Analysis of an Incentives-based Secrets Protection System

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Protecting Passwords

- Passwords grant access to e.g. a paid subscription service
- Passwords can be easily copied, posted online, shared with friends…
- Service provider loses money / potential customers

Approaches to Protect Access to Accounts

- Enforcement: turn off account, sue subscriber
  - detect inappropriate use: too many simultaneous logins, disparate IP addresses
    - problem of false positives
- Prevention:
  - only one login at a time
    - but you can still have sharing…
  - Tie login to one computer by hardware signatures, IP address, MAC address
- Incentives

Our approach: SPIES

(Secret Protection Incentive Based Escrow System)

- Provide financial incentive not to share
- Applicable to content that
  - is not widely available
  - needs to be protected a short while
- Best application: protecting passwords

Features of SPIES

- no hardware or software restrictions
  - compatible with any type of device
  - password can be backed up
  - password can be stored on different devices
- password can be shared with anyone trusted
  - friend keeps a copy for emergencies, like house-keys
  - can have third-party backups

Players in SPIES

- Alice, a password provider
- Bob, a customer
- A trusted escrow service
- A charity

Basic Operation of SPIES

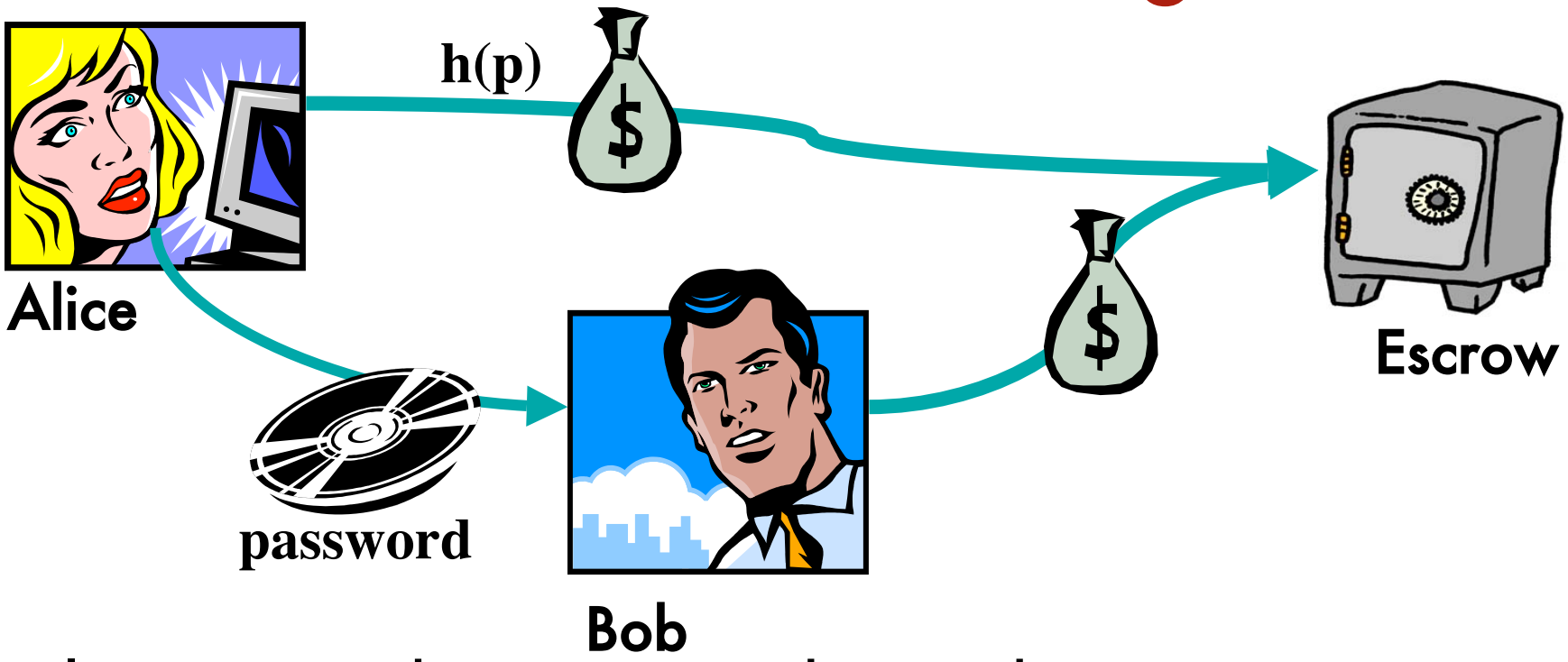
- Bob gives a security deposit to an Escrow service
- Anyone who has the password can present proof of possession to the Escrow service ("register") for a payment.
- At the end of a protection period, Bob's security deposit is returned. It is reduced if someone presents such proof.

SPIES Protocol Phases

- Exchange
- Registration
- Payment

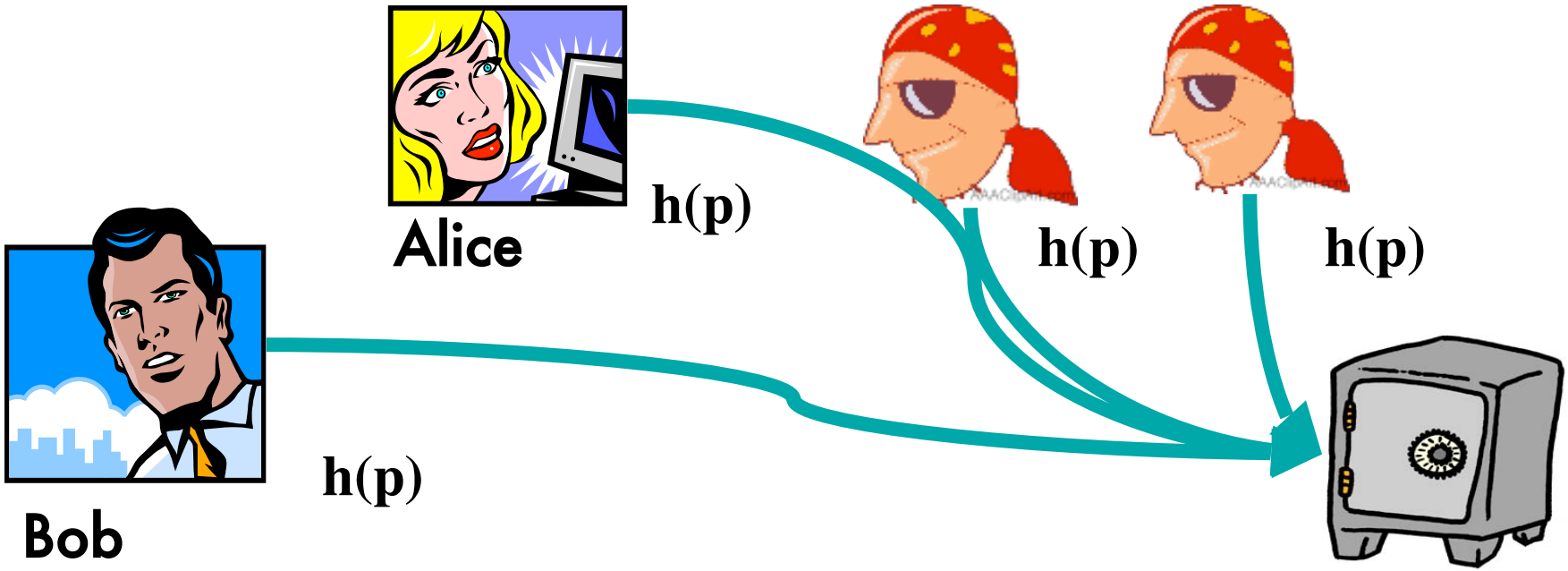
} Protection Period

Phase 1: Exchange



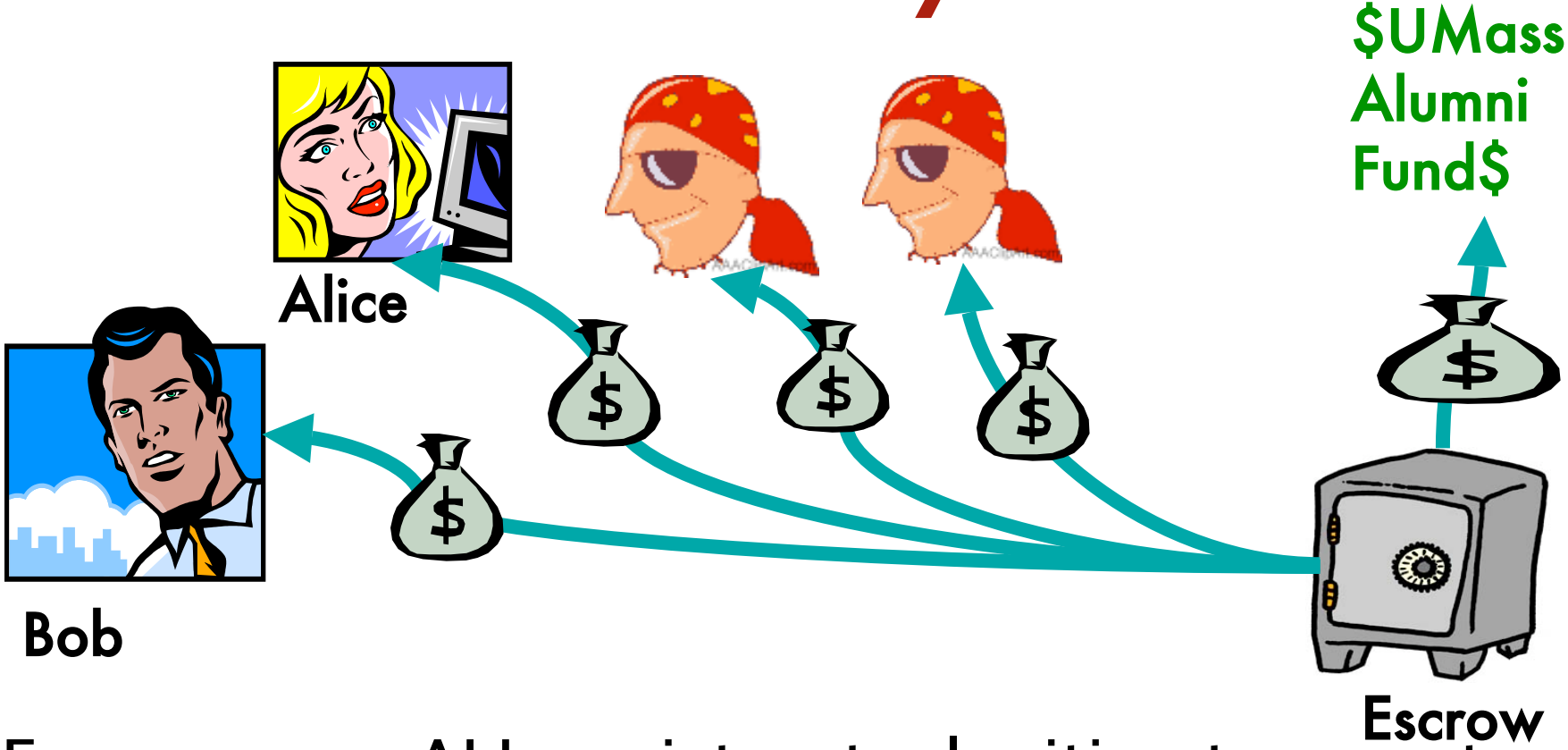
- Alice gives the password to Bob
  - typically: Bob gives some payment to Alice too
- Alice and Bob give a security deposit to Escrow,
- Alice sends a hash of the password to Escrow
- Alice and Bob are the “legitimate possessors”

Phase 2: Registration



- Bob and Alice present proof of password possession to the Escrow Service
  - hash of the password
- So does anyone else who somehow has access to the password, whether stolen or bought
  - this registration can be anonymous

Phase 3: Payment



- Escrow pays ALL registrants, legitimate or not.
- Alice & Bob lose some of their deposits if there are illegitimate registrations
- Charity gets excess money if sharing occurred

Setting the Security Deposit

- It should not be so high that Bob won't participate
- It should be more than Bob can get in total by selling the password
  - Can be difficult to determine
- One way to determine security deposit level: detect multiple people using an account

Account Limits for Setting the Security Deposit

- Suppose that use of an account by x or more people can be detected, and account disabled
- Set escrow amount so Bob would need to sell to more than x to recover escrow
- Unauthorized possessors shouldn't buy
  - Bob is probably selling a worthless password
  - Other buyers may have resold as well
- Bob probably won't be able to make a net profit. He shouldn't sell at all.

Attacks on SPIES

- Alice registers twice to get Bob in trouble
  - she loses her escrow
- Alice shares the data with someone else
  - she loses her escrow
- Someone registers many times
  - exponential payout function: they get **less** money total
  - charity gets non-distributed money

Exponential Payout Function

- Each registrant gets only $1/2^{x-2}$ of the amount they would get where x is the number of registrations.
- Example: $5 deposit
  - Alice and Bob register once; each gets $1/2^0$ of $5, I.e. $5
  - Bob makes 5
    - there are 6 shares (Alice's 1 plus 6 for Bob)
    - Each share gets $1/2^{(6-2)}$ =1/16 th of $5
    - Bob gets 5/16 of $5 or about **$1.56**, not $5.
    - Alice only gets $0.31!
- Details in paper

Strategies of Content Possessors

- Authorized Possessors
  - Don't share unless you think someone else has
    - sharing reduces the returned security deposit
    - Different from Prisoner's Dilemma!
  - register exactly once
- Unauthorized Possessors
  - If you have the content, register exactly once
  - don't spread the content further – maybe.
    - depends on benefit, escrow amount, number of unauthorized possessors

Strategies of other participants

- Escrow: assumed to be honest
  - It can collaborate with a charity to get security deposits
- Charity: can get all the money if it gets the content
  - Use a large number of charities; secure coin flip to choose one

Nash Equilibria and Rationalization

- Def: given other's actions, no one can improve their utility with different action
- We found two Nash equilibria: neither shares and both share.
  - Both do best if they don't sell
  - If one sells the other does better to sell too
  - Still works with more than two participants
- Depends on being able to make a fixed, limited amount of money by selling
- If Bob knows Alice is rational & vice-versa, no-one shares: "rationalized" outcome

Key: Incentives Levels

- Can always ensure non-sharing
  - death penalty for authorized possessors if there are too many registrations
- To get users to participate, their expected utility must be positive
- Again, Alice prefers a high security deposit, Bob a low one; these must be balanced.

Other uses

- Non-disclosure agreements between companies
- Entertainment content shared to a reviewer pre-release
- Exclusive photographs shared with a newspaper by the photographer
- In these cases, the hash serves as a commitment: a human must determine if the content is identical
  - content can be obscured in many ways

Conclusion

- SPIES Provides an incentive to users
  - not to share
  - to protect their content
- useable as an additional layer of protection with other technologies and policies
  - DRM, Watermarking, lawsuits
- Applicable to passwords and other content