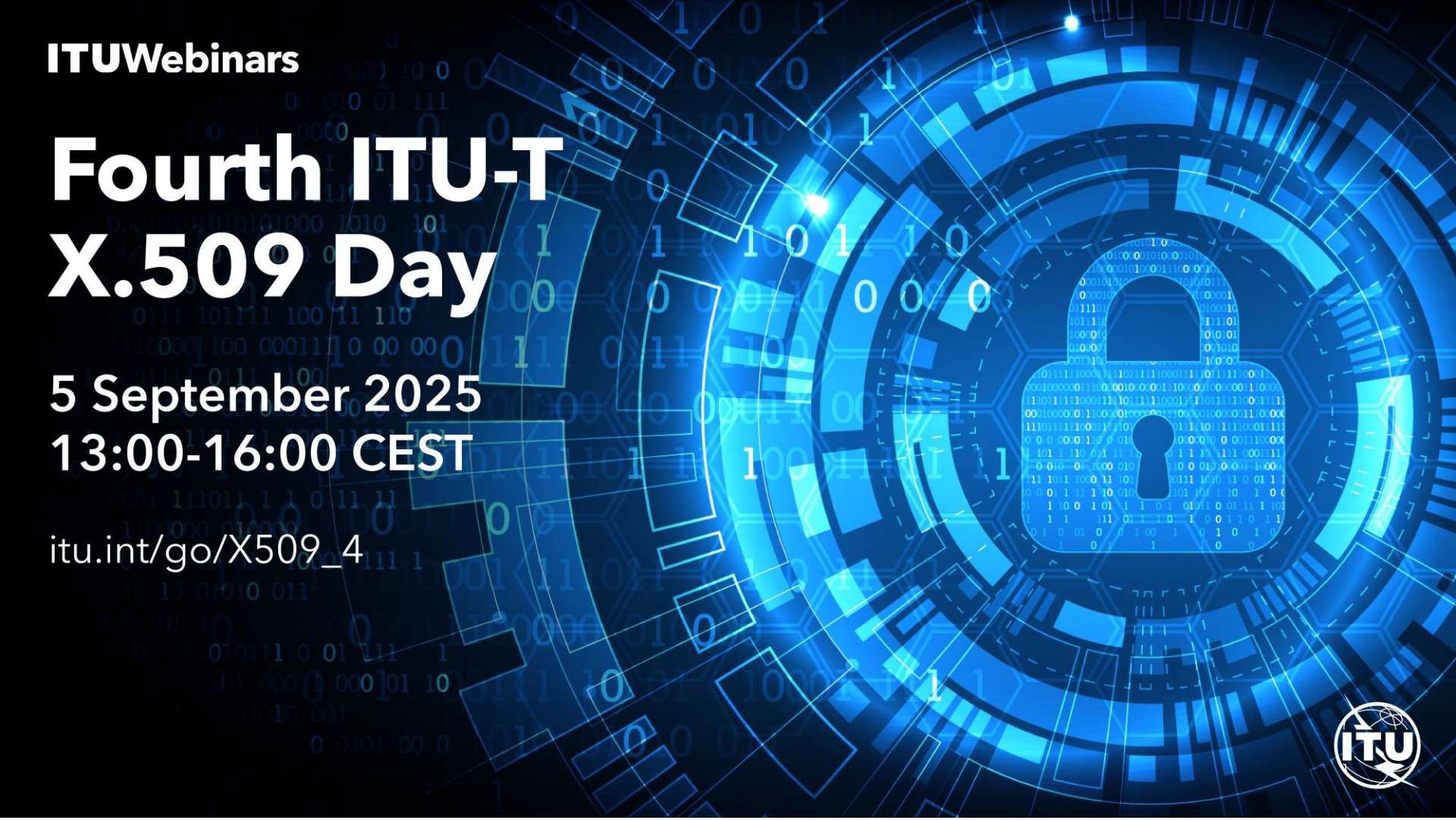

Protecting Legal Documents with Digital Signatures in the Quantum Computing Age

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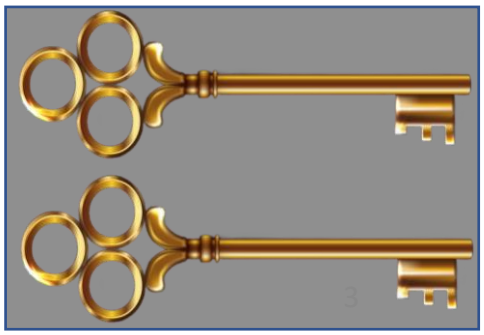
One day quantum computers will break digital signatures

We will lose the ability to state that we can assert that a presented document was signed by a specific entity and has not been altered since it was signed.

Asymmetric encryption

- A pair of keys
- The key used to encrypt cannot decrypt.
- Knowing a key does not give a hint of the other.
- Jane's key is kept *private*.
- Bob's et al keys are declared *public* and are given to one or more entities.
- Anything Bob locks in box can only be seen by Jane.
- Everyone knows when Jane locked box.



How digital signature works

- Asymmetric encryption is based on mathematical problems that are difficult to solve without some additional information.
- These are called trap door functions; there are several including RSA.
- RSA is based on the difficulty of factoring a number, X, i.e. determining which integers divide into X with no remainder. E.g. 15 can be evenly divided by 15, 5, 3, and 1.
- Can you factor 153? 1, 3, 9, 17, 51, and 153
- A prime number can only be divided by itself and 1.
- RSA's strength is based on the difficulty of factoring the product of two large prime numbers.

701,111 = 907 x 773

Can a classical computer factor such a product?

- In 1991the RSA Factoring Challenge provided a list of numbers that were the product of two prime numbers.
  - 155 decimal digits (512 bits) factored in 1991.
  - 250 decimal digits (829 bits) factored in 2020.
  - Challenge ended in 2007.
- NIST SP 800-131A, *Transitioning the Use of Cryptographic Algorithms and Key Lengths* recommends algorithms and key sizes.
- The standard is revised as processors become more powerful.
- It recommends an RSA minimum key size of 2048 bits as adequate until 2030; then 128-bit strength with < 3072.
- A predictable race between key size and processing power but quantum computing is a game changer.

Quantum computing effect on asymmetric encryption

- In 1994 Peter Shor published an algorithm that would quickly determine the prime numbers that went into the large product used to create a public and private key.
- It will also defeat other trap door functions that support other asymmetric encryption algorithms. In 2001 IBM implemented Shor's Algorithm to factor 15 using seven qubits.
- Don't just monitor the growth in qubits; quantum computers are noisy and require error correction; qubits are not yet persistent enough to support significant computation.
- A recent draft of SP 800-131A describes the quantum resistant algorithms but does not yet propose a transition schedule.

We have to have a plan

- Deploy the quantum-resistant algorithms recently standardized by NIST as quickly as we can.
- It's a risk decision as to when one starts using the new stuff.
- Effective quantum computing may take awhile but attorneys and notaries who digitally sign long-lived documents should consider signing those with the new algorithms as soon as they have been deployed.
- When it does arrive, it will be necessary to protect the integrity of documents already signed.
- Do we need to protect the original signing ceremony?

Let's ask some legal folk