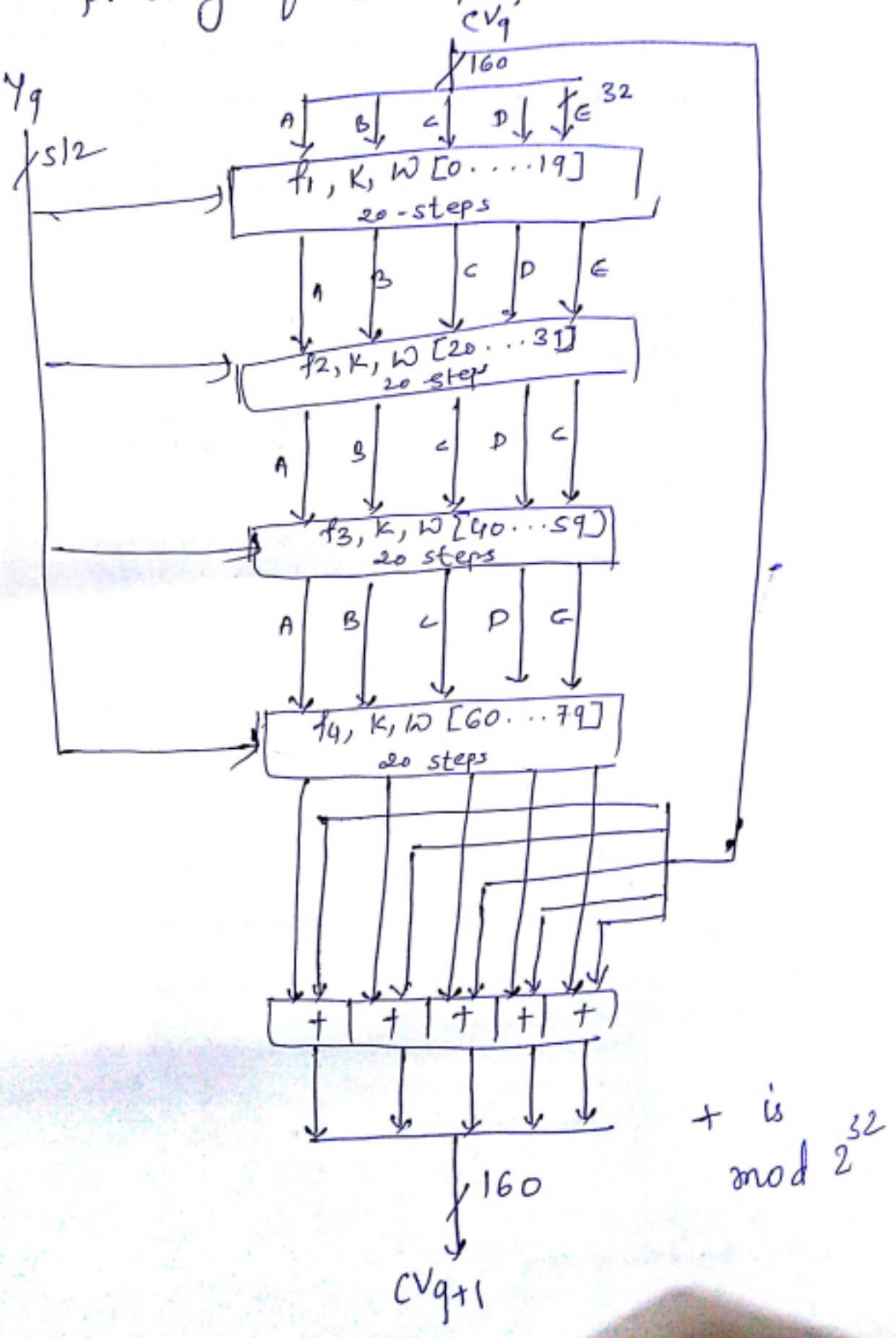
- A 160 bit buffer is used to hold intermediate & final result of the hash function.
- The buffer is 5 - 32 bit registers (A, B, C, D, E)
  These regi are initialize as

  A - 67452301
  B - EFCDAB89
  C - 98BADCFE
  D - 10325476
  E - C3D2E1F0

→ These values are stored in big-endian
  - MSB is stored at lower adr byte p

Step : 4 : Process only in 512 bit (16 word) block

- The heart of algo is 4- Rounds of processing of 20 steps




+ is mod $2^{32}$

- Each round takes 512-bit block as i/p ($Y_q$) & 160-bit buffer value ABCDE & updates the content of buffer.
- Each round also makes use of an additive constant $K_t$ where $0 \le t \le 79$ indicates one of the 80 steps across ~~five~~ 4 rounds.

| step no. | Hex | Take int part of: |
|---|---|---|
| $0 \le t \le 19$ | $K_t = 5A827999$ | $2^{30} \times \sqrt{2}$ |
| $20 \le t \le 39$ | $K_t = 6ED9EBA1$ | $2^{30} \times \sqrt{3}$ |
| $40 \le t \le 59$ | $K_t = 8F1BBCDC$ | $2^{30} \times \sqrt{5}$ |
| $60 \le t \le 79$ | $K_t = CA62C1D6$ | $2^{30} \times \sqrt{10}$ |

**Step 5:**

- after all L 512-bits blocks have been processed the o/p from the $2^{th}$ stage is 160-bit msg digest

So behavior of SHA-1 is given as

$$CV_0 = IV$$
$$CV_{q+1} = SUM_{32}(CV_q, ABCDE_q)$$
$$MD = CV_L$$

IV = Initial value of ABCDE buffer

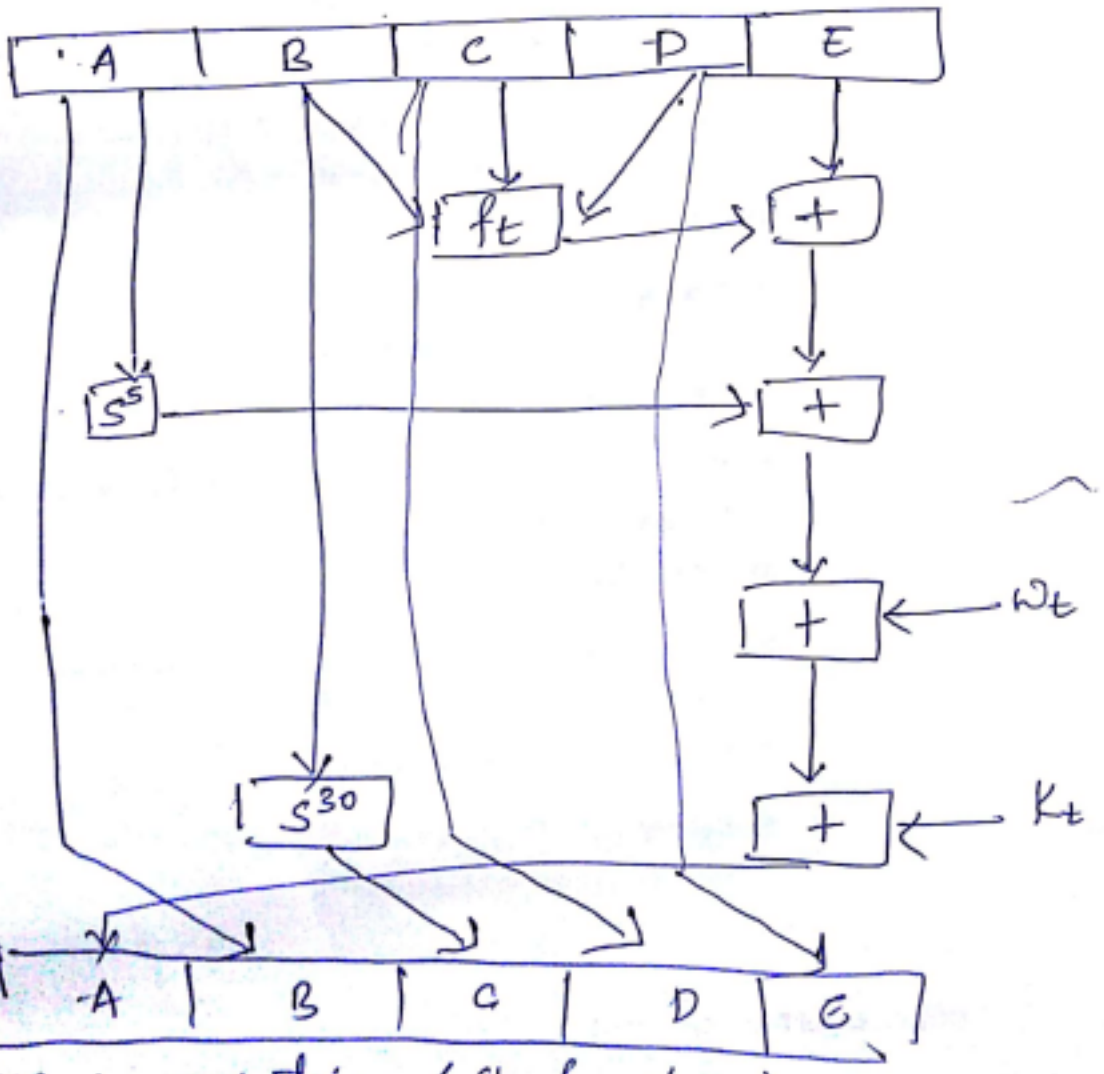
$ABCDE_q$ = O/P of the last round of processing of the $q^{th}$ msg. block

L = no. of blocks in msg

$SUM_{32}$ = Addition mod $2^{32}$ performed separately on each word of the pair of i/p

MD = final msg digest value.

## SHA-1 Compression function




SHA-1 operation (Single step)

Each round is of the form :

$$A,B,C,D,E \leftarrow (E, f(t,B,C,D) + S^5(A) + W_t + K_t) + A, S^{30}(B), C, D$$

$A,B,C,D,E \rightarrow$ 5 words of the buffer

$t \rightarrow$ step no. $(0 \leq t \leq 79)$

$f(t,B,C,D) =$ primitive logic function for step $t$

$S^k =$ Circular left shift of 32 bit argument by $k$ bits

$W_t =$ a word derived from current 512 bit block.

$K_t =$ additive constant
four values are used.

$+ =$ ✓ modulo $2^{32}$ addition

- each primitive function takes 2 - 32 bit words as i/p & produces 32 bit word o/p
- each function performs a set of bitwise logical operations ;

The functions are

| step | function Name | function value |
|---|---|---|
| $0 \le t \le 19$ | $f1 = f(t, B, C, D)$ | $(B \wedge C) \vee (\bar{B} \wedge D)$ |
| $0 \le t \le 39$ | $f2 =$ " | $B \oplus C \oplus D$ |
| $0 \le t \le 59$ | $f3 =$ " | $(B \wedge C) \vee (B \wedge D) \vee (C \wedge D)$ |
| $0 \le t \le 79$ | $f4 =$ " | $B \oplus C \oplus D$ |

$\wedge \rightarrow$ and —— $\vee \rightarrow$ or — $\rightarrow$ not $\oplus$ XOR

f1 → conditional function
If B then C, else D

f2 & f4 → generates parity

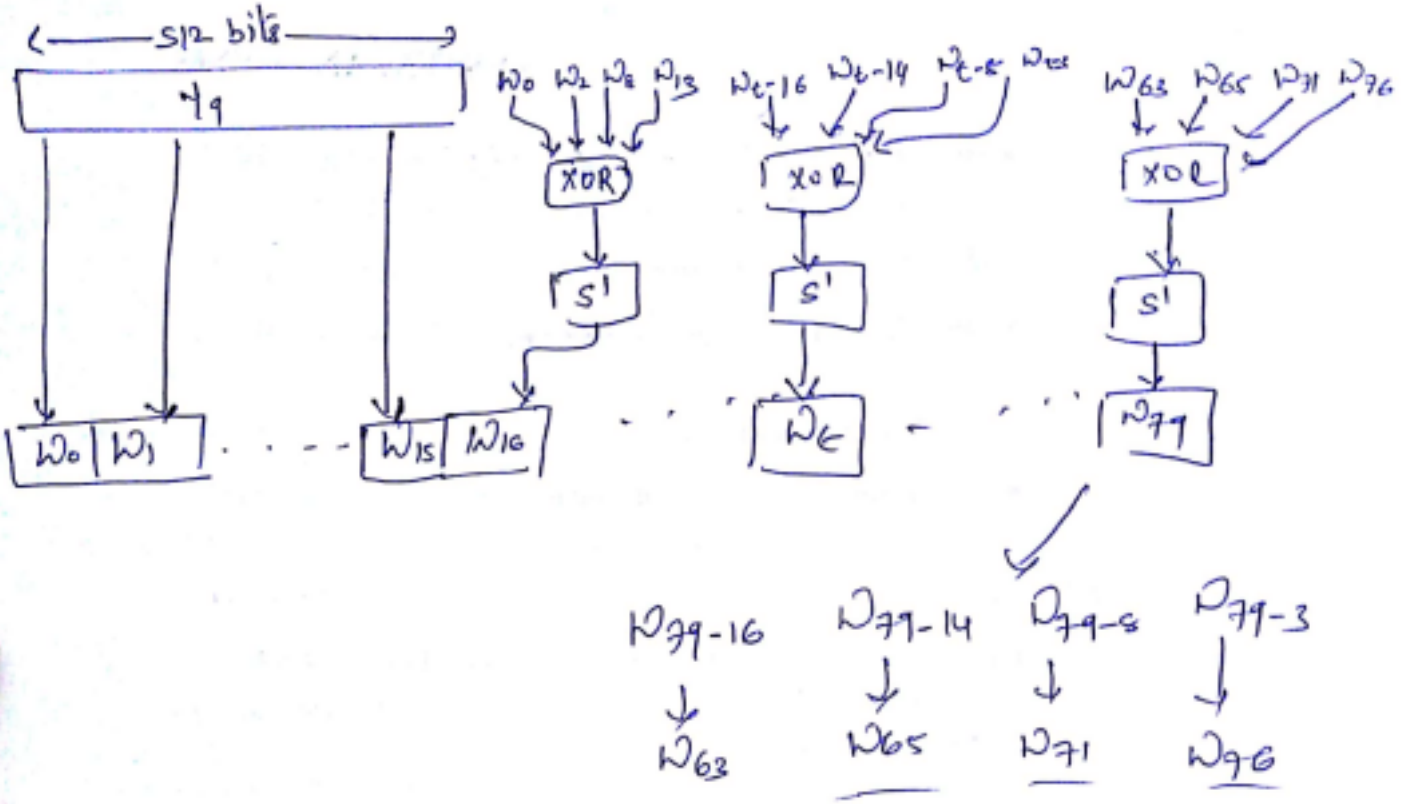
f3 → function is true if 2 or 3 arguments are true.

⇒ How $W_t$ is derived from 512 bit i/p block

→ 1st 16 values of $W_t$ are taken directly from the 16 words of the current block.

→ remaining values are ~~taken~~ defind as

$$W_t = S^1(W_{t-16} \oplus W_{t-14} \oplus W_{t-8} \oplus W_{t-3})$$




Creation of 80-word i/p seq. of SHA 1.

## Comparision of MD5 & SHA-1

(1) ~~Secu~~ Security against brute-force →

- SHA-1 Digest is 32 bit longer than MD5
- using brute force it is difficult to produce any msg having a given msg digest is $2^{128}$ in MD5 & $2^{160}$ in SHA1
- SHA-1 is considerably stronger than MD5

2) Security against cryptanalysis

- MD5 is vulnerable to cryptanalytic attack
- SHA-1 is considerably not.
  bcz of the design criteria & its strength is more diff. to judge.

3) Speed :→

- as algo is based on addition modulo $2^{32}$.
  both do well on a 32 bit architecture.
- SHA I involves more steps (80 versus 64) & must process 160-bit buffer compared do MD5's 128 bit.
- Thus SHA-1 executes slowly than MD5

4) Simplicity & compactness

- Both algos are simple to describe & simple to implement
- it doesn't require large progs or substitution tables.

5) Little Vs big endian architecture.

- MD5 uses Little endian for interpreting msg seq. of 32-bit words
- SHA-1 uses big endian scheme
- no significant adv. of either approach.