DNSSEC Tutorial

Public / Private Keys

DNSSec and Cryptography

Three Key Concepts

- Public / Private keys
- Message digests, checksums, hashes
- Digital signatures

Are at the core of DNSSEC. If these do not make sense, then DNSSEC will not make sense.

Ciphertext

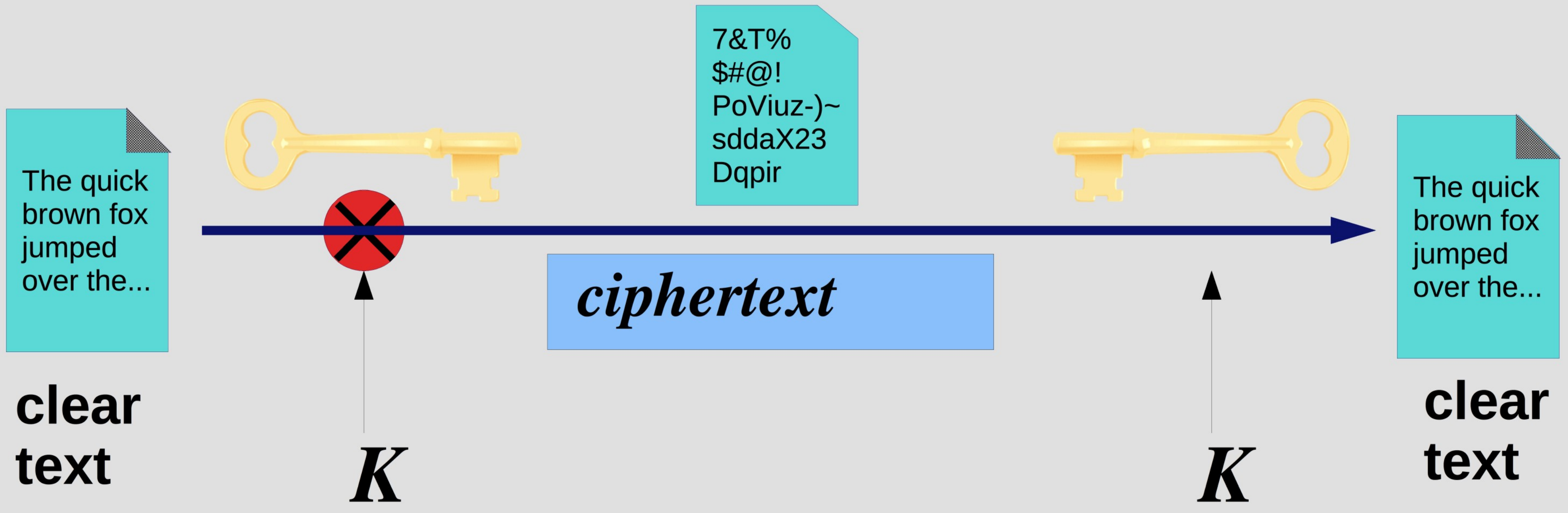
- We start with *plaintext*. Something you can read.
- We apply a mathematical algorithm to the *plaintext*.
- The algorithm is the *cipher*.
- The *plaintext* is turned in to *ciphertext*.
- Creating a secure *cipher* is *a difficult process*.
- The standardization process for AES, the replacement for the aging DES protocol, took 5 years

Keys

- In *symmetric* cryptography, a *plaintext* is transformed into a *ciphertext*, and back into *plaintext* using a*key* to the *cipher* (the algorithm used) on both ends.
- Assuming that the *cipher* method is known, the security of the *ciphertext* rests with the *key*. This is a *critical* point. If someone obtains your *key*, your *plaintext* is compromised.

Symmetric Cipher

Single Key/Symmetric Ciphers


The quick brown fox jumped over the...
clear text
K
7&T% $#@! PoViuz-)~ sddaX23 Dqpir
ciphertext
K
The quick brown fox jumped over the...
clear text

The same key is used to encrypt the document before sending and to decrypt it once it is received

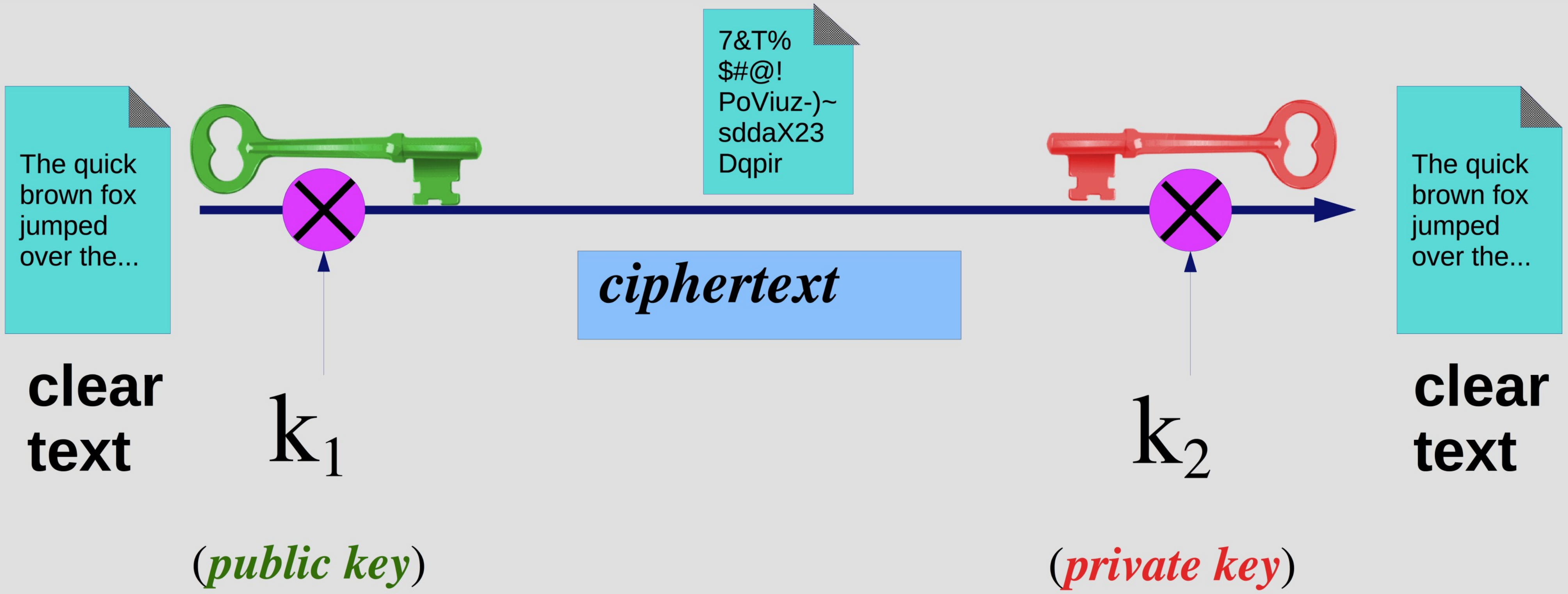
The Big Question...

- Issue: how do you securely distribute the key to the intended receiving party or parties ?

Public / Private Keys

- We generate a cipher key pair. One key is the *private key*, the other is the *public key*.
- The *private key* remains secret and should be protected.
- The *public key* is freely distributable. It is related mathematically to the private key, but you cannot (easily) derive the *private key* from the *public key.*
- Use the *public key* to encrypt data. Only someone with the *private key* can decrypt the encrypted data.

Example Public / Private Key Pair


The quick brown fox jumped over the...
7&T% $#@! PoViuz-)~ sddaX23 Dqpir
The quick brown fox jumped over the...
ciphertext
clear text
k_1
k_2
clear text
(public key)
(private key)

One key is used to encrypt the document, a different key is used to decrypt it.
This is an important aspect!

Issues

- For larger data transmissions than used in DNSSEC we use *hybrid systems*.

- *Symmetric ciphers* (single key) are *much* more efficient than *public key* algorithms for data transmission!
- Attack on the *public key* is possible via chosen-plaintext attacks. Thus, the *public*/*private key pair* need to be large (2048 bits).
- For instance, SSH uses *public*/*private* cryptography to setup the initial session, and exchange the dynamically calculated s*ymmetric* session-key.

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One-Way Hashing Functions

- A mathematical function that generates a fixed length result regardless of the amount of data you pass through it. Generally very fast.
- You cannot generate the original data from the fixed-length result, thus the term “one-way”.
- Hopefully you cannot find two sets of data that produce the same fixed-length result. If you do, this is called a *collision*. (Example, md5).

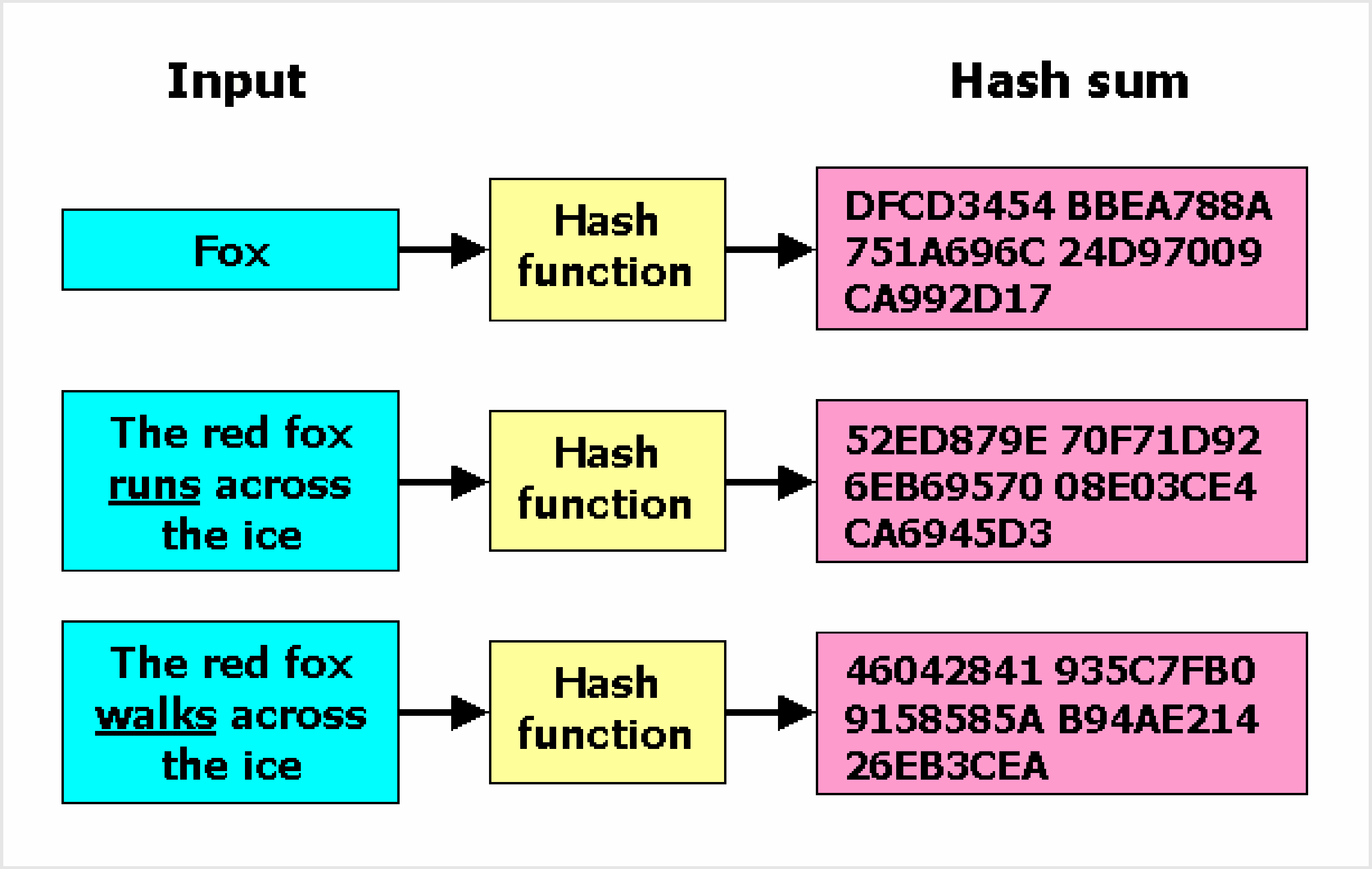
- The fixed length result is known as a ***Message Digest*** **or a** ***checksum*** **or a** ***hash*****.**

One-Way Hashing Functions cont.

- The fixed-length result of a hashing function is referred to as a *checksum, message digest* or *hash.*
- Some popular hashing functions include:
  - **md5**: Outputs 128 bit result. Fast. Collisions found. http://www.mscs.dal.ca/~selinger/md5collision/
  - **sha-1**: Outputs 160 bits. Slower. Collisions in 2^{63}.
  - **sha-2**: Outputs 224-512 bits. Slower. Collisions expected (2^{80} attack).
  - **sha-3**: TBA: Currently in development via a new *NIST Hash Function Competition:*

    http://csrc.nist.gov/groups/ST/hash/sha-3/

Hashing
another example


Input
Hash sum
Fox
Hash function
DFCD3454 BBEA788A 751A696C 24D97009 CA992D17
The red fox runs across the ice
Hash function
52ED879E 70F71D92 6EB69570 08E03CE4 CA6945D3
The red fox walks across the ice
Hash function
46042841 935C7FB0 9158585A B94AE214 26EB3CEA

Note the significant change in the hash sum for minor changes in the input. Note that the hash sum is the same length for varying input sizes. This is extremely useful.

*Image courtesy Wikipedia.org.

What use is this?

There are several:

- Passwords encryption (in Linux, Unix and Windows), using multiple rounds of hashing (MD5 or other)
- You can run many megabytes of data through a hashing function, but only have to check a fixed number of bits of information (160-512 bits). This is used to create a *digital signature*.

Digital Signatures

Reverse the role of public and private keys.

To create a digital signature on a document do:

- *Hash* a document, producing a *message digest*

1. Encrypt the *message digest* with your private key.

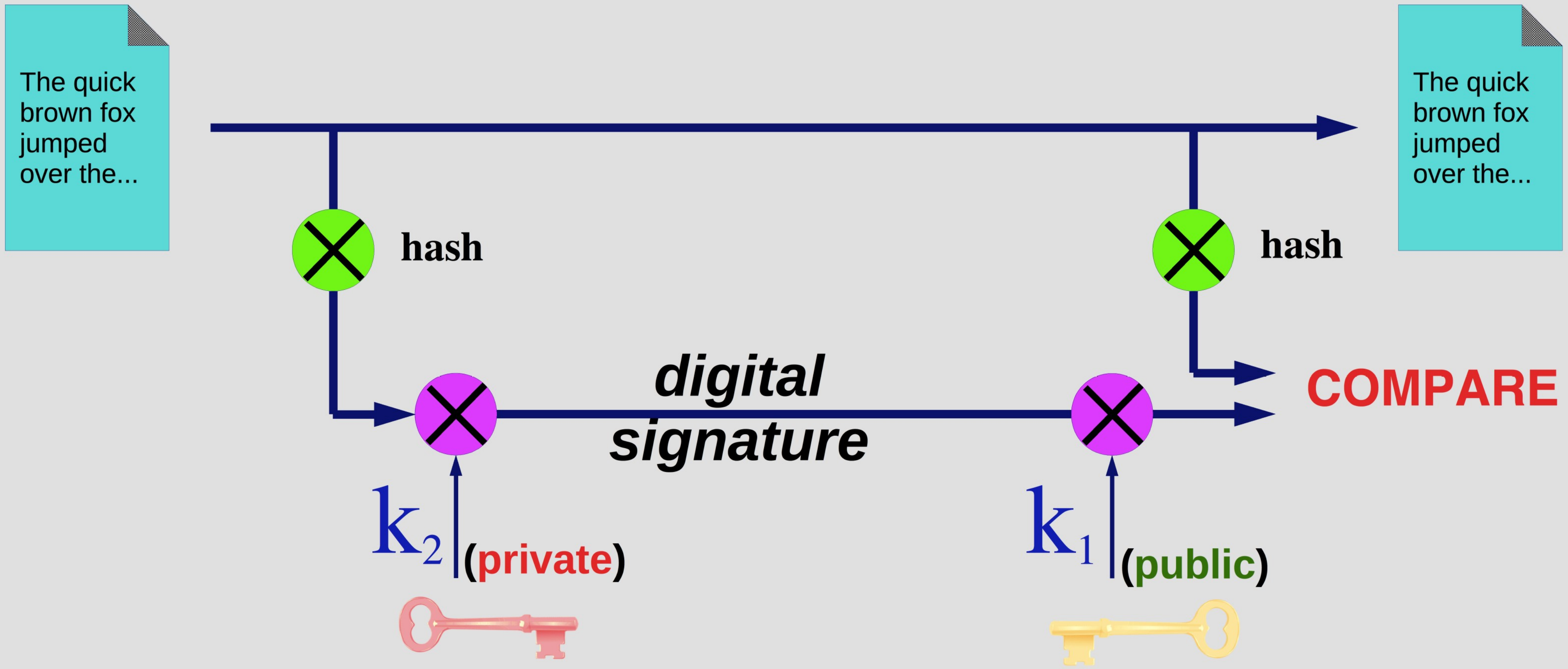
- Send the document plus the encrypted *message digest*.
- On the other end *hash* the document *and* decrypt the encrypted message digest with the person's public key.

1. If the results match, the document is authenticated.

This process creates a *digital signature*.

When Authenticating:

Take a hash of the document and encrypt only that.
An encrypted hash is called a "*digital signature*"


The quick brown fox jumped over the...
hash
digital signature
k_2
(private)
k_1
(public)
The quick brown fox jumped over the...
hash
COMPARE

Conclusion

- Public / Private keys
- Message digests, checksums, hashes
- Digital signatures

Are at the core of DNSSEC.