Key Exchange

Diffie-Hellman
Diffie-Hellman Weaknesses
Passing Key Using Public Key

Prof Bill Buchanan OBE

https://asecuritysite.com/dh
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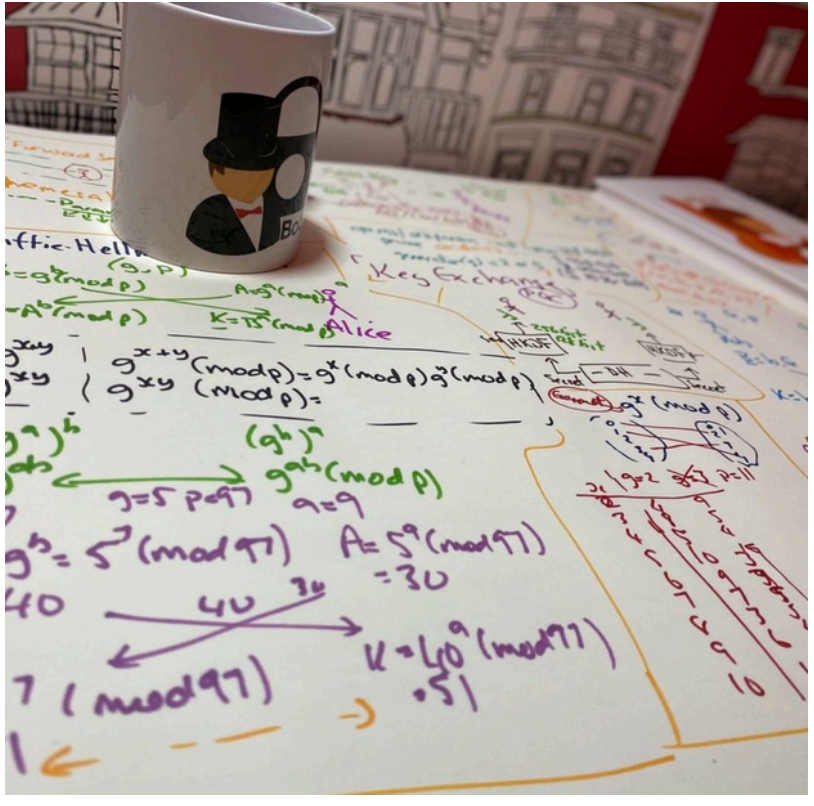


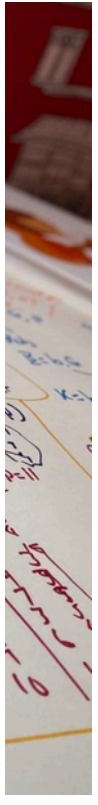
Key E

Diffie-Hellm
Diffie-Hellm
Passing Key

Prof Bil

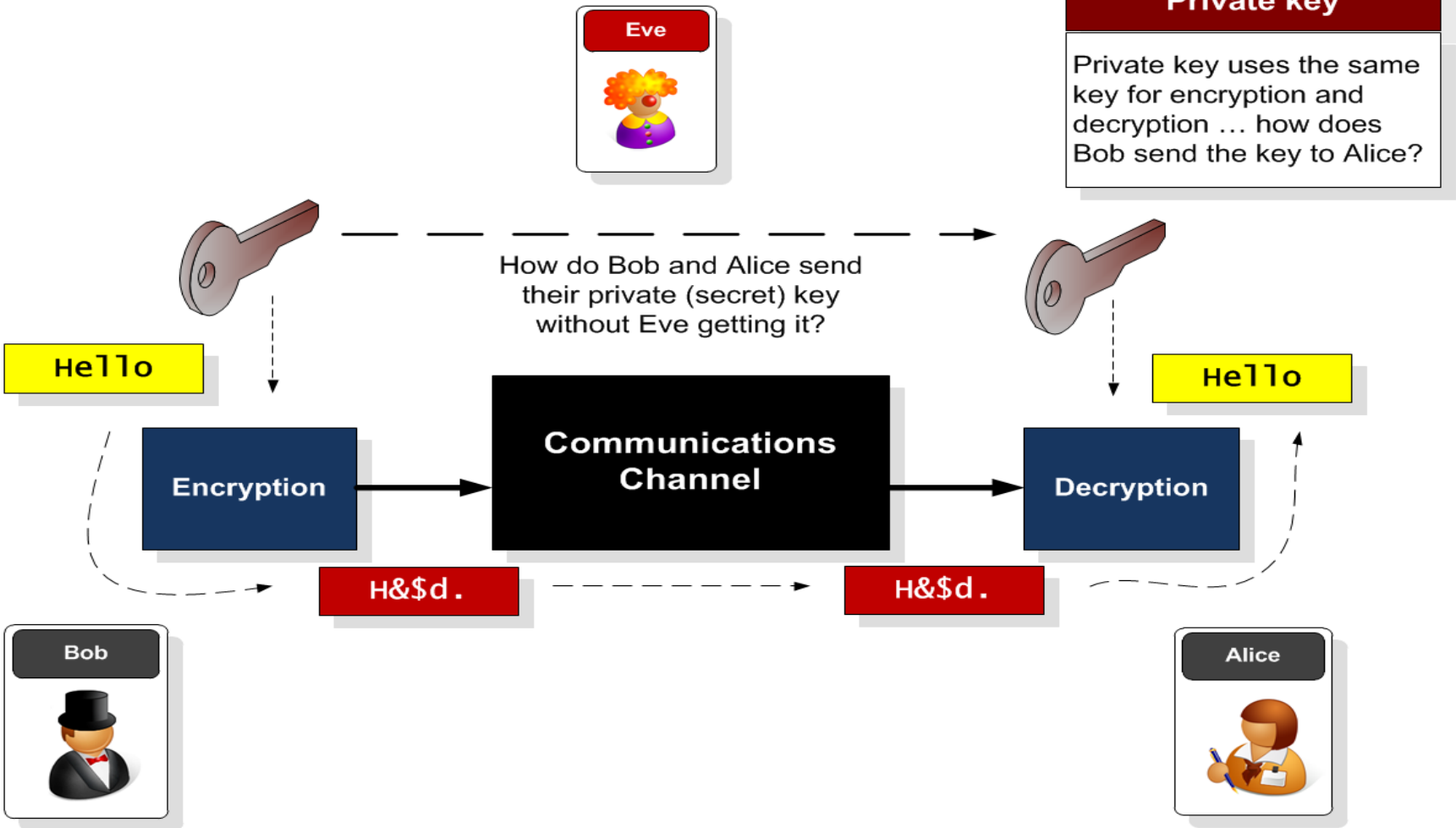
https://asec
https://asec

No	Date	Subject	Lab
2	18 Sept 2025	1. Introduction [Link] 2. Intrusion Detection Systems [Link]	Network Security Lab 1
3	25 Sept 2025	3. Network Security (Risks and Models) [Link]	Network Security Lab 2
4	2 Oct 2025	4. Ciphers and Fundamentals [Link]	AWS Security and Server Infrastructure Lab 3
5	9 Oct 2025	5. Secret Key 6. Hashing [Link]	Symmetric Key and Hashing Lab 4
6	16 Oct 2025	7. Public Key [Link] 8. Key Exchange [Link]	Public Key and Key Exchange Lab 5
7	23 Oct 2025	Reading week/Revision session	Reading week/Cipher Challenge
8	30 Oct 2025	9. Digital Certificates	Certificates Lab 6
9	6 Nov 2025	Test 1 here (6-8pm, JKCC)	
10	13 Nov 2025	10 Network Forensics here	Network Forensics Lab 7
11	20 Nov 2025	11. Splunk here	Splunk Lab Lab 8
12	27 Nov 2025	13. Tunnelling Here	Tunnelling Lab 9
13	4 Dec 2025	14. Blockchain and Cryptocurrencies here	Blockchain Lab. here
14	11 Dec 2025		
15	18 Dec 2025	Hand-in: TBC [Here]	



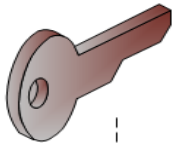
Private key

Private key uses the same key for encryption and decryption … how does Bob send the key to Alice?

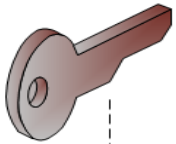


Diffie-Hellman

One of the most widely method for creating a secret key which is the same for Bob and Alice



How do Bob and Alice send their private (secret) key without Eve getting it?



Hello

Encryption

Communications Channel

Decryption

Hello

H&$d.

H&$d.

This problem was solved by Whitfield Diffie, who created the Diffie-Hellman algorithm, which is the most widely used method for passing secret keys

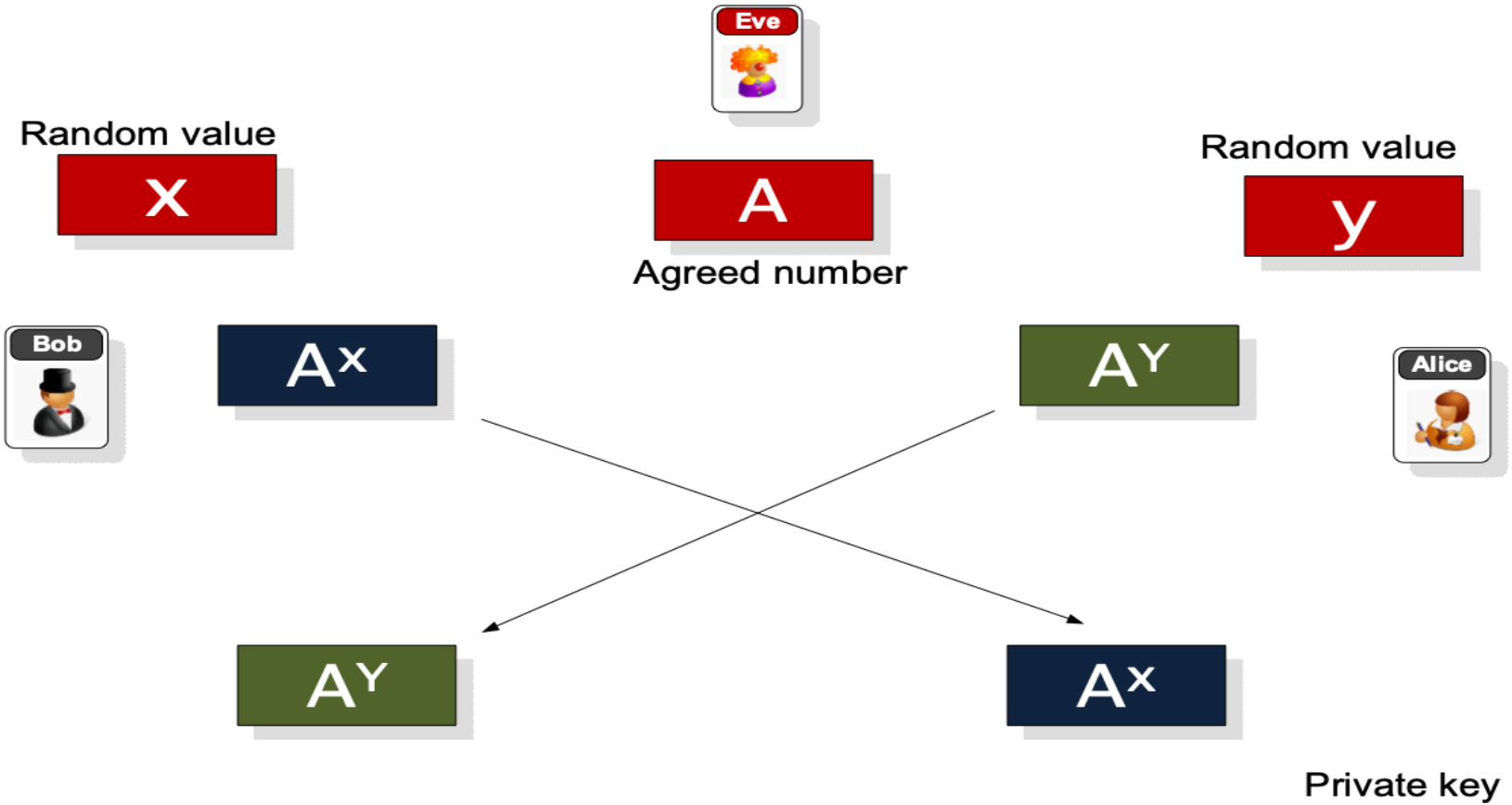
Key Exchange

- **Forward secrecy** (FS), which means that a comprise of the long-term keys will not compromise any previous session keys. A leakage of the public key of the server would cause all the sessions which used this specific public key to be compromised. FS thus aims to overcome this by making sure that all the sessions keys could not be compromised, even though the long-term key was compromised.
- **Ephemeral**. With some key exchange methods, the same key will be generated if the same parameters are used on either side. This can cause problems as an intruder could guess the key, or even where the key was static and never changed. With ephemeral methods, a different key is used for each connection, and, again, the leakage of any long-term would not cause all the associated session keys to be breached.

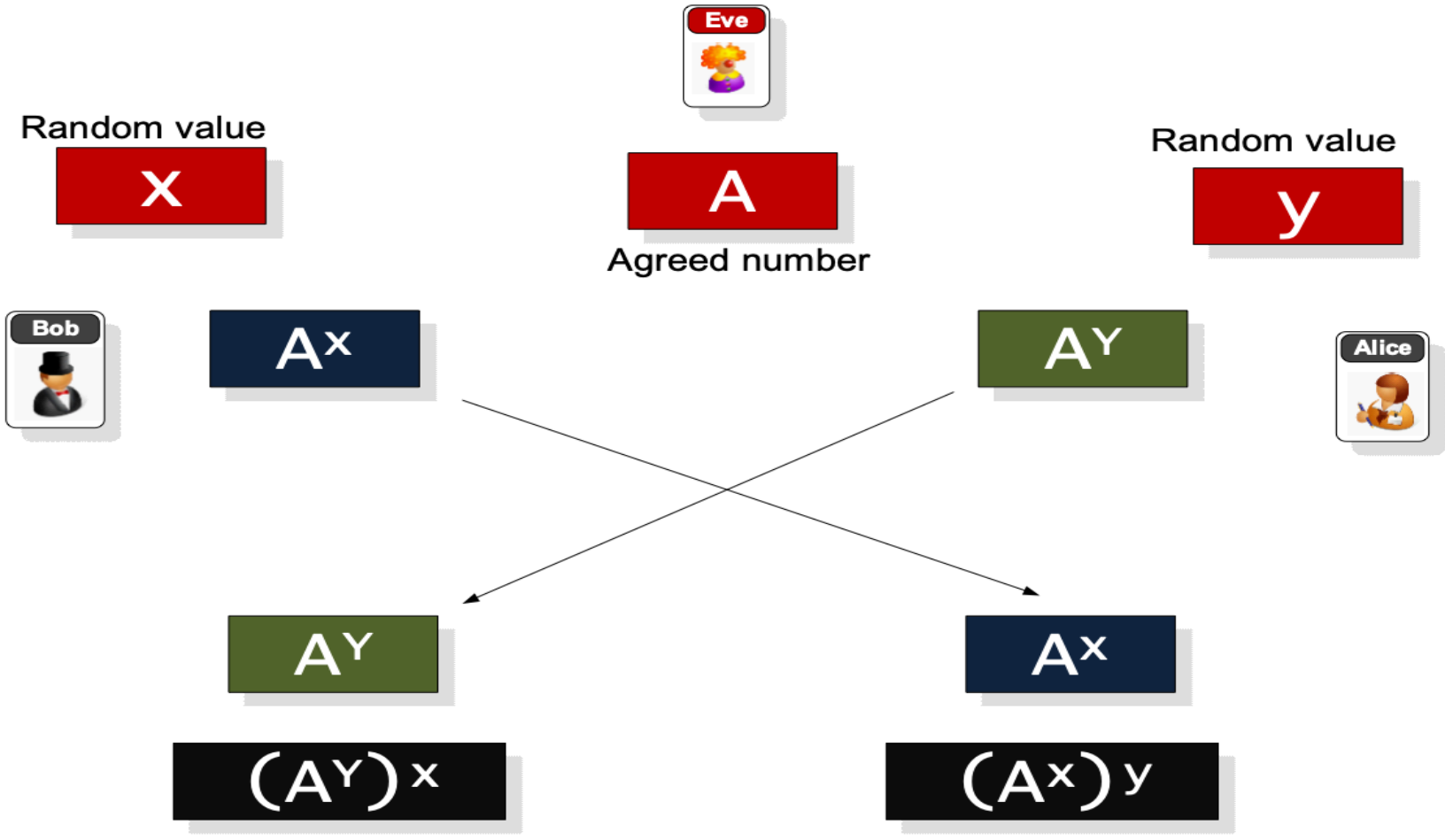
$A^x A^y \rightarrow A^{(x+y)}$

$(A^x)^y \rightarrow A^{xy}$

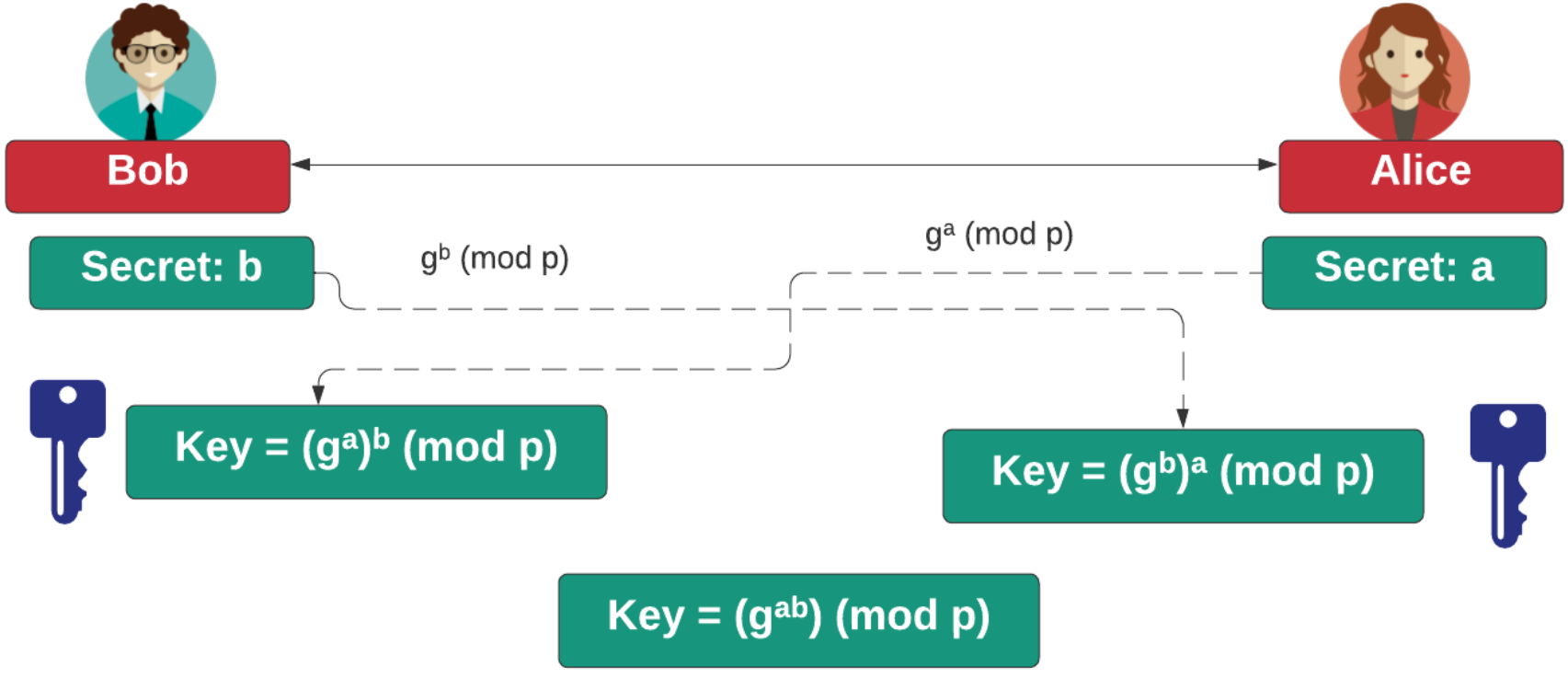
Author: Prof Bill Buchanan

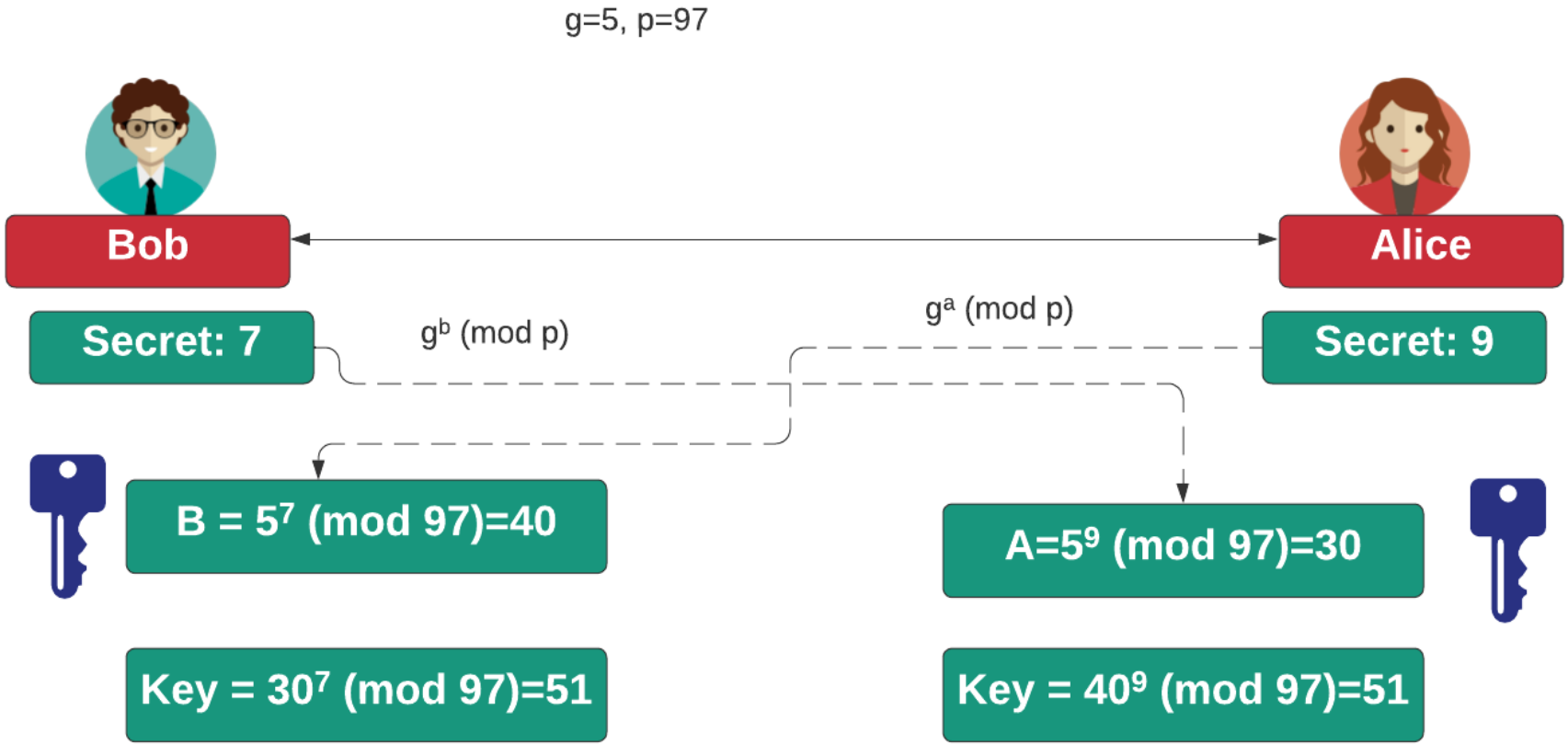


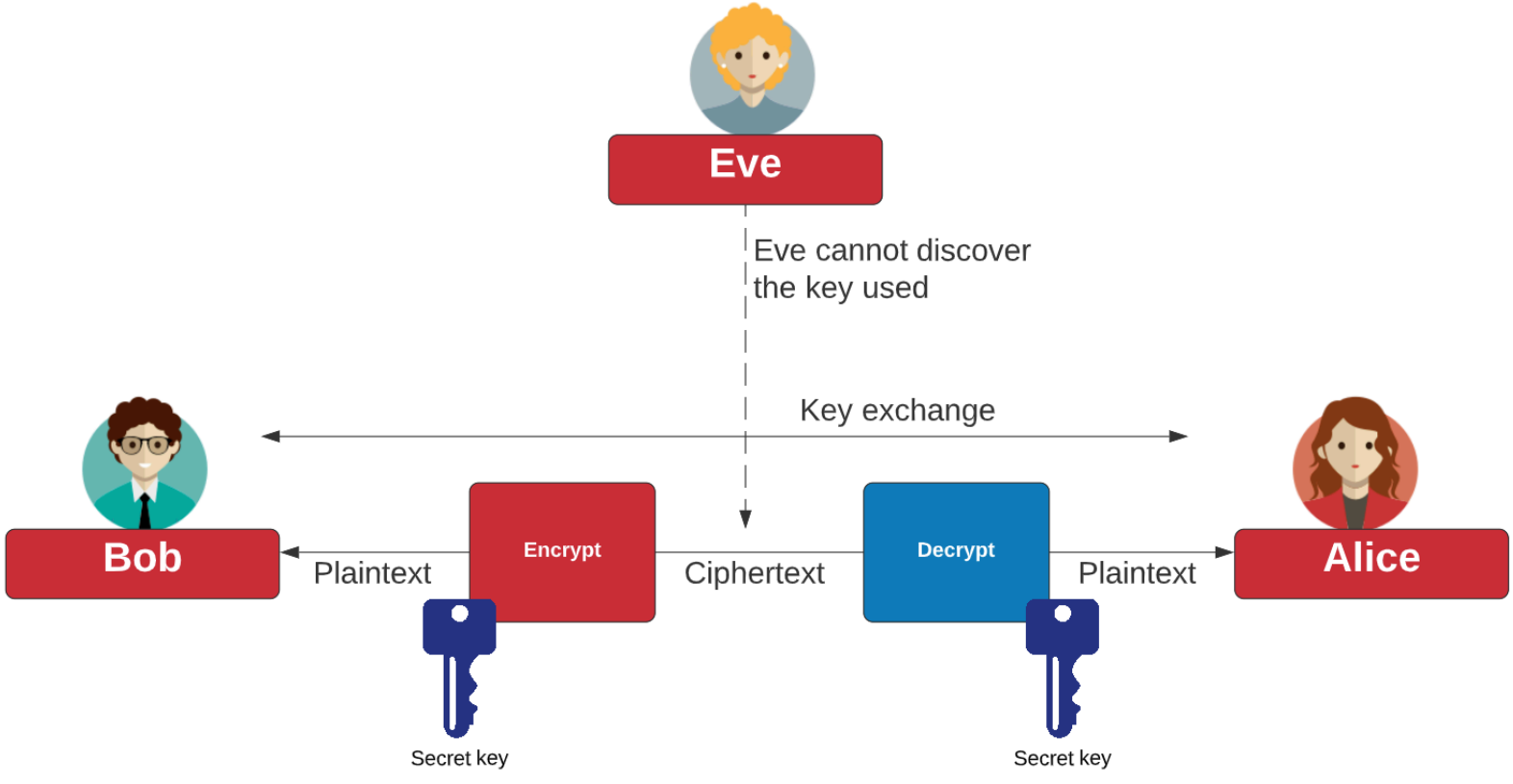
Author: Prof Bill Buchanan



Author: Prof Bill Buchanan


Bob
Alice
Secret: b
Secret: a
$g^b \pmod p$
$g^a \pmod p$
Key = $(g^a)^b \pmod p$
Key = $(g^b)^a \pmod p$
Key = $(g^{ab}) \pmod p$


g=5, p=97
Bob
Alice
Secret: 7
Secret: 9
$g^b \pmod p$
$g^a \pmod p$
$B = 5^7 \pmod{97}=40$
$A=5^9 \pmod{97}=30$
$Key = 30^7 \pmod{97}=51$
$Key = 40^9 \pmod{97}=51$


Eve
Eve cannot discover
the key used
Key exchange
Bob
Alice
Encrypt
Decrypt
Plaintext
Ciphertext
Plaintext
Secret key
Secret key

Diffie-Hellman Generator

$$Y = g^x \bmod p$$

p	11							
Generator	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
x	**g^x mod p**	**g^x mod p**	**g^x mod p**	**g^x mod p**	**g^x mod p**	**g^x mod p**	**g^x mod p**	**g^x mod p**
2	4	9	5	3	3	5	9	4
3	8	5	9	4	7	2	6	3
4	5	4	3	9	9	3	4	5
5	10	1	1	1	10	10	10	1
6	9	3	4	5	5	4	3	9
7	7	9	5	3	8	6	2	4
8	3	5	9	4	4	9	5	3
9	6	4	3	9	2	8	7	5
10	1	1	1	1	1	1	1	1

Picking G

Diffie-Hellman Generation

```
C:\> openssl dhparam -out dhparams.pem 768 –text
C:\> type dhparams.pem
Diffie-Hellman-Parameters: (768 bit)
    prime:
        00:d0:37:c2:95:64:02:ea:12:2b:51:50:a2:84:6c:
        71:6a:3e:2c:a9:80:e2:65:b2:a5:ee:77:26:22:31:
        66:9e:fc:c8:09:94:e8:9d:f4:cd:bf:d2:37:b2:fb:
        b8:38:2c:87:28:38:dc:95:24:73:06:d3:d9:1f:af:
        78:01:10:6a:7e:56:4e:7b:ee:b4:8d:6b:4d:b5:9b:
        93:c6:f1:74:60:01:0d:96:7e:85:ca:b8:1f:f7:bc:
        43:b7:40:4d:4e:87:e3
    generator: 2 (0x2)
-----BEGIN DH PARAMETERS-----
MGYCYQDQN8KVZALqEitRUKKEbHFqPiypgOJlsqXudyYiMWae/
MgJlOid9M2/0jey
+7g4LIcoONyVJHMG09kfr3gBEGp+Vk577rSNa021m5PG8XRgAQ2WfoXK
uB/3vEO3
QE1Oh+MCAQI=
-----END DH PARAMETERS-----
```

- **DH Group 5**: 1,536 bit prime.
- **DH Group 2**: 1,024 bit prime.
- **DH Group 1**: 768-bit prime.

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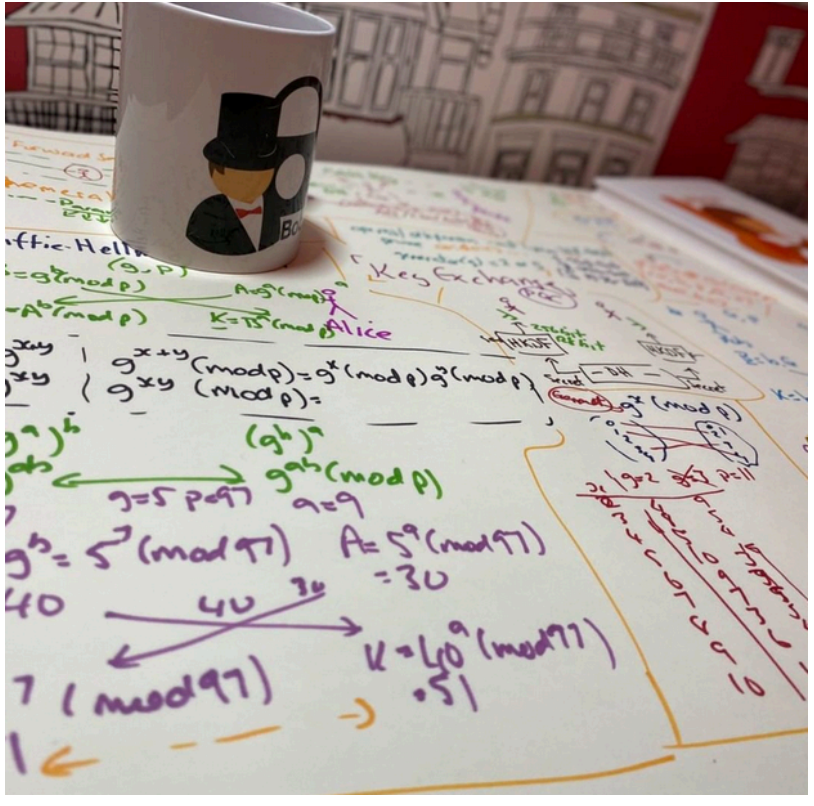
http://asecuritysite.com/crypto05

http://asecuritysite.com/encryption

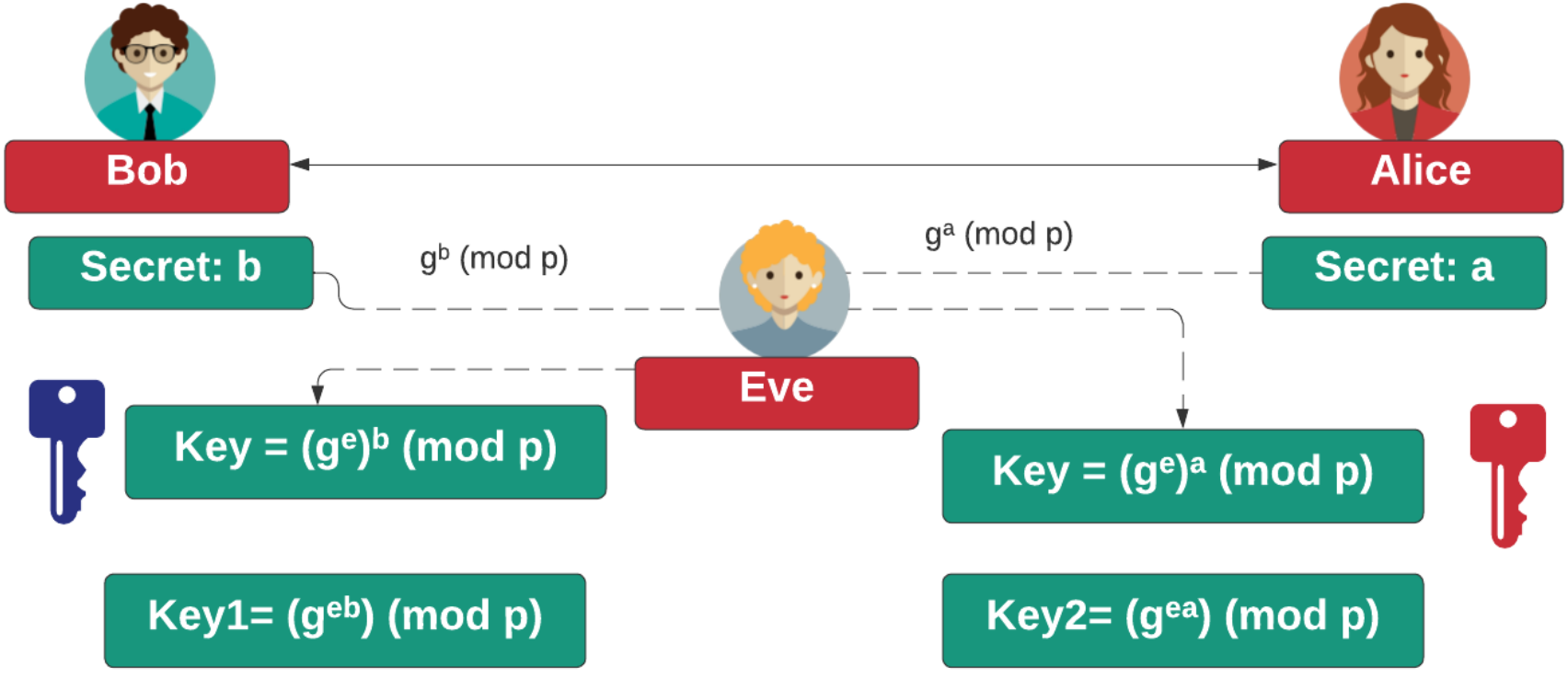


Diffie-Hellman Weaknesses

- In 2015, a paper entitled *Imperfect Forward Secrecy: How Diffie-Hellman Fails in Practice* – showed that it was fairly easy to precompute on values for two popular Diffie-Hellman parameters (and which use the DHE_EXPORT cipher set).
- The research team found that one was used as a default in the around 7% of the Top 1 million web sites and was hard coded into the Apache httpd service. Overall, at the time, it was found that over 3% of Web sites were still using the default.

- Diffie-Hellman-Parameters: (512 bit)
- prime:
- 00:9f:db:8b:8a:00:45:44:f0:04:5f:17:37:d0:ba:
- 2e:0b:27:4c:df:1a:9f:58:82:18:fb:43:53:16:a1:
- 6e:37:41:71:fd:19:d8:d8:f3:7c:39:bf:86:3f:d6:
- 0e:3e:30:06:80:a3:03:0c:6e:4c:37:57:d0:8f:70:
- e6:aa:87:10:33
- generator: 2 (0x2)

Eve-in-the-middle



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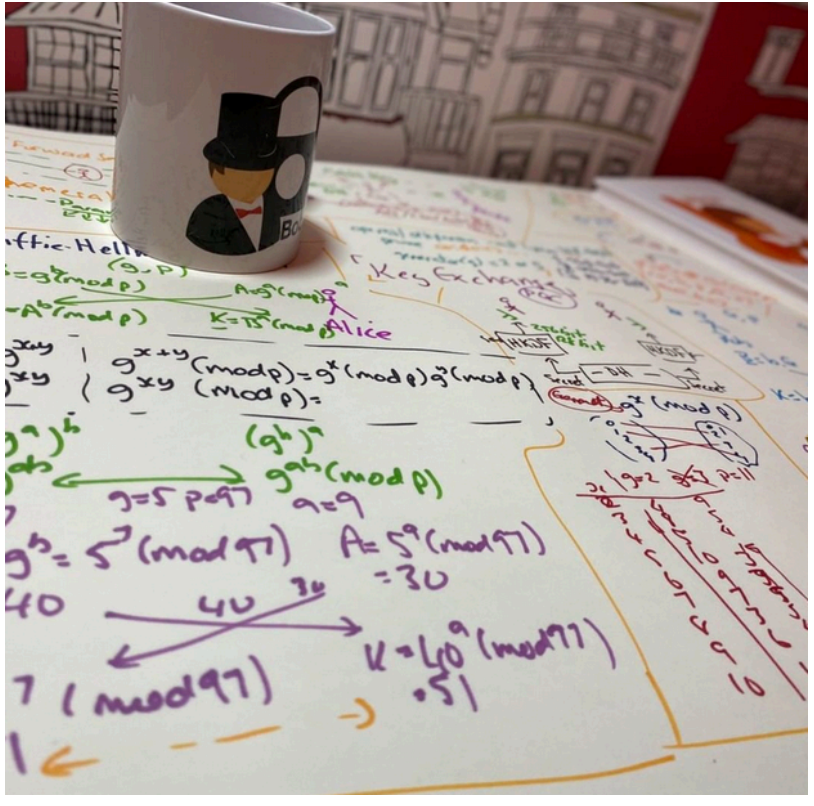
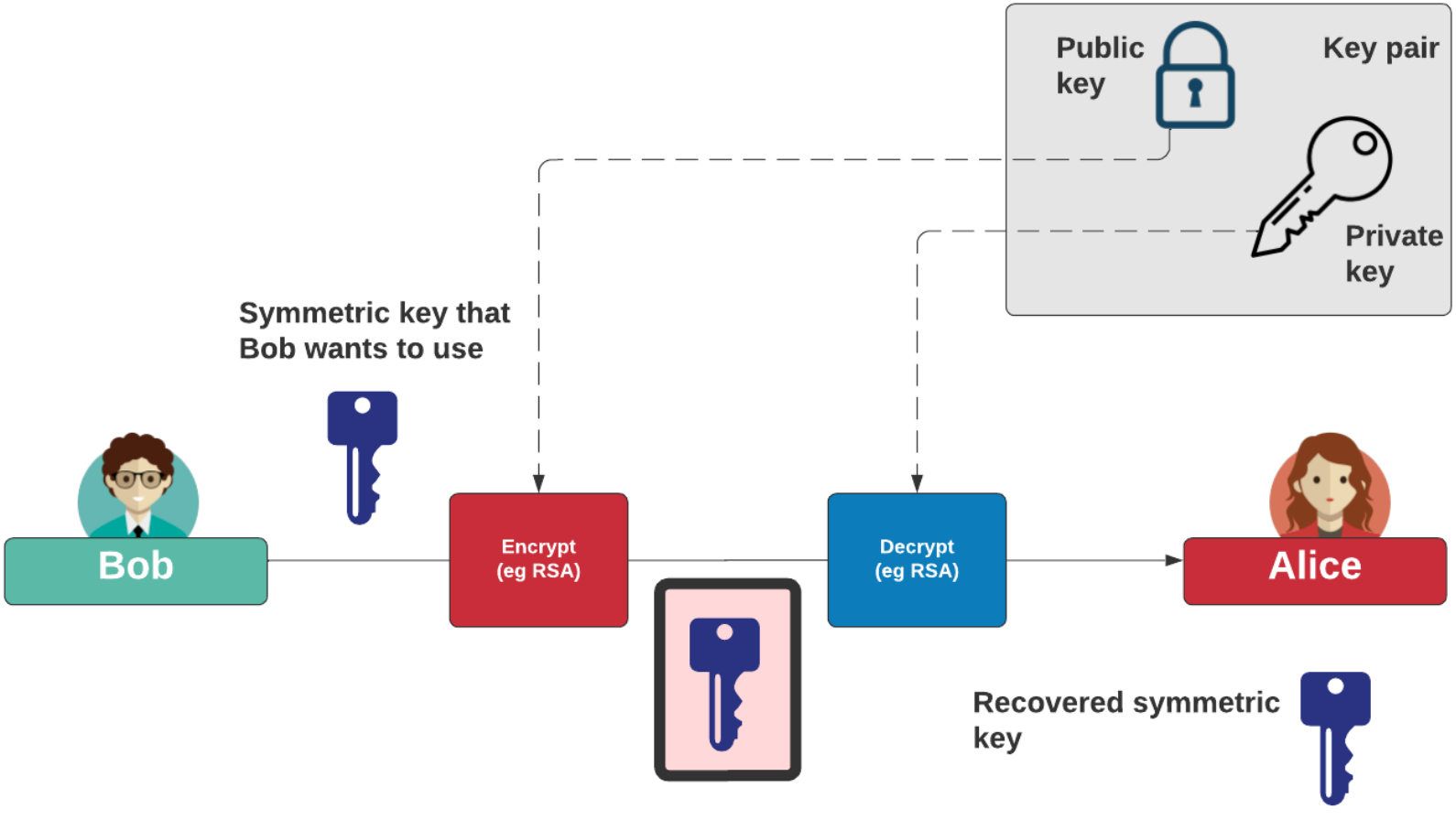
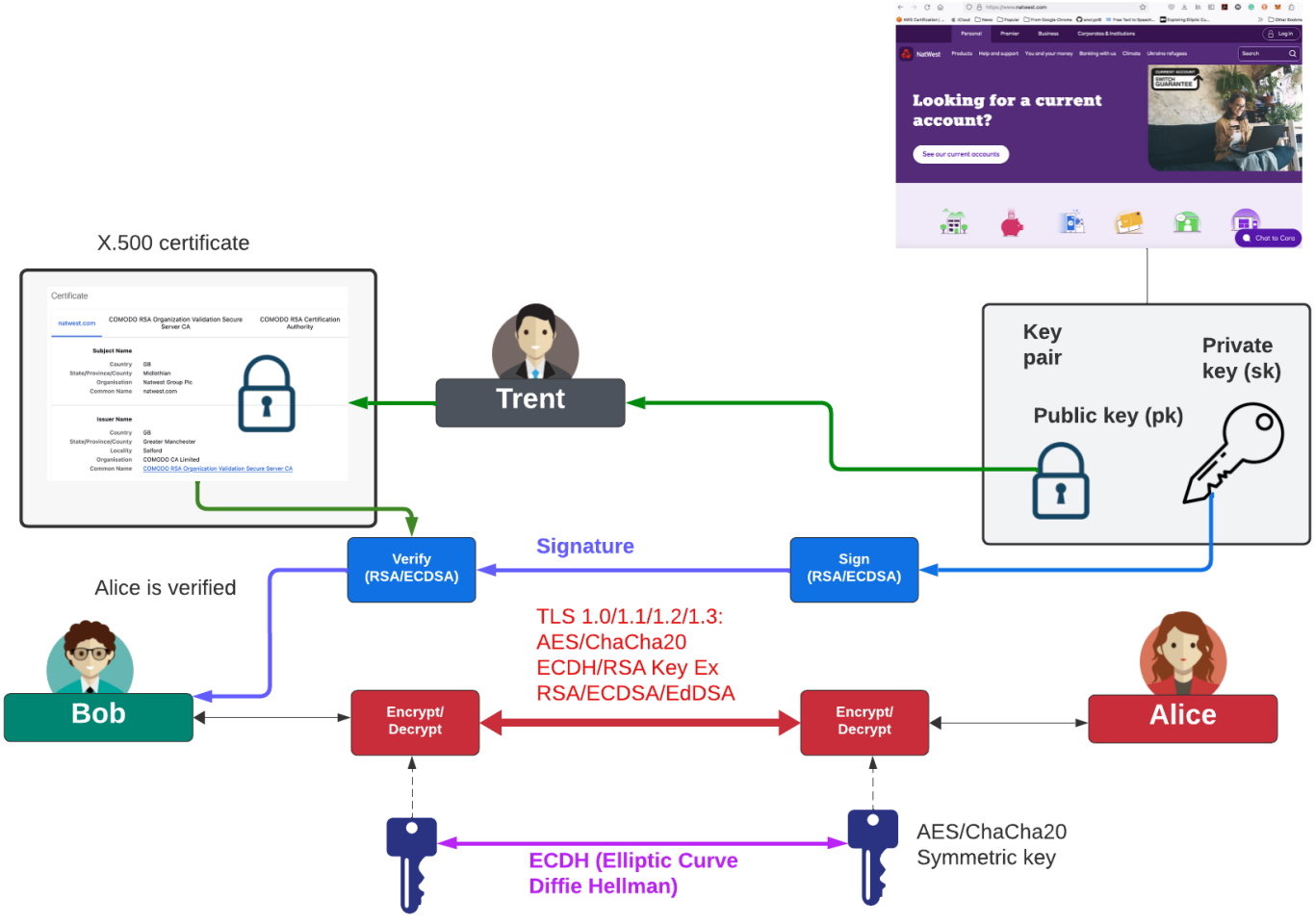


Key Exchange with Public Key



Key Exchange and Digital Signatures



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