Cryptography

Reference:

Network Security

PRIVATE Communication in a PUBLIC World.

by Kaufman, Perlman & Speciner.

Secret Key Cryptography

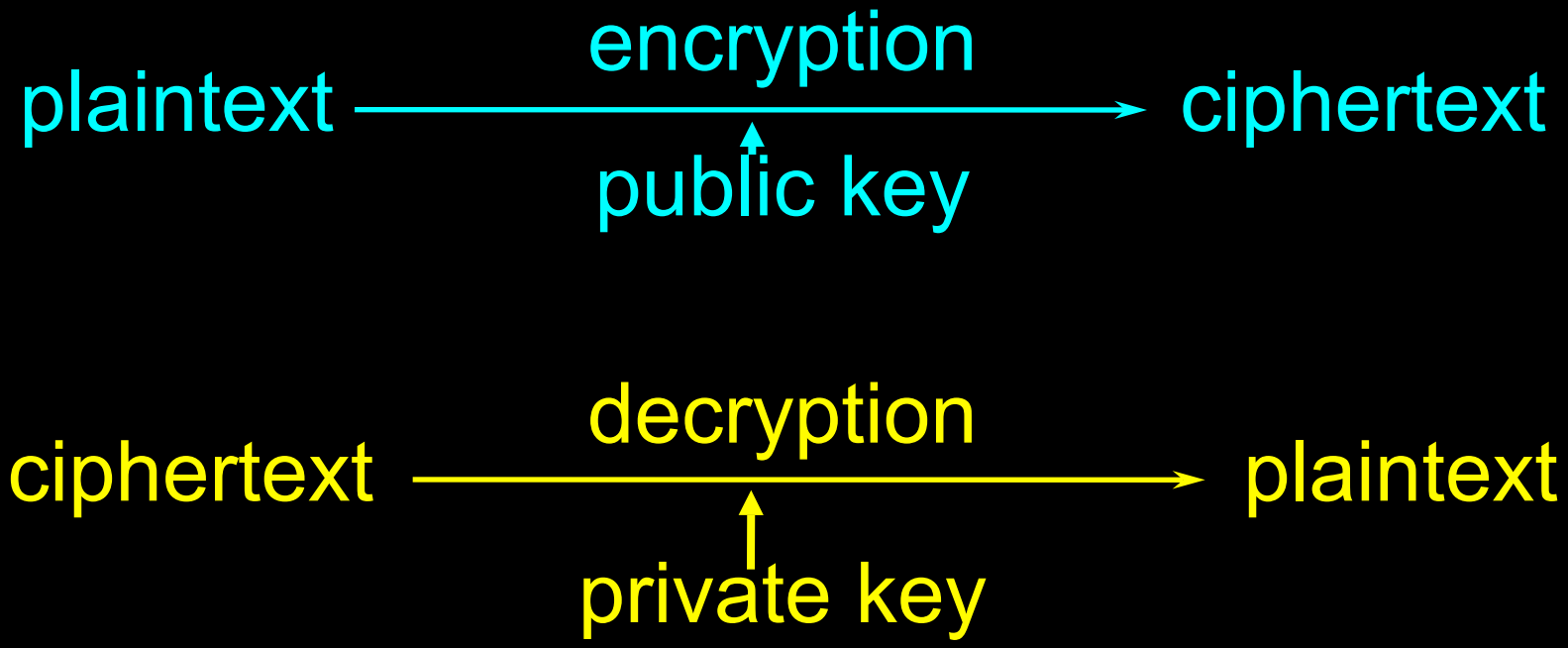
- Single key used to encrypt and decrypt.
- Key must be known by both parties.
- Assuming we live in a hostile environment (otherwise - why the need for cryptography?), it may be hard to share a secret key.

Public Key Cryptography
(a.k.a. asymmetric cryptography)

- Relatively new field - 1975 (as far as we know, the NSA is not talking).
- Each entity has 2 keys:
  - private key (a secret)
  - public key (well known).

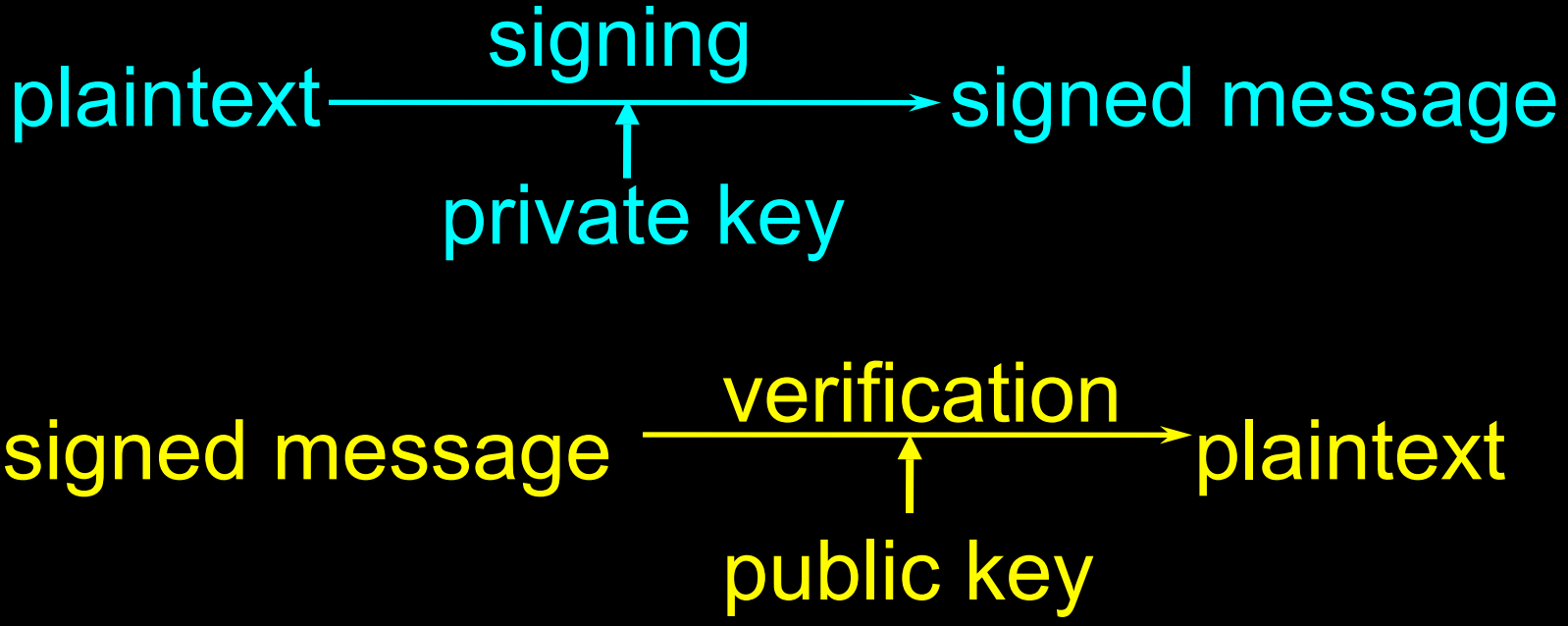
Using Keys

- Private keys are used for decrypting.
- Public keys are used for encrypting.



Digital Signature

- Public key cryptography is also used to provide digital signatures.



Transmitting over an insecure channel.

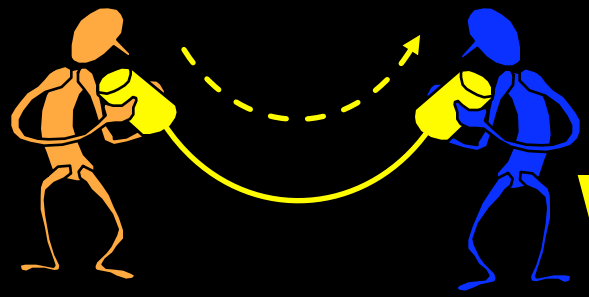
Alice wants to send Bob a private message.

A_{public} is Alice's public key.

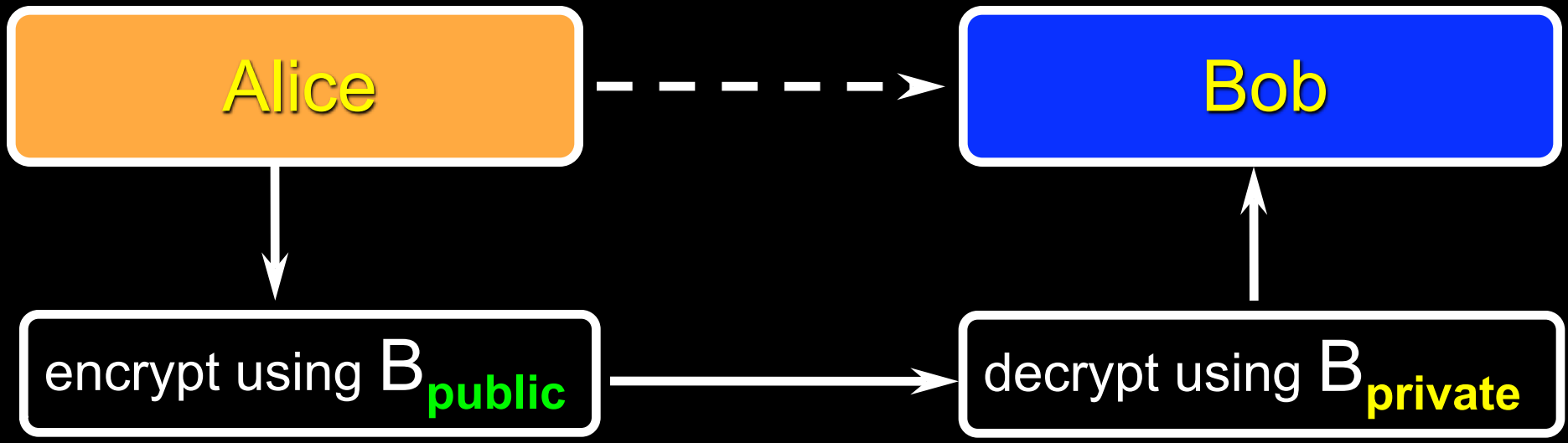
$A_{private}$ is Alice's private key.

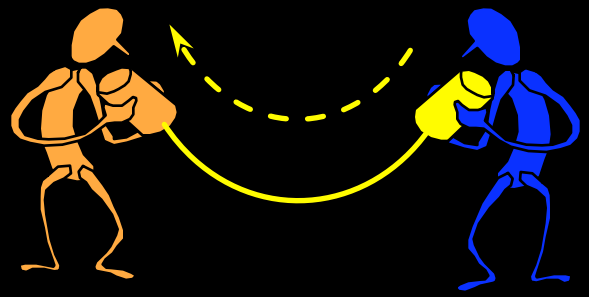
B_{public} is Bob's public key.

$B_{private}$ is Bob's private key.

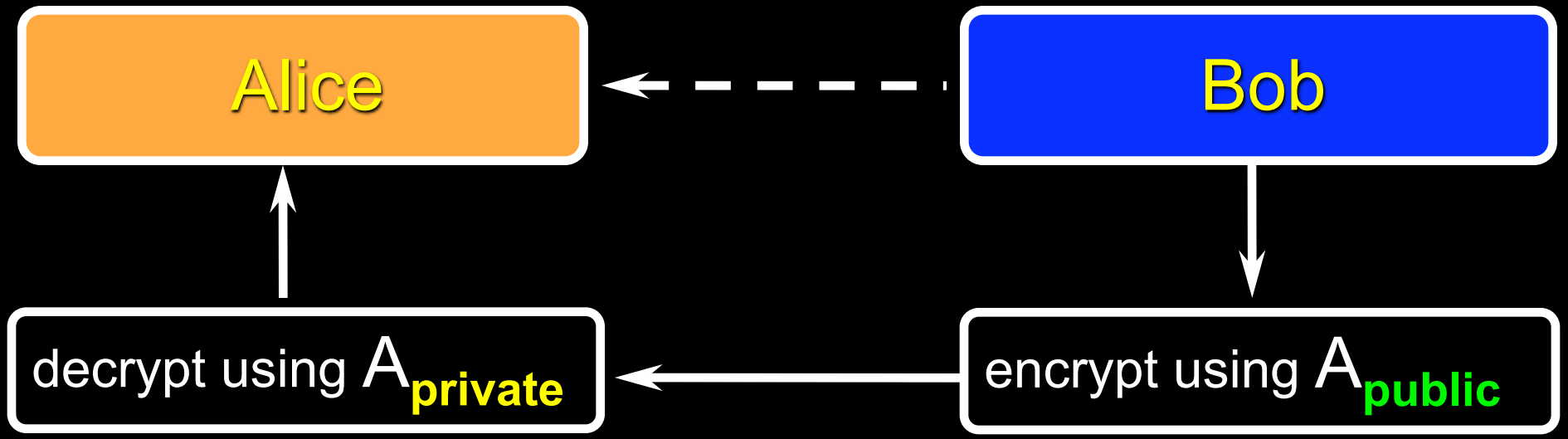


Hello Bob, Wanna get together?





OK Alice, Your place or mine?



Bob's Dilemma

- Nobody can read the message from Alice, but anyone could produce it.
- How does Bob know that the message was really sent from Alice?

- Bob may be comforted to know that only Alice can read his reply.

Alice can sign her message!

- Alice can create a digital signature and prove she sent the message (or someone with knowledge of her private key).
- The signature can be a message digest encrypted with $A_{\textbf{private}}$.

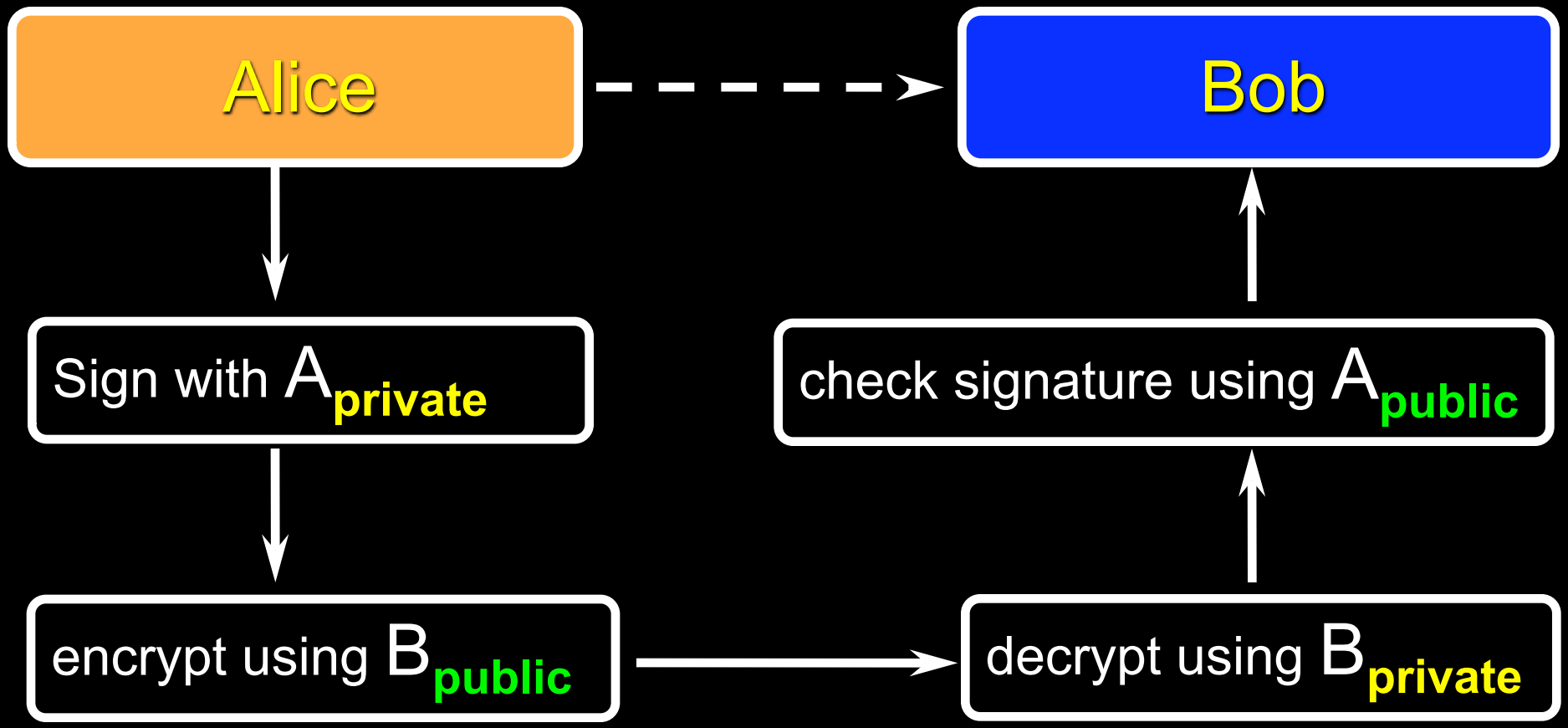
Message Digest

- Also known as “hash function” or “one-way transformation”.
- Transforms a message of any length and computes a fixed length string.
- We want it to be hard to guess what the message was given only the digest.
  - Guessing is always possible.

Alice's Signature

- Alice feeds her original message through a hash function and encrypts the message digest with $A_{\textbf{private}}$.
- Bob can decrypt the message digest using $A_{\textbf{public}}$.
- Bob can compute the message digest himself.
- If the 2 message digests are identical, Bob knows Alice sent the message.

Revised Scheme



Why the digest?

- Alice could just encrypt her name, and then Bob could decrypt it with $A_{\textbf{public}}$.

- Why wouldn't this be sufficient?

Implications

- Suppose Alice denies she sent the message?
- Bob can prove that only someone with Alice's key could have produced the message.

Another possible problem

- Suppose Bill receives a message from Alice *including* a digital signature.

  "meet me at the library tonight"

- Bill sends the same message to Joe so that it looks like the message came from Alice.
- Bill includes the digital signature from the message Alice sent to him.
- Joe is convinced Alice sent the message!

  Hilarity will surely ensue!

Solution?

- Always start your messages with:
  - Dear Bill,
- Create a digest from the encrypted message and sign that digest.
- There are many other schemes as well.

Speed

- Secret key encryption/decryption algorithms are much faster than public key algorithms.
- Many times a combination is used:
  - use public key cryptography to share a secret key.
  - use the secret key to encrypt the bulk of the communication.

Secure Protocols

- There are a growing number of applications for secure protocols:
  - email
  - electronic commerce
  - electronic voting
  - homework submission
  - ordering breakfast

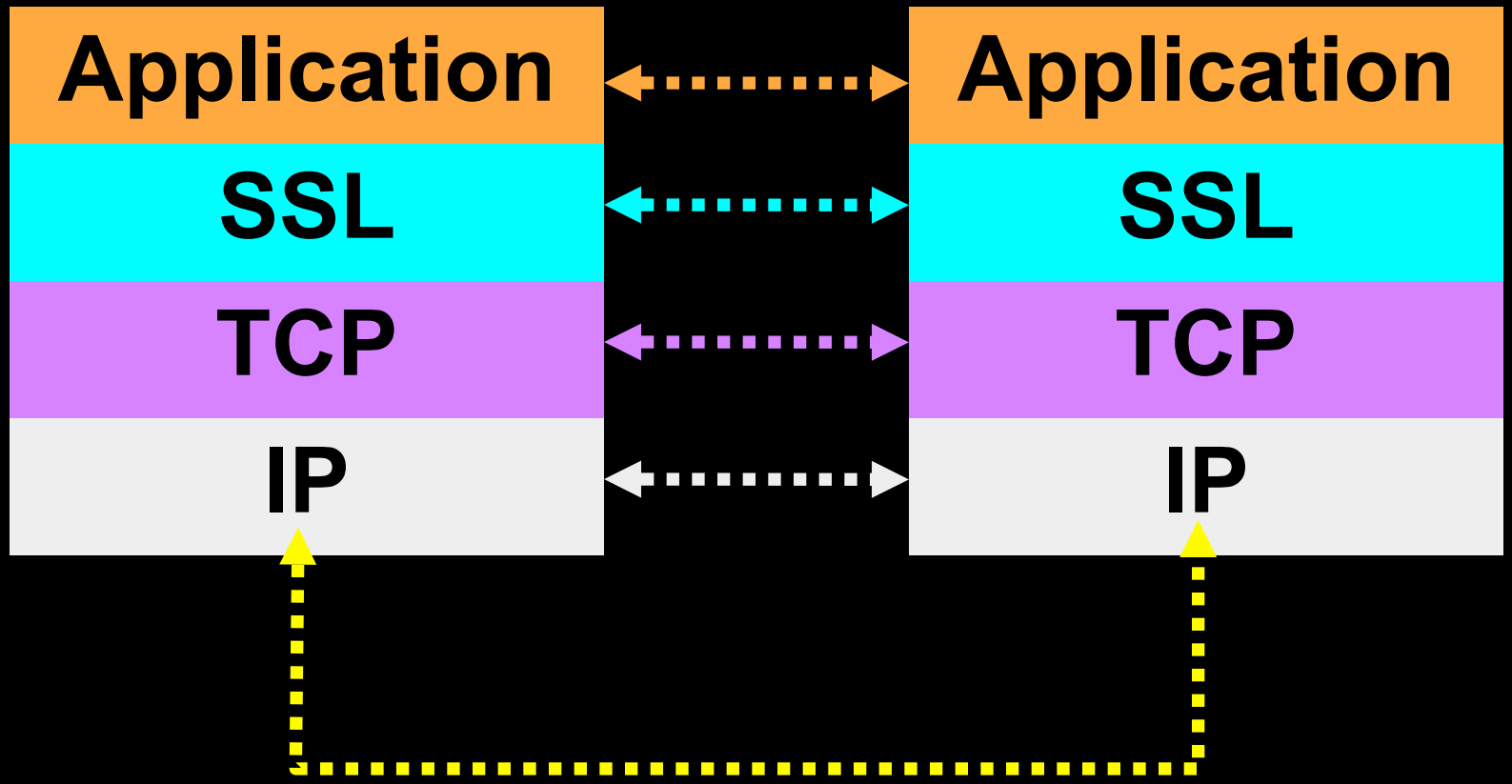
Secure Protocols

- Many application protocols include the use of cryptography as part of the application level protocol.
  - The cryptographic scheme employed is part of the protocol.
  - If stronger cryptographic tools become available, we need to change the protocol.

SSL and TLS

- Secure Sockets Layer (SSL) is a different approach - a new layer is added that provides a secure channel over a TCP link.
- TLS is Transport Layer Security (IETF standard based on SSL).

SSL layer



Advantages of SSL/TLS

- Independent of application layer
- Includes support for negotiated encryption techniques.
  - easy to add new techniques.
- Possible to switch encryption algorithms in the middle of a session.

HTTPS Usage

- HTTPS is HTTP running over SSL.
  - used for most secure web transactions.
  - HTTPS server usually runs on port 443.
  - Includes the notion of verification of server via a certificate.
  - Central trusted source of certificates.
    - Course grading system has an untrusted certificate - Dave is too cheap to pay for a “trusted certificate”.
      - certificate or donut - what would you pick?