Ex3

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1 Estruturas Criptográficas - Criptografia e Segurança da Informação

Grupo 03

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1.1 TP4 - Exercício 3

Construir tabelas de comparações das suas implementações, para os vários níveis de segurança NIST e em termos dos seguintes parâmetros:

1. Tempos: geração das chaves, produção da assinatura e verificação da assinatura.
2. Tamanhos: da chave pública, da chave privada e da assinatura.

Librarias Utilizadas Esta secção é dedicada ao import das librarias necessárias para a realização do exercício.

[ ]:
```
from sage.all import *
import hashlib
import time
import matplotlib.pyplot as plt
import numpy as np
```

1.1.1 Implementação Dilithium

Implementação do esquema de assinaturas Dilithium em Pythob+Sagemath como descrita no exercicio 1.

[ ]:
```
def bits_to_integer(y):
    alpha = len(y)
    x = 0
    for i in range(1, alpha + 1):
        x = y[alpha - i] + 2 * x
    return x

def bits_to_bytes(y):
    c = len(y)
```

```
    num_bytes = ceil(c / 8)
    z = [0] * num_bytes
    for i in range(c):
        z[i // 8] = z[i // 8] + y[i] * 2**(i % 8)
    return z

def bit_reverse(x, bits):
    y = 0
    for i in range(bits):
        y = (y << 1) | (x & 1)
        x >>= 1
    return y

def bytes_to_bits(z):
    d = len(z)
    y = [0] * (d * 8)
    for i in range(d):
        for j in range(8):
            y[8*i + j] = z[i] % 2
            z[i] = z[i] // 2
    return y

def bitlen(x):
    return x.nbits()

def simple_bit_pack(w, b):
    z = []
    for i in range(256):
        z = z+integer_to_bits(w[i], bitlen(b))
    return bits_to_bytes(z)

def simple_bit_unpack(v, b):
    c = bitlen(b)
    z = bytes_to_bits(v)
    w = [0] * 256
    for i in range(256):
        # BitsToInteger((z[ic], z[ic + 1], . . . z[ic + c - 1]), c)
        w[i] = bits_to_integer(z[i*c:(i+1)*c])
    return w

def bit_pack(w, a, b):
    z = []
    for i in range(256):
        z = z+integer_to_bits(b - w[i], bitlen(a + b))
    return bits_to_bytes(z)

def bit_unpack(v, a, b):
```

```
    c = bitlen(a+b)
    z = bytes_to_bits(v)
    w = []
    for i in range(256):
        wi = b - bits_to_integer(z[i*c:(i+1)*c])
        w.append(wi)
    return w

def H1024(input_bytes):
    hash_output = hashlib.sha256(input_bytes).digest()
    concatenated_output = hash_output
    while len(concatenated_output) < 128:
        hash_output = hashlib.sha256(hash_output).digest()
        concatenated_output += hash_output
    concatenated_output = concatenated_output[:128]

    bit_array = []
    for byte in concatenated_output:
        bits = bin(byte)[2:].zfill(8)
        bit_array.extend(int(bit) for bit in bits)

    return bit_array

def integer_to_bits(x, alpha):
    y = [0] * alpha
    for i in range(alpha):
        y[i] = Integer(x) % Integer(2)
        x = x // 2
    return y

def coef_from_three_bytes(b0, b1, b2, q):
    if b2 > 127:
        b2 -= 128
    z = 2 ** 16 * b2 + 2 ** 8 * b1 + b0
    if z < q:
        return z
    else:
        return None

def coef_from_half_byte(b, n):
    if n == 2 and b < 15:
        return 2 - (b % 5)
    elif n == 4 and b < 9:
        return 4 - b
    else:
        return None
```

```
def rej_ntt_poly(seed, q):
    a_hat = [None] * 256
    j = 0
    c = 0
    hsh=bits_to_bytes(H1024(bytearray(seed)))
    while j < 256:
        a_hat[j] =␣
 ↪coef_from_three_bytes(hsh[c%128],hsh[(c+1)%128],hsh[(c+2)%128],q)
        c += 3
        if a_hat[j] is not None:
            j += 1
    return a_hat

def rej_bounded_poly(seed, q, n):
    a = [0] * 256
    j = 0
    c = 0
    hsh=bits_to_bytes(H1024(bytearray(seed)))
    while j < 256:
        z = hsh[c%128]
        z0 = coef_from_half_byte(z % 16, n)
        z1 = coef_from_half_byte(z // 16, n)
        if z0 is not None:
            a[j] = z0
            j += 1
        if z1 is not None and j < 256:
            a[j] = z1
            j += 1
        c += 1
    return a

def expand_a(p, q, k, l):
    A_hat = [[None for _ in range(l)] for _ in range(k)]
    for r in range(k):
        for s in range(l):
            bits_s = integer_to_bits(s, 8)
            bits_r = integer_to_bits(r, 8)
            combined_bytes = bytearray(p) + bytearray(bits_s) +␣
 ↪bytearray(bits_r)
            A_hat[r][s] = rej_ntt_poly(combined_bytes, q)[s]
    return A_hat

def expand_s(p, l, k,q,n):
    s1 = [rej_bounded_poly(p + integer_to_bits(r, 16),q,n) for r in range(l)]
    s2 = [rej_bounded_poly(p + integer_to_bits(r + l, 16),q,n) for r in␣
 ↪range(k)]
    return (s1, s2)
```

```python
def polynomial_mul(a, b, q):
    return [(a[i] * b[i]) % q for i in range(len(a))]

def ntt(w, q):
    w_hat = [0 for _ in range(256)]
    for j in range(256):
        w_hat[j] = w[j]
    z=1753
    k = 0
    length = 128
    while length >= 1:
        start = 0
        while start < 256:
            k += 1
            zeta = Integer(z**bit_reverse(k, 8)) % Integer(q)
            for j in range(start, start + length):
                t = zeta * w_hat[j + length]
                w_hat[j + length] = (w_hat[j] - t)
                w_hat[j] = (w_hat[j] + t) % q
            start += 2 * length
        length = length // 2
    return w_hat

def ntt_inverse(w_hat, q):
    w = [0 for _ in range(256)]
    for j in range(256):
        w[j] = w_hat[j]
    z=1753
    k = 256
    length = 1
    while length < 256:
        start = 0
        while start < 256:
            k -= 1
            zeta = (-1 * Integer(z**bit_reverse(k, 8))) % Integer(q)
            for j in range(start, start + length):
                t = w[j]
                w[j] = (t + w[j + length])
                w[j + length] = (t - w[j + length])
                w[j + length] = zeta * w[j + length]
            start += 2 * length
        length *= 2
    f = 8347681
    for j in range(256):
        w[j] = f * w[j] % q
    return w
```

```
def mod_plus_minus(m, alpha):
    m_prime = Integer(m) % Integer(alpha)
    if m_prime > alpha // 2:
        m_prime -= alpha
    return m_prime

def power2_round(r, q, d):
    r_plus = Integer(r) % Integer(q)
    r0 = mod_plus_minus(r_plus,2**d)
    r1 = (r_plus - r0) // (2**d)
    return (r1, r0)

def pk_encode(p, t1, q, d, k):
    pk = bits_to_bytes(p)
    max_value = (2 ** (bitlen(q - 1) - d)) - 1
    for i in range(k):
        pk += simple_bit_pack(t1[i], max_value)
    return pk

def pk_decode(pk, q, d, k):
    y = pk[:32]
    len_z = 32*(bitlen(q - 1)-d)
    z=[]
    for i in range(k):
        z.append(pk[32+i*len_z:32+(i+1)*len_z])
    p = bytes_to_bits(y)
    max_value = (2 ** (bitlen(q - 1) - d)) - 1
    t = [None for _ in range(k)]
    for i in range(k):
        t[i] = simple_bit_unpack(z[i], max_value)
    return p, t

def sk_encode(p, K, tr, s1, s2, t0, d, n):
    sk = bits_to_bytes(p) + bits_to_bytes(K) + bits_to_bytes(tr)
    for si in s1:
        sk = sk + bit_pack(si, n, n)
    for si in s2:
        sk = sk + bit_pack(si, n, n)
    for ti in t0:
        sk = sk + bit_pack(ti, (2**(d-1))-1, 2**(d-1))
    return sk

def sk_decode(sk, d, n, l, k):
    f = sk[:32]
    g = sk[32:64]
    h = sk[64:128]
```

```
    a_len = 32 * bitlen(2*n)
    y=[]
    for i in range(l):
        y.append(sk[128+i*a_len:128+(i+1)*a_len])
    z=[]
    for i in range(k):
        z.append(sk[128+l*a_len+i*a_len:128+l*a_len+(i+1)*a_len])
    w_len = 32*d
    w=[]
    for i in range(k):
        w.append(sk[128+(l+k)*a_len+i*w_len:128+(l+k)*a_len+(i+1)*w_len])
    p = bytes_to_bits(f)
    K = bytes_to_bits(g)
    tr = bytes_to_bits(h)
    s1 = [bit_unpack(yi, n, n) for yi in y]
    s2 = [bit_unpack(zi, n, n) for zi in z]
    t0 = [bit_unpack(wi, (2**(d-1))-1, 2**(d-1)) for wi in w]
    return p, K, tr, s1, s2, t0

def matrix_mutl(m_a,m_b,q):
    m_c = [[0 for _ in range(len(m_b[0]))] for _ in range(len(m_a))]
    for i in range(len(m_a)):
        for j in range(len(m_b[0])):
            for k in range(len(m_b)):
                m_c[i][j] += m_a[i][k] * m_b[k][j]
                m_c[i][j] %= q
    return m_c

def decompose(r,q,y2):
    r_plus = Integer(r) % Integer(q)
    r0 = mod_plus_minus(r_plus,(2*y2))
    if r_plus - r0 == q - 1:
        r1 = 0
        r0 = r0 - 1
    else:
        r1 = (r_plus - r0) // (2*y2)
    return (r1, r0)

def high_bits(r,q,y2):
    (r1,r0) = decompose(r, q, y2)
    return r1

def low_bits(r,q,y2):
    (r1,r0) = decompose(r, q, y2)
    return r0

def expand_mask(seed, mu, l, gamma_1):
```

```
    c = 1 + bitlen(gamma_1-1)
    s = [None for _ in range(l)]
    for r in range(l):
        n = integer_to_bits(mu+r, 16)
        v = [ None for _ in range(32*c)]
        byts = bits_to_bytes(H1024(bytearray(seed+n)))
        for i in range(32*c):
            v[i] = byts[(32*r*c + i)%128]
        s[r] = bit_unpack(v, gamma_1 - 1, gamma_1)
    return s

def w1_encode(w1, k, q, y2):
    w1_tilde = []
    for i in range(k):
        w1_tilde = w1_tilde + bytes_to_bits(simple_bit_pack(w1[i], Integer(((q␣
 ↪- 1) / (2 * y2)) - 1)))
    return w1_tilde

def sample_in_ball(seed, tau):
    c = [0 for _ in range(256)]
    k = 8
    for i in range(256 - tau, 256):
        while bits_to_bytes(H1024(bytearray(seed)))[k%128] > i:
            k += 1
        j = bits_to_bytes(H1024(bytearray(seed)))[k%128]
        c[i] = c[j]
        c[j] = (-1) ** (H1024(bytearray(seed))[i+tau-256])
        k += 1
    return c

def make_hint(z, r, q, y2):
    r1 = high_bits(r,q,y2)
    v1 = high_bits(r + z,q,y2)
    if r1 != v1:
        return 1
    return 0

def use_hint(h, r, q, gamma_2):
    m = (q - 1) // (2 * gamma_2)
    r1,r0 = decompose(r, q, gamma_2)
    if h==1 and r0 > 0:
        return (r1 + 1) % m
    elif h==1 and r0 <= 0:
        return (r1 - 1) % m
    else:
        return r1
```

```
def hint_bit_pack(h,omega,k):
    y = [0] * (omega + k)
    index = 0
    for i in range(k):
        for j in range(256):
            if h[i][j] != 0:
                y[index] = j
                index += 1
        y[omega + i] = index
    return y

def sig_encode(c_til, z, h, l, y1, omega, k):
    o = bits_to_bytes(c_til)
    for i in range(l):
        o = o + bit_pack(z[i], y1 - 1, y1)
    o = o + hint_bit_pack(h,omega,k)
    return o


def hint_bit_unpack(y, k, omega):
    h = [[0]*256 for _ in range(k)]
    index = 0
    for i in range(k):
        if y[omega + i] < index or y[omega + i] > omega:
            return None
        while index < y[omega + i]:
            h[i][y[index]] = 1
            index += 1
    while index < omega:
        if y[index] != 0:
            return None
        index += 1
    return h

def sig_decode(o, y1, lbd, l, k, omega):
    lbd = lbd // 4
    w = o[:lbd]
    x = []
    for i in range(l):
        x.append(o[lbd + 32*(1+bitlen(y1-1))*i:lbd + 32*(1+bitlen(y1-1))*(i+1)])
    y = o[lbd + l*32*(1+bitlen(y1-1)):]
    c_til = bytes_to_bits(w)
    z = [None for _ in range(l)]
    for i in range(l):
        z[i] = bit_unpack(x[i], y1 - 1, y1)
    h = hint_bit_unpack(y,k,omega)
    return c_til, z, h
```

```
def ML_DSA_KeyGen(k, l, q, d, n):
    eps = [randint(0, 1) for _ in range(256)]
    H_output = H1024(bytearray(eps))
    p = H_output[:256]
    p_ = H_output[256:768]
    K = H_output[768:]
    A_hat = expand_a(p, q, k, l)
    s1, s2 = expand_s(p_, l, k,q,n)
    NTT_s1 = []
    for i in range(l):
        s1_poly = PolynomialRing(Zmod(q), 'x')(s1[i])
        NTT_s1.append(ntt(s1_poly, q))
    A_NTT_s1 = matrix_mutl(A_hat, NTT_s1, q)
    t = [ntt_inverse(PolynomialRing(Zmod(q), 'x')(A_NTT_s1_row), q) for␣
 ↪A_NTT_s1_row in A_NTT_s1]
    for i in range(k):
        for j in range(256):
            t[i][j] = (t[i][j] + s2[i][j])
    t1, t0 = [], []
    for tt in t:
        tt1, tt0 = [], []
        for ti in tt:
            t1i, t0i = power2_round(ti, q, d)
            tt1.append(t1i)
            tt0.append(t0i)
        t1.append(tt1)
        t0.append(tt0)
    pk = pk_encode(p, t1, q, d,k)
    tr = H1024(bytearray(pk))[:512]
    sk = sk_encode(p, K, tr, s1, s2, t0, d, n)
    return pk, sk

def ML_DSA_Sign(sk, M, Tq, q, d, n, l, k, tau, gamma_1, gamma_2, omega, beta):
    rho, K, tr, s1, s2, t0 = sk_decode(sk, d, n, l, k)
    mu = H1024(bytearray(tr+M))[:512]
    s1_hat = [ntt(poly, q) for poly in s1]
    s2_hat = [ntt(poly, q) for poly in s2]
    t0_hat = [ntt(poly, q) for poly in t0]
    A_hat = expand_a(rho, q, k, l)
    rnd = [randint(0, 1) for _ in range(256)]
    rho_prime = H1024(bytearray(K + rnd + mu))[:512]
    kappa = 0
    z, zz, h = None, None, None
    while z is None or h is None:
        y = expand_mask(rho_prime, kappa, l, gamma_1)
        NTT_y =[]
```

```
        for i in range(l):
            y_poly = PolynomialRing(Zmod(q), 'x')(y[i])
            NTT_y.append(ntt(y_poly, q))
        A_NTT = matrix_mutl(A_hat, NTT_y, q)
        w = [ntt_inverse(PolynomialRing(Zmod(q), 'x')(A_NTT_row), q) for␣
↪A_NTT_row in A_NTT]
        w1 = [[high_bits(n,q,gamma_2) for n in poly] for poly in w]
        c_til = H1024(bytearray(mu + w1_encode(w1, k, q, gamma_2)))[:(2*Tq)]
        c_til_1, c_til_2 = c_til[:256], c_til[256:]
        c = sample_in_ball(c_til_1, tau)
        c_poly = PolynomialRing(Zmod(q), 'x')(c)
        c_hat = ntt(c_poly, q)
        cs1_hat = [ntt_inverse(PolynomialRing(Zmod(q),␣
↪'x')(polynomial_mul(c_hat,s_hat,q)), q) for s_hat in s1_hat]
        cs2_hat = [ntt_inverse(PolynomialRing(Zmod(q),␣
↪'x')(polynomial_mul(c_hat,s_hat,q)), q) for s_hat in s2_hat]
        z=[[Integer(y[i][j])+Integer(cs1_hat[i][j]) for j in␣
↪range(len(cs1_hat[i]))] for i in range(len(cs1_hat))]
        r0 = [[low_bits(Integer(w[i][j]) - Integer(cs2_hat[i][j]), q, gamma_2)␣
↪for j in range(len(cs2_hat[i]))] for i in range(len(cs2_hat))]
        zz = [[mod_plus_minus(ze,q) for ze in zl] for zl in z]
        if max(map(max, zz)) >= gamma_1 - beta or max(map(max, r0)) >= gamma_2␣
↪- beta:
            z, h = None, None
        else:
            ct0_hat = [ntt_inverse(PolynomialRing(Zmod(q),␣
↪'x')(polynomial_mul(c_hat,t_hat,q)), q) for t_hat in t0_hat]
            h = [[make_hint((Integer(-1) *␣
↪Integer(ct0_hat[x][y])),(Integer(w[x][y])-Integer(cs2_hat[x][y])+Integer(ct0_hat[x][y])),q,
↪for y in range(len(w[x]))] for x in range(len(w))]
            ct0_pm = [[mod_plus_minus(y,q) for y in x] for x in ct0_hat]
            if max(map(max, ct0_pm)) >= gamma_2 or sum(map(sum, h)) > omega:
                z, h = None, None
        kappa += l
    sigma = sig_encode(c_til, zz, h, l, gamma_1, omega, k)
    ctilt,zt,ht = sig_decode(sigma, gamma_1, Tq, l, k, omega)
    return sigma

def ML_DSA_Verify(pk, M, sigma, q, tau, gamma_1, gamma_2, omega, beta, Tq, k,␣
↪l, d):
    rho, t1 = pk_decode(pk, q, d, k)
    c_til, z, h = sig_decode(sigma, gamma_1, Tq, l, k, omega)
    ctil_, _ = c_til[:256], c_til[256:]
    if h is None:
        return False
    A_hat = expand_a(rho, q, k, l)
```

```
    tr = H1024(bytearray(pk))[:512]
    mu = H1024(bytearray(tr + M))[:512]
    c = sample_in_ball(ctil_, tau)
    ntt_z = [ntt(PolynomialRing(Zmod(q), 'x')(poly), q) for poly in z]
    A_NTT = matrix_mutl(A_hat, ntt_z, q)
    ntt_c = ntt(PolynomialRing(Zmod(q), 'x')(c), q)
    ntt_t1= [ntt(PolynomialRing(Zmod(q), 'x')([x*(2**d) for x in poly]), q) for␣
↪poly in t1]
    t1_c = [polynomial_mul(ntt_t1[i], ntt_c, q) for i in range(len(t1))]
    fntt=[[(Integer(A_NTT[i][j])-Integer(t1_c[i][j])) % q for j in␣
↪range(len(A_NTT[i]))] for i in range(len(A_NTT))]
    waprox = [ntt_inverse(PolynomialRing(Zmod(q), 'x')(poly), q) for poly in␣
↪fntt]
    w_prime = [[use_hint(Integer(h[i][j]) % q,Integer(waprox[i][j]),q,gamma_2)␣
↪for j in range(len(waprox[i]))] for i in range(len(waprox))]
    c_til_ = H1024(bytearray(mu + w1_encode(w_prime, k, q, gamma_2)))[:(2*Tq)]
    zz = [[mod_plus_minus(ze,q) for ze in zl] for zl in z]
    return c_til==c_til_ and max(map(max, zz)) < gamma_1 - beta and␣
↪sum(map(sum, h)) <= omega
```

1.1.2 Testes ao Dilithium

Função de teste

[ ]:
```
def Dilitium_Test(version, message):
    q = 8380417
    d = 13
    tau=39
    lbd = 128
    gamma_1 = 2**17
    gamma_2 = (q - 1) // 88
    k = 4
    l = 4
    n = 2
    beta = 78
    omega = 80
    if version == 65:
        tau=49
        lbd = 192
        gamma_1 = 2**19
        gamma_2 = (q - 1) // 32
        k = 6
        l = 5
        n = 4
        beta = 196
        omega = 55
    elif version == 87:
```

```
        tau=60
        lbd = 256
        gamma_1 = 2**19
        gamma_2 = (q - 1) // 32
        k = 8
        l = 7
        n = 2
        beta = 120
        omega = 75

    time_start = time.time()
    pk, sk = ML_DSA_KeyGen(k, l, q, d, n)
    time_kg = time.time() - time_start

    M_bytes = bytearray(message.encode())
    M_bits = bytes_to_bits(M_bytes)

    time_start = time.time()
    sign = ML_DSA_Sign(sk, M_bits, lbd, q, d, n, l, k, tau, gamma_1, gamma_2,␣
↪omega, beta)
    time_sign = time.time() - time_start

    time_start = time.time()
    is_valid = ML_DSA_Verify(pk, M_bits, sign, q, tau, gamma_1, gamma_2, omega,␣
↪beta, lbd, k, l, d)
    time_verify = time.time() - time_start

    return [time_kg, time_sign, time_verify, is_valid, pk, sk, sign]
```

Teste Manual Teste manual ao esquema de assinaturas Dilithium

[ ]:
```
message = input("Enter the message: ")
version = 1
while version not in [44, 65, 87]:
    version = int(input("Enter the version 44/65/87: "))
tkg,ts,tv,ver,pk,sk,sign=Dilitium_Test(version, message)

print("Key Generation Time: ", tkg)
print("Signing Time: ", ts)
print("Verification Time: ", tv)
print("Public Key: ", bytes(pk))
print("Public Key Size: ", len(pk))
print("Secret Key: ", bytes(sk))
print("Secret Key Size: ", len(sk))
print("Signature: ", bytes(sign))
print("Signature Size: ", len(sign))
if ver:
```

```
    print("Signature is valid.")
else:
    print("Signature is invalid.")
```

```
Key Generation Time:  0.6438472270965576
Signing Time:  1.5895066261291504
Verification Time:  1.1228954792022705
Public Key:  b'\x18Y\x98\xc9\xceR\xeb\x97\xbd5\x96,9I\x89\x9cd\xf4\xd6\x1c5\xc7n
\x05\xdc`\xd4\x0bW[r\x14\xc1&!T\x87\x1f=:\xe1Vk\xb1\xca\xbfn4\\\xa2\xa2\x06\x16|
\x07ltO\xd8\xd2\xa0!0\x8c\x82\x06\x01\x11\xf7\xa0:\xdaS\x15v[ \xb5\x92\xf5hK>\xf
6,\x93\xe7\xc9UU\x84]\x9c3\xa48\x9d\x8bF\x88\xc4\xec\xdeK\xe22\x83WR\xbe&QOo\xf1
t\xd3\xe7\xd1UM<\xfa\xc1\xa0M\x9e\xc2\x17F\xfew\x9bg\x9crpFZ\xc5\x167\xe3E\xa7\x
9e\xdb\x8b\xbb*&\x11\xc3\xc2\x11\xbe%\xcbU\xf7\xddn\xf4\x7f\x12eB\xc0\x04,d\xbb\
xa2\xb0\x83N\xdaD\xdez\xf1\x9dM\xffJ\x113\xdb~y\x82\xddH\xf1(\xc1\x85\x95"\xa0z4
R\x0e\xef\x085\x03d8w\x96g\x11\x7f7\x9ap\xb8\xbb\xb0\x92\x1a\xd1\t\x8a3\xd4y\x10
\x94\xde/f\x9cy0PA/I\xe6\x13z\xe3\xfd\xbd\x8e&\x17\xee\n\x00\xca!\x08\xcc\xec\x8
fq\xbc\'\xdb>*\x89\xf1\xbe\xa0 \xfaH\x10\xa3yK\xce\xbe(\x8a\xc7\xe5\xf3\x03\x17&
d7M\x19\xfc\xa0\x0e\xa9\x87j\xa3\xfdk\xc91<\xe4\xd4d\n\xe7\xeb^\xfe\x01\xa5\xc1\
xd2\xeb\xaf\x13\x9a\x98\xe0\xdfA\x06\x97\xdcE\x1fi\xc1\x14\x920\xe0\x93\xf7\xed\
x18[}\xa7\x88\x13\xc6\xcc\xe1-
LUOd\x04.\xf62|\xed\x7fW\xb7\xcf\xab\x9b\xd4lGnh\xf5\x0f\xdf@c\xa0\x17\xd3\xe8\x
de\xe4\x10b\x96\x08\xfc\xb7\xd3\x11X\x0c\xe1L\t\r\xe8mV\xbe\x1aP!\xce$\xd7\x01\x
b4\'T\xec\xc2D7m\xb6\xa5S*\x16\xd0}\x1a\x9a\x9c\x08l{a\xa1\x05\to\x89tO6\xd9v\xa
a)H\x88\xb4\xc9`\xed_\x98\x80\x18\x92Q\x9b\xcd\xce2\x96l\xbd\xfc\xf8wh\x00\x15\x
1c=\xa0\xb20\xc1e]{\x84\xf4\x13\xd1\xb3>\xc5\x9c\xdfm\xe0\x06e\x17+Bn\x93?\x15\x
9f.Q\xcf\xdap3\x91s\xfd\x96\xc9\xe8Le\x9a\x01\xbc\x1a\xae\x90\x9ey\xe02\x84Zl\xf
c\xce\xad2\xbc=\x9ep\x84\x06\x9f\xb0\x81\xea\x94\x90T.^\x9b\x9d*\xed\xe9!\xb1\x9
4\xfe\xf1\xce\x8b\x95^\xf1?\x11\xceCD\x9c{\xb0\x85S\xb2G3\x9bZ^\x0572\xa8\xf4&5?
B\x1c\xb6\x96>\xe8\xbey\xd1\xba\xa8\xa8\x89\xdd\xdbcW\xabk\tY2\x87E\x1f\xe0t\xf1
\x16\x9cM@0\xa3\xe6#=q\x99\x10\x81>\xc4\xd22`\xe4\xef:\x96\xce\xa5UT\xac\x9dx\xa
9L\xc1\xc4b\x8b\xc1\x12ltP/x\x9a\x9a\xa9J\x15\xca\xa0\n\xb2\x0c\x9c\xf8\x18\x02\
x90\xdeg\x18O\x97\xfb\x87\x11m]\x19B@\x02f\x8d\xa58\xc1\xab5\rN7\xbb_\xd8\xa29\x
c1`\xa5\x1c\xde\xe4\xa2\xcf>\xcc\xdc\x88F\xa2)\x8f\x0b\xcd\x94\xa1\xf1\xc7"\x92D
\xb55\xee\x1a\xc4R\xb1Ib\xee\xf1C]:\xde\xbf\x13\xa5\x8f\xf3\xca\xe7e\x10Z\xa7\x8
4\xab\x1b\xcd\x01\x0c\x9f\x08\x8e\x89L\xb8B\x89\xff\x89\xc8\x9b1\xb3\x91\xbb\xbb
\x15\x7f\xa3\xc4s\x1bI&i\x86\xf3\xb7\xf0d\x98\x89\xfd\x86c\xb3\rI\xffM\xd9\xd0p\
xcfw\xfd^Z\xa4\x94\xf5"\xbfN-
\x997\xbc<\x03\x068\xf4]\x9ddX\x1a\xc8\xb2\xdfR\xb8/\xaa\xda\xcfa\x910\xbb#M|aDL
\xd5\x06#6>\x03\xeb\x05\xee\tc[M\x8f\xed)V2.\x07BTdj\xa8.\xe4\x96\x1f}\xd2k\xab\
x98L\x8c\xf9*\x0c\xb9\x8c&\xb1\xbe\xc8\rt\xdeJ\xd1\xa5\xcf\xb9\x89\xab\'\xaa\x90
*\xfe\xd1\xc1\xeeO\x1b\x7fZIn+\xd7\x9b\x13{\xcb\xbc\xacc\x8b\x1c\x18\x9c\x96\xcd
\x08i$*\x14[uu\x16\xf3n\xf0H\xe9\xab\xb4\xd3\xeeu\xb3s*t\x9f_g\x0c3e\xf6@H\x9e\x
dal\x90y\xad\xe3QuH\r\xd6\x98:\x90\xe1F\xd8\x85p\xdc\xe08\xd5\xbe\xba\xd6\xbb\xc
d\xaaj\x1a\xba\x11\x1c\xb1\xdc3|\xe8\x01\x0b\x1c?Le\xb1w*n\xd7V\x07<\x10\xc1\xb3
\x1e\x1c\xf9\x10;\xfa\n\x93zT\xf8\x1c\x03^/\x9cq\'\xf8|\x8f\xc6\x14f"\xbe\xbd\x0
0\x9d\xd3\xd3Dn\xc3\x84B\x9a\x85g\xa7C:p\xd6\xf5+,\xa5ZtGd\x8d:\xdb\xe2YP\xdb\xe
2n\xc1\xb0E\xc3\x13\xe3x\xe59\x953\xd0i\x88\x85\xd2n\xae\xc4yD\xb3d\x87\xe9\xf9\
```

x8d9n1\x1b\x8b\xd9\xa8\xcdQ\x07\x7f\x08\x8b\xdb\x8f\x89/\xdb\x87er\xc3Mm\x82*&\x
fc\xb4\xa20x\xe1\xb6\x9b?\xfe\xd8vi\xda\x9c\rk\x96\x91\xbft9p9#\x9cB\x98\xdc\xd5
\xcca\x87\xf2/\xea\xd5\xdf\xc0\xd9{ w,\x16\xd8\xe0\x98b\x02\xc8\x00\xf7>\x0c\x1f
\xb8\xd0"8\xae\xdb\xec\x1d\x9d\xb4\x07yWv\xb5\xae\x90\'\xd5\xcak\x94d\x02UZ1s\xe
7\xb5\xa1=?D\xe3q\x98DzI\xd7\xab\x12\xc1\xcc\xaaR#k\xa2\xc6I\xdc\xc9\x0f\x99\x98
a\xbcS\xad^\x04\x0f$\x06\xeb\xd3 \x062\x97\xb1\xd8\x19*\x05+nB\xde\xcc\x89c\xd6K
?\x15\xe6G\x11\xc12^\x9bL\xd9r7iKi\xf9\t\x89\xff\xf3\xd4\xe2\x06\xd9u\xac\x1e\x9
9T\x88\xa1\xea\xf5\x91\x1al\xc1nk87\xd63\xd8\'Q\xbe4\x16o\x98\x97Y2D|\x90\xf4t@[
R\x8e\x82n\x00e\xbb\xce\xff)\xfb\x96\xd7\xea\xe5^\xd3\x08\xb4\'\x15-
xL\x870(\xd2C\xe7`\x1a\r\xbb\x82p\xcd\x91\xe3\xc6N\x1c\x1fd\xc3=R\x01\xdc\xfb\x9
e\xd6e\xb3\x97p\r\x0b\xfc\xc8s\xc3*\x87\x1c<\xc7Ec4\xe3\xf5w\xddO\xbe,_\x13\x93\
xff\xd2\xf3\xc3\xb7\x9f-\xc3\xaaG`\x19b\x98\x11jl3\xf6lT\x80\xe0\xd6\x10\x8e \x8
2vY\xa8\xd09\x83\x1f\xf6\x9c\xd7\xc0\x03\xc5\x8f\xdeWQ\xf2Q\x8fW\x01PB\xfb\xb6\x
0e\xeevL/\nD 5\x97tH\x93\x15\xcd\x1a\xeay\xcb\xecT\xc8\xe0\xdd\xcd\xca\xa2\xaf\x
d6Y\x9f\x90\x87\x1e\x84\xe7eho8?\xb7\xffy\xee\x9dc[h\x06\xca\x01\xba\xe4\x97\xd8
D\xe8Gg\xc72\xfeB]W\x14\xfb5\xb7\xb131I\xf3\xfd\\\xf9\xe7\xa3A\xb9\x1d\x90\xca\x
d7\xaaX\t\x93JG\t\xb5\xf6\xa0\xf2j\x1e\xe3>\xd8kr\xa0\x9fU"\xa9\xfal\xbd\x8c\xd3
\xb8Z\x08hh\xb4\x0cJ\xc3\xf4\x07\xba\xe3_;\'I\x80\x1b\x8f)\x1d\xf54\xe2\xce[Tx\x
bbh~% N\xfb\xc2\x96:\xf7\xbf\xa2M\xa9\xff\x8b\xa2\'8\xb1\x7f,$\xde3\x9a\xd5Yuh\x
e6\xf3\x83-
\x94\x1e(\xe8\x17\xd6D8z2HV\xd2\xb6\x0e\xdfy\x1e\xb7\x1fy\x8b\x93\xb7\x9c\x90@\x
9e\xd2\xd8U\xeb\xe2\xe5X]+B\xc9\xd6L\xf6u\xe9\xbdw\xbad\xed?\x92v%\xb2\x1f\xca\x
e7\xbcuk\xe2\xc5\x89\xa4\xbfR\x002\x7f\x17\xe2\x02\xf6*\xbf\xd9\xd3\x95\x938\x9f
\xa9hs\xaae\xeeT\x02\xdc\x16\xe4\xf4\xe4\xc3g\\\xf2\x02\xa4p\xe7\xb7\x01\xe5\x81
\xed\x19\xa4\xa2L\xda_C\x86\xb8Yr\xca\xedu\xe3\xfdJ\xf6\xf1\xd9Q\xec\xe2\xce\xf4
m\x83a\xb1\xef\x86\xfe\xf1\x93\x8a%*\xe6\xcc\x9c\xf9Lj`?|\xb0\xa3\t&\xabHr\n\x12
\x99\xc3\x88\x04\xa6+p!\xa0\x82#\x06\x13\x0b7\xa1\xbb9\xe0\xc4^\xb4j\xee{F\xed\x
e4C"\x06\x82T\x12~\xdf\x1f9\x92\x9a;\xa3G(W\x0e\xf3\xf3\x99K\xbd\xdd"\xfc\x19\x0
3\xcby\xb7\xf9\x98ra\xb6\xe8)&\x1b{\xa9\xd9\xe7\x045<\xca\xe9R\xb56\xaeK\x0cz\xb
0\x04\xc7EM\xcb\xca\xf4\xb1\xdb\xa3,0\x895hI\xf4\xc3{\x02\x07z\xd2;\xb3\\PT\xed\
xfe\x96\xc9\xdf\x11\xb1;Q\xef\x92\xb1%\x9a\xb8\xd2\xc3gk\xe5z\xc1\x9d\x1ah\x10\x
d9\xbb\x0b\x0f\xe2\x0f\xed\x0c\xa5\xbf\x0c~\x0eM0\x8a\xd8\x90A\tW\xa8\xf63\xc7\x
19yzf\xa1\xf0G\x18\x8e\xfd\x89j\x01\xad\xdbW\xd1\x1f\xa0\x12\xaa\xeaM\x1c\xf4fl\
xf3G\xb6\xab\xb0\x1c\xcck\xb4\\\xf3\xb4\x1c*\x84q\xb3\xb2\x0eE\xe6\xe9\xd7\xcc\x
caal\xb6I(\xa8\xfbL\xd1>k\xdfN{\xc9\xd8M\x9b\xe7F\xdd(y\xd5\x8d?,\x945\xb6\xc9Q\
xd3\xc4\xa3\xc9"g\xec\xd8\x0f\xb82\xd4\xc2\xf9\xa0\xe6@g\x9b@\x0cXj\xfb\xd6\xae\
x81M\xf0jP\xf6i\xbe9B\x98\x84\xf9$\xa3\xa3\xcc\x06\xf4\x11\xef\x8f\xde\xf2\x077i
OW\x89\xf4x\xcdhH\x87\xc6\xc7\x03\x9e\x86w\xd3IY\x13\xfd=\xbe\x1f \x84\xea\xf03/
(\x9e\xc9\xd9\xea\xb2\x85J\xc4\x82v\xea\xbd\xa2,;~\x15\x17!\x9d\x034\xa7]\x1eR9\
xaf\x1f\xa6\x9f\x87]1\xe9|\xc8Z7\xc7\xc6\xbe\x0e\x1f\xd0Ta\x8a!\xec\x87S\x11\xe6
w\xc4\xd0rN\xdb\xf5\xfb1\x8a\x87\n\xc3\xdd\x82)$|\x05\xf3f\xc9P0\xf6\\\x8d\xdf\x
be\xc9:\xa4\x85\xebDQ6\xd3\x18\x8a5\x97T:\x99\xd31\xb7\xacz\xf8\xfb\xe2K\xf0$\x1
c\xe1\x1c%d\x17\xb0\xe2tx2\xbb\x1c\x87p\xdfD\xb3\xb3\xa9;\xe9\xb2\x87Uk\x00\x1f\
xa6\x15\x9e5\xeb{\x88\x0f\r\x95\x17\x12\x9dL%\xa0\x82\x8b\x0f\x82\xceI5\xa7\x82\
xc9\xee\x0f\x14\x83\xe6\xab\x11\xfa]K\xa5\xd0\x1dtw\xd3Dr\xab\xdf\xa8\xf8\x9e\x9
9N\xceK\xb8\x04p\xde^\x86:\xf1=\x95\x91\xdfK\xa9\x93\xec\x18\xd7\x1f\xe6\x19\xfb
3}K\xcb{\x11Tf\xcaI\xeb \xd8\xe5\xcd\x08\'\xfe\xa1\xbe\xe0\xd0Yb7\xc3\x02\xa7\xe
5\x83\xcf\xa6\xe8\xee\x03\xc4\x12\xa2![:"\xad\xaf\x83\xeb\x9c\x1d\xa7:\xe1X\xca\

xc0]V\xe2f%\xfe@\x1a\x1fI\x9a\xc1$\xe4B\xf3\xf7\xcc\xbb\xc9\xef\xae\x1e\xd2A\xe1
\x03\xf9\xbd\xb3\xb0w\xc2\xbfQ/}i\x12kh\x18\xc8\xa4O\x9dW9w\xc6\xedw\n1\x07%\xbd
c`$1Ny\x10\xf4U\x01\xdf1`\xb80\x91u>\xc2+nf^p\x11\x8b\xfc\x98\x18\xee[\xea\x00\x
d2~\xd0\xbbv\x01\xb0^\x10\x9a{\xeb\xff\xd1\xa5\xb8/0\xa6Y|V;,\x01\xfa\xbe\xaa\xa
0\x9d\xf3\xc6\xd5\xadil"|\x8d\xd4\xc87\xbfZ\rR\xbb\xd1\x1e\xc9bJ\x0cJ\x1ba<\\d67
\xae\x00\xfbV\xe0\xcf\xeb\xd2Y:\xa2\xbf,\x85\xf8m\x1a]\xb7\xb3\xf7j-
9\x8bu\xeeS\x99)OL\xa6.iO\xfe\x17\x8c\xfd\x12'
Public Key Size: 2592
Secret Key: b'\x18Y\x98\xc9\xceR\xeb\x97\xbd5\x96,9I\x89\x9cd\xf4\xd6\x1c5\xc7n
\x05\xdc`\xd4\x0bW[r\x14$S\xb7{E\xb8r\xd5\x86u\xfetf\xe5\x86U\xef]\x9d\xed\xf2\x
8eE_U\xcf\x16\x03\x10\x9f\x969m\xf2\n\xb3+\xa5v@\xff4\x08d\xefi\xf0\xeb\xcb1\xbf
\x18?\xf2\x90\xdd\xed\xb2C-
f\xdd\x7fm\xd0\xcb\xea\xed\xca\xc3:\x9d\xf9\xf9/\x00\x1bh\x86$n\xf4\x1f\x9dS\xb6
\x8e\xc9\x1d\x1e\x80\x8a0\x8awB\xe0\x82\x90\x99\x12\x0e\x0c\x85\x80\x1a\xa0\x8d\
x1cGa\n\x95)\x83\xc0\x8c\x0b\x14\n\x08\x15\x06\x18\x140\x1b\x06\x0c\xd0\x18J\x00
A\x02P\xc8)\x196lX\x18Qc&R\xc0\x96\x88\x81(\x8c\xe4\x000\xc8\xa4\x85\x92\x84\x89
\n2\x05\xc36d \xa8\x84\xda\x18f\x02\x81\x8d\x19\x16\x06\xd86\x00 #pA\xc8L\t\x07\
x86\x18\xa8\x91\x014-#Dh\xdb\xb8e\xc18APD-
\xa0\x84a\xc3\xc2\t\xa1\x06\x01\x84\x86\x90\x93\x16\x01\x03\x880[&2D\x12J\xc1\xc
0\x91\xdc\x92L\x8a\x12\x8c$\x14e\x93\xc6PS\xa4\x88\xcaB(\x920\x84\x99\xa2\x05b\x
a6a\x14\'2T\xb0\x8c\x147b\x11\xa6\x8cH\x96i\x01\xb4\x08\x0352\x80\xa6e\x90\x92%\
x19)i\xca\xb6PL8\x0ed\xc2m\x836Q\x14\x92\r\x03E\x00\x94\x80\x08\x011QH&\x80Z\xc4
-\xc4\x98%P\xc2a\x10\xc6i\x1c5\x02`FeH\x12\x85\x11\x93\x08\xd9\x84`\x8c\xb0M\x13
\xb2,\x00\xa4iR\x86\x0cS\xc8(\x9c\xc4M\x00\x17@\x1a\xc0\x89\x1c\x80,\xc4\x84l\x8
0\x94,\xc9HIQ@b\x02\x16P\x8a\x16L\n\x12\x84\x8b@\x8aZ6\x08\xc2&j\xc98 \xc0\x062Z
\xb2,!8!\xdc\x92m\x9a\x06*\x19C\x80\x82D\x84\xc4\xc2a\x82\x84\x8c\x93\x08E\x0cE\
x04\x92D\x8a\x189h`\xa0%\xd8H \x12EES@$\xc4\xa0$\x898\x00\x01\xa0\x00Q\xc2p#\x02
\x06\x8c\x02\x12\x13\xb0\x80@\xc8AA8\n\x00\x15d\x12\xb4L\xc2@\x02R\xc8\x0c\x8a\x
06!I&\x11\x12\x03"D\x06BP\x98`$@*"\x11@\xdc$\n\x18\x10\x8a\xe422\x98\xc8\x01\x00
@ \x13(\x11K\x82e\x18)\x12\x18\x08J\xda\x10a\x18\xa4\r\xa2\xb0\x0c\x82\x84\x08H2
@`Bn\xa3B\x0e\xa1\x94q\x00\x06\x84\x1c\x14\x84R\x14\r\x1a\tI\x04\'J\n\xb0lX\x08\
x8c\x13\x00\x11\xd9\x98\x90\x84H\n\x98\xb0m\x19 $\x19\x99\x08C\x82\r\x1a5\x0e\x8
2\xa6d\xc1\x04M\x98\x98\x90\x90\x92\r\x0c0)\x03\xa0l\x0c\x110K\xb6\x91#\x801\x8b
\x10\x8c\x81"Q"\xa7%J(\x02\xd00*\xa2\xa6\x81A\xc0 \x91\x16\x08\xda\xa4(\x1a4\x12
\xd0&"@\x16Q\xda2\taDb\x90\xc8h\x99\xc8\x05\x84\xa8%PD,\x0b\xc7\x04\x80\x96m\xa1
Fq\n&\x81\x99\x10\x90\xd90\x12\x139\r\xd4\x14`\xda\x18\r\x1aI\x84\x0c\x16F\xc9\x
06B\x0c0 \x84\x84E\x8a&J\xa4\x14\x8c`\xa0p\xc4(ICB\rS\xa6\r\x03\xc4hK\xc4l \xa0M
D\x80,\xa3@\x8eX"d\xe2\x92(\x12(H\x1b\xb4\x05\x08\x810\xc18\x04\xc4\xc4Q\xe0\xc0
A\x19\x19\x8aPB\x06L\xb6%\x98"\x89\x83\x00i\x88\xa0$\xdcD\t\xe4\xb6!\x14\xc3\t\x
83\x96m\x0c\x82AX\x12R\xc10%b \x8c\x01\xa7LH2R\x80\x16,\x10\x10"\xdb\xb8%d\x12\x
80CF\x81\x1c\xb1D\xc8\xc4%\x83\x88D`\xa21\x83\xa0mCDn\xc2\xa2h\x14\xb3A\x83\x18\
nA&\x8cS\x18d\\\x02-\x10\xc9l\xc2\xa6e\x1b\x98-
\\\xb0\x88a\xc4\x00\xcc2E\xca8f\x8a\xa0\x01\x1a\x00q\x1b9,\x81\xc0e\xd220\x142p\
x81\xc6a\xc94\x91\x89\xb0\x0c\x19\x17P\xc0\xa2\x80"\x14I\x08\xb6\x91\xa4\x06\x11
\x89\xc0D\xa28&[\x06\x01\x94&\x89\x00GM\x894N\x90&\x8d\xc1\x08\x02\x00F\x10\xa2&
\x06\x98\x04.\x1c\x08F\x14C \x1cEH\x81\x18F\x18\xb3\t\xd8\x14N\xe4\x06\x05A\x18\
x11\x0b\x84\x8c\x90\x08n\x94\xa8\x90\xd98\x8d\n\xc6!\xa1@\x0cS\xb2\x80S\xc2P\xa1
0e\x89\xb01\x99\x08q!\xb11\x14\xc51\xd92\x08YBa\x01!.\x1a7-

d\x16,\xc8\x06\x91\x00\xa2%d61\x94\x16\n"\xc6A\xe3\x84h\xe1@\x8c\xd0\x90e#8A\x81
\xc21\x0c\x06d\n\xa8da\x14,\x1a\xb6\x05\x93 \x90S2\x89\xa1\x04\x0e#\xa2\x85\x822
\x82\xcbF\x04\x0c\xb8\x05\x8b\x14,!\x991\x00B\x8dA$\x04\xa0\xc8,\xa1\xb0\x80\x10
\x17\x8dA\xb8,\x82\x80\x8d\x98\xc0\x85\x0c9\x0c\xd46\x0c\x92&\x11\xdc\xa4\x88KB%
\x0c1)\xc3\x14$\xd4&%\t\xc4m@\x14l\x1b\xb9hc\x86`\xd8\x12\r\x08\xc3\x08\n(@QDP\x
14\x04&\xa4D, %0 \x97\x81
\xc1m\xdb&E\x0b\xb0!\xe42\t\x11\xb4qX\xb8`\x08\x87\x84L\x10.\x8b `A\x94E\x1aA!\x
89\x94\x8c\xcc\x16\r\xd9\x10\x88\\\x18e\x94\xa4\x88\x03HR#\x86\x00\x1c%\x08\x04\
x87\x11\x1110R"Qa0\x02\x19\x830\xd4BlS\x02*#\xc7I\x08\x140\x8b\x80hI(.L@p"IR\x11
\x06\x0e\xd8\x92\x04\t\xc3q\xd20j\x01\x91,\xa3\x08\x91\x11\'\x8c`\x82 \xca"\x8d!
\xc3)C\x00N\x93\xa4hQ\xa80\xd4\xc8M@\x04m\x0b\x88q\x9a\x04F\x08(\x81\x12\t\x8d\x
c1@dSBL\x02\xa81\x19F`\xcc\x10-\x12\x11"\t"\x8c\xc8\xb2 \x03\t\n\x034\x8dT&%\x81
\xc0\x89\x122-
\xc0\x80,\x82B\x11\x92\x12\x85\xcc\x04!\x03\xc2\x85\xc82\x8a\xda\xc6\x89\x08\x19
N\x19\x02p\x12E&\xd9\x10\x12\x11\xa4`$\xa7 K\x84l\x90
\x81\x12\xb6\x01\x80\x82d@\x12N\x01H \x84\x92\x84"3\x0c\t\xa1(\x1cDL"I-\x01\x19-
T\x82\x8d\x8cH*\xc8\x16A\xe4\xa4AR\x90\x88\x12\xa5hD0\x80\xcc\x98Q \x12\x11\x94D
.\x8b\xc4D\xd32,\x8c\x80\x91\x83\xa8\x10\x12E&\xd9\x10\x12}Z0\xbc\xbfHu$y\xdcO\x
c4\x18K\xf8\xe8\x8af\xcf\xb8|\xd4\xce.\xba\xf5\xb1\xad\x11\x90\x90&R\x92\xf5Nn\x
d43\x1dV\x8ay\x17\x0b\xceN@\xc7\x07[\xab\xeb]-
\xd5p8\xae\xd8\x17\xdc\xbc\x12j\x87\xf2\xdf\x1a\x8a\xf1\xa9\xccS\x97R\xe8h/\x11$
\xb4o\xbc\xcf\x1bY\xba^\x194\xf9\x87\x00j\xfe\xb9\xae5\xa7>d)\xd2l\xbc\xdcNf=\x9
8\xd3e\xbbrz\xfc\xe2\x11\xa4\xa3%(\xf9\x1br\x00\xe2\xc5\x05P\x8e\x1bk\xbd\x82\xf
1\x171:.\xf3\xfcp\x94\x88/4\x95\xe1\xd6\xfb\xd3\x01\x03\'\x80`C\r\xc8R\xea\x87\x
b0\x8f\x84\x04\x91\xc6\xc9#CY\xda\x7f\xc1\x96\xfc^+m\x07\xfb\xb7kp\x9a\xee:\\$\x
a0\x08f0\x0c\x16?\x01s=\x08\xb9\xd8Q\x17xm\x18Z>\xd4p6\xe2\xd3\xb1`\xdd\xce,\xe2
</cO\xa4\xf1\x98\x1e\x82|T\x17\xfc\x84\x18\x89\x89\xd0{M\xf4 \x02\xcb\x89b\x15\x
02\xd9\x99\x9d$\x9a\xd6\xa7@P\x95\x96F\xc3B\x12C\xff`f\xe1\xa4`\x12\x10\xeb7>\xe
6j\xe4$r\x1a-\xc8\xdfg9\xce\xfc\xa6\xc4\x1d-
\xeb\xd6e\x7f\xb2n\x1a\x17\x8cV\x95+O~\xacI\xb3S0\xf6\x80P\xdf\xa55\x987\xeb\xea
\xcb\x03\xf0\xd8\x97\x93\xf4L\x95\x05n:L28O\xa5\xb5\xb2\xacj3\xc1P/(*N\xfb\x9d\x
80\x9d\xb0I\xb6\xa93kP\xeb\xbae\xdcb\xb2\x96\to\xe0K[\t\xf1\xc1\x9d\xf8\xa0\x97\
x9d\xd6\x85\xbe\xced\xd3.\x0c\x8d\x0ff$G\x07\x94\xac\x01\xf0\x0c\xaeW\xe90\xe0=g
\x0c\xfeO\x87\x19\xfa\n\x91\xec\xfa0Y\xee\xf3\xc8i\xb2h\xd4\x94y\x95\x9a)\xe6\xe
6{\x18\xe4\x0f]\x15U\xd8\xb9\xf2\xac\xc6\xb9_L,\xaf\xf9\xa2\x89eF\xf5\x95\x04\xc
7\xc6\xcdJy=5r\x13\x0c\x863d\x18j\x147\x94\x1d\xb9\xc8\x1f\xe2\x03X\xaf\x01Z\xab
F\xbd\xecb\x8ft\x80\xc2\xe4\xe1\xec*\x193I\x08\xa3\xa2\xa6\xd5\xc4\x08\x8b\x13\x
02}\xa8$Z\x14\x97X\xd9+?V\xd3\xd8\xf6\xc5\xe9\x83\x14GM\x8cQ\x91o"\x1d\x9d\xe8~7
\xd9\xb7Z \xf0]\x06\xc5\nM\xacIp\xf9\xe3\x7f]\x98Ea\xaa\xa3\xf2\x19\xbd_\xf1Z\x1
4\xd7\xe8\x1e"\x93\xab\xee]\xec\x8e\xd4\x8a\xd6nI!\x0c\xe1\xc4_\xfe\xcb\x84\xfe\
xbeOb\x94+\r\x86\x91h|p\x12^N\xd2\xc1\x06\xaf\x86\xe7w\x8f\xc8\x18>\xa63\x80\x1f
\xa9\x8b\x83@\x0b{\x94\xfc\x18\n\x17\xdc\xa9\xfd\x1c\xc6\xef6\xba3"\xc7`\x12\xae
b\xec*\x11\xd5mD\xb3v\x95#!\xbc\xfbN\xf1|\xd7\xd9\xee]\x03w3v)\x95M}G*\xbf\xe62\
xf4\x07\xa4\x11\xb8\xc4V\\cC$f\xf8\x00\xd2&\xafLL \xe1\xcdl\xbb\x95\x11\xffaWC\x
a0x\x1eb\x80\xcc\x8e\xdd\x9de\x172\x8a.\x8d\x11\xcdg\xe1\xb0\r\x92\x8c\xa7p\xd0{
|%3[\xc7\x82\x06\'\x1f\x92\xd9\xf2{o\xc7Gj\x028\xc0\xa1\x07]\x03\xb7\xd3\x0bA\xb
e\xe4\xa2\x1b\xe8\xac1\xc8\x0c\xaa}e\x89aA~1\x03\xd9,\xf2\'\xbe\x06,\xb9\xa9)+\x
e9^\x91\xb1\xc1\xaf\xa5\xc2\x1e\xd9\xbe\xe1\x83!\xa12\x1b1\x86\x05z\x00\xbe\x8e\

xc0\xdd\xabD\x10\x85\x88\xb4FZi\x97;\x8e"oR\xae\x19e\x197\xb2S\xc9\x9e2Z\xf1
@\xb6b\xb6\xbe\x0c\x93\x03B\x84\xe4\xb6Lp\xb9\xbe \xe6\xfa\x08\x83(\x18\xbb\xb3\
x8c\xdb\xc4L\x90\x9b\xeaCb\xae\xdc4\x8a]\xe0nCJ\xebc\x9a\'^\xe3\x0fAmQ\x86H\xe1#
Q\x19N\x8b\x8bb\xe9|G\x86F\xe6>\x9c\x140\xd5\x10\x91\x18;\x1a-
l\xff]\xd5\xd2\x06\xef+!\x17r+\x7f\xa6\xa0\xd2\xab\xa8"\xde\xb6{}=n\xcc\xdd^\x96
l"\xdc\xff\\W\xb7x\xb7\x91\x98Z\xf1Ma\x81\x94\x1ab\xe2\xa76m>r\xf7\x93\x8aY<\x89
\xd5\x82\x03\xbd\x8c\xa42;5\xc1x\xc8!k\xd1=\xfeC\xe5gM\xfc\x80{\xfd\x92yVfA\x08\
xe2)A\xf5"\x9d\x15\x02\xbd\x829\xa4\xf8\x8dx\x07\x7f5z\x91\xf6\x87\xc9i\x07X\x0c
\x8d\xda\xe2\xd7p\x8b\xfb\xe08De\'\x95\x91\x04? b\x18MG%\xe4+\xe6o\xe8\xb9\xea\x
bf\x12V)\x15G\x08MWn\x95QW\x1b\x8c\xa5\xdcNA2-
\x1bM\x13/\xdf\xcd4C\xdbM#@\xd6\xfc\x02\xb0^\x82J\x8d~\xfcC\xc6\xd2\x07\xe4\xd8\
xad1\xd5\x89\xce\xa8\xf2\xef\x04\xdb\x17h\x89\x97\xb9h\x7f:\xfc^\x9fW\xc8\xfe\x8
cU<X\rl|\x1e\x89\xa7\xa1m\xb3\xe25p\rqCc\xc4\x1a\xbe\x10\x192nj\xb4flD\xc3\xb7\x
a1B(C\xcb\xe0\x02\rHS\xa9\xa0\xb8\x85\xe7\x8a\xfd\xf0\x8f\xfaj\x08\x93V\x94\xde:
<\x9e;\xf9\xc2\xcc\x97\x83\xdc\x94\xec"K\xaa\x91\x1ea36\xb0]\x8f\x8d\x11\xa6\x82
C8\xcb\xafuF`\x1fX\x83T\x88\x93i*\xdd\x0b\x7f{"u}M\x96#\x9bny\xa7/<\xa0\xf7\xfb\
x8f\xc6t\xa3\xdcL\x0f6\xd3\xa4\xcd\xe3\x0f\xe9\xcc+X8Y\\\x91\xc7W\xcbk\xece@\xe9
\xf5\x83\t\xa2\x0c\x84i&*\xd1\xe7\xebNN&\xe2<\x11O\xef\x97\xcb\x13\xbb\x00\xc3\x
da\x08A\xaf\xdb\xb7\xa6M\xb3=\xc7\x07\x17\xb6m?\x8db\x95\xabK\x91`\xc9\x99W\xdb\
xe8\'\xb2\x16\xa9=\xfa\xe7\x16^t\xd0\x9e\xa5\xc2\x9eUIJ\xf5u\x88\xf4\x07\xe8\x15
\x1d\x9a\x04\xd0\xd9\xd5\x14Y\xfb\xf1RB\xb8+\xa0\xe2\xab\xb4\x84\xeb\x80\xbc\tX\
xbfq\x8d\x9dh&\xb6\x80+\xd5\xf2\xaf)\xaf\xc0\xc1\xae\xcd\xb3*\x8a1\xc5\xea\x9a\x
db\r\xde\r\x9f\xc7\x9e\x19\xcbu\xaa\xc1\xedO\xda\n\xa9\xb7\xc8].\x918D\x9a\xb8Z\
xa0x\'-
\x9e&a\xe3v\x1e\x1d\xf2\xc5\x83|\xea!W\x8dSB\x85\xb5A\xcc\x903\xfd(\x9c$\xea\xb9
\xbe\xe9J\xc99\x9a!\xb6\xf3&s_y=P\x10\xe9\x16\xaa\x87\x1e\x14\x0b&\x9a\xd4e\xe8\
xd4H\x9f\x06B[}\x9a=@\x07\xd6r\xf9\xda\x84\xe6\xb3\xbd#\x1a\x06\xcdn)j \x12\xae\
x86\xf9\x0b\x80\xd8\xdc\xef\xca?V\x82\x86\xdc,\xa6c+\r\x1d\x02\xac\t\xd0^\x12\x9
f\xadP\xcd\xf4;G@\x86\x93z\xa0\xe1\xbc\xddTB\xfc\x0e\x90V\xdbd\xeb\xad\x04J\r\xf
dk2\xe5\xc0\x15:Z\xb5\xc4\x1e^\xc1\xf8\xa8\x92\x19x\xb1c\x0e\xbfsa\x05!Y\xbasK\x
8b\x01\x8d\xf1\x01i\xab9\xab\xfdrS\x15\x94\x86\xde\x00`a\xb0\xd2\xe05\xa2>g\xcc}
\xefquSQQ\'ML$\xc6z\xa9kSA\xb2f9\x1e\xe2\xd1W?t\xbb\x08\xcb\xb9+\xb8V\xcf\xb9\xc
a\xa4\xb2(`-
Or\x12]\xd1^z\x07\xfcTu\xc0\x03\xc4\xbd\x92z\x80\xf1\xce5O\xa6\x98\xc3\x1a\xc7v\
xbdL\x11\xfa\x98\x853\xf6\xbf\xb0d-
\x9e\xbe5\x0f\xear\x8fW\x10\xfd\x0b\x13\xe6\xcc\x19\xe0:\xa3\x06\xb6?\x1a\x9a\xb
c\xf3\xe1\x84\x05\xdf/M\xfd\x11\x03o\x1e\xfc\x0c\xad\x15\r\xe4\xb0\x96J\xbd\xb2\
x12\xd5\xa1\x15\x94tep\x97\xc5,\xc3\x85\x10\x06`\xc9\x13b\xec\xe2x\xe3\x86\xf5F|
\xee\xdb\xf0!\xcb\x9f\x1b\x8e\x16\x86V=\xdc\xaf\x9f\x06q\xa9\xfb\xcd5"\x84EA\xd9
{\xaf\xf2\x82\xe9\x8c\xb3\'\x19\xd0\xba\xca]\xdf \xf4\xe1\xcd\x00\x13W#z\xe8Q]\x
c3\xf8RZ\x9b\xc3x\x11!*#\xe4d\rf/\xec\x87O\xb3\xe5e\x07|\xa4H\xd4i\xe4V@\x93\xb2
\x80\x07(\x06\xee\xc5\xee\x997\xf0m?C\xb5\x05\xbd\n\x82\xca\xf6\x85\x80A\xb3:?:l
\xd9\xcf\xffj\x18:\xee\x13\xe8\x995\x1f\xe0\x1b{Sa\xe6e\x0b|\x04\xc8$\xf9\xb56\x
a3\xd7\xc5\xd5\xf1\xa4\xa3DG\x03+\xd3x\x9f+\xce\x84\xa2\x9b\xcd\x80\xc1\xc4v\x10
\xb3\x10\x983Oy\xb7\x99\x90\x1f\x8e\x13{,j\xbeY\x94\xeb%\xf6\xb3,\x87\x99\xa5\xa
9\xb0\x99`\xbb\xb4\xfbs\x03\xfc10\xe0T\xb8\xbd\x0e\x0e
\x89\xc4\xa6iA\xd3\xa2\xcc5\xc9\xab\xc7\x15\xe6\x10\x84\xa3\x05.=\x8f\xb1. \xa5\
xc8\x948\xdb\x88b\x99\xfav\xa6\x84\xf3]\xde\x19\xa9\xa9\xbe\xd6\xcePP\'B\xa1\x98

\xd4\x84\x8b\xef\xcc\xf8\xaejGL\xe1U:\xe6j\xed|\xc3\r&Kc\xdd25\xe3\x86\xebth\xac
\x7f \x0c!8\xc5\x82r\x8c|#\x9e\x88\x8b\xa9\x9e\xa6*9\x1f;\xcfM!\xc6\xef)\xa5\xd0
\x02\xc3\xd3\xbd\xa5z\xbfb\x914n\xde0\x9dX\xe9\xb4\x8fkU\xe7\xacO\xc1\xab|\xe3\x
b68\xbb\xd5\xa8\xec\xe3\xdc\x1d\x8f\x01}\x05\xdbm\x98u\x90\x82#\xa2tS\x14\xa9\x9
b\x80\xe9\xba\xdaS\xf3\x8ca:.\xa2\xc2\xe8B\xeb\xffq\x088\xdd\x86\xeb\xe8+\x81#\x
ed\xfc\x84\xe4\x87\xabF\x0e\xc3[\xbf\x05\xa7\xdf`Vm_z\xe8*\x18%\xbd"[5)\xd6\x8d\
x87.\x88\x9c\xee\x08~\x97\xf0\x89H\x9dpe\xe0U\xb9\xea\x7f\x1f\xc2\xe5\xec3;\xc5\
x03. \xbc\xe8&|"\xdd\x13\xa4\x0fW\xf9\xf8\x0b\x84\xdf4\x1a\x92\x1ed\x03d\x80/\xb
ae8%\xa3,p\xdd\xb8+\xfc\x96\xb5\xed\xc4l\x07\xe3\xfde5\xc2g\xe47\xe9W\xae\xfe\xf
6\x88$\xfa?\x12\x0e\xd5\x9ez\xd9G\xae\r\t\xdf\x17a\xd1I\xbc\x19\xd9w\x87\xf3\xcb
`\xf8HQ\x03UEB\x81AodJ\x94\xe2\xde\xaf\xe8\x8dN\x18\n*\x92\x91fV\xf7\xdf\x1c\xc3
\x07=\xd3\xc6\x93]\x99 \x8f\xca\xbf\xac\xa2\xff\xe55\x99\xbfG:\x7f?\xf7[\xcf\x98
\xbb\x03s\xe0\xeaq\xaf-
\xf1+\xc4\xc3\x000\xd0\x9a\x92\xca\x1a\xa5\x88\xc4\xd7\xcd&d\xee\xcb\x12@8\x004\
'\xf0n\xb0\xa9>\xfa\x01~\xcez5=R\x99\x84\xa4-
F\xa8\r,v\x05\xces/\xdd3\xed\xc5\xb22\xf4/\x9aEe\xd3\x07ah`8\x8bd\x9aBB9\xa7\xc0
\xef(\xf6\x1bSj\xb5\xdc\xdb\xffL(\x98\xdd\x99`eq\xd9\x1b\xb9\x8d\xe5\x19B\x1d\x1
2\x14Y\x86\xb0h\xd6hg\x91\x1e\xea\x80d\xd4\xd4\xc1\x0b\xe4\x8er\xfc>&\xa6\xd9\xd
6^\xf0)\x8aT\xb9\x0f\xc3\xd9\xd2D\xc3\xb04w%\x88\x12+\xc9o\x85{\xc6\xb7\xe2\xc9\
xac\t\xc8a\xb0\xc7t\'\x18\x12\xadK\x0fd\x1d\xe9\xa5\xbd\x82\x16\xf8\x85\xee.=!$\
x12,\xa3s=\xaf\x8d\xd2\x1e\x07\tYr]\x1c\xc2C\xdb\xad\xdc\xdf}Fv\xa1\xc2\x97\xd8\
x7f\x8c\x84\xfa#,\xf1\xb1\x08&L\'"c\x9d\xa9\x0b\x80\x91\xdfc\xa1\x8f\x06\x0e\x04
\xfbK\x19\xbfN\xb3>\xf7\xba0a\x92.R\xc4\xca\xf5\x82\x10\xc4\x0e\xa3(\xd4\x7fm1!a
\x07\x14\xf7\xb9\xefn6R_\x92\x10\xaf")<#\xb5s\x18e%\x97Y<\x1f\xac!(;\xd36M H\xda
\x84S\x1aJ\x83\x18L\'\xd1{\xd2\x96Y\xbaNn\xd7b\x9d\xa2\x92\x9a\xd3\x8a\x06`]\xc4
\xd4\x8c7\x8c\xbd\xfe}\xdd\xdd\x82*\x15u\xa5\r\x1e\x96WA\xaf\x11s\x16\x14\xcfU\x
1aI\xfe\x98\x1a\xc8\x81\xe0\xdd\xc5\xce#\xc2\xce\xdaC\x81\xb8\x14\xb0\xcf0W\xbd\
x08y\xa4\xc9\x89mh\xd1\xfc\x06\xe1\xde\xf7?3\x17\xd8\xddp\xc4\xf3Y\xa9\x08T<O-
\xa5\xb7\xf7\x94\x01\xf9\xce\xe3<6u}T\xce\x0c$\x90\x06H\xb5q\xf0zW\xa3\x10\xda\x
01\x91Q\xd1|\xe4\x1f9\x9f~6\xd3N\x8dw\xfa\xcb\xd2P\xe5\xcb\xbd\x9a\x14WH\xa8\xec
\x04\x19Ww\xbf\x8c\xdfe\xb3\xdc\x00F\x95\xb0\xcb\xc6\xb2^~L2\x0f\xbe\x99;\xf9?w\
xa7v\xba*\x96\xd4L\xb0\xae\xaaV\x98\xe0\xbfJ\x0f\xff\xd5\xca\xb7\xb0\xce")\x99\x
b2\x0b\xebBO\x0bK\xb4@\xd8\xbf-
\xce\xf7\x8c\xd7\xdc\x91\xfb\xdbh\x9e0\xc6\\\xa8\xd2\xb2\x90 \xc9\xae\x93\xd1\xc
8\xc5p\x0b\xb8\x9e"4-
\xfas\xe6Z\x16\x14b\x84\xedZ\xc1:\xa1X\xc8q\xfb\x9e\xed\x8c\xd2C\x84%\xbd\x1dO\x
d5\xd8C\t\x91\xef\x01\xd1@\xb6m\xee\xa3\x9c\xb3\xaf\xd5u\rH[\x94\xb9\xf7\xc3\xc9
\xee&tt\x190\xa6n\xa1\xb6S\xe7\xc0{+ u\xb3\xf5\xec\xb9b\xad\xbdn\xe5#9\x89+\xa2\
xef\xae\x13\x98\x89t\x99\x9acB\x8d\xd8\x1b\xb3\x8d2\x91J"\xa4\xad\x17\xa4\xf0\xb
7%\xd5I\x82o\x0cU\xcf=L\xd2\xa7G&\xfa\x03\xebNs\x96\x8e\x88\xc5\x11\x8b\x0c\x8b)
\xbb\xf1\x10\xfe\xef\xc6?r\xb8\xf7\xd1\xf8#\xaf\x10Z\xf2\xf9P\xd3i\xd8\xea\xdb\x
90\xb7\xad\xde\x06#lwT)ia\\\xd4\xfd\xfa\x11\xb7/w\xd2n\xe3\xb5>-
\x07\x01{\x9a\x189o\x99\x1f\xf4\x01;\x16\x17\xd6)\xf7\xed\r;\x9a\x8e\xfe\xed\x86
\xed%\x9a\xa10\x14\x98\x828Cu\x1b\xe5>\xf7\xb3F\xc8\x1d6H\x12\xbf\xf3\xc8@:\xe6\
xb9\x1f\xd8\r#N\xe3\\\xe7\'~\x9c\xe6.\xe6\xfbJ\x7f>8 f\x93\xfe\x05\xa7\r\xf6q\xb
dG\xd7\xb7!\xe2\x04\xf8\x04L\x1fX\xa3}\xb0\x9a\xfcI\x89\xcf\xe7\x11\xed\xab\xa1\
xee\xfd\x91\x1f\x06\xbf\x00\xc1\xf8\xbaB\xffwo\xc0\xa7\xfe\xc7@+~\x01w\xdd\xae2g
\xcfE\x87\x87\x9a3\xf4b\xcf\xa2O+\x08\xfd

r\xaa\x07\xad\x16\xcb\xe2\x03\xee\xadi\xaa@\x94=\xb6'
Secret Key Size: 4896
Signature: b'\xc5}\xd7\x12Ec\x1aWz\x8c@.:J\n\xc2\xbd\xb0\x87.\xf8\xc4Q$\x9e0u+B
\xe7\x04\xd0\xe7\xed\xb3\t!E\x8f\x18\x13\xce\xe5\xc0\xc8\\\xfa\xef(\x98}#\xf0V\x
b8\xb6\xe9C\n\'\x90gS\xd9\xd9\xc0gB\x0eU\x980`_k"\x81\xf1\xbf\xa4\xcbX\x16\xaa2\
x93B\xde\xb1\x88\x1f\xd3\x19\x17\x03\x02\xc8\x1c\x07Jz\'\xf4\xecY"\x13\xbeg\xf9\
xbe\x13\xef\xb6v\xe1\xea\xb2k\x14-
\x93\x8c\x99+\x92\x12\x01\xee\xf9\xa2\xff\xf2\xb8\x91\xf2!\x1f!\x1c<\xec\xcb\xdc
R\xdb\x05\x83u0\x0f\xc0\x08o\xd8\xc7g\xff}\x95\xee\xb2\xed\x01\xd2\x0e\xc8Z(\x9e
\x8e\xd7\x80\x12\xcb\x0c\xb9b)\x80\x03\xc8\x7f\xa6\tfD\xd6~\xa4\x16\x04\xea\xc0A
B\x9eL\x98\x04`\xefs"\xd0\xf1\xef\xb6\xcb\xda\x15**\x93\x1b\xe0Av\x1f@\x19\xf7\x
04\x02\x0b\x1cGGzV\xf5lN"C\xbd\x97\xf0\xbe\xc4\xee\xc6\x84\xe1\x89\xb3[\x10-
\xc3\x8c\t$\x92\x83\x01\xfe\x08\xa3l\xf2H\x94\xf2A\x1fA(<\x06\xcb\xfc`\xdb5\x83e
:\x0f\xda\x07?\xd3\xc7\xc6\xfd-
\x9d\xee\x96\xec\xa1\xd8\x0etZ\xd8\x90\x8e{\x82\xa2\xdd\x0c\xc3ays\x03L\x7ff\x05
f\xe4\xd5\x0e\xa8\x16r\xe9@HB\xf9KH\x11`UtR\xc0\xf1\xcd\xb6\x1b\xe9\x15\xa6)C#\x
e0\xacv\xbf2\x19\x16\x05\x82\x08\x1c\x0bG\xaaW\xf5\xdbMrR\xbde\xf0~\xb3\xee\xb7\
x83Q\x9c\xb3_\x10\xdd\xc2\x8c\x9f%\x02s\x01\xfa\x08\xd3p\xf2\xae\x94rQ\x1f\x1a(<
\r\xcb\xd6`+5\x83a9\xff\xf0\x07l\xd2g\xc7\xfdu\x9b\xae\xa3\xec\xf5\xd8.\x88Z.\x9
1nw\x82\x14\xdeL\xc9a$t\xa37\x7f\xaf\x046\xe5\xd5\x80\xa9fd\xe9\xbfG\xb2\x0eL\xa
6\x10\xe0]t;\xc1\xd1\xbf\xb6\xba\xe8\xb5\xaa)\x9e"\x90\xb2v\'3\xd9\x17\x05\xfb\x
07\xcc\x06GrWE\xedM(S\xfdg\xf0\xb3\xb3\x1e\xb7\x83\xde\x9a\xe3l\x108\xc3\xac\x98
%\x8drQ\xee\x08\xa4oR\xb8\x94\xe8QO!(6\x0c\xbb\xdc`\xd75su9\x01\xf0go\xd2\xc9\xc
7]~\x9b\xe6\xa2\xac\x00\xd9\x0b\x88\xba(\x91rw\xb2\x12\xde\xfc\xc8\x01(t\xf67\x8
f\xa6\x04q\xe4\xb5~\xa9 d\xa9\xc1G4\x0e\x0c\x97\x10q_d"\xc1\xfb\xbf6\xca\xe8\x13
\xaa\xb9\x93"\xe4\xb1v\x1f3\x02\x17\x15\x02\x08\x15\x07gzW\xdd\xec-
"S\xcag\x10\xbf\xb3\xf7\xb6\xa3\xe1\x9a\xb3k\xa0-
\xc3\x91\x99\x95\x92r\x01\xee8\xa3o\xf9\xb8\xb4\xf2Q\r!\x18<\x0c\xdc\xdc\xa0\xdb
5\xa0ui\x10\xf0\noR\xc7\xc7\r~{\xee\xa2\xe4\x01Y\r\x88J(\x91\x90w\x8d\x12\x9e\x0
b\xc9h)\xd4\x038x\xa6$f\xe4\xd8~\x89\x16d\x83 \xf4CA\xdf^h\xae\x85\x9c\xcc\xf0&V
\xe6L\xfd\xd5\x81J\x9eC\xe1\x11Zr\n\xa0\xab\xf8f9\xc1\x8b\xafiq\xb9h\x86\xfb>\x8
3l\xd5\x0c \x86E)y\xde\xa5p`\xbfi\xa0\x7fT\xe1q\xd9\x13\xec\x97\x8c"\xf7\xa4\x98
\xab;\x81\x00\x1drj0\xf7d\xfb\xa2/}4\xbb\xdd\x84\xd3\xa17\xbav\x0fz\xcc\xd2\xe4\
x1c\\\x85\xa92\xce\xa6\x06$M\xd4\xc6\x18\x1c}C\x91\xdbWM\x15_\xd8\x8e6\xe94\xbe{
\x07D\x11\xe2^m\xae\x95\x99\xcc\xbd&\xb6\xe4L\xe7\xd4\x81X\x9e\x83\xe0\xc1hr\x9e
\xa0\x1b\xeef\x1f\xc1\xab\xaci6\xb8\x98\x83\xfb)\x84\xdc\xd4\x0c\n\x87E\x13y.\xa
60c\xbf\x0b\xa1\x0fQ\xe1g\xd9\x03\xf8\x97I#w\x96\x98\xfc:1\xf8\x1cai\xa0\xfad\xd
d\xa3\xaf}4\xf3\xdct\xd3\xa1\xf1\xba\x96\x03z\xb0\xd2\x94\x19\\\xb8\xa9B\xd1\xa6
\x84#M\xcf\xc6\x1d\x1c\x9dM\x91\x82W\xfd&_\xf0\x8d\x06\xf44V{\xe0#DD\xe1\x0ei\xa
e\x8a\x99\x1c\xb1&V\xe4,\xde\xd4\x89W\xbe\x83\xe0\x0ejB\x9a\xa0\xa1\xee6)\xc1\x9
f\xac\x99A\xb8k\x82\xcb>\x84\x80\xd5,\x10\x87K\x14\xf9\x1d\xa6xc\xcf\t\xa1\x8cQ\
xc1p\xd9\x16\xf8\x87;#\x02\x97\xe8\xfb:}\xf8\x1cai/\xfa\xf4\xeb\xa34\x7f\xa4\xe9
\xdc\x98\xd3\xf1\xf8\xbaw\x03\xda\xac\xd2\xde\x19\xac\xa4\xa96\xd2\xf6\x86#?\xcf
F\x18\x1cvM1\x8bWQ\'\xdf\xe8\x8d5\xf3\x04O{>$4A\xe1`h\xae\x85\x99\xcc\xb0\xc6U\x
e4K\xdd4\x81W\x99\x83@\x12j\x81\x9a@\xab\xeeg)\xf1\x8a\xacoAxi\x82\x07?4k\xd5\x1
6\x10\xf7D\x14\x86\x1e\x86pc\xc5\t\xa1\x7fQ\xe2qY\x13\xf8\x9e<s\xf6\x96\x8e\xfb\
n\x82\xf8\x16b\xc9/\xfae\xebC/\x7f0\xeb\x0c\x85\xd3\x88\xf7Zw\x03|\xac2\xe5\x19O
\xa5\xd91\xd2\xa3\x86\xa3M\xcf\xc4\x18\xec|M\x87\x8b7N\'e\xe8\xfd5\xf3)N[$>A\x0

```
1_h\xa4\x85\xa9\xcb\xb0&V\x04M\xdd\xd5\x81\x97\x9f\x83\xec\x11\xbar\x9a\xaf\xab\
xaee)\xc0\x8b\xaciA\xb3h\x82\xfb>\x94l\x95\r\x10|E\xe4x\x1e\x99pS\xc0\t\xa8\x7f\
x11\xe1q\xed\x13\x08\x99<9\xf7\x16\x99\xfb6\x81\x08\x1ebW0\xaad\xeb\x9a/?4\xeb\x
da\x84\x83\xa2\xf7\xa9vCz\xac\xda\xe4\xb9\\\xa5\xa22b\xa6\x86/M\xff\xc6\x18"}M\x
92\x8b[M\xd7^\xe8\x936\x134NK\xf1\xb4\xcc`\xe6\x81\x1au\xfa;\x95\xd4\x06\xa2I\xe
e\xb4\xfala\xb51\xd2q\x00\xc7T\xb7\xf0\xce\xe8\xc2\xec:\xf9\xb9"Lu\xfb\r\x8b\x03
\xbf\xe59)[\x88\x07\xd1\xfbp\xd8\x8cV_\x00\xa6(s}\x93\xc76R\x11F\x19f\x90\x95\x1
e\x0e\xc5\xefR\xda\xb7\xa1\x8f7F1\x05\x95F~{k]\xdav\x1f\x8a\xfb+\xe1\xb9\x1d\xd1
`\x1e[\xa9\xe2\x8eV\xc9\xf3E\x15\xfdR\xd0\xdd\x00\xec\'\x9a\x9e\xfb\x88F+\x1e\x9
9Y\xf1=\xcd\x00\xda\x81Wtz?\x95=\x06\xa2G\xee\xc9\xfa|d\xb5\xda\xd1\x01\xfd\xc6\
x99\xb7\x00\xd1\xe8Z\xec\xfa\xe0\xb9kK\xe5\xf7\r(\x03\xaf\xdb9\x93Z\x08\xff\xd0L
r\xd8\x98V\x13\x00\xd6\x19sp\x94wCR EY\\\x90\xe1\x1e\xce\xbd\xefU\xdbG\x88\x8f\x
18F\xd1\x0f\x95\xa4~\xbbk]\xefv\x7f\x83\xfbs\xe29\x18\xd1\xf1\x1d;\xad\xe2\x06W9
\xdfE\x8e\xfd"\xca\xdd\xfd\xeaG\x96\x9e\xc2\x88\xa6/\x1e\x92YA5\xcdb\xda\x01:t\x
f9>\x85D\x06\x9cG~\xd5\xfabee\xe2\xd1\\\xfe\x86\x94\xb7\xee\xd1XS\xec=\xe1\xf9QK
z\xf7\xed+\x03\xd2\xdby\x88Z\x87\xff\xa0Kr\xee\x99\xc6\x0f\x00\x9f\x19Cm\x94\xc2
Cr"E\x1d\\\x10\xd6\x1e\x03\xbe\xefS\xdb\xa8\x89\xef\x06F,\x10\xd5\xb6~ql\xcd\xe9
v\x1f\x84\xdbl\xe2\xb5\x18\x91\x01\x1eU\xac\xc2\xfeV\xc5\xdf\xe5\x84\xfdE\xcb\x8
d\x01\xeb$\x95n\xcd\x886/\xde\x89Y\xfd4\x9da\xda~:\x84\xfa>\xa5D\x16\xa3G\xe8\xd
4\x8ame\xc0\xe1Aq\xfe\xb3\x94\xd7\xf0\xd1\xd6RL;\xe1\xcbR{u\xf7\xfe*\xb3\xbf\xdb
8\x89\xca\x87\xff\xc9K\xa2\xd8\x99`\x0fp\xa5\x19sm\xc4\xc7CQ!\x15\x19\\\x8c\xd5>
\x0e\xbe\xd1Rk\xb8\x89\x86\x07F1\x10\x98\xb6~zlX\xeaF\x1f\x84\xf2k\xb2\xb9\x18\x
b7\x00\xaeZ\xac\xed\xfe\xe6\xc8\xdf1\x85\xddP\xcb\xe0\x00\x1b(\x95\x98\xcb8F/\x1
2\x89\xc9\xf14\xe7`\x8a\x81:j\xfa~\x95D\x08\xa2\x17\xee\xd4\xfalE\xb4\xe1\xd5qn\
xc7\x94\xba\xf0\x91\xe8R\xf8:\xf1\xb8RYu\xb7\r+\xfb\xbe\xeb8\x89W\x88\xaf\xd1K\x
82\xd8yW\x0f\x05\xa6)sm\xa2\xc7\x93Q!d\x19\xfc\x8f\xd5\x1e\x0e~\xf0R\xd9\xb7y\x8
f\x07V1`\x96\xb6\x7f{\x1c]\xear\x1f\xf4\xfbk\xd9\xb9\xe8\xd0\x00\x1e[\x8c\xe3\xf
eN\xc9\xafD\x85\x02S\xeb\xdc\x00\xdf\'\x95\x9e\xcb\x98F\xaf\x1d\x89\xff\xd8\xfc_
\x9d,\x07\xc9\xa4\xf4G\x13\x96\x98\xb9\x89\x1fu\xccY\xa5R\xa9\xa3\xd6}n\'\x95|]\
x9dv\xa0\x1d\x96R<\xed\xd4\x1a\x84\xbe\xe8\x14\xd6\x81\xf2\xf8\xb3|\x8eW\xc6sl\x
8bI\x7f\xef\xb2\xeb\x82\x83T\x11v\x17\xf3^\xc7\xc9\xa8\x9a\xa3{:\xc3\x82\xb1\x80
\xe6\x9e\x95Dd\x07\xb2\x90\xa6*\xd5v]\x9d\xc7x\xa2L\xf4\xcf\xb0\xd3\xbdBH\xbf\xd
b\x1e\x1b\xc3\x03{\xbfy\xcd\xc1\x93\xdc\xb3\x07\xcal8\xfc\x81?\x8a\xf5\xd8\xfc_}
\'\x07\x0f\xa5$M\x13\xbc\x97\xd9\x8f\x1f\xf5\xcc\xb9\x99R\xe0\xa2\x86\x98n\x1f\x
96la\x9d\xf7\x9f-
\x8bR\x8f\xed\xe4\x1a\x84\xbf\xe8\x94\xde\x81y\xf9sv\x8e\\\xc8cf\x8b\x16~\x1f\xb
b\xeb\xae\x83\x04\x0fv\xbc\xf3n\xbf\xc9m\x9b\xc3t:\xe8\x81\xa1\x8a\xe6E\x96\xf4S
\x07\xfa\x91\xc6/\xd5\xfd^=\xc8x\x7fLd\xcf\xb0\xbf\xbe"7\xbf\x84\x1e\x9b\xb8\x03
X\xc0\t\xc5\xc1\x9f\xdc\x13\x03\xca$9\\\x92?\xdb\xf4\x98\xfc_\x92\'G\t\xa5\xf1LS
\xc5\x97\xb3\x8e/\xe5\xcc`\x9a\xc2\xd9\xa2\xde\x97\x8e\x16\x96\x81b]\xf6\x9f\'\x
8b\xf2\x8b\xed\xca\x19\xe4\xce\xe8%\xdf\xb1p\xf9\xa3u\xfeW\xc8kf\xfb\xf8}\xf1\xb
9K\xa3\x83Z\x0e\x86\xb6\xf3V\xc0\xf9W\x9b\x9ctz\xe3\x81\xa3\x89v0\x96NT7\x01\x92
\xa00e\xf6^\x9a\xc78\x83L\xe3\xce@\xa3\xbeM7\xaf{\x1e\x12\xb9SZ\xc0t\xc4!\xa4\xd
c\xb5\x02\xea,9\xf4\x91?\xda\xf4\xde\xfc\xdf\x9d\'\x0b\t\xe5\xf3L\x10\xc6\xf7\xb
8\x8e\x0e\xe5\\Y\x9a`\xd9B\xd7\x97v\x17\x96|b\x99\xf6\x7f\x1f\x8b]\x8c-
\xd4\x19\x8b\xce\x88\x14\xdf\x83r\xe9\xb2u\x98Whrf~\xf9}\xef\xb9\xf2\xa2#T\x0ez\
xb73`\xc0\xc2X{\xa3t4\xe3!\xb2\x89\xf6N\xe6CT\x18\x02R\xa60\xdc\xf6N\x9e\xc7z\x8
2\x9c\xf3\xce\xbb\xa3\xfeA7\xbf{\xae\x1b\xb9\xf6Z`y\xc4\xcd\xa3\x0c\xb4\x02\xd1,
```

\xc9\xfb\x91;\xdaD\xd8\xfcf\x9d\x07\x06\t\xa2\xf4\xbc\x12\xc6\xa2\xb9\xfe\x1e\xe
5\xceY\xfaR\xd9\xa5\xd67o\x17\xa7|\x12\x9d\xf6\x89\x1d\xdbR\x8c\xf9\xd49\x84\xce
\xe4\x14\x8f\x81r\xf7\xb3E\x8eW\xadsV\x8b\xf9\x86\xefy\xeb\xa2\x8bT\x1ev\xb7\xf7
^@\xcbX\x83\xa34:\xe3\x80\xb1\x89\xe6N\x94D\x84\x08\x02\x8f\xa6\x80\xd5\xf6a\x9d
\x87x\x82J\xf4n\xaf\xa3\xc5B\xb7\xbe{"\x1b\x19\x03[\xc1y\x04\xc1\xa3\xe1\xb3\x82
\xc9,@\xfc\x11?\xda\xbd=9h\xa3\xa1fx\xec\xc3\xff\xaa\xedY`\xeb\x1f\xa8\xd4\xf4M\
x96\x1d\x8c\xd2\xccv\xb6\x94 kH8?\x02\xda\x96^\xcc\x86\x9b\xc7?\xbe\xda,\xca\xea
\xf6\xf5SY-
:T+\xd0#\x08\x7f(6LU;\xebcxx\xf0M\xd8\x89\xc1b\xa1Y\x1a\xec3!ir\x95e\xfe\xa2\x90
R\x14\x04\xb9\xa3\xe0\xabLo]\xfc\xf2\x8c\x81\x0c\x974\x01~\x94\xcdu\x07\xd3+\x83
\x82a\xc9v\xa3\xf5^{\xb1\x1f\x7f\xb6\xe9\x19\xcb=yg\x83\xb5f\x8e\xec\xa3\x0b\xab
\x12Y0\xf3\x1f\xa8\xd4tF\x96U\x8c\x82\xefvL\x94 bH6>\xf2\xd5\x96\x8d\xcc\x86\x9a
\xc7y\xbd:"\xca_\xf6\x15QY\x879\xf40\xd0\xea\x07\xef16\xa3U\x8b\xf2c{w\x10E\xd8\
xbc\xc1b\x93Y\x03\xed\xf3\x12i\x97\x95\xb5\x06\xa3\xe4R\x84\x0c\xb9\x9a\xe0KMo\x
01\xfd\xc2\x82\x811\x97t\xfd}\'\xce\xd5\xfe\xd2l\x82\xf2f\xc9\xe5\xa3\xd5V{Y \xb
f\xc2\xe9\xa9\xca=yg\x93\xb5\xc6\x97\xec\xb9\n[\x1eYh\xf3?\xa8\xd4\xe7F\x86L\x8c
\xdb\xef\xe6T\x94\x08bx8>\xfe\xd5\x96\x8e\xcc{\x99\x97\x7f\xbd\xe7!*[\xf6\xf8O\x
c9\x8c9I0\xa0\xe4\x07\x8e1\xf6\xacU9\xf2\xf3\x88w\xd8C\x88\xba\xc1m\x92\xc9\n\xe
d"\x12y\x93\x95a\x06\xb3\xf0R\x01\r\t\x93\xe0\xa6L?\x0f\xfd\xe2\x83\x81<\x97?\xf
d\xfd#\xceo\x00C|\x82{e\x99\xd6\xa3\xf6V\xbba \x87\xc2\x19\xaa\xcaCyw\xa3\xb5k\x
98\x8c\xc3\n\xaf\x1d\xf9`\xf3\x15\xa8T\xf4F\x90M\x9c\xd1\xefiV$\x1fbQ8\xbe\x02\x
d6\x87\x8e\xdc\x86\x99\xc4\x7f}\xd9!\xc0Z\xa6\xf5OO\x8diT0\xce\xe3\xc7~1/\xac\xa
5;\xf2g\x88g\xf1C\xcb\xb9ad\x92`\n\xad4\x12d\x92\x05e\x06\x9f\xf0B\x13\r\xb3\x93
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8\x19\xa8k\xbd\xf4\xa3B@\x14i\xc0oLLL\xf5\x11\xd4Y\xf4y\xb3\xdd\xa7\xfa\xc7\xfa>
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88\xf5I\xd4#\xc8\xc8\x16\xa8D\xbdT\xafB\xc2\x14I\xc0o\xe0KL\xfa\x11\xd1Zdz\xb3\x
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c5\xcf\xeb\xf3\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x04\n
\x13\x1f&+2<'
Signature Size:  4627
Signature is valid.
```

Testes Automáticos Testes automáticos aos diferentes niveis de segurança do Dilitium. Nestes são testados os tempos de geração de chaves, assinatura e verificação da assinatura, bem como os tamanhos da chave pública, privada e assinatura e se o algoritmo funciona corretamente.

[ ]:
```python
times = {"44": [], "65": [], "87": []}

for i in range(10):
    message = "".join([chr(randint(65, 90)) for _ in range(randint(100,10000))])
    print(message)
    for version in [44, 65, 87]:
        tkg,ts,tv,ver,pk,sk,sign=Dilitium_Test(version, message)
        print(version,tkg,ts,tv,ver,len(sk),len(pk),len(sign))
```

```
        if not(ver):
            print("Invalid Signature")
            break
        times[str(version)].append([tkg, ts, tv, len(pk), len(sk), len(sign),␣
 ↪len(message)])

# Times and lens from Dilithium 44 Tests
dil_dsa44_kg_times = [x[0] for x in times["44"]]
dil_dsa44_sign_times = [x[1] for x in times["44"]]
dil_dsa44_verify_times = [x[2] for x in times["44"]]
dil_dsa44_pk_len = times["44"][0][3]
dil_dsa44_sk_len = times["44"][0][4]
dil_dsa44_sign_len = times["44"][0][5]
dil_dsa44_message_lens = [x[6] for x in times["44"]]


# Times and lens from Dilithium 65 Tests
dil_dsa65_kg_times = [x[0] for x in times["65"]]
dil_dsa65_sign_times = [x[1] for x in times["65"]]
dil_dsa65_verify_times = [x[2] for x in times["65"]]
dil_dsa65_pk_len = times["65"][0][3]
dil_dsa65_sk_len = times["65"][0][4]
dil_dsa65_sign_len = times["65"][0][5]
dil_dsa65_message_lens = [x[6] for x in times["65"]]

# Times and lens from Dilithium 87 Tests
dil_dsa87_kg_times = [x[0] for x in times["87"]]
dil_dsa87_sign_times = [x[1] for x in times["87"]]
dil_dsa87_verify_times = [x[2] for x in times["87"]]
dil_dsa87_pk_len = times["87"][0][3]
dil_dsa87_sk_len = times["87"][0][4]
dil_dsa87_sign_len = times["87"][0][5]
dil_dsa87_message_lens = [x[6] for x in times["87"]]
```

PFFMZRBKYWXZGQEXGREVGEOVMDZYPRNVOHCIHAUNJQKTWHCTQNYLLMRFUYOOVSWAPSZJEBULYPICCOPG
SOXOGCAZDFRHEVBMAQAOGHRVNCJSQCIEXOGAOZJNBNXTBESCUTETWUIJZNRGKXSJABCDVGSWMXLLTZQR
DAWTFUFERHUMYSLBQEJLEICKJSGJAZYJYYLWWDVXDRGQZMGXXNCATCLYVSABWTTSOLSREDUXKVRNGEXQ
VBTSIMZPNYIGNMMQTIKAMVFSWVFEVPJBKSZJTUCRPHHUBBDAVGTMHRILNKIPIXTMAHDOMVNDRDOPPYYB
IHOZDNPQYOIQTNZPBBJKDFNATBDLROEOFFHVOABIJRTGGUEKUHNUAYPKZUEAFDVYMKANZCGVYANQEKLK
PFAKMUJCSQZAWEZFCAGWLFCMDQAWUQUEYYPQCDYXAHARVYXVMNUTBGXCQCFKMQLBJQDHRKHVIQWFXQOO
NLCULZVODHJMGHFMGPLSVDIKWYVEPJDGHPFUHHZQQJKIXERZXFFVVZQHHZLAWEXOXGKZCAVAAPJYCNGS
SHPLISXVKULZGWSGAEIIRTNKPBKICEQTEFZSTNUFVSTEFZATCEWTLHBZKSMJDVKNWBKWCKRTBCQKSMZV
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GLRJBJASFODPXLPDHWMGBUOXTSFTZHPCRMFEJTACPLEEWFBFGRFPVQTTPMVPQLRFRHVWSXCHIQOTDUBX
FDYHDAUVDTTAHNMSZSISUVEVNLKLAMZERTTDVRGTFDSMRRZXEQULVLBPLJMFZFSONBLMGPQNWEBQHZKB
TZTWMQYVLPCAJOJFVPCTVFSPDYGJWOYMIPSQWPNQGHYBHVHEMRMSVZSQPFFMGKUWYABVZHSNXKBAYDHN
CARDMFAIHNOTYONEIXDQBCCFXBTYOCIMJXSGIZTXNBUDWZDRTOZCWKILMHJWCNXJEGORHXEHPLDJUFYP

TUVQYCZKBUGDNUWRXRCZAKHLYPLTQWJUWXQKHRQOLXYEUYDGPVNAJEHBKCOLMATRYELHIRZIGCCQEHSS
ENLNPEVDJTWQCRGKSKXBYXQYTYCVNPXXMSLWJPVOVJEHIVNGUORJTHZLKRECOSZBUZKWABLPFYVOKHLI
TVASRUPEKEKOZEZAFEBVFECZKNUFSRYHMDDDVHCSETJDVAHEPNXLUXKCTRPKYCBXIYRTOLPHPLEZEPRP
FOXRAIYECEIDWMRMVRWJBXFRFAXZFRKNJCBHIMARLMSVUKZQXBZGVHBJVCSDAHCGSKMPYBSOTAHTANBF
HGXSBCMBEETGWSYQLDMSMZDJLCCHGBGXMKJPEKHJLOMNUBKHRWDLHKSXFBCSMPRLYVNFARDSHQOUMNJR
ECIUIAZSSKXFVMABQJVSDUKIWUHXADDEZZCTKGSOGJPYBSZCMGGKBYPRCOXWTHBBJXCGHVZCNOUAHPPP
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LYJXEFJIGEJYOMOYVTDIUWYPSOFQDEGWETQJRDXMMPUUHVAKEURXGNRZCQPYFAUDJXTPNEJHKUWUZZVI
TRQOWEPVCAMBXPFJEWFUGFJWAMTPSCMAEYJTOKWOAMKHKHNELGZWSUBJCURTZVLKWNVUBQPZTGTZOQWE
CKVERQECUZHPRQPPBWEWGUPTRIGVITYTPYRULMGUBQHWLEQTTATFYYHFFFNDPFMBJNJBHDIDWUFKOZHY
JUDJVNJKPFCZNFXQEBDJNHQPRBMHYQEBLTUDQHUMEQCVPRGSBBOLZPHWLDYLWPJLTPRZXTQDPJJGGIQF
ZCRVHCHRLJKTIDJNCKNKCSQUEWZQBIEGWNDEEDCSPUPMCBRTYIVSNAMFVOIZORFDPNGXSECTHTKWYPAK
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YTVKQFIMRDJYCWBCWNDZHXGYZWFMOMVADIEDMBABQKVWWFIIIQHAFVWOEIKNITCCDZDANTRZMFMQPHAB
ICBGWCPYCRNBBIQXGRIDHYBJBNUNROELIHXANVUAMWQCFGCAOILNLRHGGXFUBGRXXLJGZWUWFFFKBNKO
OFZVNNRWOJIWIJYPIJIDXZQECHLUWKMCCGAUMHBJIKBIUOUYEIFAAYQHWUPPZQQOKWFFWJBORAMPPEMB
VKTBTRHXOPCDPBCWTJKGUGSDVKSKKNXMATDAYIBHGVGKCKNMJOGATEASVCNNKJBDXWKHDGJCHYYEQZZL
BZSSZHZETMJQKBLBCKPRLPYFSUTUHUZNASTMDEPKGVXDKGMHYNAIRIOKXMUDWLWSMYBBMKUULCTBUYXW
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RUHCIDSFLKCSKQIFAKKJLEJCZCDXASSANQKSTFDAWBLXVKGONCLSCOBJGEVNPXYWPPMMVADHGAJUYQVJ
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GHYZVDYVGOHLBLKUIHPOGXDKQZDSPAGPBFEXDSSEULCDFQOHMCWCNVNRHWXFFPFXPHINKSMLYKRYHAWQ
FULDOWQCNHVDXHVIQVYOLVLDFWWDFDCXKQWMYSBUTPUMEEQRTTGROHXOGBKEMSZRQDPCELPMXLNJPIBM
DUIIUABBZXWPCZOXKYYQFFBLRJAGWNNSZJAACMUIDMUZFWUFKCMGKBUTFUTWPWAHYEZUMUKNSHIYUYYE
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LUHITNIOEYURFUOGICVENRXEIWGQYXIENDYIGVGQIEIEKCJBPTMNKLXVDYDXKKHDBZLMDILGSVEELHDI
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OKSVJZRIJVPVOATSJXAVIRGMOGSXIIAVXCCJETEGQAZWNBRUPSNZJFXPKWILEXCHNCFVDRTLXAGGDXPI
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YTWLYLFLQXIJVBRHTKFZUGVUMMHKWSCQJRDZYMYSJWMVKYHDOEUKOXBATFN
44 0.2915046215057373 0.8287069797515869 0.5780596733093262 True 2560 1312 2420
65 0.4006361961364746 1.0208897590637207 0.6984672546386719 True 4032 1952 3309
87 0.616485595703125 1.4487121105194092 0.9335939884185791 True 4896 2592 4627
EPANRKGKSOPMMRBYHAUTZXVPGUPLRCRAIUILLIEKDVBSRRKEISJXZIXNVAFZOZDQDTTQQPNZIKXTMJVS
YOXIQIQTNRVPBMPZAVLBYQITCFNGCWNSSBRNAZFSGAYCDNEJCKYDCXPHAXPSOBZGWSXABGMUAUGTSNBX
HBCDKVOKAIAZNHWNDZSOHKOREKZTAOODPQXSBUCWPNTVHRVTNLUPYDTEYZDQCAZJQVTATOPBXOHXBNNI
EXVGUMJSAQGMZGFZPPCEQERMLQZUVGJBMTUOBWLOKPLJSYTNHPPJMKKISBRPZGVTEOZVZYEPATDOJBQH
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WQTRMYVUJLFEFNZAFNBUEPTXVZLKLMJCSSFVUWHYAOICQDDWQXTGGNQTHFATUACGWLLEDVHYRSPIVLFN
UGOEDPEXBMMNCSXSXFPYZBTWONXOJZDAKCZSQCOCCWZNTTQFGOCAOSTAODLVKUNJYWQJOOTZXMESOOOS
GTXMWQURAQNVWPNEXJUOQOJVZPXIOCPJHVYJWPCRYINDXHCGKFLXDZCIGGCVKDTEKOFGCCXZNMTJZQPC
RLBCUEUYXFKXRNAWRLMCHFTLTSQKRLJAVHXQJENJXARPAGJMSNBUMCVLGWHNVTTVXXVRMHQPTSYNENUU
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LYAWWNUUSHGRLXRDHWHVBORAHCPYNBTOVVNQZBOOKXJDCDXJCEZGYMDNGJBQOTTLQRGLPBXILXMSZBAN
TYZBRTVCNDBIRVFFSVSEWYSOXSQNVBYMTNUQCQYKJYRADBZZAPTJCARYWTEFSBSDXFKFBWVTWOSMAGJZ
KLROWAKFACSZBZAEMWAFFNXCFOZEEXSSUALPZDIIUTLDEXKDEYCFDLZVORGEPSCORSXTDIDAMSZMKWIF
RFFCFXAFFPQYHORIBBJCNZVYVWAGZITIBUZMOUDVIYKJWFFDCDQZENZYSSPTOGGSJNSZESFOENCLORPI
VFYCHYUYABAGISDLZHKUABEZJKKCECFRQKDMEUPSZXIMMLPYRLWNADXEPLQDSXYDOIZGAKDNUTZKIPDK
RGXGKAQOJLUFVNAAOFZISHLNMVLRDMCTUHJWWKLDIBWVTFZNJUAUBGCVYDKAKNGLFSIAVLRAIZBMUNLJ
MPAXSJCPRNLEDEDKRZBPOWJQMLRCILWEUQGJWVESLZPJMYLFUDYPHLXCDAHJTGEQXVGDRWYXCQEMFBXI
CZQKGSJUDHWYAWLRBNALYPHXVDKAMFCUQWDIEMONBIZYKYNYIXZVNRERRYZGKASAIXILPWVMYITRZQ
44 0.26203465461730957 1.186126470565796 0.49564266204833984 True 2560 1312 2420
65 0.41565752029418945 2.7970757484436035 0.6748759746551514 True 4032 1952 3309
87 0.5848491191864014 3.0973775386810303 0.9338617324829102 True 4896 2592 4627
```

Análise aos resultados

Tamanhos da chave Pública, Privada e Assinatura

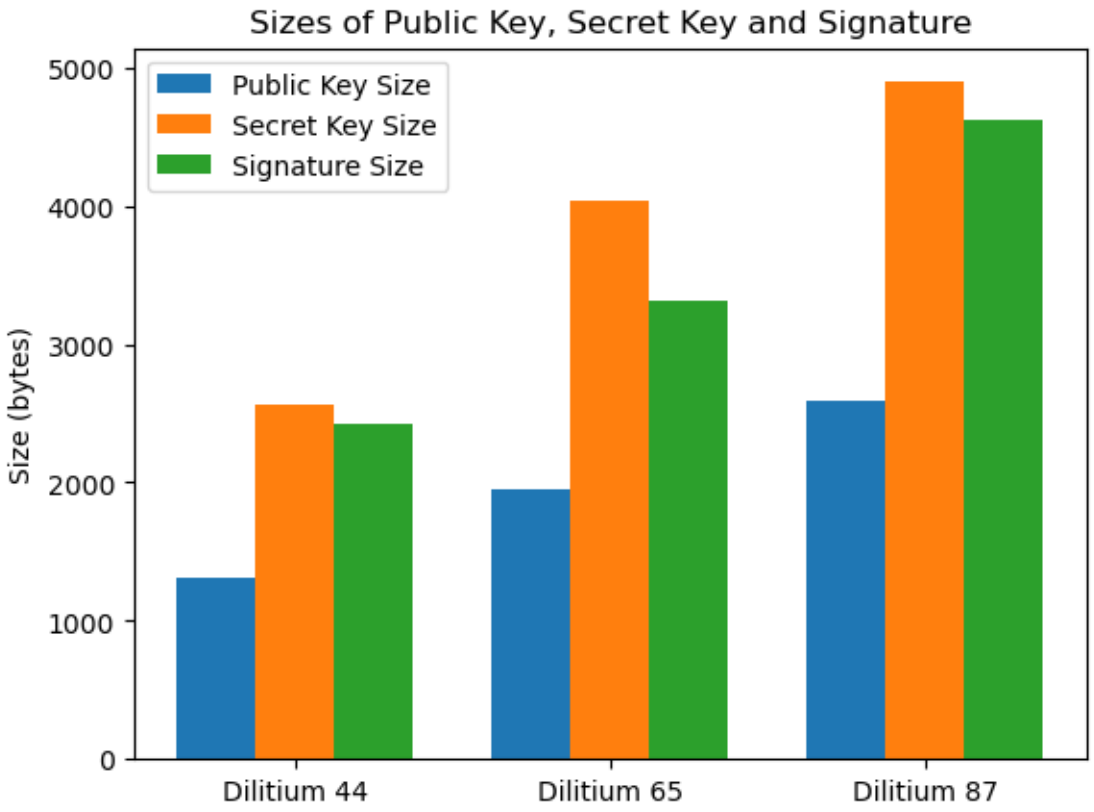
[ ]:
```
labels = ['Dilitium 44', 'Dilitium 65', 'Dilitium 87']
pk_lens = [dil_dsa44_pk_len, dil_dsa65_pk_len, dil_dsa87_pk_len]
sk_lens = [dil_dsa44_sk_len, dil_dsa65_sk_len, dil_dsa87_sk_len]
sign_lens = [dil_dsa44_sign_len, dil_dsa65_sign_len, dil_dsa87_sign_len]

x = np.arange(len(labels))
width = 0.25

fig, ax = plt.subplots()
rects1 = ax.bar(x - width, pk_lens, width, label='Public Key Size')
rects2 = ax.bar(x, sk_lens, width, label='Secret Key Size')
rects3 = ax.bar(x + width, sign_lens, width, label='Signature Size')

ax.set_ylabel('Size (bytes)')
ax.set_title('Sizes of Public Key, Secret Key and Signature')
ax.set_xticks(x)
ax.set_xticklabels(labels)
ax.legend()

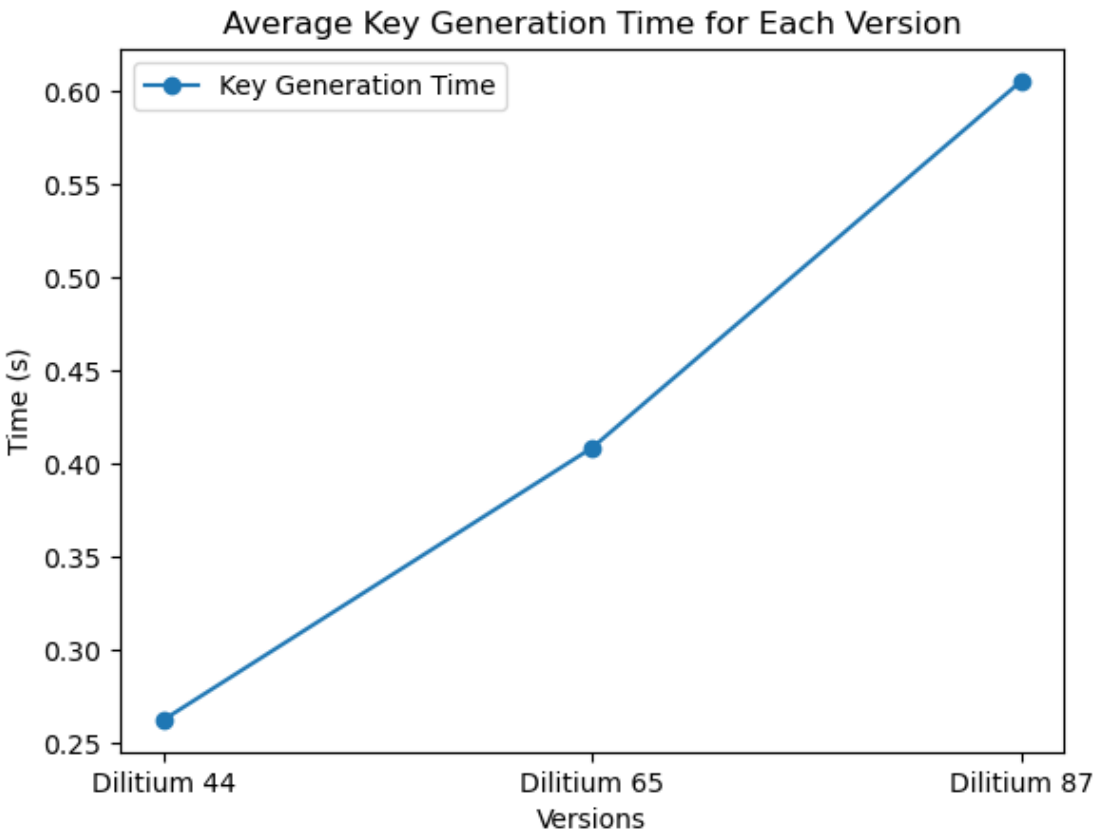
plt.show()
```



Tempo médio de geração de chaves

[ ]:
```
labels = ['Dilitium 44', 'Dilitium 65', 'Dilitium 87']

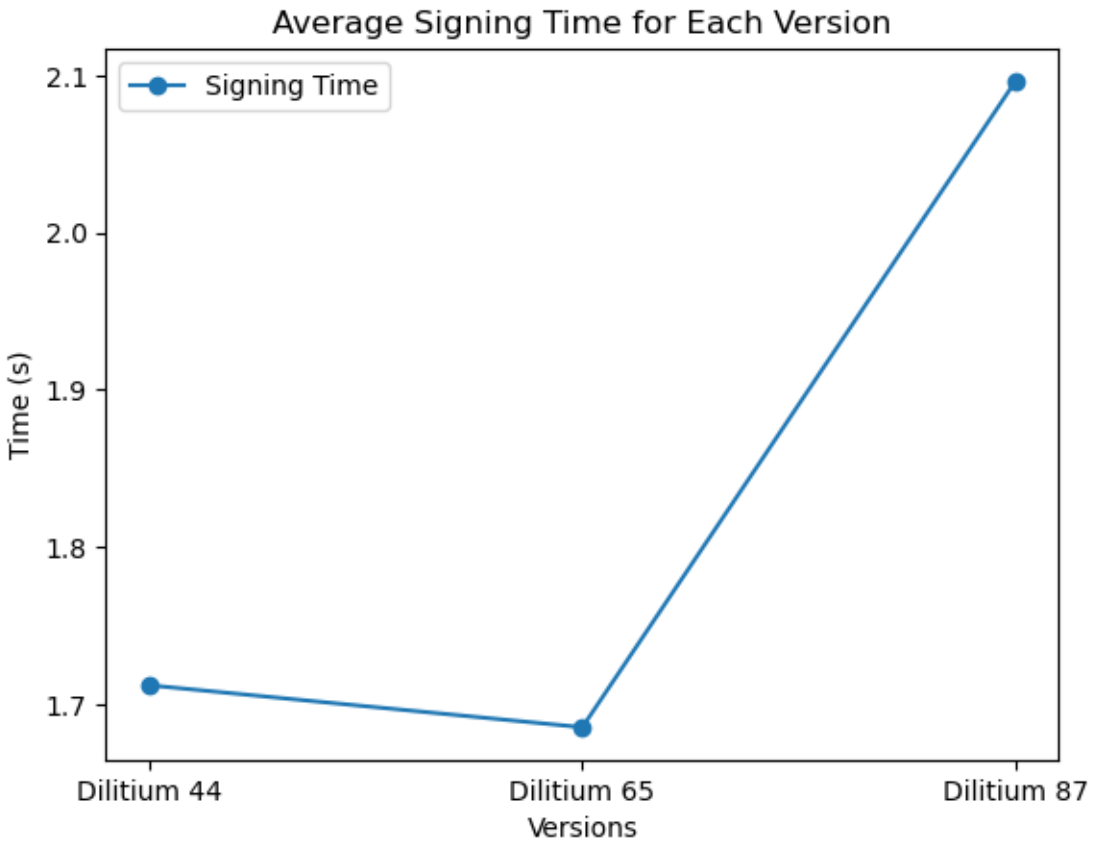
kg_times = [sum(dil_dsa44_kg_times)/len(dil_dsa44_kg_times),␣
 ↪sum(dil_dsa65_kg_times)/len(dil_dsa65_kg_times), sum(dil_dsa87_kg_times)/
 ↪len(dil_dsa87_kg_times)]
plt.plot(labels, kg_times, label='Key Generation Time', marker='o')
plt.xlabel('Versions')
plt.ylabel('Time (s)')
plt.title('Average Key Generation Time for Each Version')
plt.legend()
plt.show()
```



Tempo médio de assinatura de mensagens

[ ]:
```
labels = ['Dilitium 44', 'Dilitium 65', 'Dilitium 87']

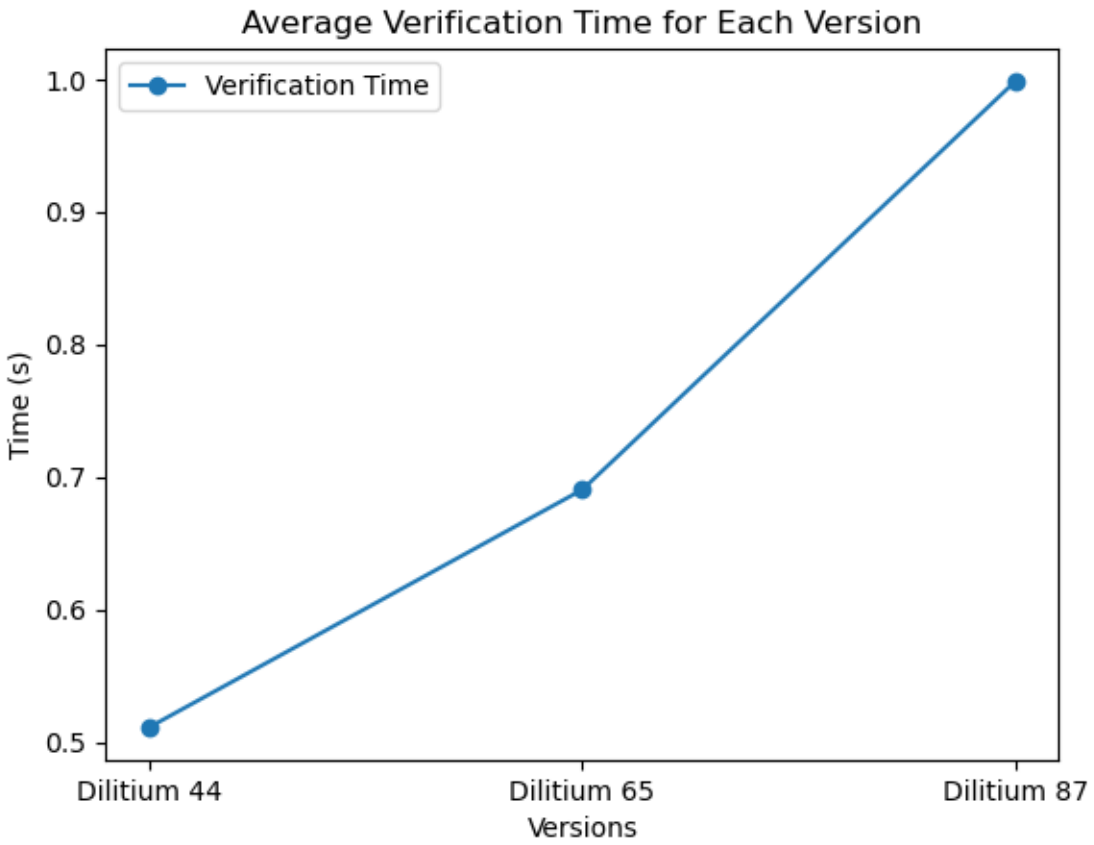
sign_times = [sum(dil_dsa44_sign_times)/len(dil_dsa44_sign_times),␣
 ↪sum(dil_dsa65_sign_times)/len(dil_dsa65_sign_times),␣
 ↪sum(dil_dsa87_sign_times)/len(dil_dsa87_sign_times)]
plt.plot(labels, sign_times, label='Signing Time', marker='o')
plt.xlabel('Versions')
plt.ylabel('Time (s)')
plt.title('Average Signing Time for Each Version')
plt.legend()
plt.show()
```



Tempo médio de verificação de assinaturas

[ ]:
```
labels = ['Dilitium 44', 'Dilitium 65', 'Dilitium 87']

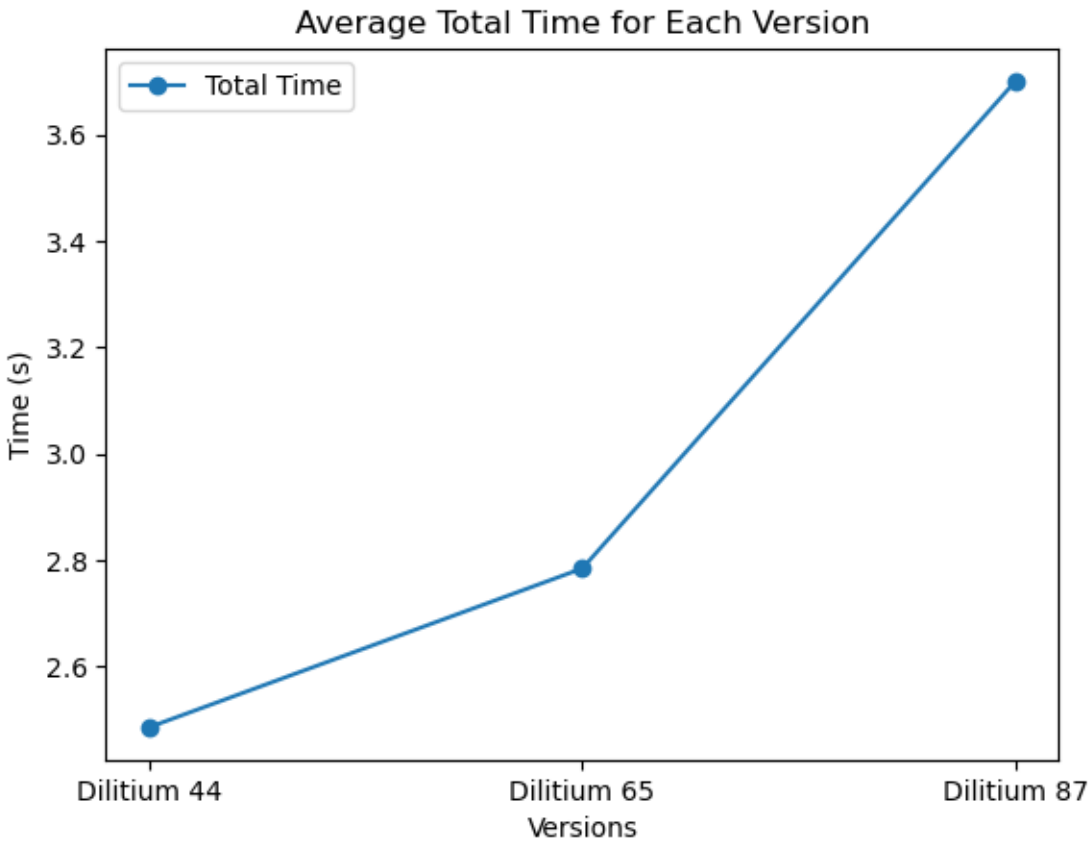
verify_times = [sum(dil_dsa44_verify_times)/len(dil_dsa44_verify_times),␣
 ↪sum(dil_dsa65_verify_times)/len(dil_dsa65_verify_times),␣
 ↪sum(dil_dsa87_verify_times)/len(dil_dsa87_verify_times)]
plt.plot(labels, verify_times, label='Verification Time', marker='o')
plt.xlabel('Versions')
plt.ylabel('Time (s)')
plt.title('Average Verification Time for Each Version')
plt.legend()
plt.show()
```



Tempo médio total

```
[ ]: labels = ['Dilitium 44', 'Dilitium 65', 'Dilitium 87']

total_times = [sum(dil_dsa44_kg_times)/len(dil_dsa44_kg_times) +␣
 ↪sum(dil_dsa44_sign_times)/len(dil_dsa44_sign_times) +␣
 ↪sum(dil_dsa44_verify_times)/len(dil_dsa44_verify_times),␣
 ↪sum(dil_dsa65_kg_times)/len(dil_dsa65_kg_times) + sum(dil_dsa65_sign_times)/
 ↪len(dil_dsa65_sign_times) + sum(dil_dsa65_verify_times)/
 ↪len(dil_dsa65_verify_times), sum(dil_dsa87_kg_times)/len(dil_dsa87_kg_times)␣
 ↪+ sum(dil_dsa87_sign_times)/len(dil_dsa87_sign_times) +␣
 ↪sum(dil_dsa87_verify_times)/len(dil_dsa87_verify_times)]
plt.plot(labels, total_times, label='Total Time', marker='o')
plt.xlabel('Versions')
plt.ylabel('Time (s)')
plt.title('Average Total Time for Each Version')
plt.legend()
plt.show()
```



Comparação dos tempos médios das várias componentes

[ ]:
```
labels = ['Dilitium 44', 'Dilitium 65', 'Dilitium 87']

kg_times = [sum(dil_dsa44_kg_times)/len(dil_dsa44_kg_times),␣
 ↪sum(dil_dsa65_kg_times)/len(dil_dsa65_kg_times), sum(dil_dsa87_kg_times)/
 ↪len(dil_dsa87_kg_times)]
sign_times = [sum(dil_dsa44_sign_times)/len(dil_dsa44_sign_times),␣
 ↪sum(dil_dsa65_sign_times)/len(dil_dsa65_sign_times),␣
 ↪sum(dil_dsa87_sign_times)/len(dil_dsa87_sign_times)]
verify_times = [sum(dil_dsa44_verify_times)/len(dil_dsa44_verify_times),␣
 ↪sum(dil_dsa65_verify_times)/len(dil_dsa65_verify_times),␣
 ↪sum(dil_dsa87_verify_times)/len(dil_dsa87_verify_times)]
```

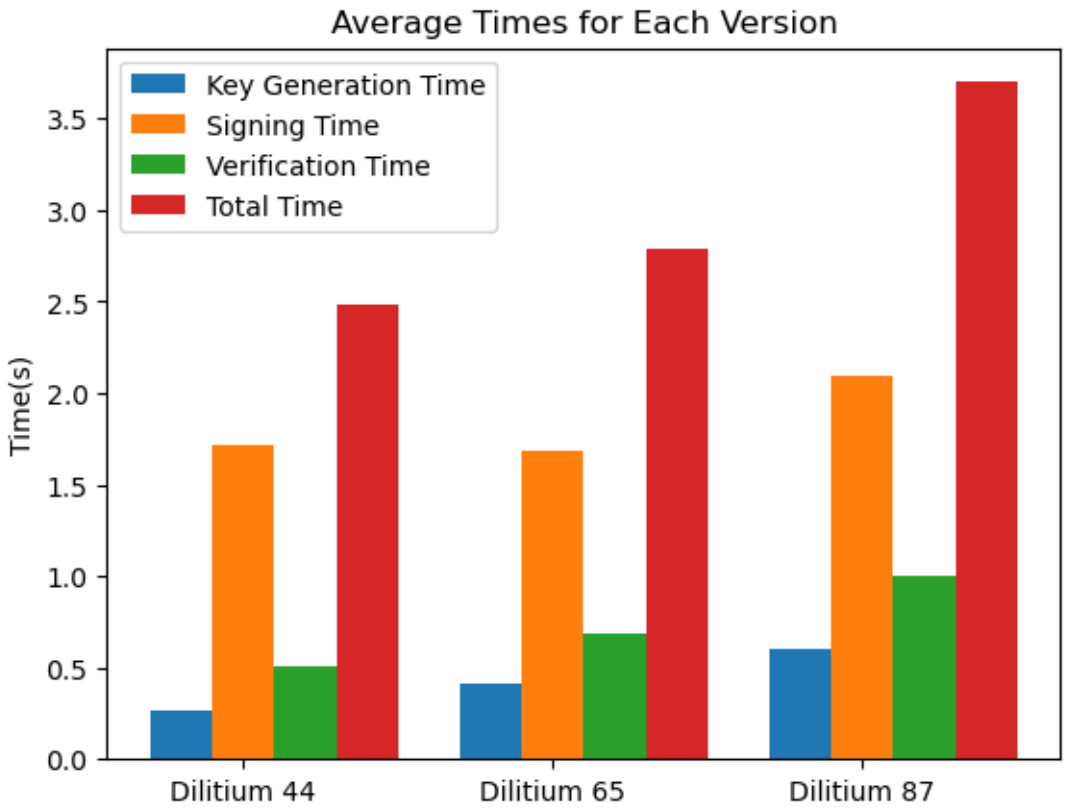
```
total_times = [sum(dil_dsa44_kg_times)/len(dil_dsa44_kg_times) +␣
 ↪sum(dil_dsa44_sign_times)/len(dil_dsa44_sign_times) +␣
 ↪sum(dil_dsa44_verify_times)/len(dil_dsa44_verify_times),␣
 ↪sum(dil_dsa65_kg_times)/len(dil_dsa65_kg_times) + sum(dil_dsa65_sign_times)/
 ↪len(dil_dsa65_sign_times) + sum(dil_dsa65_verify_times)/
 ↪len(dil_dsa65_verify_times), sum(dil_dsa87_kg_times)/len(dil_dsa87_kg_times)␣
 ↪+ sum(dil_dsa87_sign_times)/len(dil_dsa87_sign_times) +␣
 ↪sum(dil_dsa87_verify_times)/len(dil_dsa87_verify_times)]

x = np.arange(len(labels))
width = 0.2

fig, ax = plt.subplots()
rects1 = ax.bar(x - width, kg_times, width, label='Key Generation Time')
rects2 = ax.bar(x, sign_times, width, label='Signing Time')
rects3 = ax.bar(x + width, verify_times, width, label='Verification Time')
rects4 = ax.bar(x + 2*width, total_times, width, label='Total Time')

ax.set_ylabel('Time(s)')
ax.set_title('Average Times for Each Version')
ax.set_xticks(x)
ax.set_xticklabels(labels)
ax.legend()

plt.show()
```



1.1.3 Tabela de Resultados

```
[ ]: # Make a table with sizes and average times for each version

data = {'Version': ['Dilitium 44', 'Dilitium 65', 'Dilitium 87'],
        'Public Key Size': [dil_dsa44_pk_len, dil_dsa65_pk_len,␣
 ↪dil_dsa87_pk_len],
        'Secret Key Size': [dil_dsa44_sk_len, dil_dsa65_sk_len,␣
 ↪dil_dsa87_sk_len],
        'Signature Size': [dil_dsa44_sign_len, dil_dsa65_sign_len,␣
 ↪dil_dsa87_sign_len],
        'Average Key Generation Time': [sum(dil_dsa44_kg_times)/
 ↪len(dil_dsa44_kg_times), sum(dil_dsa65_kg_times)/len(dil_dsa65_kg_times),␣
 ↪sum(dil_dsa87_kg_times)/len(dil_dsa87_kg_times)],
        'Average Signing Time': [sum(dil_dsa44_sign_times)/
 ↪len(dil_dsa44_sign_times), sum(dil_dsa65_sign_times)/
 ↪len(dil_dsa65_sign_times), sum(dil_dsa87_sign_times)/
 ↪len(dil_dsa87_sign_times)],
```

```
        'Average Verification Time': [sum(dil_dsa44_verify_times)/
 ↪len(dil_dsa44_verify_times), sum(dil_dsa65_verify_times)/
 ↪len(dil_dsa65_verify_times), sum(dil_dsa87_verify_times)/
 ↪len(dil_dsa87_verify_times)],
        'Average Total Time': [sum(dil_dsa44_kg_times)/len(dil_dsa44_kg_times)␣
 ↪+ sum(dil_dsa44_sign_times)/len(dil_dsa44_sign_times) +␣
 ↪sum(dil_dsa44_verify_times)/len(dil_dsa44_verify_times),␣
 ↪sum(dil_dsa65_kg_times)/len(dil_dsa65_kg_times) + sum(dil_dsa65_sign_times)/
 ↪len(dil_dsa65_sign_times) + sum(dil_dsa65_verify_times)/
 ↪len(dil_dsa65_verify_times), sum(dil_dsa87_kg_times)/len(dil_dsa87_kg_times)␣
 ↪+ sum(dil_dsa87_sign_times)/len(dil_dsa87_sign_times) +␣
 ↪sum(dil_dsa87_verify_times)/len(dil_dsa87_verify_times)]}

# dont use pandas
def format_cell(content):
    return f"{content:<30}"

# Print the header with separators
header = (
    format_cell("Version") + "|" +
    format_cell("Public Key Size") + "|" +
    format_cell("Secret Key Size") + "|" +
    format_cell("Signature Size") + "|" +
    format_cell("Average Key Generation Time") + "|" +
    format_cell("Average Signing Time") + "|" +
    format_cell("Average Verification Time") + "|" +
    format_cell("Average Total Time")
)
print(header)
print("-" * len(header))

# Print the data rows with separators
for i in range(3):
    row = (
        format_cell(data['Version'][i]) + "|" +
        format_cell(data['Public Key Size'][i]) + "|" +
        format_cell(data['Secret Key Size'][i]) + "|" +
        format_cell(data['Signature Size'][i]) + "|" +
        format_cell(data['Average Key Generation Time'][i]) + "|" +
        format_cell(data['Average Signing Time'][i]) + "|" +
        format_cell(data['Average Verification Time'][i]) + "|" +
        format_cell(data['Average Total Time'][i])
    )
    print(row)
```

```
Version                       |Public Key Size                |Secret Key Size
|Signature Size                |Average Key Generation Time    |Average Signing
```

```
Time           |Average Verification Time     |Average Total Time
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
-------
Dilitium 44                    |1312                          |2560
|2420                           |0.2627302010854085
|1.7121216985914443             |0.5110272301567925
|2.4858791298336453
Dilitium 65                    |1952                          |4032
|3309                           |0.40870338678359985
|1.6854148209095001             |0.690295547246933             |2.784413754940033
Dilitium 87                    |2592                          |4896
|4627                           |0.6052512781960624
|2.0962279524121965             |0.9984170368739537
|3.6998962674822122
```