Off-the-Record Communication, or, Why Not to Use PGP

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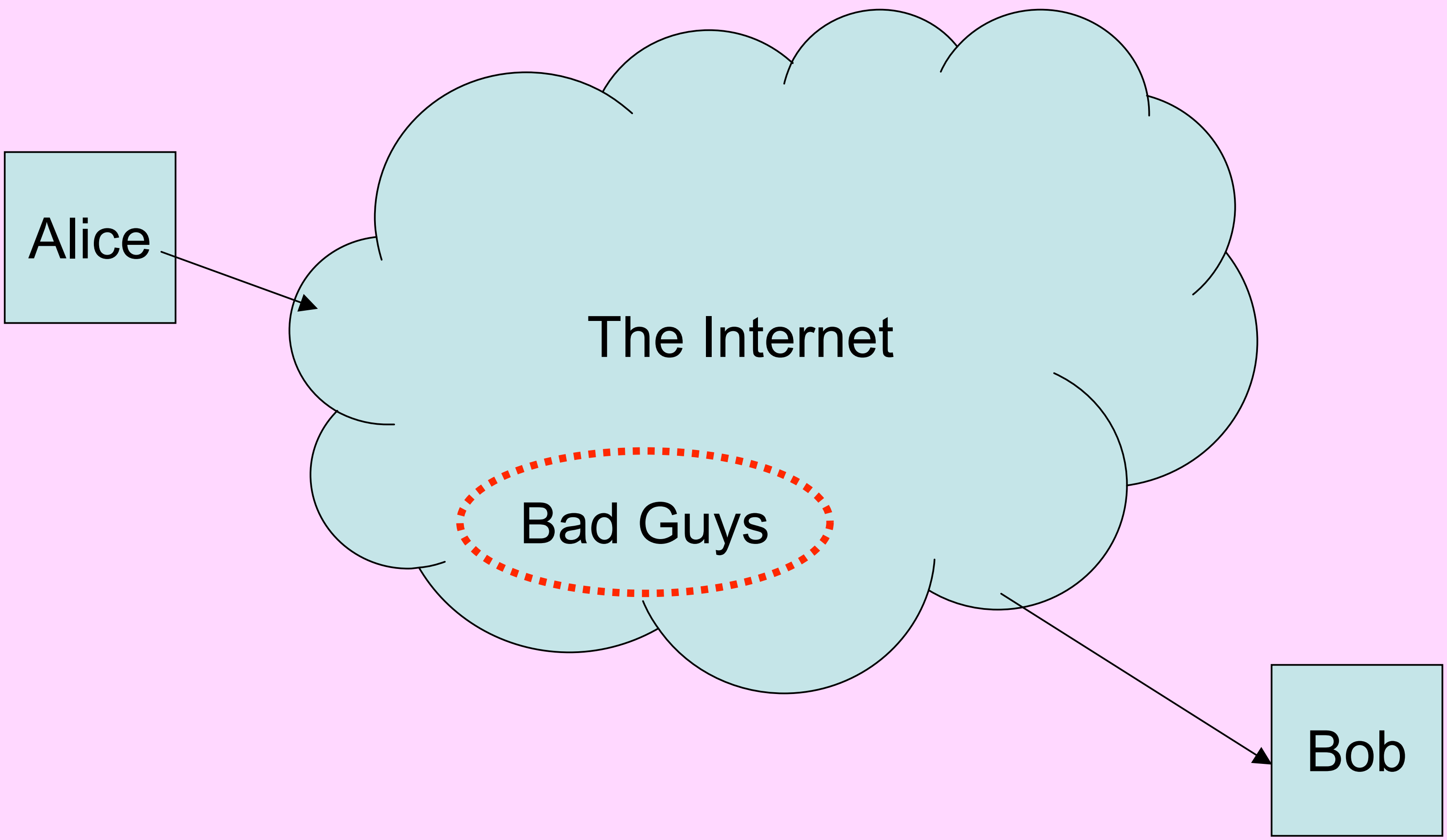
Our Scenario

- Communication privacy is a complicated problem
- Generous assumptions
  - Alice and Bob both know how to use PGP
  - They both know each other's public keys
  - They don't want to hide the *fact* that they talked, just what they talked about

Threat Model



Solved Problem

- Alice uses her public key to sign a message
  - Bob should know who he’s talking to
- She then uses Bob’s public key to encrypt it
  - No one other than Bob can read the message
- Bob decrypts it and verifies the signature
- Pretty Good, no?

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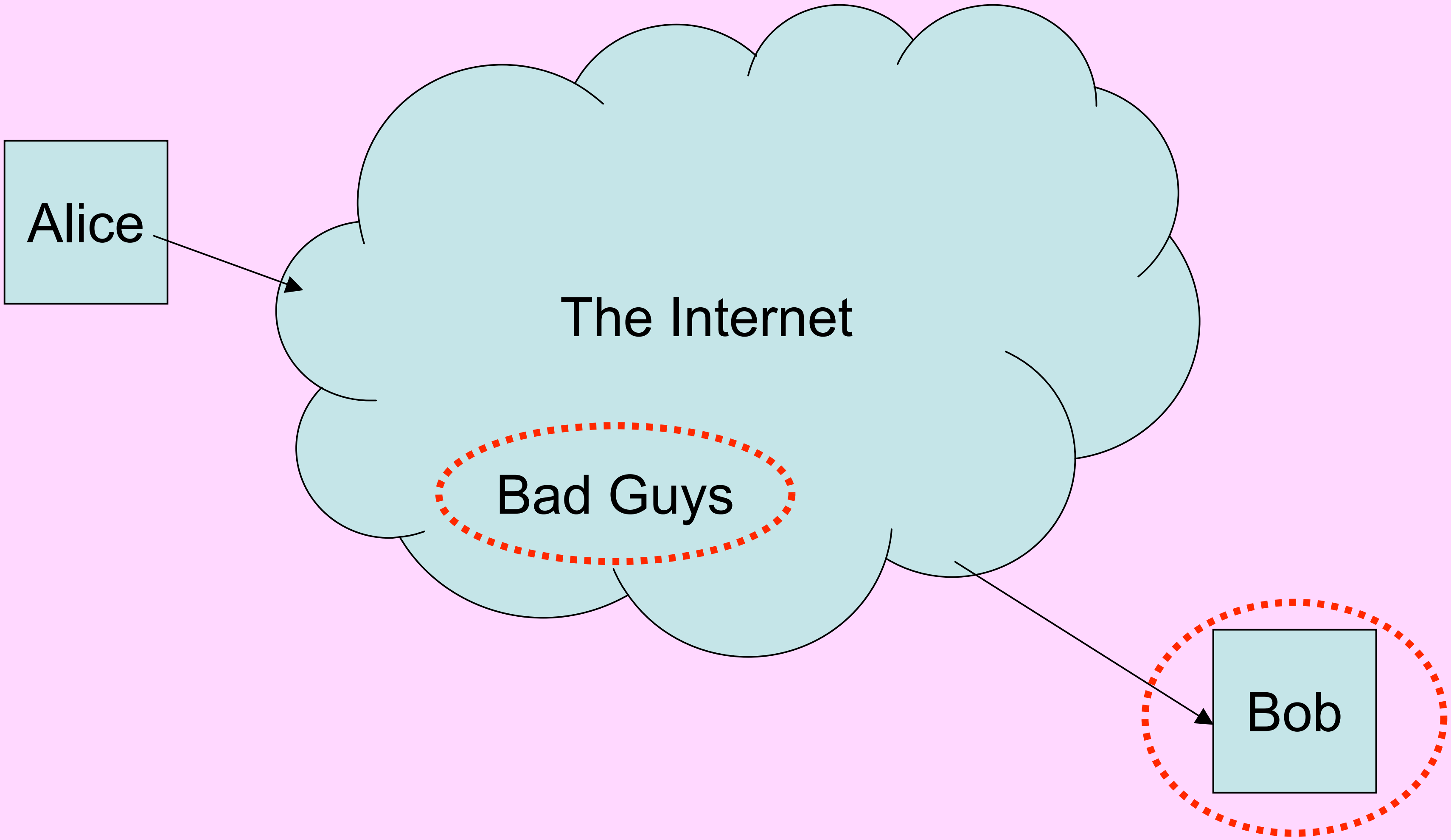


Plot Twist

- Bob’s computer is stolen by “bad guys”
  - Criminals, competitors
  - Subpoenaed by the FBI
- Or just broken into
  - Virus, trojan, spyware, black bag job
- *All* his key material is recovered
  - Oh no!

Bad guys can…

- Decrypt past messages
- Learn their content
- Learn that Alice sent them
  - And have a mathematical *proof* they can show to anyone else
- How private is that?

What went wrong?

- Bob's computer got stolen?
- How many of you have never…
  - Left your laptop unattended?
  - Not installed the latest patches?
  - Run software with a remotely exploitable bug?
- What about your parents?

What *Really* Went Wrong

- The software created lots of incriminating records
  - Key material that decrypts data sent over the public Internet
  - Signatures with proofs of who said what
- Alice better watch what she says
  - Her privacy depends on Bob’s actions

Casual Conversations

- Alice and Bob talk in a room
- No one else can hear
  - Unless being recorded
- No one else knows what they say
  - Unless Alice or Bob tell them
- No one can *prove* what was said
  - Not even Alice or Bob
- These conversations are “off-the-record”

We Like Off-the-Record Conversations

- Legal support for having them
  - Illegal to record conversations without notification
- We can have them over the phone
  - Illegal to tap phone lines
- But what about over the Internet?

Crypto Tools

- We have the tools to do this
  - We've just been using the wrong ones
  - (when we've been using crypto at all)
- We want *perfect forward secrecy*
- We want *repudiable authentication*

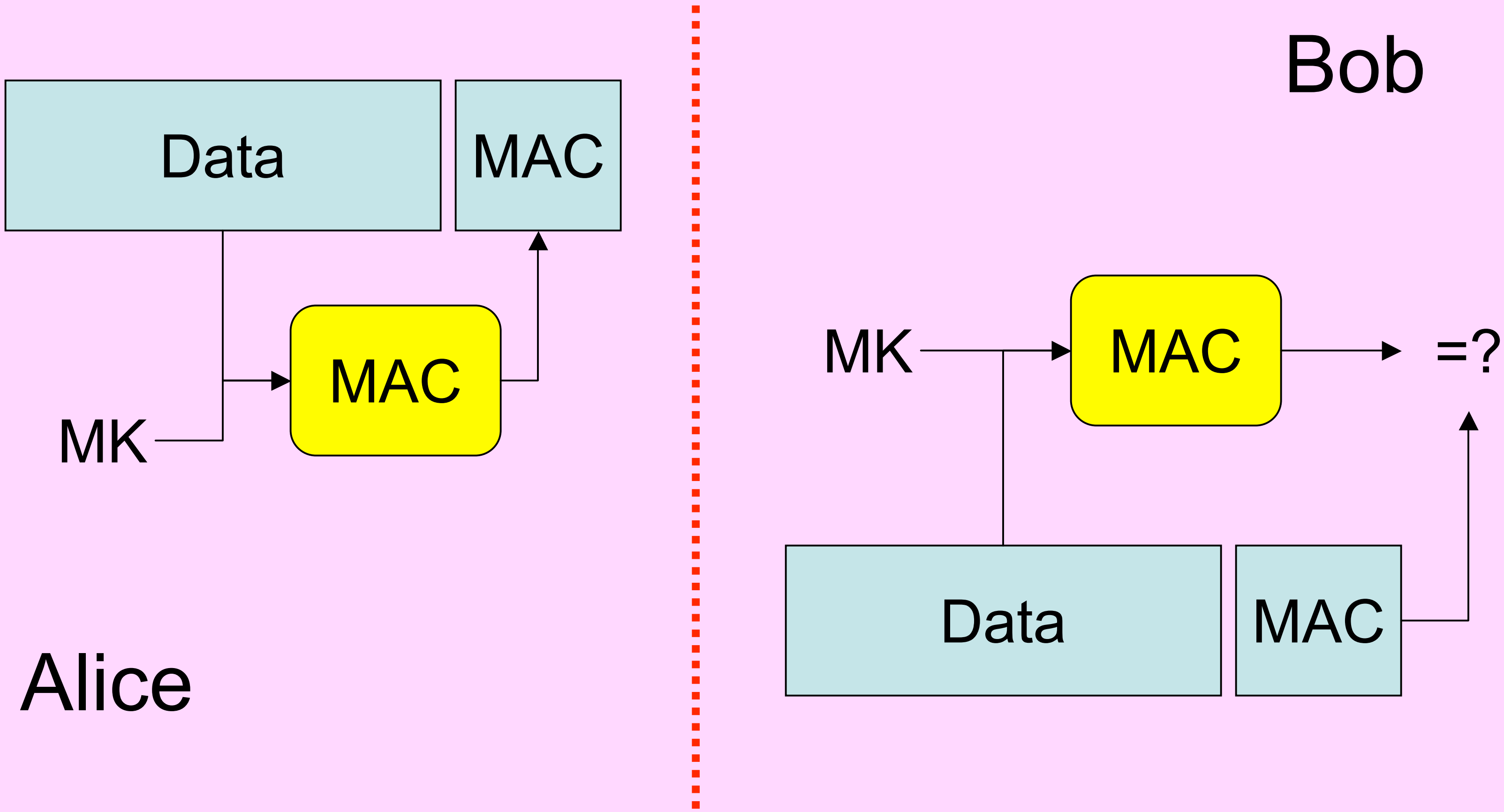
Perfect Forward Secrecy

- Future key compromises should not reveal past communication
- Use a short-lived encryption key
- Discard it after use
  - Securely erase from memory
- Use long-term keys to help distribute & authenticate the short-lived key

Repudiable Authentication

- *Do not* want digital signatures
  - Leave non-repudiation for contracts, not conversations
- *Do* want authentication
  - Can’t maintain privacy if attackers can impersonate friends
- Use Message Authentication Codes (MACs)

MAC Operation



No Third-Party Proofs

- Shared key authentication
  - Alice and Bob have same MK
  - MK required to compute MAC
- Bob cannot prove that Alice generated the MAC
  - He could have done it, too
  - Anyone who can verify can also forge

Off-the-Record Protocol

- Rough sketch of protocol
  - Details on our web page
- Assume Alice and Bob know each other's public keys
  - These keys are long-lived, but we will only use them as a building block
- No forward-secure requirement for authentication

Step 1: Diffie-Hellman

- Alice and Bob pick random x, y resp.
- A->B: g^x, $Sign_{Alice}(g^x)$
- B->A: g^y, $Sign_{Bob}(g^y)$
- $SS=g^{xy}$ a shared secret
- Signatures authenticate the shared secret, not content

Step 2: Message Transmission

- Compute EK=Hash(SS), MK=Hash(EK)
- A->B: $Enc_{EK}(M)$, $MAC(Enc_{EK}(M),MK)$
- *Enc* is symmetric encryption (AES)
- Bob verifies MAC using MK, decrypts M using EK
- Confidentiality and authenticity is assured

Step 3: Re-key

- Alice and Bob pick x',y'
- A->B: $g^{x'}$, MAC($g^{x'}$, MK)
- B->A: $g^{y'}$, MAC($g^{y'}$, MK)
- SS' = H($g^{x'y'}$)
- EK' = H(SS'), MK'=H(EK')
- Alice and Bob securely erase SS, x, y, and EK
  - Perfect forward secrecy

Step 4: Publish MK

- Alice and Bob do *not* need to forget MK
  - They no longer use it for authentication
- In fact, they *publish* the old MK along with the next message
  - This lets *anyone* forge messages, but only past ones
  - Provides extra deniability

IM implementation

- Instant messaging suited for casual conversations
  - Current security options not satisfactory
- Implemented libotr for secure instant messaging
- Uses:
  - OTR plugin for GAIM (multi-platform IM client for Linux, Windows)
  - Prototype plugin for Adium (OS X IM client based on gaim)
  - Prototype AIM-specific proxy for other clients/platforms
- Toolkit for forging transcripts
  - Any claimed transcript is automatically untrustworthy

Comparison to Other Systems

- gaim-encryption
  - Encryption and authentication
  - No deniability or perfect forward secrecy
  - Like PGP with signatures
- Trillian SecureIM
  - Encryption with perfect forward secrecy
  - No authentication at all
- SILC
  - Completely separate network
  - Share messages (securely) with SILC server, *or*
  - Pre-shared long-term secret, *or*
  - Peer-to-peer communication (hard with NATs)

Conclusion

- Current software provides the wrong privacy properties for casual conversations
- We want
  - Perfect forward secrecy
  - Repudiable Authentication
- Use our OTR protocol
  - http://www.cypherpunks.ca/otr/