

Network Security - ISA 656

Email Security

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The Usual Questions

Email Security

The Usual Questions

Assets

Secure Email

Threats

PGP and S/MIME

Phishing

- What are we trying to protect?
- Against whom?

Assets

Email Security

The Usual Questions

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- Confidentiality — people often discuss sensitive things via email
- Authenticity — who really sent the email?
- Anti-spam?
- Phishing?
- Authenticity has many motivations here

General Strategy

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General Strategy

Some Details

Transit

Signing

Headers

General Flow

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PGP and S/MIME

Phishing

- Basic scheme is pretty straight-forward
- Encrypt the message body with a symmetric cipher, using a randomly-generated traffic key
- Use public key cryptography to encrypt the traffic key to all recipients
- Digitally sign a hash of the message
- But there are many details

Some Details

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- Obvious ones: which symmetric, public key, and hash algorithms to use?
- More subtle: which algorithms do the recipients understand?
- Where do certificates come from?
- Do you sign the plaintext or the ciphertext?
- How do you handle BCC?
- Will the ciphertext survive transit intact?
- How are header lines protected?
- What about attachments?
- Many possible answers to all of these questions

Transit

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Phishing

- Not all mail systems accept all characters
- Cryptographic transforms won't survive even minor changes
- Very few are 8-bit clean
- EBCDIC vs. ASCII? Unicode? Tabs versus blanks?
- Solution: encode all email in *base 64*, using characters all systems accept: A-Za-z0-9+/
Use 4 bytes to represent 3; overhead is 33%
- Only those characters matter; everything else is deleted on receipt, including white space

Signing

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Phishing

- If you sign the plaintext and then encrypt, the sender's identity is hidden from all except the proper recipients
- If you sign the ciphertext, a gateway can verify signatures and present mail accordingly — perhaps better for anti-spam and anti-phishing

Headers

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Phishing

- Headers change in transit
- Obvious example: Received: lines are added
- Less-obvious example: Email addresses are often rewritten to hide internal machines, and present clearer addresses to the outside:
-astavrou-@gmu.edu →
-Angelos.Stavrou-@gmu.edu
- Consequence: headers are *not* protected by secure email schemes

General Flow

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- Collect input message
- Put in canonical form
- Encrypt and sign, or sign and encrypt
- Add metadata: encrypted traffic key, your certificate, algorithm identifiers, etc.
- Convert to transit form
- Embed in email message

Eavesdropping

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Password Theft

Hacking

Screen Dumps

Subpoena Attacks

Rubber Hose

Cryptanalysis

Spoofing

Systems Issues

PGP and S/MIME

Phishing

- Most obvious way to read email: eavesdropping
- The bad guy “simply” listens to the network
- Harder than it sounds, except for some wireless nets
- Frequently used by police and intelligence agencies, i.e., the FBI’s *Carnivore* device

Password Theft

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Phishing

- Most email is retrieved by login and password
- Anyone who gets your password can read your email
- It's much easier for an eavesdropper to pick those up — passwords are usually sent each time someone polls for new email

Hacking

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Phishing

- The real threat to email is while it's in storage
- This can be temporary storage, waiting for you to pick it up
- It can also be your personal machine, for email you've sent or received
- What if your laptop is stolen? Does it have plaintext copies of all the secure email you've sent and received?

Screen Dumps

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Phishing

- Connect via X11
- Use some other Trojan horse software to dump user's screen periodically
- Reflection off the back wall...

Subpoena Attacks

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- What if your records are subpoenaed?
- This is a legal issue; technical wiggling won't help!

Rubber Hose Cryptanalysis

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- What if the local secret police want to know what some intercepted email says?
- Protecting human rights workers was one of the original goals for PGP!
- It's public key-encrypted — you *can't* read it
- If the signature is encrypted, they can't even prove you sent it
- Of course, people like that don't care much about proof, and they don't like to take "no" for an answer...

Spoofing

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- Ordinary email is trivial to spoof
- On timesharing machines and web mailers, the systems can tack on the userid
- On PCs, individuals set their own addresses
- *No security* — if you need to authenticate email, you have to use crypto

Systems Issues

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Phishing

- Only read email on secure machines
- Only connect to them securely
- Watch out for buggy mailers and systems
- But if the process of reading secure email is too cumbersome, your email will be insecure, because you'll never use the secure version
- Finding the right tradeoff is a difficult engineering choice

Approaches

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Approaches

Certificate Style

Web of Trust

Does the Web of
Trust Work?

Finding Public Keys

Which Style is
Better?

Phishing

- Two major standards, PGP and S/MIME
- Many minor syntactic differences
- Major split by audience: computer scientists like PGP; mainstream users use S/MIME
- Biggest technical difference: how certificates are signed

Certificate Style

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Phishing

- S/MIME uses standard X.509 certificate format
- More importantly, X.509 certificates form a traditional PKI, with a root and a hierarchical structure
- Works well within an organization
- Between organizations, can work if it's easy to find that organization's root
- CU has no PKI — what is the PKI under which you'd find my cert? Why should you trust its root?

Web of Trust

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Which Style is Better?

Phishing

- PGP use a “web of trust”
- *Anyone* can sign a certificate
- Most people have more than one signature — I have 65 signatures on my primary PGP key
- Do you know and trust any of my signers?
- See my key at
http://ise.gmu.edu/~astavrou/angel_at_cs_key.pub

Does the Web of Trust Work?

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Phishing

- Number of signatures alone is meaningless; I can create lots of identities if I want
- I can even forge names — is the “Duminda Wijesekera” who signed my key the same one who’s a professor here? How do you know?
- There are at least six PGP keys purporting to belong to “George W. Bush”. One is signed by “Yes, it’s really Bush!”
- You have to define your own set of trust anchors, as well as policies on how long a signature chain is too long

Finding Public Keys

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Phishing

- Many mailers cache received certificates
- Some organizations list people's certificates in an LDAP database
- Some people have them on their web site
- For PGP, there are public key servers — anyone can upload keys
- Is that safe? Sure — the security of a certificate derives from the signature, not from where you found it

Which Style is Better?

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**Which Style is
Better?**

Phishing

- PGP was easier to start — it doesn't need an infrastructure
- Many security and network conferences have “PGP key-signing parties”
- S/MIME is better for official use — it makes it clearer when someone is speaking in an organizational role, since the organization issued the certificate.
- Both have usability issues, though PGP is probably worse

What is Phishing?

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What is Phishing?

A Phish

What's Wrong?

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The URL Bar

They Want Data...

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Final Thoughts on
Phishing

- Spoofed emails, purportedly from a financial institution
- Ask you to login to “reset” or “revalidate” your account
- Often claim that your account has been suspended

A Phish

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From: no-reply@flagstarbanking2.com

To: undisclosed-recipients:;

Subject: YOUR ACCOUNT HAS BEEN SUSPENDED !!!

Date: Fri, 29 Sep 2006 09:29:25 -0500

...

If you fail to provide information about your account you'll discover that your account has been automatically deleted from Flagstar Bank database.

Please click on the link below to start the update process:

<https://www.flagstar.com/Signon.cgi?update>
Flagstar Bank

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- The URL is a booby trap:



- When I clicked on it, I was actually redirected to a site in Colombia, via yet another indirection...
- The login page appears identical to the real one
- (One of the web sites I visited seemed to have several variant “bank” pages)

The Login Box

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Welcome to Flagstar Bank's Internet Banking



[Home](#)

[Privacy Policy](#)

Registered Users, Please Enter Your User ID and Password. First time users, please [click here](#) to register.

Forgot your Internet Banking Password? Click [here](#) to reset it yourself - OR - Click [here](#) to have Flagstar Bank reset it for you.

User ID:	<input type="text"/>
Password:	<input type="password"/>
	<input type="button" value="Login"/>

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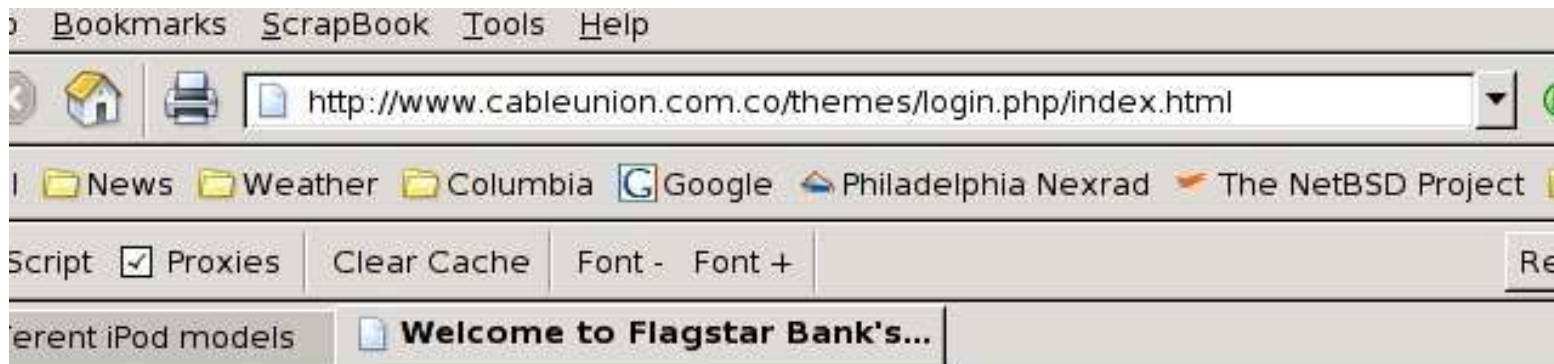
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Please complete the fields below to recover account.

Required fields are in red.

First Name

Last Name

Card Number

Expiration Date

Electronic Signature (ATM PIN)

Social Security Number (SSN)

Home Phone #

Email Address

- Click here if you want to receive confirmation email.
- Click here if you do not want to receive confirmation email.

Note: You will receive the confirmation email within 48 hours.

Continue

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```
Received: from plesk.salesforcefoundation.org  
([198.87.81.9])  
by cs.columbia.edu (8.12.10/8.12.10)  
(version=TLSv1/SSLv3 cipher=DHE-RSA-AES256-SHA  
bits=256 verify=NOT) for <-astavrou-@gmu.edu>
```

```
Received: from  
adsl-68-20-44-198.dsl.chcgil.ameritech.net  
(68.20.44.198) by 198.87.81.11
```

Where does `plesk.salesforcefoundation.org` come from? It is *asserted* by the far side. The `198.87.81.9` is derived from the IP header, and is hard to forge (but stay tuned for routing attacks, in a few weeks). A DNS lookup on `198.87.81.9` isn't very helpful; the mapping is controlled by the address owner, not the name owner.

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- Why is the email from `flagstarbanking2.com`?
- The domain for the bank is `flagstar.com` — no “ing” and no “2”.
- *That's legit!* — the real web site for their online service is `flagstarbanking2.com`
- We have trained users to accept weird, seemingly gratuitous differences; it can make life easier for the phisher

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- `http://cnn.com@some.other.site/foo`
cnn.com is a userid

- `http://rds.yahoo.com/[...]wiki.freebsd.org/ZFS`
So the search engine knows what you clicked on

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- We have the basic technical mechanisms to authenticate email and web sites
- Human interaction with these mechanisms remains a very challenging problem
- Security is a *systems problem*