NetSec - Exercise 03

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Task 3.1 (theoretical): Authentication Beyond Passwords

Part (a)

1. Biometrics:

In this technique completely private information of a person is used to act as authentication media such as finger print, voice, heartbeat, eye, etc.

Advantage: Biometric information is unique. That is, two people can never have the same finger print but people can have same passwords.

Disadvantage: We can change a password thousand times but we cannot change our heartbeat or finger print. If somehow a hacker steals someone's finger print then the person is as good as dead, he has to get new finger.

Use: Samsung Galaxy S6 edge uses this way to unlock the phone.

2.Token:

In this technique a user is provided with a unique piece of data such as a picture, a sound clip, etc. to act as authentication media.

Advantage: It can provide a second layer of authentication when used along with password which is easy and low cost and gives more security than using only password. The user can forget password but with token there is no chance for that.

Disadvantage: A digital media is required to carry the token.

Use: FlixBus (a travel bus company) provides its travelers with barcode tokens and authenticates them by reading the token with mobile phone camera. I know it as I use this bus service to travel every time.

3.Temporary and single password:

In this technology when a user wants to login to a service every time the service provider sends a temporary and new password directly to the user phone by SMS. This technology was proposed by Yahoo! in 2015.

Advantage: Users don't need to remember their passwords and as the password is renewed every time a hacker cannot trace it.

Disadvantage: The phone which receives the password could be lost or stolen, then who ever have the phone can login as a real user.

Use: To access Yahoo! mail from 3rd parties by apps like iOS mail, Android mail or Outlook, Yahoo! requires users to use this technology.

Part (b)

Two Factors:

In this technique along with password a second media is used to provide strong authentication.

Advantage: Hackers may get my password but he/she cannot get the code number which is directly sent to my phone by the website or server of a particular organization as a second factor of my authentication.

Disadvantage: If the media that carries the second factor after password is somehow not accessible then a user cannot login to the particular service which can cause a big issue. However, in pure password based authentication the users carry their passwords in their mind which they can access any time if they are alive.

Use: While transferring money online, a user needs to use both of his/her bank pin code and TAN.

Task 3.2 (theoretical): Reconnaissance in the SecLab

- We use **ifconfig** to find out ip addresses and corresponding subnet masks of the current SecLab computer. Based on the above information, we employ **sudo nmap -O ip_address/subnet_mask** to discover all computers under certain subnets. The information of computers consists of ip addresses, running services with ports and operating systems plus versions.

- The script we use is as following (Download):

+++++START+++++

```
#!/bin/bash

rm -rf scanSummary.txt

# use ifconfig to gather ip addresses and subnet masks of the current computer of SecLab
addrOfThisHost=`ifconfig | grep "inet addr" | sed -r 's/^.*inet addr:([0-9]+\.[0-9]+\.[0-9]+\.[0-
9]+).*Mask:([0-9]+\.[0-9]+\.[0-9]+\.[0-9]+).*$/\1 \2/g' | grep -v "127.0.0.1"`

i=-1
for addr in $addrOfThisHost
do
```

```
    i=$((i+1))
    addrMaskInfo[$i]=$addr
done

index=0
while [ $index -lt $i  ]
do
    # arrange the document output
    case "${addrMaskInfo[$((index+1))]}" in
        "255.0.0.0")    mask=8              addrMaskInfo[$index]=`echo ${addrMaskInfo[$index]} | sed -
r 's/([0-9]+).*/\1\.0\.0\.0/g'`
        ;;
        "255.255.0.0")    mask=16        addrMaskInfo[$index]=`echo ${addrMaskInfo[$index]} | sed -
r 's/([0-9]+\.[0-9]+).*/\1\.0\.0/g'`
        ;;
        "255.255.255.0")    mask=24     addrMaskInfo[$index]=`echo ${addrMaskInfo[$index]} | sed -
r 's/([0-9]+\.[0-9]+\.[0-9]+).*/\1\.0/g'`
        ;;
    esac

    # output the ip address and subnet mask to scanSummary.txt
    echo -e "===${addrMaskInfo[$index]}/$mask===" >> scanSummary.txt

    echo "+++=======START nmap=============+++"
    # scan computers under certain subnets and save the result of "nmap -O" to nmap.txt
    sudo nmap -O "${addrMaskInfo[$index]}/$mask" > nmap.txt
    echo "---=======END   nmap=============---"

    serviceStart="n"
    # read nmap.txt line by line
    cat nmap.txt | while read line
    do
        echo $line | grep "Nmap scan report for"
        # discovered computers with ip addresses
        if [ "$?" == "0" ]; then
            nowIP=`echo $line | sed -r 's/.*Nmap scan report for ([0-9]+\.[0-9]+\.[0-9]+\.[0-9]+).*/\1/g'`
            echo -e "$nowIP:" >> scanSummary.txt
            echo -e "----------------" >> scanSummary.txt
            continue
        fi

        echo $line | grep -E "PORT\s+STATE\s+SERVICE"
        # discovered computers with running services and ports
        if [ "$?" == "0" ]; then
            serviceStart="y"
            echo -e $line | sed -r 's/(.*)\s+(.*)\s+(.*)/\1\t\t\2\t\3/g' >> scanSummary.txt
            continue
        fi

        if [ "$serviceStart" == "y" ]; then
            echo $line | grep "/"
            if [ "$?" != "0" ]; then
```

```
            serviceStart="n"
            echo -e "" >> scanSummary.txt
            continue
        fi

        port=`echo $line | sed -r 's/([0-9]+)\/.*/\1/g'`
        if [ "$((port/1000))" -gt "0" ]
        then
            echo -e $line | sed -r 's/(.*)\s+(.*)\s+(.*)/\1\t\2\t\3/g' >> scanSummary.txt
        else
            echo -e $line | sed -r 's/(.*)\s+(.*)\s+(.*)/\1\t\t\2\t\3/g' >> scanSummary.txt
        fi
    fi

    echo $line | grep -E "OS\s+(CPE)\:"
    # discovered computers with operating systems and versions
    if [ "$?" == "0" ]; then
        echo -e $line >> scanSummary.txt
        continue
    fi

    echo $line | grep -E "OS\s+(details)\:"
    if [ "$?" == "0" ]; then
        echo -e $line >> scanSummary.txt
        echo -e "" >> scanSummary.txt
        continue
    fi
  done

  echo -e "" >> scanSummary.txt
  index=$((index+2))
done
```
-----END-----

- All gathered information is as following:

+++++START+++

```
===10.0.0.0/24===
10.0.0.5:
----------------
PORT        STATE       SERVICE
22/tcp      open    ssh

OS CPE: cpe:/o:linux:linux_kernel:3 cpe:/o:linux:linux_kernel:4
OS details: Linux 3.2 - 4.4

10.0.0.10:
----------------
PORT        STATE       SERVICE
22/tcp      open    ssh
53/tcp      open    domain
```

OS CPE: cpe:/o:linux:linux_kernel:3 cpe:/o:linux:linux_kernel:4
OS details: Linux 3.2 - 4.4

10.0.0.11:

PORT	STATE	SERVICE
22/tcp	open	ssh
5432/tcp	open	postgresql

OS CPE: cpe:/o:freebsd:freebsd:7 cpe:/o:freebsd:freebsd:8 cpe:/o:freebsd:freebsd:9 cpe:/o:freebsd:freebsd:10
OS details: FreeBSD 7.0-RELEASE-p1 - 10.0-CURRENT

10.0.0.12:

PORT	STATE	SERVICE
22/tcp	open	ssh
80/tcp	open	http
4242/tcp	open	vrml-multi-use

OS CPE: cpe:/o:linux:linux_kernel:3 cpe:/o:linux:linux_kernel:4
OS details: Linux 3.2 - 4.4

10.0.0.13:

PORT	STATE	SERVICE
22/tcp	open	ssh
2049/tcp	open	nfs

OS CPE: cpe:/o:linux:linux_kernel:2.6.32 cpe:/o:linux:linux_kernel:3
OS details: Linux 2.6.32, Linux 2.6.32 - 3.10, Linux 2.6.32 - 3.13

10.0.0.42:

PORT	STATE	SERVICE
21/tcp	open	ftp
135/tcp	open	msrpc
139/tcp	open	netbios-ssn
445/tcp	open	microsoft-ds

OS CPE: cpe:/o:microsoft:windows_xp::sp2 cpe:/o:microsoft:windows_xp::sp3
OS details: Microsoft Windows XP SP2 or SP3

10.0.0.99:

PORT	STATE	SERVICE
22/tcp	open	ssh
2222/tcp	open	EtherNetIP-1

OS CPE: cpe:/o:linux:linux_kernel:3 cpe:/o:linux:linux_kernel:4
OS details: Linux 3.2 - 4.4

10.0.0.1:

PORT	STATE	SERVICE
22/tcp	open	ssh
111/tcp	open	rpcbind
139/tcp	open	netbios-ssn
445/tcp	open	microsoft-ds

OS CPE: cpe:/o:linux:linux_kernel:3 cpe:/o:linux:linux_kernel:4
OS details: Linux 3.8 - 4.4

===10.1.1.0/24===
10.1.1.1:

PORT	STATE	SERVICE
22/tcp	open	ssh

OS CPE: cpe:/o:linux:linux_kernel:3 cpe:/o:linux:linux_kernel:4
OS details: Linux 3.2 - 4.4

10.1.1.2:

PORT	STATE	SERVICE
22/tcp	open	ssh
111/tcp	open	rpcbind
139/tcp	open	netbios-ssn
445/tcp	open	microsoft-ds

OS CPE: cpe:/o:linux:linux_kernel:3.19 cpe:/o:linux:linux_kernel:4
OS details: Linux 3.19, Linux 3.8 - 4.4
-----END-----
From the above, we can see **"OS CPE: cpe:/o:linux:linux_kernel:3 cpe:/o:linux:linux_kernel:4"**. This represents the operating system of the computer is Linux and the kernel version is 3-4 (similar to **uname -r**).

Bonus:
Based on the hints, we tried to connect to every service of each computer by using **nc ip_address port**. When communicating with **10.0.0.12** by port **4242 (nc 10.0.0.12 4242)**, we got

HELO
201 OK
This is a beautiful red-yellow-green-white-black-hat bonbon!

Task 3.3 (practical): DNS sniffing

- In order to spoof a DNS response, we need to intercept DNS packets to know which computers sent out DNS queries. Based on this, we are able to mimic real DNS responses, insert malicious material inside and send fake DNS responses back to those computers.

There are two types of DNS queries, **IPv4** and **IPv6:**

In **IPv4**, the DNS query is like

12:08:09.371817 IP 10.0.0.5.33487 > 10.0.0.10.domain: 56519+ A? net.cs.uni-bonn.de. (36)
12:08:09.372753 IP 10.0.0.10.domain > 10.0.0.5.33487: 56519*- 1/0/0 A 131.220.242.41 (52)

The computer **10.0.0.5** sent out an IPv4 DNS query about **net.cs.uni-bonn.de** to the DNS server **10.0.0.10**. Then, the DNS server **10.0.0.10** replied the ip address of **net.cs.uni-bonn.de** to the computer **10.0.0.5**.

In **IPv6**, the DNS query is like

12:12:31.442316 IP eduroam-203-130.wlan.uni-bonn.de.58590 > nic.rhrz.uni-bonn.de.domain: 54311+ AAAA? plus.google.com. (33)
12:12:31.443523 IP nic.rhrz.uni-bonn.de.domain > eduroam-203-130.wlan.uni-bonn.de.58590: 54311 1/4/4 AAAA 2a00:1450:4001:810::200e (197)

The computer **eduroam-203-130.wlan.uni-bonn.de** sent out an IPv6 DNS query about **plus.google.com** to the DNS server **nic.rhrz.uni-bonn.de.domain**. Then, the DNS server **nic.rhrz.uni-bonn.de.domain** replied the ip address of **plus.google.com** to the computer **eduroam-203-130.wlan.uni-bonn.de**.

- We use **"sudo tcpdump -l udp"** to gather DNS packets and use regular expression to filter out the information we want. The source code is as following (Download):

+++++START+++++

```
#!/usr/bin/env python

import re
import os
import sys
from subprocess import Popen, PIPE, STDOUT

if __name__ == '__main__':
    try:
        # filter out IPv4 DNS query
        reStringIPv4Req = '^.*?IP\s+([0-9a-zA-Z\.]+)\s+>\s+([0-9a-zA-Z\.]+).*?\s+A\?\s+([0-9a-zA-Z\.]+)\..*?'
        # filter out IPv6 DNS query
        reStringIPv6Req = '^.*?IP\s+([0-9a-zA-Z\.]+)\s+>\s+([0-9a-zA-Z\.]+).*?AAAA\?\s+([0-9a-zA-Z\.]+)\..*?'

        # filter out IPv4 DNS response
        reStringIPv4Resp = '^.*?IP\s+([0-9a-zA-Z\.]+)\s+>\s+([0-9a-zA-Z\.]+).*?\s+A\s+([0-9a-zA-Z\.]+)\s+.*?'
        # filter out IPv6 DNS response
        reStringIPv6Resp = '^.*?IP\s+([0-9a-zA-Z\.]+)\s+>\s+([0-9a-zA-Z\.]+).*?\s+AAAA\s+([0-9a-zA-Z\:]+)\s+.*?'

        # use "sudo tcpdump -l udp" to gather UDP packets
        p = Popen(["sudo", "tcpdump", "-l", "udp"], stdout=PIPE, stderr=STDOUT)

        # use regular expressions to filter out related information
        for line in iter(p.stdout.readline, b''):
```

```
        reobj = re.compile(reStringIPv4Req, re.IGNORECASE)
        m = reobj.finditer(line)
        for i in m:
            print ("++reStringIPv4Req+")
            print i.group(1), i.group(2), i.group(3)
            print ("---")

        reobj = re.compile(reStringIPv4Resp, re.IGNORECASE)
        m = reobj.finditer(line)
        for i in m:
            print ("++reStringIPv4Resp+")
            print i.group(1), i.group(2), i.group(3)
            print ("---")

        reobj = re.compile(reStringIPv6Req, re.IGNORECASE)
        m = reobj.finditer(line)
        for i in m:
            print ("++reStringIPv6Req+")
            print i.group(1), i.group(2), i.group(3)
            print ("---")

        reobj = re.compile(reStringIPv6Resp, re.IGNORECASE)
        m = reobj.finditer(line)
        for i in m:
            print ("++reStringIPv6Resp+")
            print i.group(1), i.group(2), i.group(3)
            print ("---")

        print line, "\n"
    p.wait()  # wait for the subprocess to exit
  except:
    print "Unexpected error:", sys.exc_info()[0]
```
-----END-----

- The sample output is as following:

+++++START++++
++reStringIPv4Req+
10.0.0.5.53239 10.0.0.10.domain cve.mitre.org

++reStringIPv4Resp+
10.0.0.10.domain 10.0.0.5.53239 192.52.194.135

++reStringIPv4Req+
10.0.0.5.44604 10.0.0.10.domain packetstormsecurity.com

++reStringIPv4Resp+
10.0.0.10.domain 10.0.0.5.44604 198.84.60.198

-----END-----

The computer **10.0.0.5** sent DNS query about **cve.mitre.org** to **10.0.0.10** and then got the response **cve.mitre.org is 192.52.194.135** from **10.0.0.10**.
The computer **10.0.0.5** sent DNS query about **packetstormsecurity.com** to **10.0.0.10** and then got the response **packetstormsecurity.com is 198.84.60.198** from **10.0.0.10**.

Task 3.4 (practical): Hash Collisions

- The source code is as following (Download):

+++++START++++

```
#!/usr/bin/env python

import re
import os
import sys
import random
import hashlib
from subprocess import Popen, PIPE, STDOUT

FLAG_1 = 0b1111
FLAG_2 = 0b11111111
FLAG_3 = 0b111111111111

# use SHA256 to check bit coincidence. "numOfBits" identifies how many bits must be the same.
def checkSame(seq1, seq2, numOfBits):
    for i in xrange(numOfBits/4):
        if (int(hashlib.sha256(seq1).hexdigest()[i], 16) & FLAG_1) != \
            (int(hashlib.sha256(seq2).hexdigest()[i], 16) & FLAG_1):
            return False

    return True

if __name__ == '__main__':
    # Open a file for saving all used sequences
    dataFile = open("exercise3_4_data.txt", "wb")

    # a dictionary for storing counters for 4, 8, 12, 16 and 20 bits
    allCounter = dict()
    allCounter[4] = []
    allCounter[8] = []
    allCounter[12] = []
    allCounter[16] = []
    allCounter[20] = []

    # we run this collision programming 10 times for 4, 8, 12, 16 and 20 bits
    for times in xrange(10):
        counter = dict()
        counter[4] = 0
        counter[8] = 0
```

```
        counter[12] = 0
        counter[16] = 0
        counter[20] = 0

        # this list is used to record which one doesn't find the collision yet
        bitsList = [4, 8, 12, 16, 20]

        # This counter is used to record how many times for a prefix to find a collision
        counterRun = 0
        going = True
        while going:
            counterRun += 1
            # Generate random sequences
            randomSequence1 = open("/dev/urandom", "rb").read(64)
            randomSequence2 = open("/dev/urandom", "rb").read(64)

            dataFile.write("===Sequence 1===\n")
            dataFile.write(randomSequence1 + "\n")
            dataFile.write("===Sequence 2===\n")
            dataFile.write(randomSequence2 + "\n\n")

            deletedBits = []
            # Iterate through each prefix
            for i in bitsList:
                # Check if certain prefixes have collisions
                if counter[i] == 0 and checkSame(randomSequence1, randomSequence2, i):
                    print "Collision of", i, "bits:", counterRun
                    counter[i] = counterRun
                    deletedBits.append(i)
                    print (hashlib.sha256(randomSequence1).hexdigest())
                    print (hashlib.sha256(randomSequence2).hexdigest() + "\n")

            # Remove prefixes which alreay got collisions
            for bits in deletedBits:
                bitsList.remove(bits)

            if not bitsList:
                going = False

        print counter

        # Print out all collision information
        for bits in xrange(4, 24, 4):
            allCounter[bits].append(counter[bits])

    print allCounter

    dataFile.close()
```
-----END-----

- The following is information about collision:

+++++START+++++
Collision of 4 bits: 49

e52c052fb76b26886b42c5d2e89ad156ed4dd44cf967fe5ff38a234c093375c9

eee06336ec252c85e9d227e449b331554b16626bd4bd4c650b29e9ce79b1fec6

Collision of 8 bits: 295

6c6a7419920d42016402c4916cf3dca8659688db91f4310d0ba3b8f035d471fd

6cf060b9abdf9bf0cc80288d8aecde33efbecbcf07ebb8a1be177fb6aaf89702

Collision of 12 bits: 2653

f5f484205339231e503a27857a3a9f44eca7c768491f7e723a06941f208518bd

f5f9865102cf6122b892f0fc20ae34bcb35bfd10f4fb26cd0f73fbb636050d64

Collision of 16 bits: 52310

8b3f28393912ba1e7565f5f3657aa2603695b2eee43c5caf18f5eef0e5b8cca2

8b3fadc2e63fa9cb7cdbbac85a037678a32b1ae8cb6fe36136d611bc074cce18

Collision of 20 bits: 185200

7ab94908953eaf811f9813e2f867e0e0c8218b8e4e4016547492b89a4ce74023

7ab9415c963b2ab503286ed789e65afeccf4c7397ee0c2b09eb88daef1aae256

{4: 49, 8: 295, 12: 2653, 16: 52310, 20: 185200}
-----END-----
From the above, we know that in order to find a collision of **the 4-bit prefix**, we need to use **49 times** and vice versa for other prefixes.

Also, we display some random sequence pairs which are not correlated to each other:
===Sequence 1===
^\v^[聶 JZV?繭;<84>Q?@PD<9d>#^YK 簸 S<9c>g<9f>?0?礙?
繭?繭\-{?<95>^MF 簿 mh 羸/<84>H 繭^P1<97>c 繒穡!?<82><98>羹簿穢?癒
===Sequence 2===
)繞?i^Wq\<8f>?~瞿.^Vs 瞿 i1<96>J2<95>簽 R?<9a>^^繭<82>4jJ^Ri=籀 dN 竄穢]u6<86>簣 y?
瓣 R
!a^BhF?穡 NhI%瞿 H 繩 G

===Sequence 1===
m^W^_^F?<9a>U+?簣 Z2)<97>`簧 a 繞簞穠<8e>j~04sR*R^LE^C 穡^XP^_^NR 疇^\?????簸 jF
穠^_<86>S\?G??~S(C-<96>^_
===Sequence 2===
?x 繞 v^M^<91>?;穠 z 瞿簣?繡 e<95>^A^E<96>#?職 2<9f><93>?繭^Lv^N^_繡簞 5*<9a>?簷
<8e><82>簣臘:?藩 A 疆^P
簷 CT^P@繡糧 y^C?^[[OK

● In the end, we ran this program **ten times** to generate ten different counters for each prefix to encounter a collision. The result is as following:
{
4: [49, 28, 40, 30, 5, 12, 26, 9, 11, 1],
8: [295, 168, 569, 113, 198, 318, 987, 32, 91, 38],
12: [2653, 6663, 5051, 1801, 4939, 3379, 11191, 1667, 1535, 3331],
16: [52310, 27417, 61383, 50101, 20019, 65600, 161608, 14938, 72832, 67439],
20: [185200, 476022, 309090, 4899040, 212291, 640868, 2397083, 1484002, 923254, 183082]
}

So, the averages for each prefix to have a collision are:

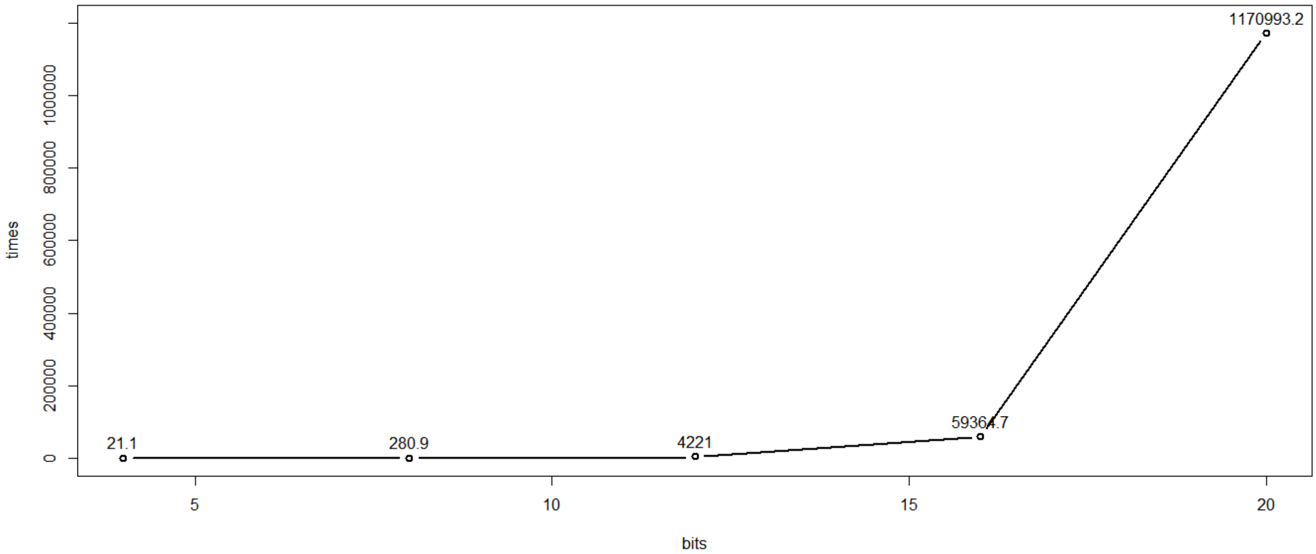
bits	**times**
4	**21.1**
8	**280.9**
12	**4221**
16	**59364.7**
20	**1170993.2**

The plotting script is the below (Download):
+++START+++
```
library(package = "lattice");

# Import the data
data <- read.table("E:/Dropbox/University_Bonn/Summer_Semester_2016/Network\
Security/Exercise_03/exercise3_4_counters.txt", header = TRUE);
attach(data);

# draw the line based on the data
plot(bits, times, ylim = c(0, 1200000), type="b", lwd="2")
# Show the value directly beside the point
text(bits, times, labels=round(times,2),pos=3)
```
-----END-----

● The output of the plotting script:



We can see that in the **20-bit prefix**, the number of trials to have a collision rocketed to **1,170,993.2** which means it will get harder and harder to find a collision when the number of bits get bigger.

Task 3.5 (theoretical): Designing Asymmetric Encryption Schemes

Part (a):

Is this method secure?

Yes this method seems secure to me because every time when the secret box is traveling, it is protected with at-least one padlock.

Does it also work with cryptographic means?

It works with cryptographic means.

Which problems could arise?

From my point of view, the main problem is time that it takes to complete the whole process.

Also, to transfer the box between the sender and receiver two times will include more cost.

Part (b):

Does it work?

Yes.

Example:

Assume, Digital data = 11 00 00 01
Bob's key = 11 11 00 00
Alice's key = 00 00 11 11

Step 1: Bob sends the data by doing bitwise XORs with his key to Alice
Digital data ^ Bob's key = 11 00 00 01 ^ 11 11 00 00 = 00 11 00 01= Encrypted data.

Step 2: Alice receives the encrypted data and performs again bitwise XORs on it with her key

Encrypted data ^ Alice's key=00 11 00 01 ^ 00 00 11 11= 00 11 11 10 = Encrypted data with both keys.

Step 3: Now Alice sends the double-key-encrypted data to Bob again so that, he can remove his lock by doing bitwise XORs on it again with his key.

Encrypted data with both keys ^ Bob's key = 00 11 11 10 ^ 11 11 00 00 = 11 00 11 10 =Encrypted data with only Alice's key.

<u>Step 4:</u> Now Bob sends the data back to Alice again where she performs bitwise XORs on it with her key and gets the actual data.

Encrypted data with only Alice's key ^ Alice's key = 11 00 11 10 ^ 00 00 11 11 = 11 00 00 01 = Actual Digital Data.

Can confidentiality be assured?
From my point of view, it is not completely assured. Because a hacker can pose as Alice and perform her role and Bob has no way to identify Alice because Bob doesn't have any information about Alice's key.

Can integrity be assured?
Yes. but, if during transmission any bit of the data is lost. Then while performing XORs with a key, the decrypted data will not match the right data.

Would choosing different random keys for each message have an impact?
Choosing random key for each message will increase the security because then the hacker cannot trace them. Hackers can only know the key length as it is at least the data size.