Cloud Storage Security

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CASED

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SIT

Cloud Storage Security
Outline

1. **Introduction and overview**
2. Features
3. Security requirements
4. Security issues
5. Trust issues
6. Drawbacks
7. Choice

Introduction: Basic Cloud Storage Services

- Simple online data storage
  - Independent of physical location
  - Provides rudimentary REST API
  - Several mature service providers
  - Very low costs
    - pay-per-use model
- Use-Cases
  - data sink for (online) applications
  - data sink for virtual machines
  - online backup for arbitrary data
  - online access to arbitrary data

Example: Amazon S3 Pricing (August 2012)	
Standard Storage (up to 1TB)	Each GB = $0.125
PUT, COPY, POST, LIST	1,000 Requests = $0.01
GET	10,000 Requests = $0.01
Transfer IN	$0
Transfer OUT (up to 10TB)	Each GB = $0.12
Example: 100GB, 10.000 Files, one Month	
Initial Upload	$0.10
Storage	$12.50
Download	$12.01
Total	**$24.61**

Introduction: Basic Cloud Storage Services

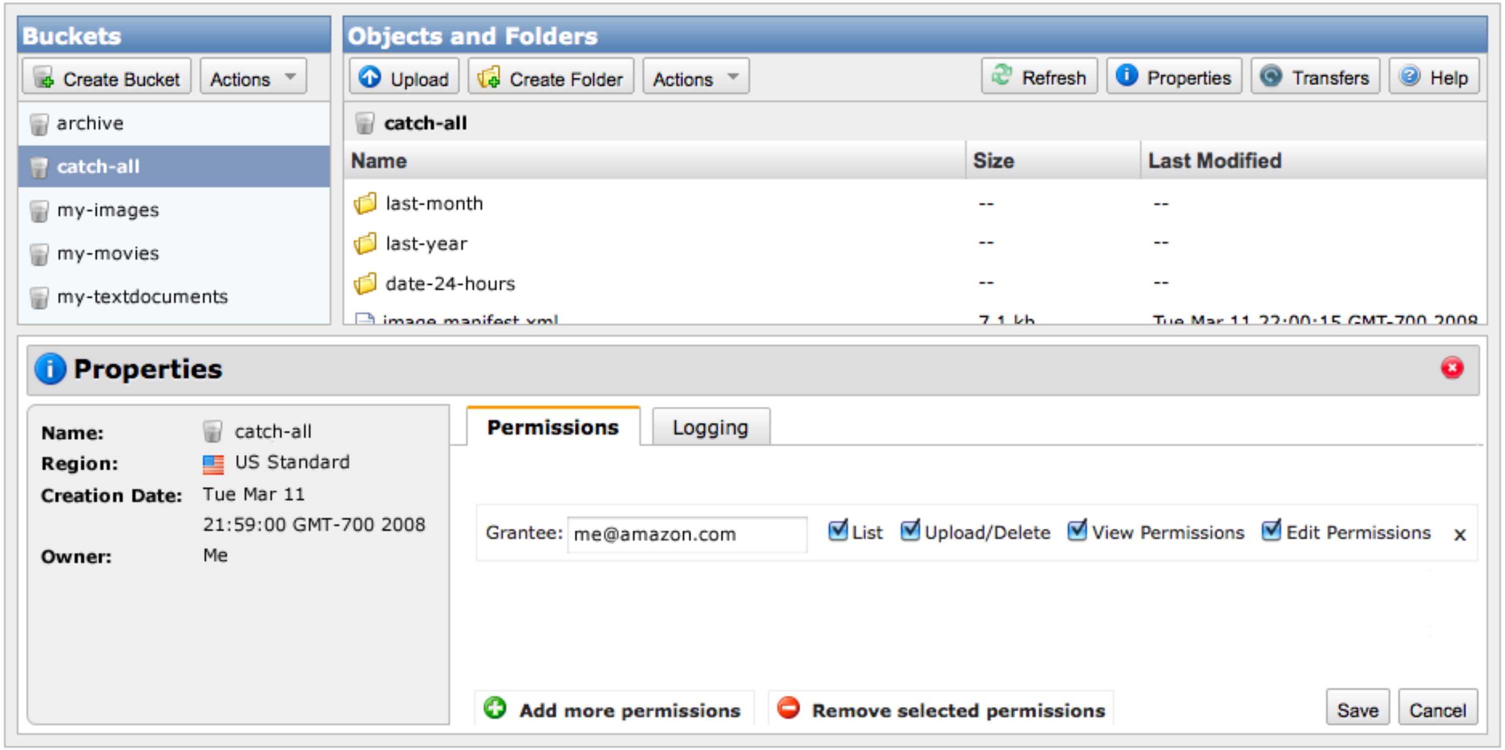
- Service includes
  - Multiple redundancy
  - 99.99999% availability
  - REST / Browser interfaces
- Vs. data center operational costs
  - Physical location
  - Staff
  - Power consumption
  - Uplink
  - Bandwidth
  - etc...

Example: Amazon S3 Pricing (August 2012)	
Storage <= 1TB	Each GB = $0.125
Storage 1TB … 50TB	Each GB = $0.110
Storage 50TB … 500TB	Each GB = $0.095
PUT, COPY, POST, LIST	1,000 Requests = $0.01
GET	10,000 Requests = $0.01
IN	$0
OUT <= 10TB	Each GB = $0.12
OUT 10TB … 50TB	Each GB = $0.09

Example: 100TB, 1,000,000 Files, one Month	
Initial Upload	$10.00
Storage	$10,511.36
Download	$4916.20
Total	**$15,437.56**

Introduction: Basic Cloud Storage Services

- Why doesn't everybody use it?
  - Costs/Data ratio scaled to massive data amounts
  - Cumbersome data handling
  - End-User clearly not targeted



- archive
- catch-all
- my-images
- my-movies
- my-textdocuments

catch-all

Name	Size	Last Modified
last-month	--	--
last-year	--	--
date-24-hours	--	--
image manifest.xml	7.1 kb	Tue Mar 11 22:00:15 GMT-700 2008

Name: catch-all
Region: US Standard
Creation Date: Tue Mar 11 21:59:00 GMT-700 2008
Owner: Me

Grantee: me@amazon.com ☑ List ☑ Upload/Delete ☑ View Permissions ☑ Edit Permissions x

Introduction: Advanced Cloud Storage Services

- Simple online data storage
  - independent of physical location
  - Very easy to use
  - Several plans with fixed costs
  - Many providers
- Great demand
  - Summer 2011: Dropbox reached 25 Million users
- Use-Cases
  - data backup, synchronization, transfer, accessibility
  - mobile data access, co-operation

CloudMe
CRASHPLAN™
Dropbox
mozy
TeamDrive
Sync your data fast & secure
ubuntu one
wuala by LACIE

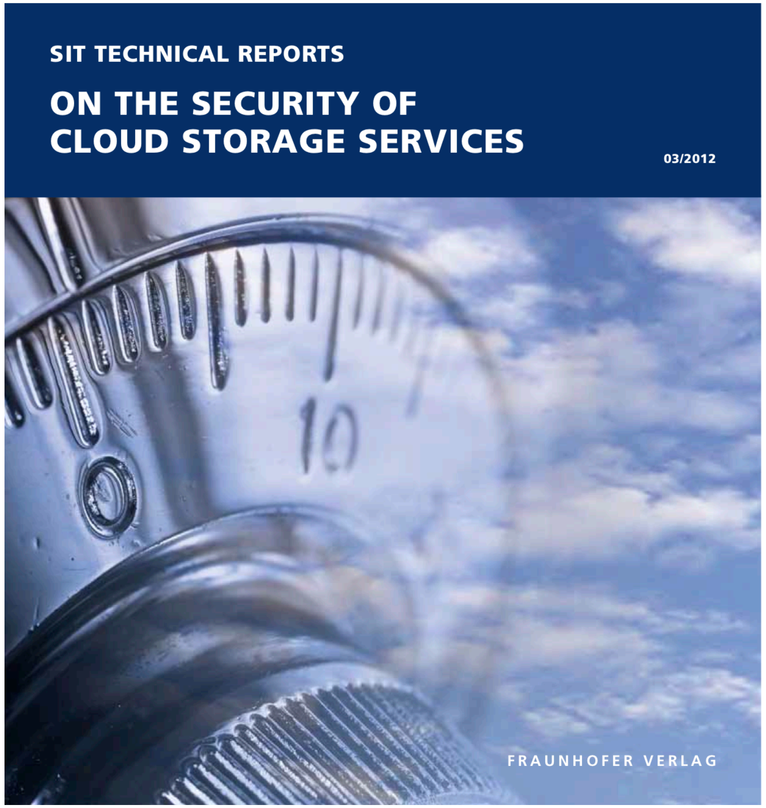
Introduction: Advanced Cloud Storage Services

- Payment models
  - Basic variant free
    - Provides a bit of space
  - Expanded variants with monthly costs
    - More storage space
    - Multiple user functionality
      - i.e. Team collaboration
    - Professional Support
      - i.e. Telephone
    - Tool Support
      - i.e. ActiveDirectory

Example: Dropbox Pricing (August 2012)	
FREE: 2GB Storage	$0
PRO: 100GB	$9.99 / month
PRO: 200GB	$19.99 / month
PRO: 500GB	$49.99 / month
TEAM: 1000GB (5 Users)	$795.00 / year
PRO 200: 200GB / account (5 users)	$995.00 / year

Interlude: Technical Report by Fraunhofer SIT

- 2011
  - Analysis of several Advanced Cloud Storage Services
    - Functionality
    - Security
- 2012
  - Published Study / Technical Report “On the Security of Cloud Storage Services”
    - freely available



SIT TECHNICAL REPORTS

ON THE SECURITY OF CLOUD STORAGE SERVICES

03/2012

FRAUNHOFER VERLAG

Download here: http://www.sit.fraunhofer.de/en/cloudstudy.html

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2. **Features**
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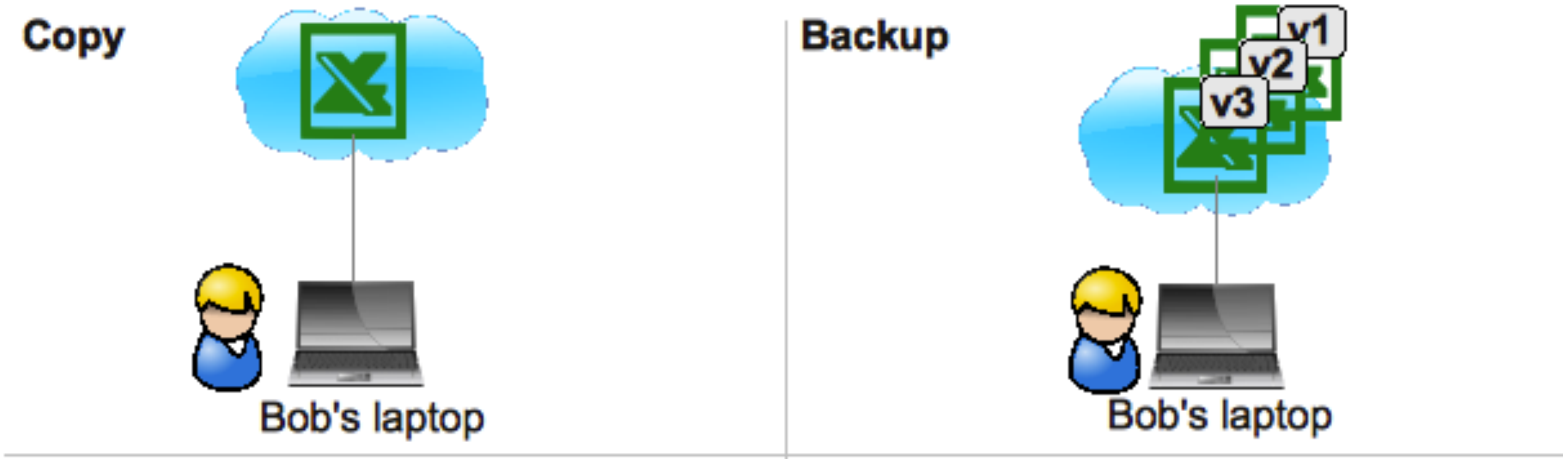
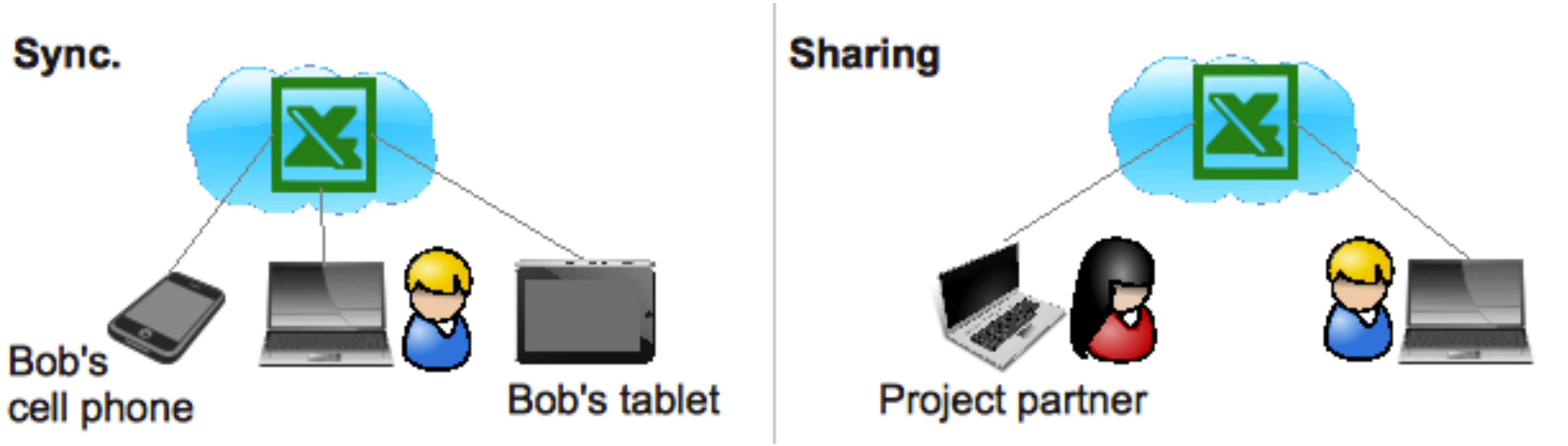
Features for End-Users

- Simple Features
  - Copy files to online storage
  - Backup files to online storage
    - Usually with versioning



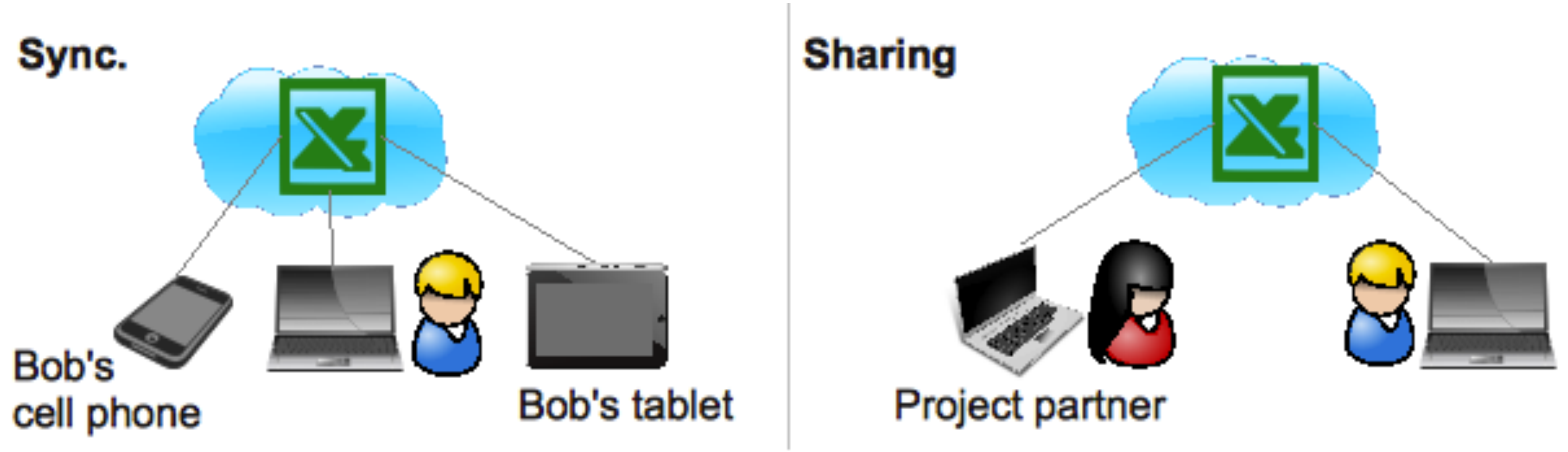
Features for End-Users

- Advanced Features
  - Synchronize files with multiple linked devices
    - Pull synchronization: manual updates (git, subversion work like that)
    - Push synchronization: automatic updates by client software



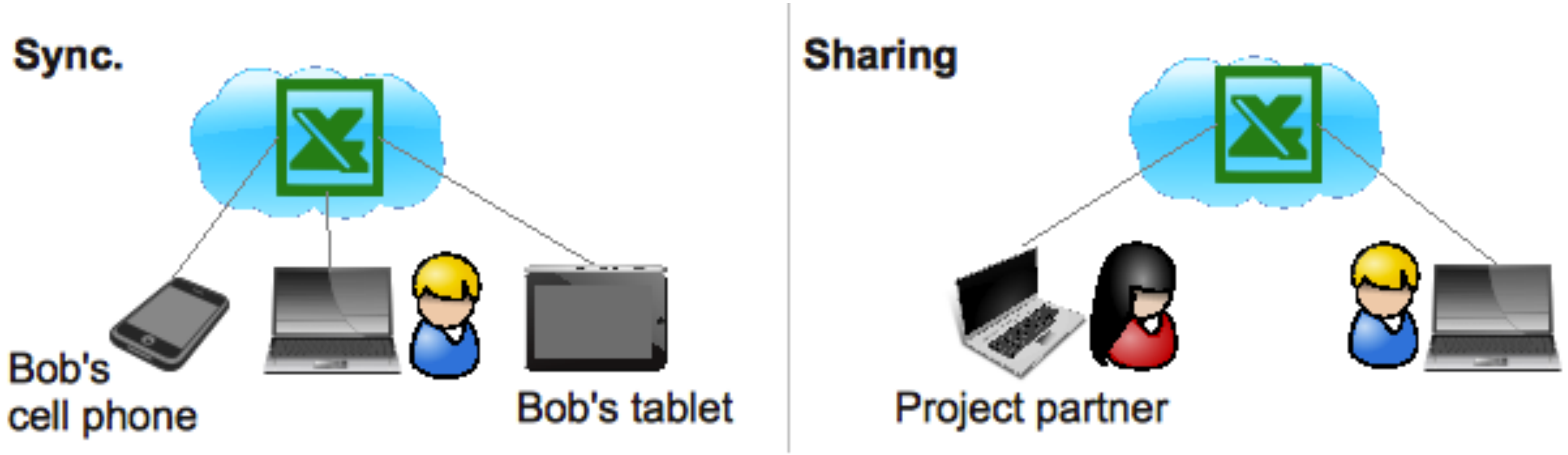
Features for End-Users

- Advanced Features
  - Share data with others
    - Sharing: exchange data with other users of the service
    - Publishing: Generate public URL and distribute to other users



Features for End-Users

- Advanced Features can be combined
  - Push Synchronization and Sharing
    - Cross-User Synchronization
      - Files changed by others automatically downloaded to linked devices



Features for End-Users

- Several Services specialize in subset
- Supported Features

Service	Copy	Backup	Synchronization	Sharing
CloudMe	✓	✗	✗	✓
Crashplan	✗	✓	✗	✗
Dropbox	✓	✗	✓	✓
Mozy	✗	✓	✗	✗
TeamDrive	✓	✓	✓	✓
Ubuntu One	✓	✗	✓	✓
Wuala	✓	✓	✓	✓

Features: Deduplication

- Service providers pay traffic and storage
- Many use internal minimization technique: Deduplication
  - Server-side deduplication
    - incoming file already exists → only save link
  - Client-side deduplication
    - Client sends file information to server
    - File already exists → do not upload, only save link
- Providers claim storage reduction of **70% - 90% !!!**

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Security Requirements

- Registration and Login
  - Strong passwords
  - Protection against username/email enumeration
- Transport
  - Server authentication & Hostname Verification
  - Suitable cryptography
- Encryption
  - Client-side encryption of data and filenames
  - Non-deterministic key generation
  - Suitable cryptography

Security Requirements

- File sharing
  - Obfuscated public URLs
  - No indexing by external search engines
  - Reversible sharing
  - Disinvited users excluded by cryptographic means
- Deduplication
  - Deduplication threshold OR
  - single-account deduplication

Security Requirements

- Synchronization
  - List of registered devices
  - Manual device activation
  - Manual device deactivation
- Client software updates
  - Integrated periodic update check
  - User-initiated or silent update
- Server location
  - Storage location information

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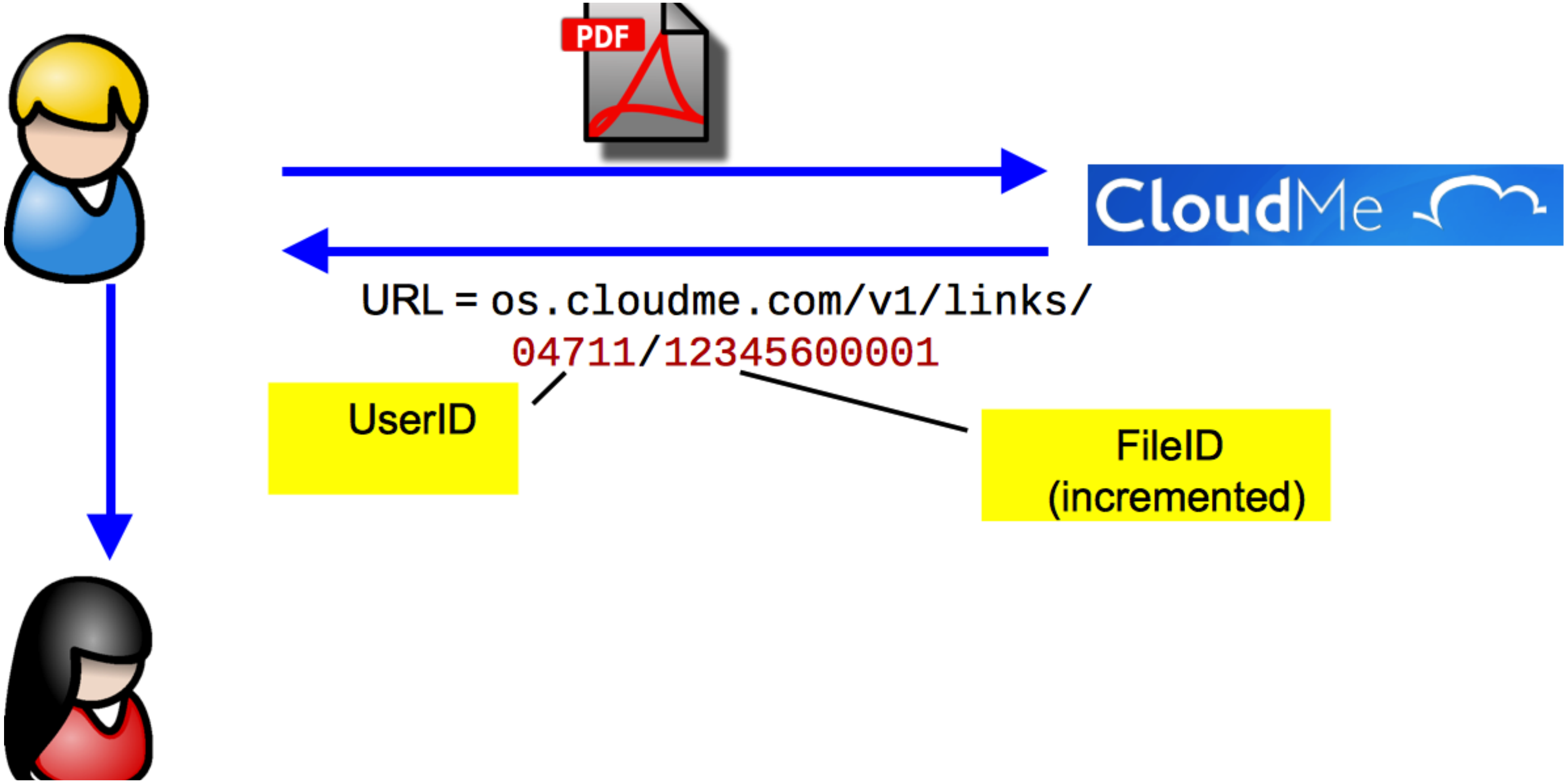
Security Issues: Careless Publication



URL = `os.cloudme.com/v1/links/`
`04711/12345600001`

UserID

FileID
(incremented)

Security Issues: Careless Publication

- Allows download of all public files
  - Iterate through UserID
    - Iterate through FileID

- Some allowed search engine indexation
  - Public files found by URL-based search
  - File contents indexed
    - Eases search for sensitive data

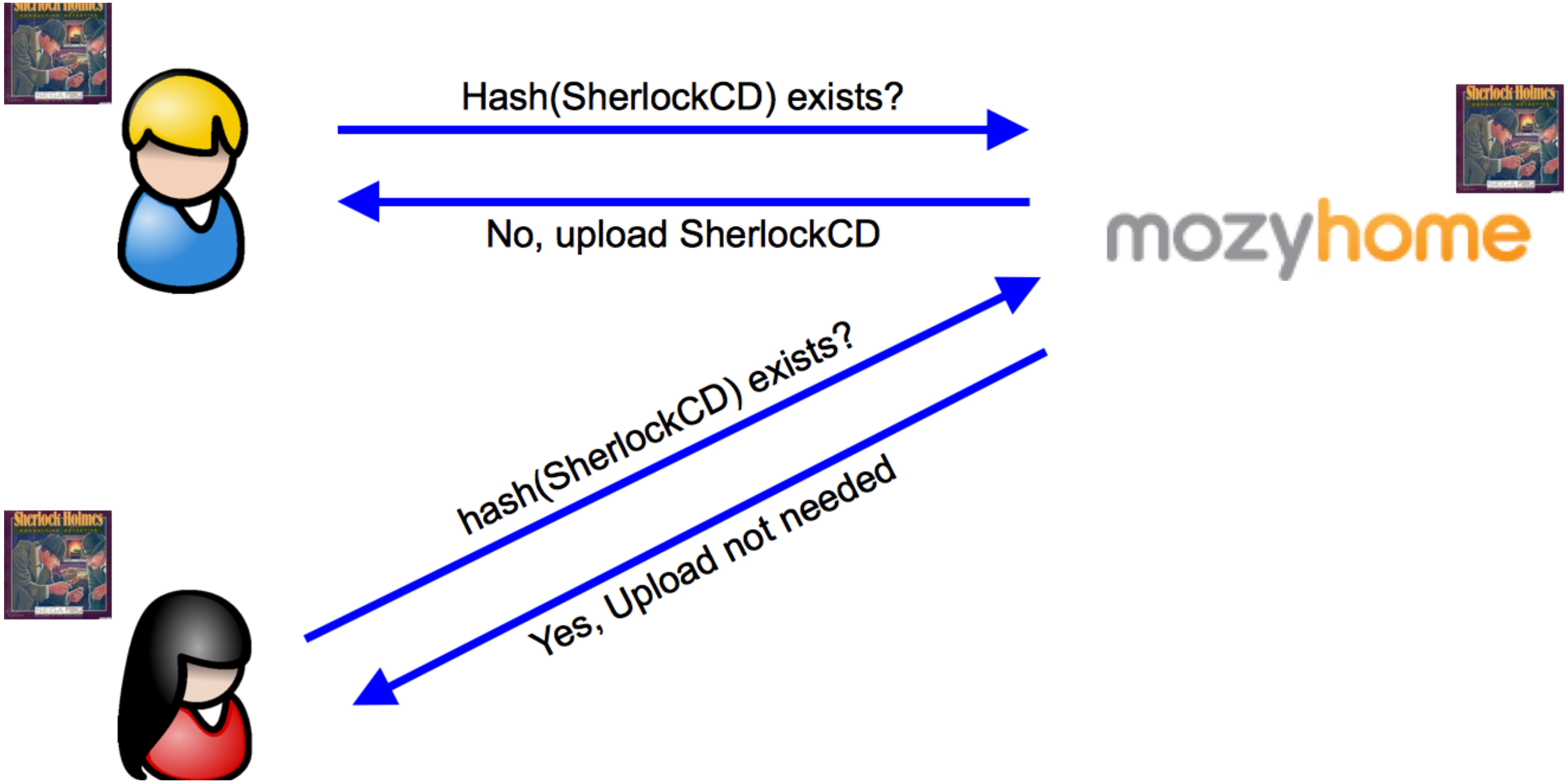
Security Issues: Careless Publication

- Mitigation Strategies
  - Use obfuscated URL
    - http://serviceprovider.com/public/<HASH(RANDOM + HASH(FILE))>
  - Disallow search engine indexations
    - I.e. robot.txt:

```
User-agent: *
Disallow: /
```

Security Issues: Deduplication

- Client-side Deduplication



Security Issues: Deduplication

- Benny Pinkas, 2010: Client-side Deduplication
  - Allows to test for file existence
    - If no upload occurs, document is already there

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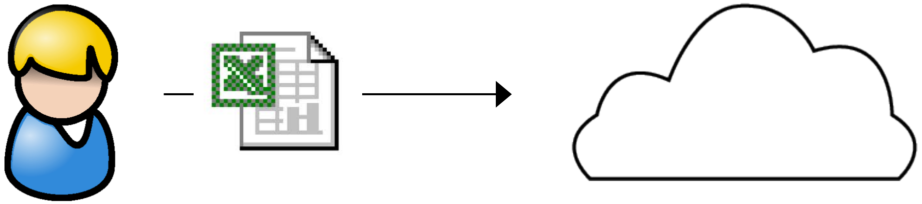
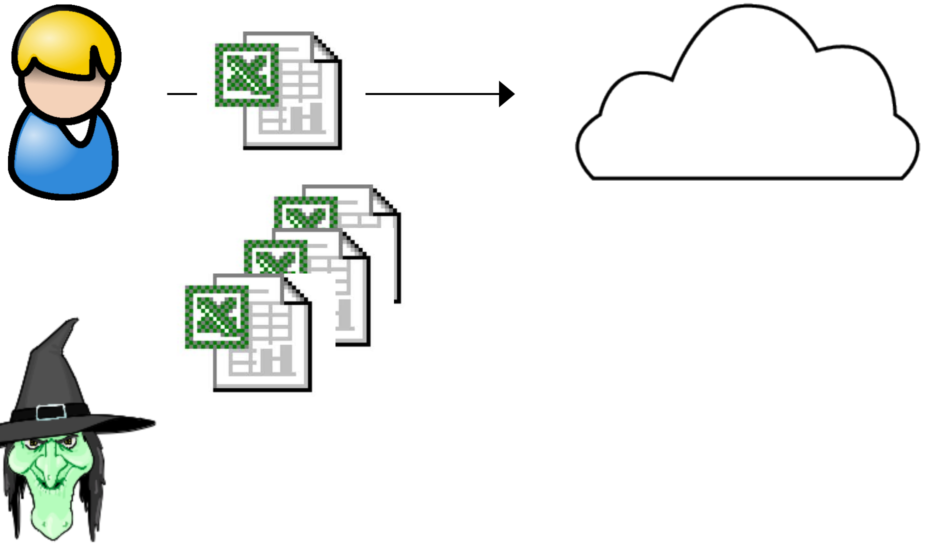
Security Issues: Deduplication

- Benny Pinkas, 2010: Client-side Deduplication
  - Allows espionage attack
    1. Bob uploads salary sheet



Security Issues: Deduplication

- Benny Pinkas, 2010: Client-side Deduplication
  - Allows espionage attack
    1. Bob uploads salary sheet
    2. Attacker knows document outline and creates possible documents



Security Issues: Deduplication

- Benny Pinkas, 2010: Client-side Deduplication
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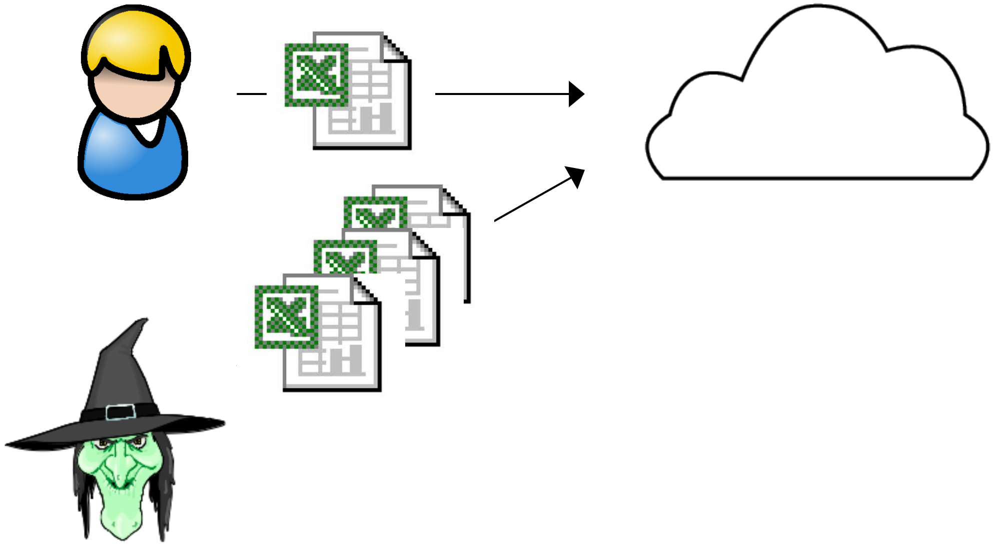
    2. Attacker knows document outline
    3. Attacker uploads possible salaries until no upload occurs



Security Issues: Deduplication

- Benny Pinkas, 2010: Client-side Deduplication
  - Allows document takeover
    1. Attacker knows the hash of a file

Hash(SherlockCD)

Security Issues: Deduplication

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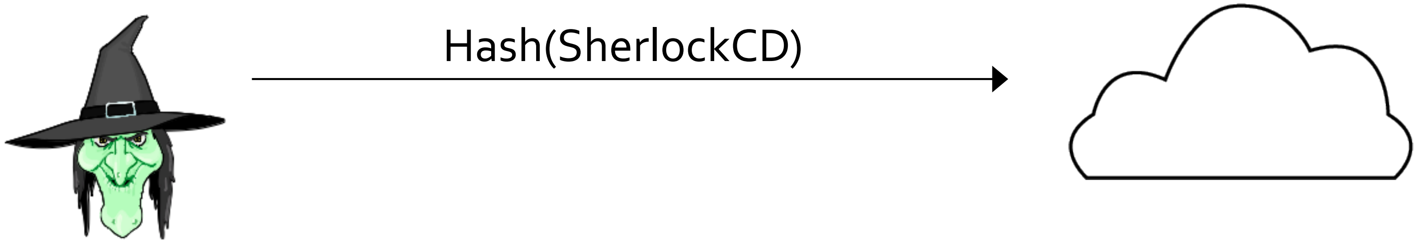
    1. Attacker knows the hash of a file
    2. Attacker manipulates communication to server and injects hash



Security Issues: Deduplication

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    1. Attacker knows the hash of a file
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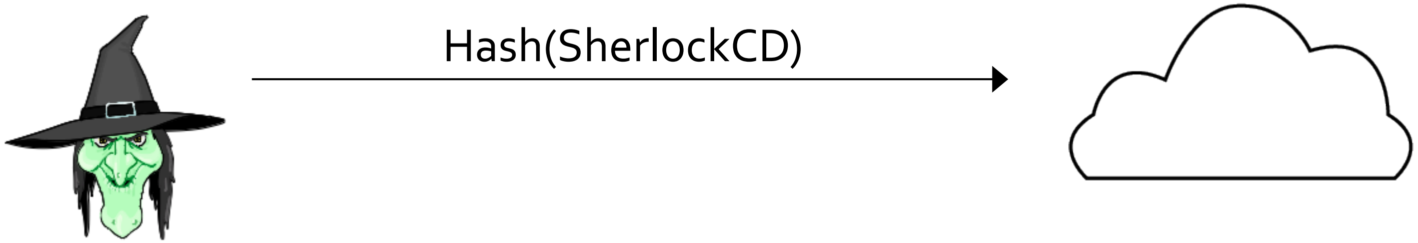
    3. Server sets a link to the file, registers attacker as owner



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    1. Attacker knows the hash of a file
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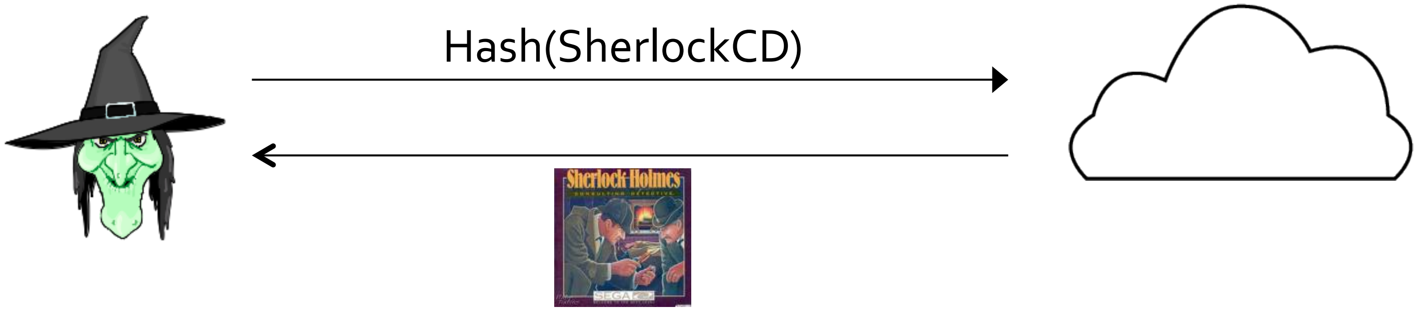
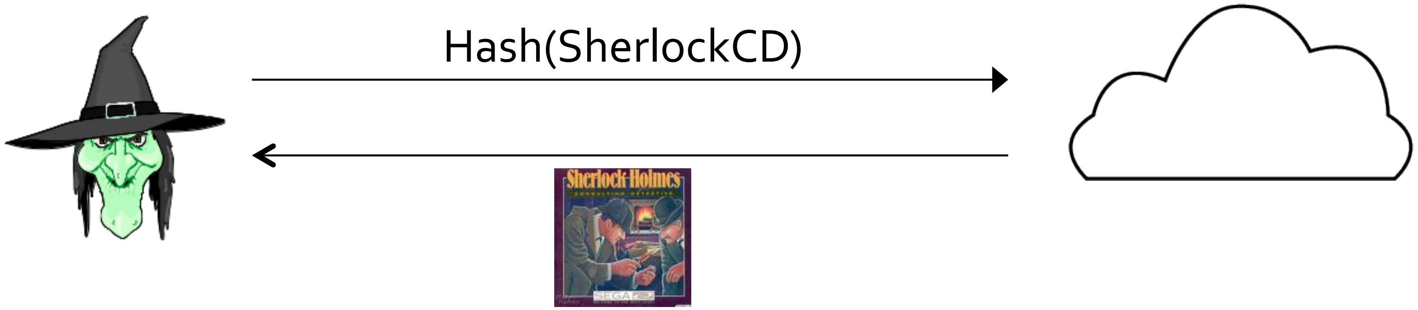
    3. Server sets a link to the file, registers attacker as owner
    4. Attacker downloads file



Security Issues: Deduplication

- Client-side Deduplication
  - 2011: Dropship (https://github.com/driverdan/dropship)
    - Open source software exploited the flaw in Dropbox
    - Insertion of hash → File appears in Dropbox folder
    - Dropbox tried to shut down the project
    - Finally, Dropbox disabled client-side deduplication

→ No Cloud Storage Service use Client-Side Deduplication today!



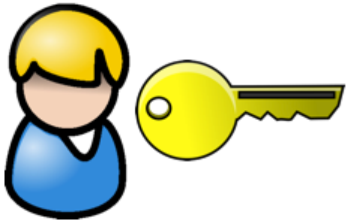
Hash(SherlockCD)

Security Issues: Encryption

- Server-side encryption
  - Data encrypted after transmission
  - No protection against internal attacker at provider
  - No protection against US PATRIOT Act

Security Issues: Encryption

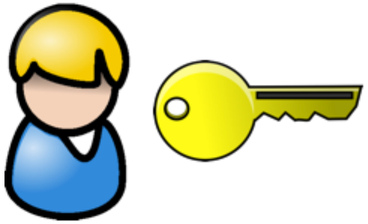
- Server-side key management
  - Client encrypts data before transmission
  - Key is transferred
  - No protection against internal attacker at provider
  - No protection against US PATRIOT Act



  - (Note: Mozy does also allow client to manage key)

Security Issues: Encryption

- Client-side encryption
  - Client generates key
  - Client encrypts data before transmission
  - Protection against external access



TeamDrive
Sync your data fast & secure

Security Issues: Encryption

- Why not always client-side encryption?
  - Lost key = no data access !
  - Not all data needs encryption ?!?

- **Client-side encryption vs. Deduplication !**
  - Copies not detectable
- **Client-side encryption vs. Sharing and Publication !**
  - Additional key exchange methods needed
- **Client-side encryption vs. Usability !**
  - Browser access difficult
  - Synchronization difficult

Security Issues: Wuala‘s convergent encryption

- Wuala employs special method „convergent encryption“

Client

$$\begin{tikzcd}
\text{file} \arrow[r, "\text{hash}"] \arrow[d, "\text{encrypt}"'] & \text{k} \\
\text{enc}_K\text{(file)} \arrow[r, "\text{hash}"] & \text{fname'}
\end{tikzcd}$$

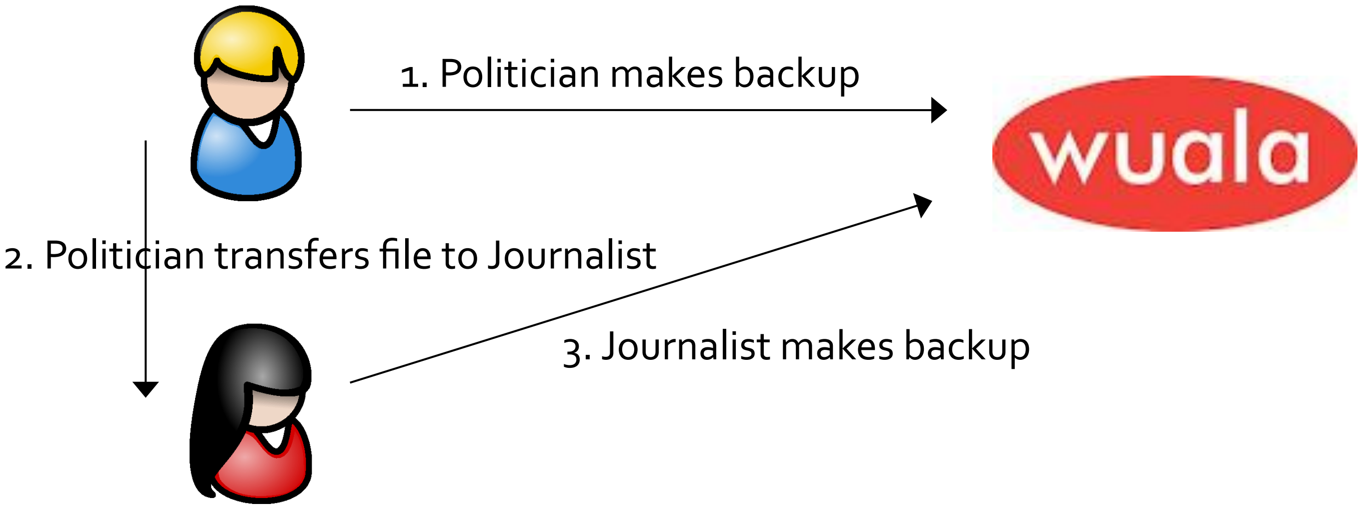
Server

filename on server:	hash(enc$_K$(file))
file content:	enc$_K$(file)
key for decryption:	enc$_S$(k)
filename on user's disk:	enc$_S$(fname)

  - allows use of deduplication
  - allows use of sharing and publication

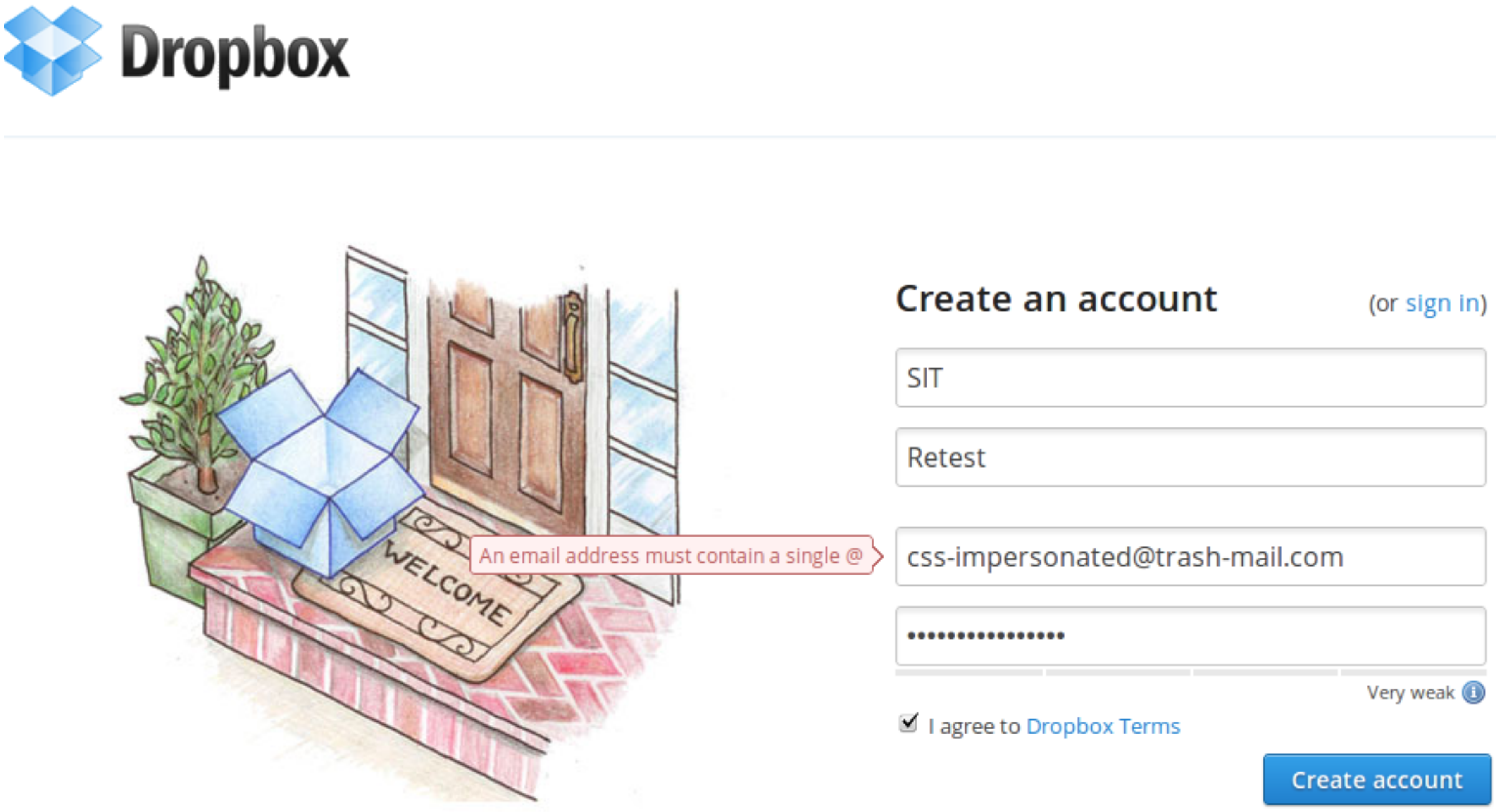
Security Issues: Wuala‘s convergent encryption

- Wuala employs special method „convergent encryption“
  - No protection against internal attacker at provider
  - Example: Leaking a sensitive Document


1. Politician makes backup
2. Politician transfers file to Journalist
3. Journalist makes backup
wuala

Wuala knows:
Politician and
Journalist share
same file

Security Issues: Unverified email addresses



Create an account (or sign in)

SIT

Retest

An email address must contain a single @

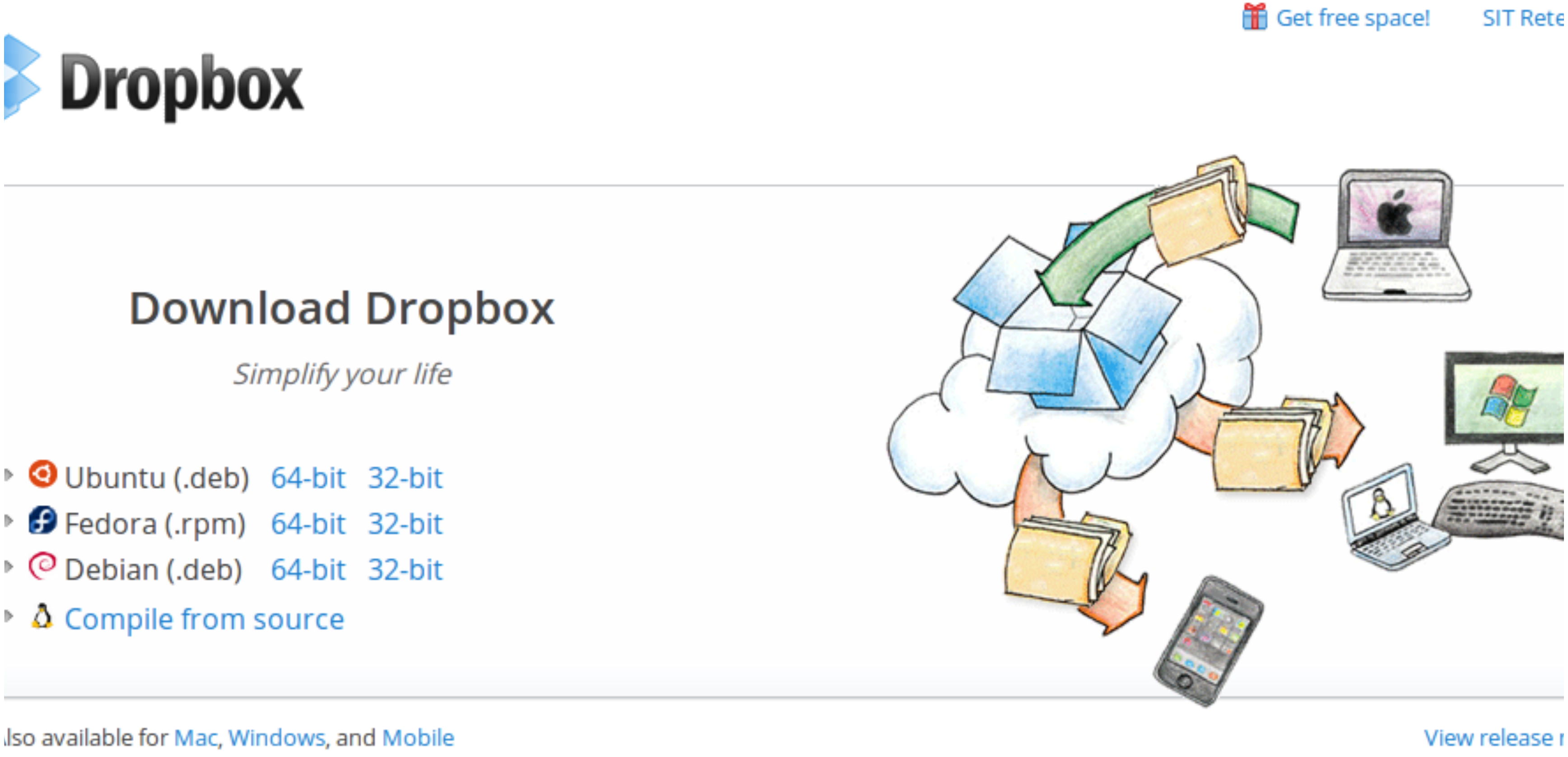
css-impersonated@trash-mail.com

••••••••••••••••

Very weak

☑ I agree to Dropbox Terms

Security Issues: Unverified email addresses



Get free space! SIT Rete

Dropbox

Download Dropbox

Simplify your life

Ubuntu (.deb)	64-bit	32-bit
Fedora (.rpm)	64-bit	32-bit
Debian (.deb)	64-bit	32-bit

- Compile from source

lso available for Mac, Windows, and Mobile

View release r

Security Issues: Unverified email addresses

- Service registration allowed without email verification
  - Many services analyzed
  - Identified as vulnerable:

CloudMe

Dropbox

wuala by LACIE

HiDrive

IDrive® Did you back it up?™

syncplicity

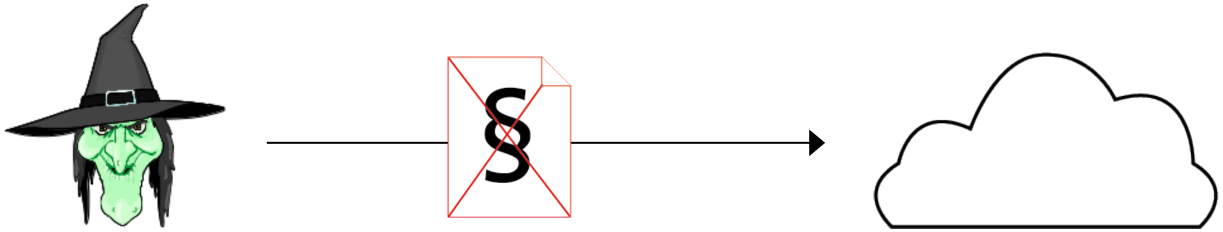
SugarSync

Security Issues: Unverified email addresses

- Several services allow registration without email verification
  - Incrimination attack
    1. Attacker registers using email of victim

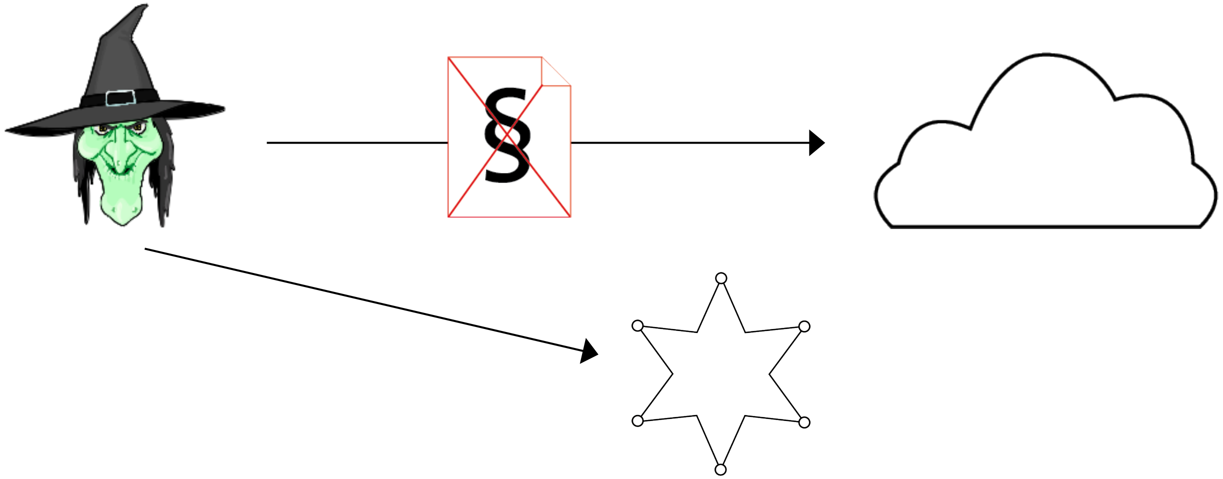
Security Issues: Unverified email addresses

- Several services allow registration without email verification
  - Incrimination attack
    1. Attacker registers using email of victim
    2. Attacker uploads incriminating data



Security Issues: Unverified email addresses

- Several services allow registration without email verification
  - Incrimination attack
    1. Attacker registers using email of victim
    2. Attacker uploads incriminating data
    3. Attacker reports to third party



Security Issues: Unverified email addresses

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    1. Attacker registers using email of impersonated

Security Issues: Unverified email addresses

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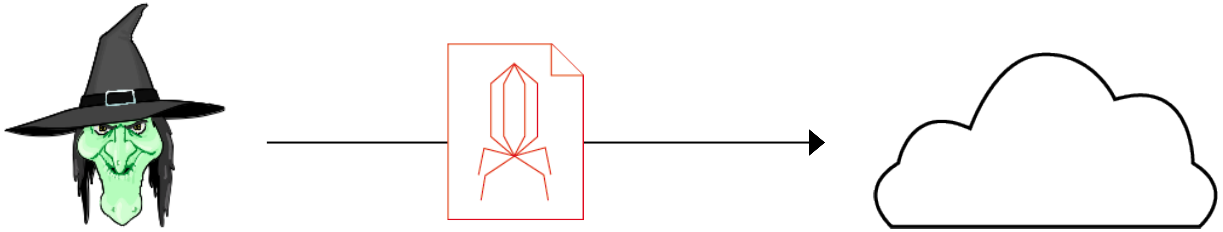

Security Issues: Unverified email addresses

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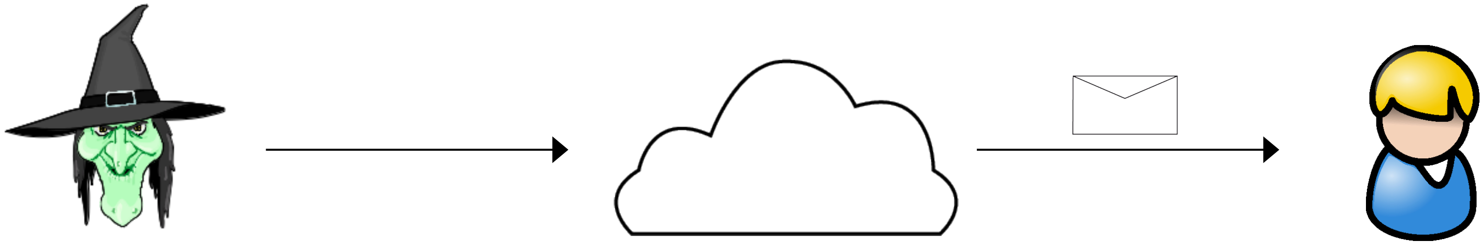
    3. Attacker uses sharing to offer data to victim (friend of impersonated)



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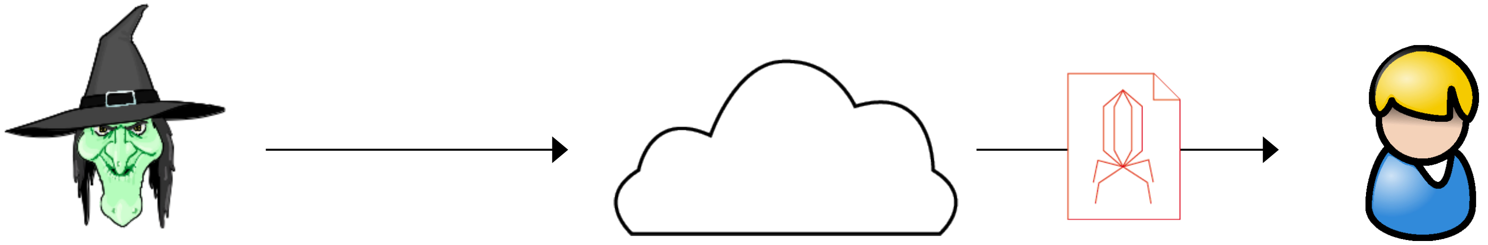
    4. Victim downloads data



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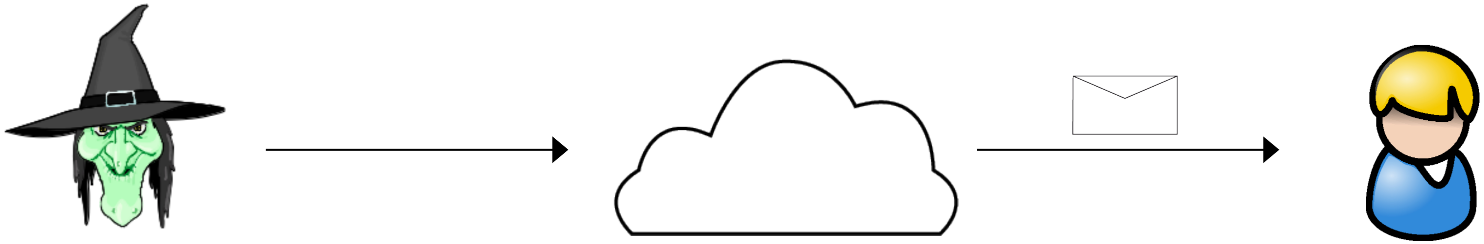

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- Several services allow registration without email verification
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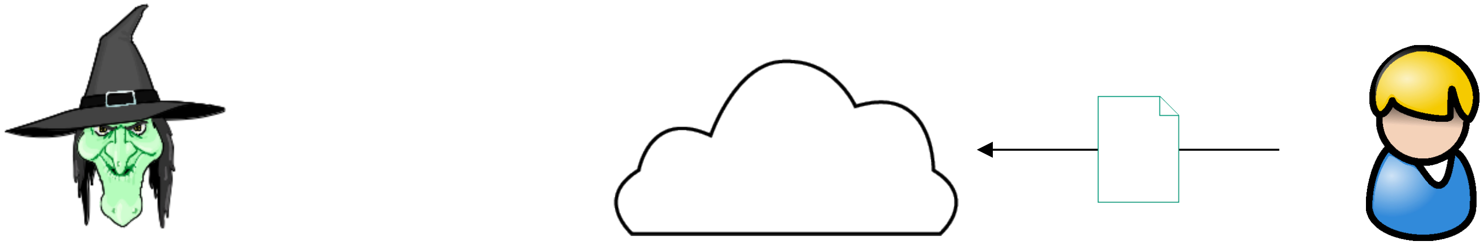
    3. Victim uploads requested data



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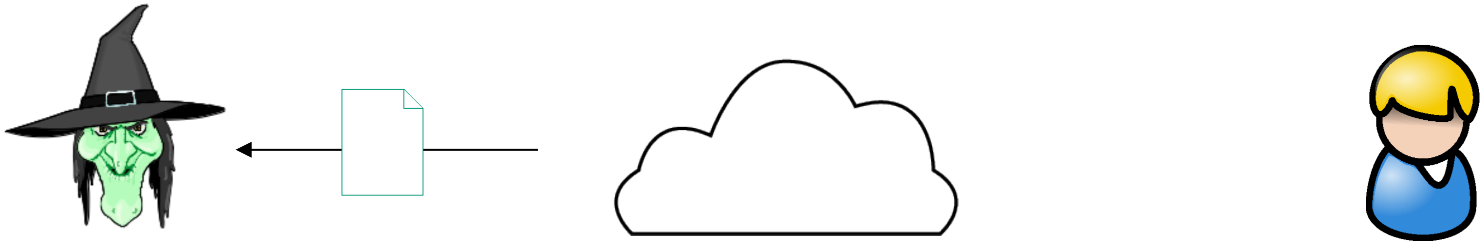

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Security Issues: Unverified email addresses

- Several services allow registration without email verification
  - How could this happen?
    - Most popular service introduced flaw
    - Other services followed
  - Security at the cost of Usability
    - Streamlined registration process
    - Subsequent introduction of sharing functionality
      - allowed attacks
  - Mitigation strategy
    - Verify email address by sending activation link

Code of Conduct: Handling security issues

- What did we do with our findings?
  - Responsible disclosure
    - Inform service provider
    - Offer to discuss possible solutions
    - Announce date of publication (3-6 months in the future)
  - Findings throughout 2011

  → May 2012: Published technical report

  → June 2012: Published Paper at IEEE TrustCom 2012

  „Vulnerabilities through Usability Pitfalls in Cloud Services: Security Problems due to Unverified Email Addresses"

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Trust Issues

- Cloud Storage Services…
  - … are highly attractive attack targets
  - … employ multiple data redundancy and backup schemes
    - Where is my data?
    - Attack surface
  - … operate internationally
    - No specialized SLAs for most customers
    - Legal issues
      - Sensitive data in off-shore data-centers

→ Server-side encryption acceptable?

→ Client-side encryption still needs trust !

Trust Issues

- Using the Cloud means
  - Replace on-premise security with trust in provider's ability
  - Replace internal security policy with Service Level Agreement (SLA)
    - But with whom do I effectively deal?

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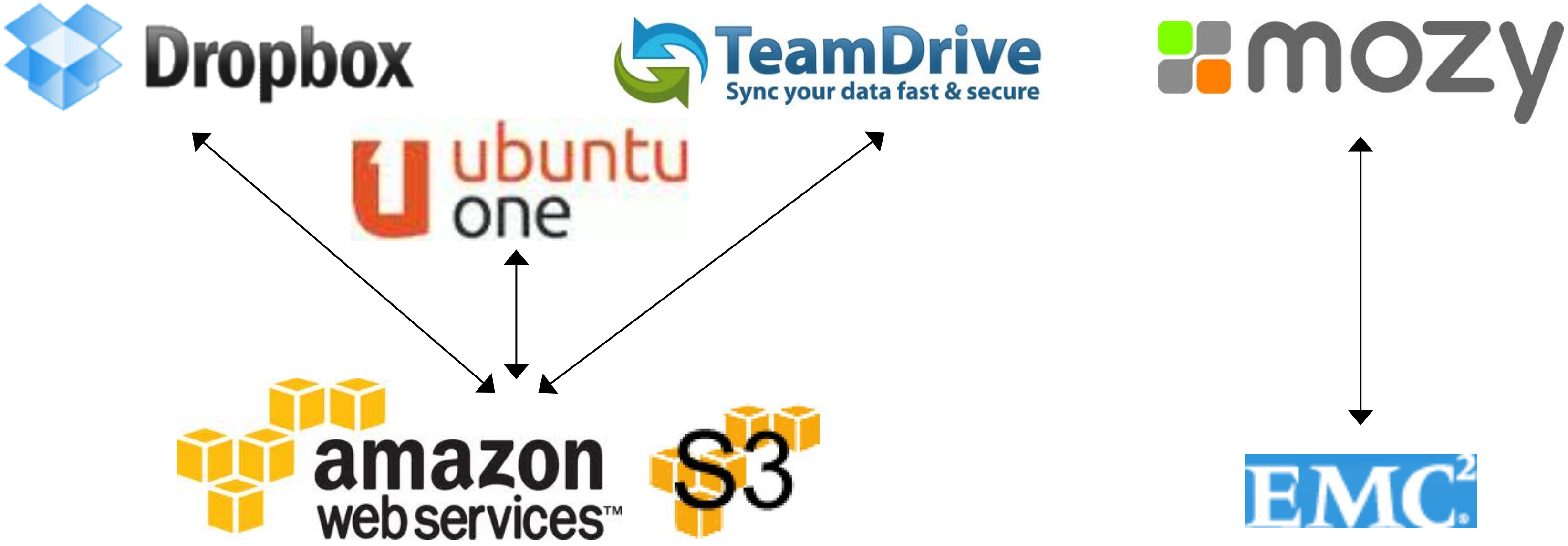

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Drawbacks of Cloud Storage

- Provider down!
  - Can I cope?
  - Recovery time acceptable?
- Data transmission time
  - Assume 500GB data, download ~1MB/s, upload ~0.25MB/s (DSL 16.000)
    - Upload time estimated: 23.7 days
    - Download time estimated: 5.9 days
- Service provider may go out of business
  - Easy migration possible ?
  - Migration time acceptable?

Cloud Storage Security
Outline

1. Introduction and overview
2. Features
3. Security requirements
4. Security issues
5. Trust issues
6. Drawbacks
7. **Choice**

Choice

- Overview of analysis results

	Registration	Transport	Encryption	Sharing	Deduplication
CloudMe	– –	– –	– –	–	⁒
CrashPlan	+	±	+	⁒	+
Dropbox	–	+	–	±	+
Mozy	±	+	±	⁒	–
TeamDrive	±	±	+	±	⁒
Ubuntu One	+ +	+	– –	+ +	+
Wuala	–	±	±	±	–

Choice

- Choice depends on requirements
  - „Data does not need to be encrypted "
    - i.e. CloudMe, Ubuntu One
  - „Data examination by third parties may be acceptable"
    - i.e. Dropbox
  - „I want client-side encryption and trust my provider"
    - i.e. CrashPlan, Mozy, TeamDrive, (Wuala)
  - „I want everything"
    - No service meets all of our security requirements

Choice

- Cloud Storage Service providers…
  - … are aware of privacy and confidentiality needs
  - … have taken steps to provide high security level
  - … actively try to improve their services
  - … have mostly upgraded their systems to address security issues
- Users need to evaluate…
  - … security level of own data
  - … necessary service functionality

Thank You for your attention ☺

Questions ?