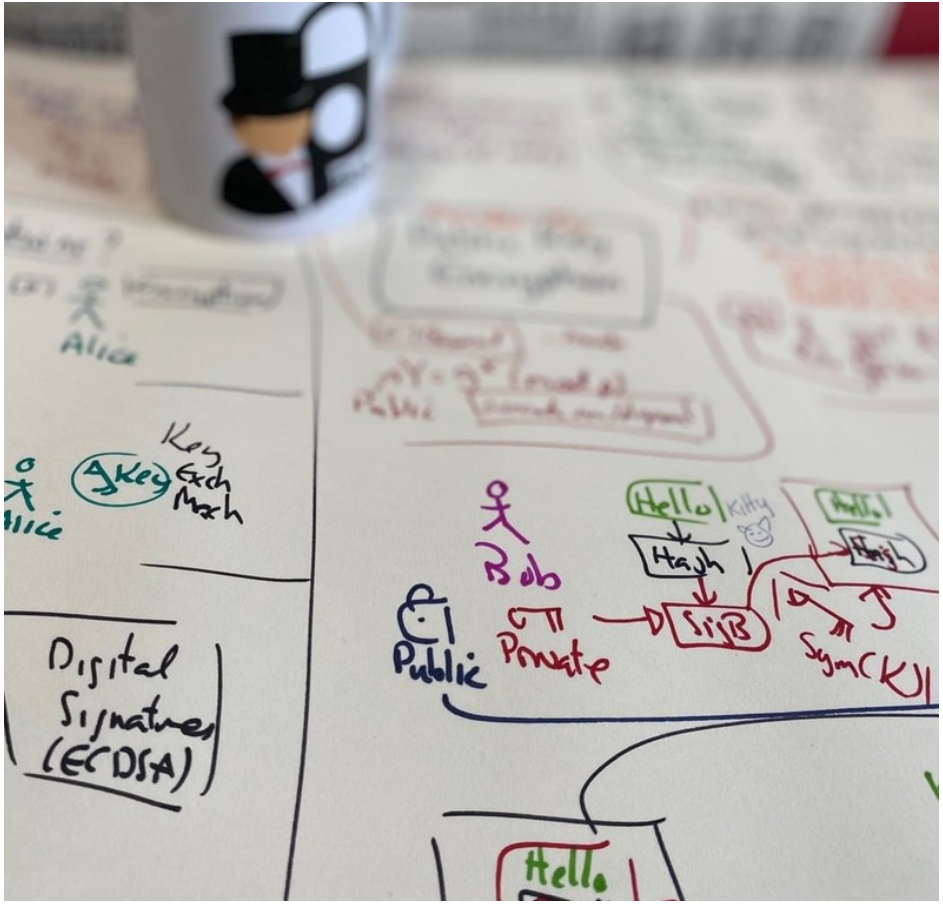
Digital Certificates

Introduction
Authentication Methods
PKI
Digital Certificate Passing

Prof Bill Buchanan OBE

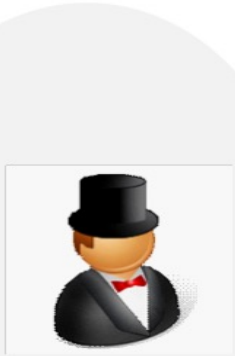
https://asecuritysite.com/tunnelling



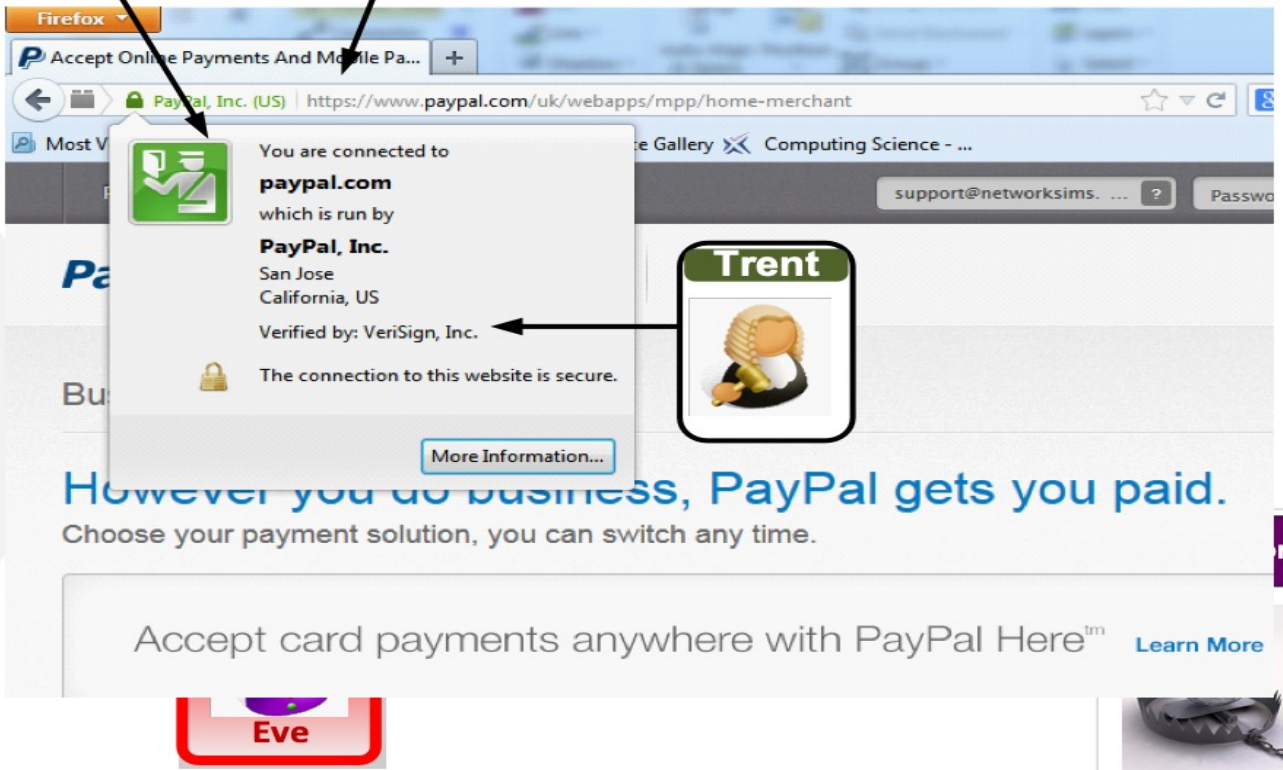
Identity on the Internet

Identifies it is trusted (Digital Certificate)

Keeps communications secure (encryption)



Bob



Fundamental principles

Authentication.
Confidence/Assurance.
Privacy/Confidentiality.

Authentication
(Device,
User, Servers,
Connections, etc)

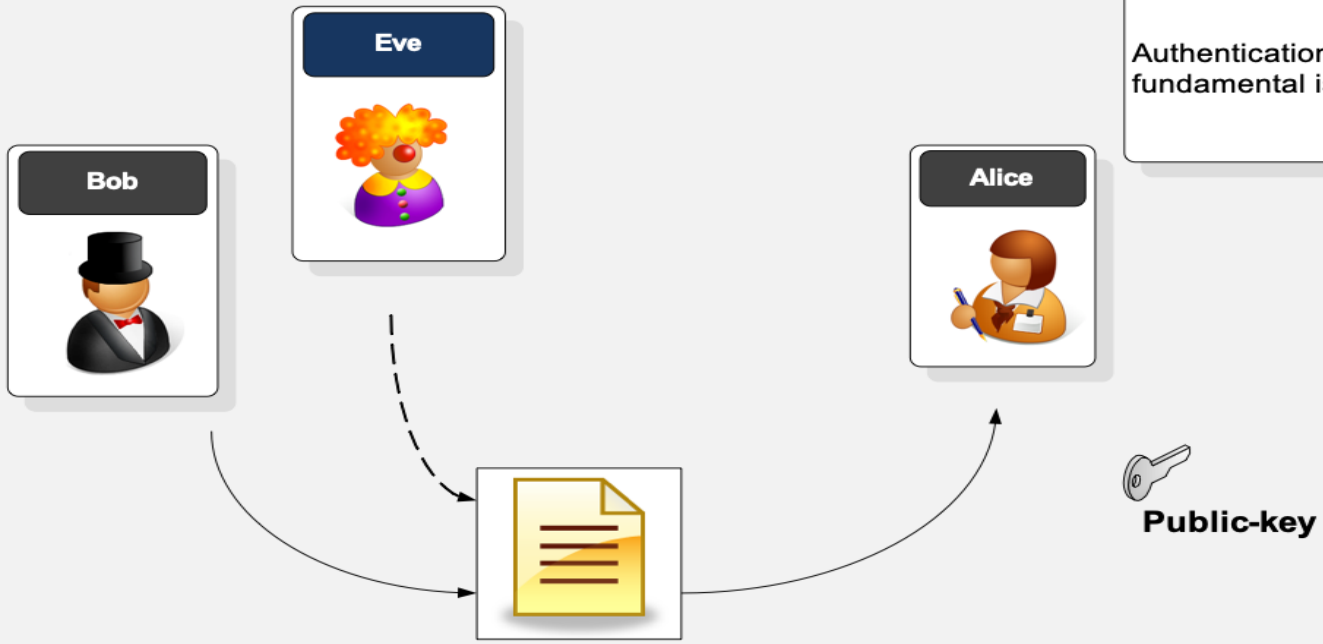
Confidentiality
(Encryption)

Assurance
(Integrity)

Author: Prof Bill Buchanan

Authentication

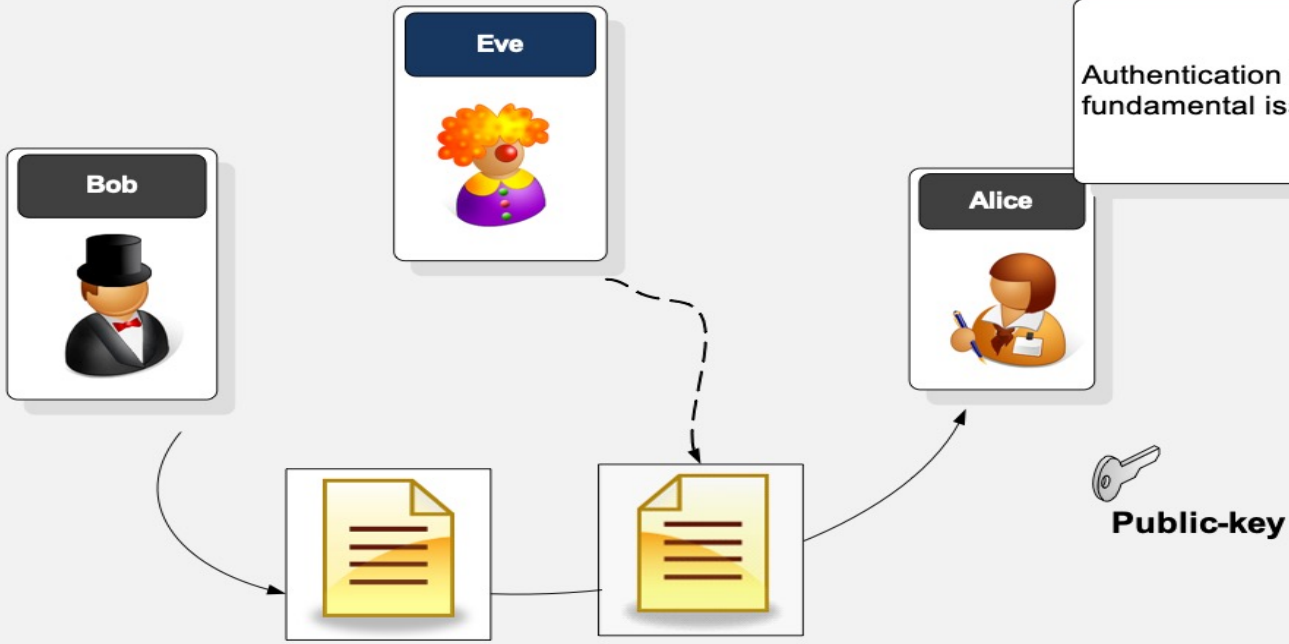
Authentication is a fundamental issue in security.



How do we know that it was really Bob who sent the data, as anyone can get Alice's public key, and thus pretend to be Bob?

Authentication

Authentication is a fundamental issue in security.

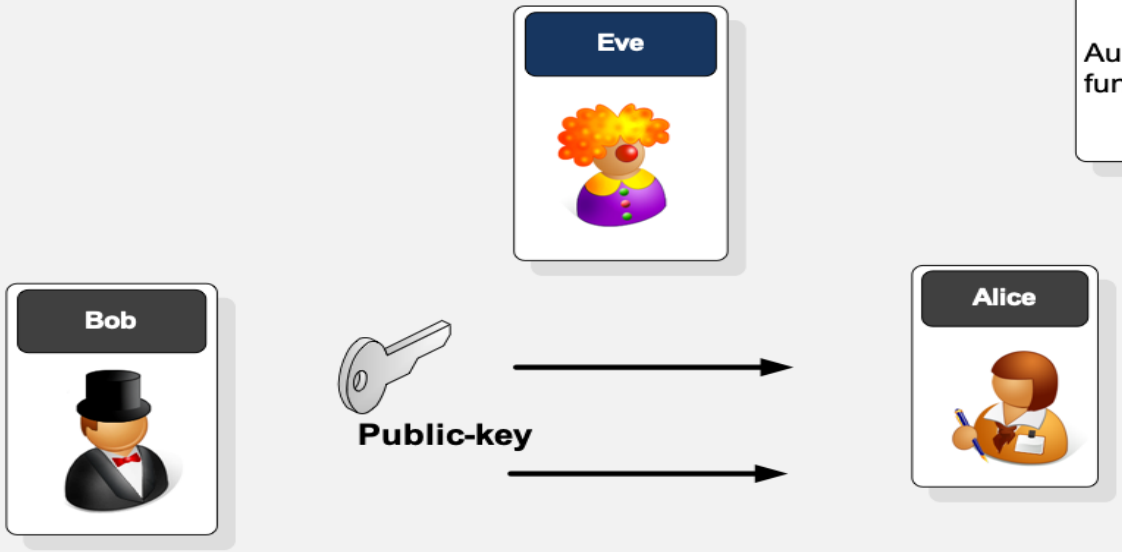


How can we tell that the message has not been tampered with ?

Author: Prof Bill Buchanan

Authentication

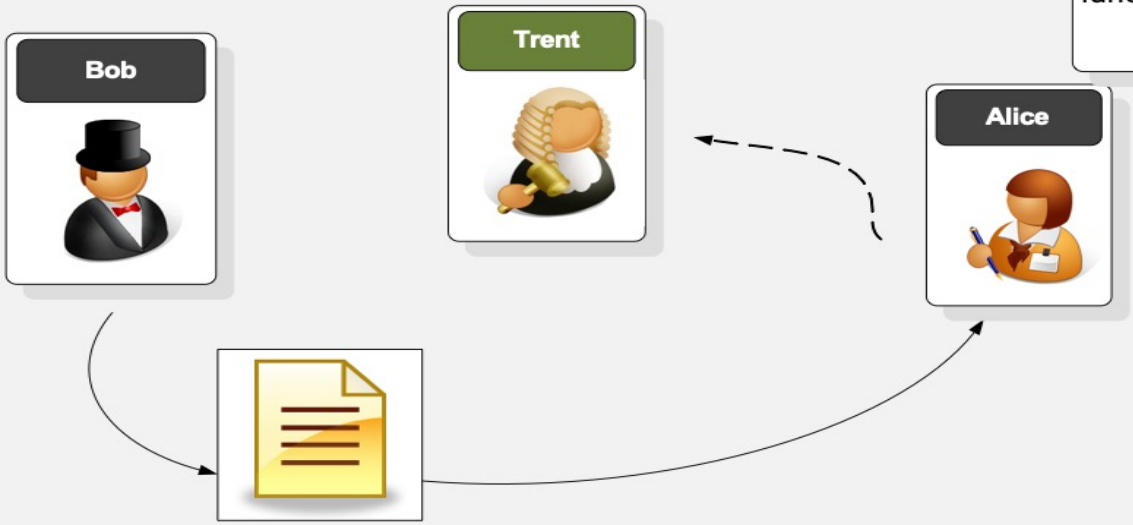
Authentication is a fundamental issue in security.



How does Bob distribute his public key to Alice, without having to post it onto a Web site or for Bob to be on-line when Alice reads the message?

Authentication

Authentication is a fundamental issue in security.



Who can we *really* trust to properly authenticate Bob? Obviously we can't trust Bob to authenticate that he really is Bob.

Unit 6: Digital Certificates

Introduction
Authentication Methods

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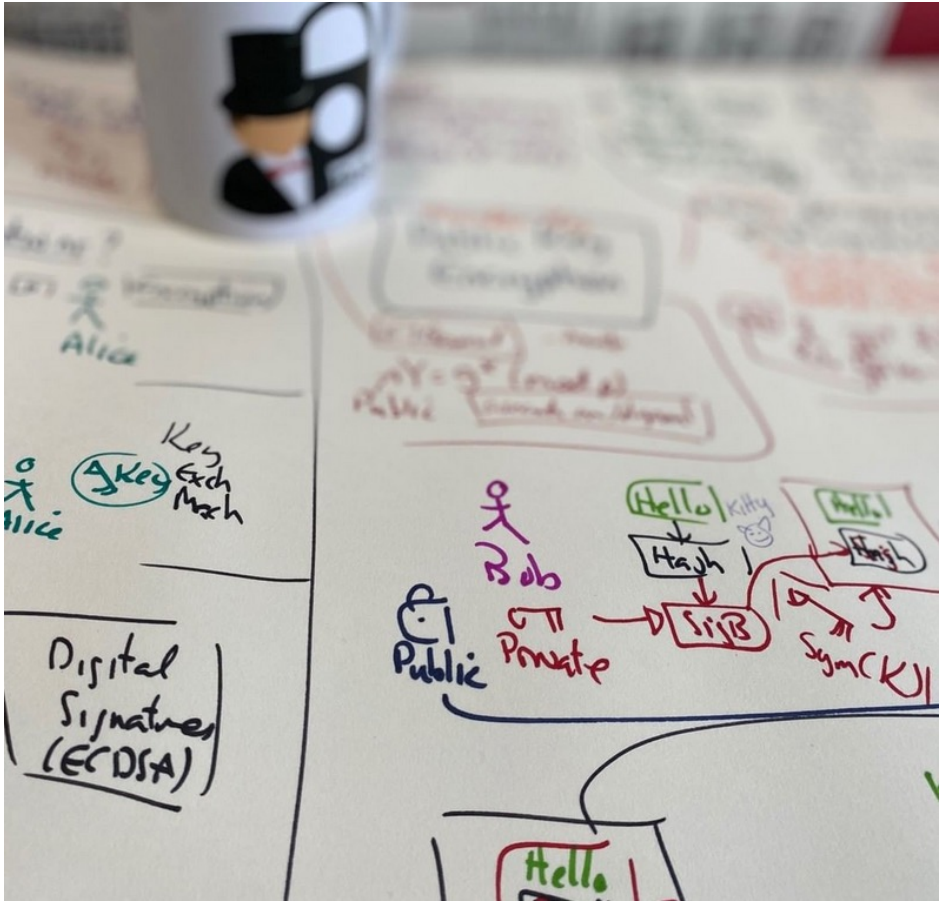
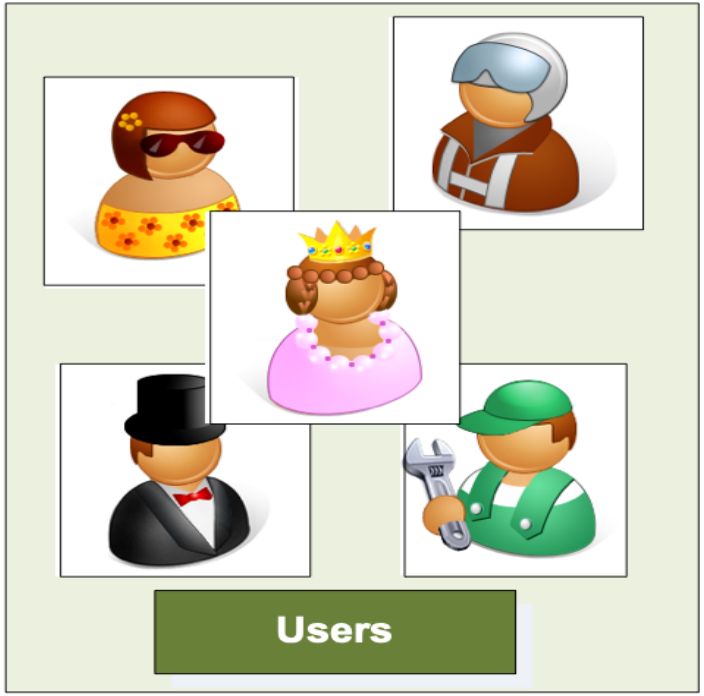
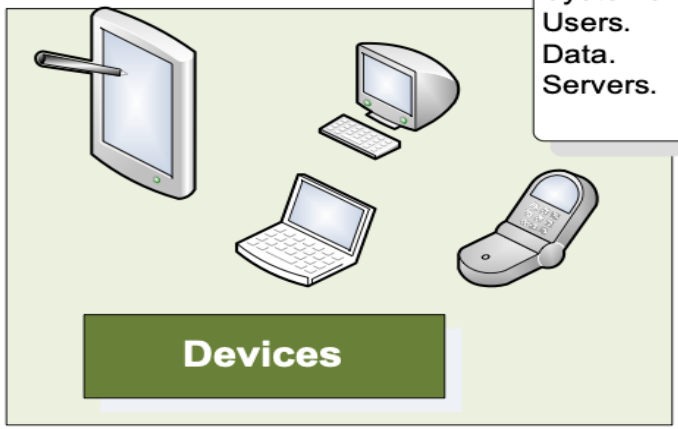
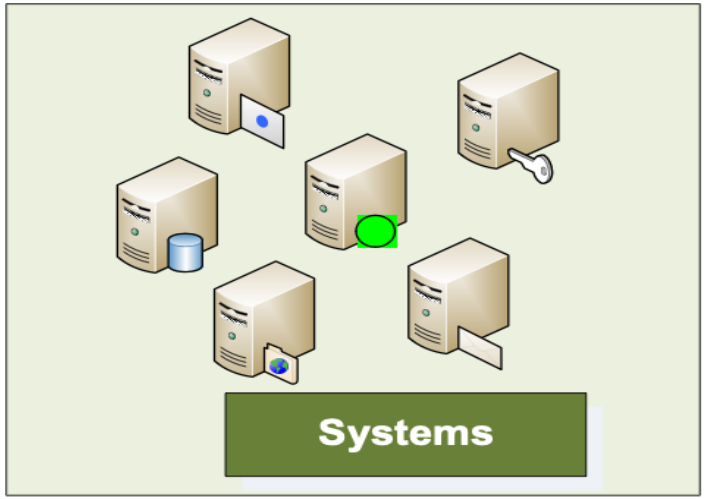


What to authenticate?

Systems.
Users.
Data.
Servers.



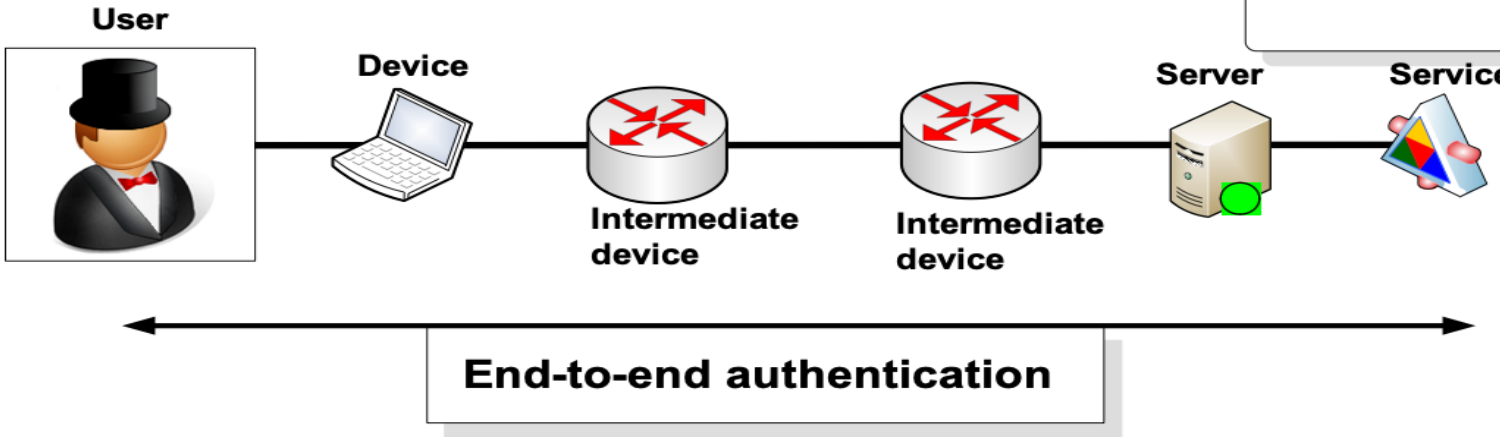


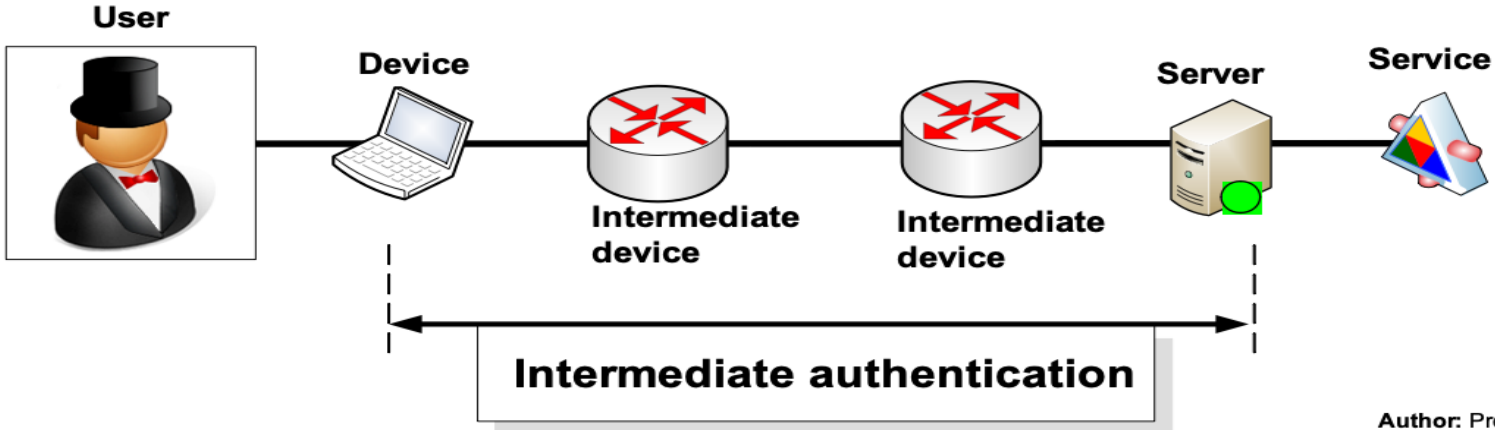


Author: Prof Bill Buchanan

Where authenticated?

End-to-end. User to service. Intermediate. Part of the authentication process.





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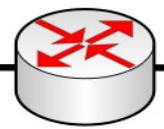
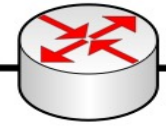
Authentication type

One-way server.
One-way client.
Two-way.

User

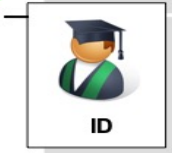
Device





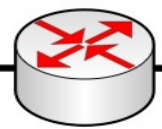
Server

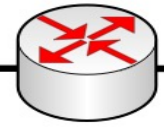
One-way server authentication. Server provides authentication to the client, such as SSL (HTTPS, FTPS, etc).

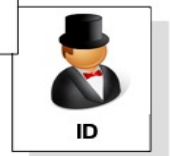


User

Device

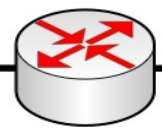


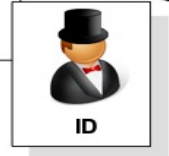




One-way client authentication. Client provides authentication to the server such as EAP-TLS in Wireless.

User





Mutual authentication. Client and server provide ID to authenticate each other. Examples include PEAP in wireless.

Author: Prof Bill Buchanan

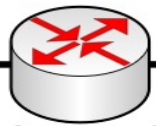
Authentication

Authentication type

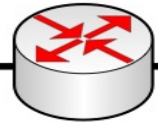
One-way server.
One-way client.
Two-way.

User

Device



Intermediate device



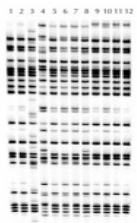
Intermediate device

Server

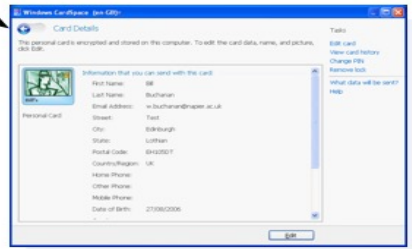
Service

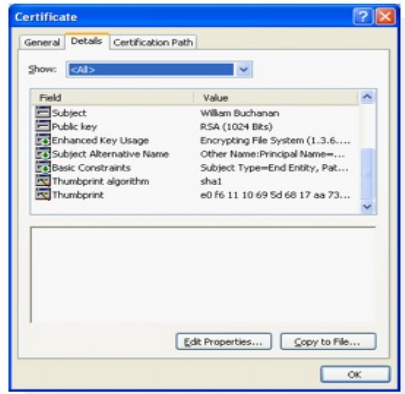
Methods

Username/password
Digital Certificate
Token Card
Soft Tokens
Session key
Pass phrase
Biometrics



Device name
Digital Certificate
Pass phrase
MAC address
Encryption key





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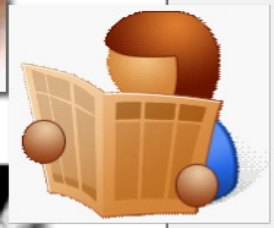
Authentication methods

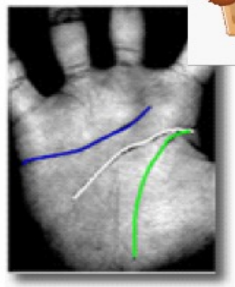
Something you have
Something you know
Something you are

Authentication Methods

Iris scans



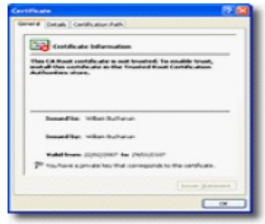
Retina scan



Palm prints

Finger prints

Something you are



Digital certificate

Network/physical address

Smart card

Something you have

Username/ password

Mother's maiden name

Something you know

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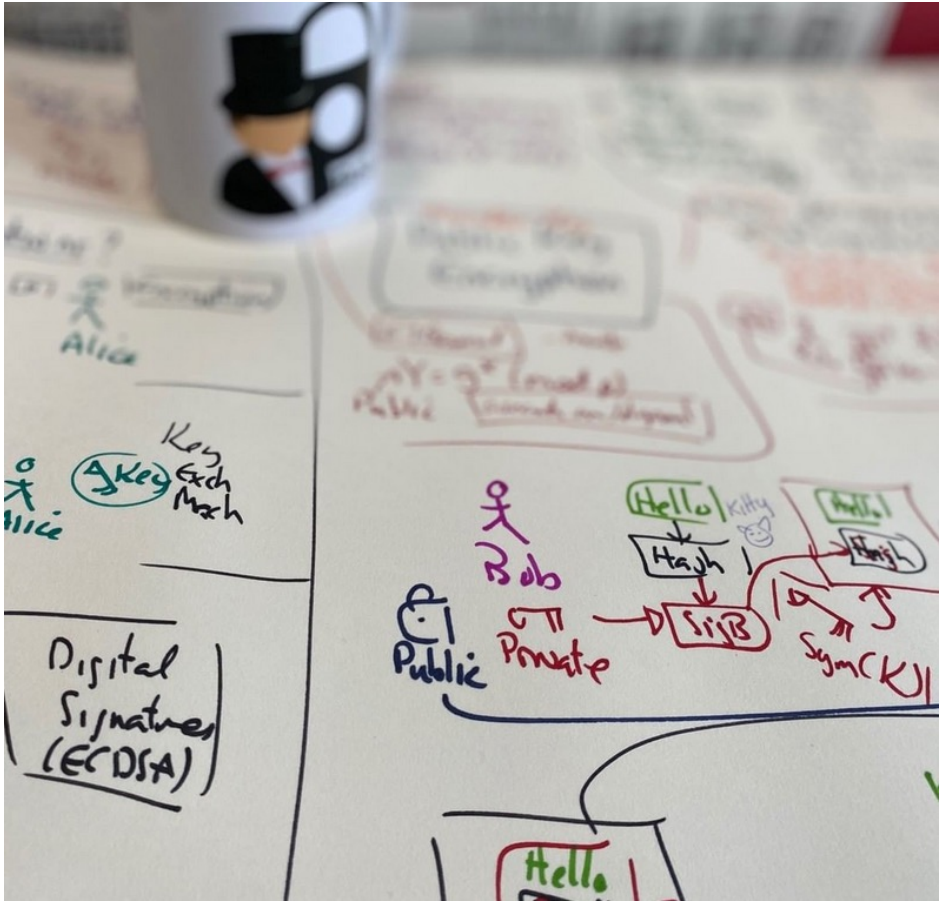
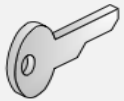


Digital Certificates

Digital certificates are a soft token of authentication, and require a trust mechanism.

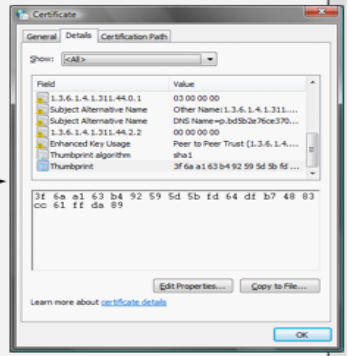


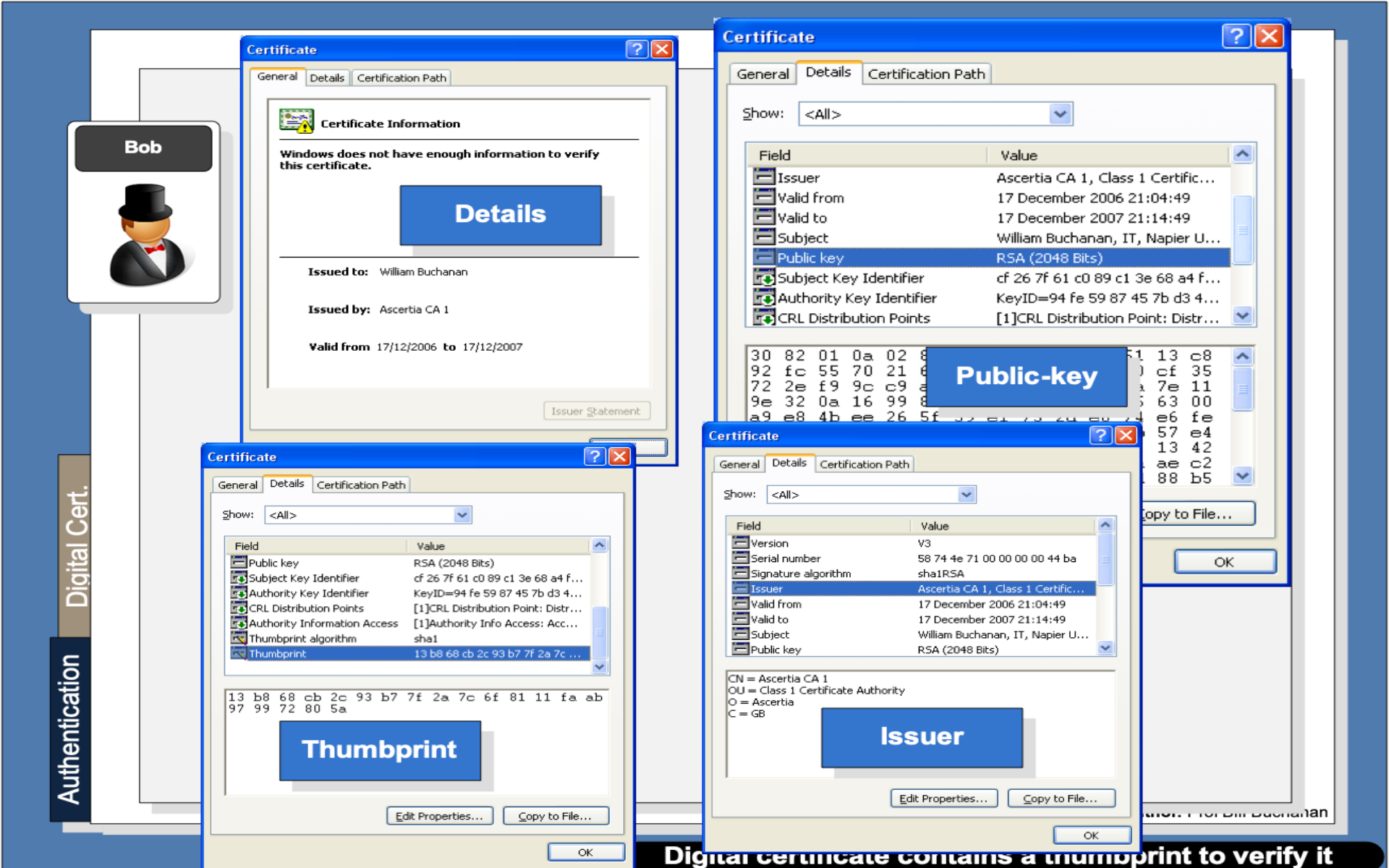
Public-key

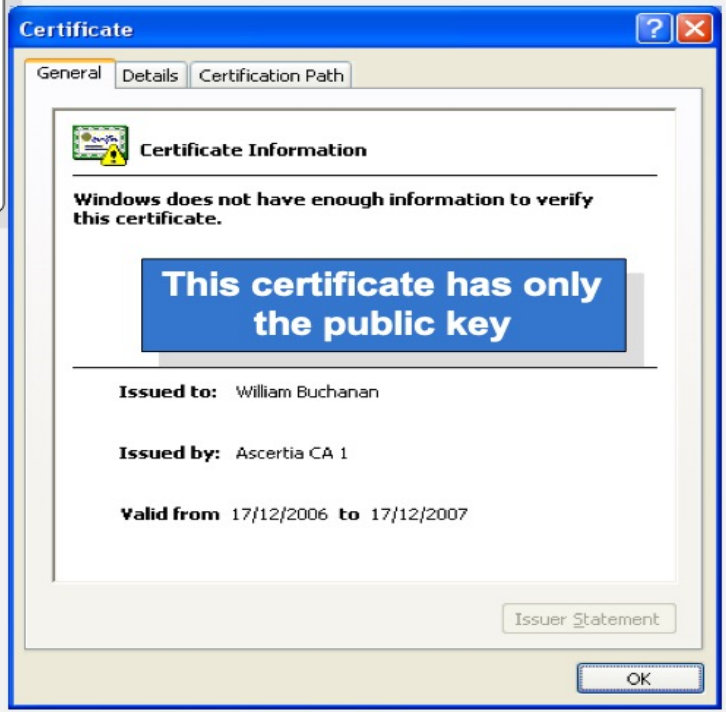
One method is the digital certificate which can carry the public key (and also the private key, if nesc.)

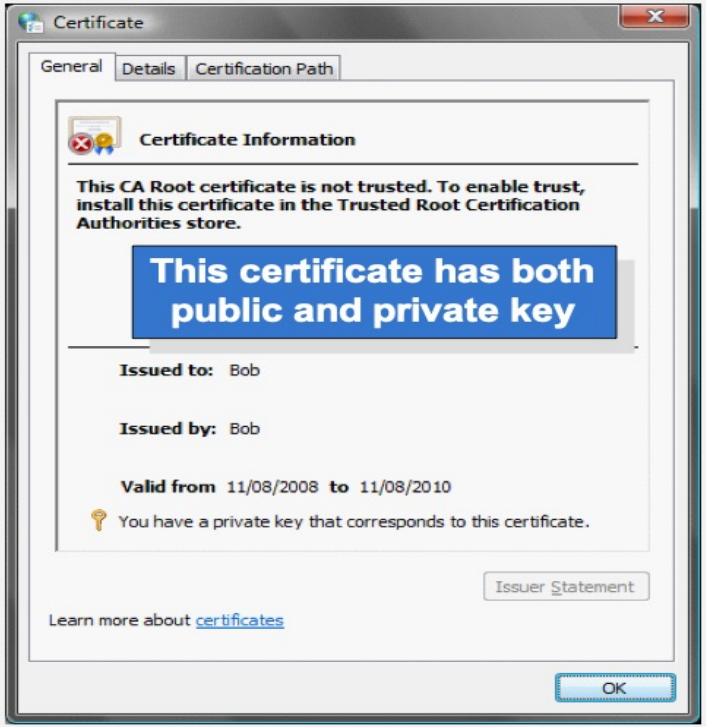
Now that we need the public key to either encrypt data for a receipiant, or to authenticate a sender...

How does Bob distribute his public key to Alice, without having to post it onto a Web site or for Bob to be on -line when Alice reads the message?




Bob
Certificate
General
Details
Certification Path
Certificate Information
Windows does not have enough information to verify this certificate.
Details
Issued to: William Buchanan
Issued by: Ascertia CA 1
Valid from 17/12/2006 to 17/12/2007
Issuer Statement
Certificate
General
Details
Certification Path
Show: <All>
Field
Value
Issuer
Ascertia CA 1, Class 1 Certific...
Valid from
17 December 2006 21:04:49
Valid to
17 December 2007 21:14:49
Subject
William Buchanan, IT, Napier U...
Public key
RSA (2048 Bits)
Subject Key Identifier
cf 26 7f 61 c0 89 c1 3e 68 a4 f...
Authority Key Identifier
KeyID=94 fe 59 87 45 7b d3 4...
CRL Distribution Points
[1]CRL Distribution Point: Distr...
30 82 01 0a 02
92 fc 55 70 21
72 2e f9 9c c9
9e 32 0a 16 99
a9 e8 4b ee 26 5f
Public-key
Copy to File...
OK
Certificate
General
Details
Certification Path
Show: <All>
Field
Value
Public key
RSA (2048 Bits)
Subject Key Identifier
cf 26 7f 61 c0 89 c1 3e 68 a4 f...
Authority Key Identifier
KeyID=94 fe 59 87 45 7b d3 4...
CRL Distribution Points
[1]CRL Distribution Point: Distr...
Authority Information Access
[1]Authority Info Access: Acc...
Thumbprint algorithm
sha1
Thumbprint
13 b8 68 cb 2c 93 b7 7f 2a 7c ...
13 b8 68 cb 2c 93 b7 7f 2a 7c 6f 81 11 fa ab
97 99 72 80 5a
Thumbprint
Edit Properties...
Copy to File...
OK
Certificate
General
Details
Certification Path
Show: <All>
Field
Value
Version
V3
Serial number
58 74 4e 71 00 00 00 00 44 ba
Signature algorithm
sha1RSA
Issuer
Ascertia CA 1, Class 1 Certific...
Valid from
17 December 2006 21:04:49
Valid to
17 December 2007 21:14:49
Subject
William Buchanan, IT, Napier U...
Public key
RSA (2048 Bits)
CN = Ascertia CA 1
OU = Class 1 Certificate Authority
O = Ascertia
C = GB
Issuer
Edit Properties...
Copy to File...
OK
Digital Cert.
Authentication
Digital certificate contains a thumbprint to verify it





Digital certificates should only be distributed with the public key

Authentication

Digital Cert.

P7b format

Bob

```
-----BEGIN CERTIFICATE-----
MIID2zCCA4WgAwIBAgIKWHROcQAAAABEujANBgkqhkiG 9w0BAQUFADBgMQswCQYD
VQQGEwJHQjERMA 8GA1UEChMIQXNjZXJ 0aWExJjAkBgNVBAsTHUNsYXNzIDEgQ 2Vy
dGlmaWNhdGUgQXV 0aG9yaXR 5MRYwFAYDVQQDEw 1Bc2NlcnRpYSBDQSAxMB 4XDTA2
MTIxNzIxMDQ 0OVoXDTA 3MTIxNzIxMTQ 0OVowgZ 8xJjAkBgkqhkiG 9w0BCQEWF 3cu
YnVjaGFuYW 5AbmFwaWVyLmFjLnVrMQswCQYDVQQGEwJVSzEQMA 4GA1UECBMHTG 90
aGlhbjESMBAGA 1UEBxMJRWRpbmJ 1cmdoMRowGAYDVQQKExFOYXBpZXIgVW 5pdmVy
c2l0eTELMAkGA 1UECxMCSVQxGTAXBgNVBAMTEFdpbGxpYW 0gQnVjaGFuYW 4wggEi
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M5FOxhSrV+Q86hsK 8cDc+1sqyJ 8TQtufuDNs 0NfNY 6tR6q7CgGqQ 8/VjSxNqzK 39
iLUF1ahhyCet /ab6O/qWzL 4iVsz 2nmL 4dyAuyilhLPlVbppHGdE 6sDQXWYd 0CpfV
ZN7pauD 5fqBESfO 6bUkCieI 47AzRMQj 3kHuDt 7MexVW 7aoX+nXLP 4wn 7IamaxasF
QvhdOKyCZhYs 82JQDGatXRCqkklztmZW 5i 6GkPsE 7xVuX 265WJQ 5afhp 2hYlAgMB
AAGjggEXMIIBEzAdBgNVHQ 4EFgQUzyZ /YcCJwT 5opPHLPlcQKkOlkJwwYWYDVR 0j
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BgNVHR 8ERjBEMEKgQKA +hjxodHRwOi 8vd3d3LmFzY 2VydGlhLmNvbS 9PbmxpbmVD
QS9jcmxzL 0FzY 2VydGlhQ 0ExL 2NsYXNzMS 5jcmwwPgYIKwYBBQUHAQEEMjAwMC 4G
CCsGAQUFBzAChiJodHRwOi 8vb2NzcC 5nbG9iYWx 0cnVzdGZpbmRlci 5jb20vMA0G
CSqGSIb 3DQEBBQUAA 0EATOCwGJ 1tS0kTlupmpjkMl 8IdxMmD 5WuhszjBlGsMhPxI
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```
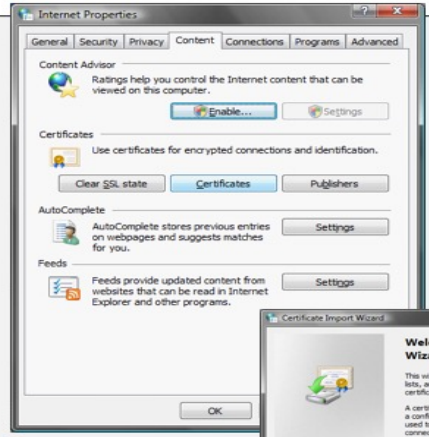
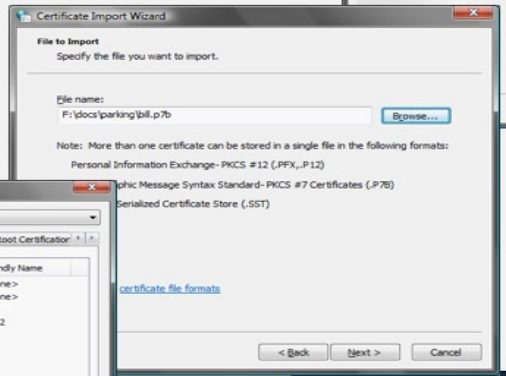
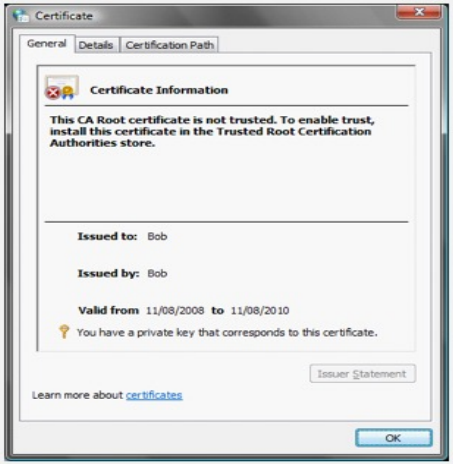
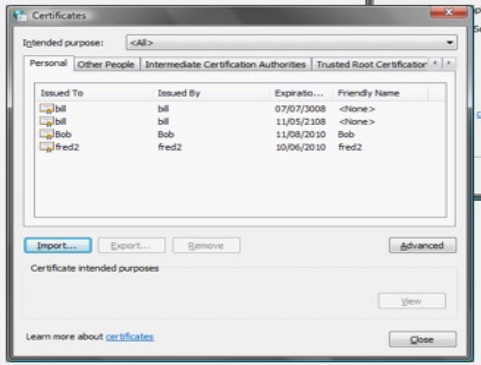









The main certificate formats include:

- P7b. Text format
- PFX/P12. Binary.
- SST. Binary.

Digital certificates should only be distributed with the public key

A. Bob creates the message.
B. Bob encrypts with Alice's public key and sends Alice the encrypted message
C. Alice decrypts with her private key
D. Alice receives the message

A

Encryption

Communications Channel

Decryption

Alice sends her digital certificate with her public key on it

Hello

B

C

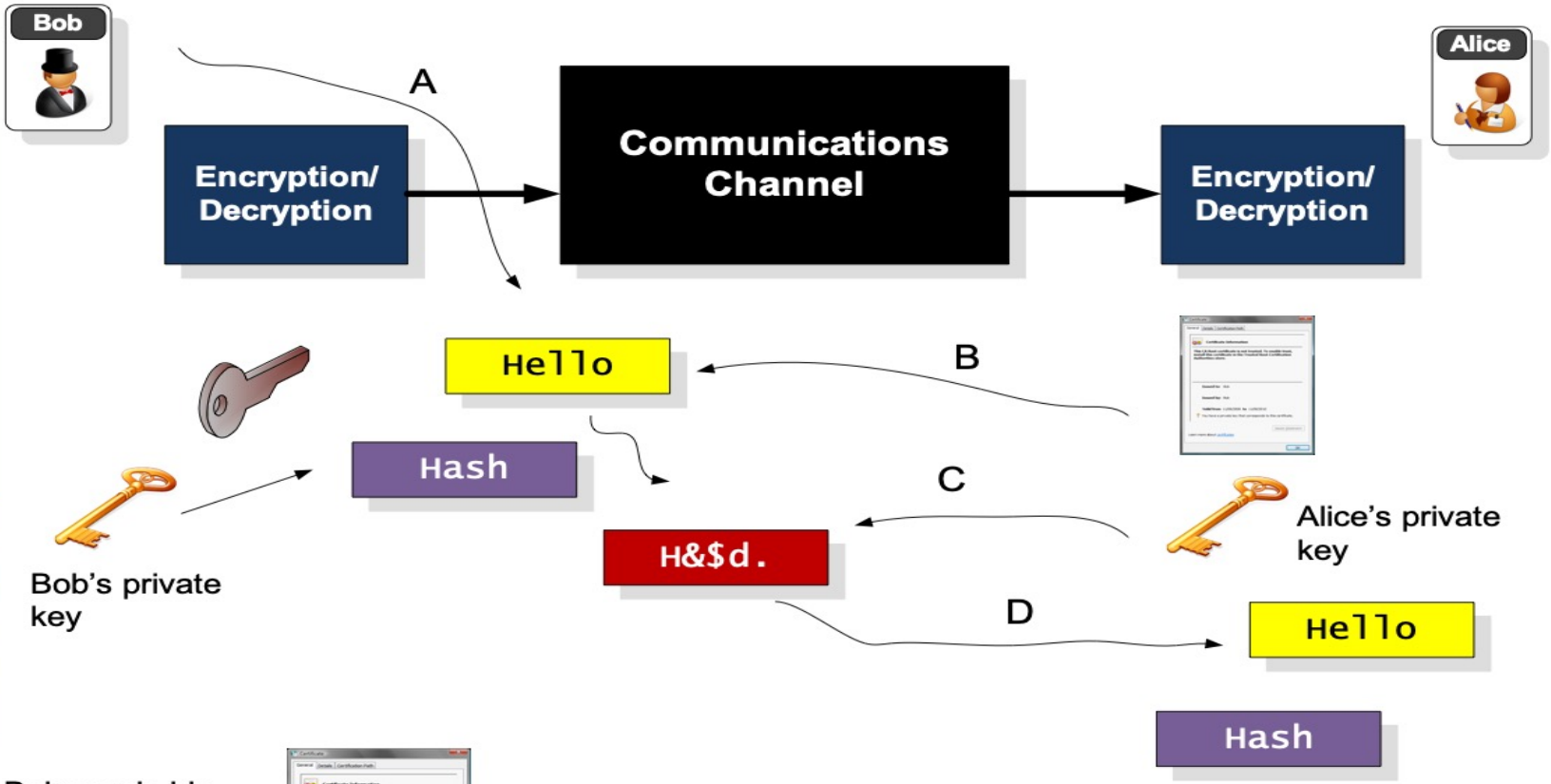
H&$d.

Alice's private key

D

Hello

Author: Prof Bill Buchanan



Bob sends his Digital certificate to authenticate himself

Alice checks the hash using Bob's public key from his certificate

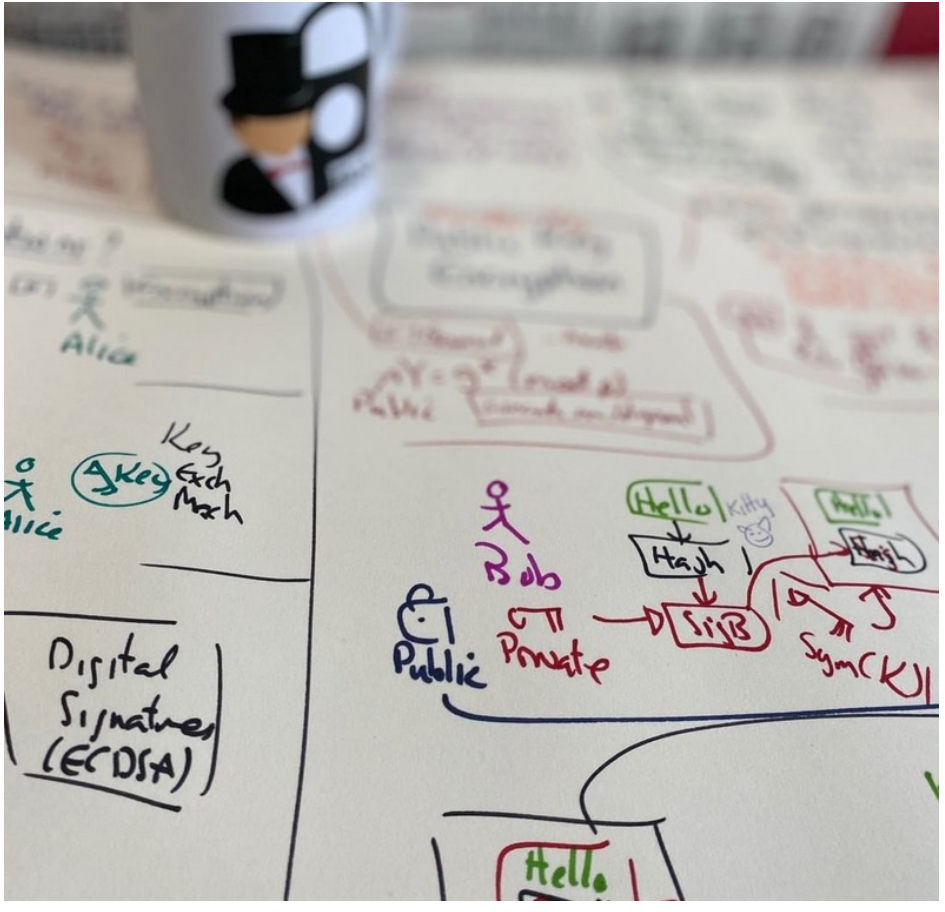
Author: Prof Bill Buchanan

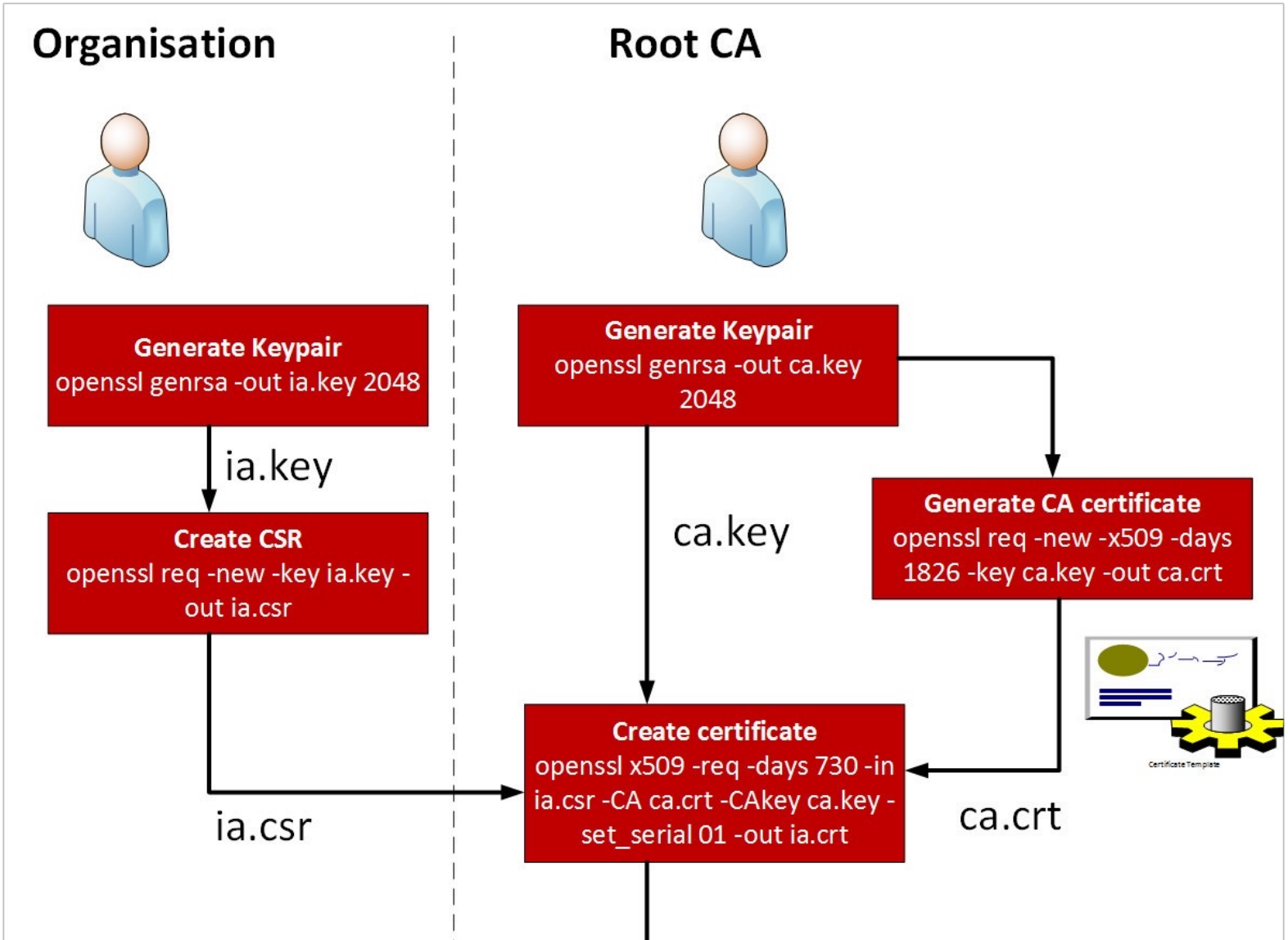
Digital Certificates

Introduction
Authentication Methods
PKI
Certificate Creation
Digital Certificate Passing

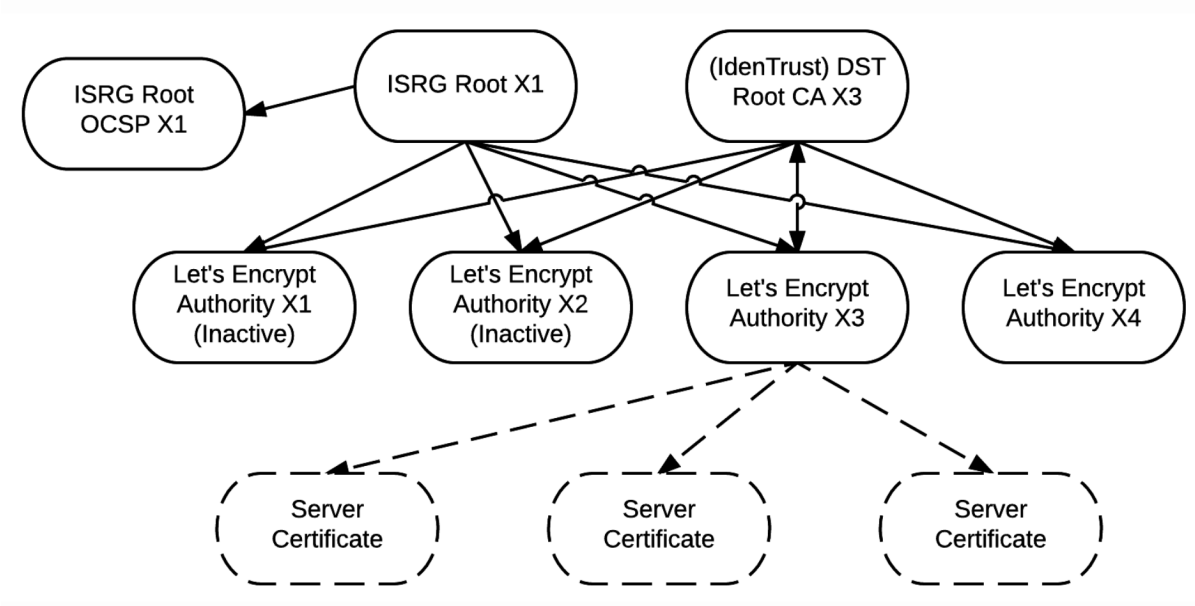
Prof Bill Buchanan OBE

https://asecuritysite.com/tunnelling




Organisation
Root CA
Generate Keypair
openssl genrsa -out ia.key 2048
ia.key
Create CSR
openssl req -new -key ia.key -out ia.csr
ia.csr
Generate Keypair
openssl genrsa -out ca.key 2048
ca.key
Generate CA certificate
openssl req -new -x509 -days 1826 -key ca.key -out ca.crt
ca.crt
Create certificate
openssl x509 -req -days 730 -in ia.csr -CA ca.crt -CAkey ca.key -set_serial 01 -out ia.crt


SECURE THE WEB
Let's Encrypt


ISRG Root OCSP X1
ISRG Root X1
(IdenTrust) DST Root CA X3
Let's Encrypt Authority X1 (Inactive)
Let's Encrypt Authority X2 (Inactive)
Let's Encrypt Authority X3
Let's Encrypt Authority X4
Server Certificate
Server Certificate
Server Certificate

PEM

```
-----BEGIN CERTIFICATE-----
MIIEwTCCA6mgAwIBAgIRAO93GGFLf                    YJKoZIhvcNAQELBQAw
QjELMAkGA1UEBhMCVVMxHjAcBgNVBAoTFUdvb2dsZSBUcnVzdCBTZXJ2aWNlczET
MBEGA1UEAxMKR1RTIENBIDFPMTAeFw0yMDAyMTIxMTQ3NDFaFw0yMDA1MDYxMTQ3
NDFaMGgxCzAJBgNVBAYTAlVTMRMwEQYDVQQIEwpDYWxpZm9ybmlhMRYwFAYDVQQH
Ew1Nb3VudGFpbiBWaWV3MRMwEQYDVQQKEwpHb29nbGUgTExDMRcwFQYDVQQDEw53
d3cuZ29vZ2xlLmNvbTBZMBMGByqGSM49AgEGCCqGSM49AwEHA0IABCzzLJYFJb8W
TpQxWL0TySDvfEWCkMe7l81CFspT60knl13YILNdTM22sUwPycyogKjBSaQZ9Axi
```

- X.509 Certificate (DER)
- X.509 Certificate (PKCS#7)

PKCS#1 v2 - Padding for Public Key

PKCS #7 v1.5 - Cryptography Message Syntax

PKCS 10 v1.7 - Certificate Request Standard.

```
tlHtqVqITZPCAI/ANvbHdZiMEePB8eA+oTiw2ucChqLlsop5Mio8ckg7aXG4/QfC
AIDbvkoffK44rs4UEpsaqGe9QqMJjTuO7ZCZrFd1m3geq2ARKPHgPoPM6UbDdqgO
TNQo9C0F5ZlOkOgV/qshvpTO4YzE7TB2U571eYEqNXH48syVx8XSk3P7FjM7FIZ2
IzbJSEipZJm8DsP10fFXpToIn+zK
-----END CERTIFICATE-----
```

PKCS#7

```
-----BEGIN PKCS7-----
MIIE8gYJKoZIhvcNAQcCoIIE4zC                    9w0BBwGgggTF
wTCCA6mgAwIBAgIRAO93GGFLfHwOCAAAAAAucZgwDQYJKoZIhvcNAQELBQAw
MAkGA1UEBhMCVVMxHjAcBgNVBAoTFUdvb2dsZSBUcnVzdCBTZXJ2aWNlczET
A1UEAxMKR1RTIENBIDFPMTAeFw0yMDAyMTIxMTQ3NDFaFw0yMDA1MDYxMTQ3
MGgxCzAJBgNVBAYTAlVTMRMwEQYDVQQIEwpDYWxpZm9ybmlhMRYwFAYDVQQH
b3VudGFpbiBWaWV3MRMwEQYDVQQKEwpHb29nbGUgTExDMRcwFQYDVQQDEw53
Z29vZ2xlLmNvbTBZMBMGByqGSM49AgEGCCqGSM49AwEHA0IABCzzLJYFJb8W
WL0TySDvfEWCkMe7l81CFspT60knl13YILNdTM22sUwPycyogKjBSaQZ9Axi
EAiJkbejggJVMIICUTAOBgNVHQ8BAf8EBAMCB4AwEwYDVR0lBAwwCgYIKwYB
AwEwDAYDVR0TAQH/BAIwADAdBgNVHQ4EFgQU9Ty3t90o7UW9+Hc6kv/j9511
HwYDVR0jBBgwFoAUmNH4bhDrz5vsYJ8YkBug630J/SswZAYIKwYBBQUHAQEE
MCcGCCsGAQUFBzABhhtodHRwOi8vb2NzcC5wa2kuZ29vZy9ndHMxbzEwKwYI
BQUHMAKGH2h0dHA6Ly9wa2kuZ29vZy9nc3IyL0dUUzFPMS5jcnQwGQYDVR0R
EIIOd3d3Lmdvb2dsZS5jb20wIQYDVR0gBBowGDAIBgZngQwBAgIwDAYKKwYB
eQIFAzAvBgNVHR8EKDAmMCSgIqAghh5odHRwOi8vY3JsLnBraS5nb29nL0dU
MS5jcmwwggEFBgorBgEEAdZ5AgQCBIH2BIHzAPEAdgCyHgXMi6LNiiBOh2b5
JSBna9r6cOeySVMt74uQXgAAAXA5cNqwAAAEAwBHMEUCIQCojKtzOe8l1JYK
bt1puqT4AE3peMVAVk/WeWGp1QIgBvRMbNkwF6i8+JVv3CfTHKvFd8e00+GY
Zb1drKEAdwBep3P531bA57U2SH3QSeAyepGaDIShEhKEGHWWgXFFWAAAAXA5
AAAEAwBIMEYCIQCQSONppELPODh65oFT5ZAGsSQz4FsjNNZedgS7WqzLnQIh
u0QUuoE3RWngfhI6W7n1kxkEmd0vSZTe6+Ql+JVuMA0GCSqGSIb3DQEBCwUA
AQCDU8CVusGstVk1lAmrtg3DyYhNV1UnKyLk3RrHKumwYz5mC25bWGoLVKvv
N3zA329/9JZq0mnn0vmPMxjTDvh9sVQ7g4znwha/KJfzL8AZKUdldD9O+hDC
qVqITZPCAI/ANvbHdZiMEePB8eA+oTiw2ucChqLlsop5Mio8ckg7aXG4/QfC
vkoffK44rs4UEpsaqGe9QqMJjTuO7ZCZrFd1m3geq2ARKPHgPoPM6UbDdqgO
9C0F5ZlOkOgV/qshvpTO4YzE7TB2U571eYEqNXH48syVx8XSk3P7FjM7FIZ2
SEipZJm8DsP10fFXpToIn+zKoQAxAA==
-----END PKCS7-----
```

Base64

```
openssl x509 -outform der -in www-google-com.pem -out google.crt
openssl pkcs12 -export -in server.pem -out keystore.pkcs12
```

Binary

DER
CER

Digital Certificates

Introduction
Authentication Methods
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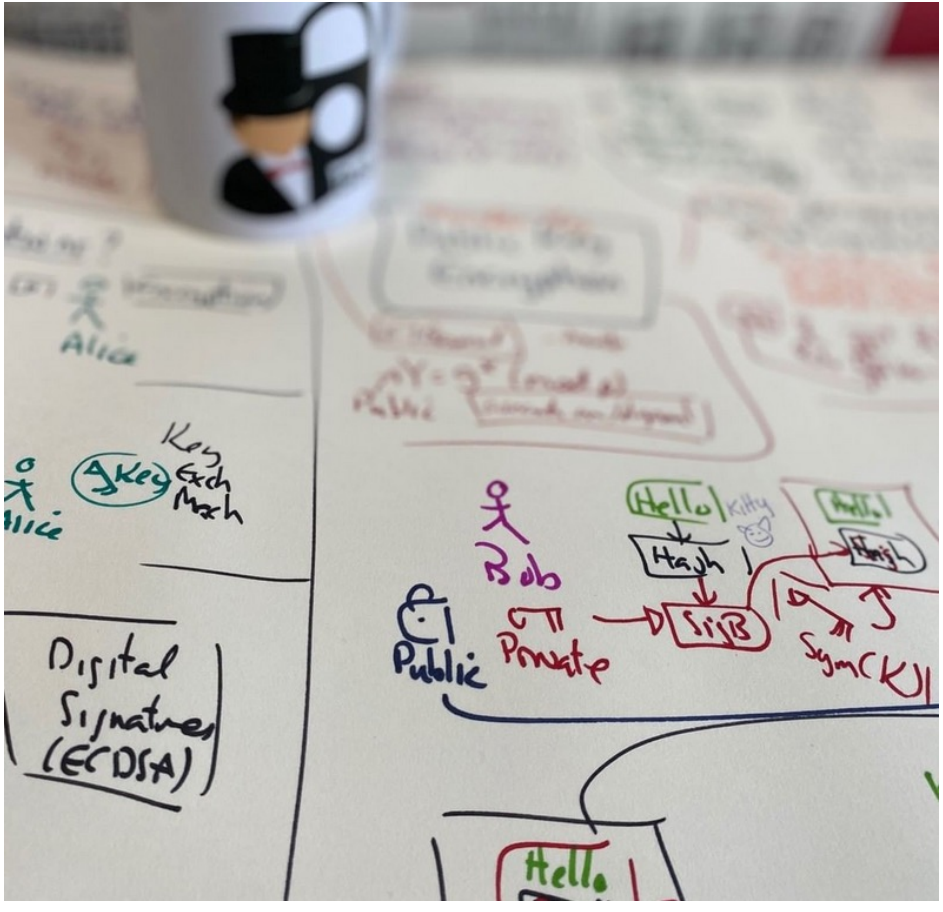
Digital Certificate Passing

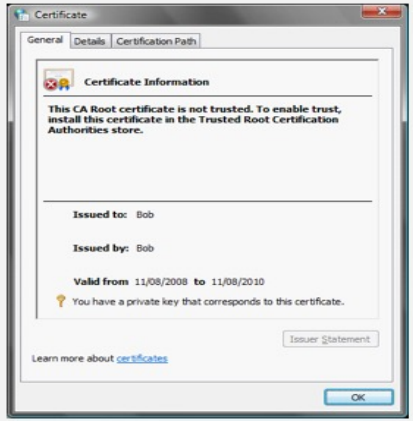
Prof Bill Buchanan OBE

http://asecuritysite.com/crypto06
http://asecuritysite.com/encryption



Digital Certificates

Digital certificates are a soft token of authentication, and require a trust mechanism.



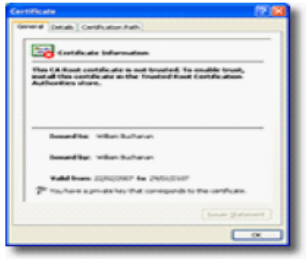
Who do we trust to get Bob's certificate … we can't trust Bob, as he may be Eve… meet Trent.

Who can we trust to get the digital certificate from ?

Trusted Root CA

Certificate Authority (CA)
- Able to grant certificates
Examples; Verisign, Entrust, Microsoft Trust.

The Trusted Root CE (Trent) checks Bob's identity and creates a certificate which he signs



Trusted root certificates are installed as a default on the machine (or installed with the user's permission)

Trusted root certificate

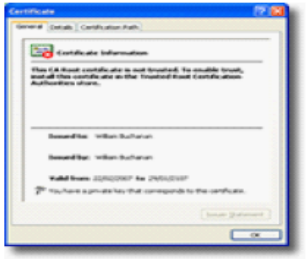
Alice checks the signature of the certificate to validate Bob. Both Alice and Bob trust the CA (Trent) as a third party.

Author: Prof Bill Buchanan

Trusted Root CA

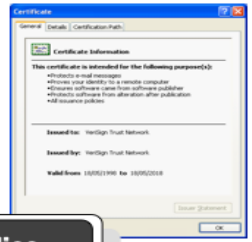
Certificate Authority (CA)
- Able to grant certificates
Examples; Verisign, Entrust, Microsoft Trust.

Eve tricks the CA to get a certificate with Bob's name



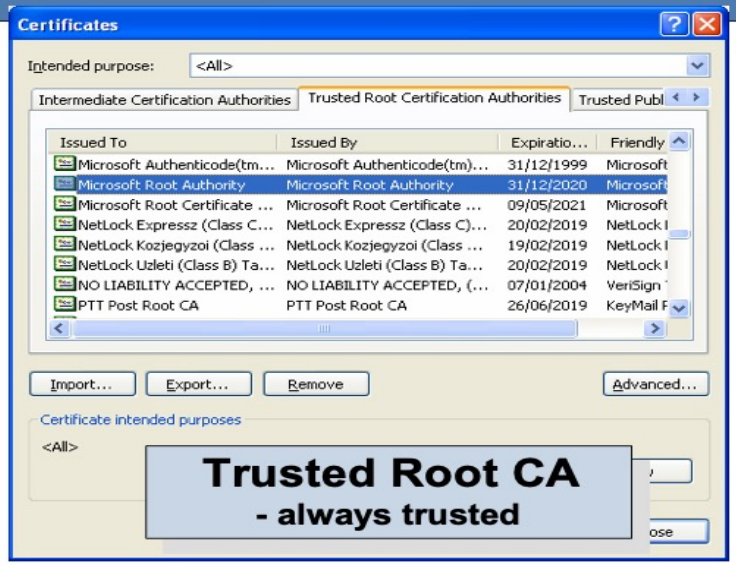
Trusted root certificates are installed as a default on the machine (or installed with the user's permission)

Trusted root certificate



Alice checks the signature of the certificate to validate Bob. Both Alice and Bob trust the CA (Trent) as a third party.

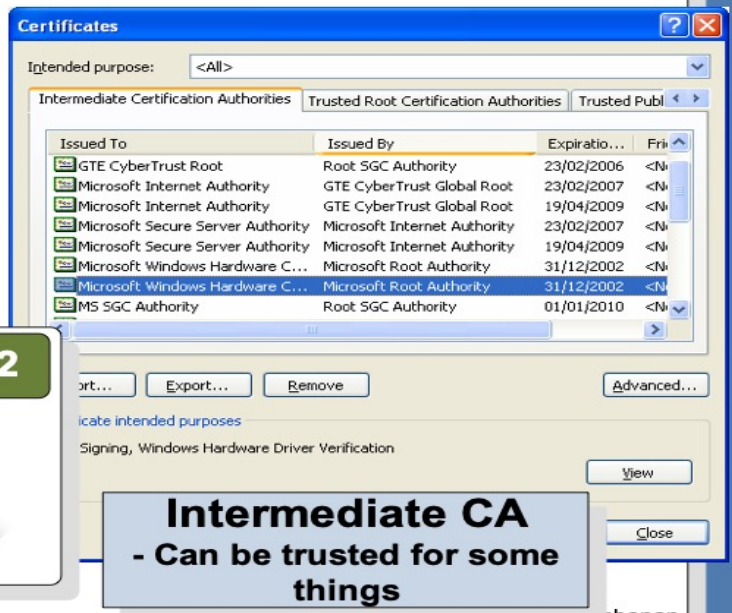
Author: Prof Bill Buchanan



Trusted Root CA

Certificate purposes:

- Secure email.
- Server authentication.
- Code signing.
- Driver authentication.
- Time stamping.
- Client authentication.
- IP tunnelling.
- EFS (Encrypted File System).

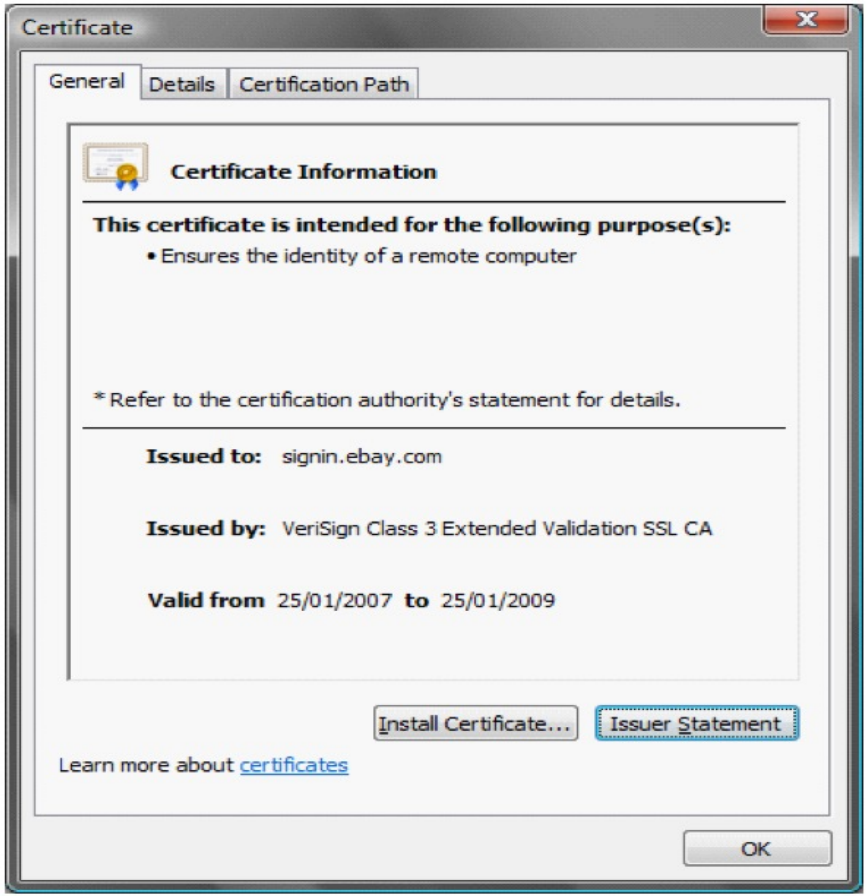


The two main problems with digital certificates are:

- Lack of understanding of how they work.
- They can be spoofed.

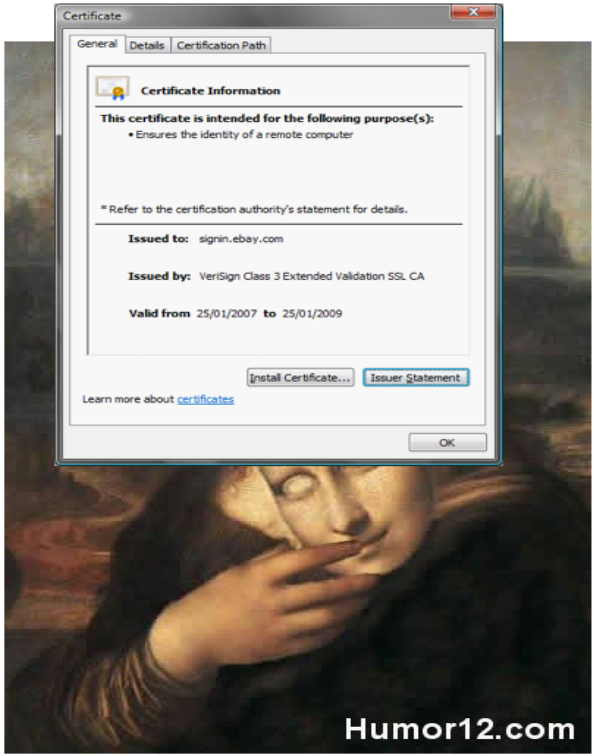
So let's look at a few … are they real or fake?

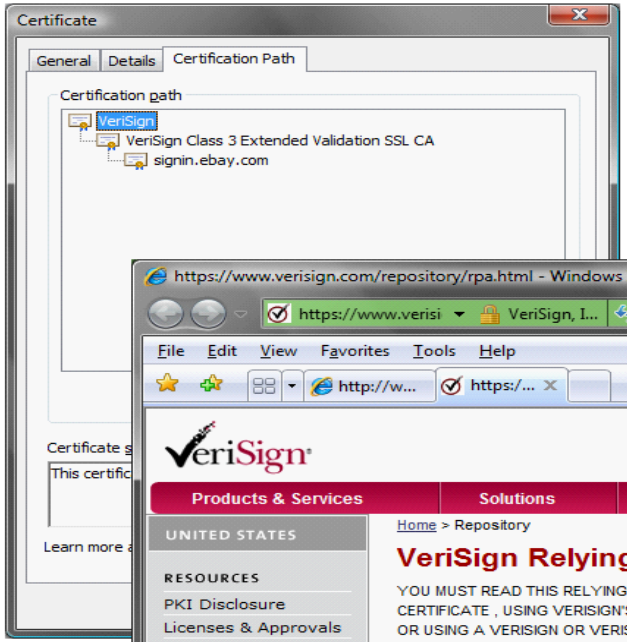
Author: Prof Bill Buchanan



Real or fake?

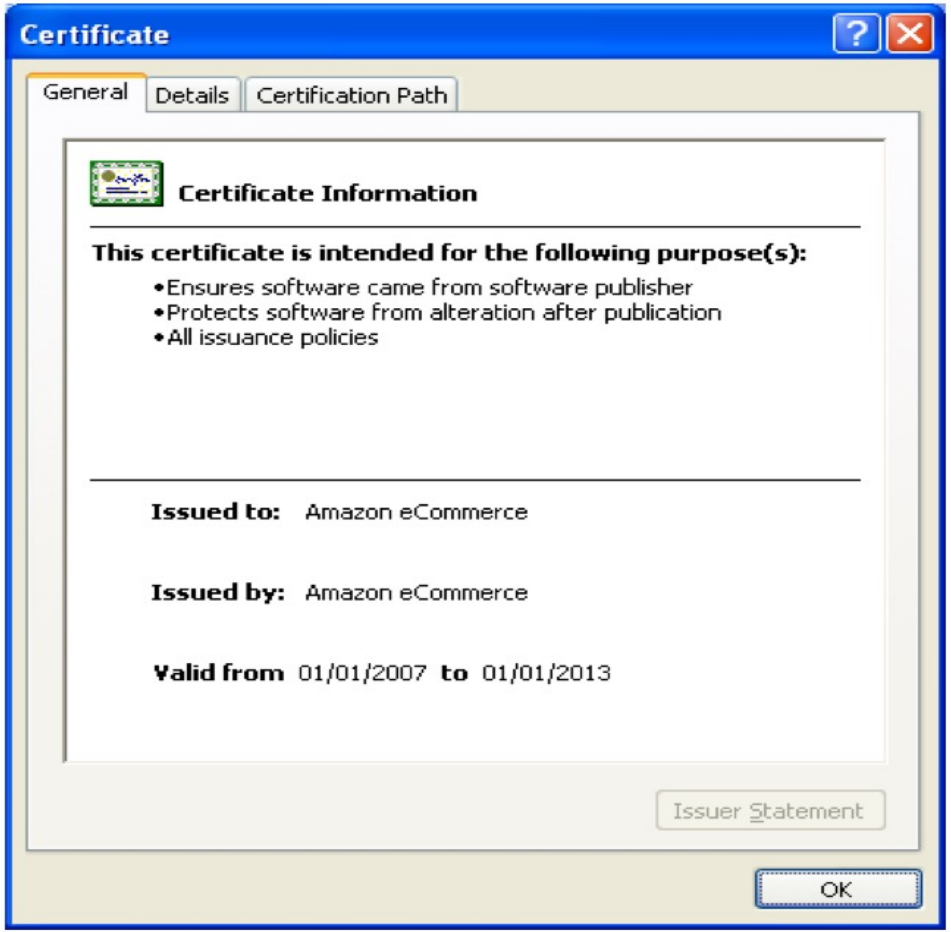
Author: Prof Bill Buchanan





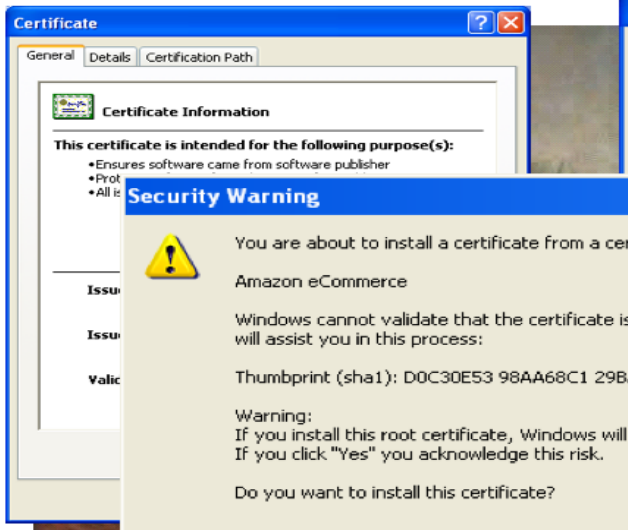
Real!

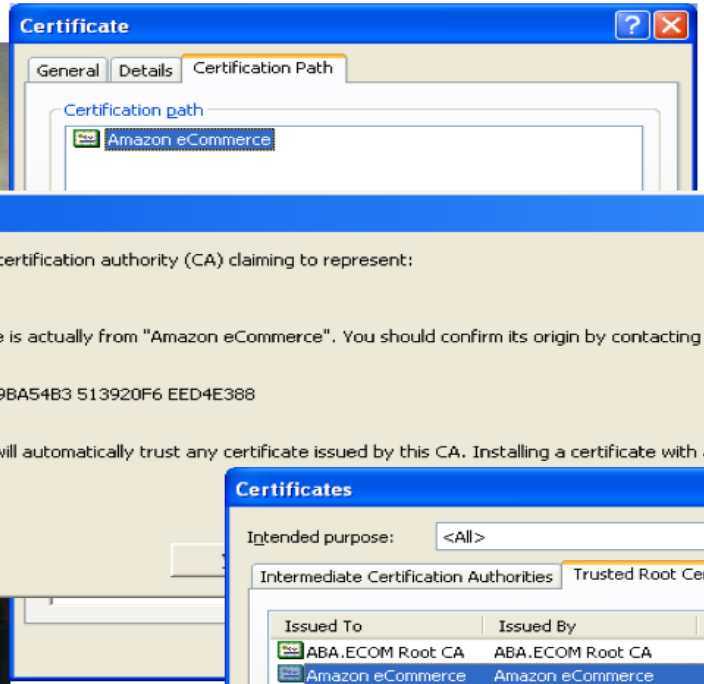
Author: Prof Bill Buchanan



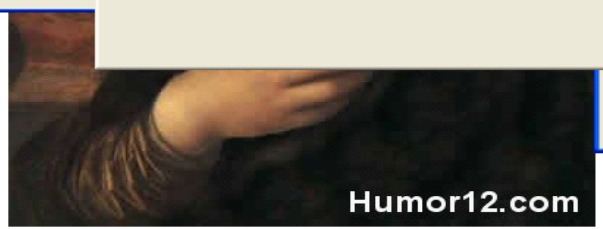
Real or fake?

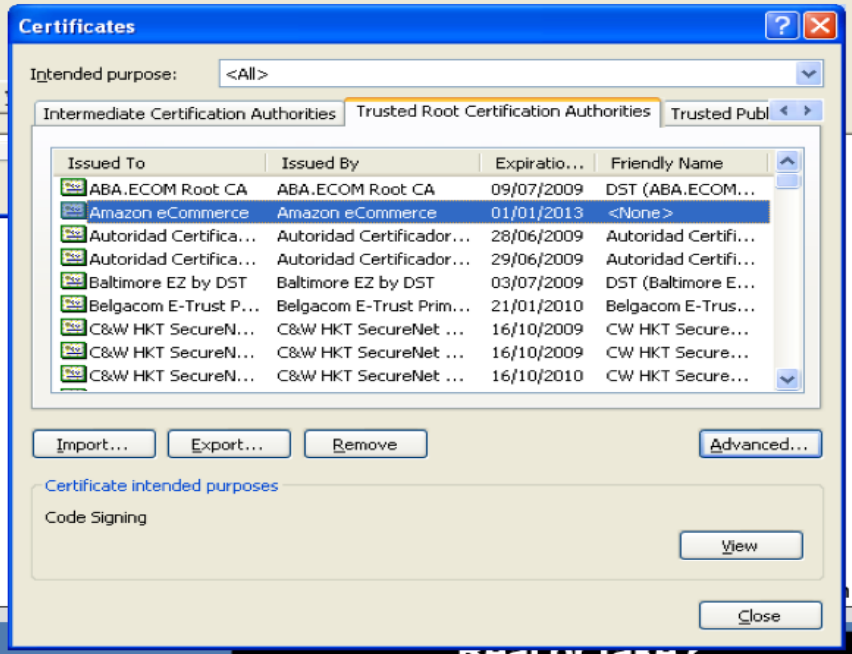
Author: Prof Bill Buchanan


Certificate
General
Details
Certification Path
Certificate Information
This certificate is intended for the following purpose(s):
•Ensures software came from software publisher


Certificate
General
Details
Certification Path
Certification path
Amazon eCommerce

Security Warning
You are about to install a certificate from a certification authority (CA) claiming to represent:
Amazon eCommerce
Windows cannot validate that the certificate is actually from "Amazon eCommerce". You should confirm its origin by contacting "Amazon eCommerce". The following number will assist you in this process:
Thumbprint (sha1): D0C30E53 98AA68C1 29BA54B3 513920F6 EED4E388
Warning:
If you install this root certificate, Windows will automatically trust any certificate issued by this CA. Installing a certificate with an unconfirmed thumbprint is a security risk. If you click "Yes" you acknowledge this risk.
Do you want to install this certificate?


Humor12.com


Certificates
Intended purpose:
<All>
Intermediate Certification Authorities
Trusted Root Certification Authorities
Trusted Publ
Issued To
Issued By
Expiratio...
Friendly Name
ABA.ECOM Root CA
ABA.ECOM Root CA
09/07/2009
DST (ABA.ECOM...
Amazon eCommerce
Amazon eCommerce
01/01/2013
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Autoridad Certifica...
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28/06/2009
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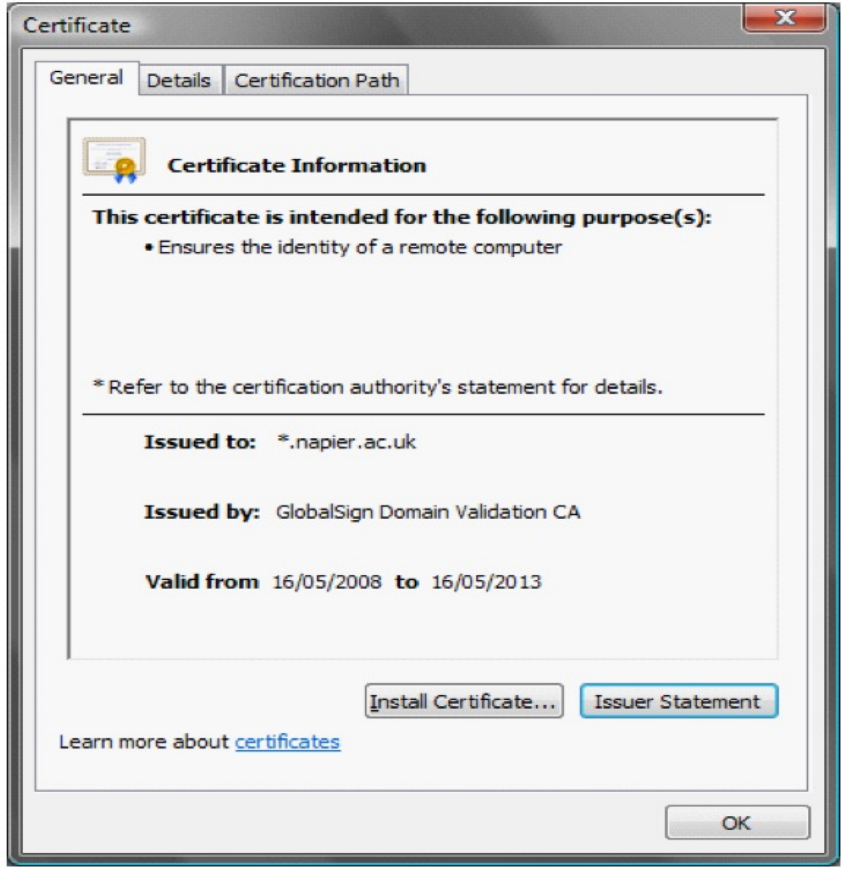
Autoridad Certificador...
29/06/2009
Autoridad Certifi...
Baltimore EZ by DST
Baltimore EZ by DST
03/07/2009
DST (Baltimore E...
Belgacom E-Trust P...
Belgacom E-Trust Prim...
21/01/2010
Belgacom E-Trus...
C&W HKT SecureN...
C&W HKT SecureNet ...
16/10/2009
CW HKT Secure...
C&W HKT SecureN...
C&W HKT SecureNet ...
16/10/2009
CW HKT Secure...
C&W HKT SecureN...
C&W HKT SecureNet ...
16/10/2010
CW HKT Secure...
Import...
Export...
Remove
Advanced...
Certificate intended purposes
Code Signing
View
Close

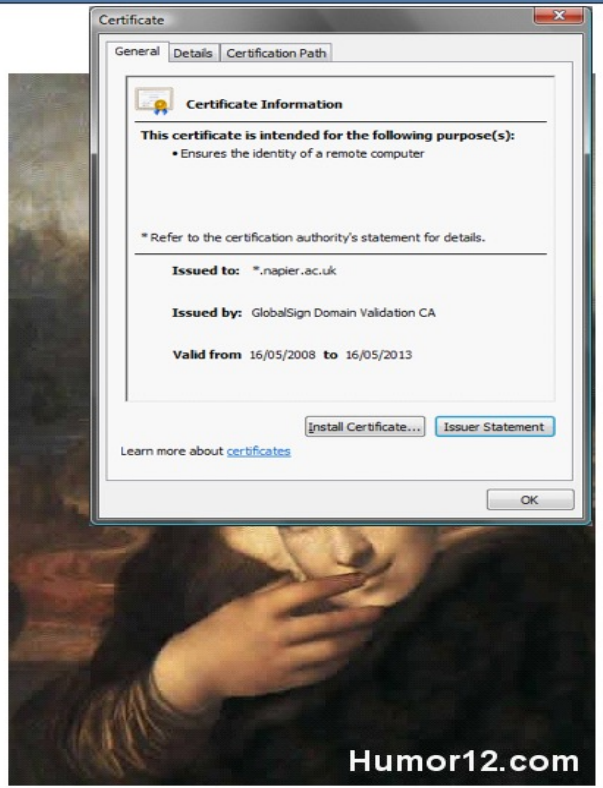

Eve

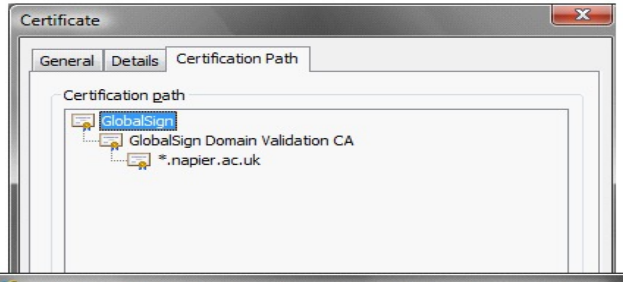
Fake!

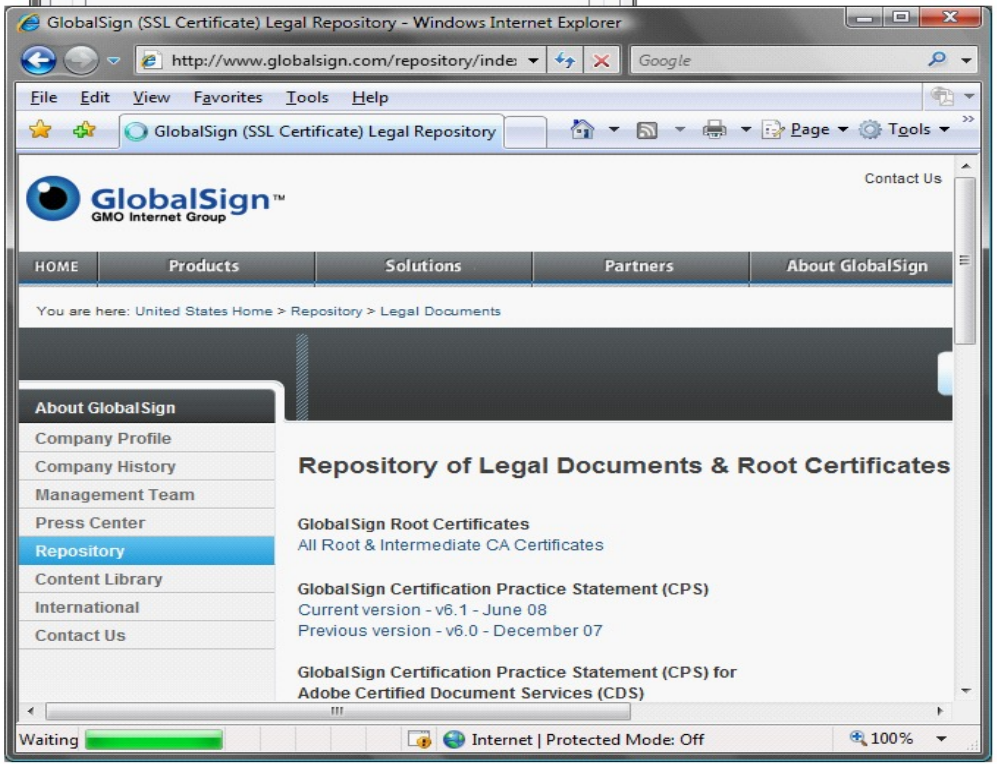


Real or fake?

Author: Prof Bill Buchanan







Real

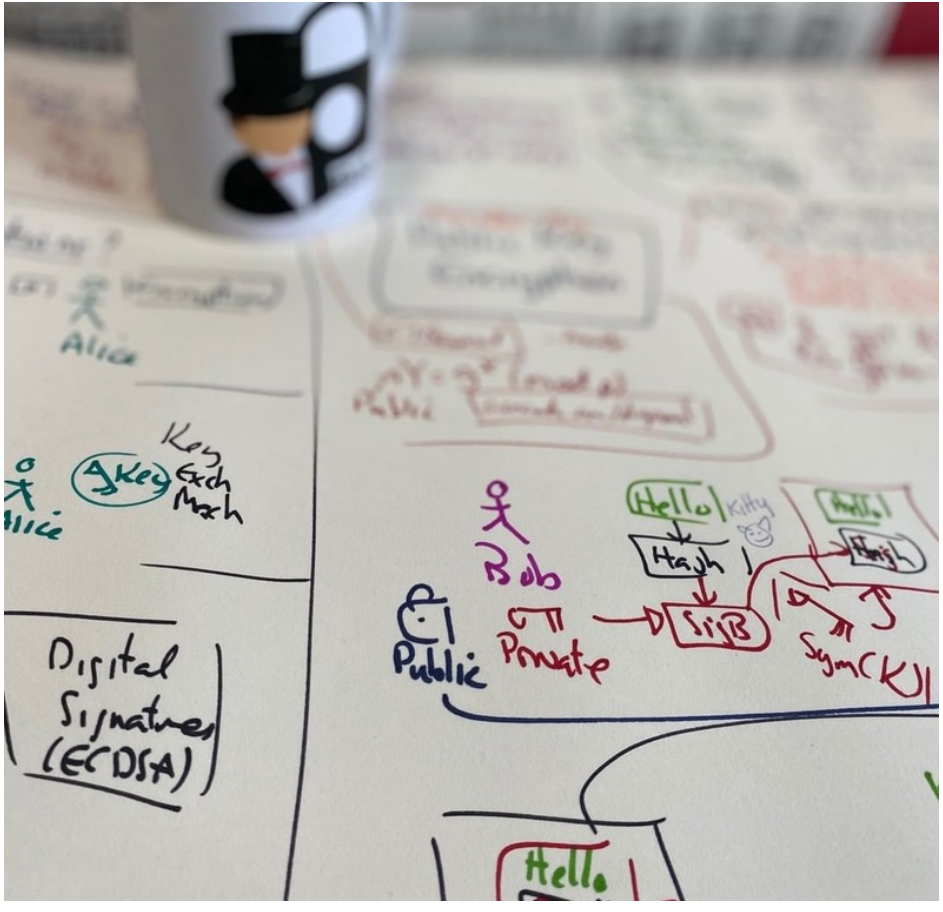
Author: Prof Bill Buchanan

Chapter 6: Digital Certificates

Introduction
Authentication Methods
PKI
Digital Certificate Passing

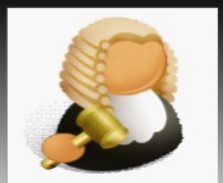
Prof Bill Buchanan OBE

https://asecuritysite.com/tunnelling



Public key encryption … secret … identity … trust

Eve

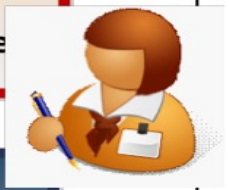


Trent

MegaCorp

ob's Private Key

Alice's Public Ke

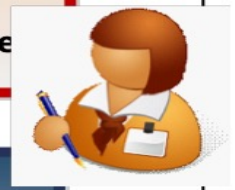


Bob's Public Key

Alice's Private Key

Public key encryption … secret … identity … trust

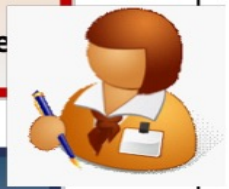
Public key encryption … secret … identity … trust



Public key encryption … secret … identity … trust

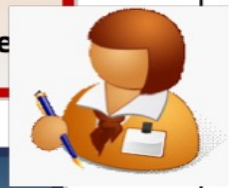
Hello Alice,
Wish you were here!
- Bob

Bob.

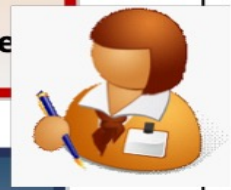


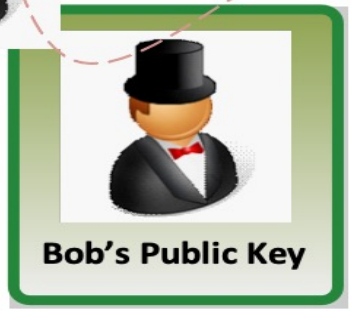
Public key encryption … secret … identity … trust

Hello Alice,
Wish you were here!
- Bob

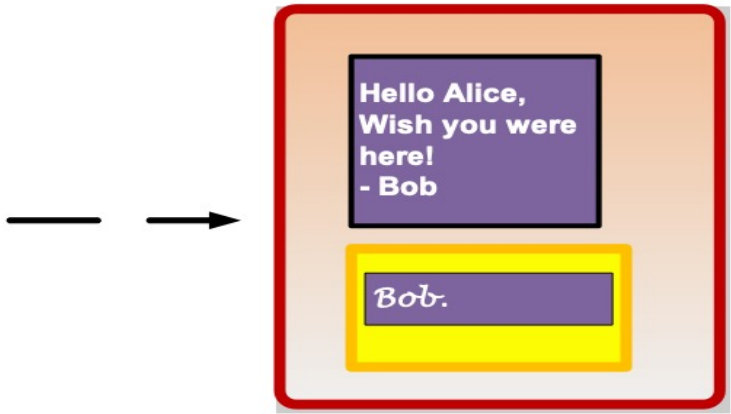


Public key encryption … secret … identity … trust

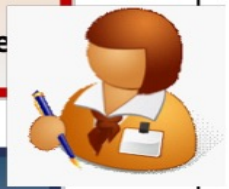




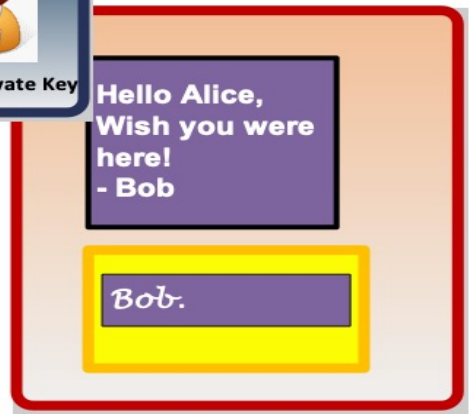
Public key encryption … secret … identity … trust



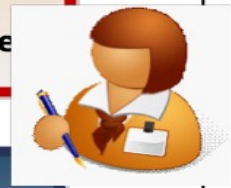
Which key to open the message?



Public key encryption … secret … identity … trust



Which key to open the message?



Public key encryption … secret … identity … trust

Eve

Trent

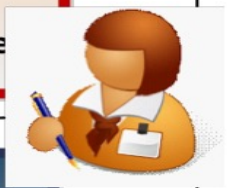
MegaCorp

ob's Private Key

Bob's Public Key

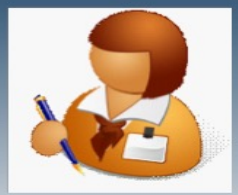
Alice's Public Ke

Hello Alice,
Wish you were here!
- Bob



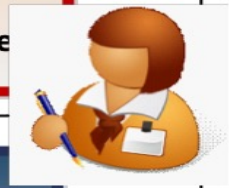
Bob.

Which key to we open the signature with?

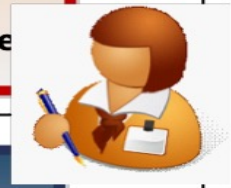


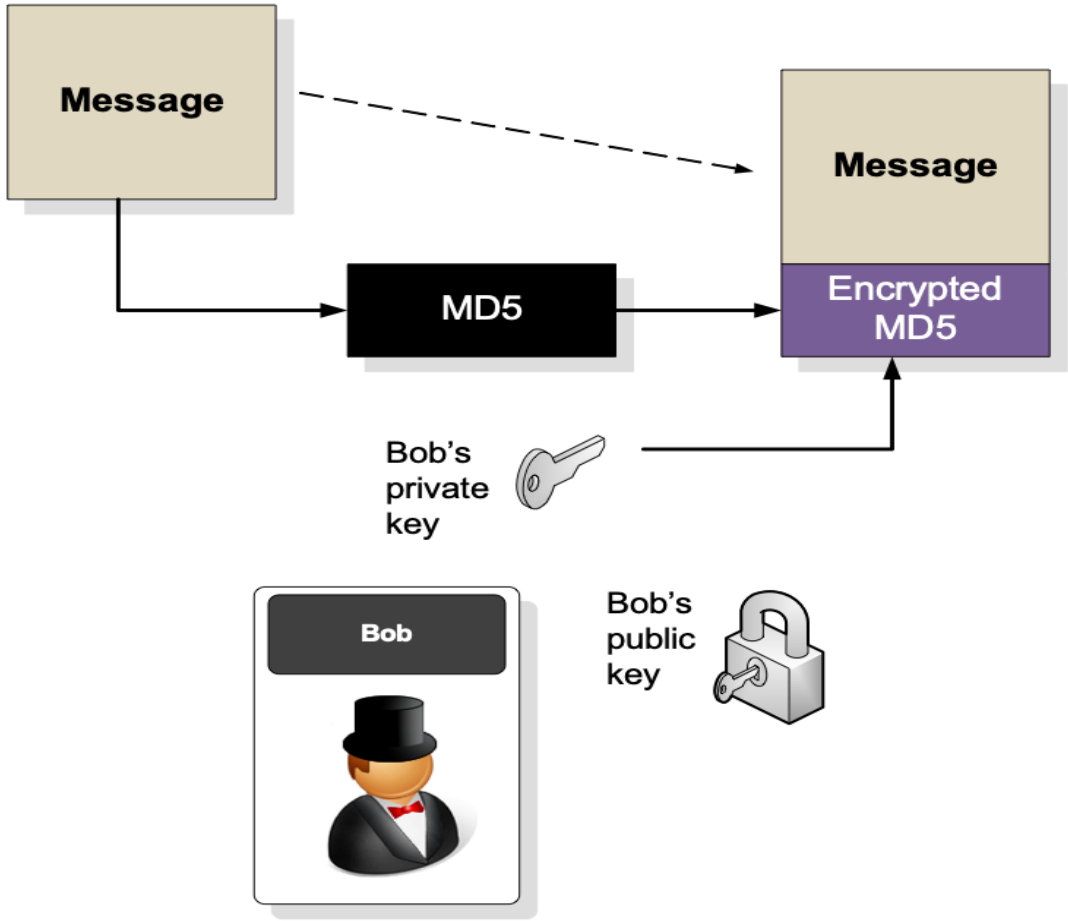
Alice's Private Key

Public key encryption … secret … identity … trust

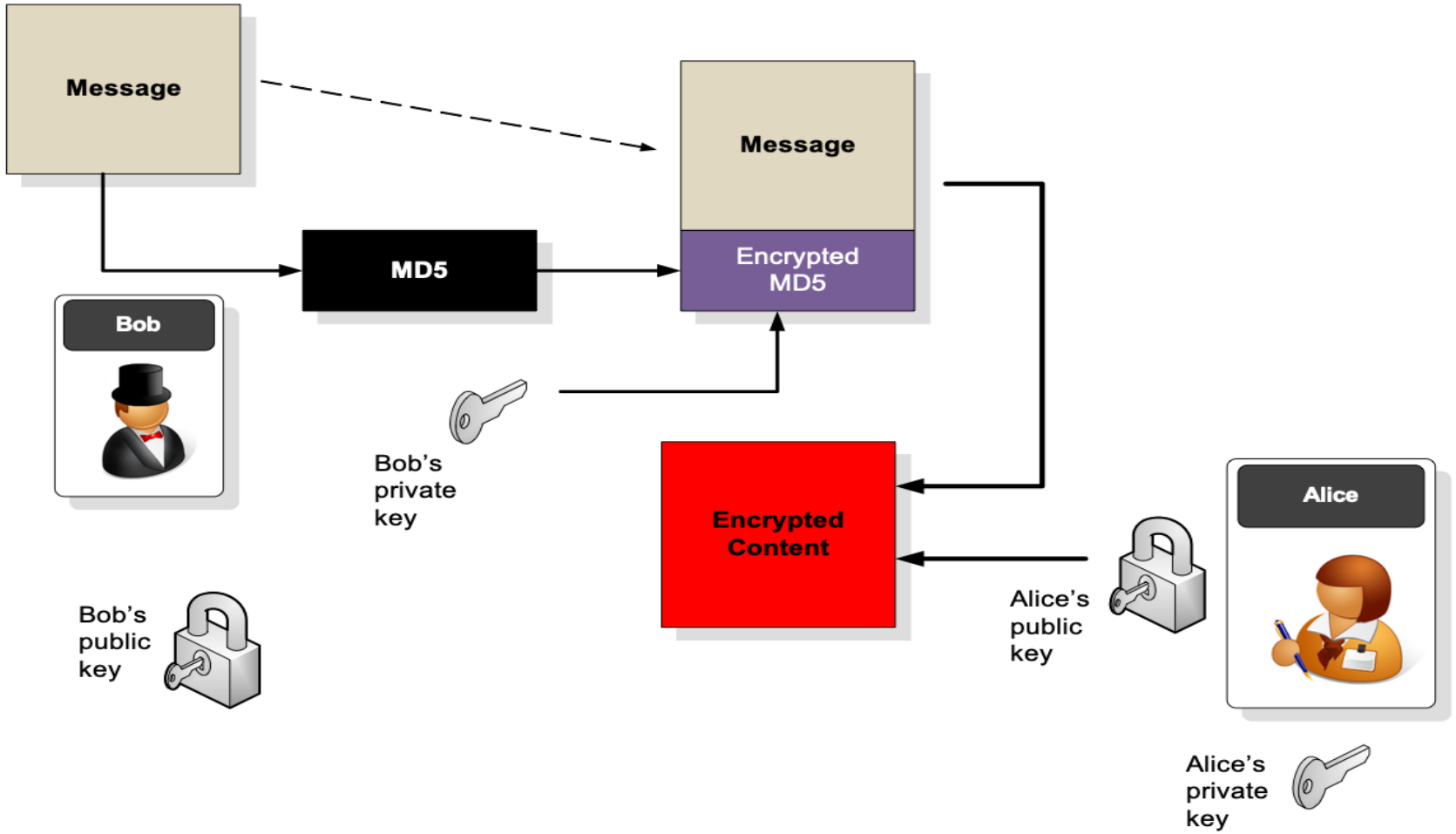


Public key encryption … secret … identity … trust



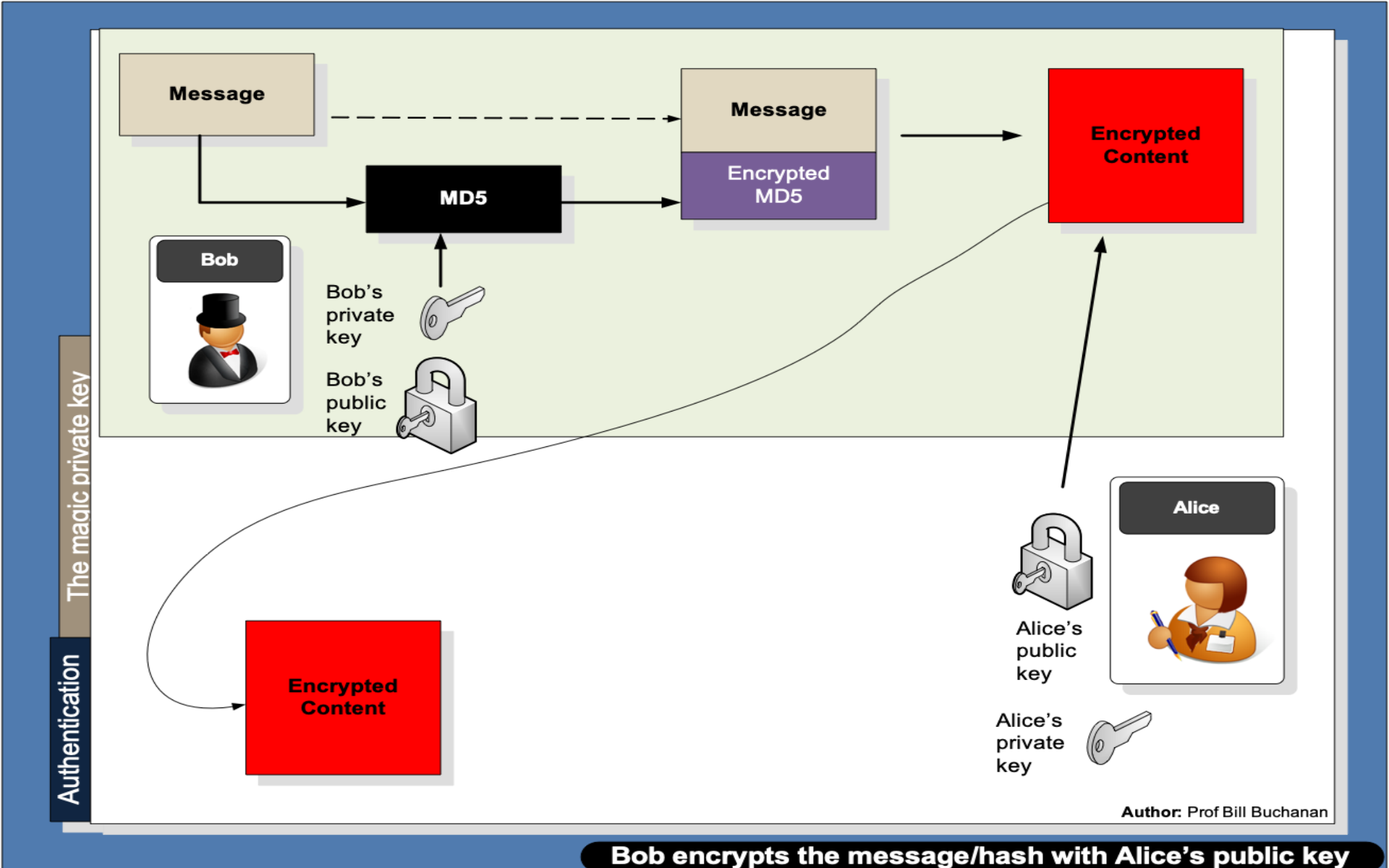


Author: Prof Bill Buchanan

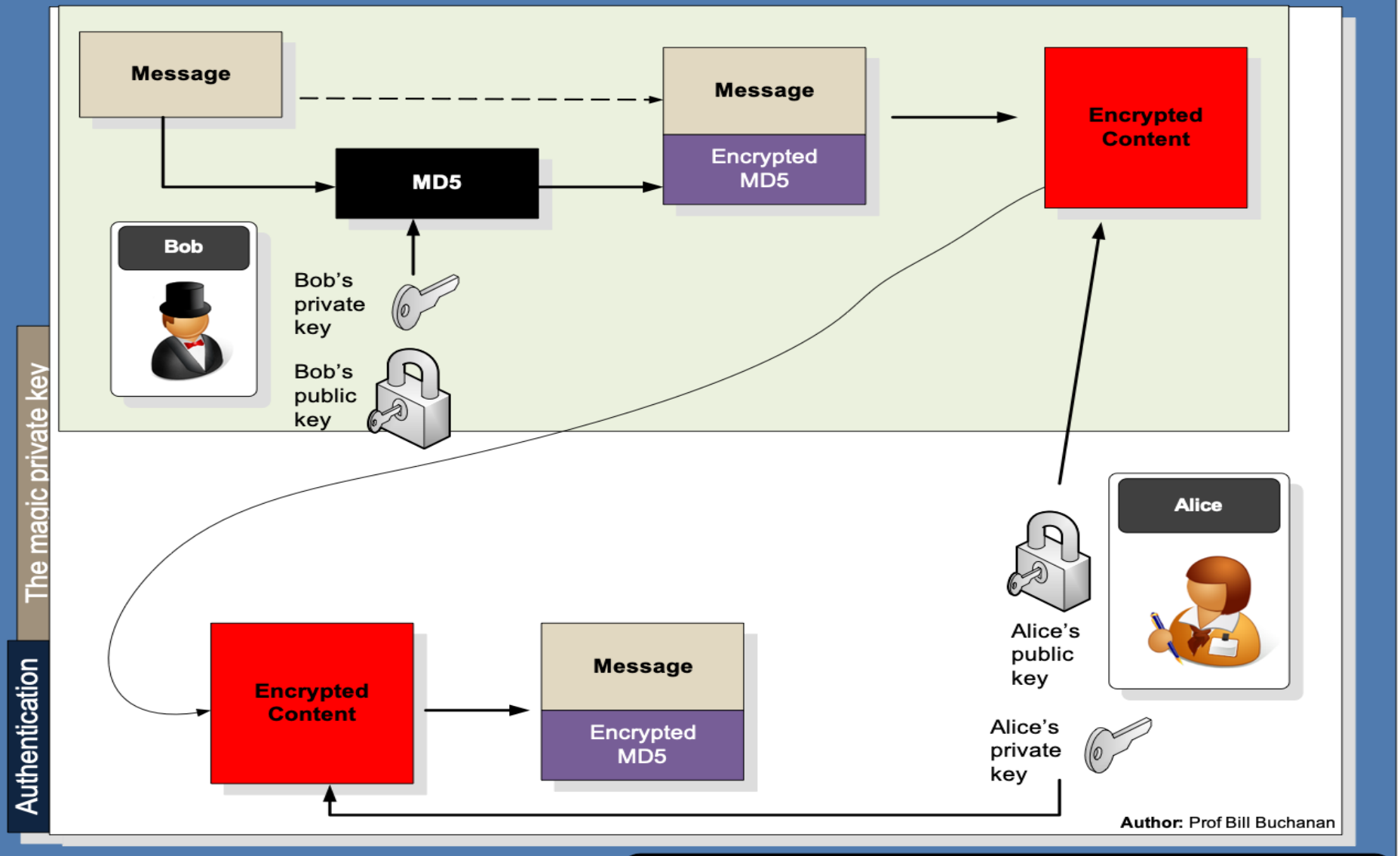


Author: Prof Bill Buchanan

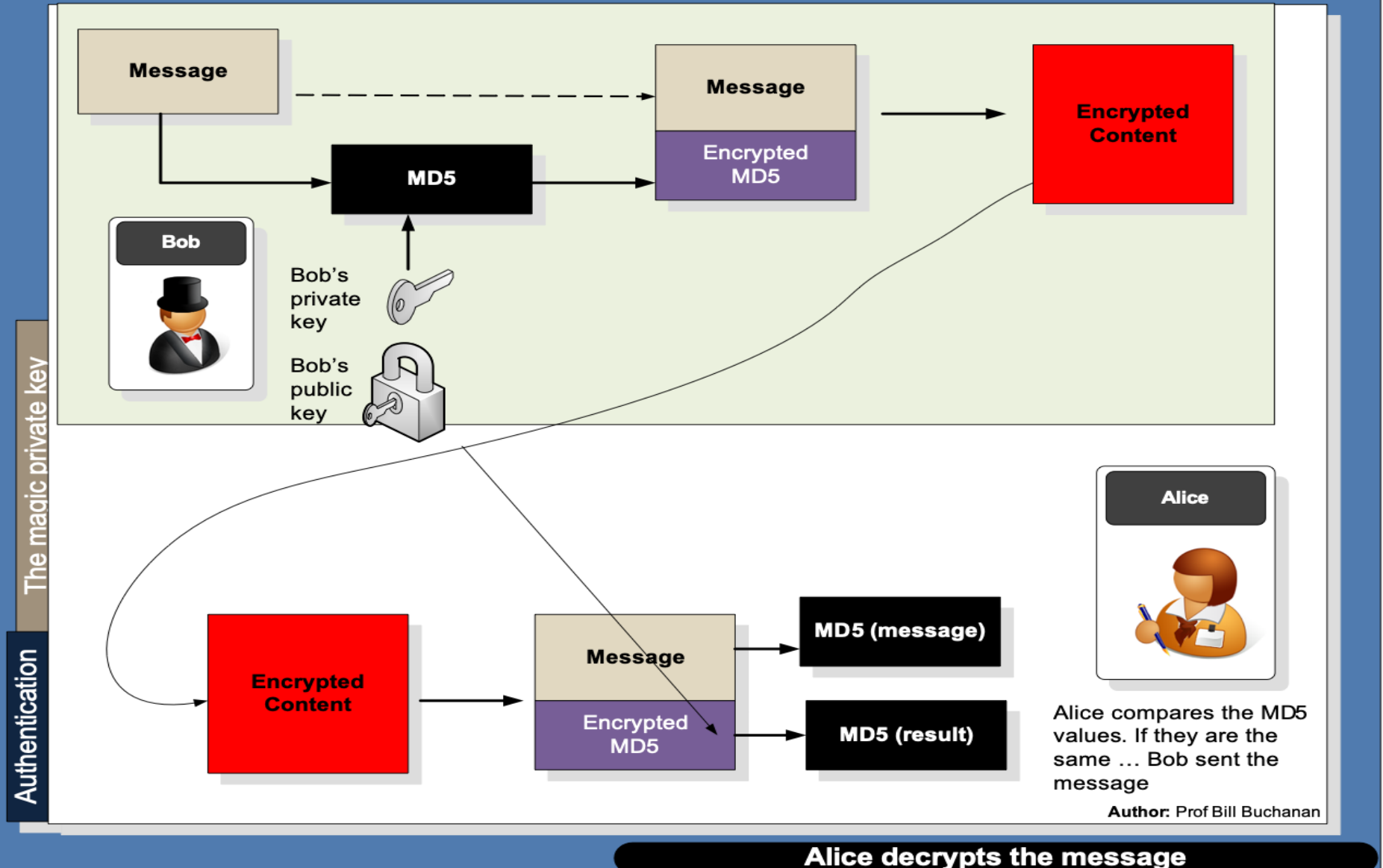
Bob encrypts the message/hash with Alice's public key



Bob encrypts the message/hash with Alice's public key



Alice decrypts the message


Message
Message
Encrypted MD5
Encrypted Content
MD5
Bob
Bob's private key
Bob's public key
The magic private key
Authentication
Alice
Encrypted Content
Message
Encrypted MD5
MD5 (message)
MD5 (result)
Alice compares the MD5 values. If they are the same … Bob sent the message
Author: Prof Bill Buchanan
Alice decrypts the message

Digital Certificates

Introduction
Authentication Methods
PKI
Digital Certificate Passing

Prof Bill Buchanan OBE

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