RSA Algorithm Implementation in Python

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Exponentiation by squaring

Description

- This method is based on the observation, that for a positive integer n we have:

$$x^n = \begin{cases} x\,(x^2)^{\frac{n-1}{2}}, & \text{if } n \text{ is odd} \\ (x^2)^{\frac{n}{2}}, & \text{if } n \text{ is even.} \end{cases}$$

- In python this is implemented by using recursive function, until the power is equal to 1

Python implementation

```
def pow_es(self, base, power):
    # Raise to power by using exponentiation by squaring
    # If power is equal to 1...
    if power == 1:
        # return base value (stop recursion cycle)
        return base
    # If power is even...
    if power % 2 == 0:
        # call same function with squared base half power
        return self.pow_es(base * base, power / 2)
    # If power is odd...
    else:
        # multiply base by value of same function with
        # squared base and half of (power - 1) as arguments
        return base * self.pow_es(base * base, (power - 1) / 2)
```

Finding inverse number

Description

- Finding inverse number (in this case the one that q mod p = 1) is achieved by checking if xq mod p is equal to 1
- This is achieved by by incrementing x from 0 until such number is generated
- When d value is needed, the function looks like this: q_inv(e, (p-1)*(q-1))

Python implementation

```
def q_inv(q, p):
    x = 0
    # Do while xq%p is not equal to 1:
    while x * q % p != 1:
        # Increment x by one:
        x += 1
    return x
```

Chinese remainder algorithm

Description

- p and q are prime numbers used for key generation
- d_p = d mod (p-1)
- d_q = d mod (q-1)
- $q_{inv} = q^{-1}$mod p
- These values allow the recipient to compute exponentiation $m = c^d$ mod (pq) efficiently as follows:
- $m_1 = c^{dp}$ mod p
- $m_2 = c^{dq}$ mod q
- $h = q_{inv}(m_1 – m_2)$ mod p
- Final result (m) is: $m = m_2 + hq$

Python implementation

```
def chinese_remainder(self, c, p, q, d):

    dp = d % (p - 1)
    dq = d % (q - 1)

    qinv = self.q_inv(q, p)

    m1 = self.pow_es(c, dp) % p
    m2 = self.pow_es(c, dq) % q

    h = qinv * (m1 - m2) % p

    return m2 + h * q
```

Live showcase:

https://isks6.pythonanywhere.com/rsa/

View source code:

https://github.com/EErikas/PythonCryptoExample