

11. Network Security

The tale of SSL/TLS and SET

Computer Security Courses @ POLIMI

Issues of Communications Security

- Problems of remoteness
 - Trust factor between parties
 - Use of sensitive data
 - Atomicity of transaction
- Internet protocol problems
 - Authentication
 - Confidentiality
- Transparency and critical mass problem

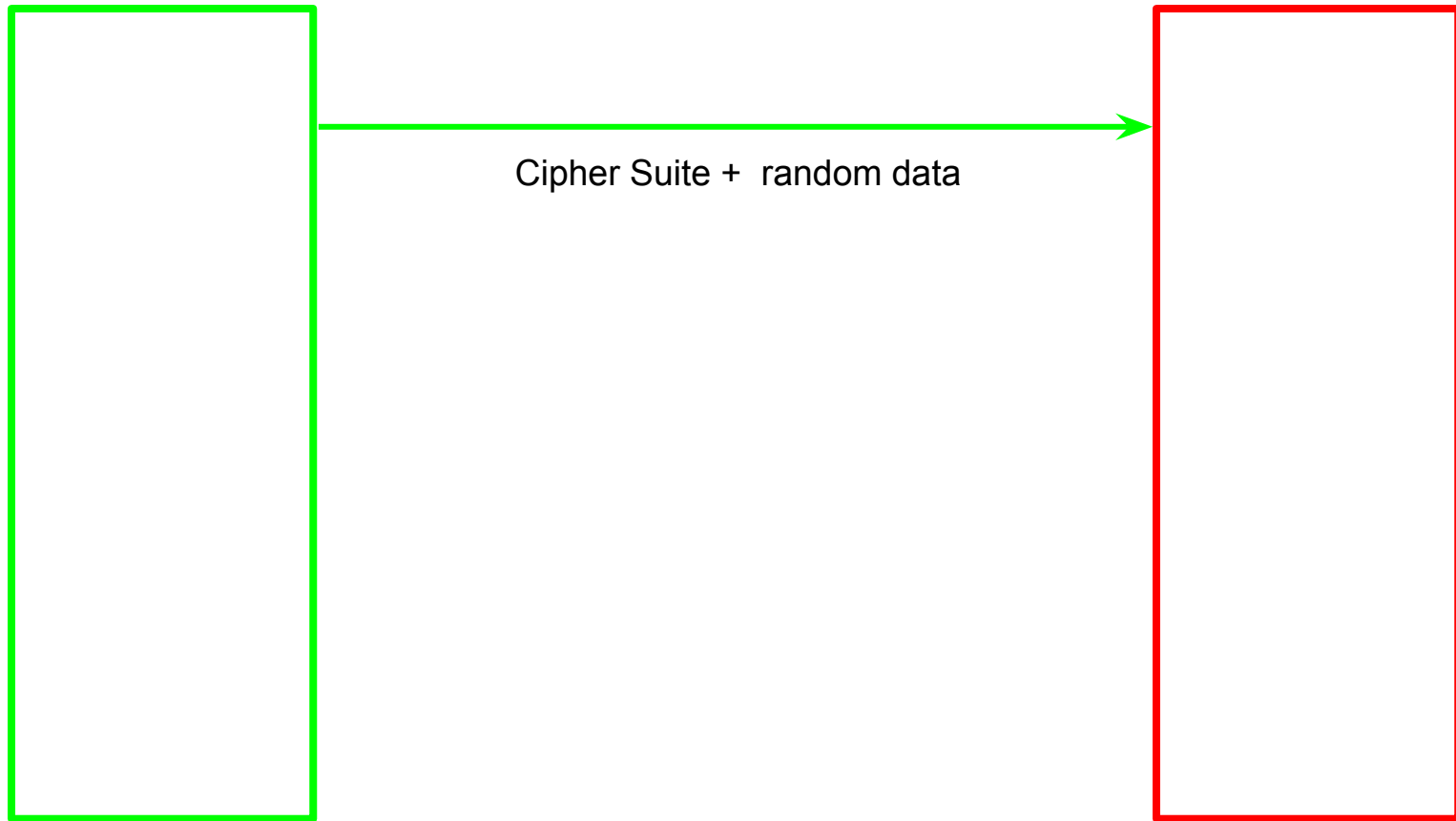
A Tale of Two Protocols

- Two valiant protocols fought against the darkness
- HTTP over SSL (Secure Socket Layer), or HTTPS
 - Communication confidentiality and integrity
 - Mutual authentication
 - No guarantees on data usage
 - No strict authentication of client (in practice)
- SET (Secure Electronic Transaction)
 - Guarantees on data usage and transaction security enforcement
 - Missing critical mass support

SSL -> TLS

- Originally designed by Netscape for securing web communication
 - de facto standard also for other protocols
 - IETF standardized TLS, which comes after version SSL v3, and is now at version 1.3.
 - All versions up to TLS 1.1 (included) are insecure
- TLS enforces:
 - Confidentiality and integrity of the communications
 - Server authentication
 - Client authentication (optionally)
- Uses both symmetric and asymmetric cryptography for performance reasons

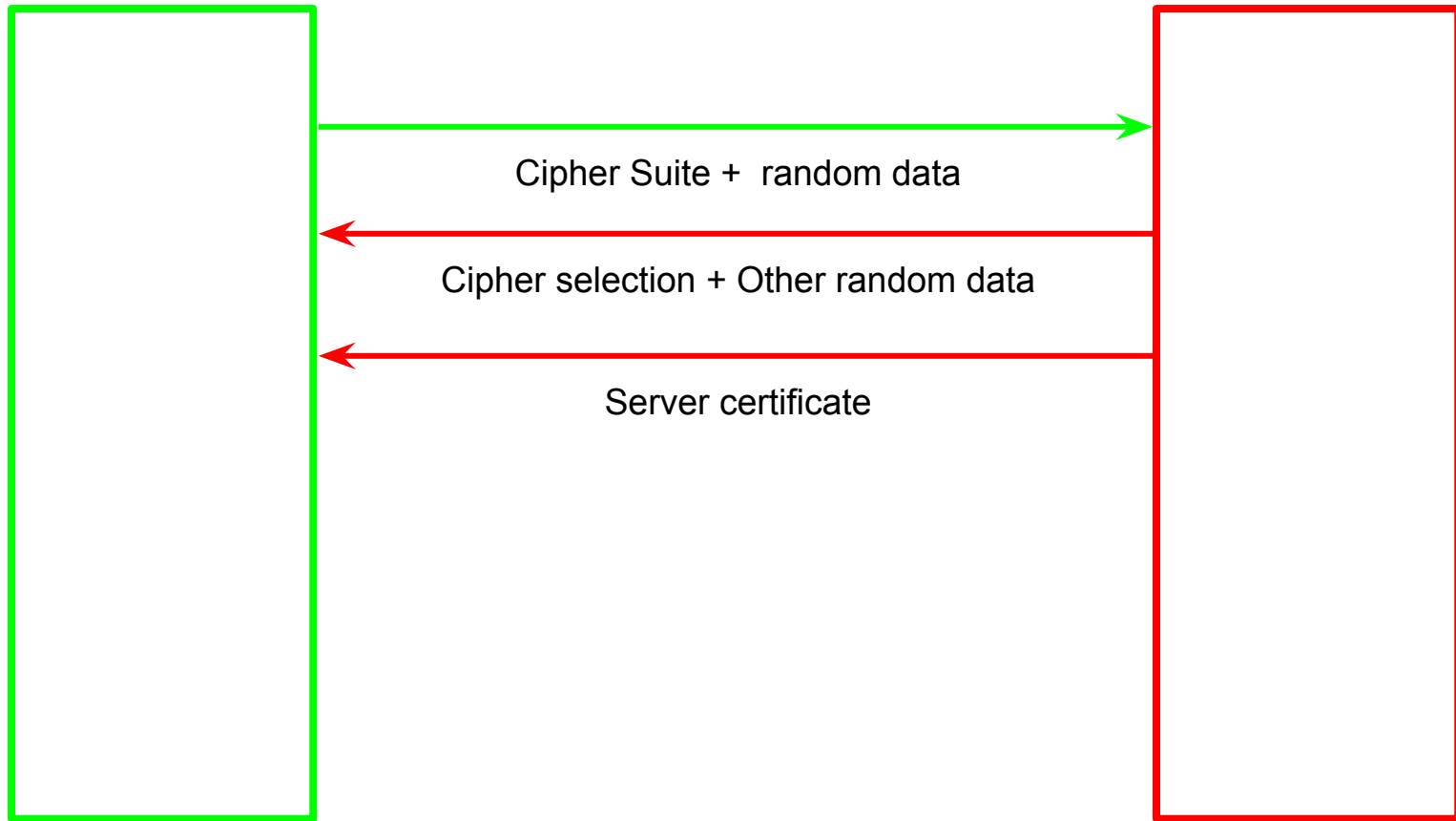
TLS Handshake Phases



Cipher Suite

- TLS designed to be flexible wrt to technical evolution
- Clients and servers may use different *suites* of algorithms for different functions
 - a key exchange/key encapsulation algorithm
 - a symmetric encryption algorithm
 - a digital signature algorithm
 - a hash function (for symm. key derivation)
- During handshake, cipher suites are compared to agree on shared algorithms in order of preference
- The standard mandates the implementation of a minimal cipher set

Server Authentication



Verification of Server Certificate

- Is the certificate in the validity period?
- Is the root CA trusted?
- Is the certificate valid?
- Is it revoked?
- **Is the *name* of the server in the certificate the same that I requested?**

Remember the implementation issues that we have learned a couple of months ago?

11. Network Security

File Edit View



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Verification of Server Certificate

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- Is it revoked?
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Secret Transmission



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(Optional) Client Authentication



Equifax Secure Certificate Authority
↳ GeoTrust Global CA
↳ Google Internet Authority G2
↳ *.google.com



***.google.com**

Issued by: Google Internet Authority G2

Expires: Tuesday 5 August 2014 02 h 00 min 00 s Central European Summer Time

✓ This certificate is valid

▼ Details

Subject Name
Country US
State/Province California
Locality Mountain View
Organization Google Inc
Common Name *.google.com

Issuer Name
Country US
Organization Google Inc
Common Name Google Internet Authority G2

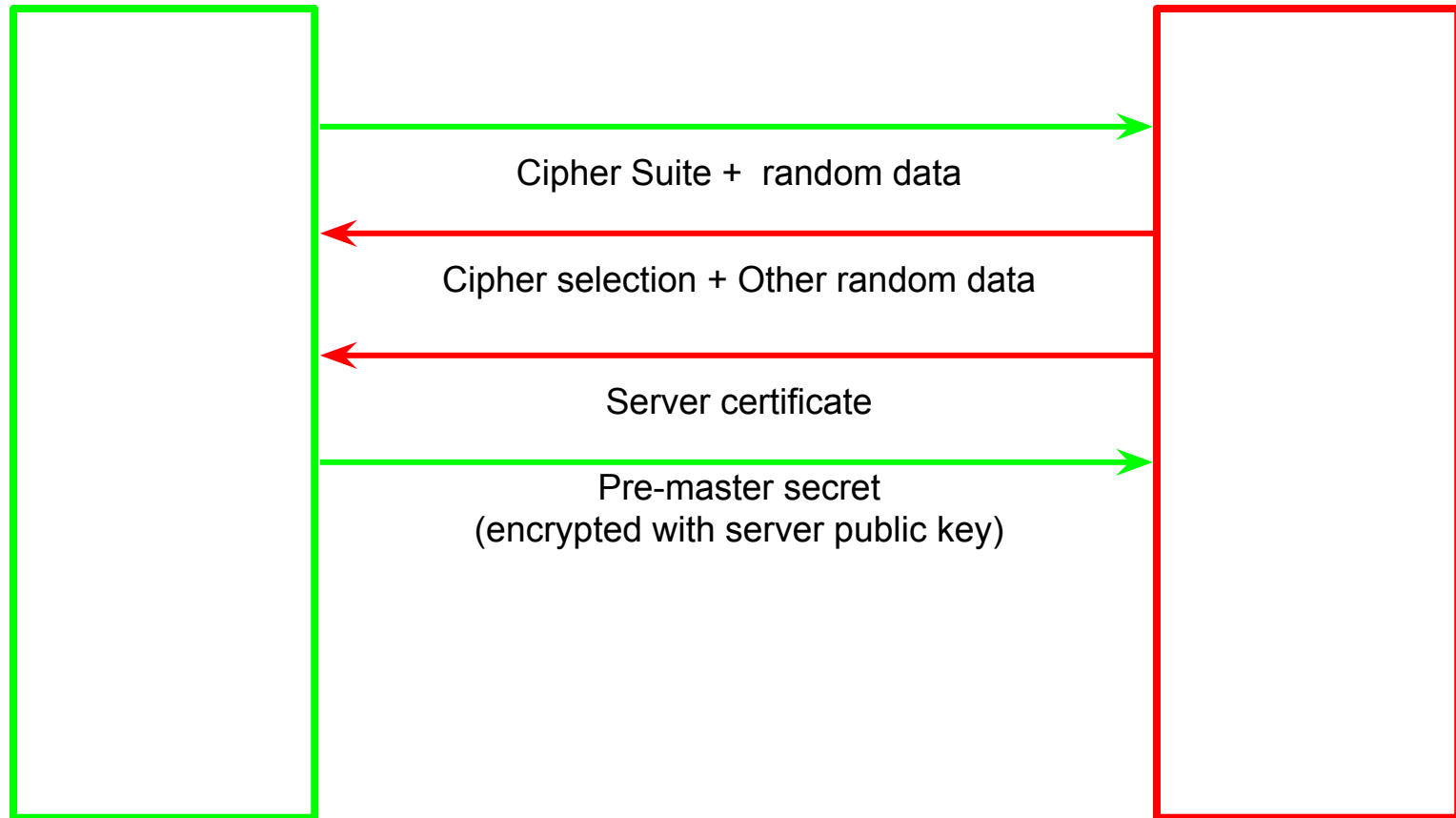
Serial Number 1405391832758935466
Version 3

Signature Algorithm SHA-1 with RSA Encryption (1.2.840.113549.1.1.5)
Parameters none

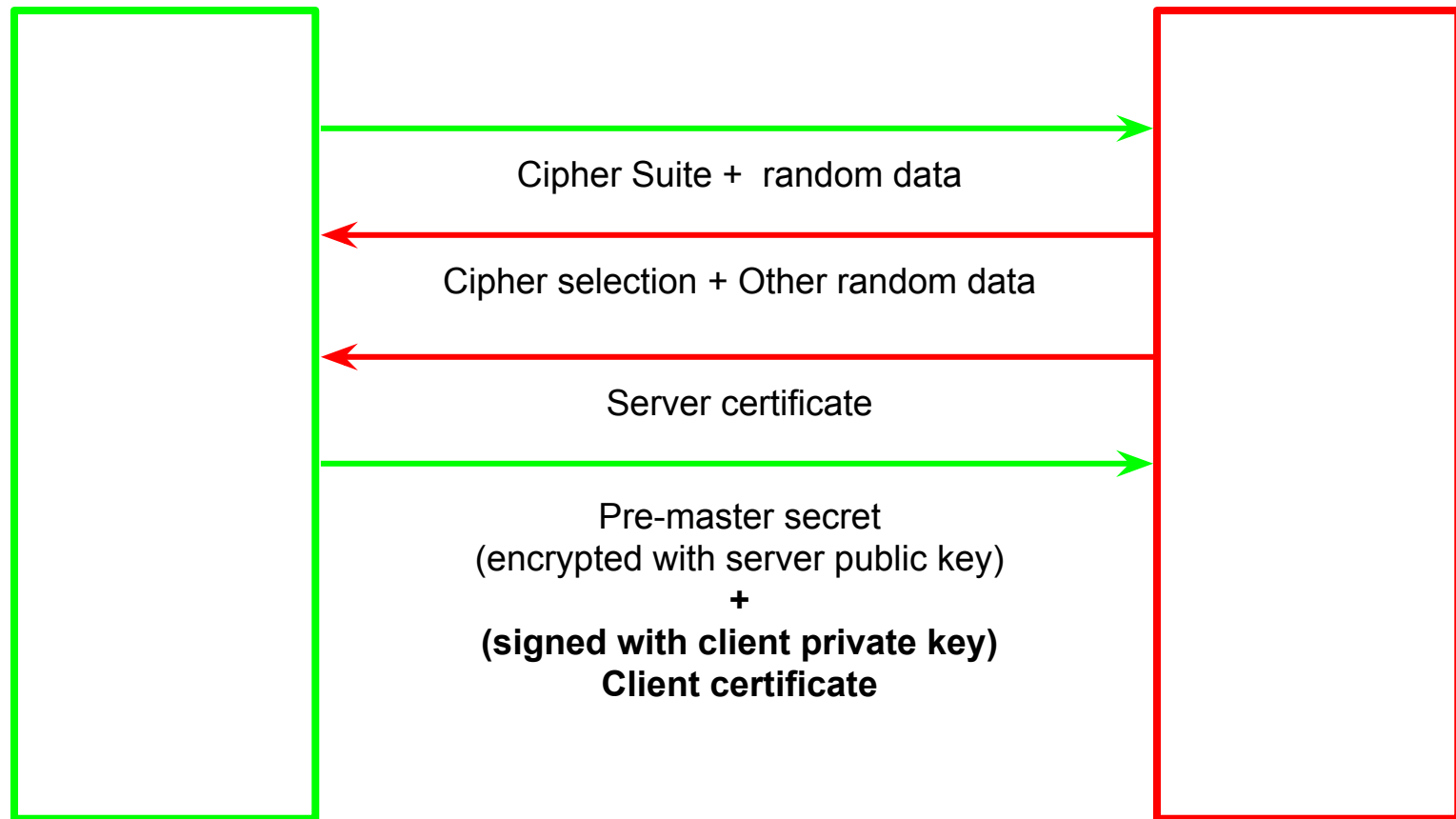
Not Valid Before Wednesday 7 May 2014 14 h 37 min 59 s Central European Summer Time

OK

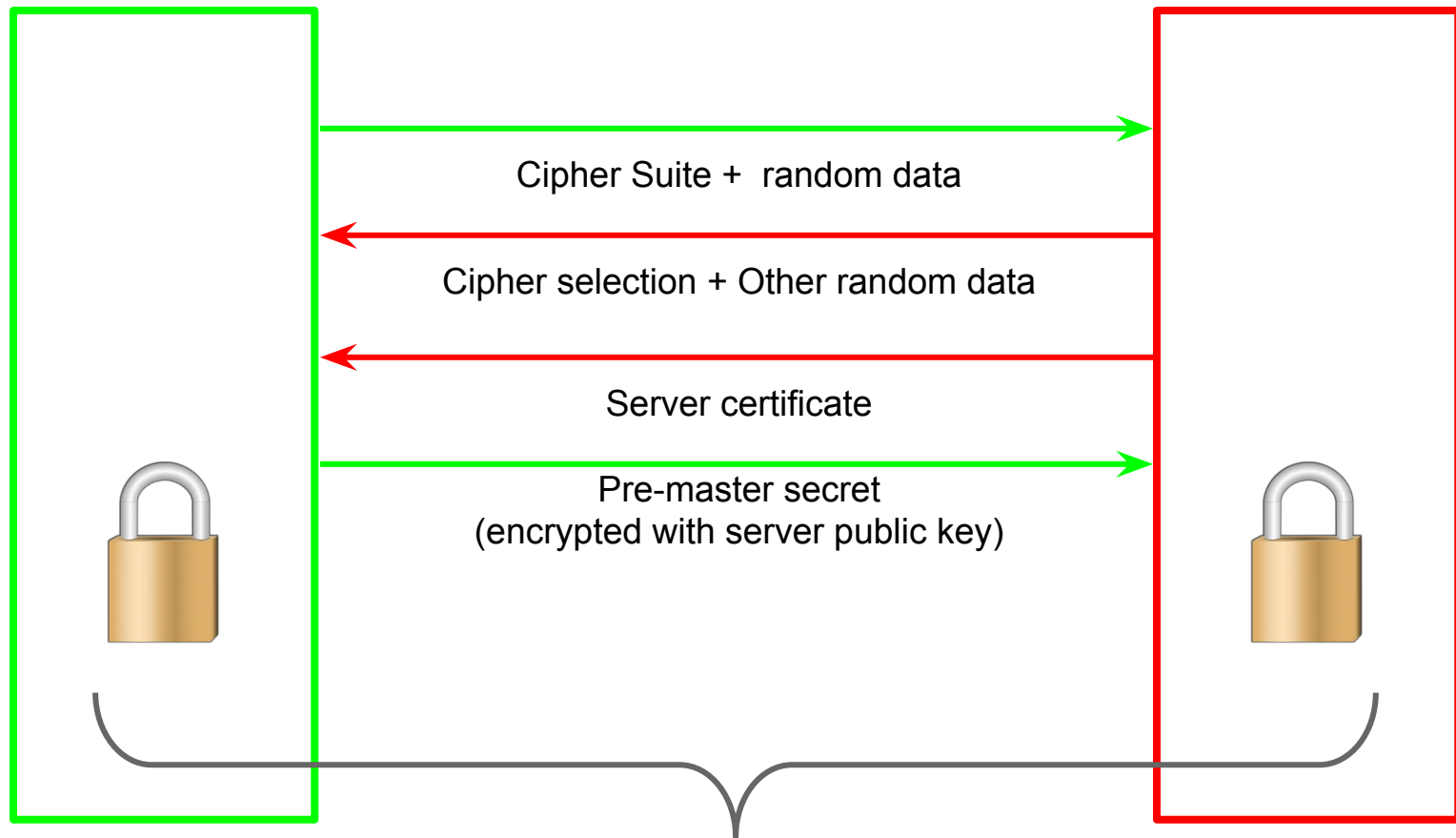
Secret Transmission



(Optional) Client Authentication

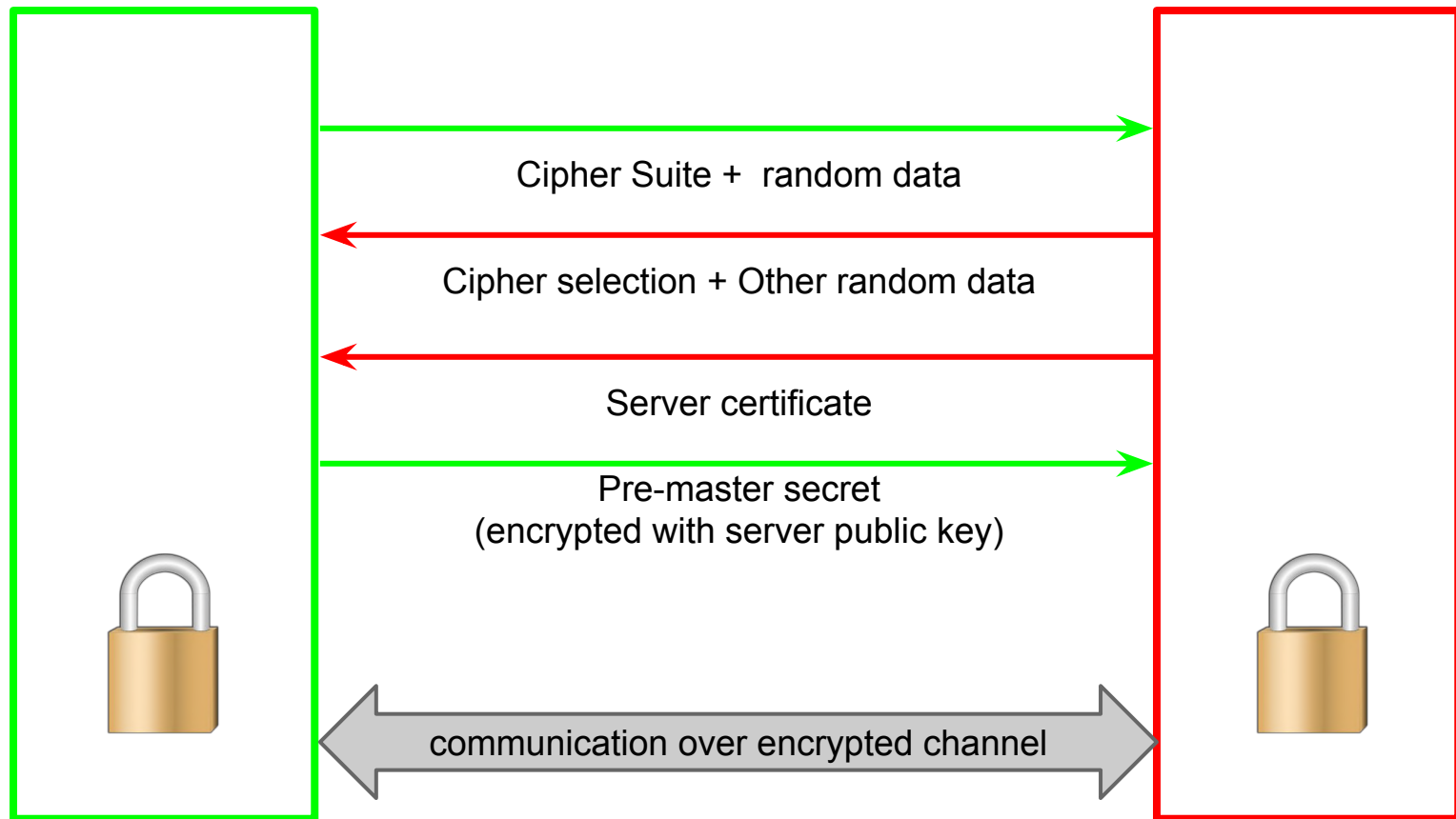


Secret Computation



Compute **shared secret** from pre-master secret, client random data and server random data

Encrypted Communication Phase

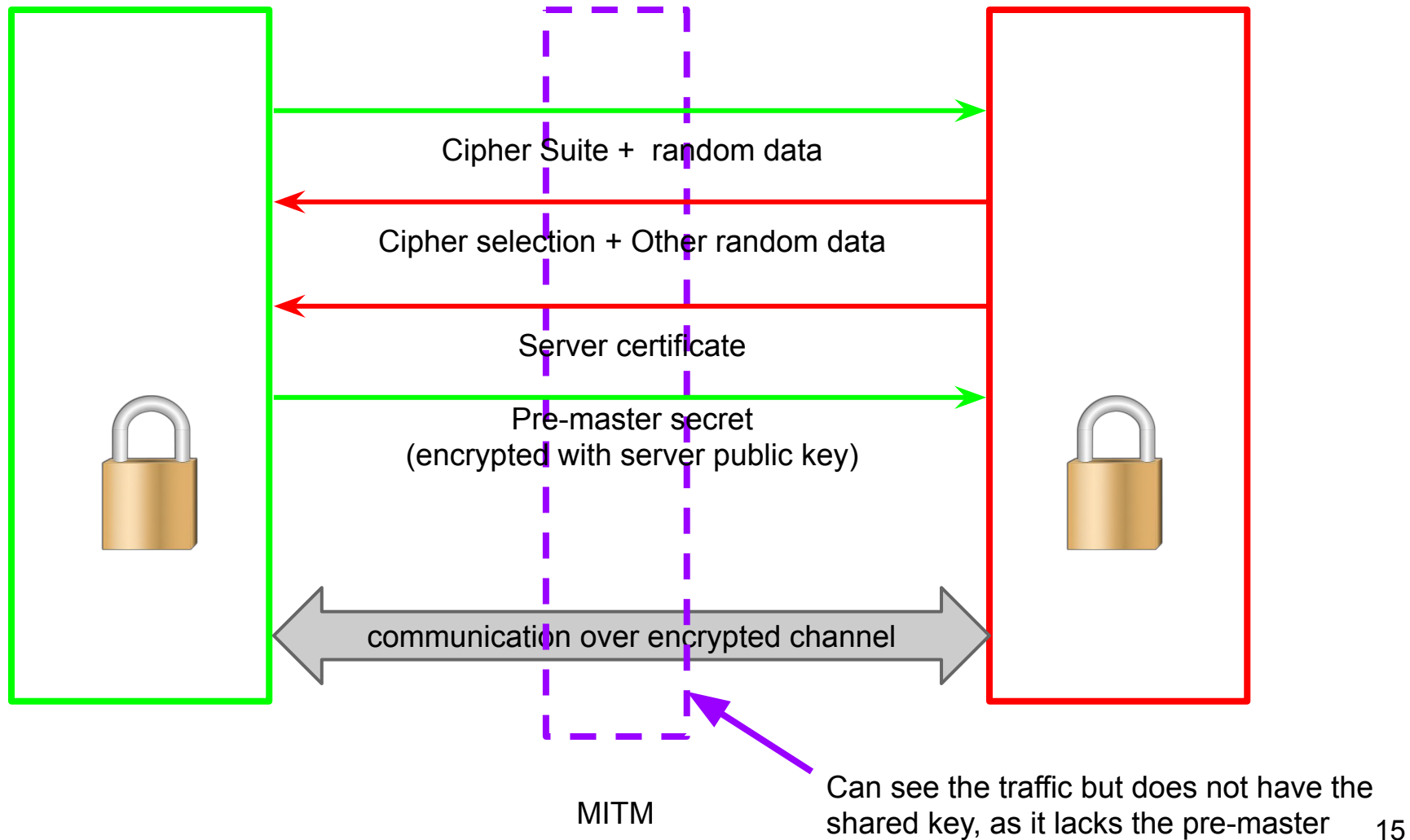


Is TLS Resistant to MITM?

What could the MITM do?

- Let the original certificate through

Cut out!

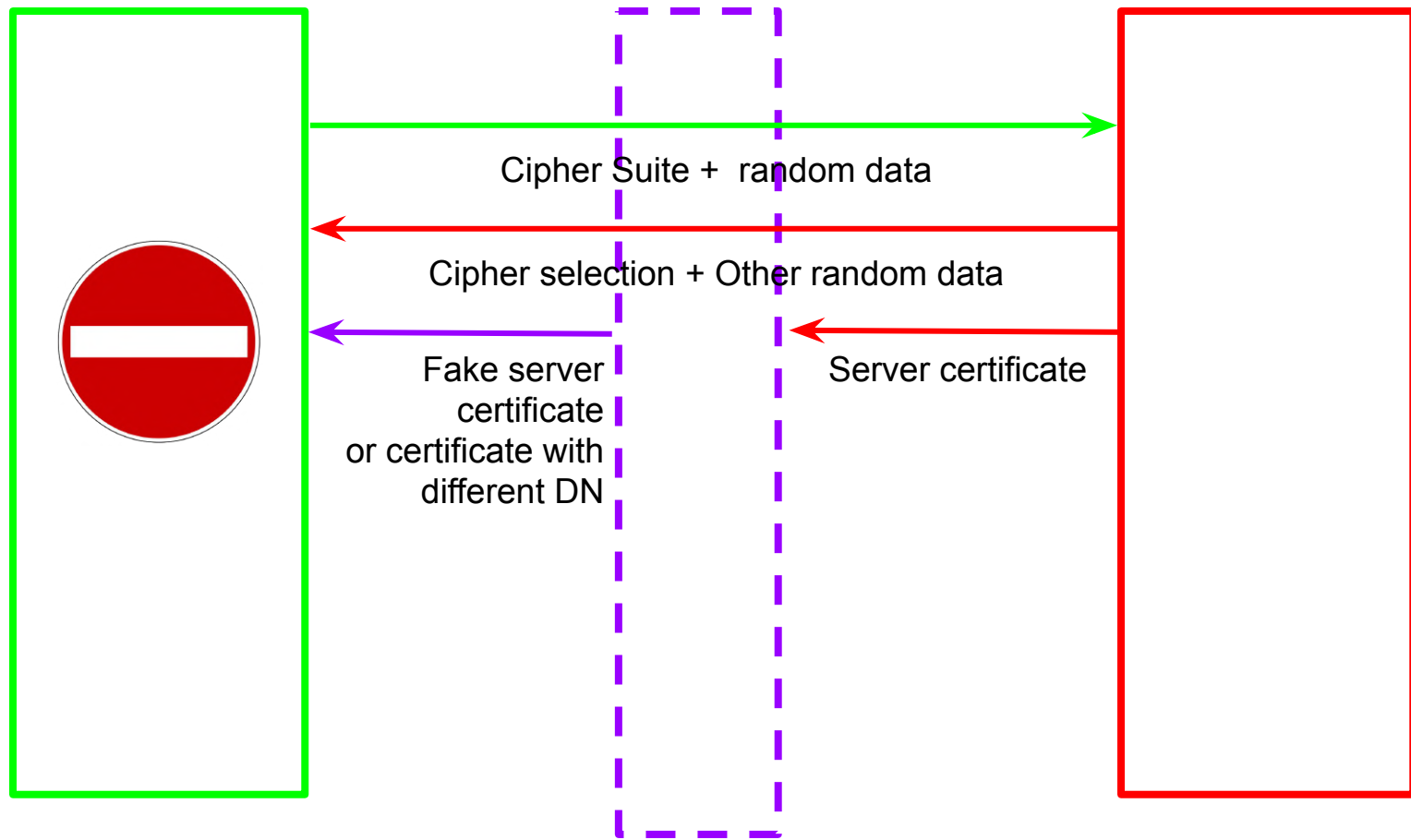


Is TLS Resistant to MITM?

What could the MITM do?

- ~~Let the original certificate through~~
 - Needs to actually have the key on that cert!
- Send a fake certificate (i.e., signed by a non-trusted CA)
- Send a good certificate with a fake name

Rejected!



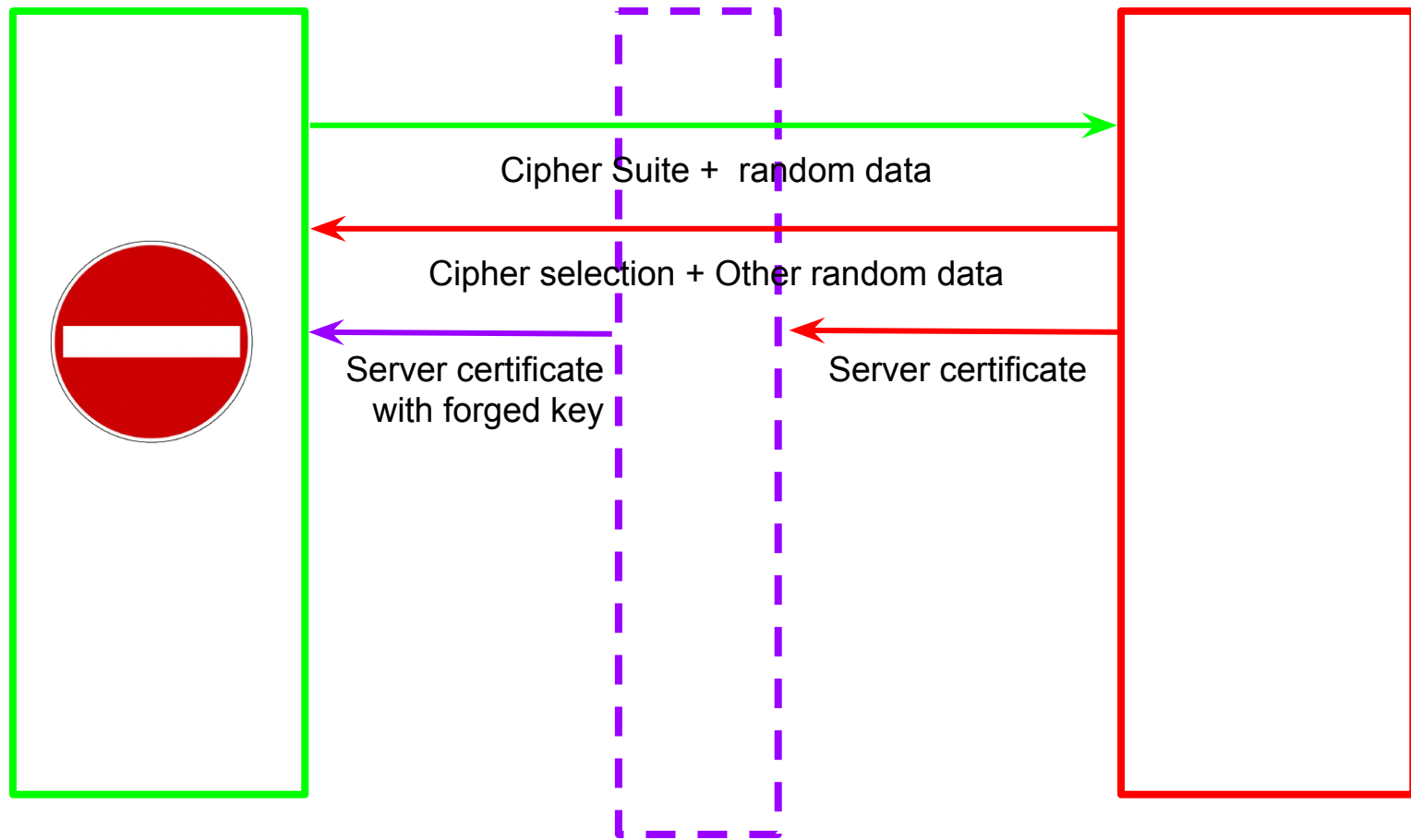
MITM

Is TLS resistant to MITM?

What could the MITM do?

- ~~● Let the original certificate through~~
- ~~● Send a fake certificate (i.e. signed by a non-trusted CA)~~
- ~~● Send a good certificate with a fake name~~
- Send a good certificate but substitute the public key (invalidating the signature)

Rejected!



MITM

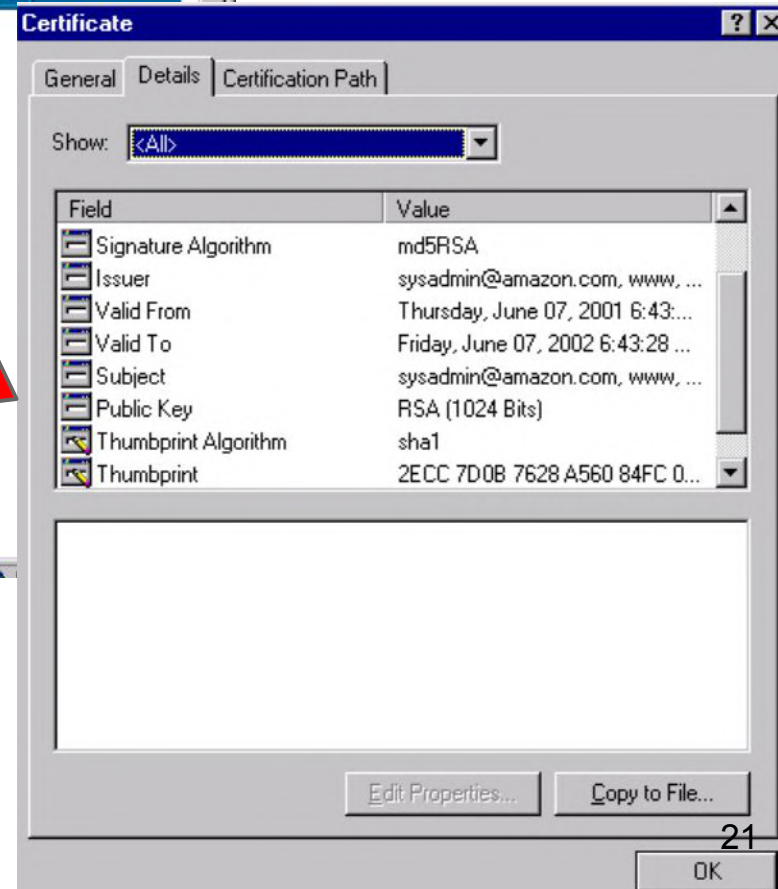
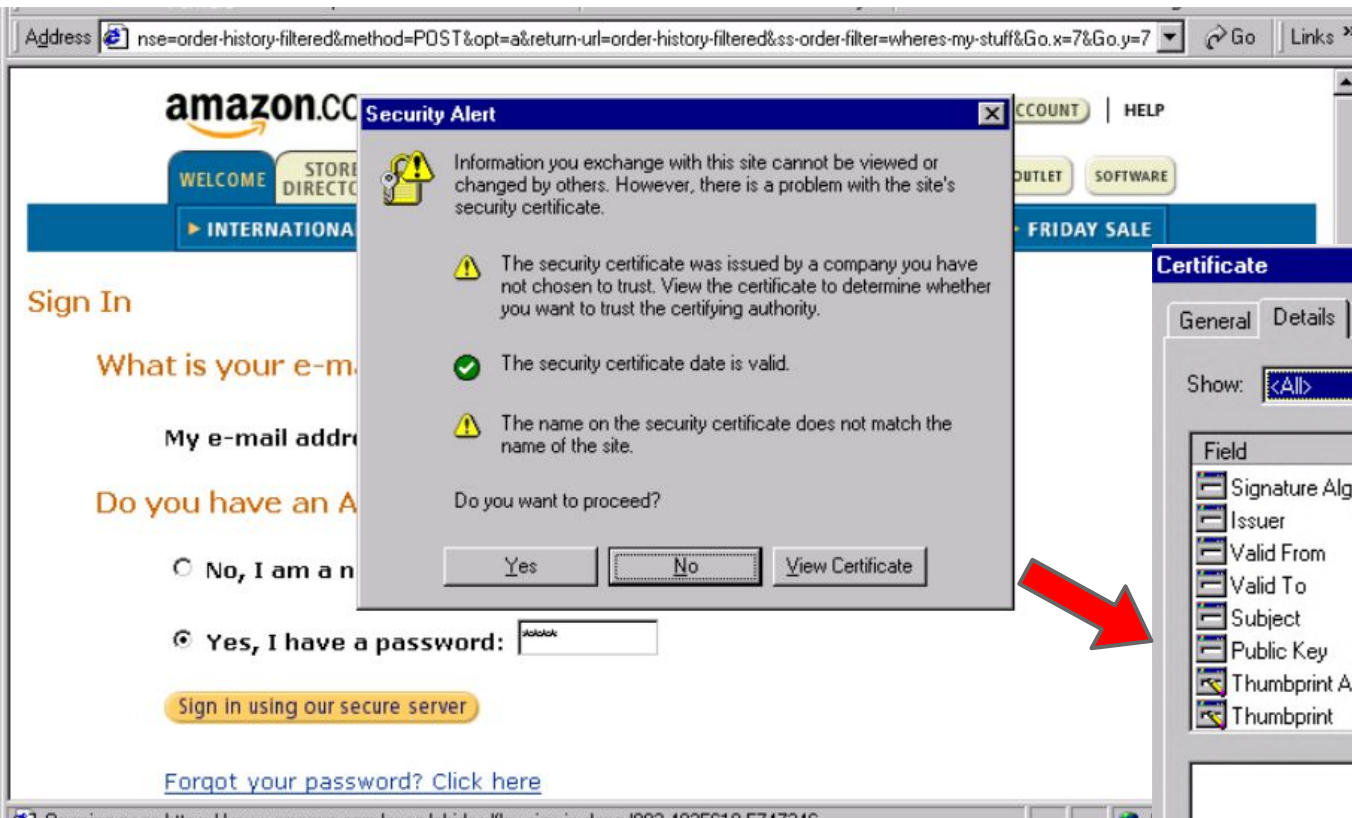
Is TLS resistant to MITM?

What could the MITM do?

- ~~● Let the original certificate through~~
- ~~● Send a fake certificate (i.e. signed by a non-trusted CA)~~
- ~~● Send a good certificate with a fake name~~
- ~~● Send a good certificate but substitute the public key (making it invalid)~~

Nothing: TLS is resistant to MITM by design!

Social Engineering = Fail

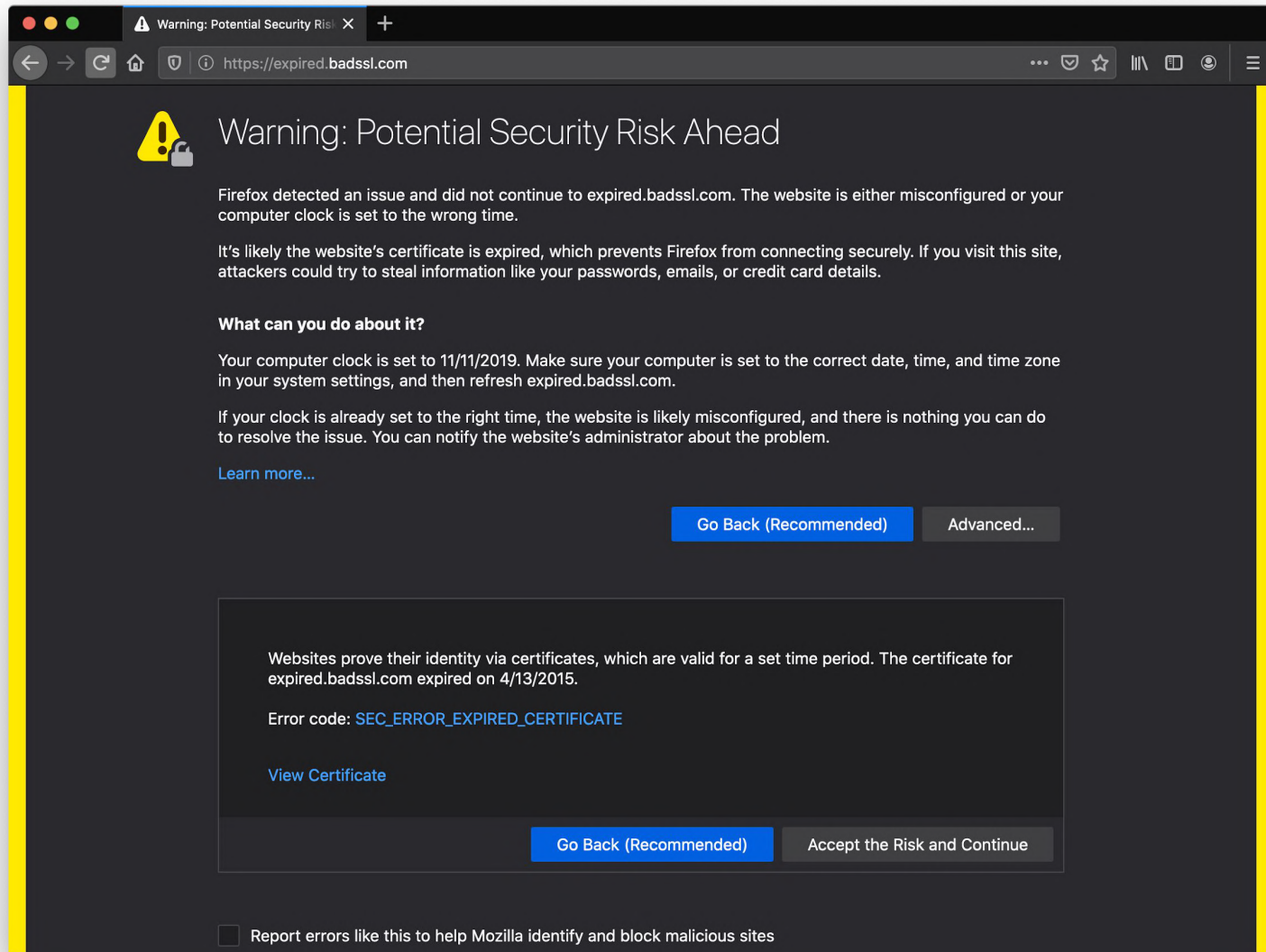


If the user clicks "yes" the assumptions of TLS are violated and attack is successful.

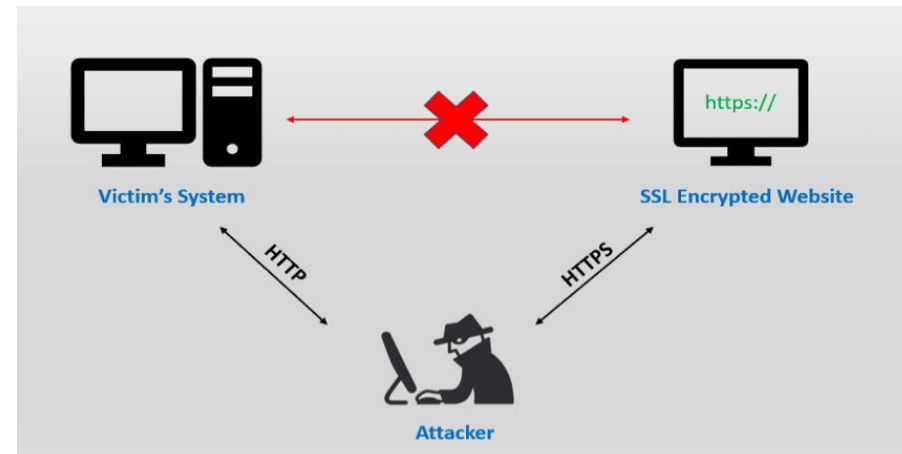
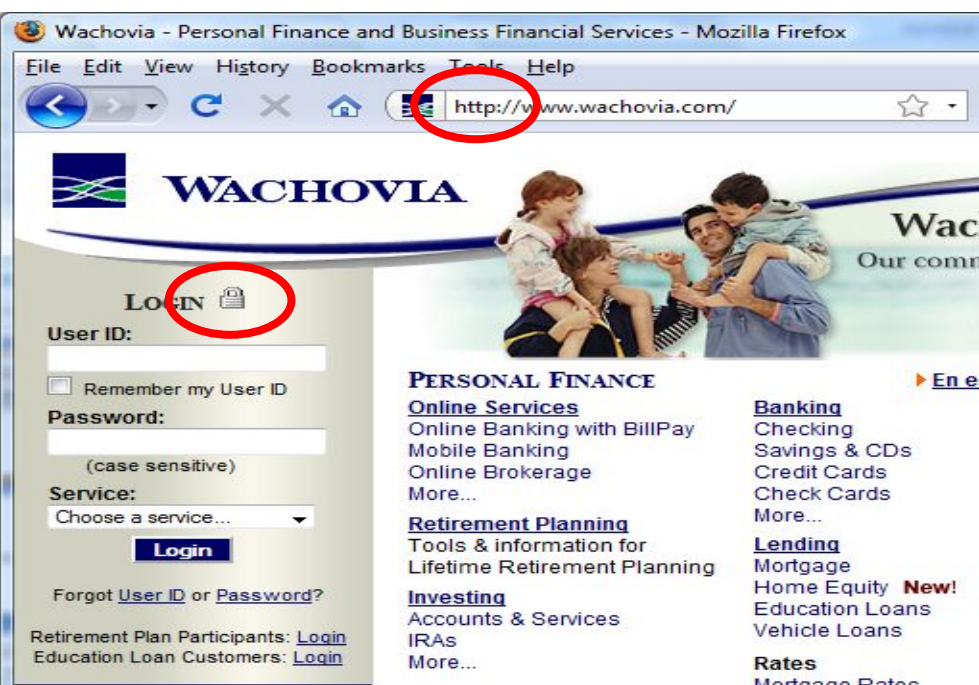
If he clicks no, he cannot buy his book.

Guess what's going to happen...

Security UI: Evolution



Security UI Pitfalls & SSL strip



View source:
<form method="post"

Source: <https://cs155.stanford.edu/>

action="**https://onlineservices.wachovia.com/...**"

Security UI: Evolution

Treatment of HTTP pages

Current (Chrome 67)

ⓘ example.com

July 2018 (Chrome 68)

ⓘ Not secure | example.com

Treatment of HTTPS pages

Current (Chrome 67)

🔒 Secure | example.com

Sep. 2018 (Chrome 69)

🔒 example.com

Eventually

example.com

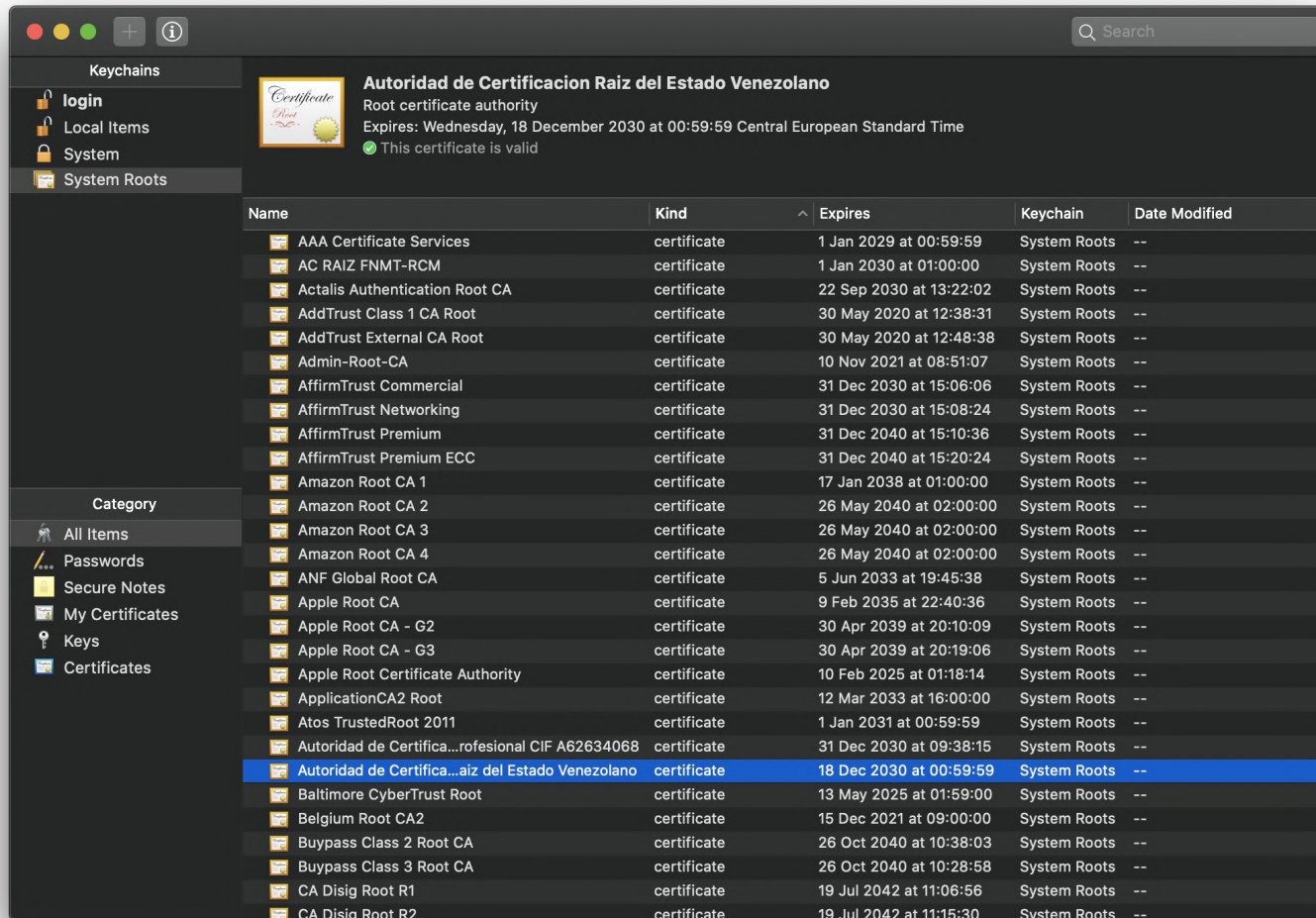
TLS: Pros and Cons

- Protects transmissions
 - Confidentiality
 - Integrity
- Ensures authentication
 - Of server
 - Of client (optionally)
- No protection before or after transmission
 - On server
 - On client (e.g., trojan)
 - By abuser (e.g., non-honest merchant)
- Relies on PKI
- Not foolproof

TLS cons: reliance on PKI

- Security guarantees of TLS depend on the security and trust of the root and intermediate CAs
- CAs can generate certs for any domain
 - They are responsible for domain\org validation
- In order to be included in browsers and OS root programs, CAs must abide to a set of requirements (CA/Browser Forum baseline requirements)
 - Dropping a non-compliant CA is a very difficult decision as it breaks websites

Reminder: CAs your OS trusts



Corollary: you need to trust the list of CA pre-installed in your computer.
It is not always so: see the 2015 Lenovo Superfish incident...

Pitfalls: A few CA Incidents

- **2011:** Diginotar as well as some Comodo resellers are compromised → rogue certs (at least 500 for Diginotar)
 - Diginotar is distrusted on all major platforms
- **2009 - 2015:** Symantec → test certificates for existing domains (e.g., Google)
 - Caught through CT logs
 - Outcome: CA gradually distrusted (2016-2018)
- **2012:** Trustwave issues a MITM certificate for a data loss prevention appliance
- **2012:** TurkTrust mistakenly gives two CA certificates to users
- **2016:** WoSign / StartSSL → various issues, including cert mis-issuance due to vulnerability in the domain verification.
 - Outcome: CA distrusted

Overcoming TLS/PKI limitations

HSTS (HTTP Strict Transport Security)

- HTTP header to tell the browser to always connect to that domain using HTTPS
- Browsers (e.g., Chrome) implement a HSTS preload list: some websites are simply never loaded over plain HTTP
- Defends against SSL stripping

Overcoming TLS/PKI limitations

HPKP (HTTP Public Key Pinning)

- HTTP header to tell the browser to “pin” a specific certificate or a specific CA
- Browser will refuse certificates from different CAs for that origin
- Defends against trust cert mis-issuance
- **Deprecated!** Can you think about why?

Overcoming TLS/PKI limitations

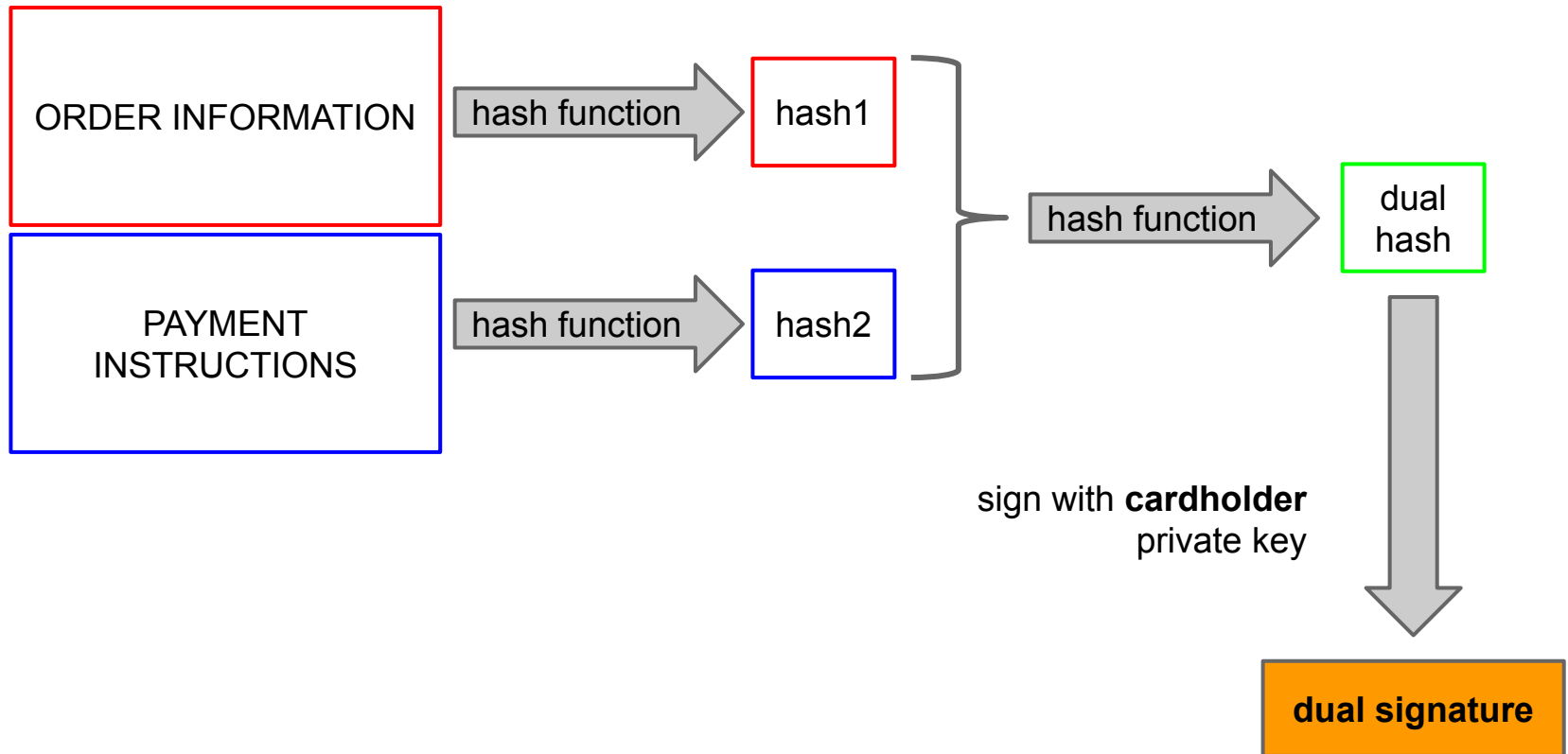
Certificate Transparency

- CA submit the metadata of every issued certificate to a (independent, replicated) log
- Can be enforced by browsers
 - browsers refuse certs not logged in CA logs
- Defends against certificate mis-issuance: site owner can check \ be notified of certificates issued for the properties they manage
- You can look at the CT logs: <https://crt.sh>

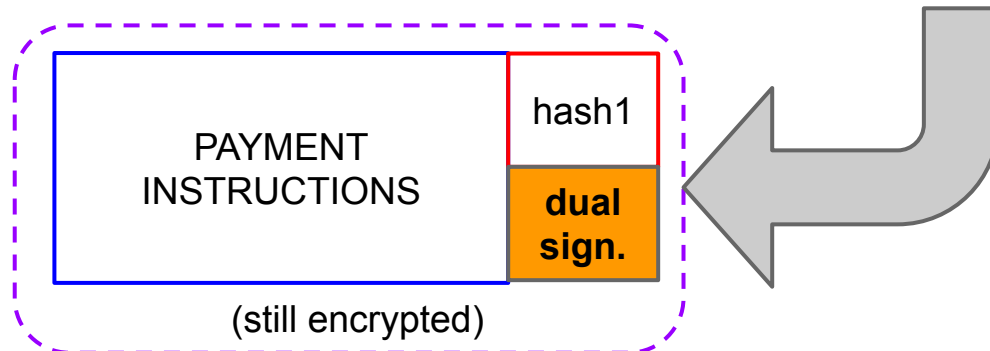
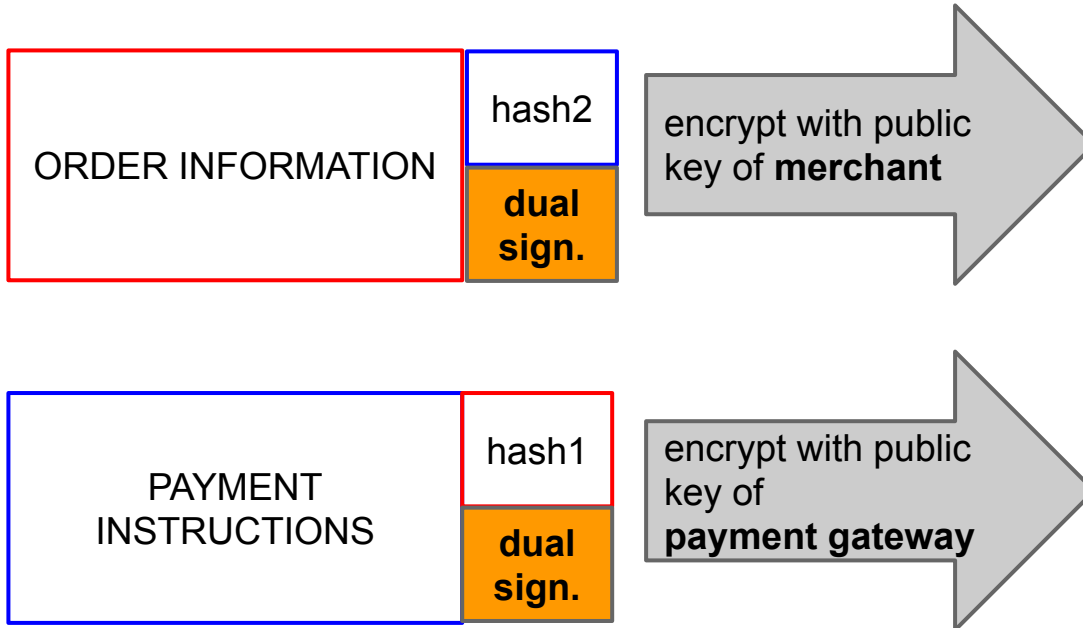
Introducing SET

- Joint effort VISA+MasterCard consortium
- Protect *transactions*, not connections
- Approach
 - **Cardholder** sends
 - the **order of goods** to the **merchant** only
 - the **payment data** to the **payment gateway** only
 - Empower gateway to verify correspondence
- Uses the concept of a dual signature
 - A signature that joins together the two pieces of a message, directed to two distinct recipients

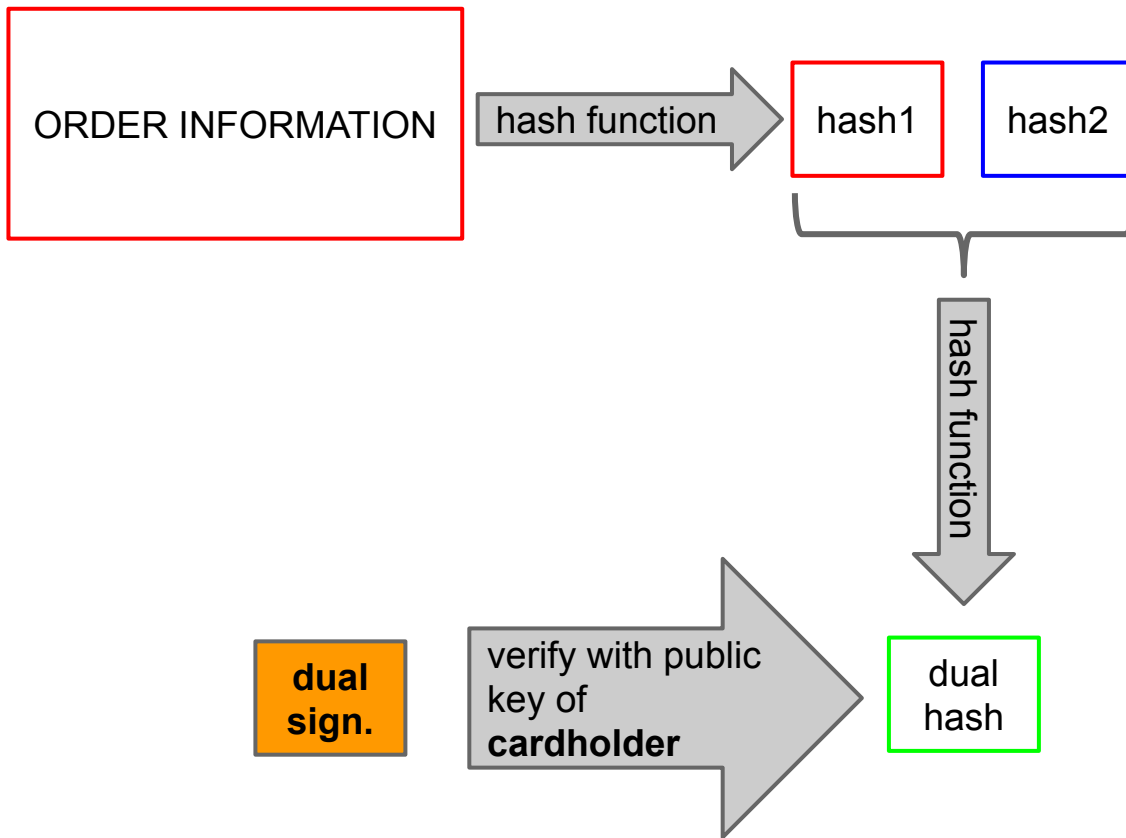
Dual Signature Generation



Data Transmission



Verification (merchant side)



(the payment gateway side verification is the perfect dual)

Why did SET Fail?

- SET requires a **digital certificate** from:
 - Merchant: OK, reasonable and feasible
 - Payment Gateway: OK, reasonable and feasible
 - **Cardholder: KO, does not scale!**
- Therefore, a pre-registration of the cardholder is needed! (won't buy that book)
- Non-transparent = less critical mass = failure
- Nowadays a simple redirect with a token to the website of the bank is commonly used
 - **Exercise:** think how this is implemented securely ;-)