RCauth service update

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RCauth

- *IGTF accredited*
- *Currently hosted/run by NIKHEF*
- *Create cloned CAs at STFC and GRNET*
  - *While retaining IGTF accreditation*
  - *Kind of like ESNET's distributed whatsamabobs*
- *Single service, single governance (PMA)*
- *Use for high availability-resilience*
- *Maybe additional usefulosity w.r.t. private key mgmt*
  - *I.e. can learn something about archiving keys*

Task Overview

- *5.1.7 RCauth Governance and operations*
  - *5.1.7.1 Documentation*
  - *5.1.7.2 Governance, PMA*
  - *5.1.7.3 Operations – support, monitoring and performance, compliance*
- *5.1.8 Resilient RCauth*
  - *5.1.8.1 Establish RCauth key at all sites*
  - *5.1.8.2 Refactoring of RCauth code (if necessary)*
  - *5.1.8.3 Central services high availability*
  - *5.1.8.4 Update governance infrastructure (e.g. support)*
  - *5.1.8.5 Pathfinder*

Copying the key

- Process agreed in outline at PMAs May ‘18 and Sep ‘18
- Say *k* is the key
  - Generate random integers of same size as *k*, *a, b*
  - Key is split in three independent parts, a, b, a¤b¤k
  - Where “¤” denotes bitwise XOR
  - No one or two parts alone have any information about the key (in an information theoretical sense)
  - Recipient ¤s all the pieces together to recover *k*

Randomness

- Randomness
  - `jensen@ganesha[2]1% openssl rand 12 >file`
  - `jensen@ganesha[2]2% ls -l file`
  - `-rw-r--r-- 1 jensen jensen 12 Jan 18 11:22 file`
  - `jensen@ganesha[2]3% od -x file`
  - `0000000 dda6 ba48 93ea 9007 30f3 c9fe`
  - `0000014`
- Needs strong cryptographic randomness
  - `openssl rand -engine xyzzy 128`
- Assuming FIPS140-2 includes checks for randomness
- Does randomness use the engine, or is the engine just used to seed, or is the engine not used at all?
- Need to consult the Documentation™

Documentation (from 1.0.1t)

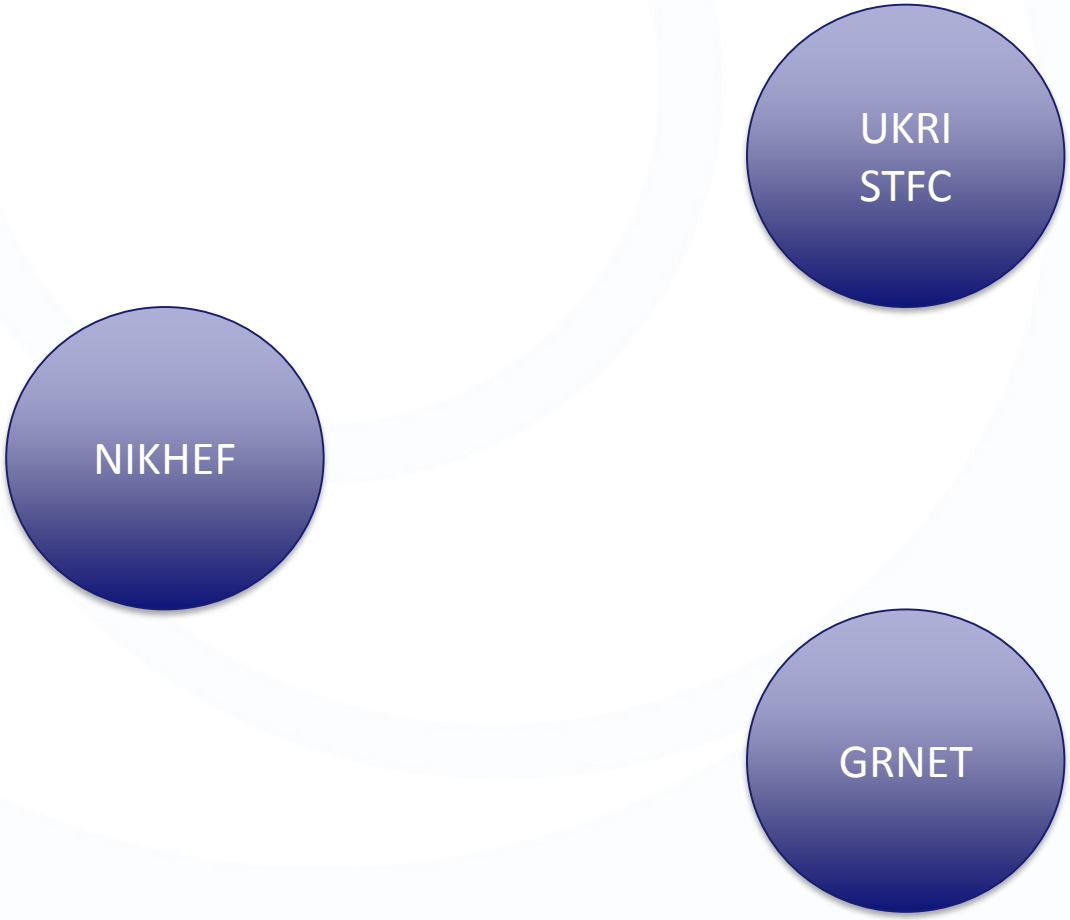
```
while (num > 0) {
        unsigned char buf[4096];
        int chunk;

        chunk = num;
        if (chunk > (int)sizeof(buf))
            chunk = sizeof buf;
        r = RAND_bytes(buf, chunk);
        if (r <= 0)
            goto err;
        if (!hex)
            BIO_write(out, buf, chunk);
        else {
            for (i = 0; i < chunk; i++)
                BIO_printf(out, "%02x", buf[i]);
        }
        num -= chunk;
    }
```

```
int RAND_bytes(unsigned char *buf, int
num)
{
    const RAND_METHOD *meth =
RAND_get_rand_method();
    if (meth && meth->bytes)
        return meth->bytes(buf, num);
    return (-1);
}
```

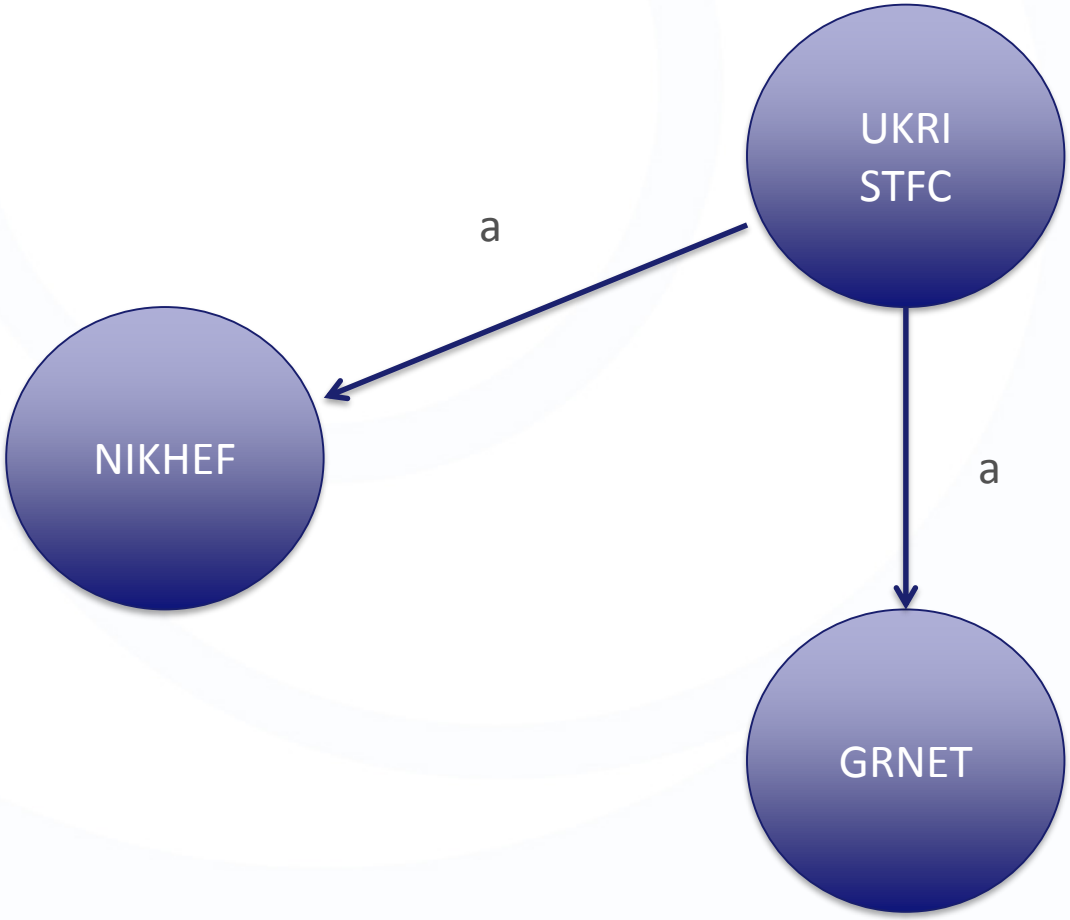
Down the Rabbit Hole…

```
const RAND_METHOD *RAND_get_rand_method(void)
{
   if (!default_RAND_meth) {
#ifndef OPENSSL_NO_ENGINE
      ENGINE *e = ENGINE_get_default_RAND();
      if (e) {
         default_RAND_meth = ENGINE_get_RAND(e);
         if (!default_RAND_meth) {
            ENGINE_finish(e);
            e = NULL;
         }
      }
      if (e)
         funct_ref = e;
      else
#endif
         default_RAND_meth = RAND_SSLeay();
   }
   return default_RAND_meth;
}
```

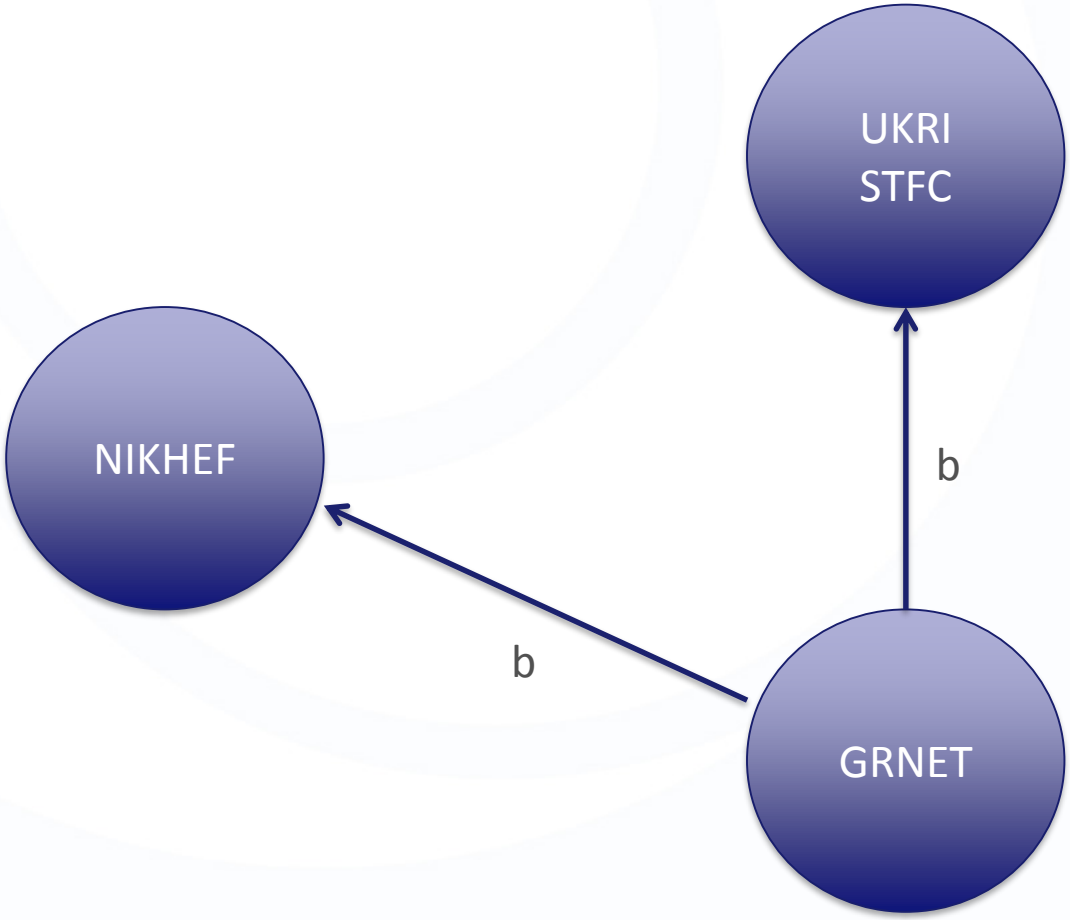
Dramatis Personae



Chinese Whispers



Chinese Whispers



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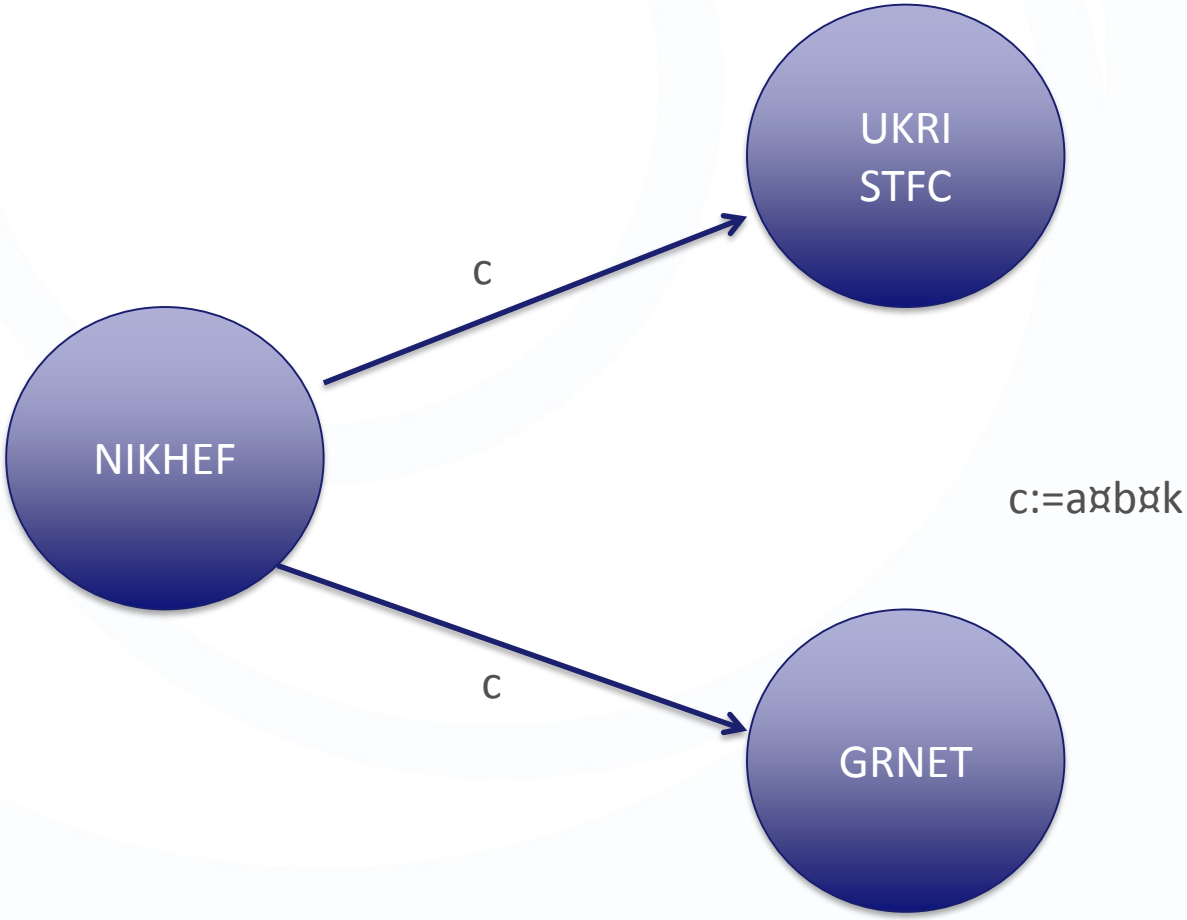

Means of exchange

- Each of *a*, *b*, *c* should be exchanged using different means
  - Physical in person delivery
  - Sent by encrypted email
  - Sent by snail mail
- If a piece is lost/compromised, regenerate it and try again
  - Or accept the compromise: no two pieces have any information about the key

A Closer Look at *k*

- If a piece {a,b,c} is exchanged on paper:
  - Use QR code
  - OCR it
  - Or type it in by hand if it's short
  - Not hand written…
- Ideally use offline methods (no office printer spooler)
- A 2048 bit key is about 1200 bytes in DER encoding
  - Nearly 1700 characters in PEM
- However,…

Anatomy of a Private Key

SEQUENCE			
	INTEGER	version	00
	INTEGER	modulus (PUBLIC)	p*q
	INTEGER	exponent (PUBLIC)	e
	INTEGER	private exponent	e^{-1} (mod lcm(p-1,q-1))
	INTEGER	prime1	p
	INTEGER	prime2	q
	INTEGER	exp1	e^{-1} (mod p-1)
	INTEGER	exp2	e^{-1} (mod q-1)
	INTEGER	inv	q^{-1} (mod p)

This is a level 1 only sequence of integers

Corollary

- Can reconstruct the private key from
  - The public key
  - And one of the primes
- See CAOPS-WG, OGF 23, Barcelona (June, 2008)
- If the modulus is 2048 bits, each prime is 1024 bits
  - Very likely
  - Definitely one prime is <= 1024 bits !
- => Protect the prime!

Reasessembling the key

- Need to understand the ASN.1
  - Which is complicated?
  - Except here, it is not at all… [Larmouth (2000)]
  - TLV (Tag, Length, Value) – all at a single level `SEQUENCE SIZE (9) OF INTEGER`
- TAG 0x30 SEQUENCE (class 0, constructed, number 16)
- 0x82 + 2 bytes of total length of value
- Each value is itself TLV encoding of `INTEGER`
  - TAG 0x02 (class 0, primitive, number 2)
  - …

Reasessembling the key

- Need to understand the ASN.1
  - Which is complicated?
  - Except here, it is not at all… [Larmouth (2000)]
- TLV (Tag, Length, Value) – all at a single level `SEQUENCE SIZE (9) OF INTEGER`
- We need only two Tags
  - TAG 0x30 SEQUENCE (class 0, constructed, number 16)
  - TAG 0x02 (class 0, primitive, number 2)

Reassembling the key

- Length
  - One byte of Length for <= 127
  - 0x81 plus one byte of length for 128 <= length < 256
  - 0x82 plus two bytes of Length for >=256
- `INTEGER` Value has leading 0x00 if MSB is >= 0x80
  - (For positive integers)
  - “top nine bits must not be the same”
- From BER to DER
  - All Ls are explicit, using the shortest encoding
  - All Vs use the shortest permitted encoding

Pathfinder

- *Repeat the exercise with Pathfinder?*
  - *DOGWOOD => RCauth*
  - *BIRCH => Pathfinder*
- *Would rekey Pathfinder upon accreditation*
- *Could do shared key generation*
  - *A la Diffie Helman except still RSA*
  - *No need to rerun distribution process*
- *Alternatively use RCauth key to share Pathfinder*
  - *Should be OK…*

Conclusion

- Interesting enough exercise to share
  - Crypto random
  - Key splitting
    - (done right, albeit with some technical requirements)
- CAOPS?

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