MAS114: Lecture 18

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Alice and Bob are of course named so as to start with the letters A and B respectively. Eve is so named because she is an *eavesdropper*, or perhaps because she is *evil*.

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The problem with this old-time approach is that the same secret is used to encrypt and decrypt the message, so needs exchanging.

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5. Alice sends Bob the encrypted message.
6. Bob uses his private key to decrypt it, and read Alice's message.

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Proposition

Let p and q be different primes. Then the number $\varphi(pq)$, of integers between 1 and pq coprime to pq, is given by

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As a result of that, we know (from the Fermat-Euler Theorem) that, for all a coprime to pq, we have

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and indeed

$$a^{k(p-1)(q-1)} \equiv 1 \pmod{pq}.$$

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$$m^e \pmod{pq}$$

and sends it on to Bob.

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Hence, using his private key, Bob can recover what m was from being told m^e.

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So the security of this approach depends (among other things) on it being difficult to factorise the number pq: if factorising large numbers were easy, we could get p and q for ourselves from Bob's public key. Currently, we know of no way to do this fast enough: we know how to generate primes that are hundreds of digits long, but not to factorise a product of two of them.

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Suppose Alice decides she needs to send Bob message 1245, which they've agreed in advance should mean "please meet me after this lecture".

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\end{aligned}
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The calculations

Then Alice has to calculate 1245^{71} modulo 10403. This sounds scary, but she can do it fairly quickly if she's careful:

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\equiv 7065 \cdot 6994
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So she sends Bob 8763.

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So she sends Bob 8763.
Bob receives this, and his task then is to calculate 8763^{431} modulo 10403.

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So she sends Bob 8763.
Bob receives this, and his task then is to calculate 8763^{431} modulo 10403. A similar strategy makes this possible, too, and he finds that

$$8763^{431} \equiv 1245 \pmod{10403},$$

so he has reconstructed Alice's message.

Square roots of 2

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The result that set the ancient Greeks thinking was this:

Theorem

There is no rational number $x \in \mathbb{Q}$ such that $x^2 = 2$.

Proof.

?

□