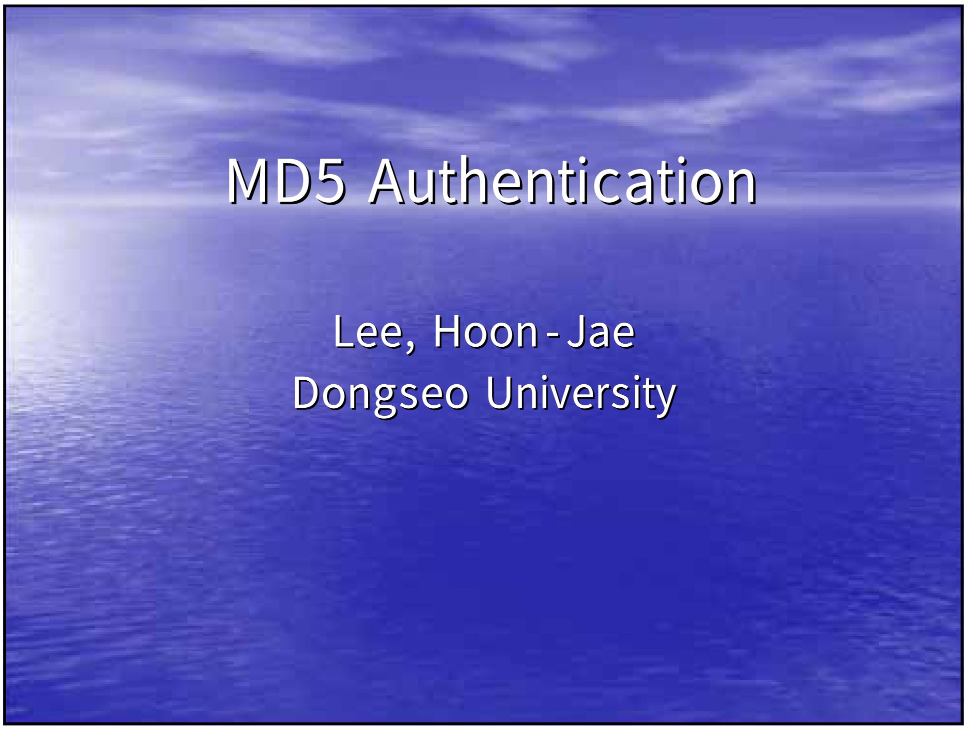

MD5 Authentication

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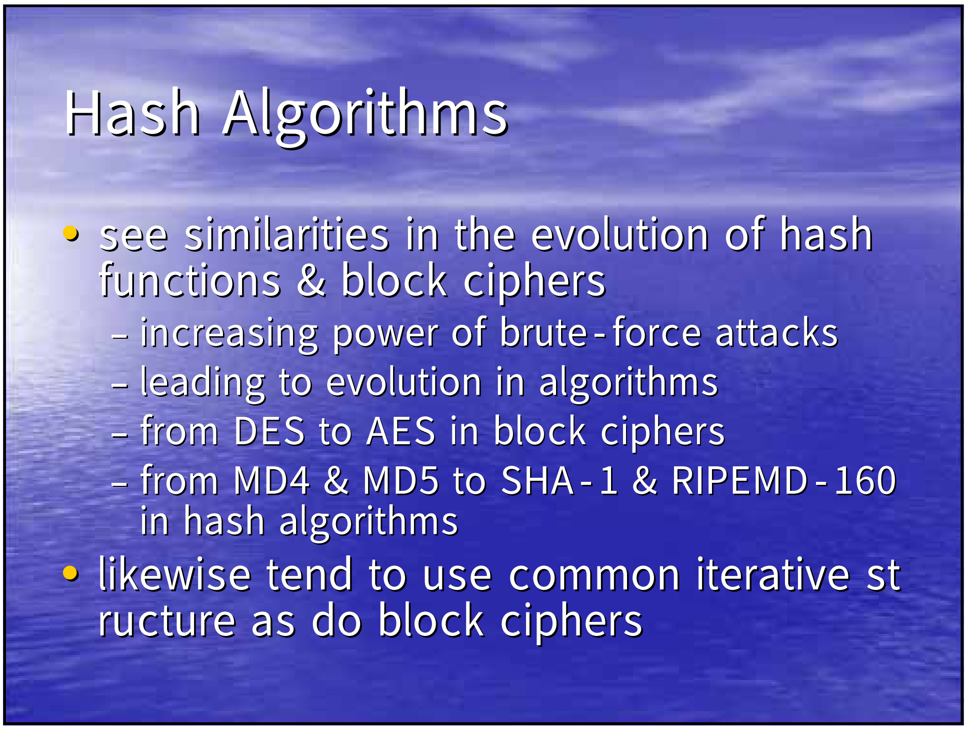
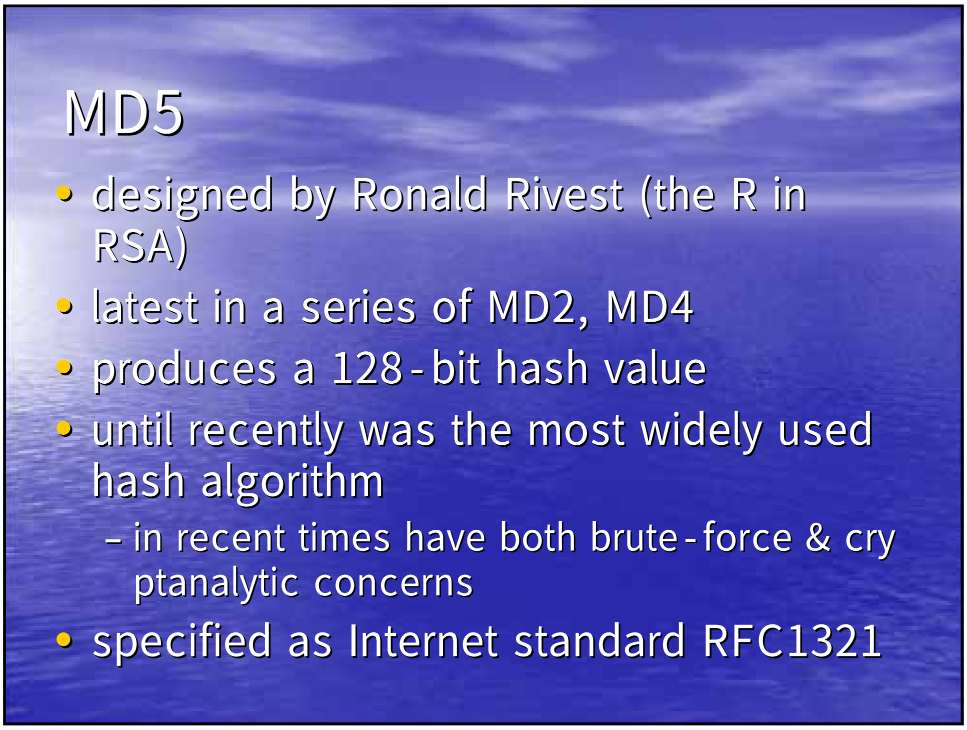


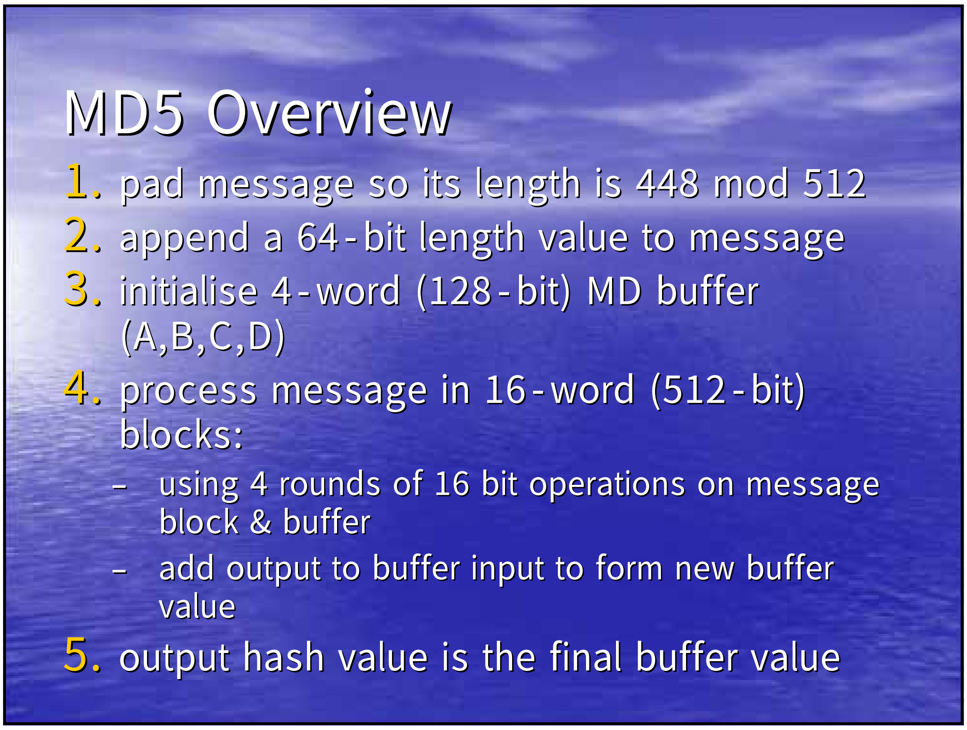
Hash Algorithms

- see similarities in the evolution of hash functions & block ciphers
  - increasing power of brute-force attacks
  - leading to evolution in algorithms
  - from DES to AES in block ciphers
  - from MD4 & MD5 to SHA-1 & RIPEMD-160 in hash algorithms
- likewise tend to use common iterative st ructure as do block ciphers



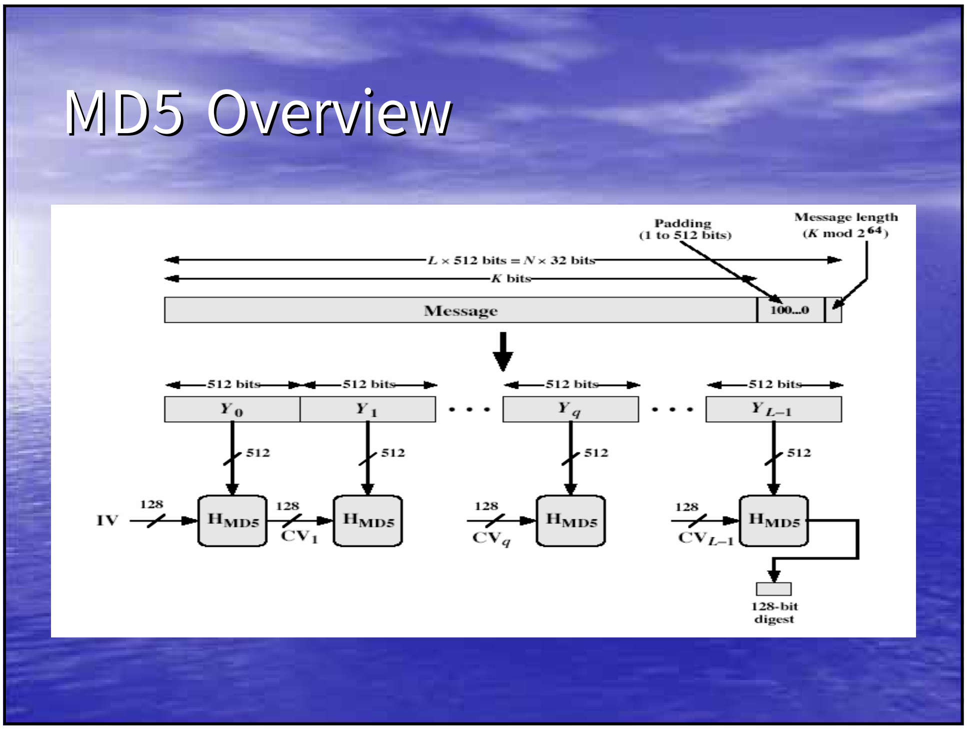
MD5

- designed by Ronald Rivest (the R in RSA)
- latest in a series of MD2, MD4
- produces a 128-bit hash value
- until recently was the most widely used hash algorithm
  – in recent times have both brute-force & cryptanalytic concerns
- specified as Internet standard RFC1321

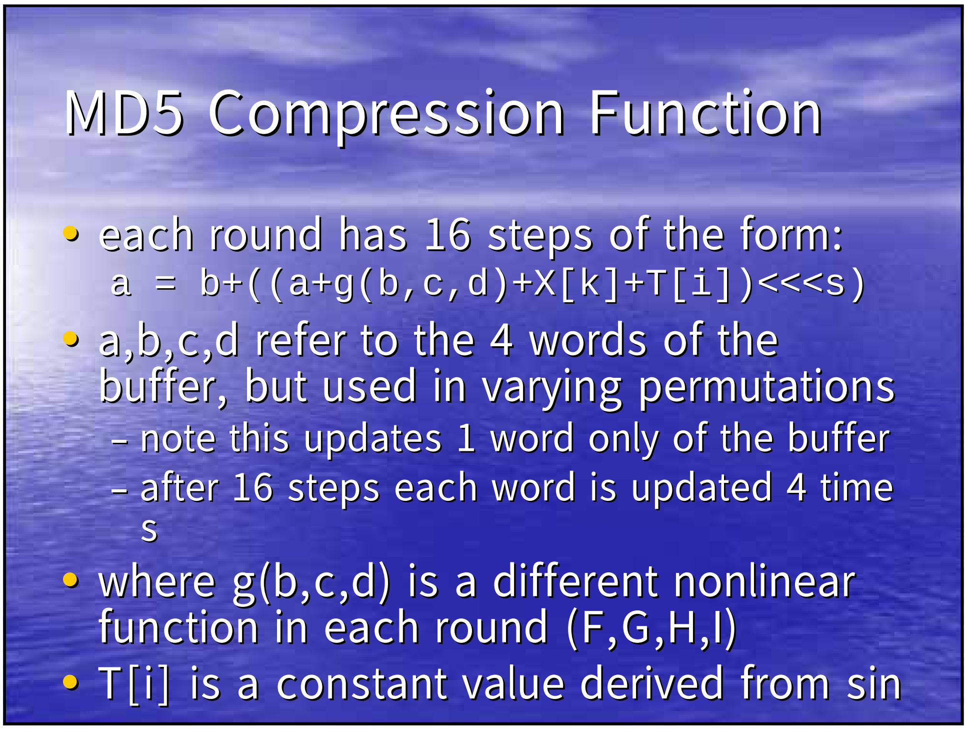


MD5 Overview

1. pad message so its length is 448 mod 512
2. append a 64-bit length value to message
3. initialise 4-word (128-bit) MD buffer (A,B,C,D)
4. process message in 16-word (512-bit) blocks:
   – using 4 rounds of 16 bit operations on message block & buffer
   – add output to buffer input to form new buffer value
5. output hash value is the final buffer value



MD5 Overview



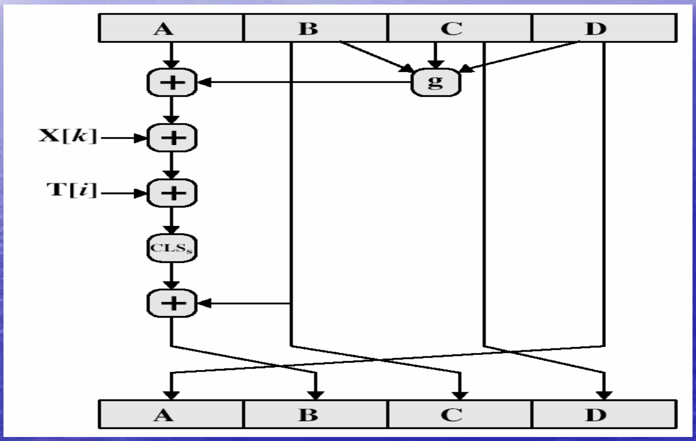
MD5 Compression Function

- each round has 16 steps of the form:

```
a = b+((a+g(b,c,d)+X[k]+T[i])<<<s)
```

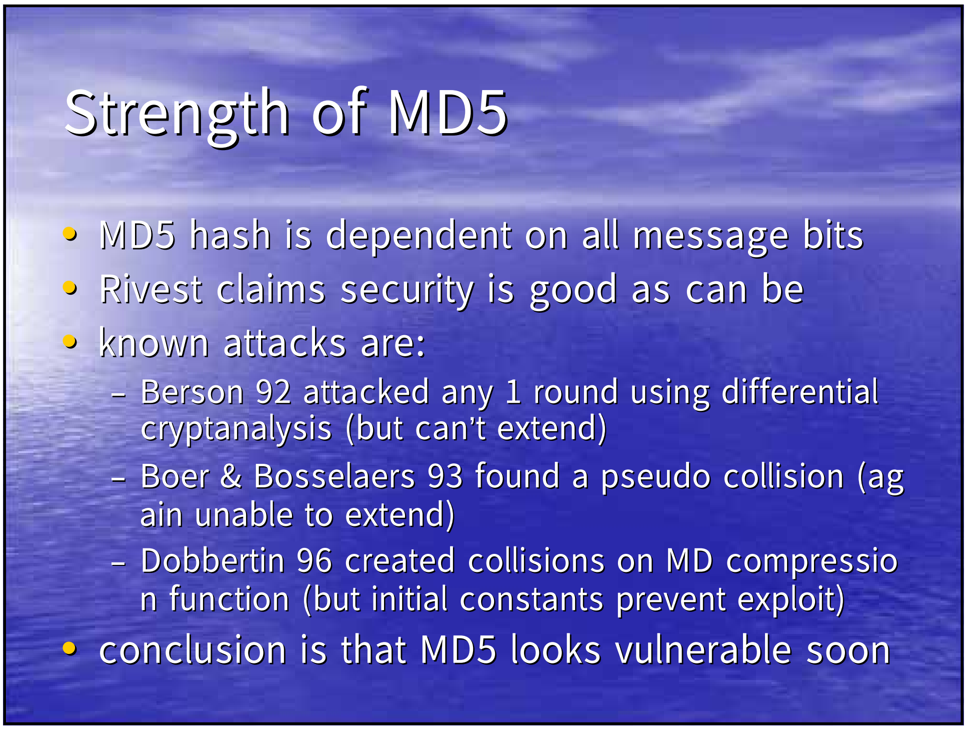
- a,b,c,d refer to the 4 words of the buffer, but used in varying permutations
  - note this updates 1 word only of the buffer
  - after 16 steps each word is updated 4 times
- where g(b,c,d) is a different nonlinear function in each round (F,G,H,I)
- T[i] is a constant value derived from sin

MD5 Compression Function



MD4

- precursor to MD5
- also produces a 128-bit hash of message
- has 3 rounds of 16 steps vs 4 in MD5
- design goals:
  - collision resistant (hard to find collisions)
  - direct security (no dependence on "hard" problems)
  - fast, simple, compact
  - favours little-endian systems (eg PCs)



Strength of MD5

- MD5 hash is dependent on all message bits
- Rivest claims security is good as can be
- known attacks are:
  - Berson 92 attacked any 1 round using differential cryptanalysis (but can't extend)
  - Boer & Bosselaers 93 found a pseudo collision (again unable to extend)
  - Dobbertin 96 created collisions on MD compression function (but initial constants prevent exploit)
- conclusion is that MD5 looks vulnerable soon