Timing Attacks on Implementations of Di e Hellman RSA DSS and Other Systems

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Abstract

Keywords

1 Introduction

2 Cryptanalysis of a Simple Modular Exponentiator

R

y^x n n y

x

y^x n y y n

x

y

R y^x n x w

```
Let s
For k     upto w
  If     k    x  is    then
    Let R_k    s_k  y       n
  Else
    Let R_k    s_k
  Let s_k      R_k       n
EndFor
Return  R_w
```

b b

b

b

b For s_b

R_b s_b y n

s_b y

R_b s_b y n

R_b s_b y n

b R_b s_b y n

b

s_b R_b n

3 Error Correction

b $R_{k\ b}$

4 The General Attack

j y y y_j
T T T_j x_b b

$$P\ x_b \quad \prod_i^j F\ T_i \quad t\ y_i\ x_b$$

$t\ y_i\ x_b$ b
y_i^x n x_b F
T $t\ y\ x_b$ y x_b F
T_i $t\ y_i\ x_b$ x_b
T_i $t\ y_i\ x_b$
s F
x_b x_b
x_b x_b'

$$\frac{\prod_i^j F\ T_i \quad t\ y_i\ x_b}{\prod_i^j F\ T_i \quad t\ y_i\ x_b \qquad \prod_i^j F\ T_i \quad t\ y_i\ x_b'}$$

F

5 Simplifying the Attack

F
T e $\sum_i^w t_i$ t_i
i e

x_b $\sum_i^b$ t_i y x_b

T e $\sum_i^w$ t_i $\sum_i^b$ t_i e $\sum_i^w{}_b$ t_i

e $\sum_i^w{}_b$ t_i

e w b t c b

e

w b c t

t

t

j

b w

c

$\sum_i^b$ t_i

t_i

e

P $\sum_i^j$ $\sqrt{w\ \ b}X_i$ $\sqrt{b\ \ c}Y_i$ $\sum_i^j$ $\sqrt{w\ \ b}X_i$

P $\sqrt{b\ \ c\ \ w\ \ b}\sum_i^j X_iY_i$ b c $\sum_i^j Y_i$

X Y j

$\sum_i^j$ Y_i j $\sum_i^j$ X_iY_i

$\sqrt{j}$

P $\sqrt{b\ \ c\ \ w\ \ b}\ \sqrt{j}Z$ b c j P Z $\frac{\sqrt{j\ b\ \ c}}{\sqrt{w\ \ b}}$

Z

$\sqrt{\frac{j\ b\ \ c}{w\ \ b}}$ x

∞ x j

w

6 Experimental Results

^{TM}

^{TM}

a b n

a b

n

y y n

s

$\sqrt{}$ s

s s

FIGURE 1: RSAREF Modular Multiplication Times

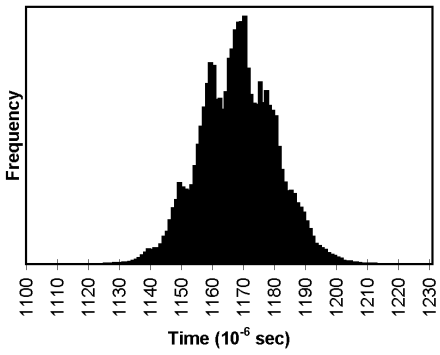
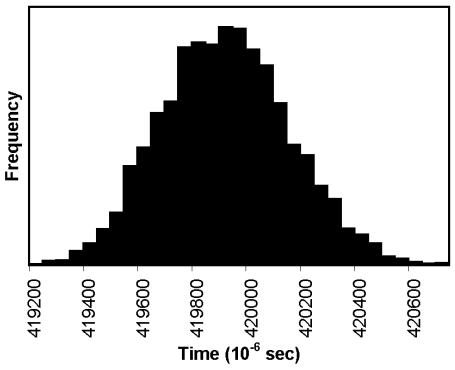


FIGURE 2: RSAREF Modular Exponentiation Times



$\sqrt{\frac{j\ b}{w}\frac{c}{b}}$

j b c w

$\sqrt{}$

b

7 Montgomery Multiplication and the CRT

n

t_b $\sum_i^w{}_b$ t_i

e

$\overline{}$

t_i

y p y q

y

y

p q

p q y

p y p y p

p y

p y p

y

p y p y p

y p

y p p

y

p

y

p

p

p

p

p q

8 Timing Cryptanalysis of DSS

s k H m x r q

r q k H m

x H m x r q

k q

x r q

H m H m q

x r

r

x

x

x x

x r

x k

9 Masking Timing Characteristics

R_i s_i y n

$\frac{ms}{ms}$ $mean$

10 Preventing the Attack

v_i v_f v_f $v_i{}^x$ n

v_i v_f $v_i{}^x$ n

v_f n

v_i $v_f{}^e$ n e

v_i n

v_f n

n

n

v_i v_f v_f $v_i{}^x$ n

v_i v_f

v_i v_f

v_i' v_i v_f' v_f

v_i v_f

v_i v_f

w

provably

n

n

11 Further Work

$$\sum_n \frac{\frac{56}{n}}{56} \qquad \frac{56}{\frac{56}{n}}$$

f

p q

12 Conclusions

13 Acknowledgements

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