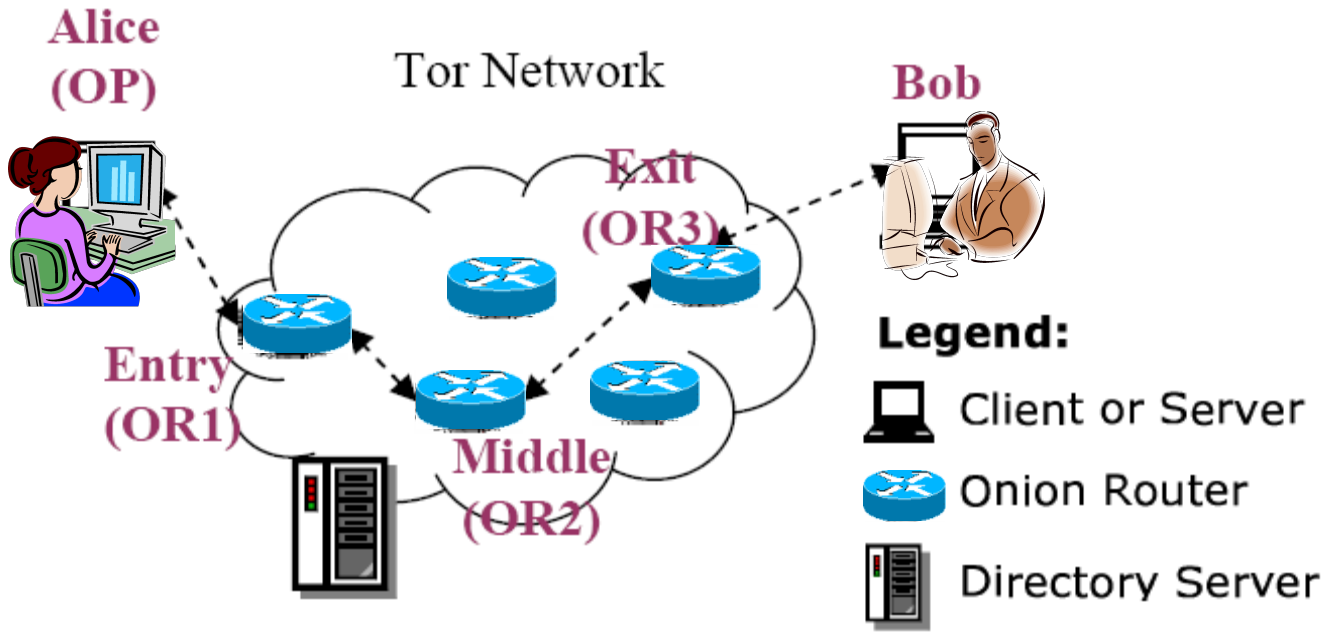
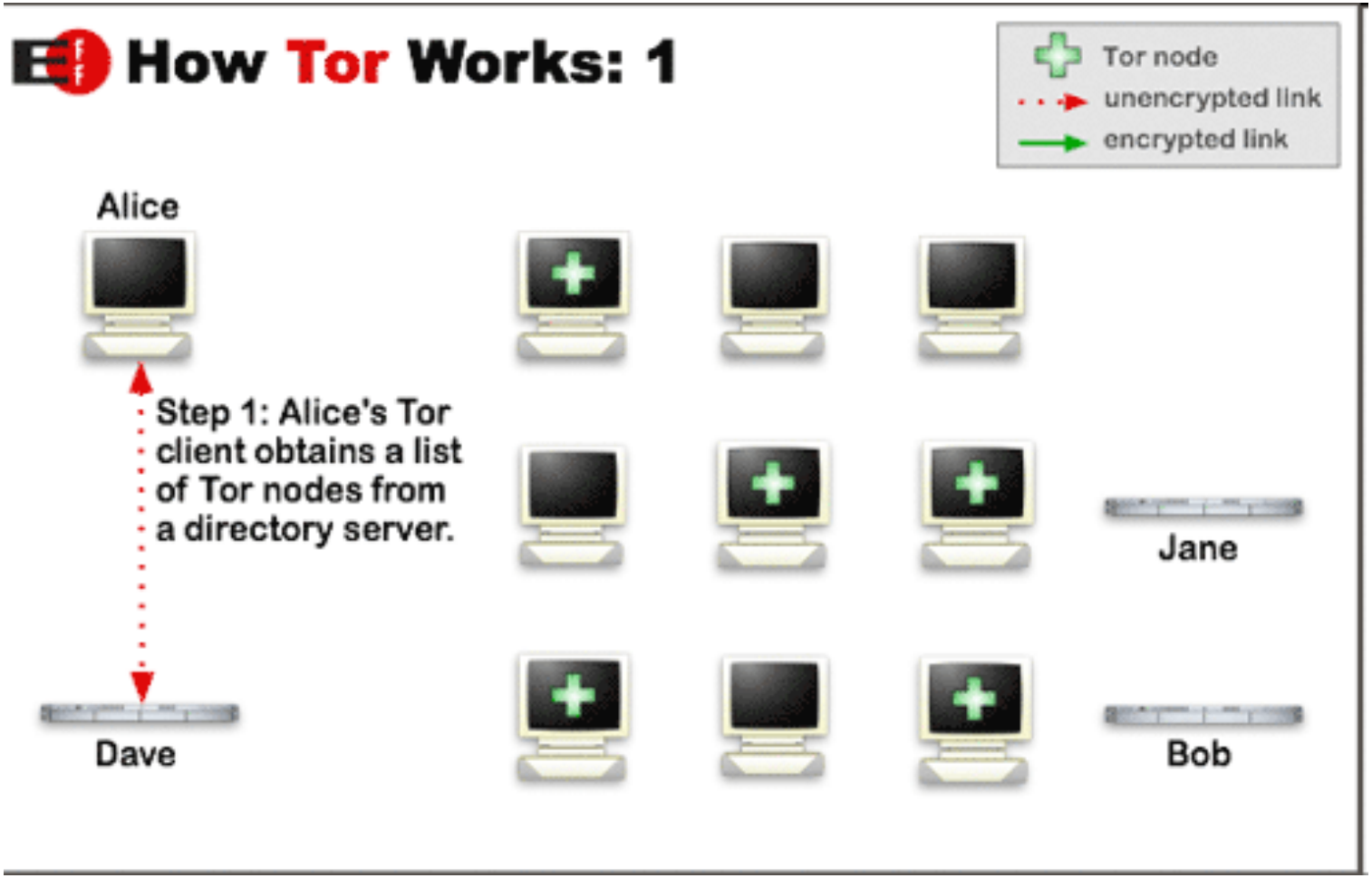
Components of Tor

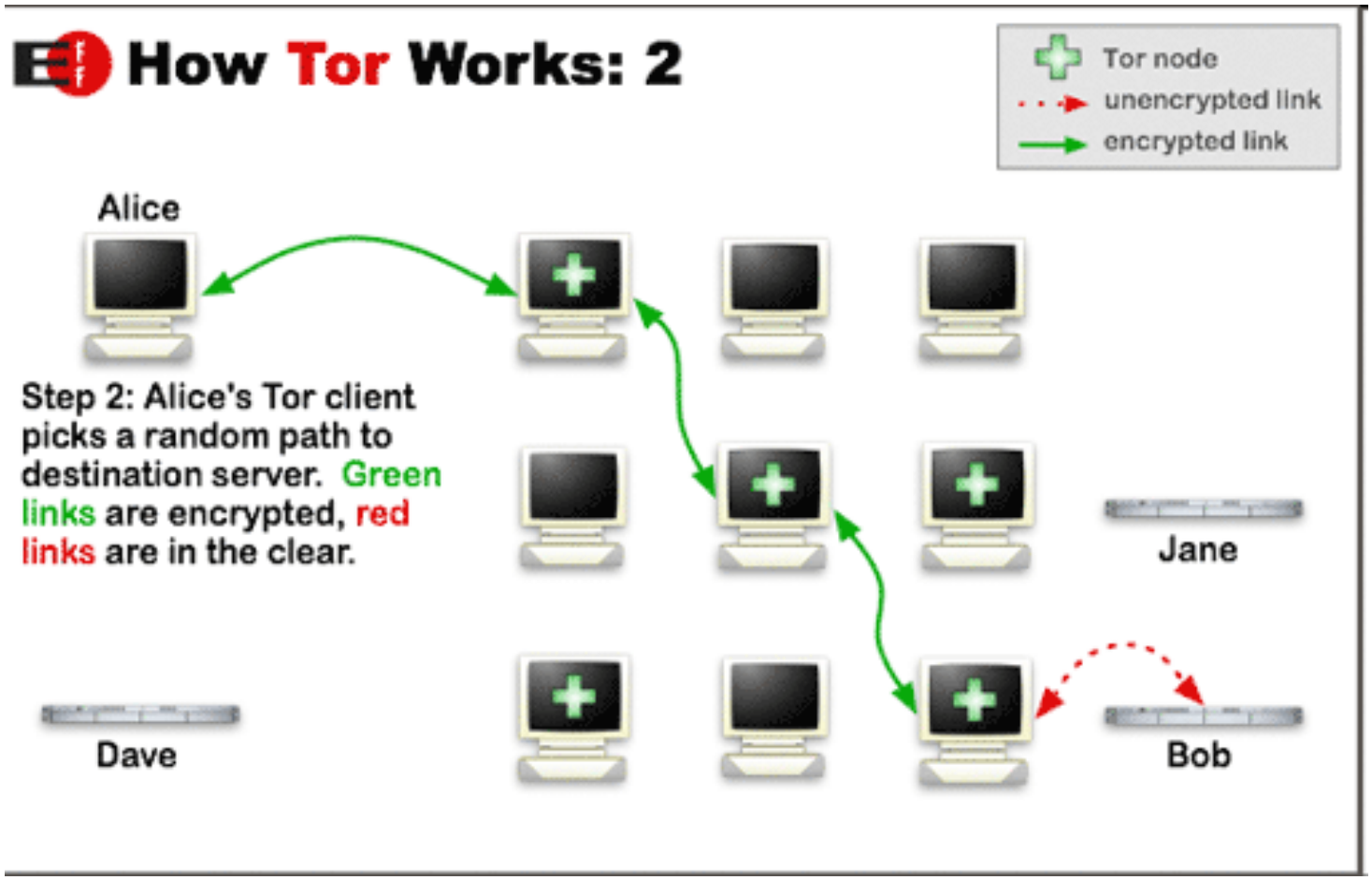


- **Client**: the user of the Tor network
- **Server**: the target TCP applications such as web servers
- **Tor (onion) router**: the special proxy relays the application data
- **Directory server**: servers holding Tor router information

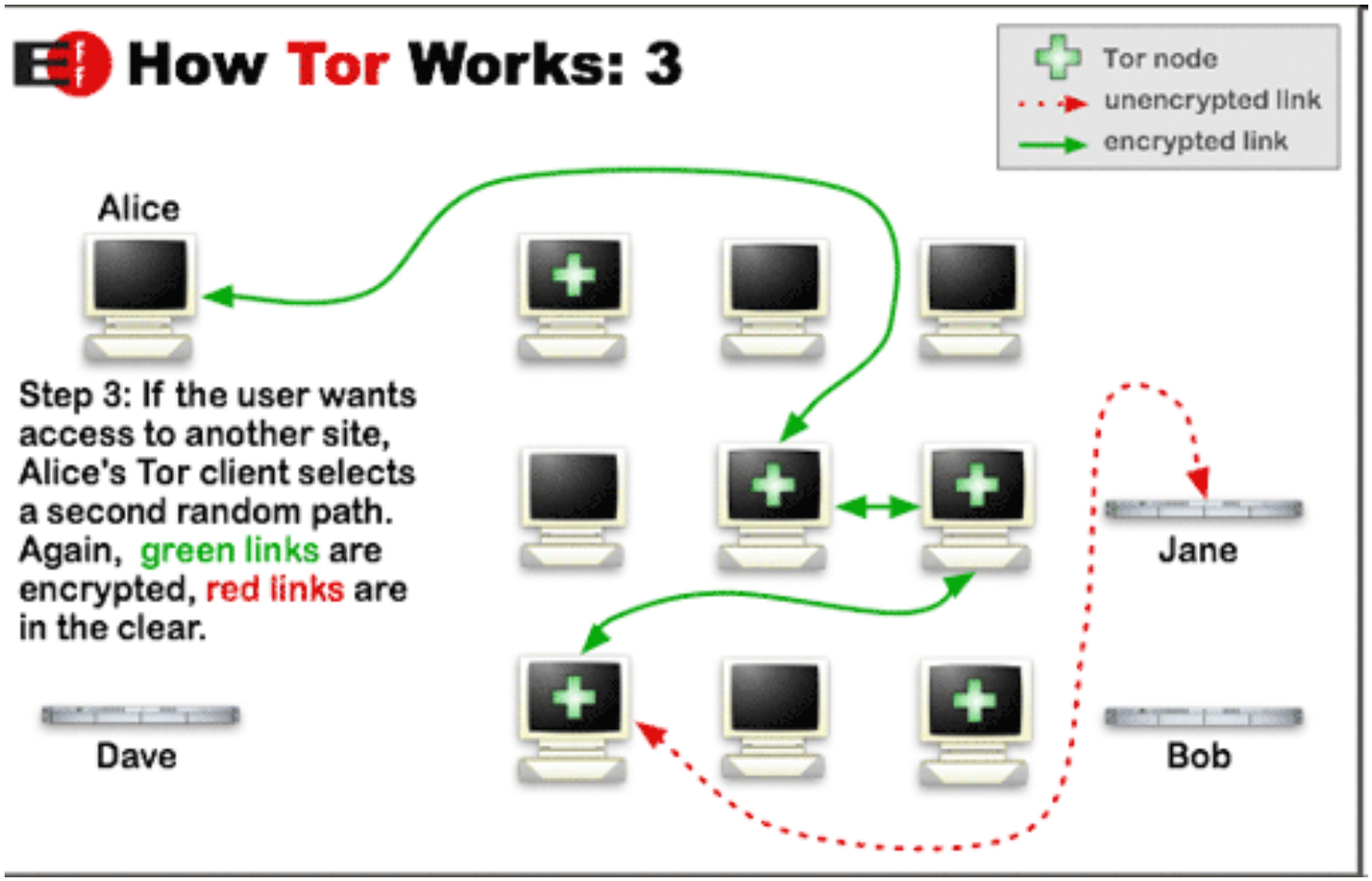
How does Tor work?



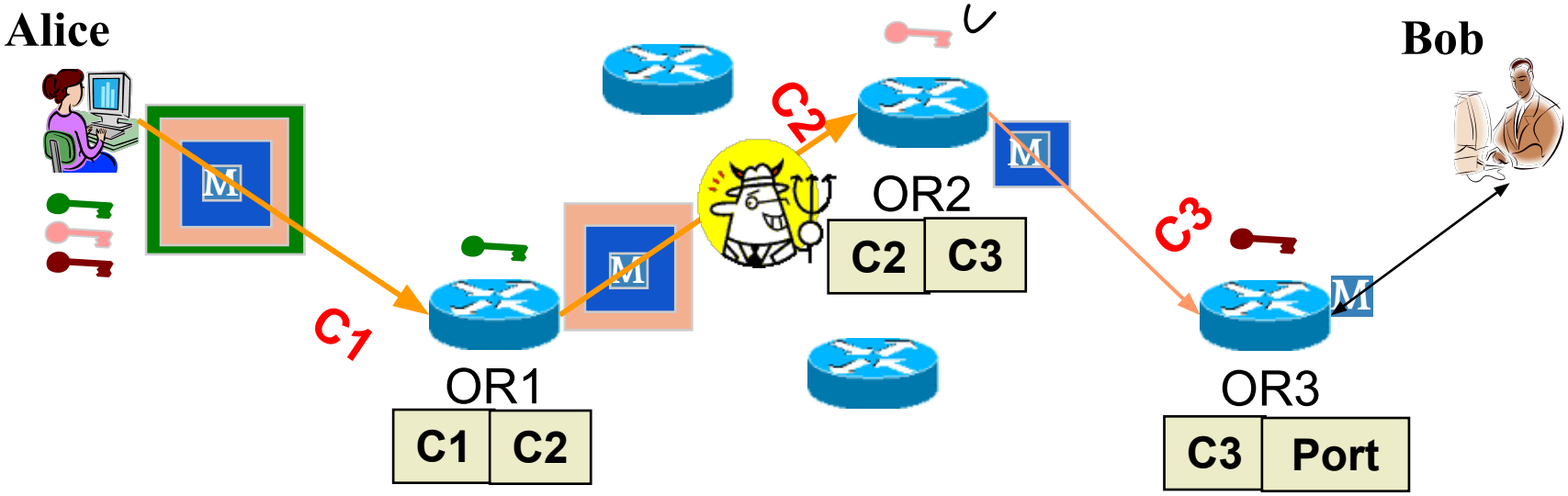
How does Tor work?



How does Tor work?

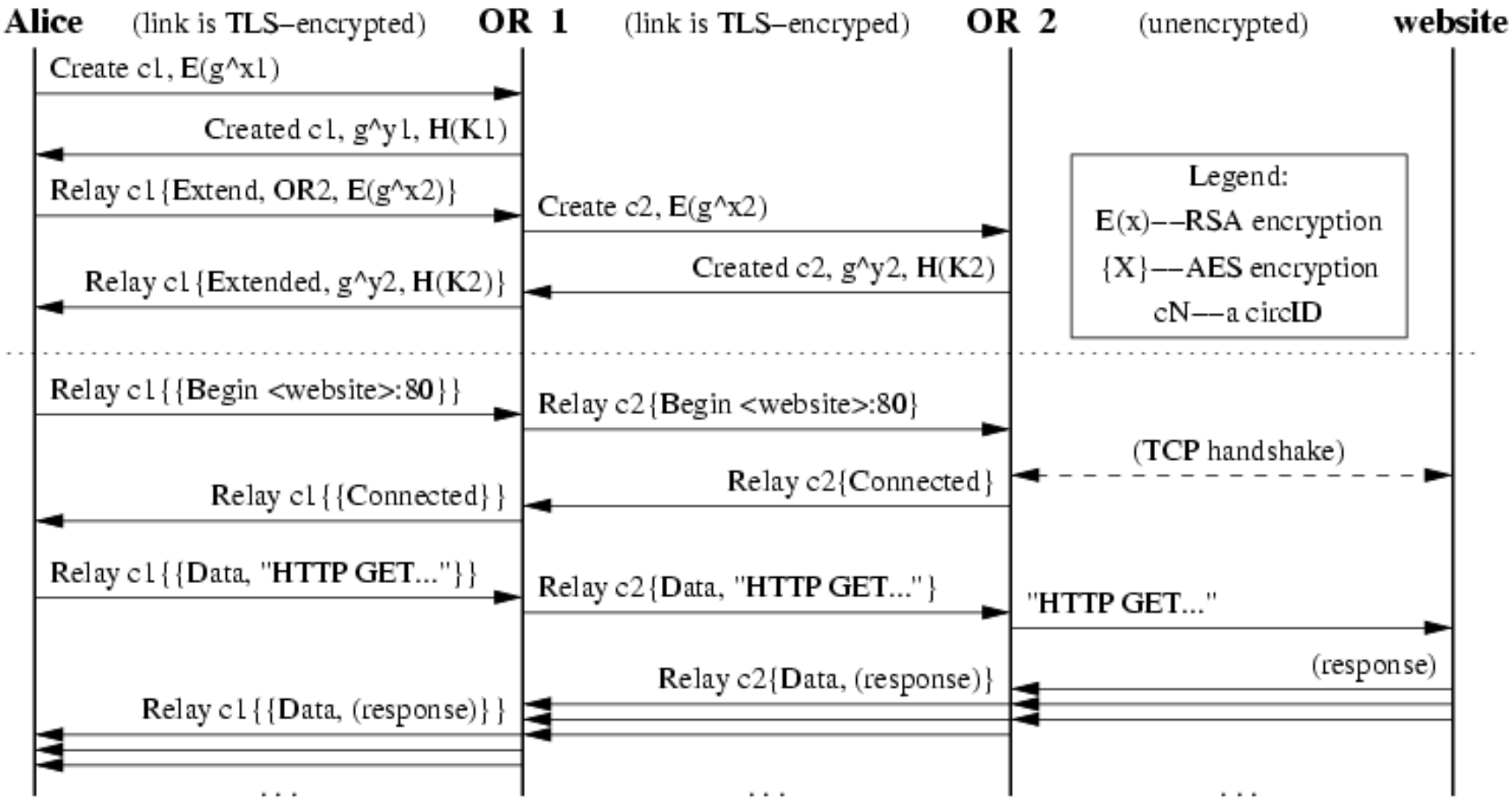


How Tor Works? --- Onion Routing



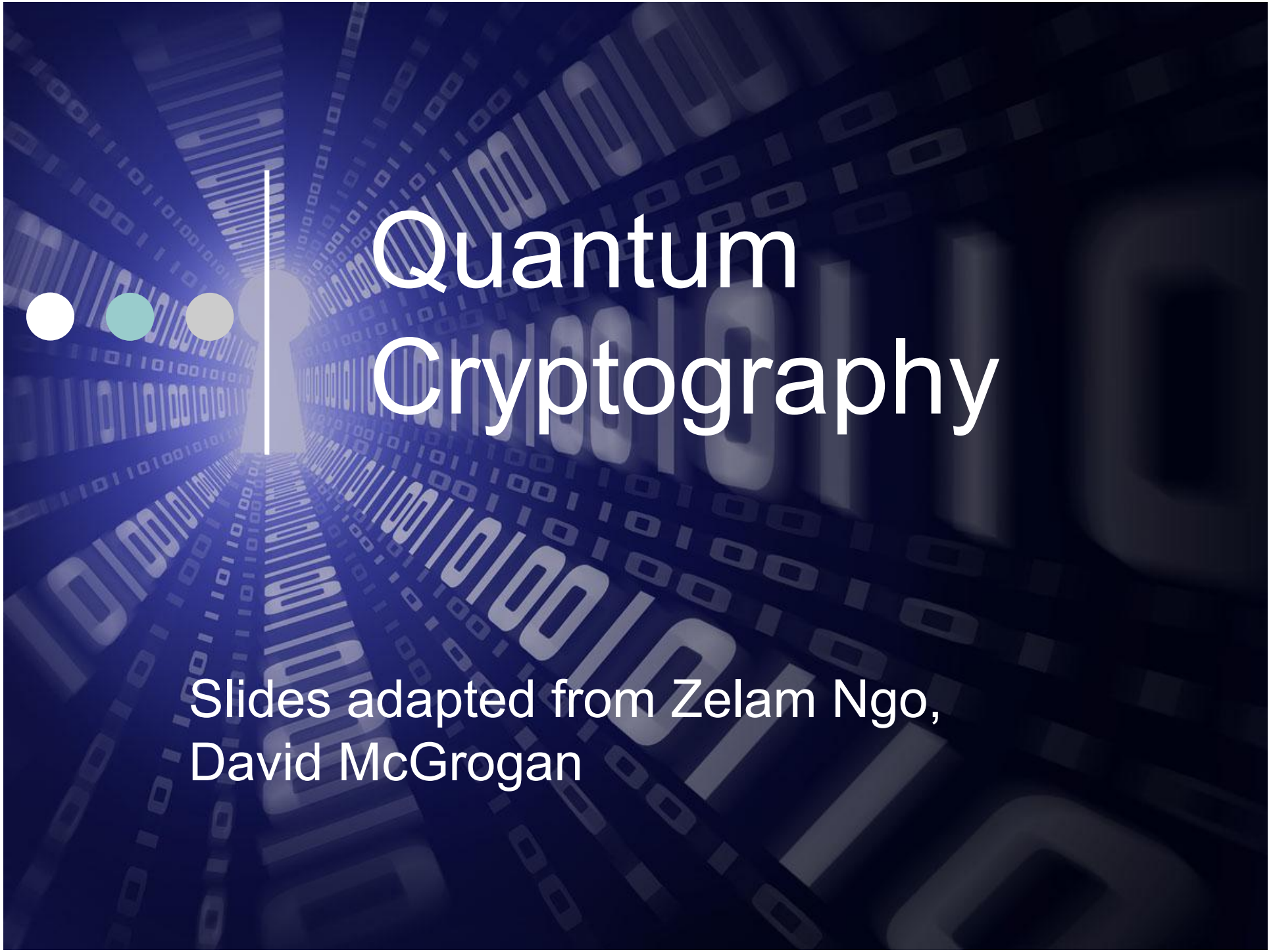
- A circuit is built incrementally one hop by one hop
- Onion-like encryption
  - Alice negotiates an AES key with each router
  - Messages are divided into equal sized cells
  - Each router knows only its predecessor and successor
  - Only the Exit router (OR3) can see the message, however it does not know where the message is from

Commands in Use



Additional functionality

- Integrity checking
  - Only done at the edges of a stream
  - SHA-1 digest of data sent and received
  - First 4 bytes of digest are sent with each message for verification


Quantum
Cryptography
Slides adapted from Zelam Ngo,
David McGrogan

Motivation

- Age of Information
- Information is valuable
- Protecting that Information

Quantum Security Benefits

- Provably Secure
- Evidence of Tampering

History

- Stephen Wiesner wrote “Conjugate Coding” in the late sixties
- Charles H. Bennett and Gilles Brassard revived the field in 1982 by combining quantum process with public key cryptography.

Fundamentals

- Measurement causes perturbation
- No Cloning Theorem
- Thus, measuring the qubit in the wrong basis destroys the information.

BB84

- Set-up
  - Alice
    - Has the ability to create qubits in two orthogonal bases
  - Bob
    - Has the ability to measure qubits in those two bases.

BB84

- Alice
  - Encodes her information randomly in one of the two bases…
    - For example,

Basis A	Basis B
$\|0\rangle = 0$	$\|+\rangle = 0$
$\|1\rangle = 1$	$\|-\rangle = 1$

BB84

Alice prepares 16 bits

0101100010101100

in the following bases,

BAABAABAAAABBBBA

Thus the following states are sent to Bob:

+10-10+0101+--+0

BB84

Alice's bits	0101100010101100
Alice's bases	BAABAABAAAABBBBA
States sent	+10-10+0101+--+0

Bob receives the stream of qubits and measures each one in a random basis:

ABAABAAABABBBBAB

BB84

Alice's bits	0101100010101100
Alice's bases	BAABAABAAAABBBBA
States sent	+10-10+0101+--+0
Bob's bases	ABAABAAABABBBBAB

So Bob gets

1-00-0+0+0-+--1+

BB84

Alice's bits	0101100010101100
Alice's bases	BAABAABAAAABBBBA
States sent	+10-10+0101+--+0
Bob's bases	ABAABAAABABBBBAB
Bob's results	1-00-0+0+0-+--1+

Then Alice and Bob compare their measurement bases, not the results, via a public channel.

BB84

Bob receives the stream of qubits and measures each one in a random basis:

ABAABAAABABBBBAB

So he gets,

00*0*0*+--**

Then Alice and Bob compare their measurement bases, not the results, via a public channel.

BB84

- So Bob and Alice are left with 7 useable bits out of 16

_ _ 0 _ _ 0 _ 0 _ 0_ 0 1 1 _ _

These bits will be the shared key they use for encryption.

BB84

- Now enter Eve… She wants to spy on Alice and Bob.
- So she intercepts the bit stream from Alice, measures it, and prepares a new bit stream to Bob based on her measurements…

BB84

So how do we know when Eve is being nosy?

Well… Eve doesn't know what bases to measure in, so she would have to measure randomly and 50% of the time she will be wrong…

BB84

- Thus, of the bits Bob measures in the correct bases, there is 50% that eve had changed the basis of the bit. And thus it is equally likely that Bob measure 0 or 1 and thus an error is detected 25% of the time.

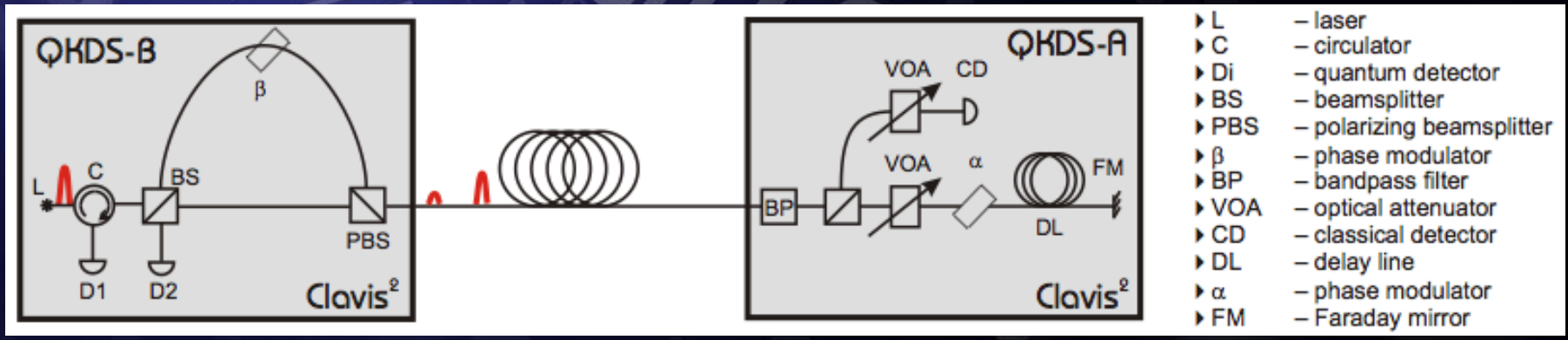
- Eve is found in the errors!

BB84

- In a world with perfect transmissions, all Bob and Alice have to do is publicly compare a few bits to determine if any error exists.
- Errors exist in reality, thus the only way to detect Eve is to notice an increase in errors.
- Thus the transmission process must not have an error rate higher than 25%.

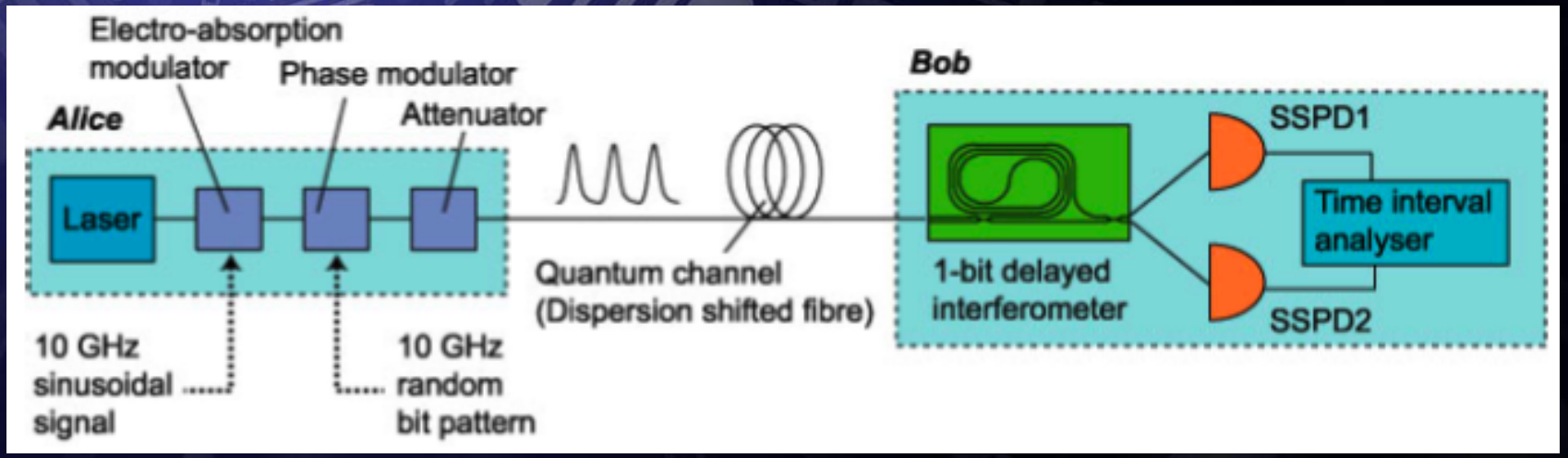
Current State of Affairs

- Commercial quantum key distribution products exist



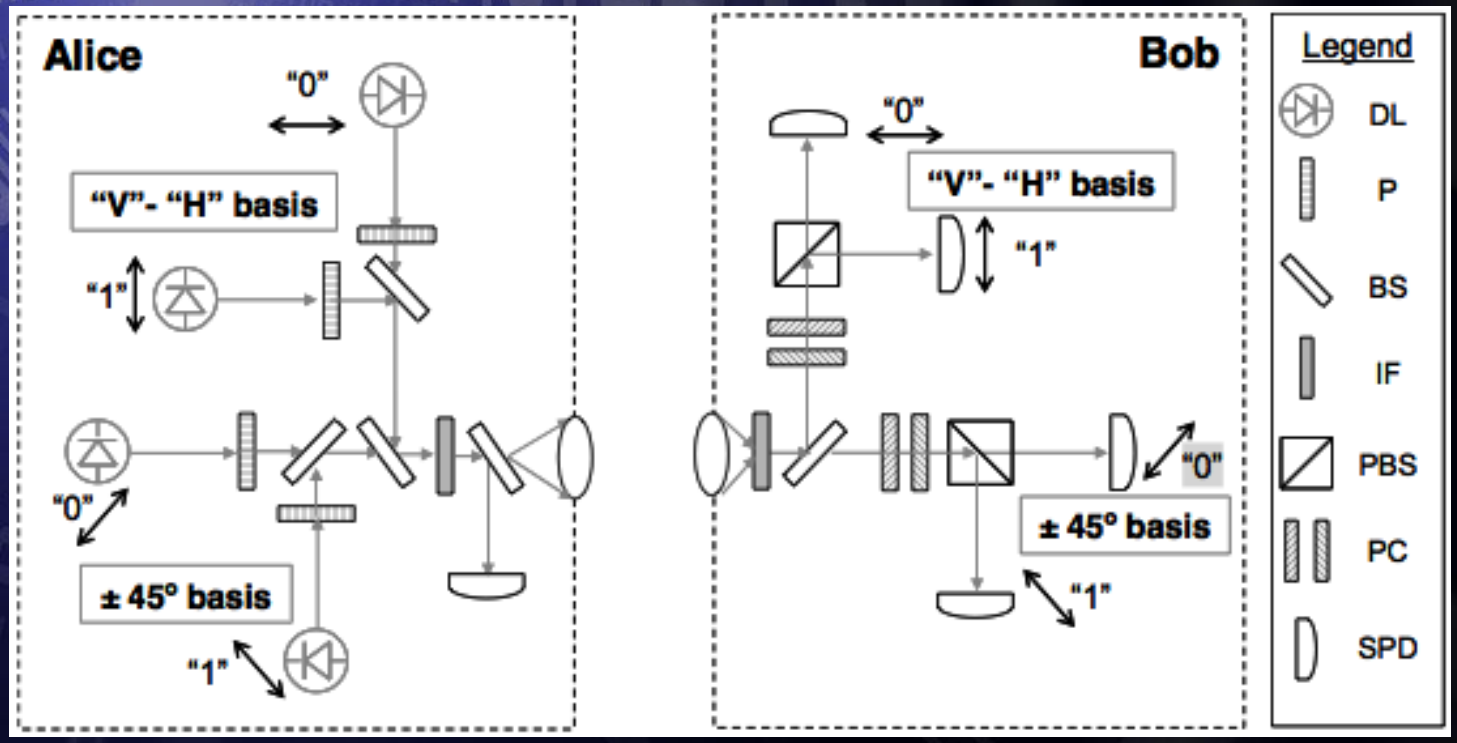
Current State of Affairs

- Current fiber-based distance record: 200 km (Takesue et al)



Current State of Affairs

- Demonstrated free-space link: 10 km



Future Prospects

- Ground-to-satellite, satellite-to-satellite links
- General improvement with evolving qubit-handling techniques, new detector technologies

Computer Security: Principles and Practice

Chapter 3: User Authentication

slides prepared by Dr Lawrie Brown (UNSW@ADFA) for
"Computer Security: Principles and Practice"

Password authentication

- Widely used user authentication method
  - user provides name/login and password
  - system compares password with that saved for specified login
- Authenticates ID of user logging and
  - that the user is authorized to access system
  - determines the user's privileges
  - is used in discretionary access control

Password vulnerabilities

- offline dictionary attack
- specific account attack (user john)
- popular password attack (against a wide range of IDs)
- password guessing against single user (w/ previous knowledge about the user)
- workstation hijacking
- exploiting user mistakes
- exploiting multiple password use
- electronic monitoring

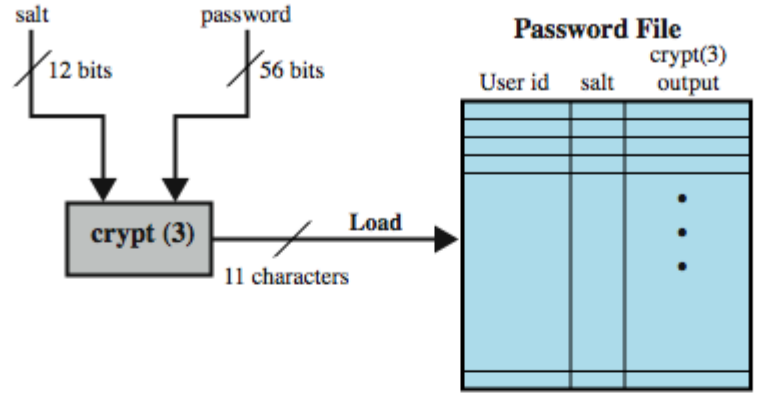
Countermeasures for password vulnerability

- stop unauthorized access to password file
- intrusion detection measures
- account lockout mechanisms
- policies against using common passwords but rather hard to guess passwords
- training & enforcement of policies
- automatic workstation logout
- encrypted network links

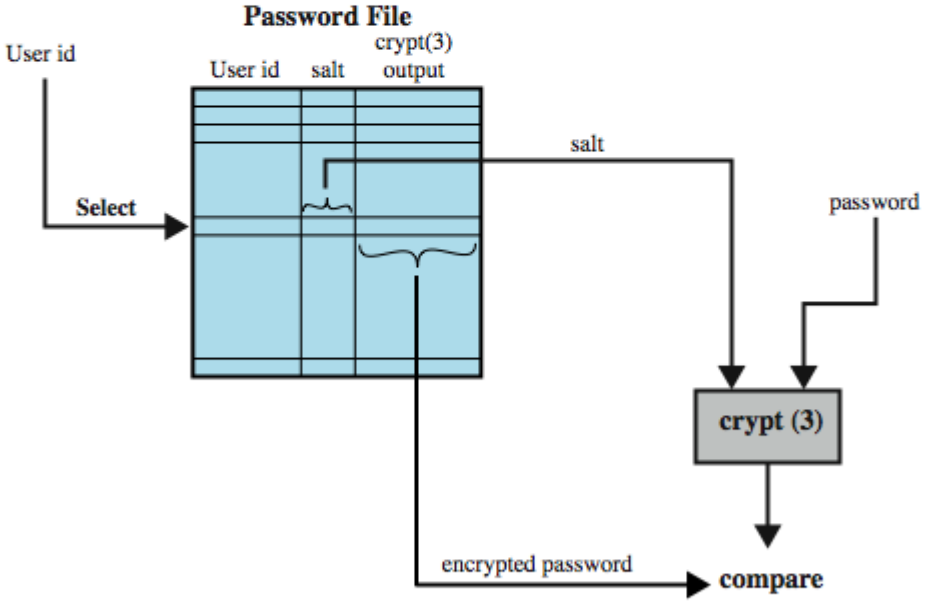
Countermeasures for password vulnerability

- It is worthwhile to study/research password and password vulnerabilities
  - Most common
  - Still the most efficient

Use of hashed passwords



(a) Loading a new password



(b) Verifying a password

Why a salt value?

- Prevents duplicate passwords from being visible in the password file
- Increases the difficulty of offline dictionary attacks
- Nearly impossible to tell if a person used the same password on multiple systems

UNIX Implementation

- Original scheme
  - 8 character password form 56-bit key
  - 12-bit salt used to modify DES encryption into a one-way hash function
  - output translated to 11 character sequence
- Now regarded as woefully insecure
  - e.g. supercomputer, 50 million tests, 80 min
- Sometimes still used for compatibility

Improved implementations

- Have other, stronger, hash/salt variants
- Many systems now use MD5
  - with 48-bit salt
  - password length is unlimited
  - is hashed with 1000 times inner loop
  - produces 128-bit hash
- OpenBSD uses Blowfish block cipher based and hash algorithm called Bcrypt
  - uses 128-bit salt to create 192-bit hash value

Password Cracking

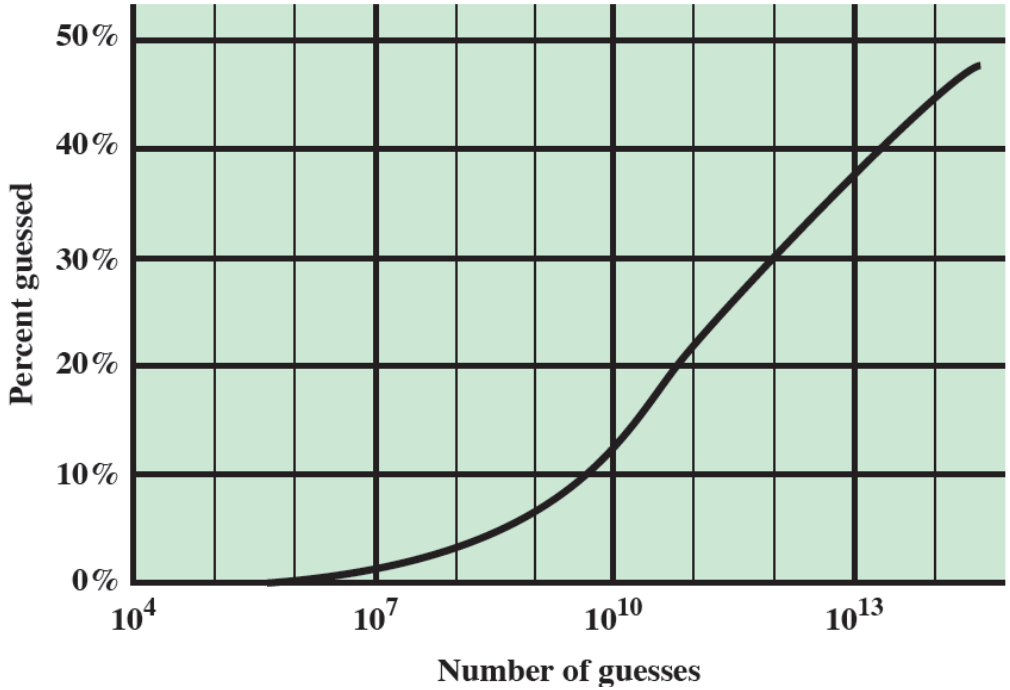
- Dictionary attacks
  - try each word then obvious variants in large dictionary against hash in password file
- **Rainbow** table attacks
  - a large dict of possible passwords
  - for each password:
    - precompute tables of hash values for all salts
    - a mammoth table of hash values: e.g. 1.4GB table cracks 99.9% of alphanumeric Windows passwords in 13.8 secs
  - not feasible if larger salt values used

Password choices/concerns

- users may pick short passwords
  - e.g. 3% were 3 chars or less, easily guessed
  - system can reject choices that are too short
- users may pick guessable passwords
  - so crackers use lists of likely passwords
  - e.g. one study of 14000 encrypted passwords guessed nearly 1/4 of them
  - would take about 1 hour on fastest systems to compute all variants, and only need 1 break!

Another case study

- An analysis of passwords used by 25,000 students
- Over 10% recovered after 10^10 guesses



Password File Access Control

- Can block offline guessing attacks by denying access to encrypted passwords
  - make available only to privileged users
  - often using a separate shadow password (for su only)
- Still have vulnerabilities
  - exploit O/S bug
  - accident with permissions making it readable
  - users with same password on other systems
  - access from unprotected backup media
  - sniff passwords in unprotected network traffic

Using Better Passwords

- Clearly have problems with passwords
- Goal to eliminate guessable passwords
  - Still easy for user to remember
- Techniques
  - user education
  - computer-generated passwords
  - reactive password checking (periodic checking)
  - proactive password checking (at the time of selection)

Proactive Password Checking

- Rule enforcement plus user advice, e.g.
  - 8+ chars, upper/lower/numeric/punctuation
  - may not suffice
- Password cracker
  - list of bad passwords
  - time and space issues
- Markov Model
  - generates guessable passwords
  - hence reject any password it might generate
- Bloom Filter
  - use to build table based on dictionary using hashes
  - check desired password against this table

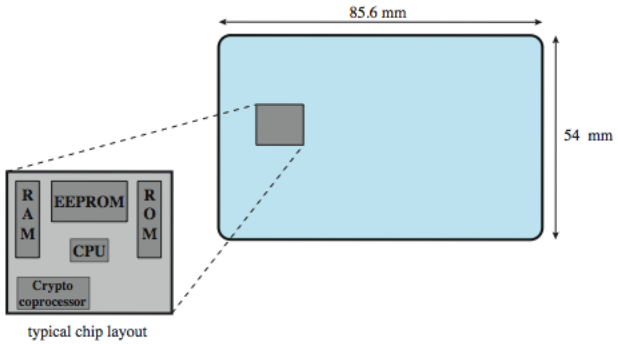
Token-based authentication

- Object user possesses to authenticate, e.g.
  - memory card (magnetic stripe)
  - smartcard

Memory Card

- store but do not process data
- magnetic stripe card, e.g. bank card
- electronic memory card
- used alone for physical access (e.g., hotel rooms)
- some with password/PIN (e.g., ATMs)
- Drawbacks of memory cards include:
  - need special reader
  - loss of token issues
  - user dissatisfaction (OK for ATM, not OK for computer access)

Smartcard



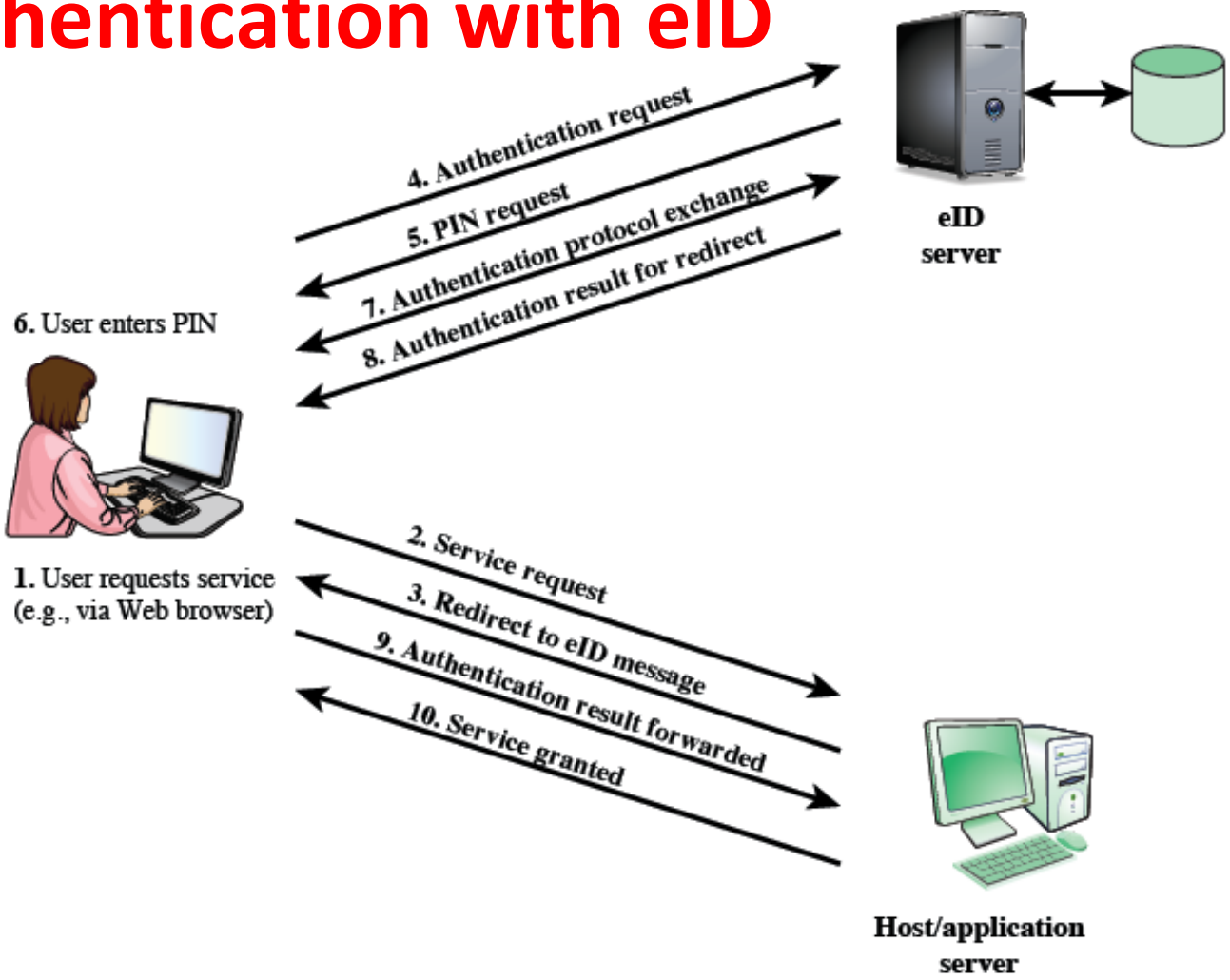
typical chip layout

- credit-card like
- has own processor, memory, I/O ports
  - ROM, EEPROM, RAM memory
- executes protocol to authenticate with reader/computer
  - static: similar to memory cards
  - dynamic: passwords created every minute; entered manually by user or electronically
  - challenge-response: computer creates a random number; smart card provides its hash (similar to PK)
- also have USB dongles

Electronic identify cards

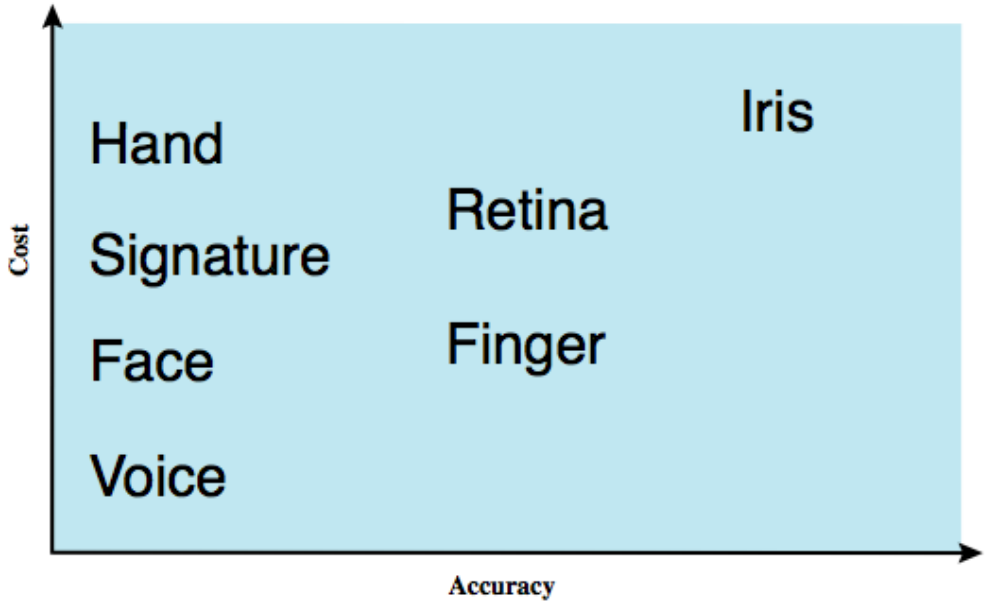
- An important application of smart cards
- A national e-identity (eID)
- Serves the same purpose as other national ID cards (e.g., a driver's licence)
  - Can provide stronger proof of identity
  - A German card
    - Personal data, Document number, Card access number (six digit random number), Machine readable zone (MRZ): the password
    - Uses: ePass (government use), eID (general use), eSign (can have private key and certificate)

User authentication with eID



Biometric authentication

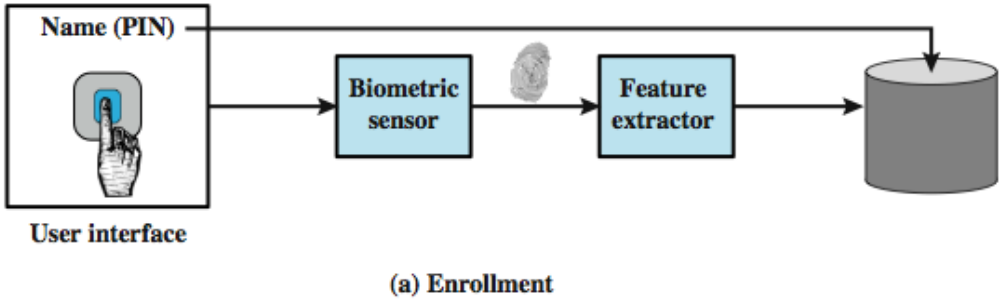
- Authenticate user based on one of their physical characteristics:
  - facial
  - fingerprint
  - hand geometry
  - retina pattern
  - iris
  - signature
  - voice



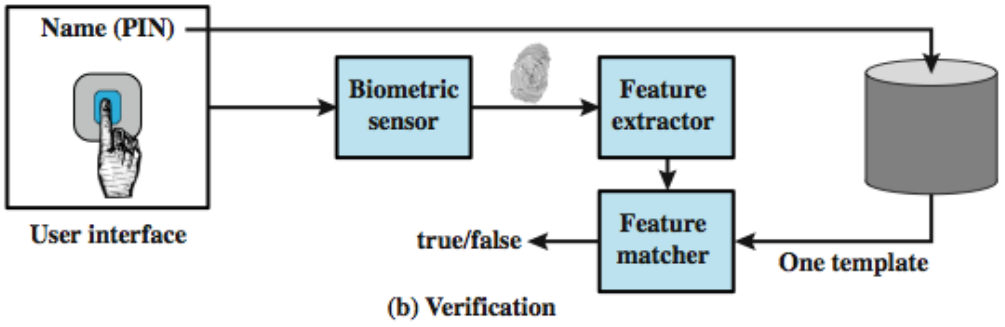
Operation of a biometric system

Verification *is analogous to user login via a smart card and a PIN*

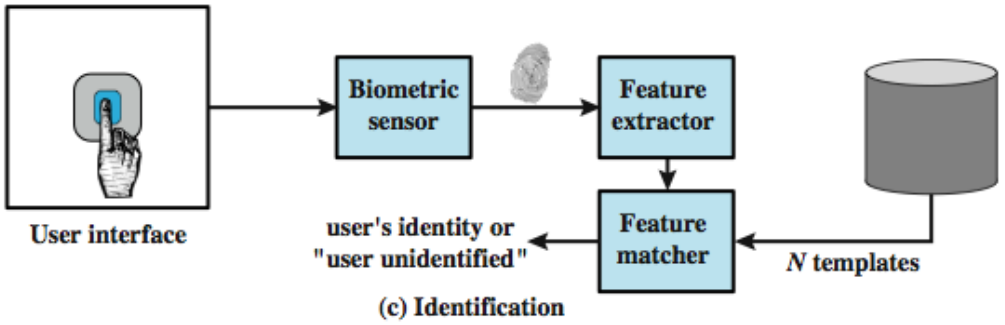
Identification *is biometric info but no IDs; system compares with stored templates*



(a) Enrollment



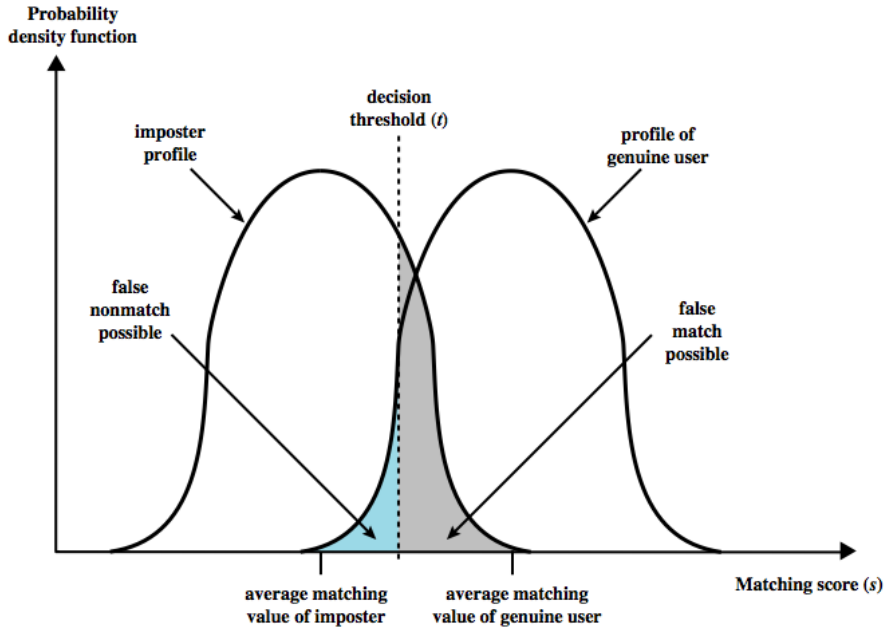
(b) Verification



(c) Identification

Biometric Accuracy

- The system generates a matching score (a number) that quantifies similarity between the input and the stored template
- Concerns: sensor noise and detection inaccuracy
- Problems of false match/false non-match



Biometric Accuracy

- Can plot characteristic curve (2,000,000 comparisons)
- Pick threshold balancing error rates