Palestine Polytechnic University

College of Engineering & Technology

Computer and Electrical Engineering Department

Communications and Electronics Engineering

Graduation Project

Improving communications in WLAN through better access point selection

Project Team

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College of Engineering & Technology

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By the guidance of supervisor, and by the acceptance of all members in the testing committee, this project delivered to the computer and electrical engineering department, to be as a partial fulfillment of the requirements of the department for the degree of B.Sc. .

Project supervisor signature

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Committee signature

..... **……..** **……..**

Department head signature

…….

إهداء

إلى آباءنا و أمهاتنا

إلى أرواح شهدائنا الطاهرة

إلى كل أسرانا البواسل

إلى كل فلسطينٍي ضحى لأجل هذا الوطن

Acknowledgement

First and for most we should offer our thanks obedience and gratitude to Allah

Our Appreciation To
Palestine Polytechnic University
College of Engineering & Technology
Department of Electrical & Computer Engineering

Our Supervisor

Dr.Murad Abusubaih

Abstract

Our project take a path in technology improvement, it aims to improve communications in WLAN through better access point selection which depends on RSSI and load.

We choose this project because it is not traditional project such as controlling something through internet or remote control. Besides, this project could be developed through in the coming years.

Finally ,we got a model which could be generalize for all the studies.

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Chapter One

Introduction

1.1 Preface

In this chapter we describe the importance of wireless communications .We provide a summary about the problem we are considering and some related works that have a relationship to this problem.

1.2 Motivation

In the last few years there has been a very fast growing in communications, and wireless communications technology is becoming one of the fastest growing technologies , especially in this century, 21st century .In other words wireless communications technology now is becoming an important part of modern life ,from cellular telephone systems to personal and local area networks. There are many projects and researches in the wireless communications field. All aim to make the communications simpler and easier.

Due to the aforementioned reasons ,we have chosen a problem in wireless communications ,specifically we focus on WLANs. Our project is in the field of Wireless Local Area Networks(WLAN) technology .This technology is widely popular. We address the Problem of load control in WLANs. We aim to improve the communication in WLAN through distribution of load among access points.
To achieve this ,we think that the current implementation of user –AP association doesn't provide the expected performance .Therefore ,we believe that a better performance can be achieved if we consider the load on APs in the association process .This can be performed either at the access point selection phase or while the network is operating.

1.3 Related works

In [1],the authors propose that the potential bandwidth between AP and end-host is an important metric in the process of AP selection. They described a methodology for estimating the potential bandwidth based on delays experienced by beacon frames from an AP.

In[2],the authors propose a description of Virgil, an automatic access point discovery and selection system. Unlike existing systems that select access points based entirely on received signal strength ,Virgil scans for all available APs at a location, quickly associates to each, and runs a battery of tests to estimate the quality of each AP's connection to the Internet.

1.4 Problem definition

The title of our project is improving communication in WLAN through better AP selection. When an AP is very loaded ,it might not be able to serve some users in a good way.

Load is defined in many ways ,it may be defined as the number of the active users connecting to AP, or how much the AP will be busy(B) due to an interval time(T) selected by the administrator as shown in the figure, therefore load is B/ T.

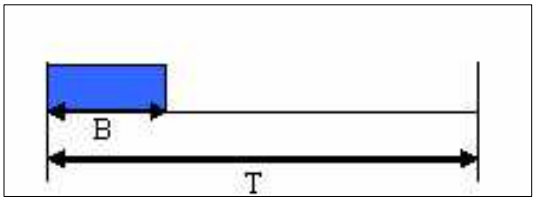


Figure 1-1: B due to T

This is the principle that we will follow. Load is not enough to solve the problem ,another condition we will follow, Received Signal Strength Identification (RSSI)value or the power level. Therefore ,the idea is that a user assess periodically its connection and move to another AP that is less loaded and has more power than the current AP .

To get the solution, we must have a general background about wireless communications technology .This background represents the difference between wired and wireless networks and the architecture of wireless networks ,and we must have a clear picture about WLAN ,this will be explained in the next chapter.

1.5 Time plan

The following time plan shows the time scheduling in the first semester.

Week / Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Selecting the project.																
Collecting information ,literature review and related theory.																
Requirement analysis																
Writing documentation																
Presentation																

Table (1-1): First semester time plan

The following time plan shows the time scheduling in the second semester.

Week / Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Installing fedora (ubuntu) on computers.																
Installing other programs (Madwifi , traffic, c++).																
Implement wireless connection between AP and computers by netgear card																
Software programming																
Implement some experiments																
Writing documentation																
Presentation																

Table(1-2):Second semester time plan

1.6 Finance study

The following table shows the hardware parts needed for the project and their cost.

Equipment	Required quantity	Cost per unit
Laptop	**3**	**1000 $**
Access point	**2**	**50$**
Netgear card	**3**	**50$**
Total cost		**3250$**

Table (1-3):hardware parts cost

1.7 Report contents

This documentation is divided into chapters ,and the following is a brief description for each chapter:

Chapter One: Introduction

This chapter introduces a general idea about the project ,its important, related works ,problem definition, time plan and finance study of the project.

Chapter Two: Theoretical Background

This chapter provides a background on WLANs(technology that we used).

Chapter Three: System Model

This chapter explains project scenario, software and components needed, and how they relate.

Chapter Four: Experiments

This chapter provides the experiments that we executed for this project.

Chapter Five: System Implementation

This chapter provides our works in Linux system ,how to associate with an access point, how to program in c language

Chapter Six: Summary

This chapter provides the implementation of the project's system, where we stopped ,what the future works of the project.

CHAPTER TWO 2

THEORETICAL BACKGROUND

2.1 Preface

2.2 similarities and differences between wired and wireless LAN

2.3 Infrared versus radio transmission

2.4 The architecture of WLAN

2.5 Types of 802.11 WLAN

2.6 Network services

2.7 Discovering and joining a network

2.8 WLAN standards

2.9 Frame format

2.10 Some enhancements of WLAN

Chapter Two

Theoretical Background

2.1 Preface

This chapter provides a background on WLANs. It explains the differences and the similarities between wired and wireless LAN, the air link in WLAN between transmitter and receiver ,the architecture of wireless networks, types of WLANs ,network services ,and the standards of WLAN (physical layer and MAC layer).

2.2 similarities and differences between wired and wireless LAN

Wireless networks are designed to support the same standards and the same protocols as wired networks support, but there are some differences between them .
These differences can be summarized as advantages and disadvantages of the wireless Local Area Networks WLAN.

Advantages of WLAN

1. Flexibility: WLAN is very flexible within the reception area ,nodes can communicate without restrictions.
2. Planning: wireless ad-hoc networks don’t need previous planning ,but wired networks need previous planning. In ad-hoc the devices follow the same standard so they can communicate ,but in wired networks additional cabling with the plugs and probably interworking units (for example switch) have to be provided ,in other words wired networks need wiring plans.
3. Design :wireless networks don’t have wires ,there is no wiring difficulties .
4. Robustness: wireless networks are more robust against disaster.
5. Cost: adding more devices in wireless network will not increase cost.

Disadvantages of WLAN

1. Quality Of Service(QOS): wireless networks have less QOS. Wireless networks have less bandwidth compared to wired networks
2. Safety and security: the protection of the transmission data in wireless networks doesn't exist or it may be less than it in wired networks. Wireless networks have low safety and security.

2.3 Infrared versus radio transmission

WLANs can be set using one of the two different basic transmission technologies, infrared light or the radio transmission .

Infrared technology uses a diffuse light .The advantages of this technology are its simple, and cheap sender and receiver which are integrated in many mobile devices, in addition to this infrared doesn't need licenses.

The disadvantages of infrared technology are its low band width compared to other LAN technologies ,and it is easily shielded. An example of this technology is IrDA(Infrared Data Association) interface available any where.

Radio technology uses the license free ISM band at 2.4GHz .Its advantages are in its coverage area .In radio technology , coverage area is large. Radio technology has very limited license for frequency band and this is a disadvantage of this technology. an example of radio technology is WLAN in laptop .

2.4 The architecture of wireless networks

The architecture of the wireless networks is divided into logical architecture and physical architecture .

2.4.1 Logical Architecture

It is the structure of the standards and the protocols that make a connection between nodes(physical devices) and control data flowing between them.

This architecture is represented by the seven layers of Open Systems Interconnect(OSI) network model ,and the protocols that operate in this model.

2.4.1.1 OSI network model

The open systems interconnection model divides the application to application connection into seven layers as shown in figure 2-1.

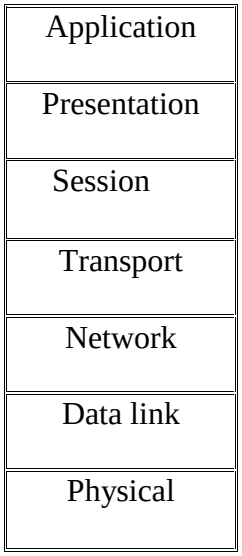


Figure 2-1: OSI layers

There are some organizations that produce the standards of many layers such as Institute of Electrical and Electronics Engineers(IEEE) .

Principally ,the logical architecture of a wireless network is determined by layer two(Data link layer) and layer one (physical layer).

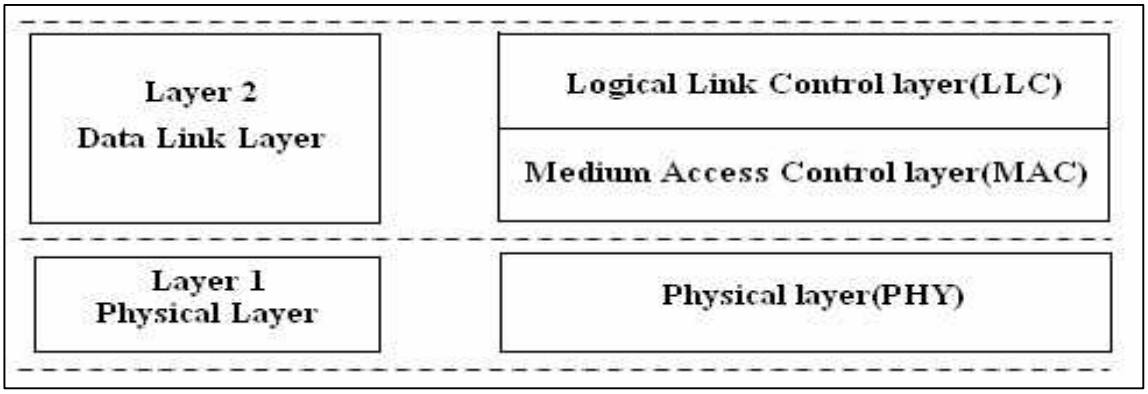


Figure 2-2:OSI layers and IEEE 802.11 specifications

2.4.2 Physical architecture

It is represented by wireless networks topologies and hardware devices .

Wireless networks topologies:

1-Point to point connections: it has many situations:

a) peer to peer connections(ad-hoc connection).

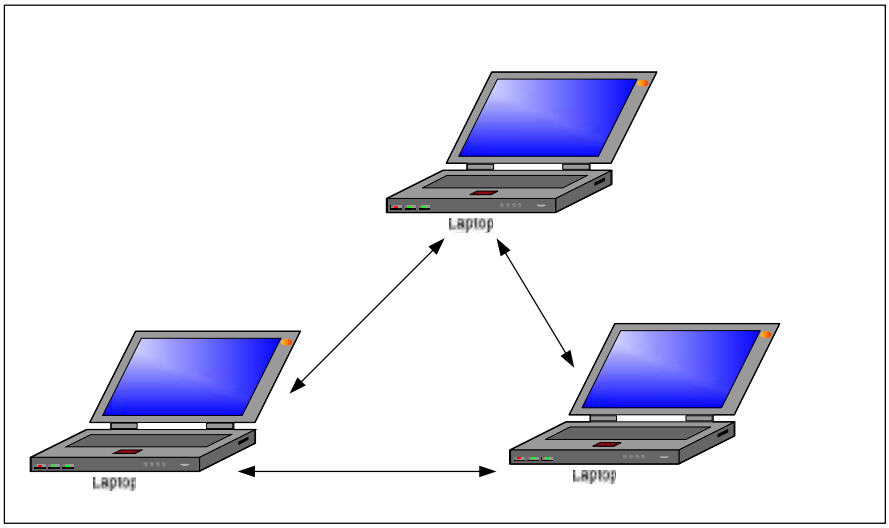


Figure 2-3: peer to peer connection

b)LAN wireless bridging.

A bridge can be used to connect networks (figure 2-4),it acts as the connection point to the Wireless LAN.

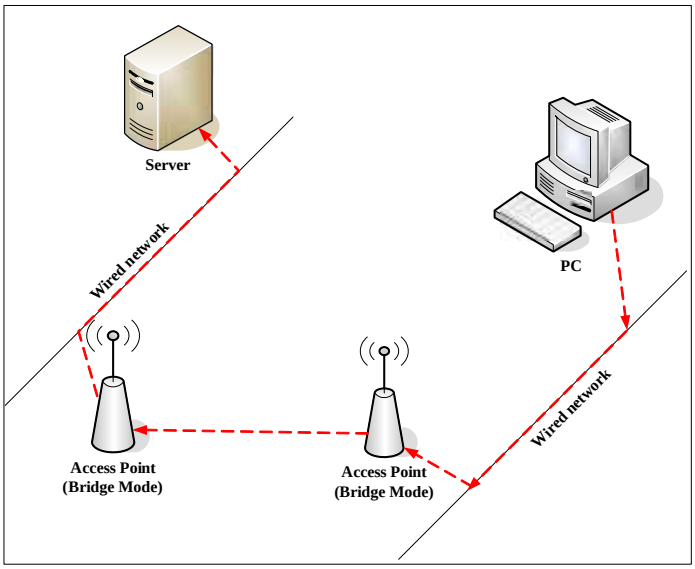


Figure 2-4: WLAN bridging

c)Bluetooth.

It is an open wireless protocol for exchanging data over short distances (using short length radio waves) from fixed and mobile devices(figure 2-5), creating personal area network(PAN).

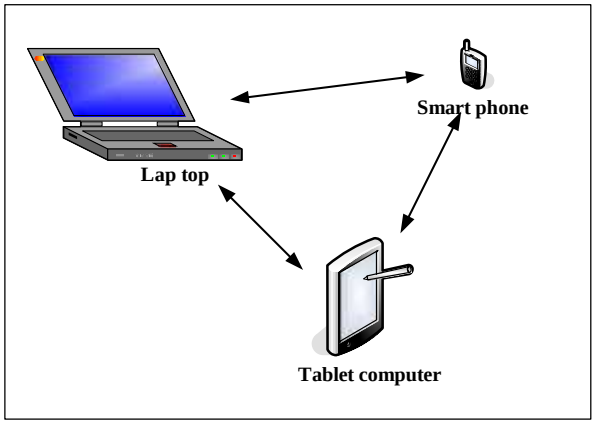


Figure 2-5: Bluetooth connection

d)IrDA(Infrared Data Association)

The Infrared Data Association is a consortium of vendors that has defined low-cost IR communications characterized by:

1.Directional point-to-point communications of up to one meter

2.115-Kbps and 4-Mbps connectivity

3.Walk-up ad hoc connectivity for LAN access, printer access, and portable computer to portable computer communications

2-Star connection

This connection is shown in figure 2-6,the node at the center may be a WiMAX base station ,WiFi access point, or Bluetooth master device.

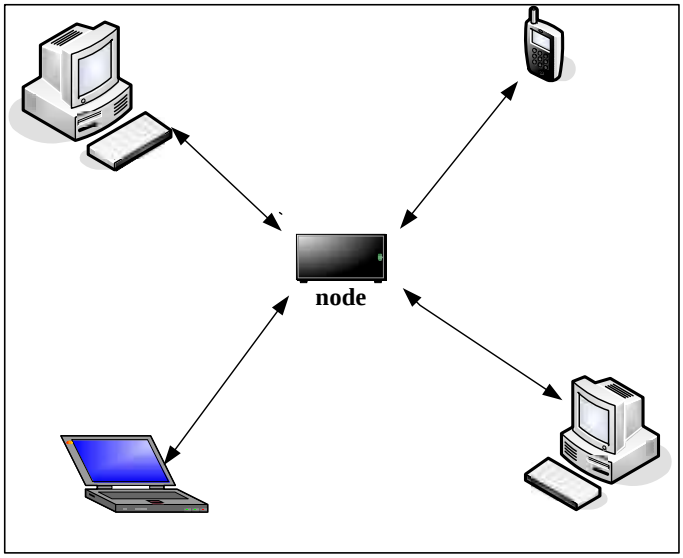


Figure2-6: star connection

2.5 Types of 802.11 WLANs

WLAN networks have 3 basic components :

1- access point(AP):it is a control medium access that provides an interface between a set of stations, known as Basic Service Set ,and the Distribution System.
2- Station: any device that implement MAC and PHY layer of WLAN .
3- Distribution System(DS): A network component that connects the access points and their associated BSSs to form an Extended Service Set(ESS).

There are two basic architectures of WLAN :

1-Ad-hoc networks also called Independent Basic Service Set IBSS ,in this network the station communicates directly with each other without connected to an access point as shown in the figure below .The stations can only communicate if they can reach each other physically ,if they are within each other's radio range.

In ad-hoc network the complexity is higher because every node has to implement medium access mechanisms ,mechanisms to handle hidden node problem.

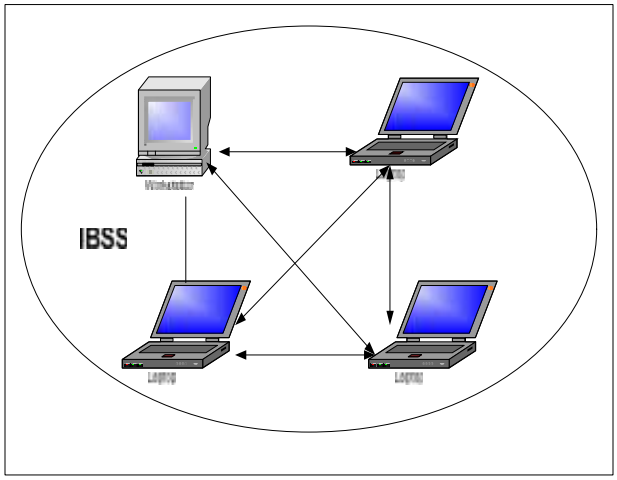


Figure 2-7: ad-hoc network

2- Infrastructure network also called Basic Service Set BSS. In this network the stations communicate with each other through an access point as shown in figure below .The design of this network is simpler than ad-hoc because most of the network functionality is within the access point. This type is better than ad-hoc network ,it doesn't restrict the distances between stations but stations should be within the coverage range of AP.

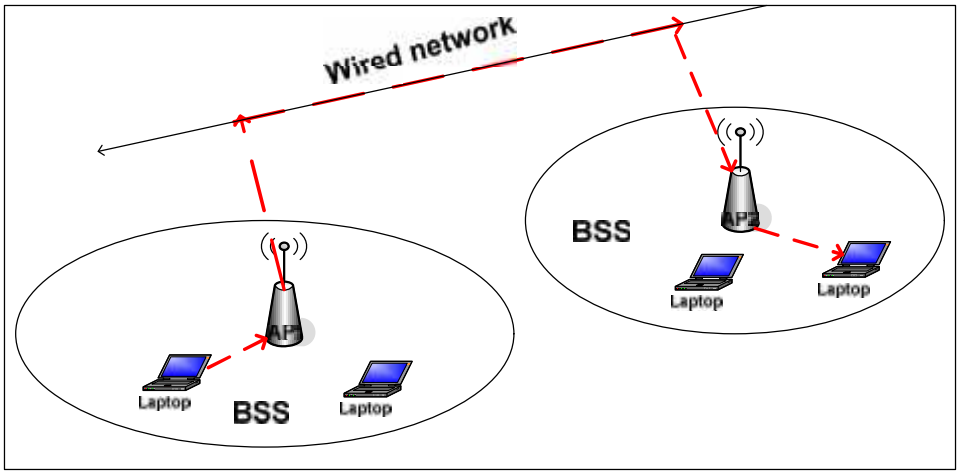


Figure 2-8: infrastructure network

2.6 Network services

In WLAN networks there are a set of services which are devided into two groups ,the station services and the distribution services.

Station services:

1-Authentication service: this service enables a receiving station to authenticate another station prior to association. There are two types of this service:

a. open system authentication :this type has less security.

b. Shared key authentication: both stations have received a secret key.

2-Deauthentication service :prior to disassociation ,the station will deauthenticate from the station that it intends to stop the communication with it.

3-Privacy service: this service enables data frames and shared key authentication frames to be optionally encrypted before transmission .

4-MAC service data unit delivery(MSDU): this service provides delivery of data frames from the MAC in one station to the MAC in one or more other stations.

Distribution services:

1- Association: this service enables a connection to be made between station and access point.
2- Disassociation: the station disassociates when it leaves the network.
3- Reassociation: this service allows the station to change its association from one access point to another exists in the same extended basic service set(EBSS).
4- Distribution: this service allows the station to send frames to another station exist in the same BSS or another within the EBSS.
5- Integration:this service is used to convert frame WLAN to frame in wired LAN and vice versa .

2.7 Discovering and joining a network

In order for the mobile station to communicate with other mobile stations in ad-hoc or with AP in infrastructure, the station must first find the stations or APs .The discovering of the stations or APs can be achieved by scanning.

The scanning may be passive or active . In passive scanning(figure 2-9a) the station listens to each channel for beacon frames ,this type of scanning allows the station to find a BSS without consuming power ,but the time needed is large.

Beacon frame that the AP sends includes basic information that the station needs to know before joining the network. These information are the channel and SSID. SSID is the human readable name for the network ,it is assigned by the administrator.

After completing the scanning ,the station has the needed information about the BSSs in its range. In active scanning(figure 2-9b) the station tries to find BSSs in its range ,this type allows the station to find BSS with a minimum time and large consuming power . the station sends a frame which called probe request for each channel and then APs send probe response frame that contains the same information the Beacon contains. After scanning ,the stations will choose one of the BSSs to join with before associating with it . joining means that the stations matches its parameter with the received parameters from BSS.

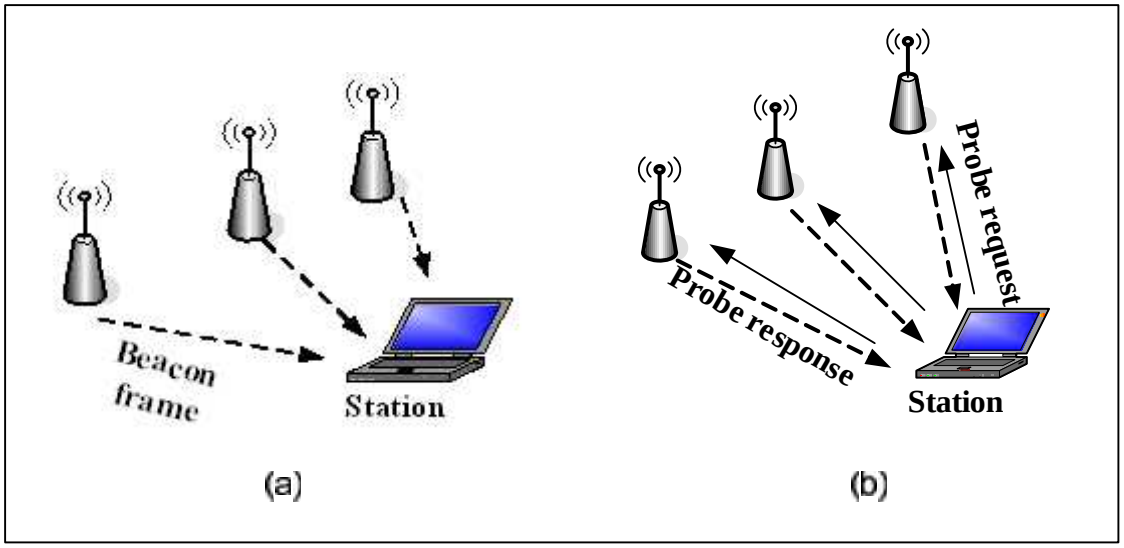


Figure 2-9: (a) passive scanning and (b)active scanning

2.8 WLAN standards

The 802.11 standards cover two physical layers ,physical layer (PHY) and medium access control layer(MAC).

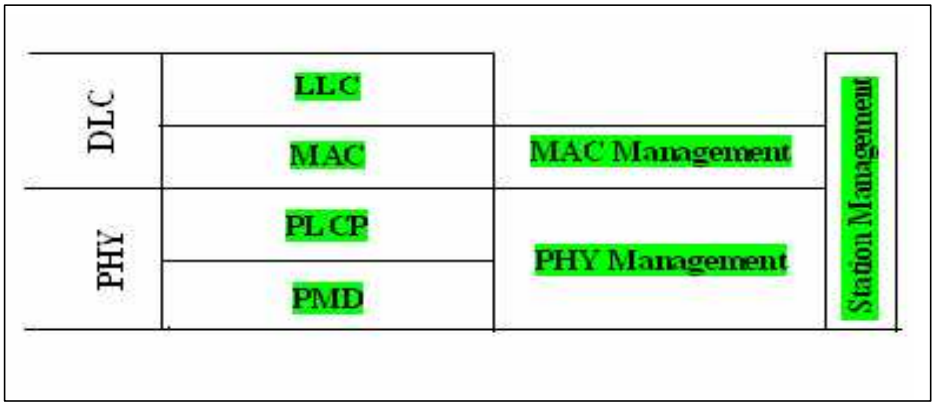


Figure 2-10: IEEE 802.11 protocol architecture and management

2.8.1 Physical layer (PHY)

The physical layer can be interface between MAC layer and wireless medium by transmitting and receiving frames. the PHY provide three sub layer ,
PLCP (Physical Layer Convergence Procedure) sub layer that controls the exchange frame between the MAC and PHY.PMD (Physical Medium Dependent) sub layer that can be control the transmitted frame, which in PHY uses signal carrier and spread spectrum modulation. The PHY provide a carrier sense which back to the MAC to verify the activity of the medium.

IEE802.11 provide three different PHY media:
1-Direct Sequence Spread Spectrum(DSSS) PHY
The DSSS PMD takes binary data from PLCP protocol data unit and transform them into RF signals, the PPDU frames consist of a PLCP preamble, PLC header and MAC Protocol Data Unit (MPDU).the PLCP preamble is to acquire the incoming signal and synchronize the demodulator and the PLC header it is contain information about MPDU, and both are transmitted at 1MHz , but MPDU can be sent at 1,2MHz.

Barker spreading method
It is a spreading sequence used in every STA in IEEE802.11. In the transmitter this sequence will be (XOR) with information in the PPDU then the signal will be spread over a wider band width, each DSSS PHY channel has 22MHz of band width. this technology uses a single wide band channel ,and operate in the unlicensed 2.4 GHz ISM band.

2-Frequency Hopping Spread Spectrum(FHSS)PHY
The FHSS PMD takes the binary information from PSDU (PLCP Service Data Unit)and transform them into RF signal for wireless medium.
The PPDU frames contain of PLCP preamble and PLCP header ,and both are transmitted at 1Mbps.the PLCP preamble which is used to acquire the incoming signal and synchronize the demodulator, and PLCP header contain information about PSDU .The FHSS PMD can be controlled the channel hopping ,so it is transmit the PSDU by hopping from channel to channel in random mode .the total available bandwidth is split into many

channels of smaller bandwidth plus guard spaces between the channels ,at the receiver must be set at the same hopping code .A set of hopping codes that never use the same the same frequencies at the same time it must orthogonal FHSS comes in two variant ,slow and fast hopping.

In slow hopping ,the transmitter uses one frequency for several bit such as use frequency F2 for transmitting the first three bit ,then the transmitter hops to the next frequency F3 and so on .the advantage of slow hopping system is cheaper and have relaxed tolerance ,but they are not immune to narrow band interference as In fast hopping system :the transmitter changes frequencies several time during the transmission of single bit so, the transmitter and receiver should be synchronized but this system is better to overcome the effect of narrow band interference and frequency selective fading .

3-Infrared (ID) PHY

IR uses visible light as the transmission media ,with wavelength 850-950 nm .It depend on line of line of sight or reflected of objects ,because it can't pass through the wall as DSSS and FHSS radio signal .IR PMD sub layer can control the data transmission over medium ,which take binary information from the PSDU and transforms them into light energy emissions for the wireless media .IR PLCP sub layer contains the PLCP preamble ,PLCP header and PSDU .The PLCP preamble has the incoming signal and synchronize the modulator and the PLCP header contain information about PSDU and both are transmitting at 1Mbps, but PSDU can send at 1,2Mbps.

2.8.2 Medium Access Control layer (MAC)

The MAC layer is implemented in every station .

MAC layer has three basic functions:

1-It provides data delivery service to the users of the MAC through frame exchange protocol.

2- It controls access to the shared medium through two access mechanisms ,distributed coordination function(DCF) and point coordination function(PCF).

3- protection the delivering data .

Frame exchange protocol

It is an access mechanism ,it is implemented by WLAN to make the source station to know if the frame that it sent is received at the destination or not.

Frame exchange protocol includes two frames ,the first frame is the frame that the source sends .When the destination receives this frame ,it sends acknowledgment to the source. This acknowledgment is the second frame .

Some times the source doesn't receive an acknowledgment due to errors in the first frame .So ,the source try again to send its frame. This situation called retransmission of the frame .

Hidden node problem

Every station in WLAN can't be expected to communicate directly with every station ,therefore the hidden node problem results.

This problem appear when there are more one station communicate with one destination, these stations are unaware of each other. The following example, shown in figure 2-11, will explain this problem.

There are three stations A,B and C. Each station has a coverage area ,it can communicate with any station exists at this area.

Station A has only station B in its coverage area, and also C has only station B in its coverage area, and station B has the both stations A and C in its coverage area . therefore both stations A and C communicate with only station B, but B communicate with both A and C. C is a hidden node for A and A is a hidden node for C.

Station A sends a frame to station B ,station C can't receive this frame so C would unaware of the transmission coming from A to B .In the same time station C will send a frame to B ,the result of the two transmissions will be a collision between the two frames.

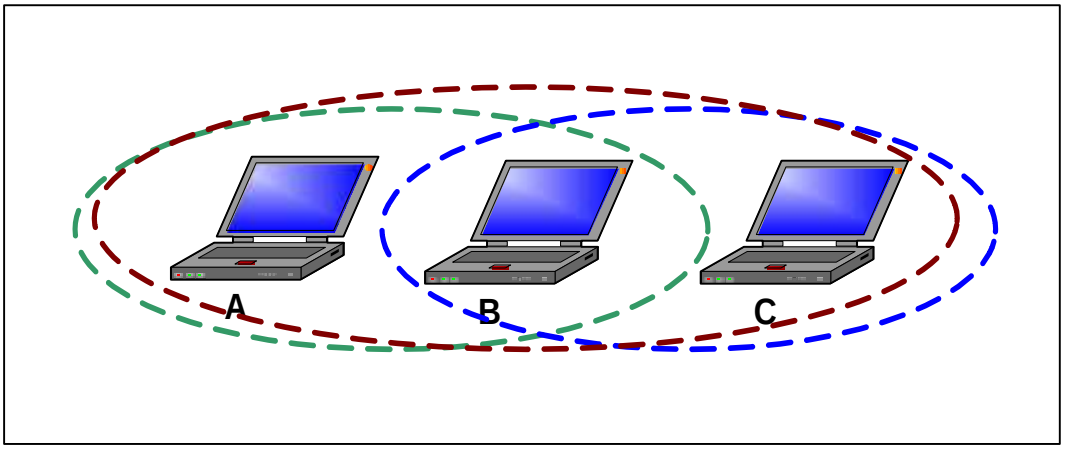


Figure 2-11: Hidden node problem

To over come this problem , two frames are adding to the frame exchange protocol, request to send (RTS) and clear to send (CTS).

The source(A) sends RTS to the destination(B) .when the destination receives this RTS it sends CTS to the source .RTS and CTS are received by other stations(C) ,these frames contain information that make other stations to delay any transmission of their own .

When the source receives CTS ,it will send its frame to the destination then the destination sends acknowledgment.

Any failing in frame exchange protocol allows other stations that received RTS and CTS to regain control of the medium and causes retransmission of frame by the source station, collision will happen in this situation .

To avoid collision ,each frame has retry counters and timers to limit life time of the frame.

2.8.2.1 The basic access mechanism in WLAN

The basic access mechanisms in WLAN is carrier sense multiple access with collision avoidance (CSMA/CA) .

CSMA/CA depends on two types of carrier sensing:

1. Physical carrier sensing : this mechanism provided by the PHY . I n this type the station listen to the medium before beginning the transmission if it is idle or not depending on timing intervals. If the medium is not idle the station will not begin its transmission, if the station begins its transmission while the medium is not idle then collision will happen .

2.Virtual carrier sensing : in WLAN ,MAC uses collision avoidance which implemented using Network Allocation Vector(NAV) .NAV indicates the amount of time that remains before the medium become idle .

Timing intervals:

In WLAN there are five timing intervals ,two intervals are determined by physical layer , the Short Interframe Space(SIFS) and time slot.

The additional intervals depend on the previous intervals:

1.Priority Interframe space(PIFS) which equal to one SIFS plus one slot time .

2.Distributed Interframe space (DIFS) which equal to two SIFS plus two slots time.

3.Extended Interframe space (EIFS) which is the largest interval timing .

DCF operation

If the physical carrier sense and virtual carrier sense indicate that the medium is not busy for an interval DIFS ,MAC begins transmission to the frame. If they indicate that the medium is busy then MAC will select a contention window(random back off window) and the retry counter will be increased ,figure 2-12.

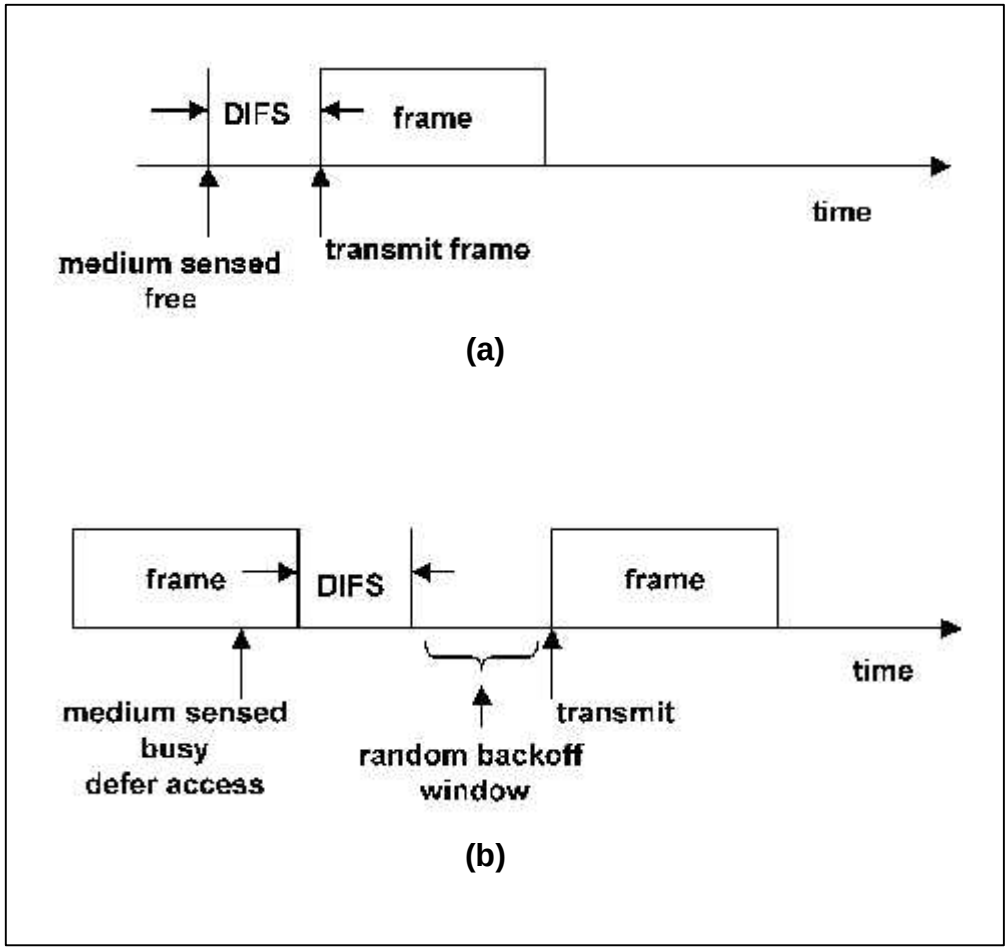


Figure 2-12: Basic access mechanism :(a) medium sensed free
(b)medium sensed busy

PCF operation

PCF is controlled by point coordinator(PC), which is located in an AP .PC has a polling list, every station requests PCF will be registered on the polling list by PC ,then PC will polls these stations for traffic .

2.9 Frame format

2.9.1 General frame format

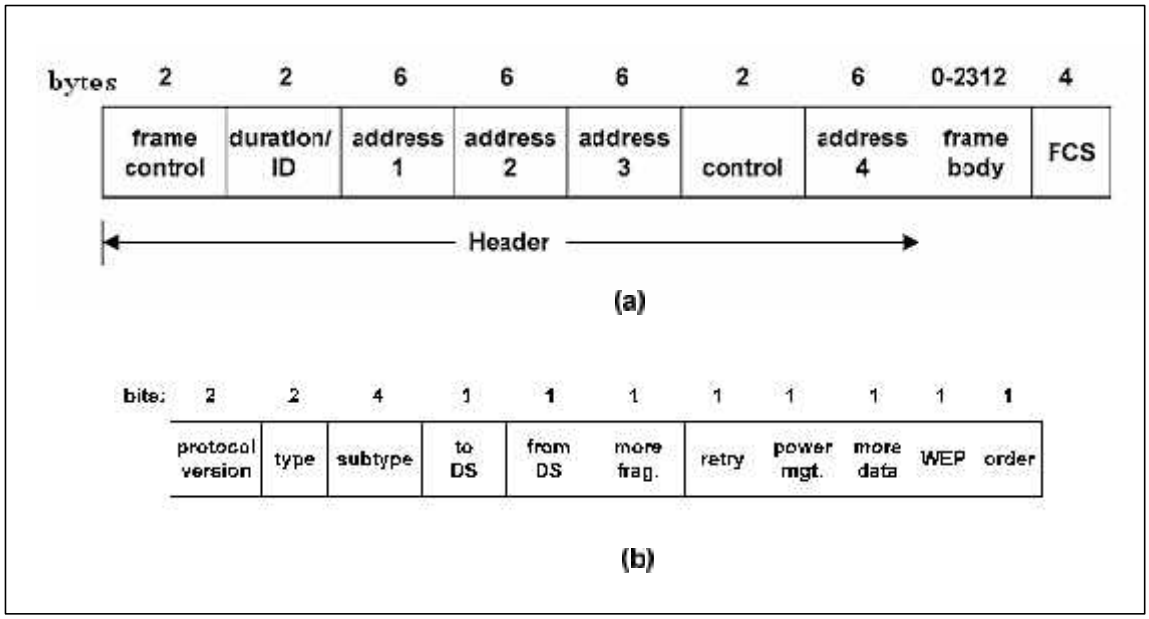


Figure 2-13: MAC frame format:(a)IEEE 802.11 frame format
(b)frame control field

The frame format has many fields ,each one is explained as the following:

1-Frame control field is 16 bits ,it contains the following subfields:

- Protocol version(2 bit): it is used to indicate the version of the current protocol.
- Type(2 bit):it is used to indicate if the frame function is control(01)or management(00) or data(10).
- Subtype: each type has many types , these types are indicated using subtype field which has 4 bit .For example management frame has 0000 for association request and 0010 for reassociation request .
- To DS(1 bit):it is used to indicate if the frame is sent from the station to an AP, in this case the bit value is 1.
- From DS (1 bit):it is used to indicate if the frame is sent from an AP to the station, in this case the bit value is 1.

- More fragments(1 bit): it is used to indicate if the frame is not the last fragment of data.
- Retry (1 bit): it is used to indicate if the frame is transmitted for the first time or it is retransmitted.
- Power management(1 bit): it is used to indicate the mode of the station after the frame transmitted successfully .If it is 0 then the station is in active mode ,if it is 1 then the station is in power save mode.
- More data(1 bit): if this bit is 1 then there is at least one frame buffered at the AP for the station, if it is 0 then there is no frame buffered .
- WEP(1 bit):it is used to indicate if the security mechanism is applied or not.
- Order(1 bit): it is used if this bit is 1 ,the received frame will be processed in restrict order.

2- Duration/ID : its length is 16 bit it has updating information for NAV. the station used this information to retrieve the frames that are buffered at the AP.

3-Address 1: its length is 6 bit. It is the address of the MAC that transmitted the frame through the wireless medium, so it is called the transmitter address (TA).

4- Address 2: it has 6 bit length .It is the address of the MAC that received the frame ,for this reason it is called the receiver address (RA).

5- Address 3: it is also 6 bit length. It is called the source address, because it point to the MAC that originated the frame.

6- Address 4: it has 6 bit length .it is the address of the destination that the frame is sent to,so it is called the destination address.

7-Sequence control: it includes two subfields ,4-bit fragment number and 12-bit sequence number.

8- frame body: this field contains the information specific to the management frame .Its length is variable

9- Frame check sequence(FCS): it contains the results of applying the CCIT CRC-32 polynomial[1] on the header and frame body.

[1] **G(x)**= $x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1$

2.9.2 Special control packets

The special control packets are:

1- Request To Send(RTS): RTS frame format[1] is shown in figure 2-14(a).

2- Clear To Send(CTS): CTS frame format is shown in figure 2-14 (b).

3- Acknowledgment(ACK): ACK frame format is shown in figure 2-14(c)

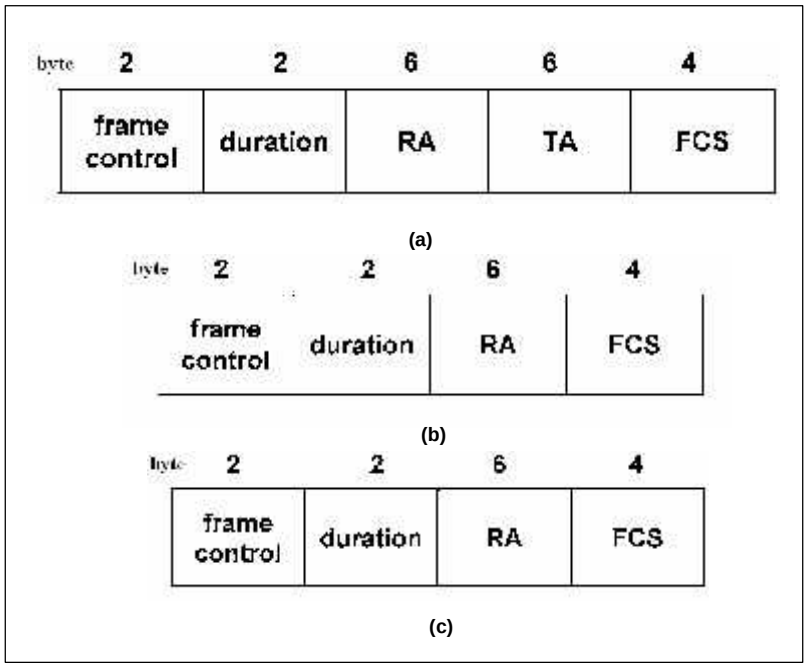


Figure 2-14: (a) RTS frame format
(b)CTS frame format
(c) ACK frame format

[1] all subfields are described in the previous section

2.10 Some enhancements of WLAN

- 802.11a allows for data rate 54Mbps and 5GHz band and use orthogonal frequency division multiplexing ,which use multiple carrier signal at different frequencies and send some bit on each frequency ,but its suffers problems with coverage because it utilizes the five GHz band ,so its covers small area ,and another problem in 802.11a devices which share the same spectrum to radar and satellite communication system ,also some countries require to mechanism for operation dynamic frequency selection (DFS) and transmit power control (TPC).
- 802.11 b is the original Wi-Fi standard ,providing 11Mbps using DSSS on the 2.4GHz band
- 802.11 g enhances data rate to 54 Mbps using OFDM modulation on 2.4 GHz band .interoperable in the same network with 802.11 b.

CHAPTER THREE

3

SYSTEM MODEL

3.1 Preface

3.2Project scenario

3.3 Flow chart

3.4 software

3.5 system components

3.6 Interface between access point and station

Chapter three

System Model

3.1 Preface

This chapter explains the system model of the project. It includes the scenario and the soft wares needed .it explains the system components and how they relate .

3.2 Project scenario

As you see in a scenario (figure 3-1)some access points are loaded, because station send sequence of frame to busy the basic service set (BSS), and other laptops located at the coverage of two or more access point, so any laptop must decide at any access point should be connect, this decision according to the received signal strength and the load in each.

There are problem will face our such as the interference, since the power maybe reach each other if the distance insufficient to far them, so we do experiment when the access point at the same channel and at different channel and at the region of coverage more than one access point and note the behavior of station, if the station found that the access point is loaded it will transfer to another one not loaded, but if all access point is loaded nothing will happen.

3.3 Flow chart

The flow chart of the system is shown in figure 3-2.

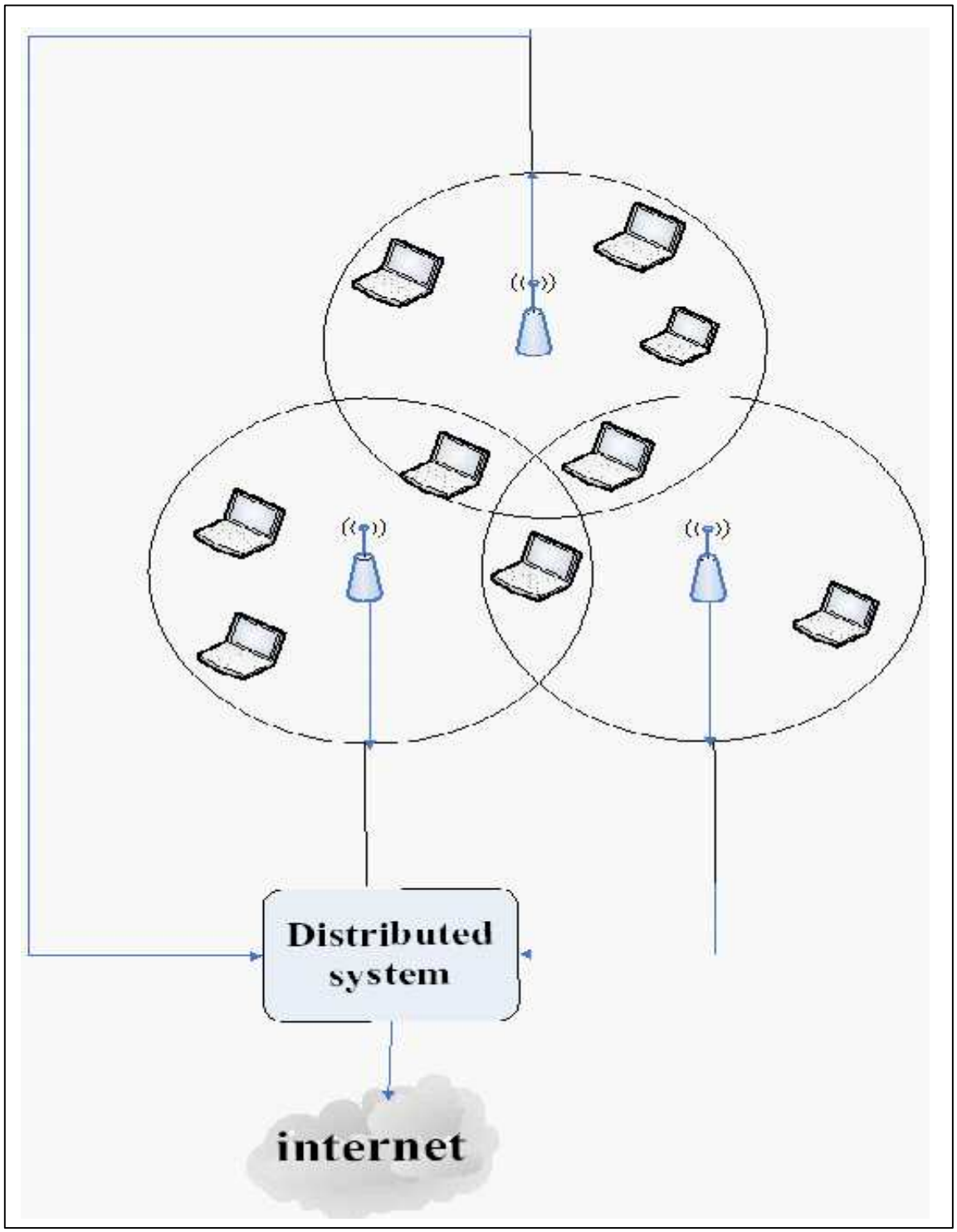


Figure 3-1: the project scenario

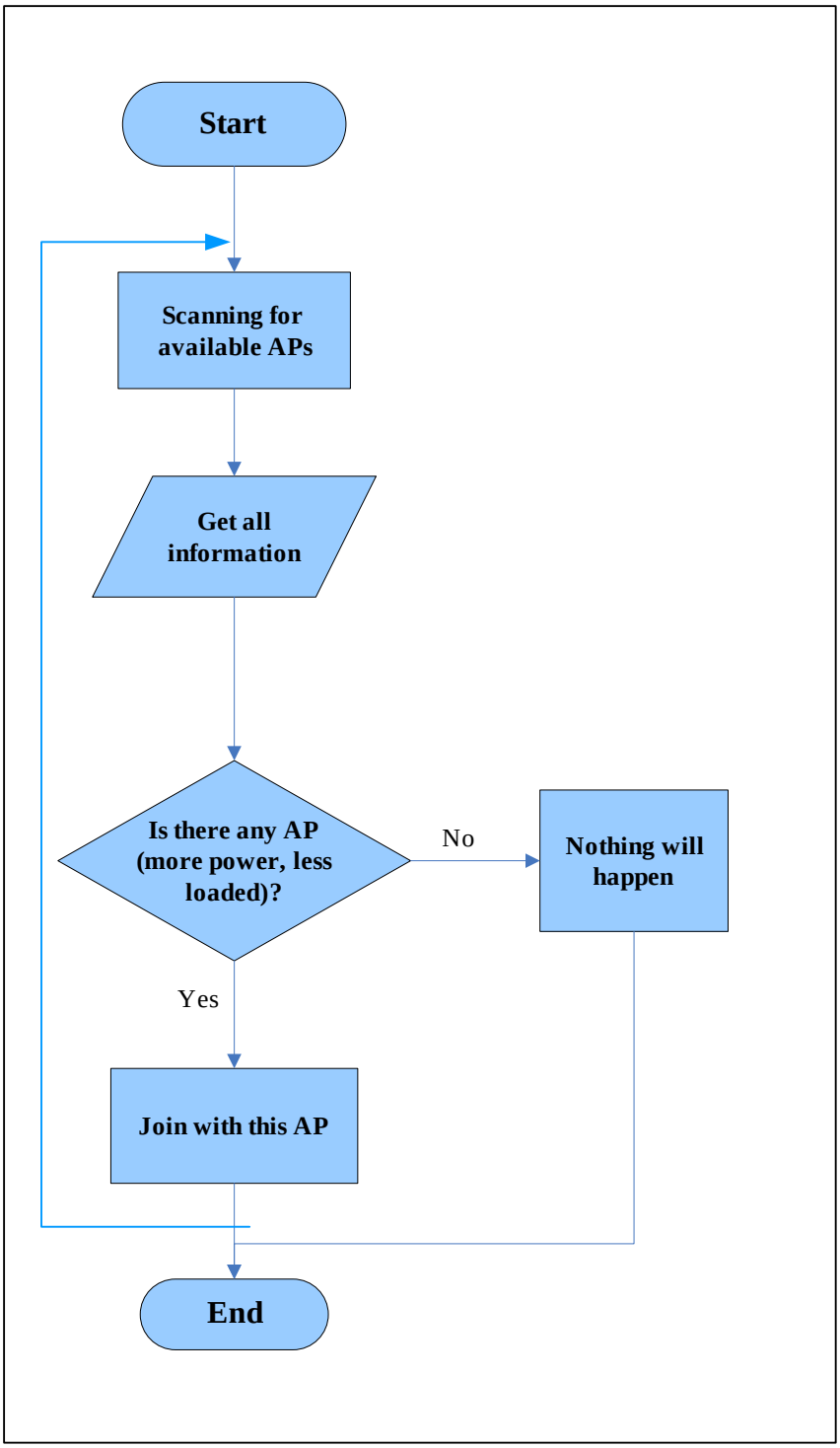


Figure 3-2: flow chart

3.4 Softwares

3.4.1 Linux

Linux :is operating system built in C language which is robust, stable and secure. the Linux WLAN support various card such as net gear wireless network cards have ordinary Ethernet names like eth0, and can also be normally addressed with tools like ifconfig or ip. and can manipulate the basic wireless parameters ,allow to initiate scanning and list frequencies, bit-rates, encryption keys, allow to get per node link quality ,allow to manipulate the Wireless Extensions specific to a driver (private) and allow to name interfaces based on various static criteria by using wireless commands(iwconfig,iwlist,iwspy,iwpriv,ifrename,...etc) .
In our project we install fedora and down load MAD WiFi driver to activate these commands.

3.4.2 Madwifi (Multiband Atheros Driver for Wireless Fidelity)

One of the most advanced WLAN driver available for Linux .It is a computer program allowing higher –level computer programs to interact with a hardware device ,and it communicate with the hardware (Network Gear Interface Cards) through computer bus ,and can describe it as translator b/w hardware device and the application operating system that use it .Madwifi abstracted into logical and physical layers .Logical layer process data for a class of devices .Physical layer communicate with the device (NGIC).When the (NGIC) needs to respond to the OS ,it uses the Physical layer to speak with the logical layer and the OS use logical layer to implement OS request to the physical layer that operate with hardware .

Operation modes in Madwifi :

- Station:

The (NGIC)will operate as typical WLAN client station (and it is the default mode if not otherwise specified .

- AP(Access point) :

The (NGIC) will operate as the Access point for other WLAN client stations .

- Adhoc (Ad-hoc) :

This device is in a peer-to-peer(s) WLAN without the need for an Access point .

- Monitor :

The (NGIC) can be used to “sniff” raw 802.11 frames .

- Wds (Wireless distribution system) :

(NGIC) can be used to create layer wireless network by linking several Access point together .Some of features that have been designed to increase throughput and a achievable ,including frame a aggregation ,jumbo frames ,on –the –fly data compression and channel bonding .

- Seamless Roaming :

Switch seamlessly to another access point if the current link gets weak .

- Wi-Fi Multimedia :

-Quality of Services extensions for WLAN (IEEE 802.11e).

-Transmit Power Control (TCP) .

-Automatic adjustment of transmit power (IEEE 802.11h).

-Dynamic Frequency Selection (DFS) .

-Automatically avoids channels that are used by radar and similar applications (IEEE 802.11h).

-Background Scanning :Scanning other channels without loosing data .

3.5 System components

1-Netgear card: it is shown in figure 3-2

PROXIM ORiNOCO 802.11b/g Gold (Model:8470-WD)

Driver:Madwifi-ng

Chipset: Atheros

Notice :To set monitor mode type "airmong-ng start wifi0"and then use ath1

If your card does not appear to be recognize when you first insert it ,type "modeprobe ath pci"and then run "dmes" again.

(a)

(b)

Figure 3-3:Netgear card for :(a) laptop (b) pc computer

2-Laptop

We will use many laptop to installing programs to do scanning operation ,traffic the network and other operations required in project ,the soft wares needed in project are Madwifi driver ,Linux and traffic generator .the laptop acts with access point which it transfers data from laptop to another in the same ESS or another or to internet and vice versa ,this transferring is made by the netgear card that is connected with laptop.
The traffic generator will operate by using laptop to make the access point busy by sending frame, in this case the access point become loaded .

3-Access point

We can describe it as a bridge to access data to the specified destination .The access point will be compatible with the network interface card (NIC) . AP providing wireless telecommunications interfaces which comprises: a radio frequency (RF) to transmit and receive data and contain a buffer and memory unit for storing data temporarily .

3.6 Interface between access point and station

As we mentioned in chapter two the scanning and joining. The access method of the MAC is CSMA/CA must be implemented in all stations, because any station that wishes to transmit a frame senses media to check whether other stations are transmitting frames. If the media are not busy, a transmission operation starts.

CHAPTER FOUR 4

EXPERIMENTS

4.1 Preface

4.2 The executed experiments

4.3 Results of experiments

Chapter Four

Experiments

4.1 Preface

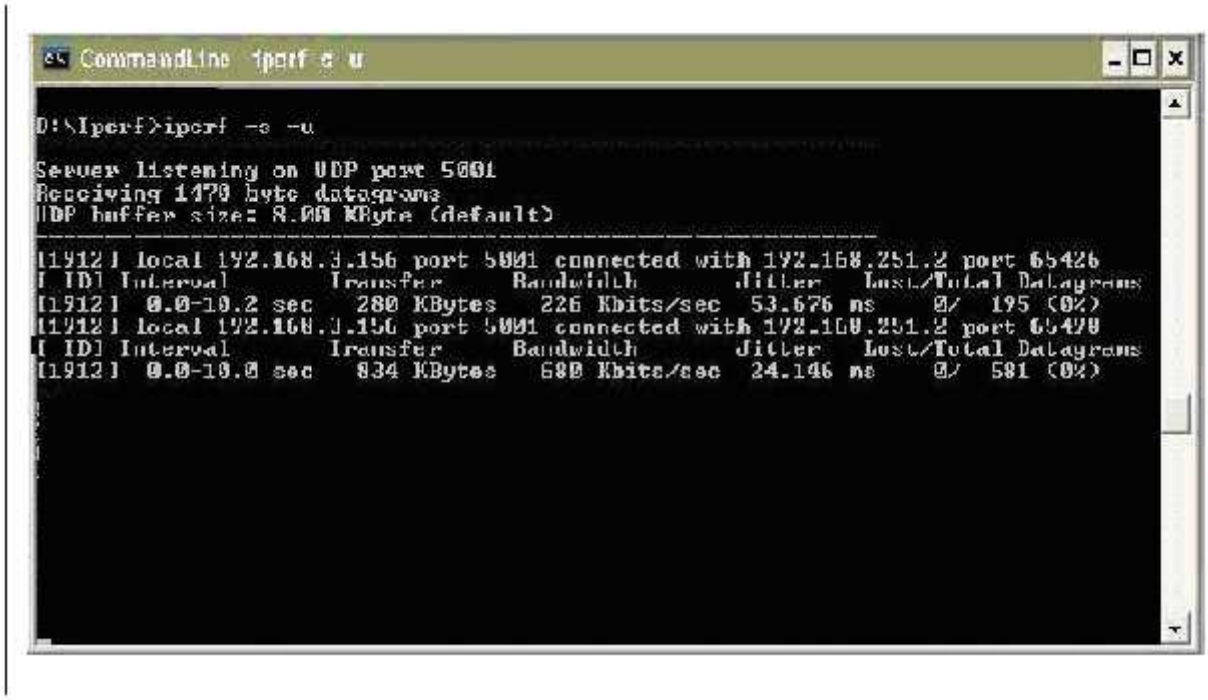
This chapter provides the experiments which we executed, upload experiment and its results , download experiments and its results .It also provides results as curves .

4.2 The executed experiments

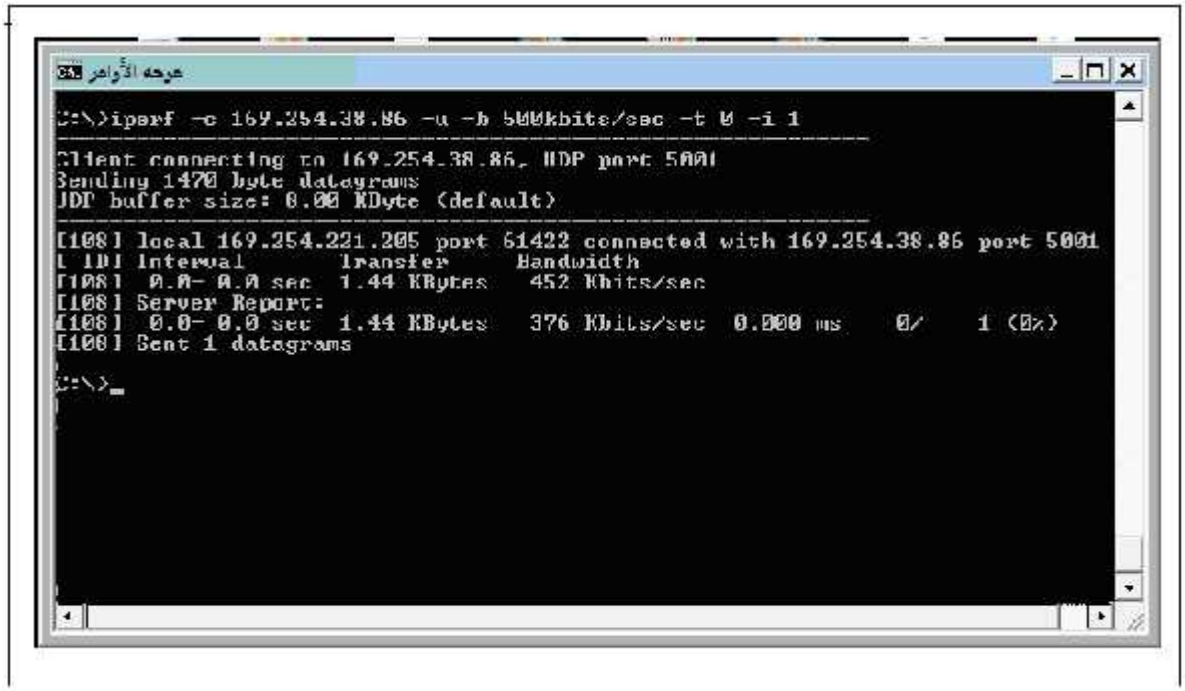
We executed some experiments to explain how the signal strength (RSSI) and bandwidth decrease when the distance between the station(client) and the access point increases and the load from the loader increases.

These experiments need hardware and software . The only software that we used is Iperf . Iperf is a simple server-client based tool for measuring TCP and UDP performance between two endpoints. We make the software to run in server mode and to measure UDP throughput by using (iperf –s –u) command (figure 4-1a), and we make it in another computer to run in a client mode by using (iperf -c IP address -u) command (figure 4-2b). Where s means server, c means client and u to measure UDP throughput . We put the IP address to till the client that the server is located at that IP address.

The hardware that we used is two access points and three laptops, one as a server and two as clients .The clients are divided into a loader and a client. loader's function is to increase the load on AP, number of bits per second ,while the client has a fixed load .



(a)



(b)

Figure 4-1: (a)the server (b) the client

We executed two experiments as follow:

First experiment

Upload : the client (station) sends to the server ,figure 4-2. This experiment is divided in three stages ,each time the distance between the client and the AP increases**.**

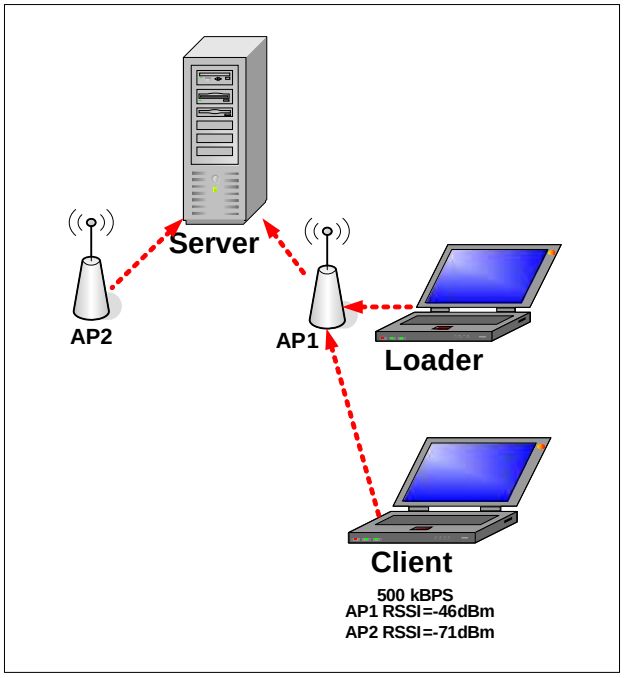
First stage, loader is nearer to AP1 than the client , we examine the RSSI [1]of AP1 at loader and client(-46dBm) locations and we note that it is higher at loader than client. As we explained previous the loader increases its load (bits/sec),in our experiments we started the load at 100Kbps and each time increases by 100Kbps until it reaches 10000Kbps then it increases by 1Mbps (shown in figures[2]) , and the client has 500Kbps . At each time the load increases we take note of the bandwidth of the client ,then we make the client to load on another access point (AP2) has less load but less RSSI (-71dBm).

Second stage is the same as the first one ,but the distance between AP1 and the client increases . Third stage is also the same as the previous stages but the distance between the client and AP1 increases more .

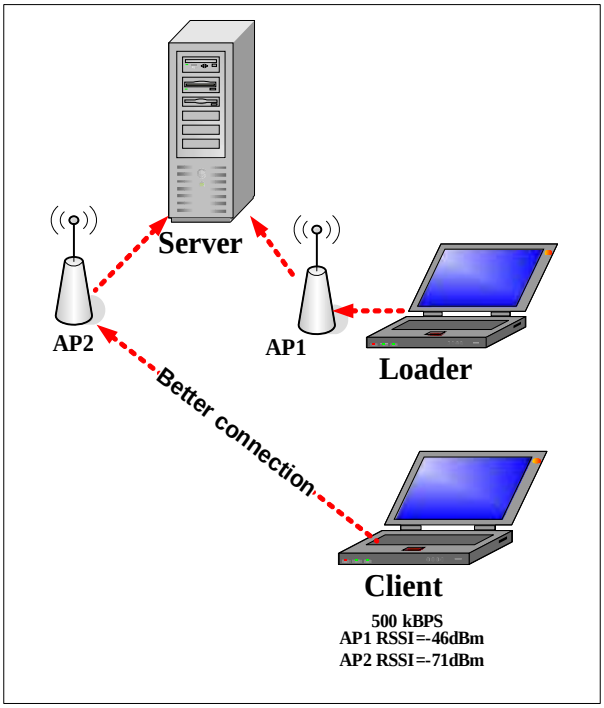
Second experiment

Download: the sever sends to the client .This experiment is divided in two stages as experiment one, each time the distance between the client and the AP increases. Here we used additional hardwares ,we used a switch and another server ,shown in figure 4-3. Server 1 sends to AP1 increased load, server 2 sends to AP2 fixed load .

[1] The way that we used to measure RSSI is explained in chapter five.
[2] The figures are shown in appendix .



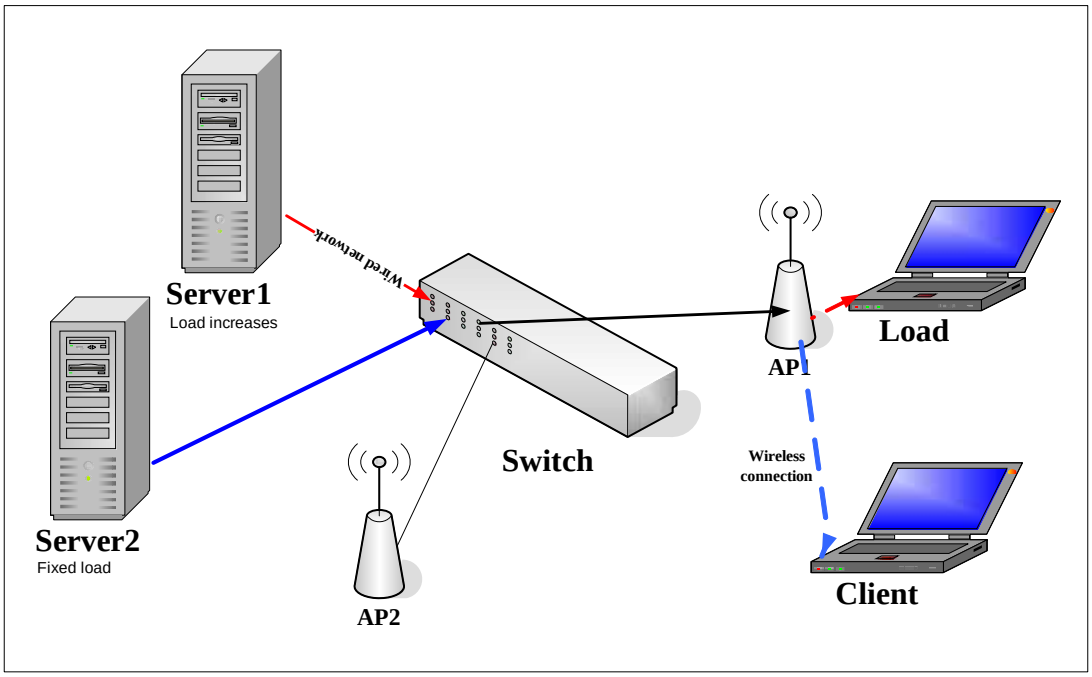
(a)



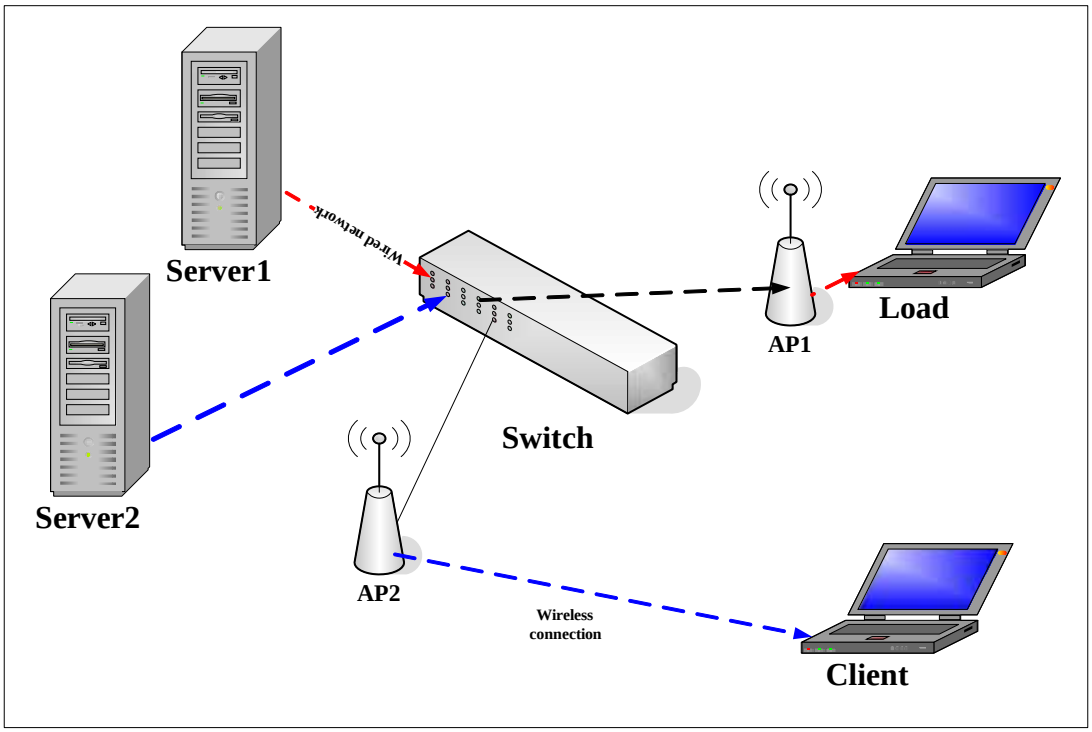
(b)

Figure 4-2 :Upload experiment(a) Client associates with AP1

(b) Client associates with AP2



(a)



(b)

Figure 4-3:Download experiment (a)client associates with AP1
(b)client associates with AP2

4.3 Results of the experiments

Results of the experiments are summarized in the following tables .

load kbits/sec	goodput kbits/sec		
100	499		
200	494		
300	500		
400	494		
500	498		
600	490		
700	470		
800	467		
900	452		
1000	436		
2000	420		
3000	406		
4000	392		
5000	346		
6000	327		
7000	318		
8000	309		
9000	261		
10000	111		
11000	11.7	maximum BW	load
12000	11.7	maximum BW	load
13000	11.7	maximum BW	load
14000	11.7	maximum BW	load
15000	11.7	maximum BW	load
16000	11.7	maximum BW	load
17000	420	at AP1	
18000	470	at AP2	

(1-a)

load kbits/sec	goodput kbits/sec	
100	452	
200	436	
300	436	
400	420	
500	368	
600	420	
700	406	
800	318	
900	327	
1000	245	
2000	203	
3000	193	
4000	190	
5000	113	
6000	103	
7000	90.5	
8000	71.3	
9000	84	
10000	84	
11000	82.2	
12000	11.7	at maximum load
13000	11.7	at AP1
14000	490	at AP2

(1-b)

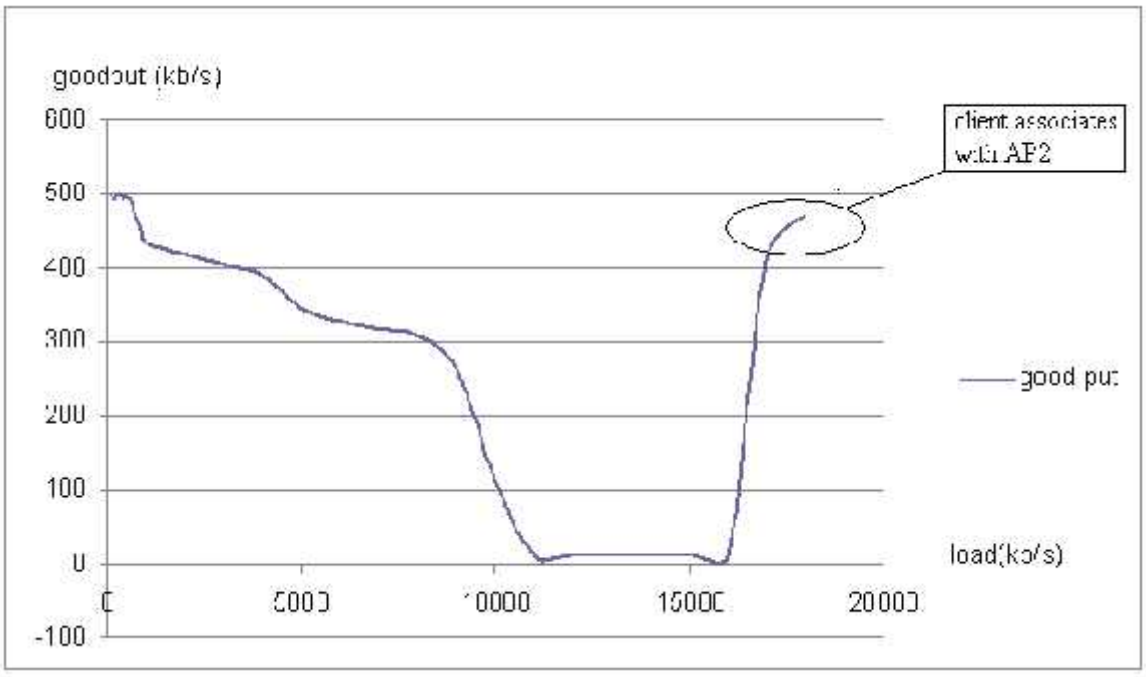
load Kbits/sec	goodput Kbits/sec	
100	490	
200	452	
300	406	
400	392	
500	318	
600	309	
700	287	
800	267	
900	226	
1000	210	
2000	203	
3000	173	
4000	170	
5000	166	
6000	134	
7000	118	
8000	114	
9000	104	
10000	84	
11000	71	
12000	11.7	maximum load
13000	11.8	maximum load
14000	11.8	maximum load
15000	392	at AP1
16000	436	at AP2

(1-c)

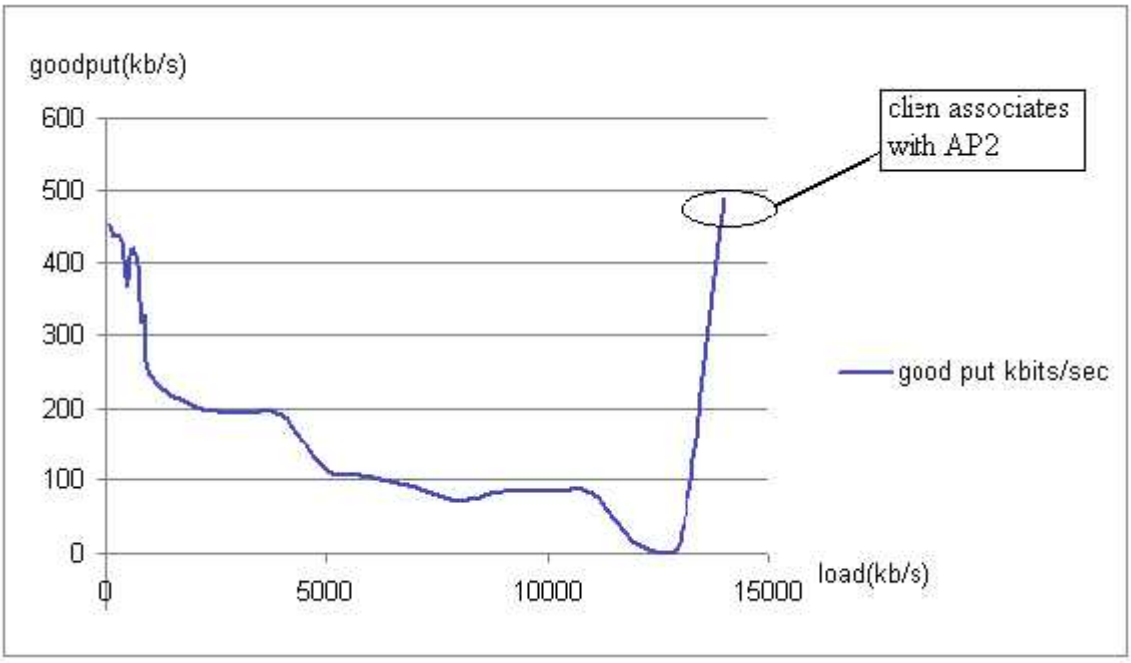
Table 4-1:Upload experiment (a) first stage
(b)second stage
(c)third stage

From the results[1], we see that in the first stage[2] (RSSI for AP1=-46dBm and for AP2 =-71dBm) the client wasn't affected with the load increasing[3] too much, the effect appear when the load becomes more than 900Kbps ,so the goodput of the client decreases but not much. When the load becomes 11Mbps ,the results don't change ;because 11 Mbps is the maximum rate that we can send ,that is because we used wireless cards(b/g).In the second stage[4](RSSI for AP1=-63dBm and for AP2 =-77dBm), results become clearer; goodput of the client decreases at the beginning (when the load is 100Kbps).At the third stage[5] (RSSI for AP1=-77dBm and for AP2 =-85dBm) ,results become more and more clearer than the previous experiments , goodput of the client decreases in bigger rate. For all stages ,goodput of the client decreases because loader takes higher bandwidth at each time load increases but it increases in high rate after the client associates with AP2 .These explanations are summarized in figure 4-4.

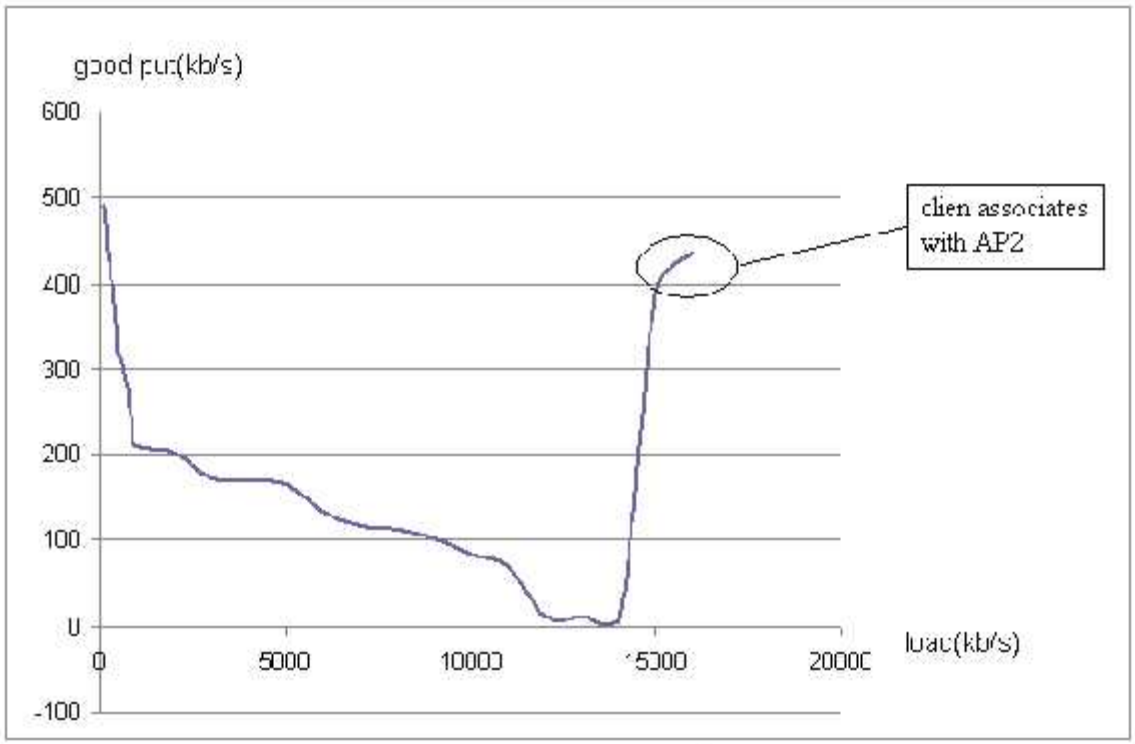
[1] Results in iperf program shown in APPENDIX .
[2] figure 2.
[3] figure 1.
[4] figure 3.
[5] figure 4.


goodput (kb/s)
600
500
400
300
200
100
0
-100
client associates with AP2
good put
load(kb/s)

(4-a)


goodput(kb/s)
600
500
400
300
200
100
0
0
5000
10000
15000
clien associates with AP2
good put kbits/sec
load(kb/s)

(4-b)



(4-c)

Figure 4-4: Upload experiment's results (a) 1st stage

(b)2nd stage

(c)3rd stage

Load Kbits/sec	Goodput(AP1) Kbits/sec	Goodput(AP2) Kbits/sec
500	981	999
600	891	978
700	841	962
800	814	869
900	808	789
1000	771	935
1500	670	654
2000	506	993
2500	356	940
3000	337	824
3500	303	745
4000	299	753
4500	214	789
5000	149	747

(2-a)

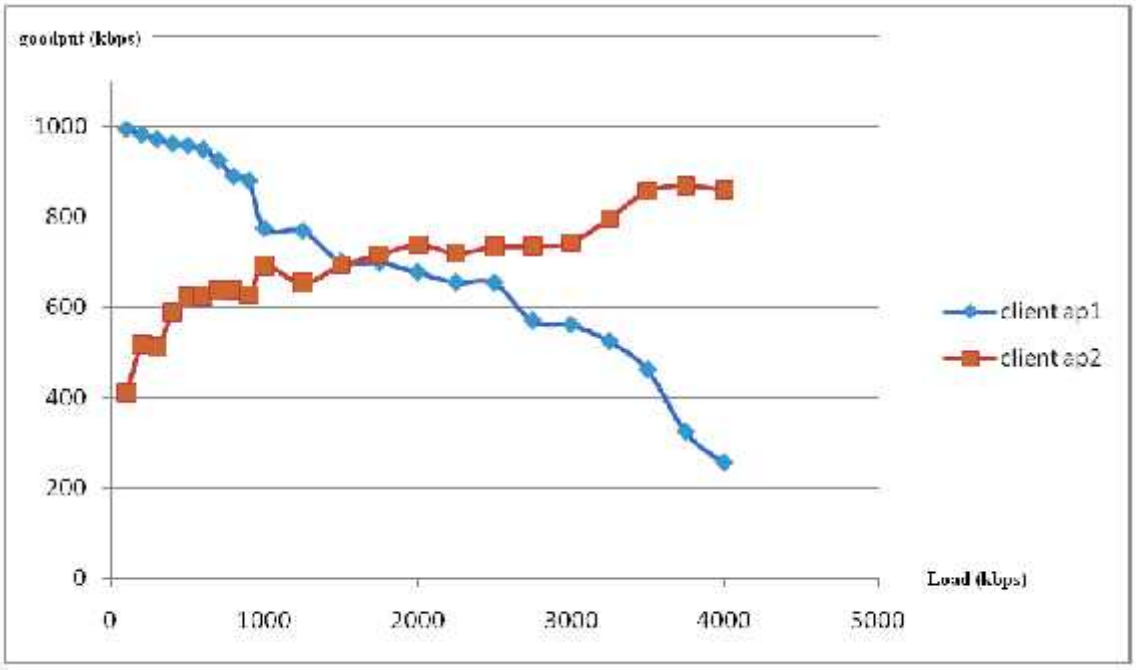
Load Kbits/sec	Goodput(AP1) Kbits/sec	Goodput(AP2) Kbits/sec
100	994	411
200	982	518
300	972	513
400	962	588
500	958	623
600	949	651
700	925	637
800	890	638
900	880	653
1000	774	692
1250	769	651
1500	700	693
1750	699	715
2000	677	738
2250	655	719
2500	654	733
2750	570	735
3000	561	743
3250	525	796
3500	462	856
3750	324	868
4000	256	859

(2-b)

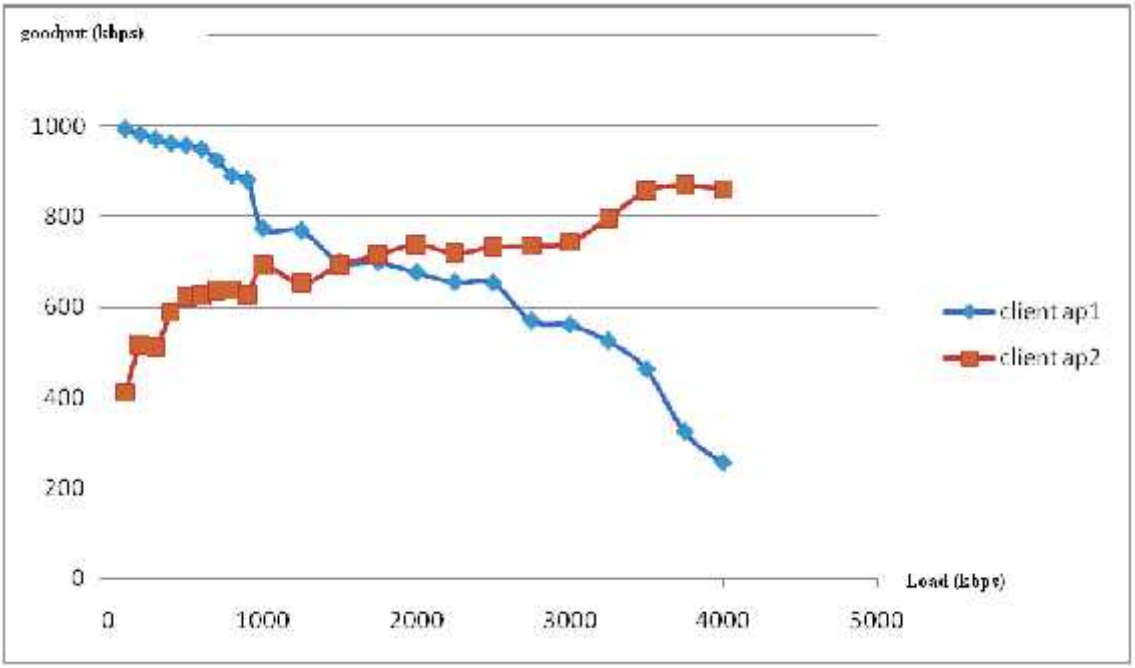
Table 4-2:Download experiment (a) first stage
(b)second stage

In this experiment ,at each time the loader increases , the client associates with AP1 then with AP2 to note the difference in the goodput results between the access points .
From the results[1], we see that in the first stage (RSSI for AP1=-60dBm and for AP2 =-81dBm) the client affected with the loader increasing on AP1from the beginning ,so the goodput decreases, here when the client associates with AP2 we see that the difference between the goodput results is not much ,so it is not necessary for the client to associate with AP2 because the connection doesn't improve much (goodput results are nearly the same).But when the loader becomes 2000Kbps ,the difference becomes clear and it is better for the client to associate with AP2 .
In the second stage ,the distance between the client and the access points increases and the signal power decreases(RSSI for AP1=-80dBm and for AP2= -88dBm), it is clear that the client must be connected with AP1 because although the loader increases ,it is better for the client to associate with AP1(more goodput than AP2) .But When the loader becomes 1750kbps,it is better for the client to associate with AP2(more goodput than AP1) . all of the previous explanations are summarized figure (4-5).

[1] Results in iperf program shown in APPENDIX



(5-a)



(5-b)

Figure 4-5: Download experiment's results (a) 1st stage

(b)2nd stage

CHAPTER FIVE 5

SYSTEM IMPLEMENTATION

5.1 Preface

5. Terminal

5.3 The association with an access point

5.4 Testing power signal level and number of received packets at access point

Chapter Five

System Implementation

5.1 Preface

This chapter provides our working in Linux system ,association with access point and testing power signal level and packets for the access point.

5.2 Terminal

Terminal(figure 5-1) is a window in Linux system used to install any program in Linux .Through it we install Madwifi driver and C++ language ,also we make an association between an access point and a station and we test the signal power level (RSSI) and number of packets that receiving at access point through it using some commands.

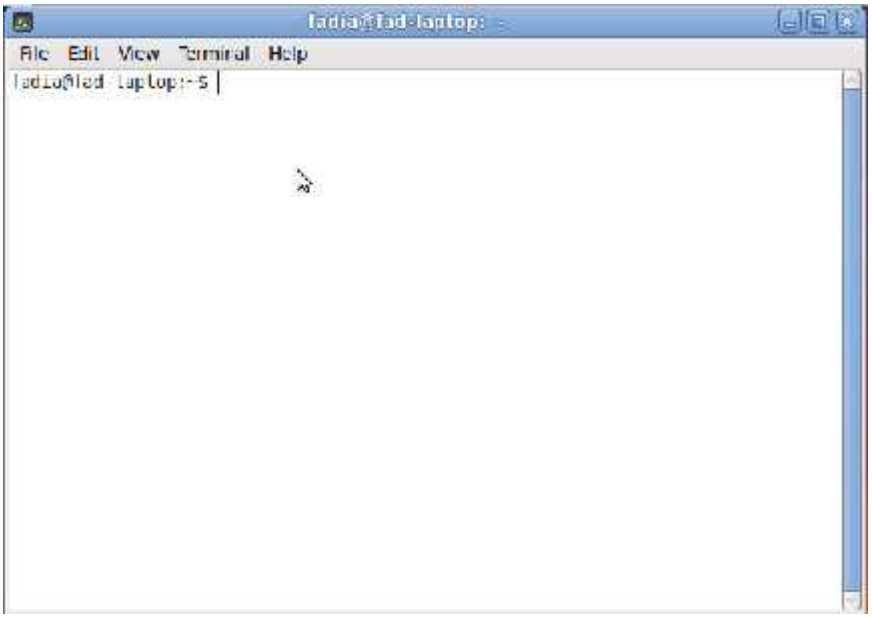


Figure 5-1: Terminal window in Linux

5.3 The association with an access point

To make an association between an access point and a station we use the command that appear in the following window:

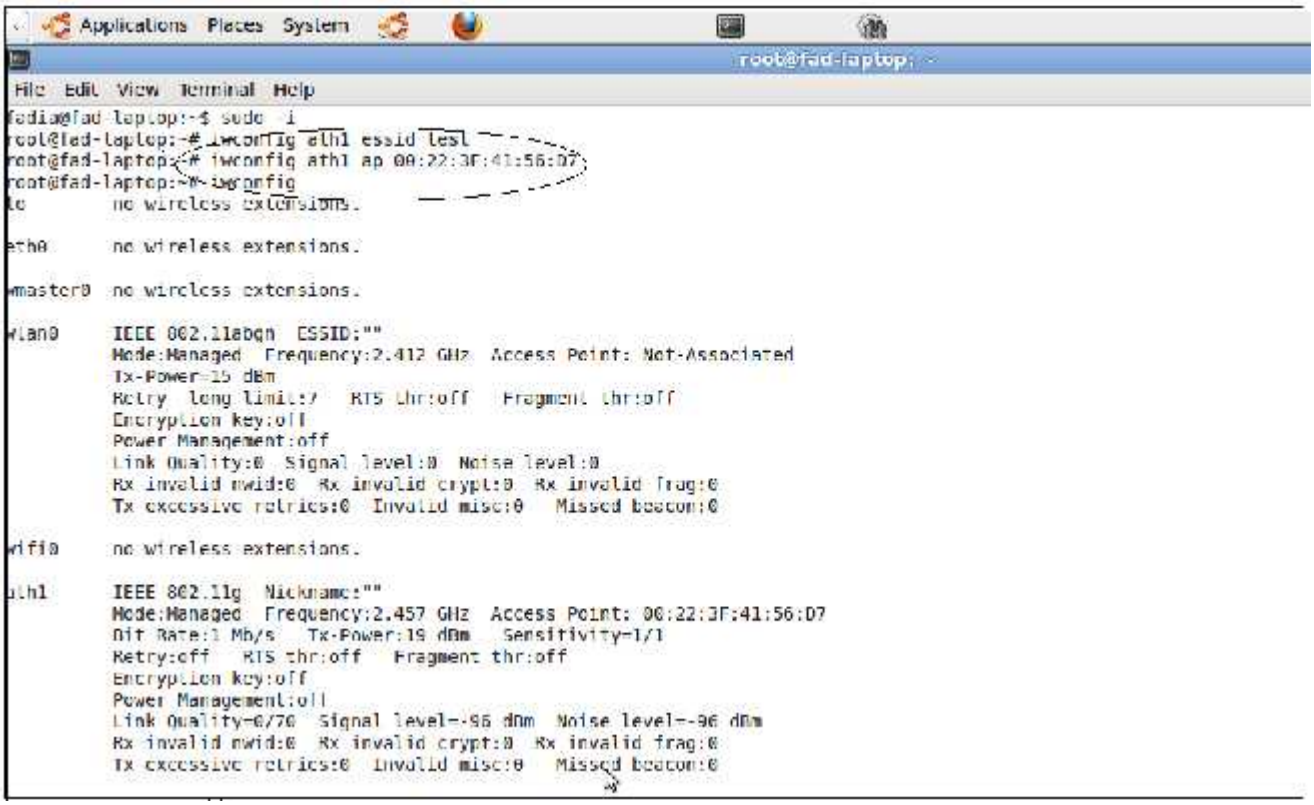


Figure 5-2: association command

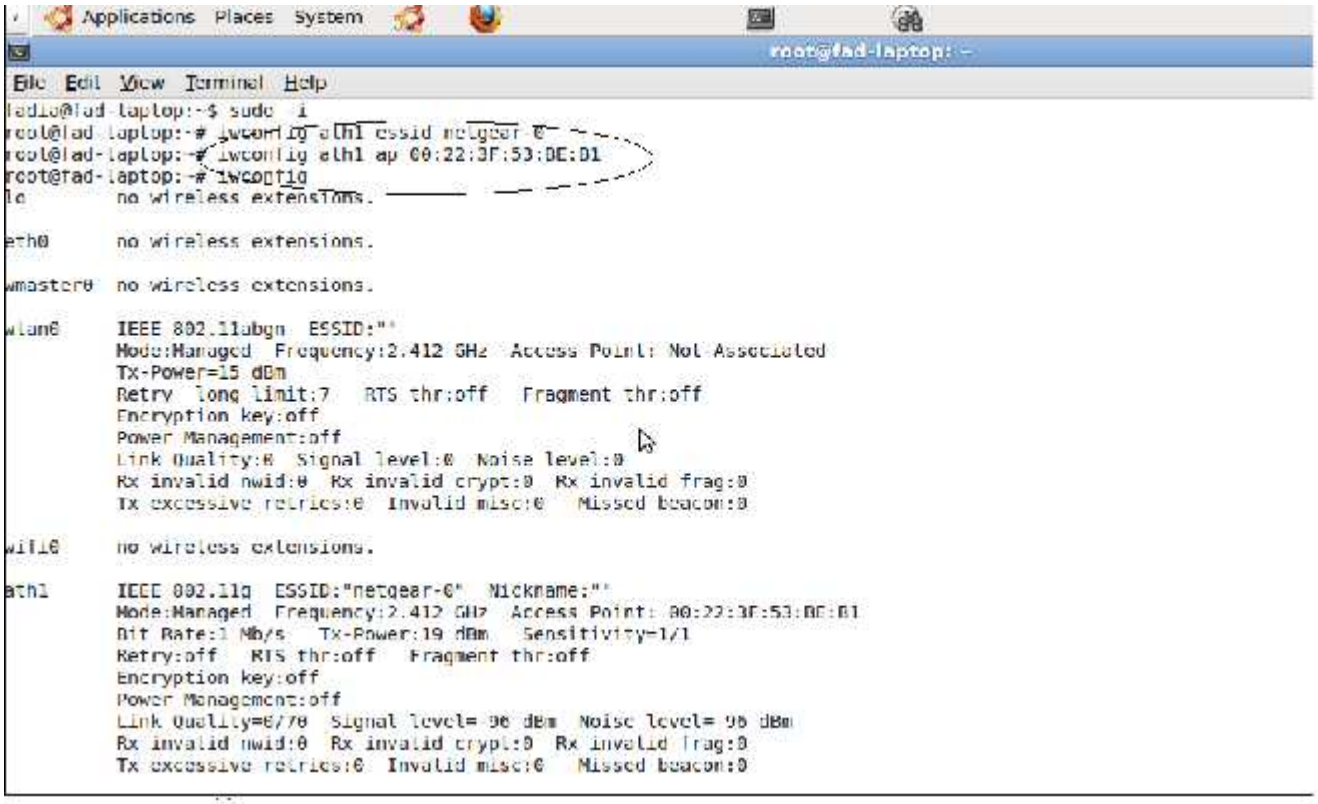


Figure 5-3: Reassociation command

5.4 Testing power signal level and number of received packets at access point

To know the power signal level we use the command :.shown in figure 5-4.

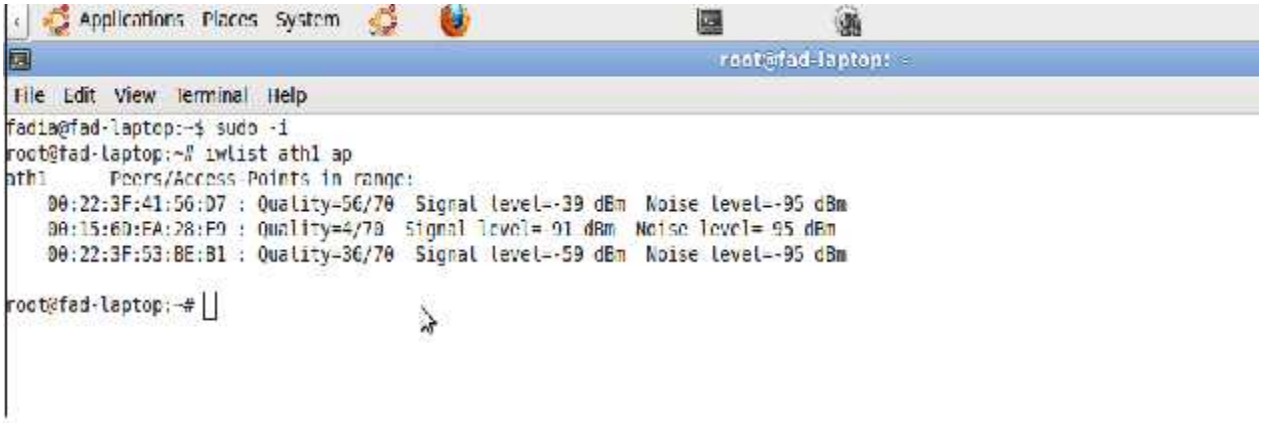
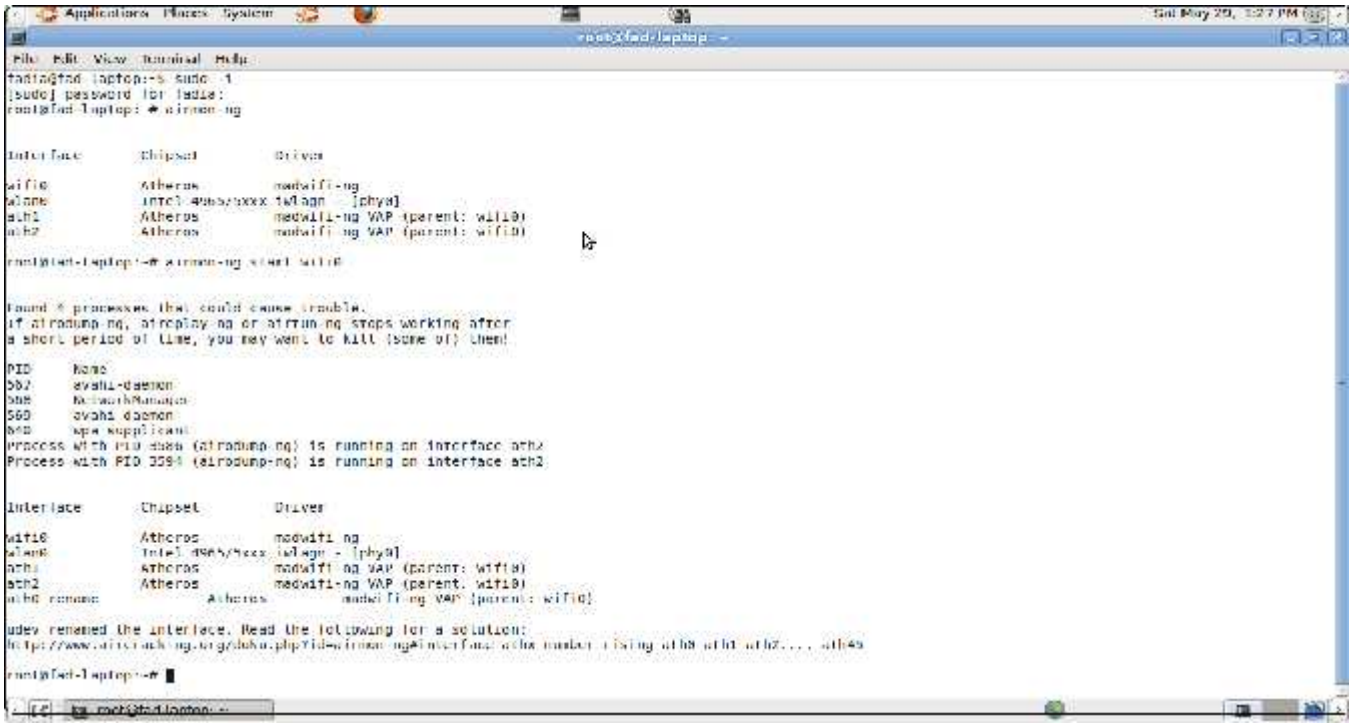


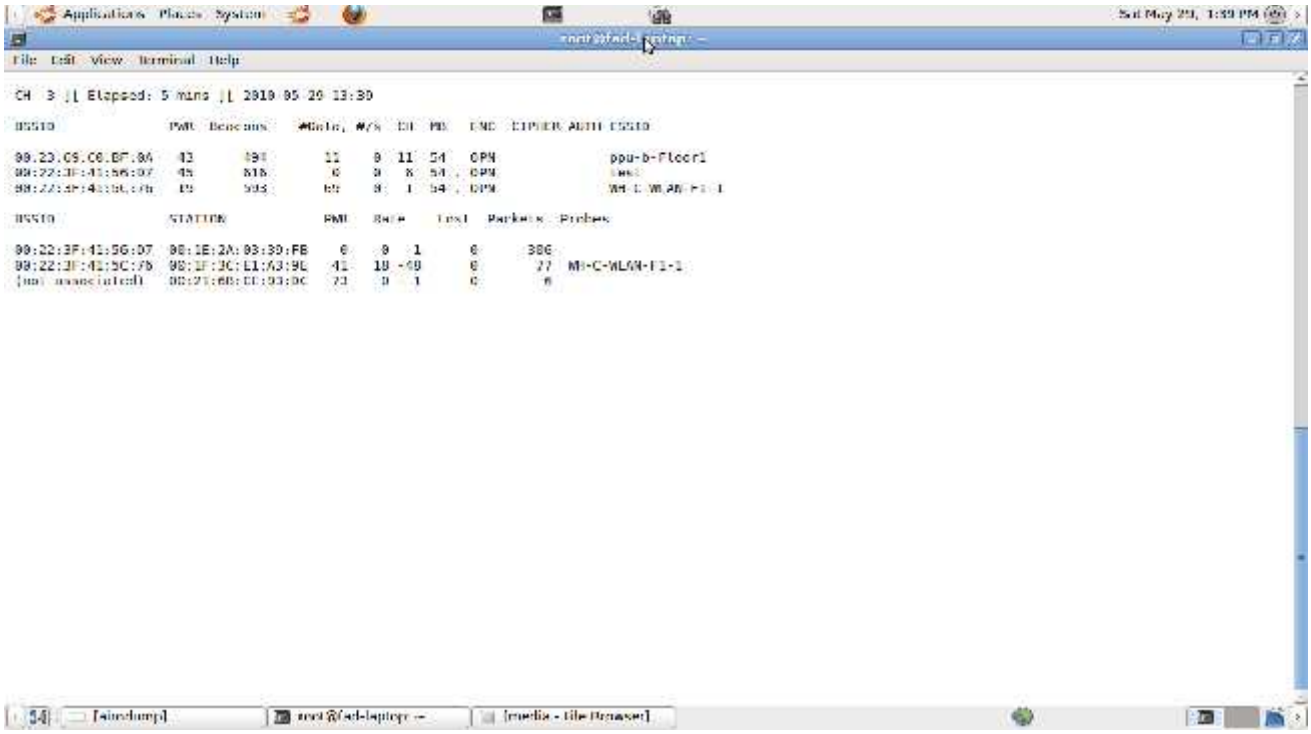
Figure 5-4: Testing power

To know number of packets that the access point receives we use Airodump-ng command

This command is explained in figure 5-5.



(a)



(b)

Figure 5-5: (a) to make the card to run in monitor mode
(b) results from using the command

CHAPTER SIX

6

SUMMARY

6.1 Preface

6.2 Conclusion

6.3 Future works

6.4 Problems

Chapter Six

Summary

6.1 Preface

This chapter provides a summary for the semester, the problems that we face through this project, conclusion from the experiments ,where we stopped and how this project developed in future works.

6.2 Conclusion

From our experiments in this project and what we see in daily life ,signal strength (RSSI) is not enough to choose which access point is the best but also there is another factor that affect on the communication quality between the access point and the station(client).It is load factor, it's a very important factor. This factor exists but theoretically . If RSSI is higher in AP2 and load is higher too and the station reassociates with this AP2 ,the connection won't improve .the differentiate must be in both RSSI and load . From the previous experiments we improved that it is better for the client (mobile station) to reassociate with another access point which has less power (less RSSI) and less load (number of bits per second) . This improved communication between the client and the access point and this is very clear in the goodput results of the experiments [1].

6.3 Future Work

Technology grows and developed daily especially in network subject (local area network) so we can't limited the future works ,it will be very wide .But there is an idea to reach to programming the driver.

[1] shown in chapter four

6.4 Problems

we face many problems in this project because it’s base is software ,programming in c language and this is the weak point that we have . At the beginning of the semester we found a problem in installing Linux system from fedora to ubuntu along a month ,then a problem in installing Madwifi driver ,traffic generator and C++ language on Linux system, in addition to that wireless cards became too late so we lost a half semester without doing any important thing. But in the second half we worked more hard ,we executed the experiments that we repeat more than one time .In c language the problem becomes more complex so we couldn’t finish the code in c ++ .another problem ,there isn't enough equipments in the university and the graduation projects lab was opened for a day and closed for ten days so we couldn’t find a suitable places to work in the project.

Related works

[1] Facilitating Access Point Selection in IEEE 802.11 Wireless Networks, S. Vasudevan, K. Papagiannaki, C. Diot, J. Kurose and D. Towsley.

[2] Improved Access Point Selection , Anthony J. Nicholson, Yatin Chawathe , Mike Y.Chen, Brian D. Noble, David Wetherall .

References

[1] " Mobile communications", Jochen schiller, second edition.

[2] "Wireless communications" , Rappaport,2002.

[3] "Wireless communications", Andrea Goldsmith, 2005

[4] "Mobile wireless communications", Mischa schwartz.

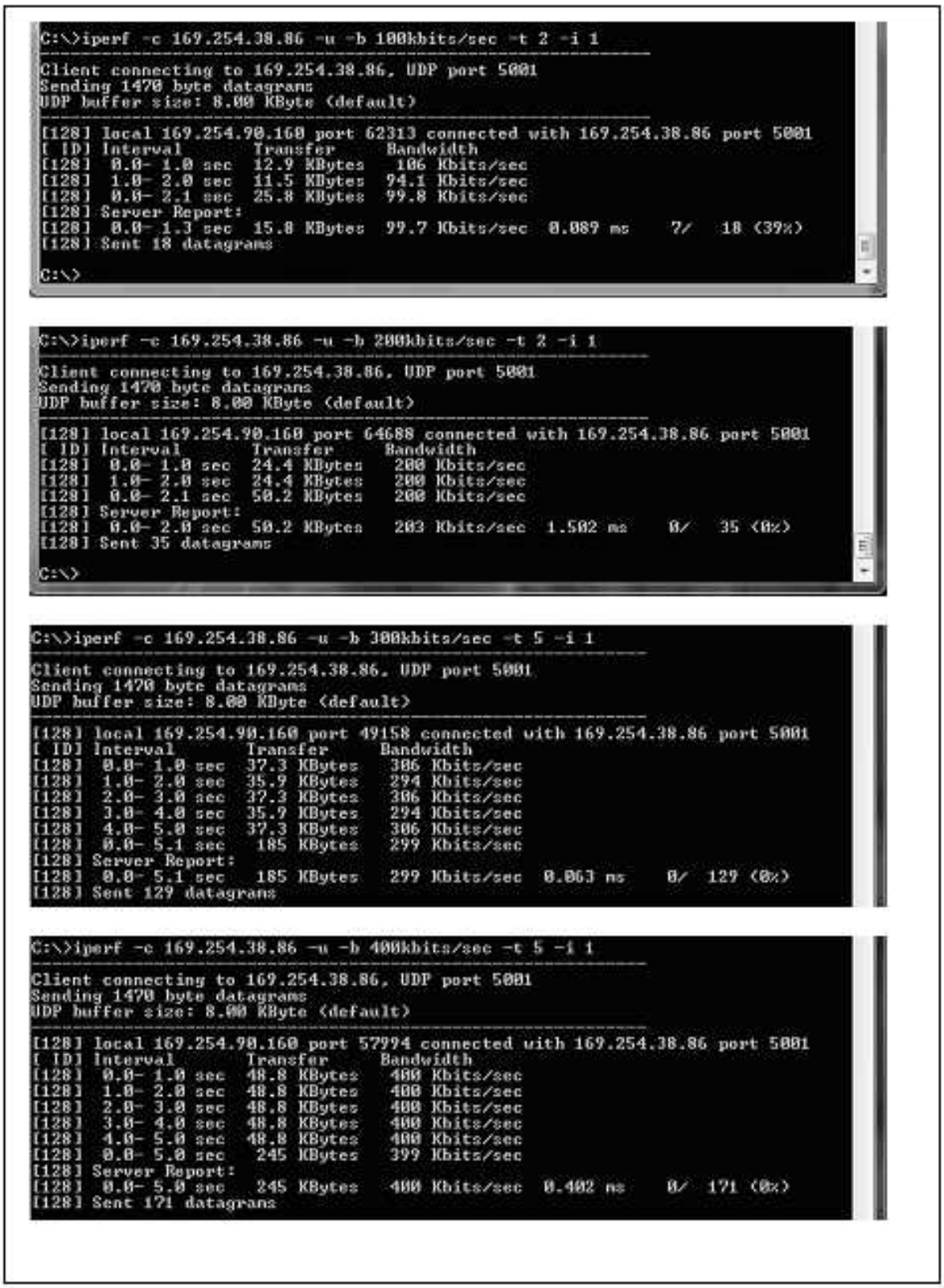
[5] http://www.faqs.org.

[6] http://en.wikipedia.org/wiki/Wireless_LAN

[7] www.networkcomputing.com

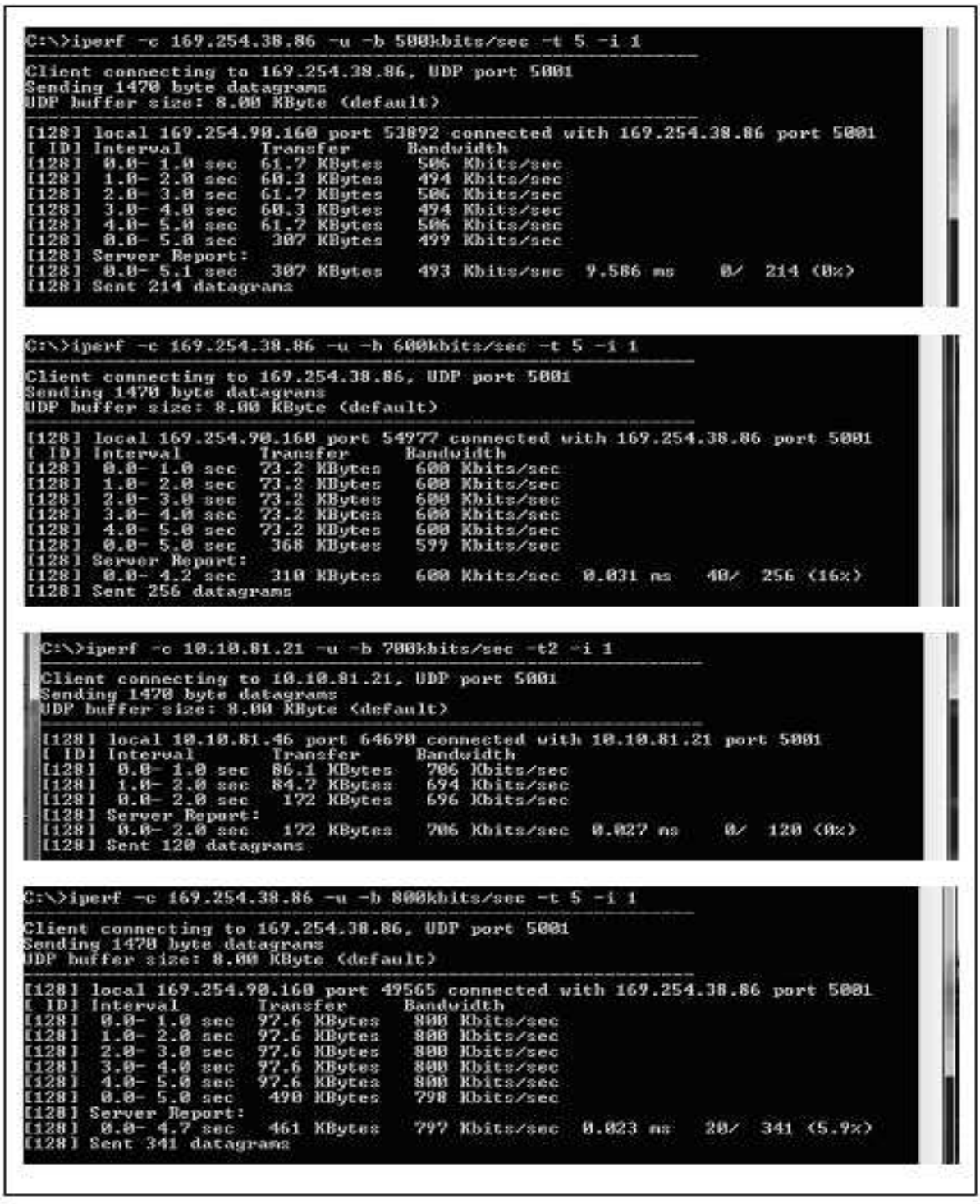
[8] http://webfolder.wireless leiden.nl/ iperf .

APPENDIX


C:\>iperf -c 169.254.38.86 -u -b 100kbits/sec -t 2 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 169.254.90.160 port 62313 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 12.9 KBytes 106 Kbits/sec
[128] 1.0- 2.0 sec 11.5 KBytes 94.1 Kbits/sec
[128] 0.0- 2.1 sec 25.8 KBytes 99.8 Kbits/sec
[128] Server Report:
[128] 0.0- 1.3 sec 15.8 KBytes 99.7 Kbits/sec 0.089 ms 7/ 18 (39%)
[128] Sent 18 datagrams
C:\>
C:\>iperf -c 169.254.38.86 -u -b 200kbits/sec -t 2 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 169.254.90.160 port 64688 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 24.4 KBytes 200 Kbits/sec
[128] 1.0- 2.0 sec 24.4 KBytes 200 Kbits/sec
[128] 0.0- 2.1 sec 50.2 KBytes 200 Kbits/sec
[128] Server Report:
[128] 0.0- 2.0 sec 50.2 KBytes 203 Kbits/sec 1.502 ms 0/ 35 (0%)
[128] Sent 35 datagrams
C:\>
C:\>iperf -c 169.254.38.86 -u -b 300kbits/sec -t 5 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 169.254.90.160 port 49158 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 37.3 KBytes 306 Kbits/sec
[128] 1.0- 2.0 sec 35.9 KBytes 294 Kbits/sec
[128] 2.0- 3.0 sec 37.3 KBytes 306 Kbits/sec
[128] 3.0- 4.0 sec 35.9 KBytes 294 Kbits/sec
[128] 4.0- 5.0 sec 37.3 KBytes 306 Kbits/sec
[128] 0.0- 5.1 sec 185 KBytes 299 Kbits/sec
[128] Server Report:
[128] 0.0- 5.1 sec 185 KBytes 299 Kbits/sec 0.063 ms 0/ 129 (0%)
[128] Sent 129 datagrams
C:\>iperf -c 169.254.38.86 -u -b 400kbits/sec -t 5 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 169.254.90.160 port 57994 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 48.8 KBytes 400 Kbits/sec
[128] 1.0- 2.0 sec 48.8 KBytes 400 Kbits/sec
[128] 2.0- 3.0 sec 48.8 KBytes 400 Kbits/sec
[128] 3.0- 4.0 sec 48.8 KBytes 400 Kbits/sec
[128] 4.0- 5.0 sec 48.8 KBytes 400 Kbits/sec
[128] 0.0- 5.0 sec 245 KBytes 399 Kbits/sec
[128] Server Report:
[128] 0.0- 5.0 sec 245 KBytes 400 Kbits/sec 0.402 ms 0/ 171 (0%)
[128] Sent 171 datagrams

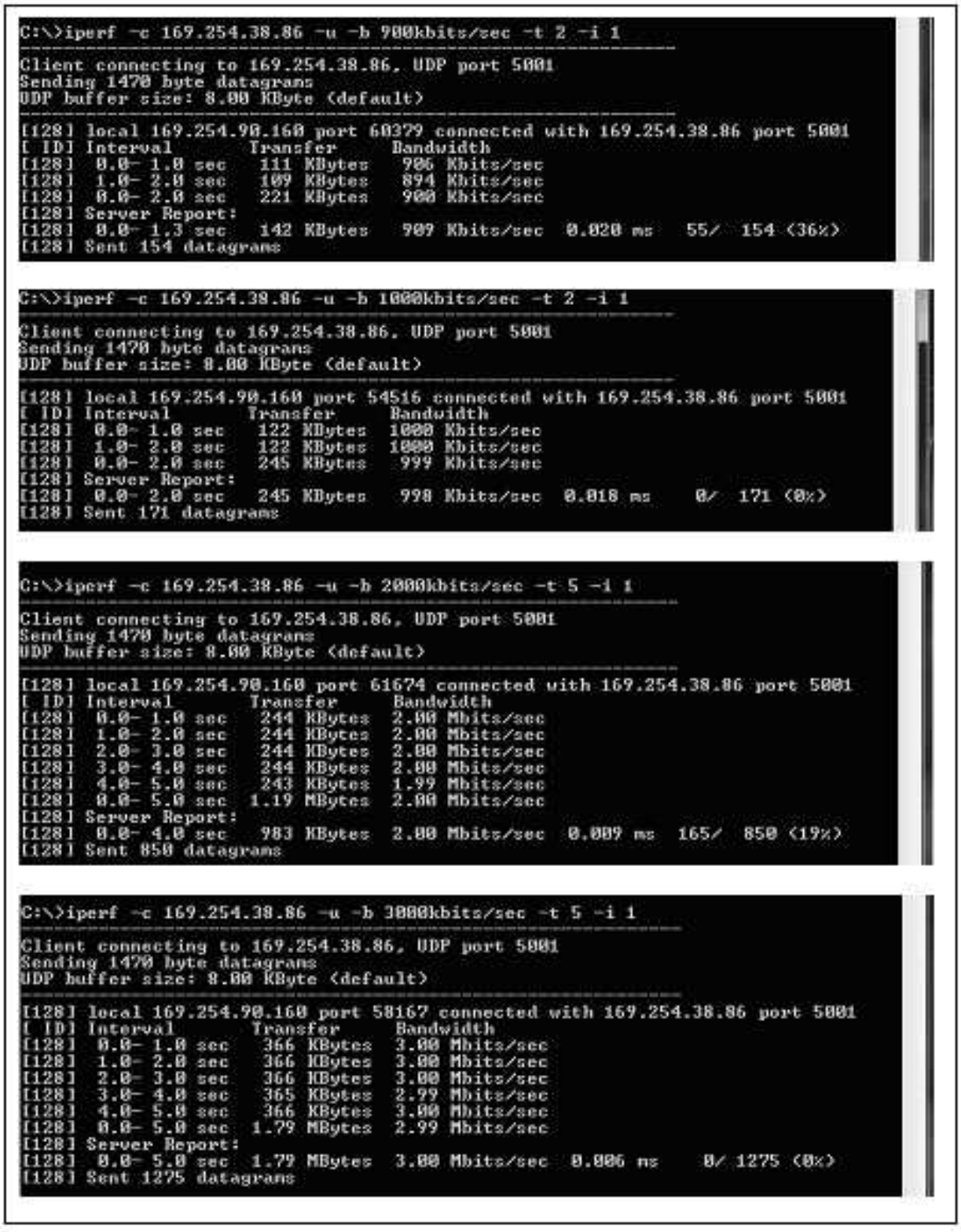
(1-a)

A


C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 5 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 169.254.90.160 port 53892 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 61.7 KBytes 506 Kbits/sec
[128] 1.0- 2.0 sec 60.3 KBytes 494 Kbits/sec
[128] 2.0- 3.0 sec 61.7 KBytes 506 Kbits/sec
[128] 3.0- 4.0 sec 60.3 KBytes 494 Kbits/sec
[128] 4.0- 5.0 sec 61.7 KBytes 506 Kbits/sec
[128] 0.0- 5.0 sec 307 KBytes 499 Kbits/sec
[128] Server Report:
[128] 0.0- 5.1 sec 307 KBytes 493 Kbits/sec 9.586 ms 0/ 214 (0%)
[128] Sent 214 datagrams
C:\>iperf -c 169.254.38.86 -u -b 600kbits/sec -t 5 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 169.254.90.160 port 54977 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 73.2 KBytes 600 Kbits/sec
[128] 1.0- 2.0 sec 73.2 KBytes 600 Kbits/sec
[128] 2.0- 3.0 sec 73.2 KBytes 600 Kbits/sec
[128] 3.0- 4.0 sec 73.2 KBytes 600 Kbits/sec
[128] 4.0- 5.0 sec 73.2 KBytes 600 Kbits/sec
[128] 0.0- 5.0 sec 368 KBytes 599 Kbits/sec
[128] Server Report:
[128] 0.0- 4.2 sec 310 KBytes 600 Kbits/sec 0.031 ms 40/ 256 (16%)
[128] Sent 256 datagrams
C:\>iperf -c 10.10.81.21 -u -b 700kbits/sec -t2 -i 1
Client connecting to 10.10.81.21, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 10.10.81.46 port 64690 connected with 10.10.81.21 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 86.1 KBytes 706 Kbits/sec
[128] 1.0- 2.0 sec 84.7 KBytes 694 Kbits/sec
[128] 0.0- 2.0 sec 172 KBytes 696 Kbits/sec
[128] Server Report:
[128] 0.0- 2.0 sec 172 KBytes 706 Kbits/sec 0.027 ms 0/ 120 (0%)
[128] Sent 120 datagrams
C:\>iperf -c 169.254.38.86 -u -b 800kbits/sec -t 5 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 169.254.90.160 port 49565 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 97.6 KBytes 800 Kbits/sec
[128] 1.0- 2.0 sec 97.6 KBytes 800 Kbits/sec
[128] 2.0- 3.0 sec 97.6 KBytes 800 Kbits/sec
[128] 3.0- 4.0 sec 97.6 KBytes 800 Kbits/sec
[128] 4.0- 5.0 sec 97.6 KBytes 800 Kbits/sec
[128] 0.0- 5.0 sec 490 KBytes 798 Kbits/sec
[128] Server Report:
[128] 0.0- 4.7 sec 461 KBytes 797 Kbits/sec 0.023 ms 20/ 341 (5.9%)
[128] Sent 341 datagrams

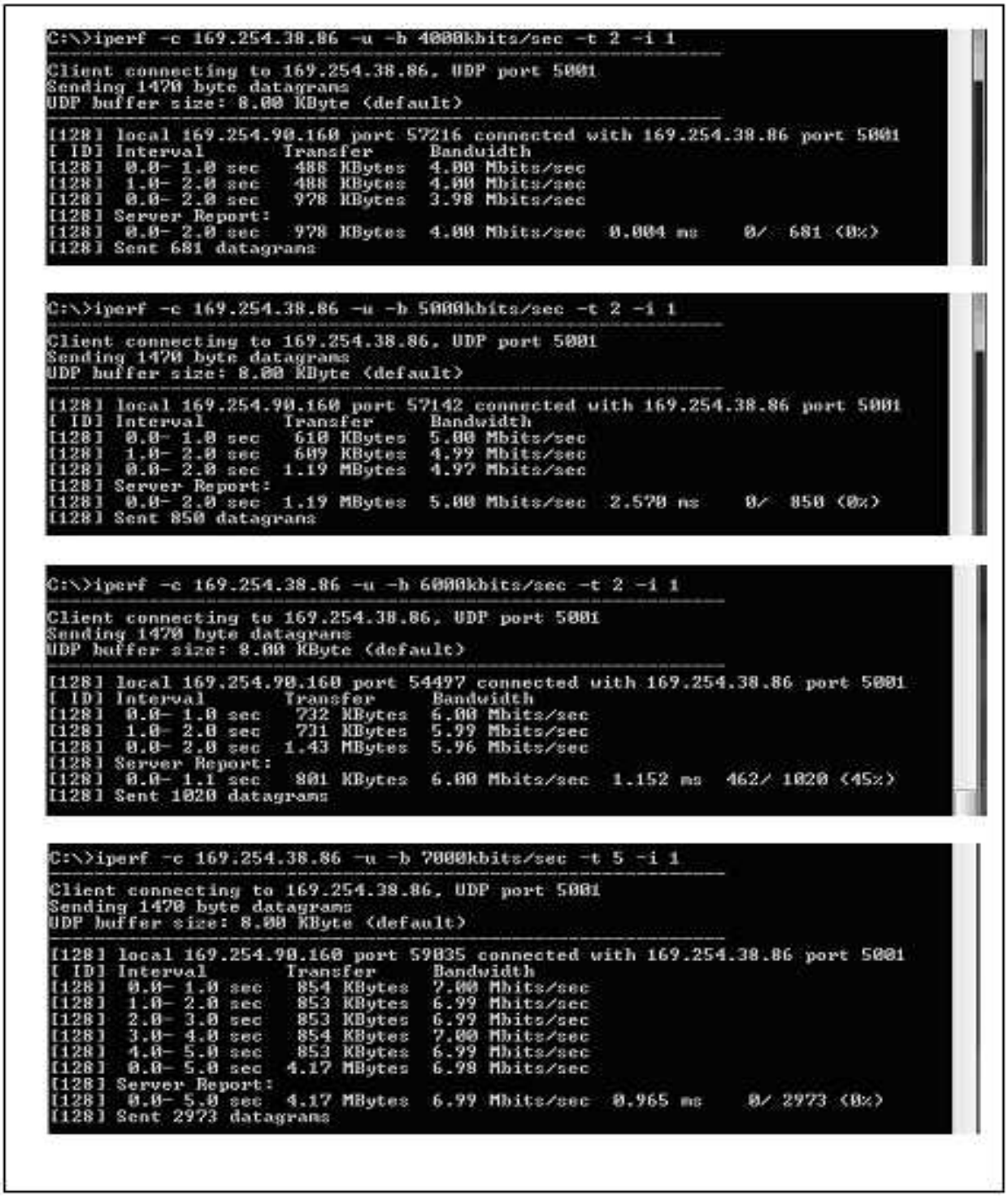
(1-b)

B


C:\>iperf -c 169.254.38.86 -u -b 900kbits/sec -t 2 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 169.254.90.160 port 60379 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 111 KBytes 906 Kbits/sec
[128] 1.0- 2.0 sec 109 KBytes 894 Kbits/sec
[128] 0.0- 2.0 sec 221 KBytes 900 Kbits/sec
[128] Server Report:
[128] 0.0- 1.3 sec 142 KBytes 909 Kbits/sec 0.020 ms 55/ 154 (36%)
[128] Sent 154 datagrams
C:\>iperf -c 169.254.38.86 -u -b 1000kbits/sec -t 2 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 169.254.90.160 port 54516 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 2.0 sec 245 KBytes 999 Kbits/sec
[128] Server Report:
[128] 0.0- 2.0 sec 245 KBytes 998 Kbits/sec 0.018 ms 0/ 171 (0%)
[128] Sent 171 datagrams
C:\>iperf -c 169.254.38.86 -u -b 2000kbits/sec -t 5 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 169.254.90.160 port 61674 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 244 KBytes 2.00 Mbits/sec
[128] 1.0- 2.0 sec 244 KBytes 2.00 Mbits/sec
[128] 2.0- 3.0 sec 244 KBytes 2.00 Mbits/sec
[128] 3.0- 4.0 sec 244 KBytes 2.00 Mbits/sec
[128] 4.0- 5.0 sec 243 KBytes 1.99 Mbits/sec
[128] 0.0- 5.0 sec 1.19 MBytes 2.00 Mbits/sec
[128] Server Report:
[128] 0.0- 4.0 sec 983 KBytes 2.00 Mbits/sec 0.009 ms 165/ 850 (19%)
[128] Sent 850 datagrams
C:\>iperf -c 169.254.38.86 -u -b 3000kbits/sec -t 5 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 169.254.90.160 port 58167 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 366 KBytes 3.00 Mbits/sec
[128] 1.0- 2.0 sec 366 KBytes 3.00 Mbits/sec
[128] 2.0- 3.0 sec 366 KBytes 3.00 Mbits/sec
[128] 3.0- 4.0 sec 365 KBytes 2.99 Mbits/sec
[128] 4.0- 5.0 sec 366 KBytes 3.00 Mbits/sec
[128] 0.0- 5.0 sec 1.79 MBytes 2.99 Mbits/sec
[128] Server Report:
[128] 0.0- 5.0 sec 1.79 MBytes 3.00 Mbits/sec 0.006 ms 0/ 1275 (0%)
[128] Sent 1275 datagrams

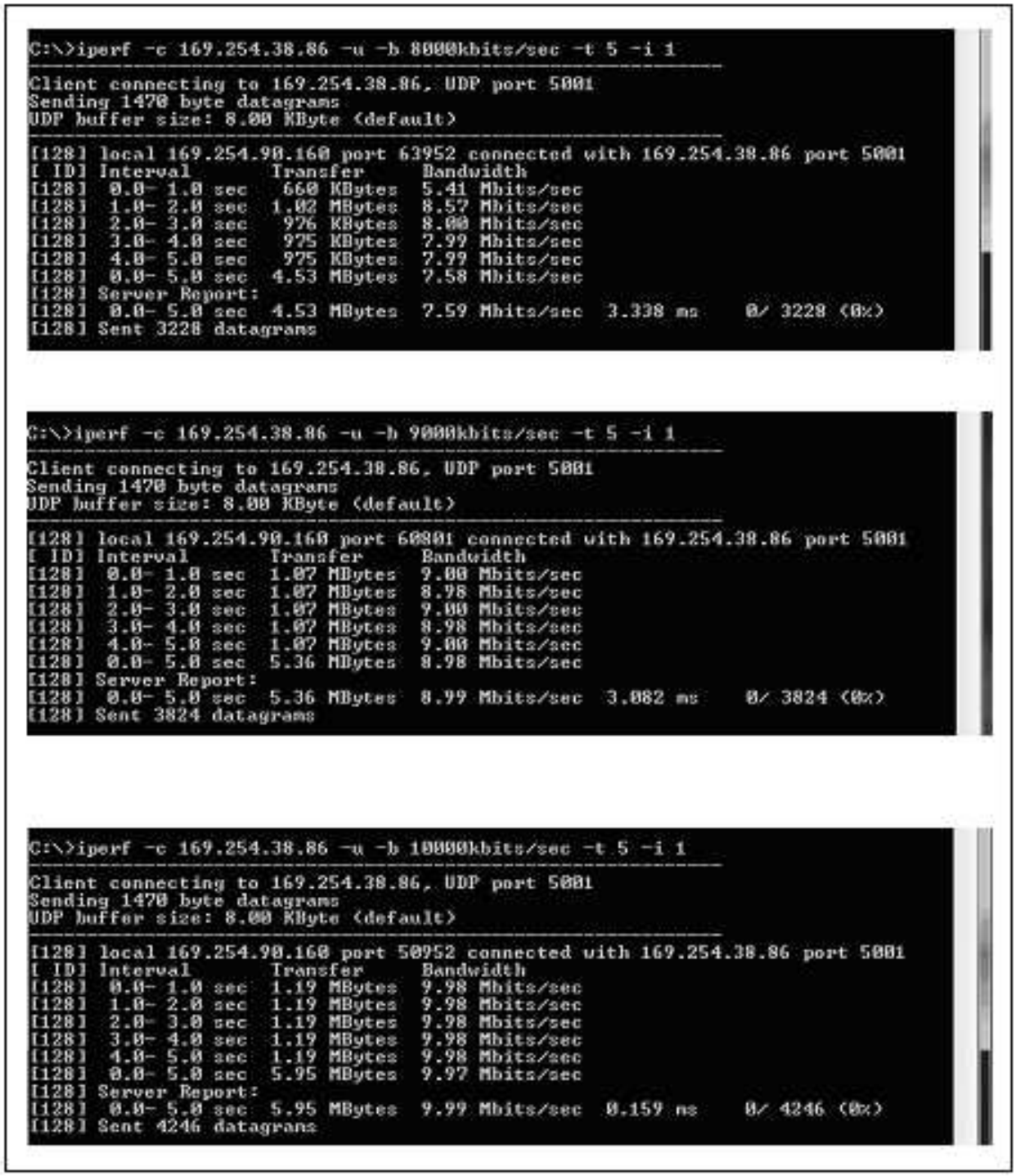
(1-c)

C


C:\>iperf -c 169.254.38.86 -u -b 4000kbits/sec -t 2 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 169.254.90.160 port 57216 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 488 KBytes 4.00 Mbits/sec
[128] 1.0- 2.0 sec 488 KBytes 4.00 Mbits/sec
[128] 0.0- 2.0 sec 978 KBytes 3.98 Mbits/sec
[128] Server Report:
[128] 0.0- 2.0 sec 978 KBytes 4.00 Mbits/sec 0.004 ms 0/ 681 (0%)
[128] Sent 681 datagrams
C:\>iperf -c 169.254.38.86 -u -b 5000kbits/sec -t 2 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 169.254.90.160 port 57142 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 610 KBytes 5.00 Mbits/sec
[128] 1.0- 2.0 sec 609 KBytes 4.99 Mbits/sec
[128] 0.0- 2.0 sec 1.19 MBytes 4.97 Mbits/sec
[128] Server Report:
[128] 0.0- 2.0 sec 1.19 MBytes 5.00 Mbits/sec 2.570 ms 0/ 850 (0%)
[128] Sent 850 datagrans
C:\>iperf -c 169.254.38.86 -u -b 6000kbits/sec -t 2 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrans
UDP buffer size: 8.00 KByte (default)
[128] local 169.254.90.160 port 54497 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 732 KBytes 6.00 Mbits/sec
[128] 1.0- 2.0 sec 731 KBytes 5.99 Mbits/sec
[128] 0.0- 2.0 sec 1.43 MBytes 5.96 Mbits/sec
[128] Server Report:
[128] 0.0- 1.1 sec 801 KBytes 6.00 Mbits/sec 1.152 ms 462/ 1020 (45%)
[128] Sent 1020 datagrams
C:\>iperf -c 169.254.38.86 -u -b 7000kbits/sec -t 5 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 169.254.90.160 port 59035 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 854 KBytes 7.00 Mbits/sec
[128] 1.0- 2.0 sec 853 KBytes 6.99 Mbits/sec
[128] 2.0- 3.0 sec 853 KBytes 6.99 Mbits/sec
[128] 3.0- 4.0 sec 854 KBytes 7.00 Mbits/sec
[128] 4.0- 5.0 sec 853 KBytes 6.99 Mbits/sec
[128] 0.0- 5.0 sec 4.17 MBytes 6.98 Mbits/sec
[128] Server Report:
[128] 0.0- 5.0 sec 4.17 MBytes 6.99 Mbits/sec 0.965 ms 0/ 2973 (0%)
[128] Sent 2973 datagrams

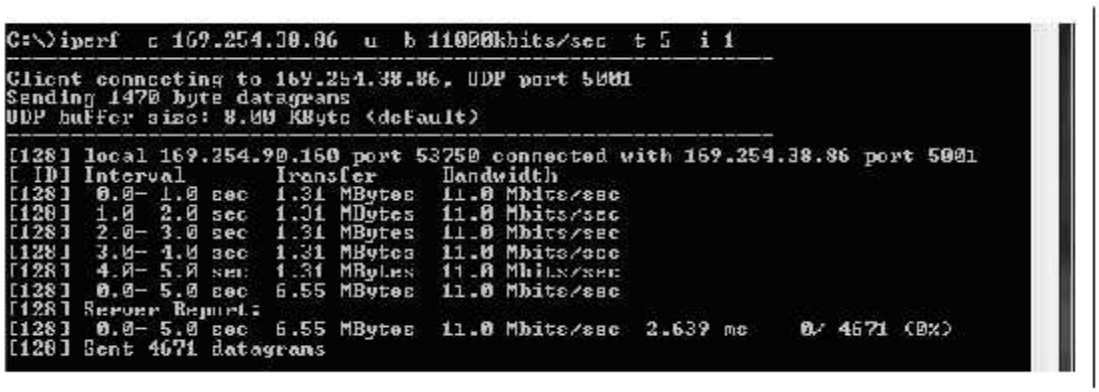
(1-d)

D


C:\>iperf -c 169.254.38.86 -u -b 8000kbits/sec -t 5 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 169.254.90.160 port 63952 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 660 KBytes 5.41 Mbits/sec
[128] 1.0- 2.0 sec 1.02 MBytes 8.57 Mbits/sec
[128] 2.0- 3.0 sec 976 KBytes 8.00 Mbits/sec
[128] 3.0- 4.0 sec 975 KBytes 7.99 Mbits/sec
[128] 4.0- 5.0 sec 975 KBytes 7.99 Mbits/sec
[128] 0.0- 5.0 sec 4.53 MBytes 7.58 Mbits/sec
[128] Server Report:
[128] 0.0- 5.0 sec 4.53 MBytes 7.59 Mbits/sec 3.338 ms 0/ 3228 (0%)
[128] Sent 3228 datagrams
C:\>iperf -c 169.254.38.86 -u -b 9000kbits/sec -t 5 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 169.254.90.160 port 60801 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 1.07 MBytes 9.00 Mbits/sec
[128] 1.0- 2.0 sec 1.07 MBytes 8.98 Mbits/sec
[128] 2.0- 3.0 sec 1.07 MBytes 9.00 Mbits/sec
[128] 3.0- 4.0 sec 1.07 MBytes 8.98 Mbits/sec
[128] 4.0- 5.0 sec 1.07 MBytes 9.00 Mbits/sec
[128] 0.0- 5.0 sec 5.36 MBytes 8.98 Mbits/sec
[128] Server Report:
[128] 0.0- 5.0 sec 5.36 MBytes 8.99 Mbits/sec 3.082 ms 0/ 3824 (0%)
[128] Sent 3824 datagrams
C:\>iperf -c 169.254.38.86 -u -b 10000kbits/sec -t 5 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 169.254.90.160 port 50952 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 1.19 MBytes 9.98 Mbits/sec
[128] 1.0- 2.0 sec 1.19 MBytes 9.98 Mbits/sec
[128] 2.0- 3.0 sec 1.19 MBytes 9.98 Mbits/sec
[128] 3.0- 4.0 sec 1.19 MBytes 9.98 Mbits/sec
[128] 4.0- 5.0 sec 1.19 MBytes 9.98 Mbits/sec
[128] 0.0- 5.0 sec 5.95 MBytes 9.97 Mbits/sec
[128] Server Report:
[128] 0.0- 5.0 sec 5.95 MBytes 9.99 Mbits/sec 0.159 ms 0/ 4246 (0%)
[128] Sent 4246 datagrams

(1-e)

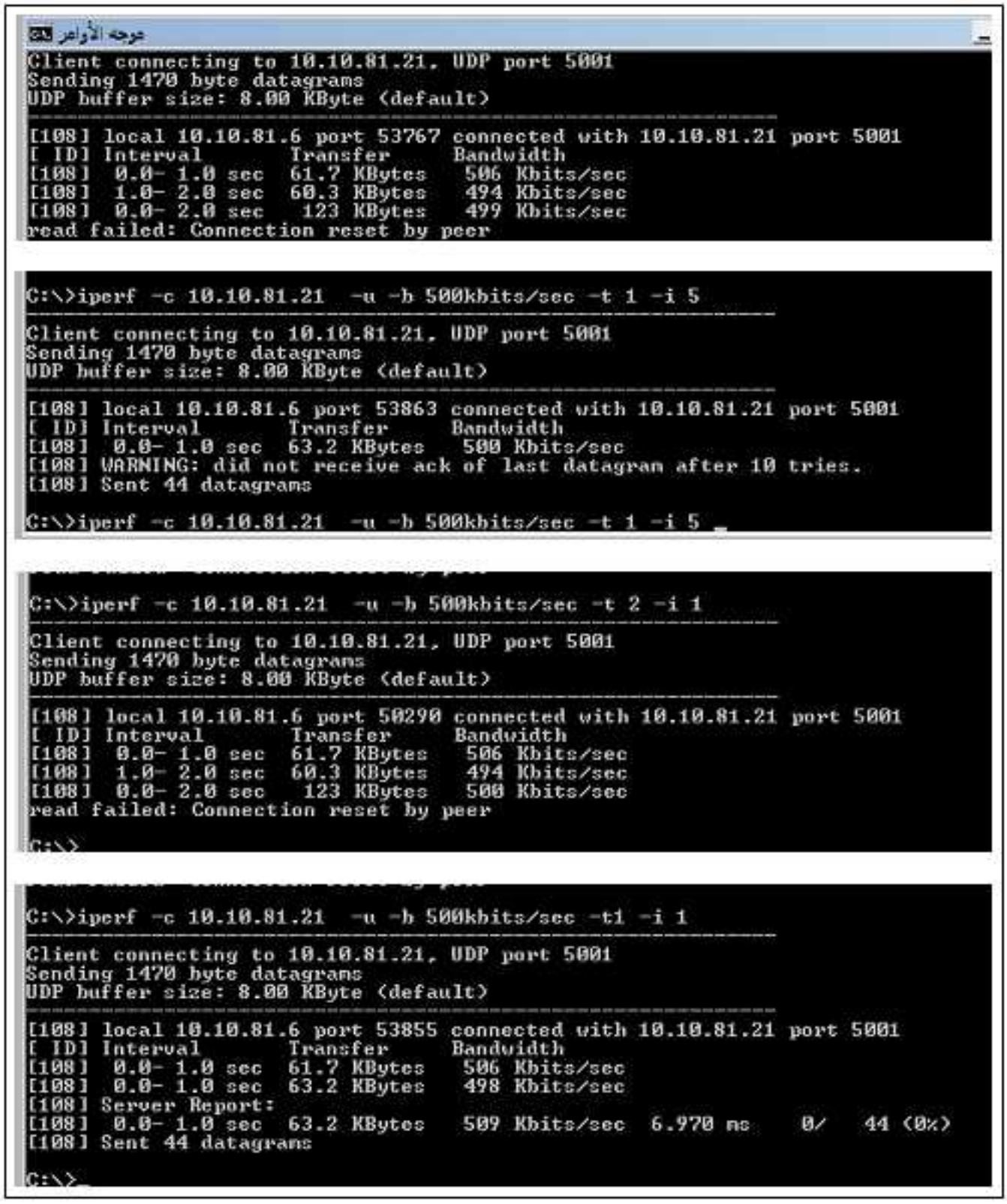
E



(1-f)

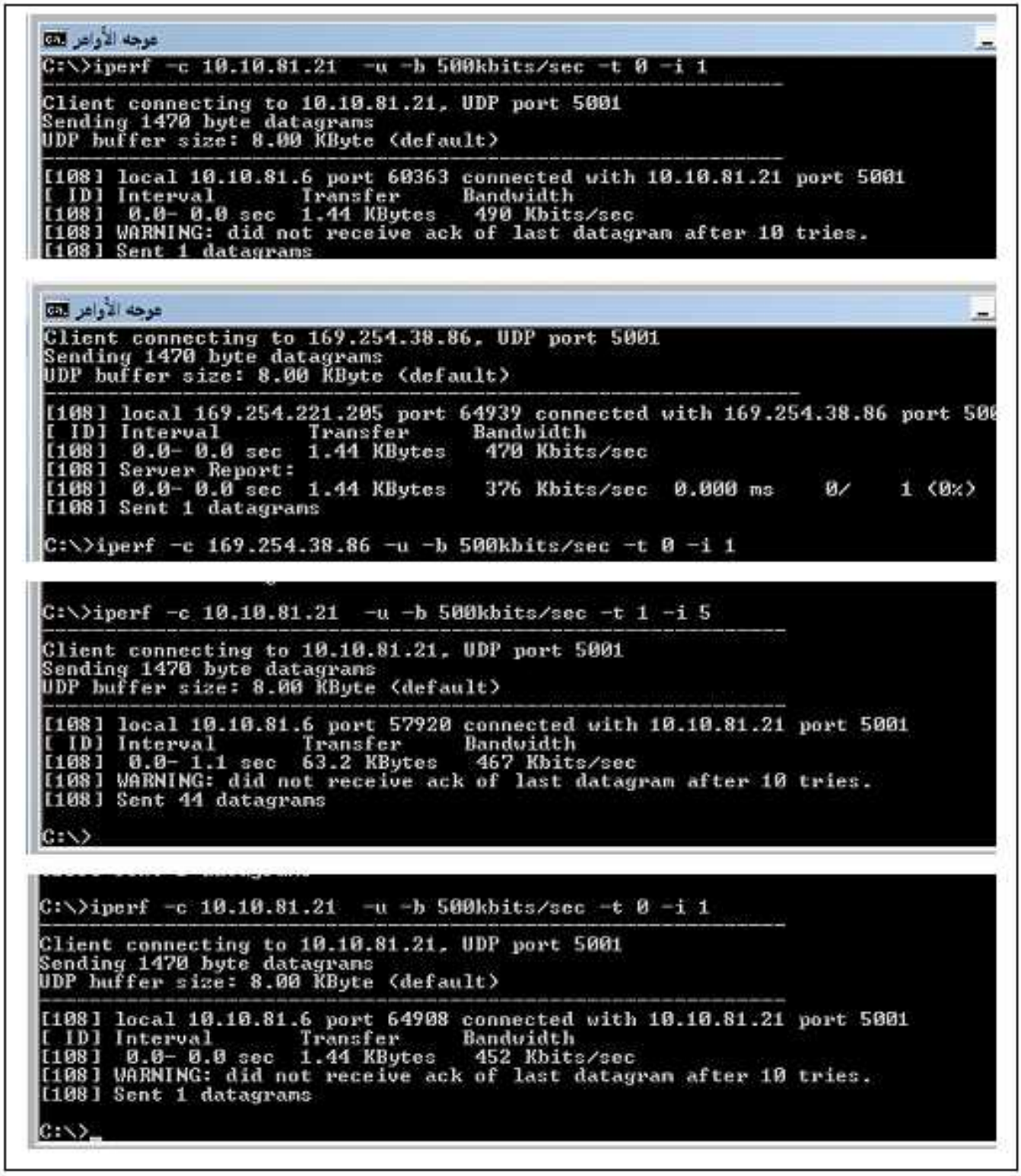
Figure 1: (a-f) load increasing from loader

F


موجه الأوامر
Client connecting to 10.10.81.21, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 10.10.81.6 port 53767 connected with 10.10.81.21 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 1.0 sec 61.7 KBytes 506 Kbits/sec
[108] 1.0- 2.0 sec 60.3 KBytes 494 Kbits/sec
[108] 0.0- 2.0 sec 123 KBytes 499 Kbits/sec
read failed: Connection reset by peer
C:\>iperf -c 10.10.81.21 -u -b 500kbits/sec -t 1 -i 5
Client connecting to 10.10.81.21, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 10.10.81.6 port 53863 connected with 10.10.81.21 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 1.0 sec 63.2 KBytes 500 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 44 datagrams
C:\>iperf -c 10.10.81.21 -u -b 500kbits/sec -t 1 -i 5
C:\>iperf -c 10.10.81.21 -u -b 500kbits/sec -t 2 -i 1
Client connecting to 10.10.81.21, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 10.10.81.6 port 50290 connected with 10.10.81.21 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 1.0 sec 61.7 KBytes 506 Kbits/sec
[108] 1.0- 2.0 sec 60.3 KBytes 494 Kbits/sec
[108] 0.0- 2.0 sec 123 KBytes 500 Kbits/sec
read failed: Connection reset by peer
C:\>
C:\>iperf -c 10.10.81.21 -u -b 500kbits/sec -t1 -i 1
Client connecting to 10.10.81.21, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 10.10.81.6 port 53855 connected with 10.10.81.21 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 1.0 sec 61.7 KBytes 506 Kbits/sec
[108] 0.0- 1.0 sec 63.2 KBytes 498 Kbits/sec
[108] Server Report:
[108] 0.0- 1.0 sec 63.2 KBytes 509 Kbits/sec 6.970 ms 0/ 44 (0%)
[108] Sent 44 datagrams
C:\>

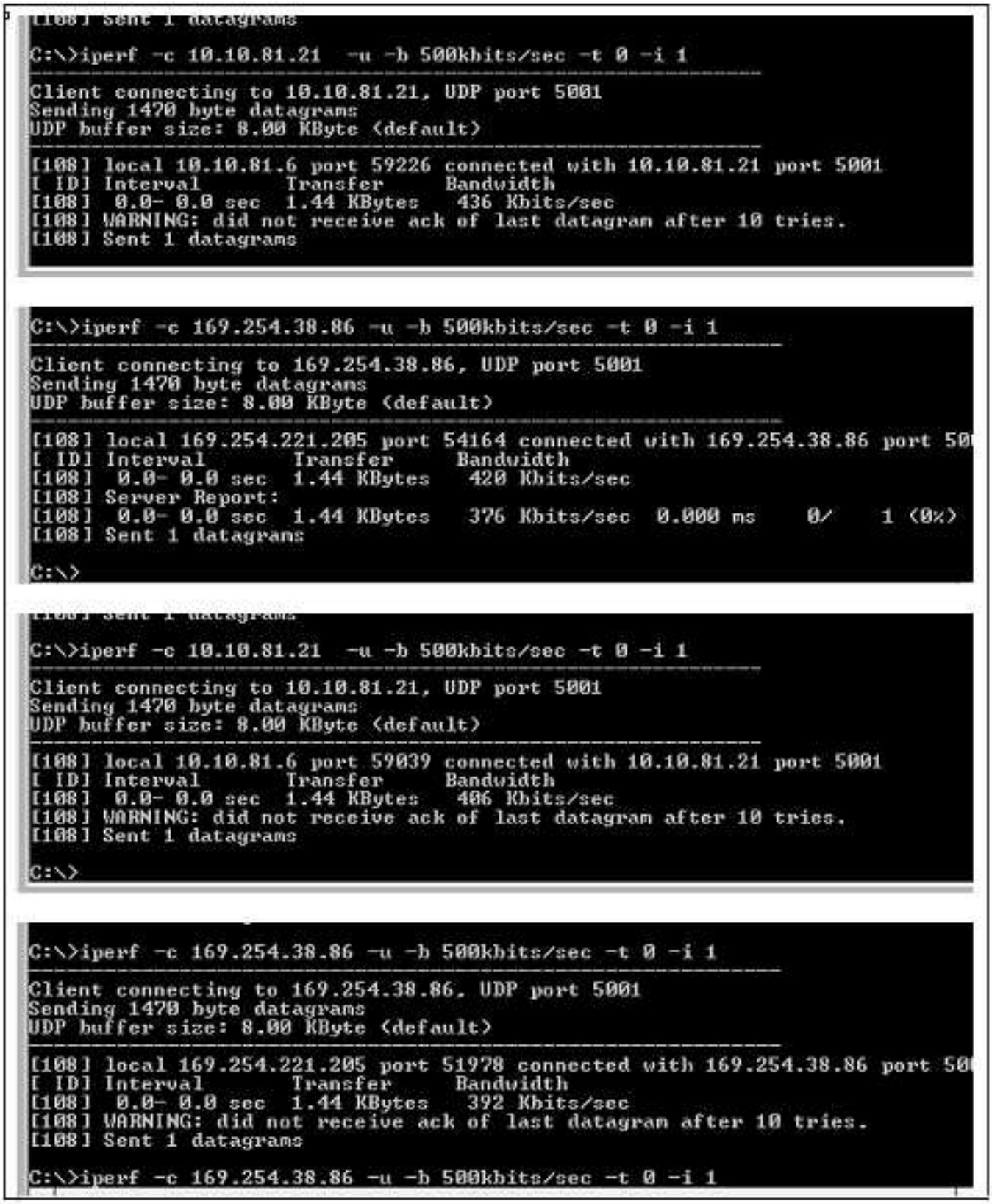
(2-a)

G


موجه الأوامر
C:\>iperf -c 10.10.81.21 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 10.10.81.21, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 10.10.81.6 port 60363 connected with 10.10.81.21 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 490 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrams
موجه الأوامر
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 64939 connected with 169.254.38.86 port 500
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 470 Kbits/sec
[108] Server Report:
[108] 0.0- 0.0 sec 1.44 KBytes 376 Kbits/sec 0.000 ms 0/ 1 (0%)
[108] Sent 1 datagrams
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
C:\>iperf -c 10.10.81.21 -u -b 500kbits/sec -t 1 -i 5
Client connecting to 10.10.81.21, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 10.10.81.6 port 57920 connected with 10.10.81.21 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 1.1 sec 63.2 KBytes 467 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 44 datagrams
C:\>
C:\>iperf -c 10.10.81.21 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 10.10.81.21, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 10.10.81.6 port 64908 connected with 10.10.81.21 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 452 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrams
C:\>

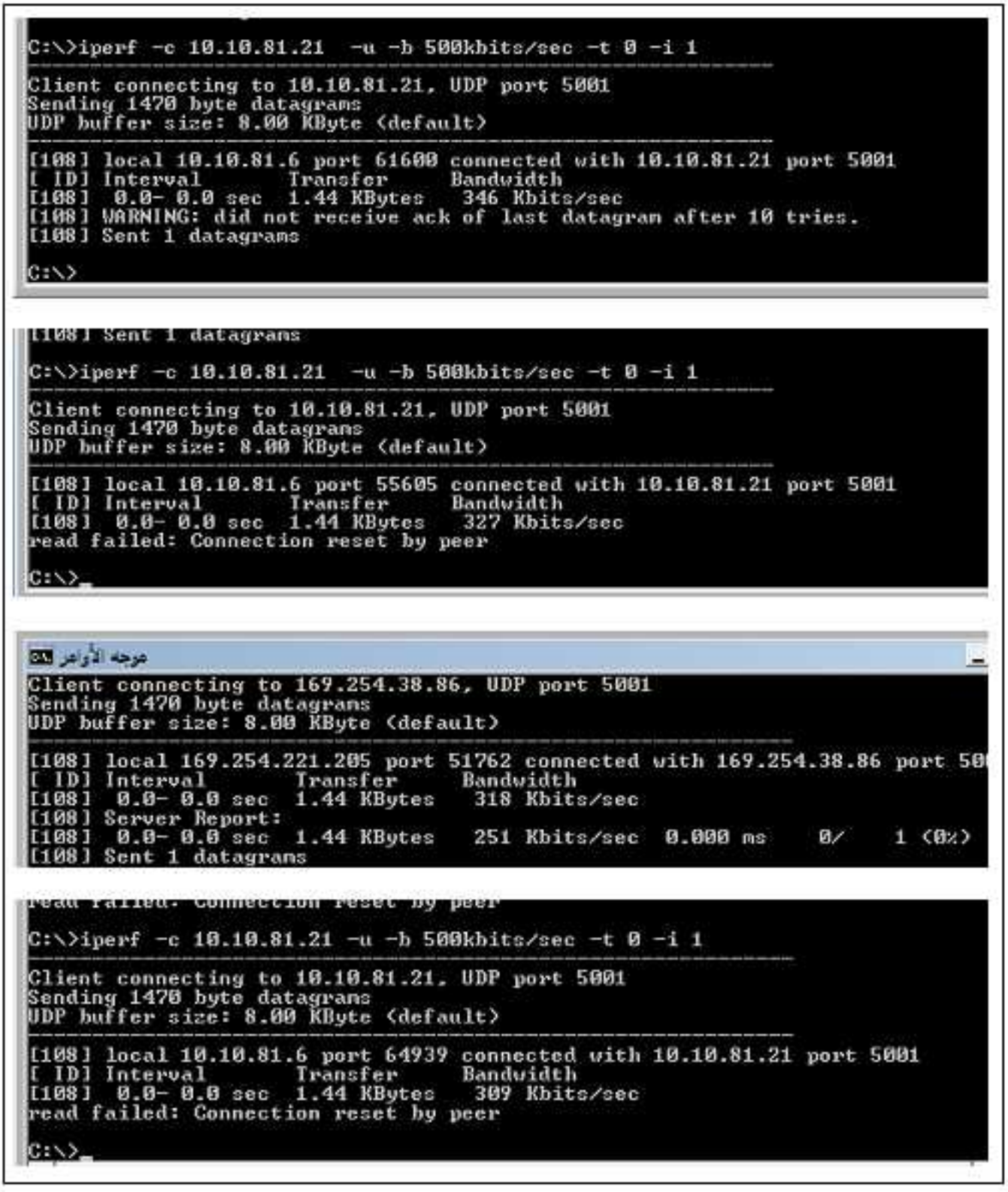
(2-b)

H

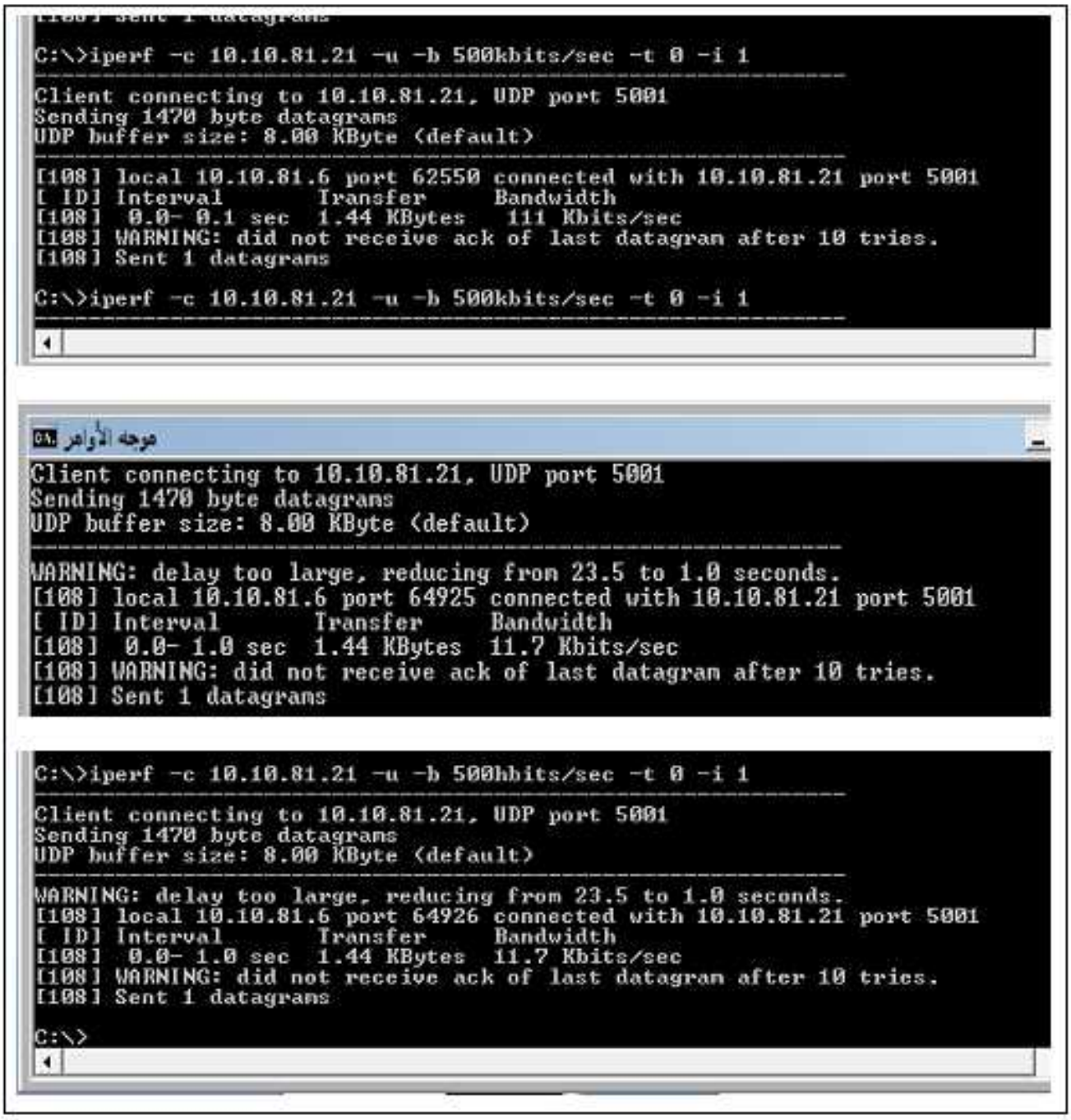

[108] Sent 1 datagrams
C:\>iperf -c 10.10.81.21 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 10.10.81.21, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 10.10.81.6 port 59226 connected with 10.10.81.21 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 436 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrams
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 54164 connected with 169.254.38.86 port 50
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 420 Kbits/sec
[108] Server Report:
[108] 0.0- 0.0 sec 1.44 KBytes 376 Kbits/sec 0.000 ms 0/ 1 (0%)
[108] Sent 1 datagrams
C:\>
C:\>iperf -c 10.10.81.21 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 10.10.81.21, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 10.10.81.6 port 59039 connected with 10.10.81.21 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 406 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrams
C:\>
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 51978 connected with 169.254.38.86 port 50
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 392 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrams
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1

(2-c)

I

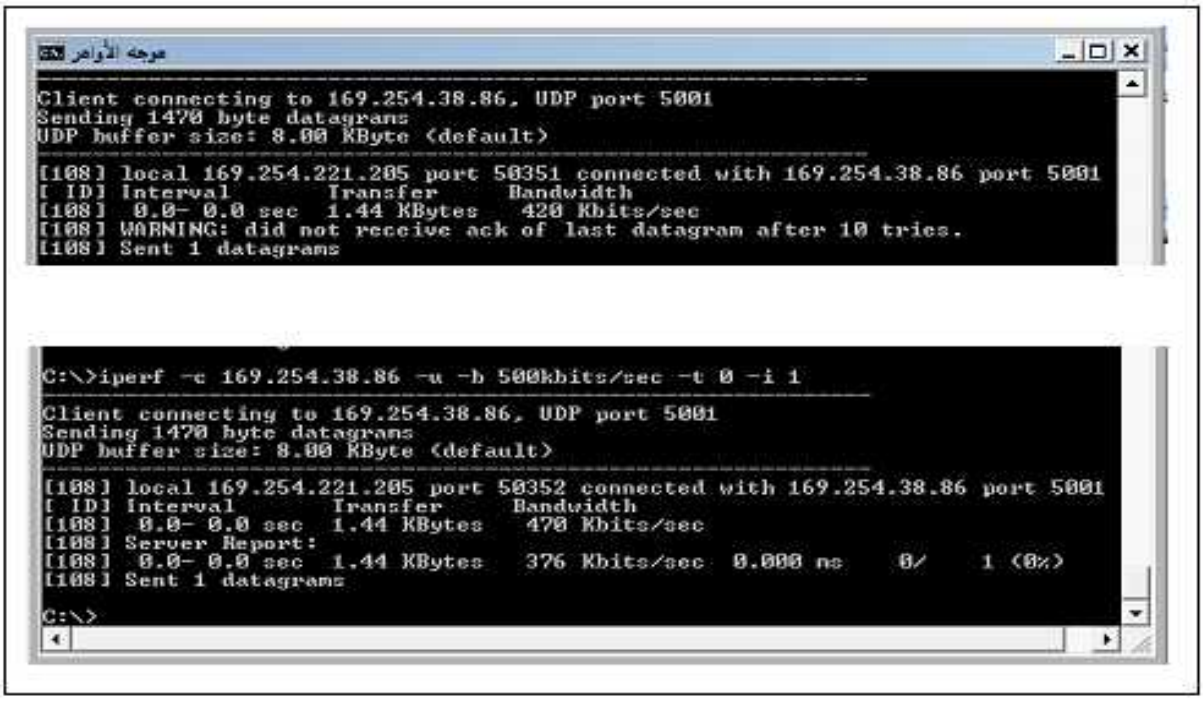

C:\>iperf -c 10.10.81.21 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 10.10.81.21, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 10.10.81.6 port 61600 connected with 10.10.81.21 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 346 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrams
C:\>
[108] Sent 1 datagrans
C:\>iperf -c 10.10.81.21 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 10.10.81.21, UDP port 5001
Sending 1470 byte datagrans
UDP buffer size: 8.00 KByte (default)
[108] local 10.10.81.6 port 55605 connected with 10.10.81.21 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 327 Kbits/sec
read failed: Connection reset by peer
C:\>
موجه الأوامر
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrans
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 51762 connected with 169.254.38.86 port 50
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 318 Kbits/sec
[108] Server Report:
[108] 0.0- 0.0 sec 1.44 KBytes 251 Kbits/sec 0.000 ms 0/ 1 (0%)
[108] Sent 1 datagrans
C:\>iperf -c 10.10.81.21 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 10.10.81.21, UDP port 5001
Sending 1470 byte datagrans
UDP buffer size: 8.00 KByte (default)
[108] local 10.10.81.6 port 64939 connected with 10.10.81.21 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 309 Kbits/sec
read failed: Connection reset by peer
C:\>

(2-d)


C:\>iperf -c 10.10.81.21 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 10.10.81.21, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 10.10.81.6 port 62550 connected with 10.10.81.21 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.1 sec 1.44 KBytes 111 Kbits/sec
[108] WARNING: did not receive ack of last datagran after 10 tries.
[108] Sent 1 datagrams
C:\>iperf -c 10.10.81.21 -u -b 500kbits/sec -t 0 -i 1
موجه الأوامر
Client connecting to 10.10.81.21, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
WARNING: delay too large, reducing from 23.5 to 1.0 seconds.
[108] local 10.10.81.6 port 64925 connected with 10.10.81.21 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 1.0 sec 1.44 KBytes 11.7 Kbits/sec
[108] WARNING: did not receive ack of last datagran after 10 tries.
[108] Sent 1 datagrams
C:\>iperf -c 10.10.81.21 -u -b 500hbits/sec -t 0 -i 1
Client connecting to 10.10.81.21, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
WARNING: delay too large, reducing from 23.5 to 1.0 seconds.
[108] local 10.10.81.6 port 64926 connected with 10.10.81.21 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 1.0 sec 1.44 KBytes 11.7 Kbits/sec
[108] WARNING: did not receive ack of last datagran after 10 tries.
[108] Sent 1 datagrams
C:\>

(2-e)

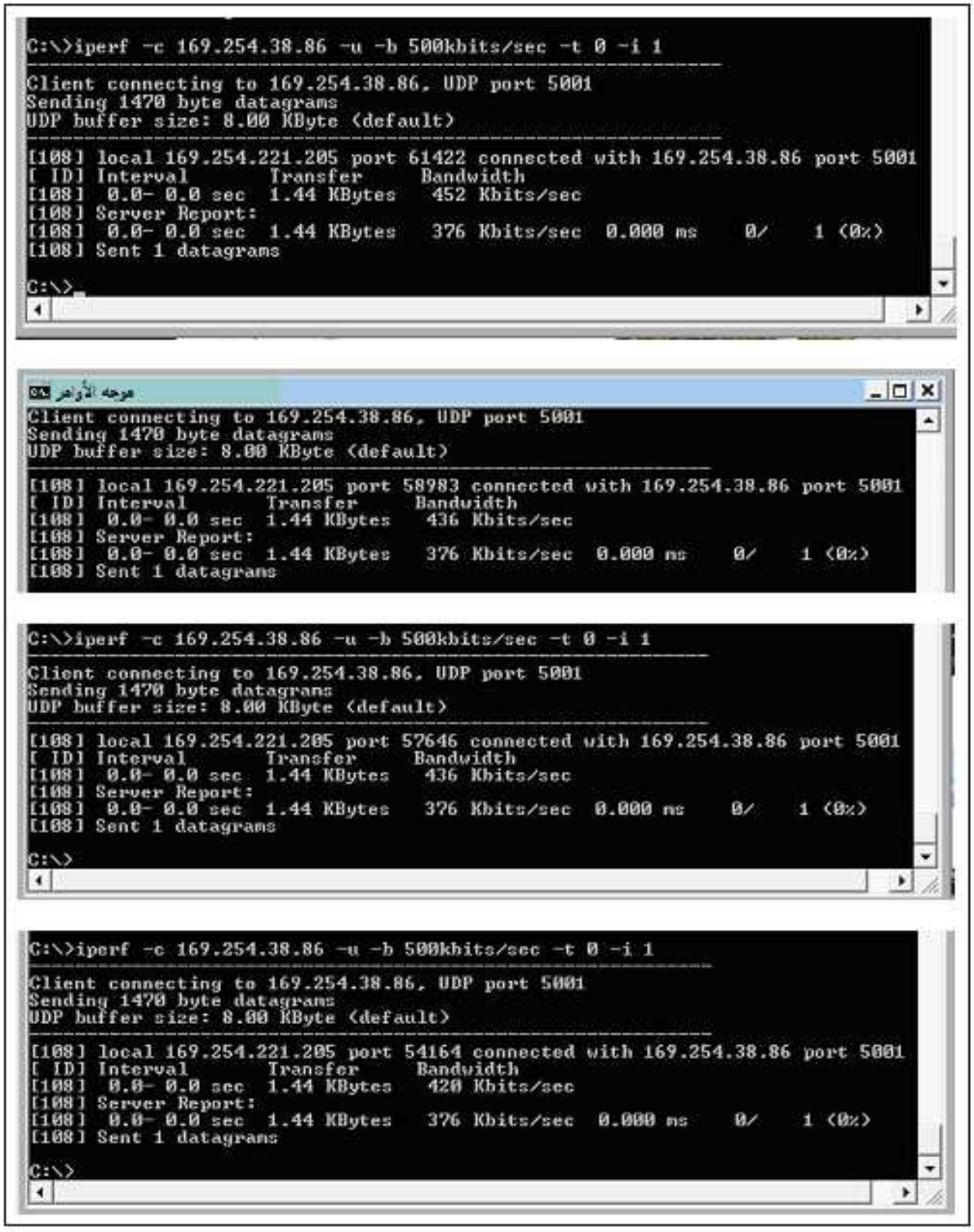
K



(2-f)

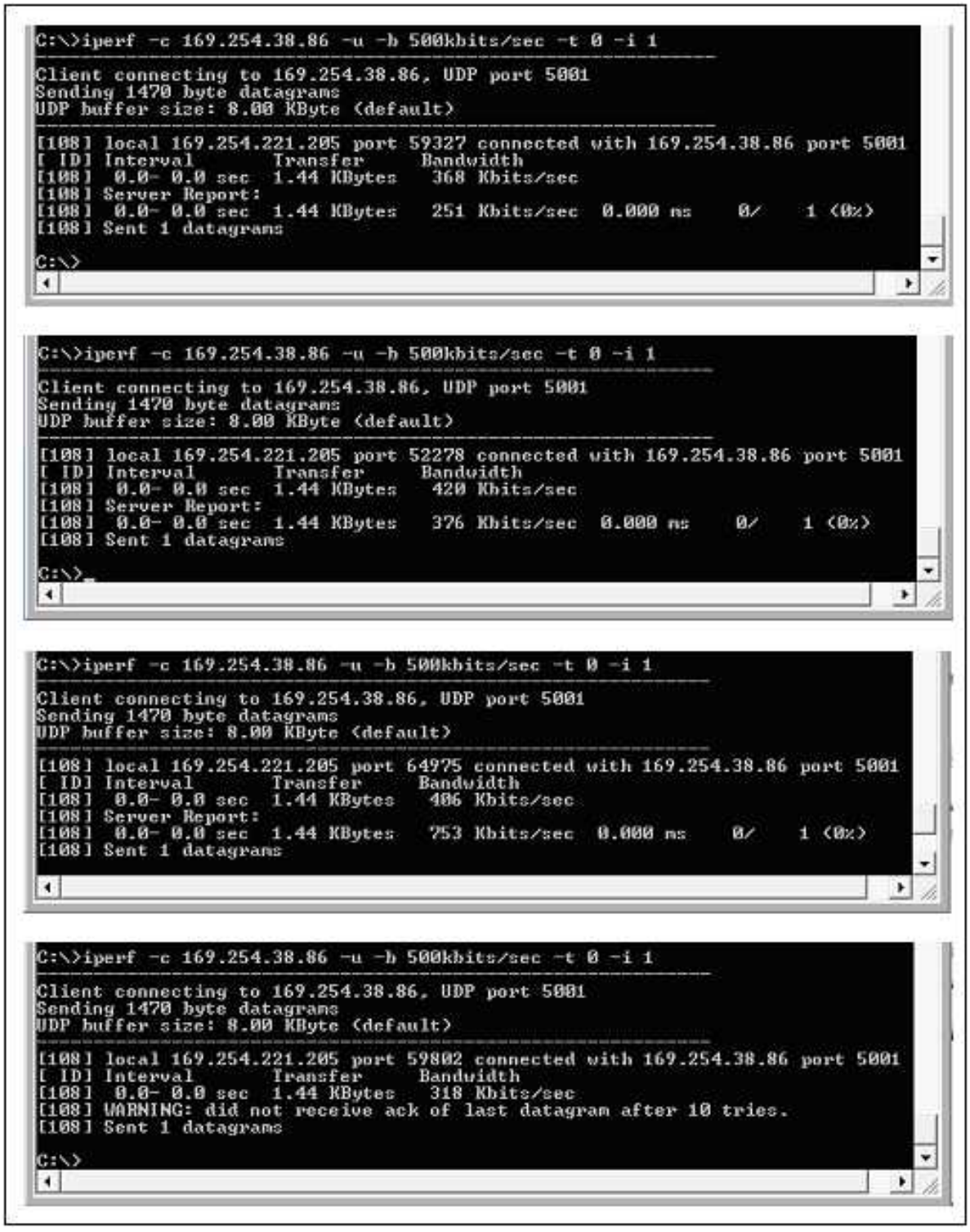
Figure 2: (a-e)client on AP1,(f)client on AP2

L


C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 61422 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 452 Kbits/sec
[108] Server Report:
[108] 0.0- 0.0 sec 1.44 KBytes 376 Kbits/sec 0.000 ms 0/ 1 (0%)
[108] Sent 1 datagrams
C:\>
موجه الأوامر
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 58983 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 436 Kbits/sec
[108] Server Report:
[108] 0.0- 0.0 sec 1.44 KBytes 376 Kbits/sec 0.000 ms 0/ 1 (0%)
[108] Sent 1 datagrams
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 57646 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 436 Kbits/sec
[108] Server Report:
[108] 0.0- 0.0 sec 1.44 KBytes 376 Kbits/sec 0.000 ms 0/ 1 (0%)
[108] Sent 1 datagrams
C:\>
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 54164 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 420 Kbits/sec
[108] Server Report:
[108] 0.0- 0.0 sec 1.44 KBytes 376 Kbits/sec 0.000 ms 0/ 1 (0%)
[108] Sent 1 datagrams
C:\>

(3-a)

M


C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 59327 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 368 Kbits/sec
[108] Server Report:
[108] 0.0- 0.0 sec 1.44 KBytes 251 Kbits/sec 0.000 ms 0/ 1 (0%)
[108] Sent 1 datagrams
C:\>
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 52278 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 420 Kbits/sec
[108] Server Report:
[108] 0.0- 0.0 sec 1.44 KBytes 376 Kbits/sec 0.000 ms 0/ 1 (0%)
[108] Sent 1 datagrams
C:\>
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 64975 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 406 Kbits/sec
[108] Server Report:
[108] 0.0- 0.0 sec 1.44 KBytes 753 Kbits/sec 0.000 ms 0/ 1 (0%)
[108] Sent 1 datagrams
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 59802 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 318 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrams
C:\>

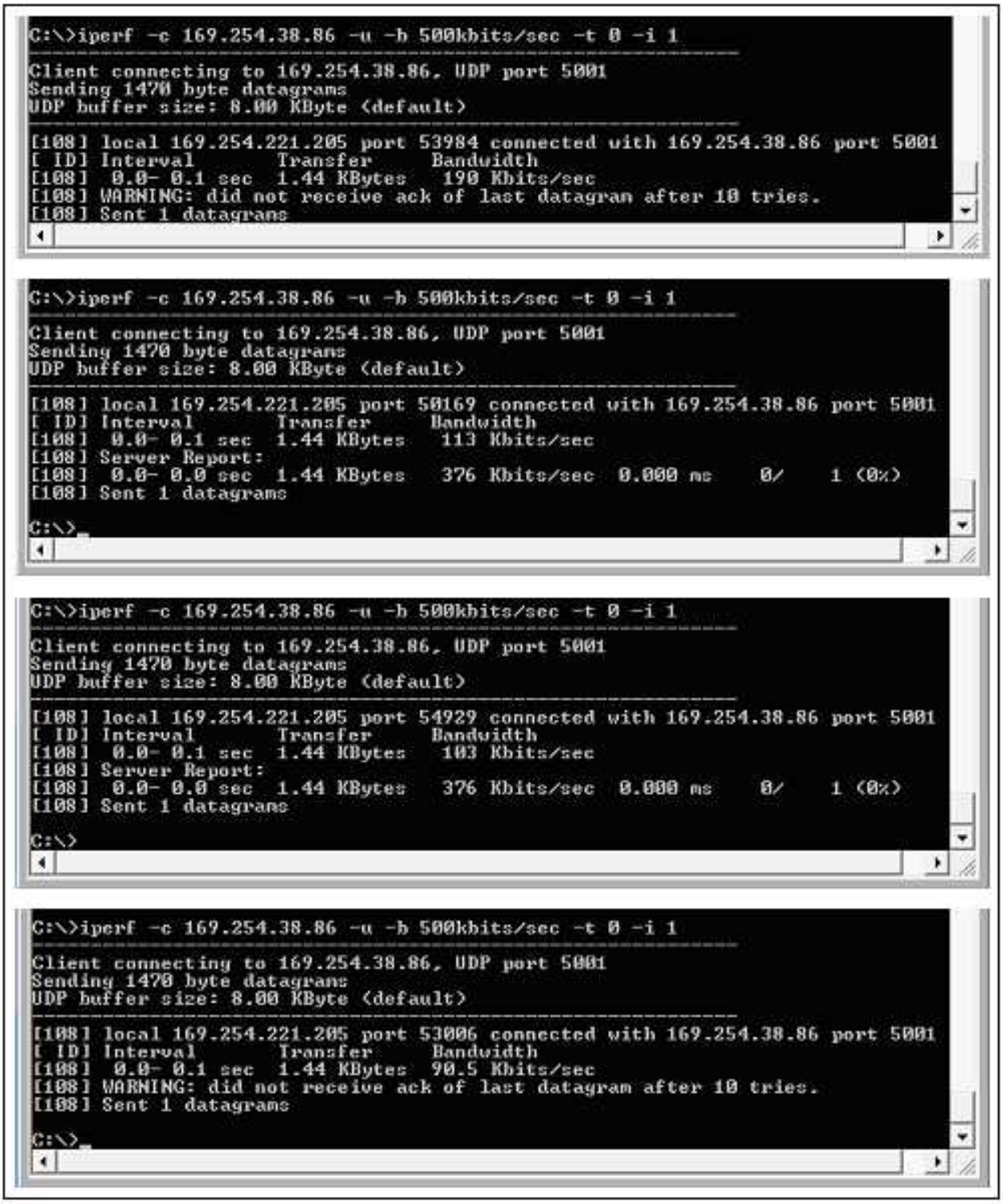
(3-b)

N


C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 53240 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 327 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrams
C:\>
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 57252 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 245 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrams
C:\>
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 51447 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.1 sec 1.44 KBytes 203 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrams
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 58957 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.1 sec 1.44 KBytes 193 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrams
C:\>

(3-c)

O


C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 53984 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.1 sec 1.44 KBytes 190 Kbits/sec
[108] WARNING: did not receive ack of last datagran after 10 tries.
[108] Sent 1 datagrans
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 50169 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.1 sec 1.44 KBytes 113 Kbits/sec
[108] Server Report:
[108] 0.0- 0.0 sec 1.44 KBytes 376 Kbits/sec 0.000 ms 0/ 1 (0%)
[108] Sent 1 datagrams
C:\>
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 54929 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.1 sec 1.44 KBytes 103 Kbits/sec
[108] Server Report:
[108] 0.0- 0.0 sec 1.44 KBytes 376 Kbits/sec 0.000 ms 0/ 1 (0%)
[108] Sent 1 datagrams
C:\>
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 53006 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.1 sec 1.44 KBytes 90.5 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrams
C:\>

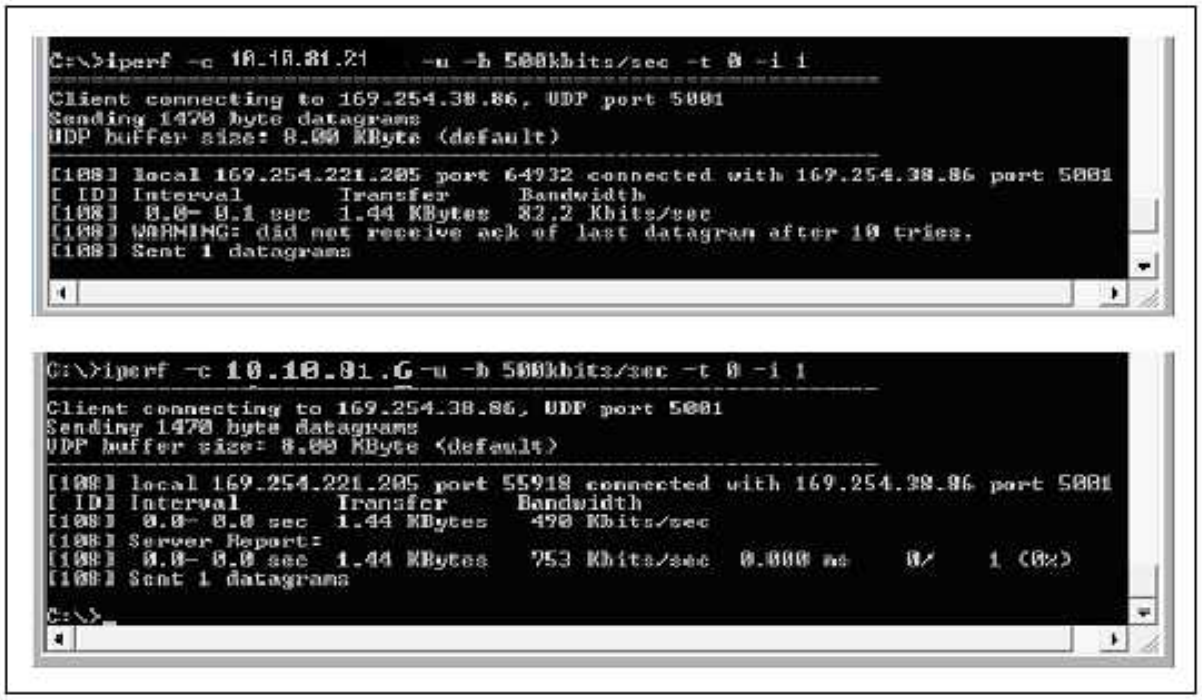
(3-d)

P


C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 64939 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.2 sec 1.44 KBytes 71.3 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrams
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 51982 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.1 sec 1.44 KBytes 84.0 Kbits/sec
[108] WARNING: did not receive ack of last datagran after 10 tries.
[108] Sent 1 datagrams
C:\>
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 51982 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.1 sec 1.44 KBytes 84.0 Kbits/sec
[108] WARNING: did not receive ack of last datagran after 10 tries.
[108] Sent 1 datagrams
C:\>
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 64932 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.1 sec 1.44 KBytes 82.2 Kbits/sec
[108] WARNING: did not receive ack of last datagran after 10 tries.
[108] Sent 1 datagrams

(3-e)

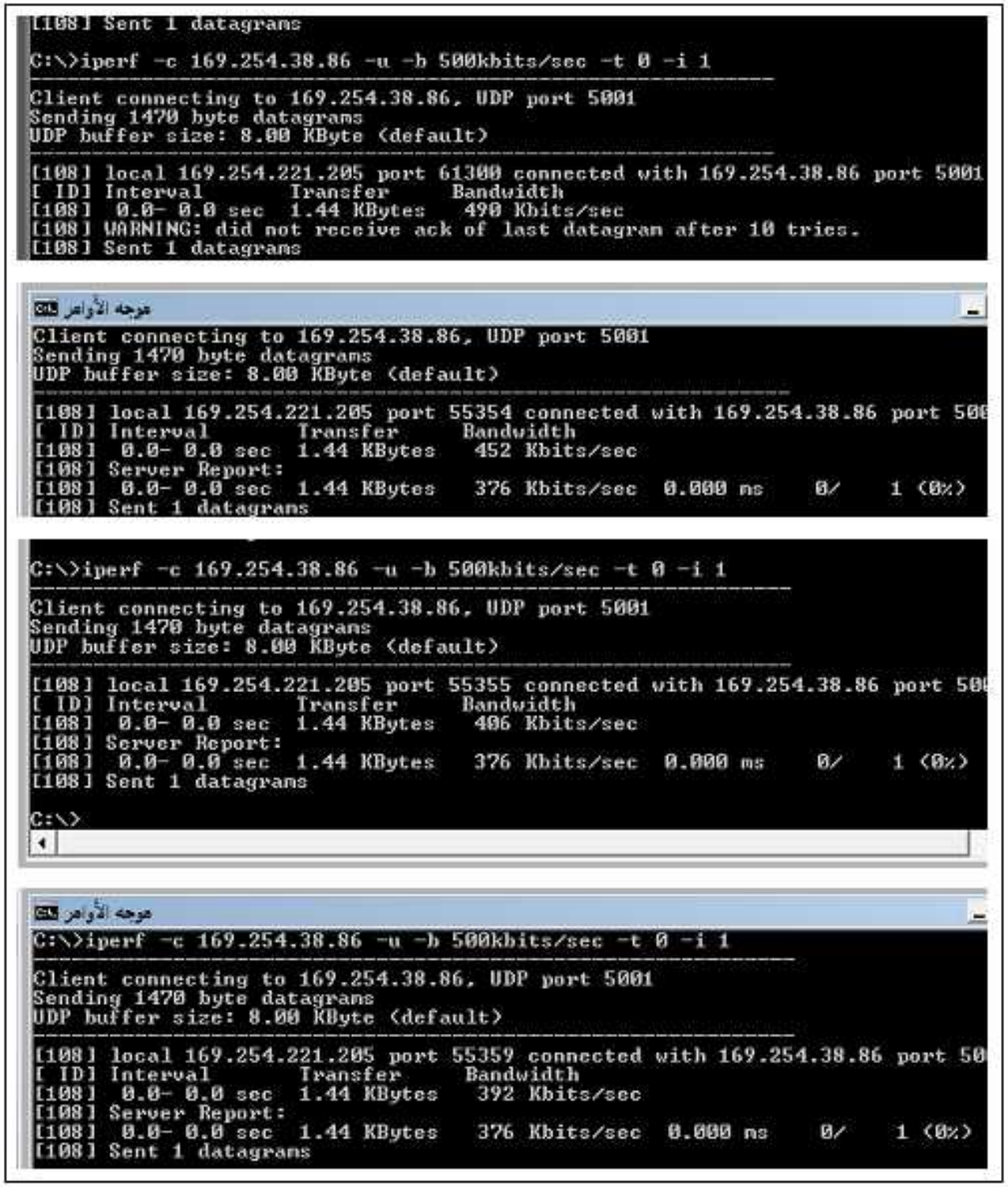
Q



(3-f)

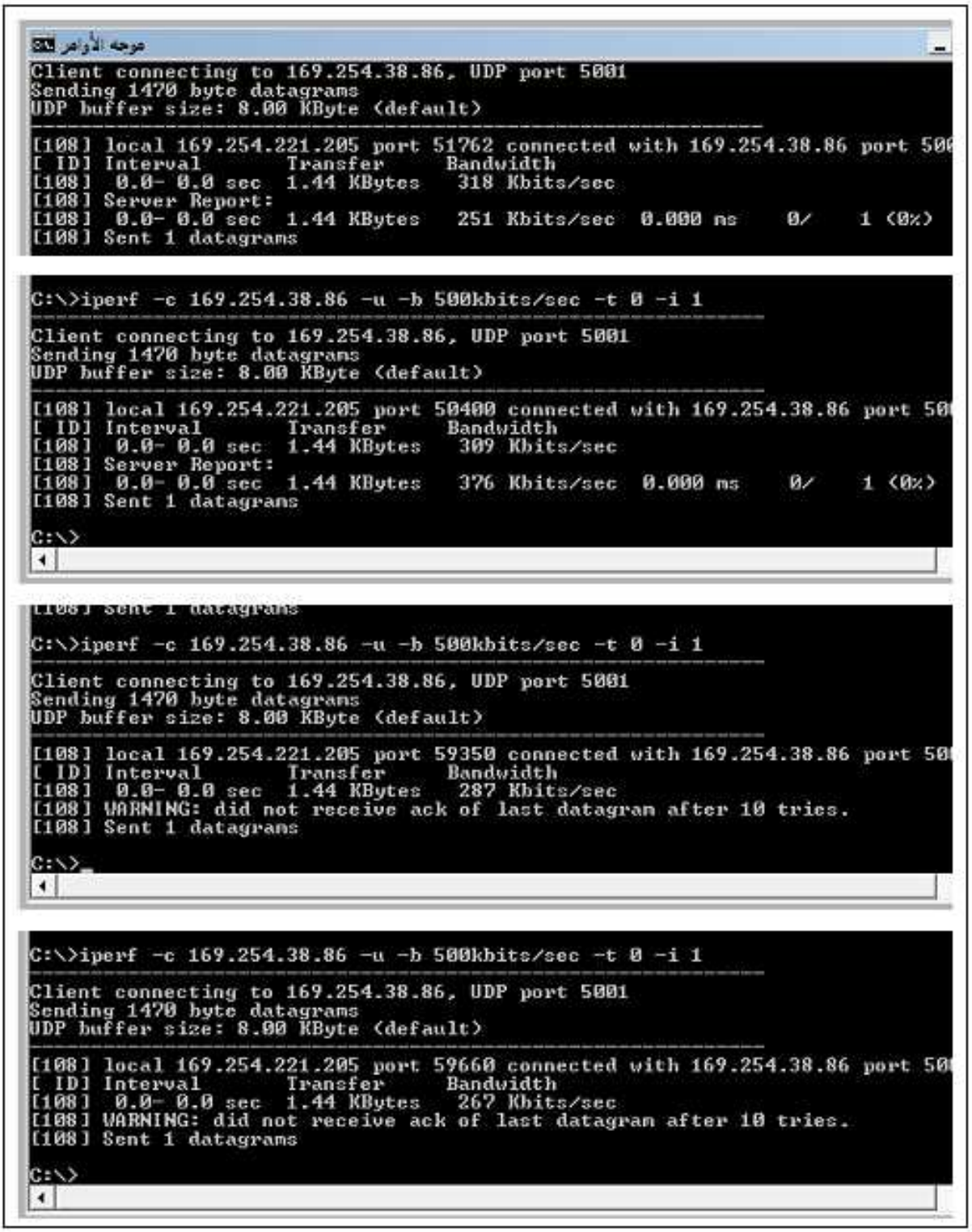
Figure 3: (a-e)client on AP1,(f)client on AP2

R


[108] Sent 1 datagrams
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 61300 connected with 169.254.38.86 port 5001
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 490 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrams
موجه الأوامر
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 55354 connected with 169.254.38.86 port 500
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 452 Kbits/sec
[108] Server Report:
[108] 0.0- 0.0 sec 1.44 KBytes 376 Kbits/sec 0.000 ms 0/ 1 (0%)
[108] Sent 1 datagrams
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrans
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 55355 connected with 169.254.38.86 port 500
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 406 Kbits/sec
[108] Server Report:
[108] 0.0- 0.0 sec 1.44 KBytes 376 Kbits/sec 0.000 ms 0/ 1 (0%)
[108] Sent 1 datagrams
C:\>
موجه الأوامر
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 55359 connected with 169.254.38.86 port 50
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 392 Kbits/sec
[108] Server Report:
[108] 0.0- 0.0 sec 1.44 KBytes 376 Kbits/sec 0.000 ms 0/ 1 (0%)
[108] Sent 1 datagrams

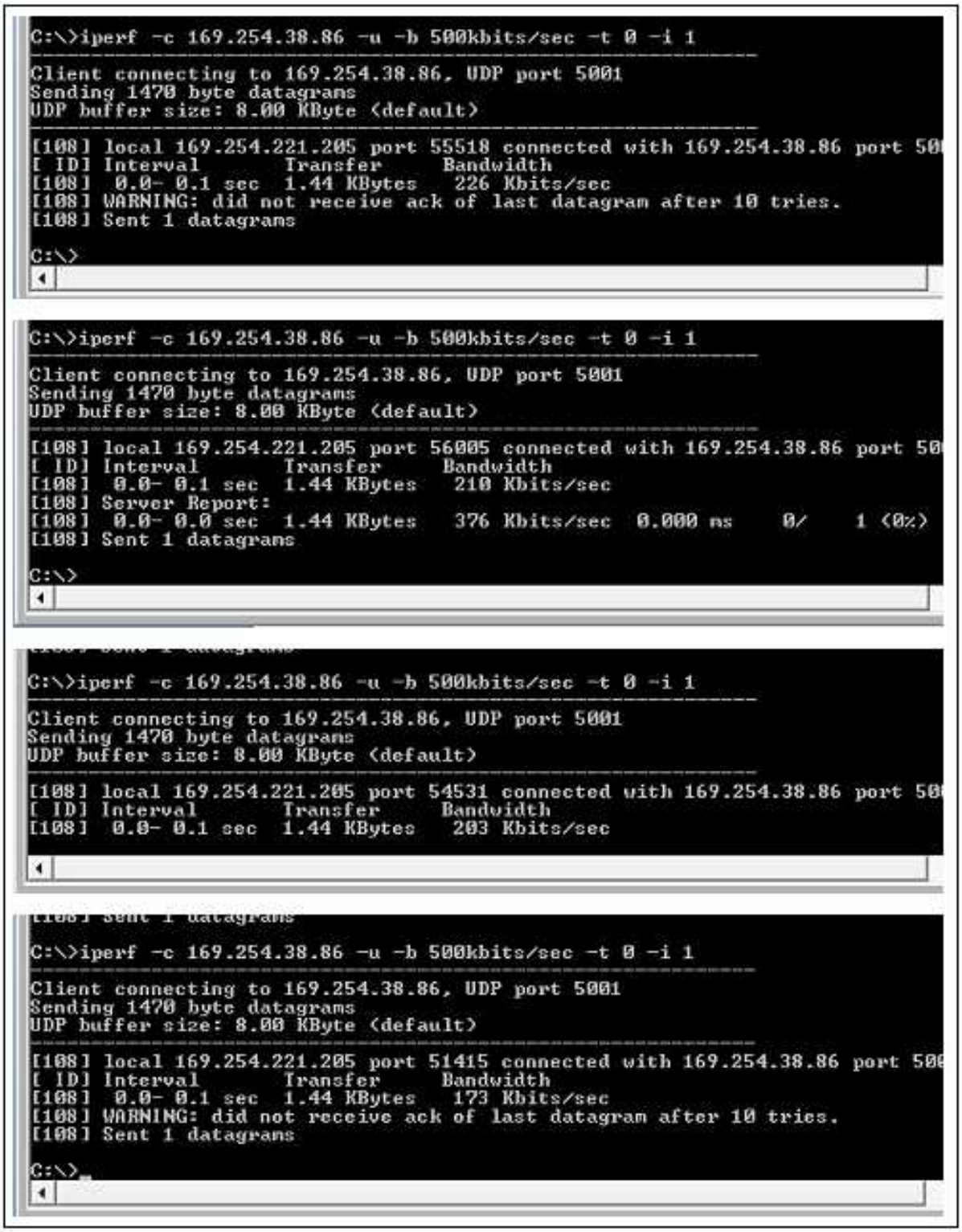
(4-a)

S


موجه الأوامر
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 51762 connected with 169.254.38.86 port 500
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 318 Kbits/sec
[108] Server Report:
[108] 0.0- 0.0 sec 1.44 KBytes 251 Kbits/sec 0.000 ms 0/ 1 (0%)
[108] Sent 1 datagrams
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 50400 connected with 169.254.38.86 port 50
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 309 Kbits/sec
[108] Server Report:
[108] 0.0- 0.0 sec 1.44 KBytes 376 Kbits/sec 0.000 ms 0/ 1 (0%)
[108] Sent 1 datagrans
C:\>
[108] Sent 1 datagrans
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrans
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 59350 connected with 169.254.38.86 port 50
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 287 Kbits/sec
[108] WARNING: did not receive ack of last datagran after 10 tries.
[108] Sent 1 datagrans
C:\>
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 59660 connected with 169.254.38.86 port 50
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.0 sec 1.44 KBytes 267 Kbits/sec
[108] WARNING: did not receive ack of last datagran after 10 tries.
[108] Sent 1 datagrams
C:\>
C:\>

(4-b)

T

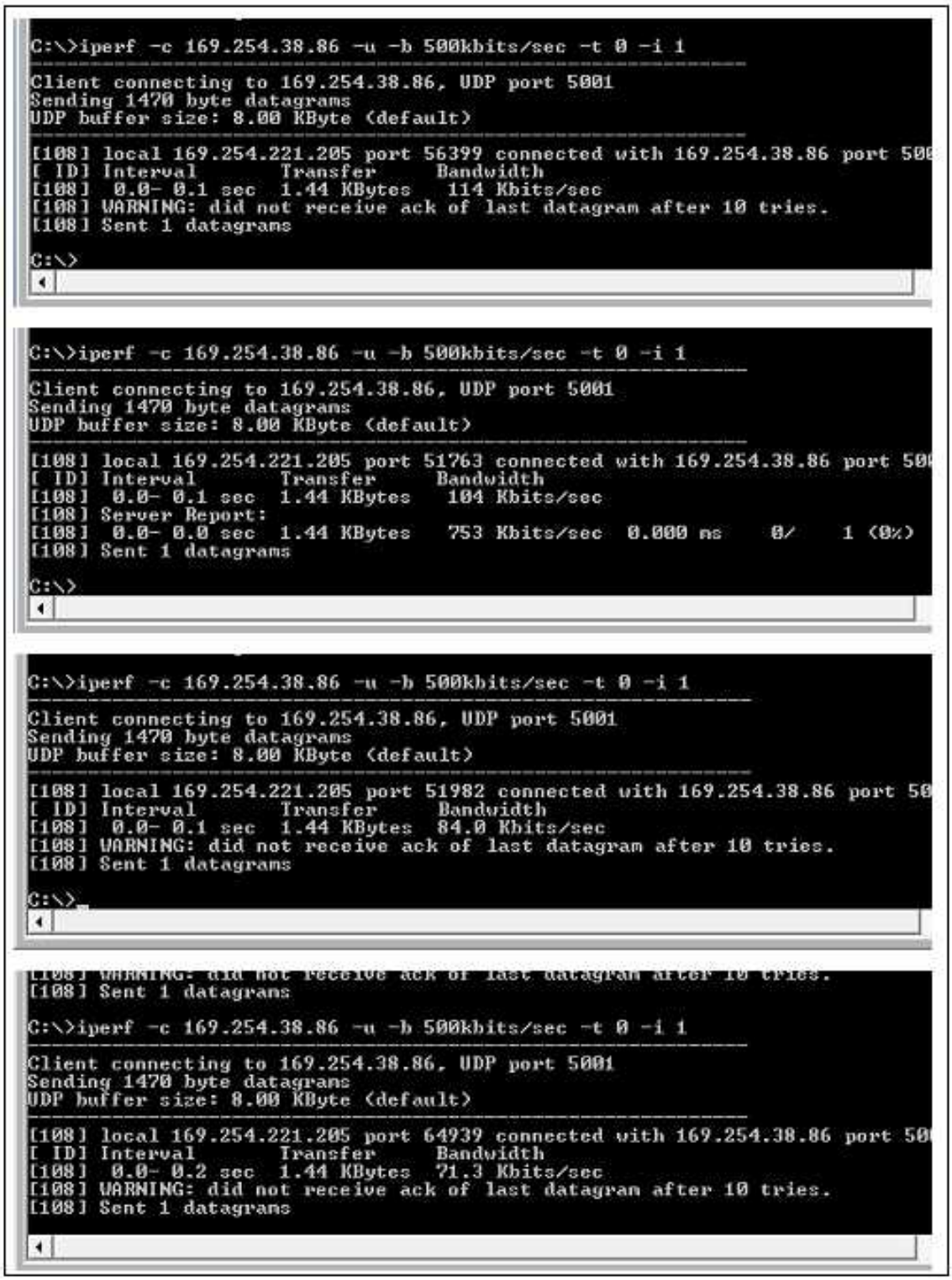

C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 55518 connected with 169.254.38.86 port 50
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.1 sec 1.44 KBytes 226 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrams
C:\>
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 56005 connected with 169.254.38.86 port 50
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.1 sec 1.44 KBytes 210 Kbits/sec
[108] Server Report:
[108] 0.0- 0.0 sec 1.44 KBytes 376 Kbits/sec 0.000 ms 0/ 1 (0%)
[108] Sent 1 datagrams
C:\>
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 54531 connected with 169.254.38.86 port 50
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.1 sec 1.44 KBytes 203 Kbits/sec
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 51415 connected with 169.254.38.86 port 50
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.1 sec 1.44 KBytes 173 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrams
C:\>

(4-c)

U

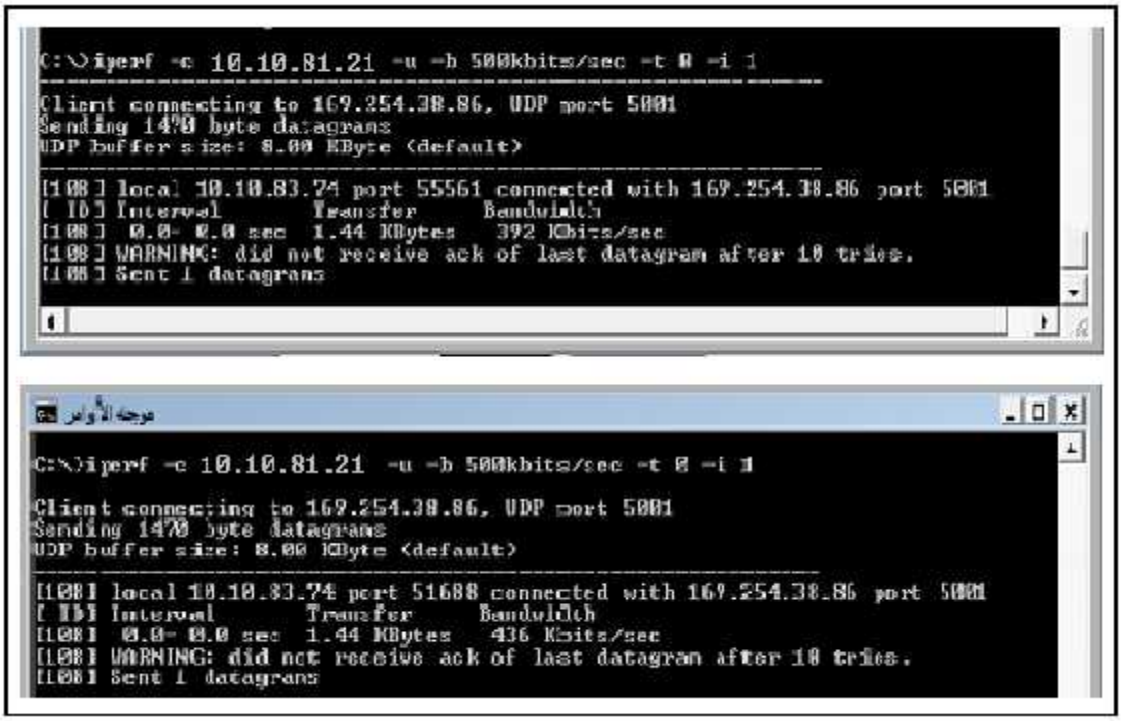

C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 52655 connected with 169.254.38.86 port 50
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.1 sec 1.44 KBytes 170 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrams
C:\>
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 51822 connected with 169.254.38.86 port 50
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.1 sec 1.44 KBytes 166 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrams
C:\>
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 51200 connected with 169.254.38.86 port 50
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.1 sec 1.44 KBytes 134 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrams
C:\>
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 64925 connected with 169.254.38.86 port 50
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.1 sec 1.44 KBytes 118 Kbits/sec
[108] Server Report:
[108] 0.0- 0.0 sec 1.44 KBytes 753 Kbits/sec 0.000 ms 0/ 1 (0%)
[108] Sent 1 datagrams
C:\>

(4-d)


C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 56399 connected with 169.254.38.86 port 500
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.1 sec 1.44 KBytes 114 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrams
C:\>
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 51763 connected with 169.254.38.86 port 500
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.1 sec 1.44 KBytes 104 Kbits/sec
[108] Server Report:
[108] 0.0- 0.0 sec 1.44 KBytes 753 Kbits/sec 0.000 ms 0/ 1 (0%)
[108] Sent 1 datagrams
C:\>
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 51982 connected with 169.254.38.86 port 50
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.1 sec 1.44 KBytes 84.0 Kbits/sec
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrams
C:\>
[108] WARNING: did not receive ack of last datagram after 10 tries.
[108] Sent 1 datagrans
C:\>iperf -c 169.254.38.86 -u -b 500kbits/sec -t 0 -i 1
Client connecting to 169.254.38.86, UDP port 5001
Sending 1470 byte datagrans
UDP buffer size: 8.00 KByte (default)
[108] local 169.254.221.205 port 64939 connected with 169.254.38.86 port 50
[ID] Interval Transfer Bandwidth
[108] 0.0- 0.2 sec 1.44 KBytes 71.3 Kbits/sec
[108] WARNING: did not receive ack of last datagran after 10 tries.
[108] Sent 1 datagrams

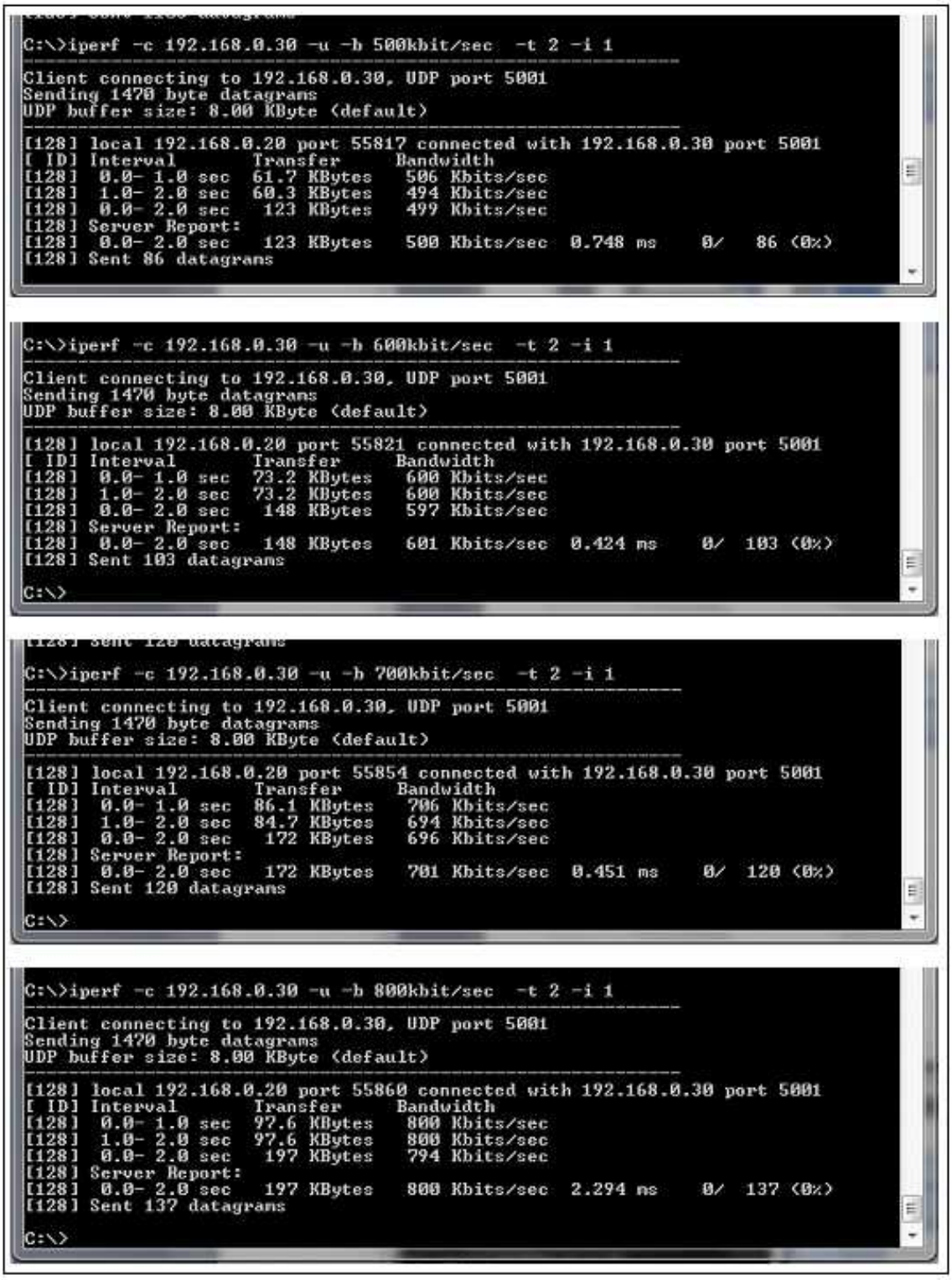
(4-e)

W



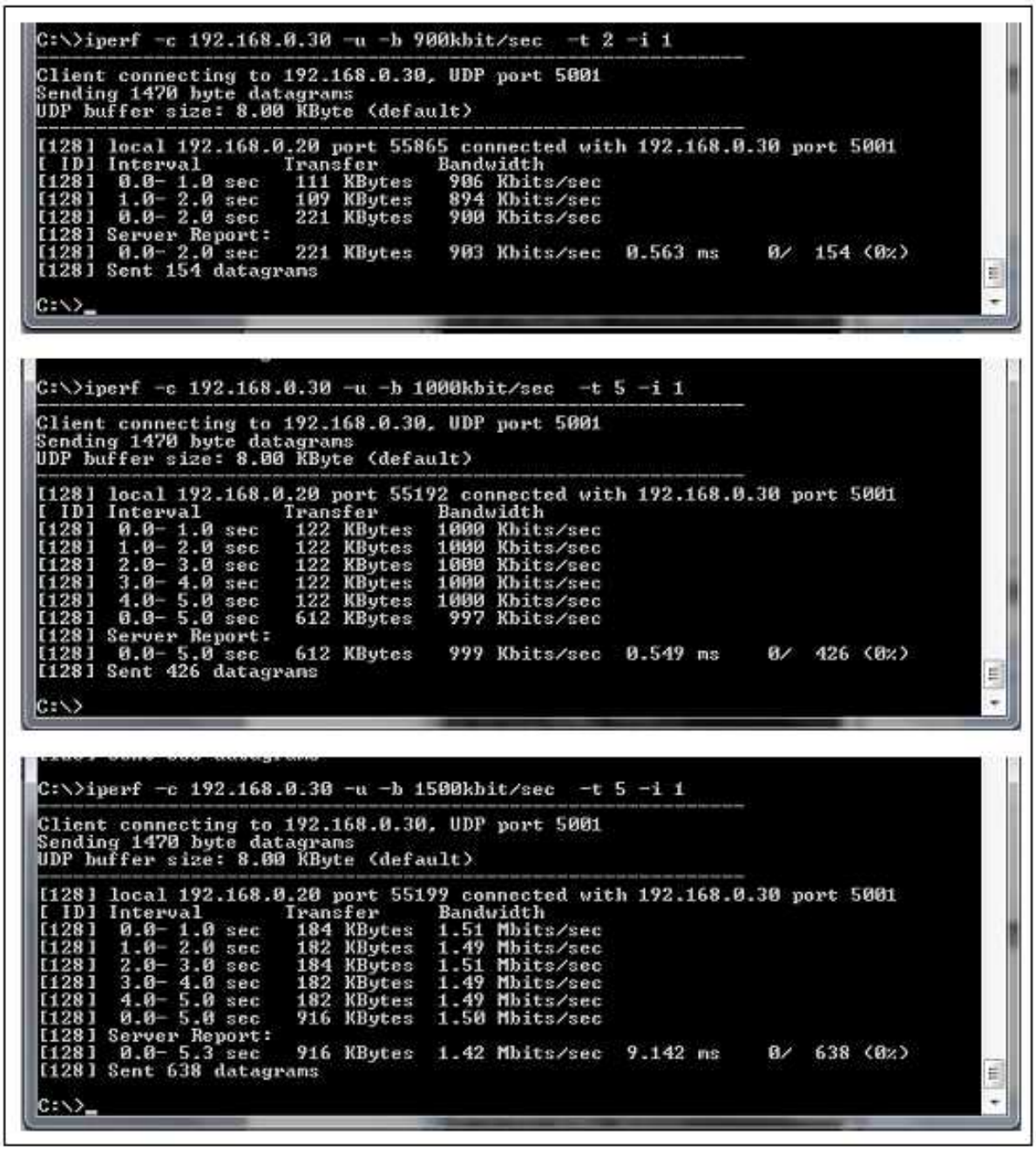
(4-f)

Figure 4: (a-e)client on AP1,(f)client on AP2


C:\>iperf -c 192.168.0.30 -u -b 500kbit/sec -t 2 -i 1
Client connecting to 192.168.0.30, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.20 port 55817 connected with 192.168.0.30 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 61.7 KBytes 506 Kbits/sec
[128] 1.0- 2.0 sec 60.3 KBytes 494 Kbits/sec
[128] 0.0- 2.0 sec 123 KBytes 499 Kbits/sec
[128] Server Report:
[128] 0.0- 2.0 sec 123 KBytes 500 Kbits/sec 0.748 ms 0/ 86 (0%)
[128] Sent 86 datagrams
C:\>iperf -c 192.168.0.30 -u -b 600kbit/sec -t 2 -i 1
Client connecting to 192.168.0.30, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.20 port 55821 connected with 192.168.0.30 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 73.2 KBytes 600 Kbits/sec
[128] 1.0- 2.0 sec 73.2 KBytes 600 Kbits/sec
[128] 0.0- 2.0 sec 148 KBytes 597 Kbits/sec
[128] Server Report:
[128] 0.0- 2.0 sec 148 KBytes 601 Kbits/sec 0.424 ms 0/ 103 (0%)
[128] Sent 103 datagrams
C:\>
C:\>iperf -c 192.168.0.30 -u -b 700kbit/sec -t 2 -i 1
Client connecting to 192.168.0.30, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.20 port 55854 connected with 192.168.0.30 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 86.1 KBytes 706 Kbits/sec
[128] 1.0- 2.0 sec 84.7 KBytes 694 Kbits/sec
[128] 0.0- 2.0 sec 172 KBytes 696 Kbits/sec
[128] Server Report:
[128] 0.0- 2.0 sec 172 KBytes 701 Kbits/sec 0.451 ms 0/ 120 (0%)
[128] Sent 120 datagrams
C:\>
C:\>iperf -c 192.168.0.30 -u -b 800kbit/sec -t 2 -i 1
Client connecting to 192.168.0.30, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.20 port 55860 connected with 192.168.0.30 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 97.6 KBytes 800 Kbits/sec
[128] 1.0- 2.0 sec 97.6 KBytes 800 Kbits/sec
[128] 0.0- 2.0 sec 197 KBytes 794 Kbits/sec
[128] Server Report:
[128] 0.0- 2.0 sec 197 KBytes 800 Kbits/sec 2.294 ms 0/ 137 (0%)
[128] Sent 137 datagrams
C:\>

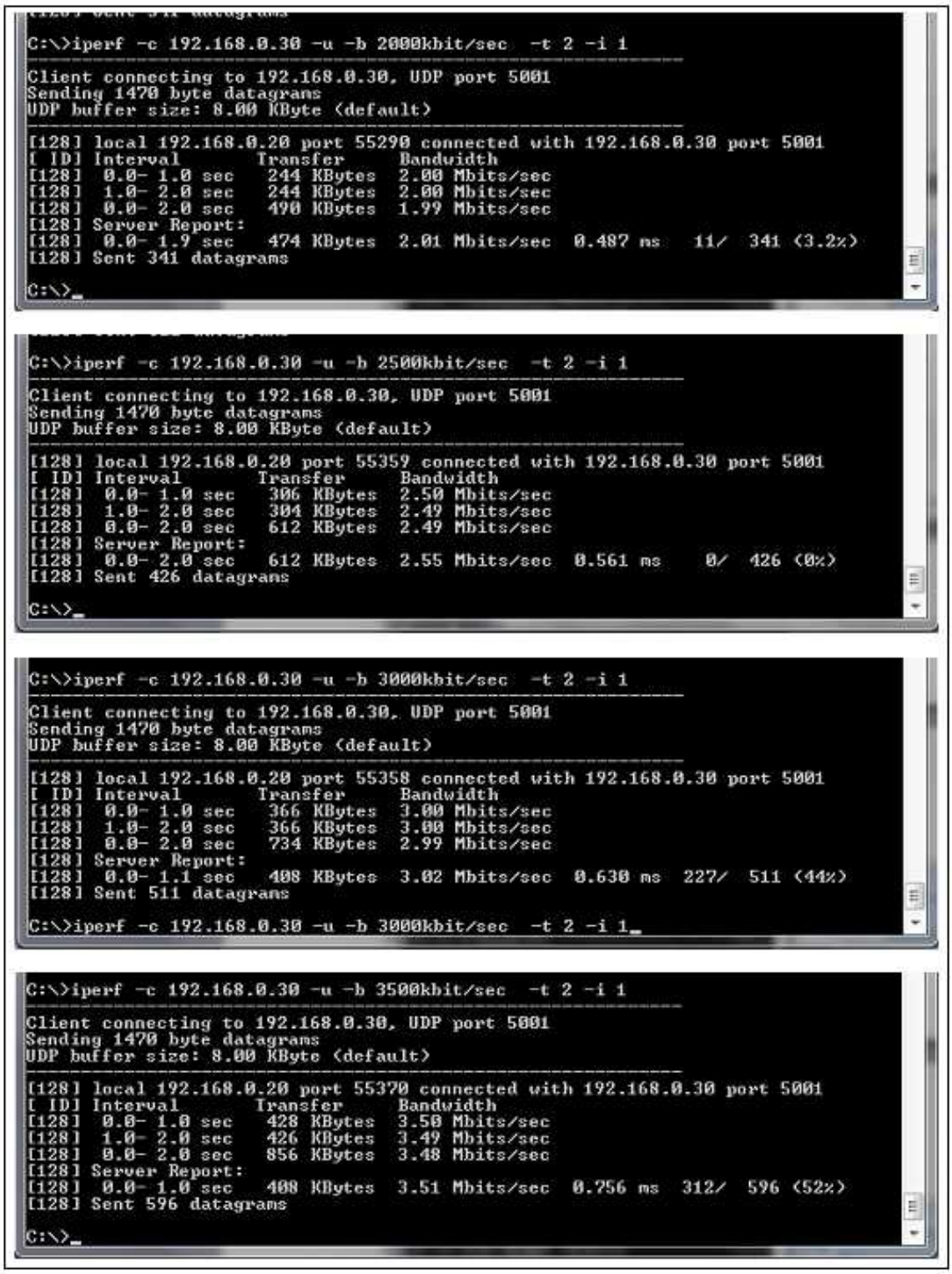
(5-a)

Y


C:\>iperf -c 192.168.0.30 -u -b 900kbit/sec -t 2 -i 1
Client connecting to 192.168.0.30, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.20 port 55865 connected with 192.168.0.30 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 111 KBytes 906 Kbits/sec
[128] 1.0- 2.0 sec 109 KBytes 894 Kbits/sec
[128] 0.0- 2.0 sec 221 KBytes 900 Kbits/sec
[128] Server Report:
[128] 0.0- 2.0 sec 221 KBytes 903 Kbits/sec 0.563 ms 0/ 154 (0%)
[128] Sent 154 datagrams
C:\>
C:\>iperf -c 192.168.0.30 -u -b 1000kbit/sec -t 5 -i 1
Client connecting to 192.168.0.30, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.20 port 55192 connected with 192.168.0.30 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[128] 2.0- 3.0 sec 122 KBytes 1000 Kbits/sec
[128] 3.0- 4.0 sec 122 KBytes 1000 Kbits/sec
[128] 4.0- 5.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 5.0 sec 612 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 5.0 sec 612 KBytes 999 Kbits/sec 0.549 ms 0/ 426 (0%)
[128] Sent 426 datagrams
C:\>
C:\>iperf -c 192.168.0.30 -u -b 1500kbit/sec -t 5 -i 1
Client connecting to 192.168.0.30, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.20 port 55199 connected with 192.168.0.30 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 184 KBytes 1.51 Mbits/sec
[128] 1.0- 2.0 sec 182 KBytes 1.49 Mbits/sec
[128] 2.0- 3.0 sec 184 KBytes 1.51 Mbits/sec
[128] 3.0- 4.0 sec 182 KBytes 1.49 Mbits/sec
[128] 4.0- 5.0 sec 182 KBytes 1.49 Mbits/sec
[128] 0.0- 5.0 sec 916 KBytes 1.50 Mbits/sec
[128] Server Report:
[128] 0.0- 5.3 sec 916 KBytes 1.42 Mbits/sec 9.142 ms 0/ 638 (0%)
[128] Sent 638 datagrams
C:\>

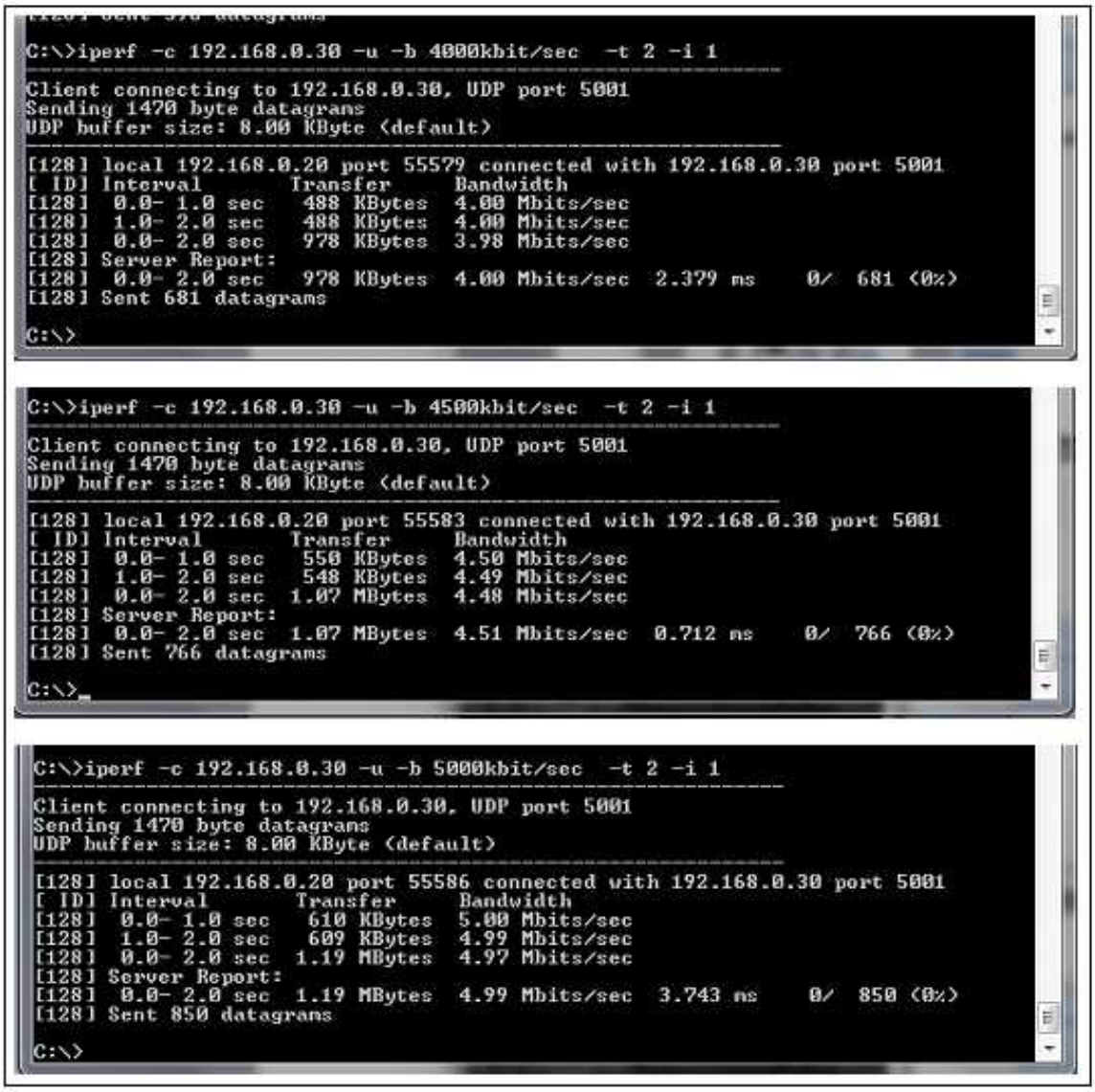
(5-b)

Z


C:\>iperf -c 192.168.0.30 -u -b 2000kbit/sec -t 2 -i 1
Client connecting to 192.168.0.30, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.20 port 55290 connected with 192.168.0.30 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 244 KBytes 2.00 Mbits/sec
[128] 1.0- 2.0 sec 244 KBytes 2.00 Mbits/sec
[128] 0.0- 2.0 sec 490 KBytes 1.99 Mbits/sec
[128] Server Report:
[128] 0.0- 1.9 sec 474 KBytes 2.01 Mbits/sec 0.487 ms 11/ 341 (3.2%)
[128] Sent 341 datagrams
C:\>
C:\>iperf -c 192.168.0.30 -u -b 2500kbit/sec -t 2 -i 1
Client connecting to 192.168.0.30, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.20 port 55359 connected with 192.168.0.30 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 306 KBytes 2.50 Mbits/sec
[128] 1.0- 2.0 sec 304 KBytes 2.49 Mbits/sec
[128] 0.0- 2.0 sec 612 KBytes 2.49 Mbits/sec
[128] Server Report:
[128] 0.0- 2.0 sec 612 KBytes 2.55 Mbits/sec 0.561 ms 0/ 426 (0%)
[128] Sent 426 datagrams
C:\>
C:\>iperf -c 192.168.0.30 -u -b 3000kbit/sec -t 2 -i 1
Client connecting to 192.168.0.30, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.20 port 55358 connected with 192.168.0.30 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 366 KBytes 3.00 Mbits/sec
[128] 1.0- 2.0 sec 366 KBytes 3.00 Mbits/sec
[128] 0.0- 2.0 sec 734 KBytes 2.99 Mbits/sec
[128] Server Report:
[128] 0.0- 1.1 sec 408 KBytes 3.02 Mbits/sec 0.630 ms 227/ 511 (44%)
[128] Sent 511 datagrams
C:\>iperf -c 192.168.0.30 -u -b 3000kbit/sec -t 2 -i 1
C:\>iperf -c 192.168.0.30 -u -b 3500kbit/sec -t 2 -i 1
Client connecting to 192.168.0.30, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.20 port 55370 connected with 192.168.0.30 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 428 KBytes 3.50 Mbits/sec
[128] 1.0- 2.0 sec 426 KBytes 3.49 Mbits/sec
[128] 0.0- 2.0 sec 856 KBytes 3.48 Mbits/sec
[128] Server Report:
[128] 0.0- 1.0 sec 408 KBytes 3.51 Mbits/sec 0.756 ms 312/ 596 (52%)
[128] Sent 596 datagrams
C:\>

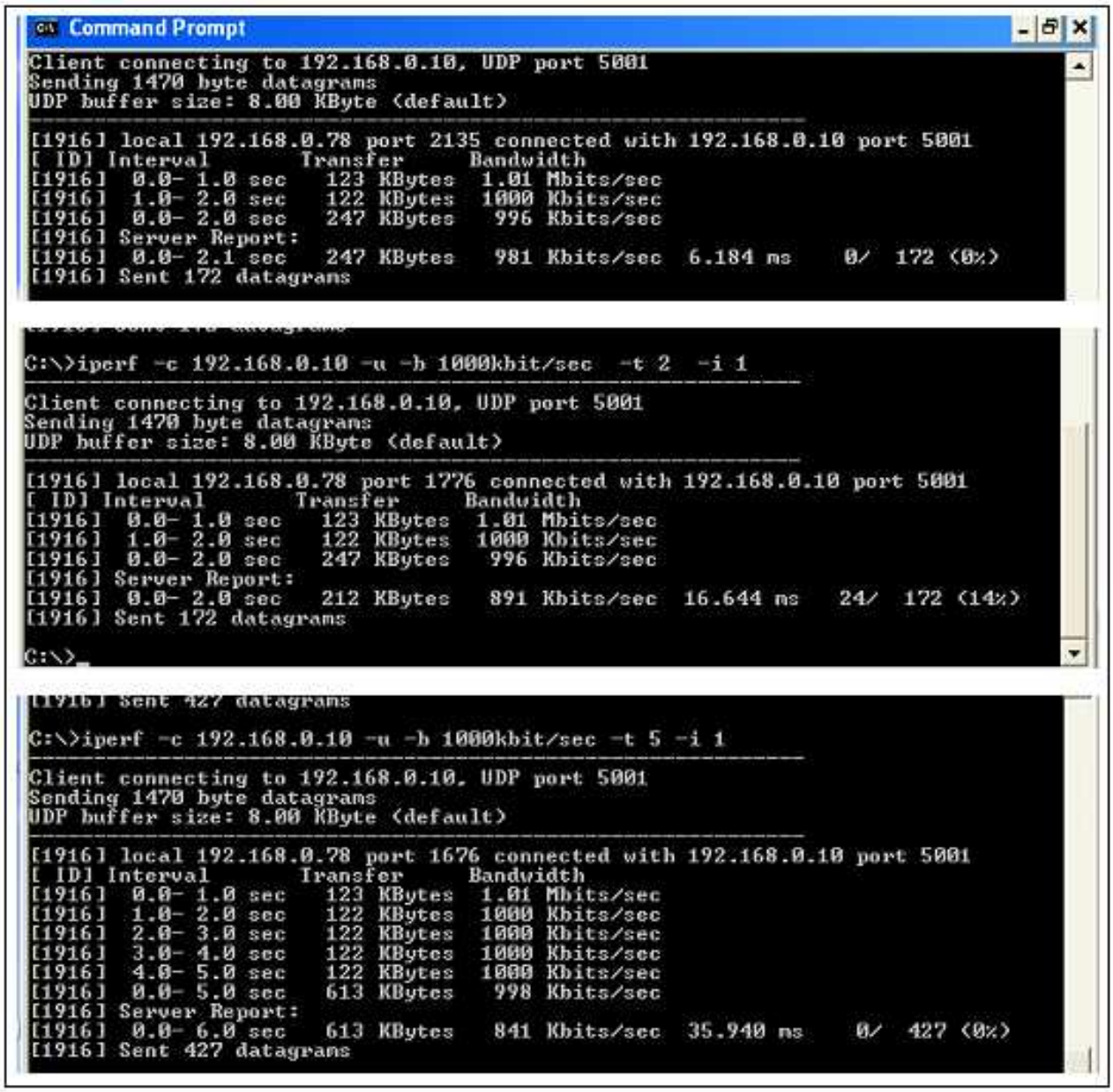
(5-c)

AA



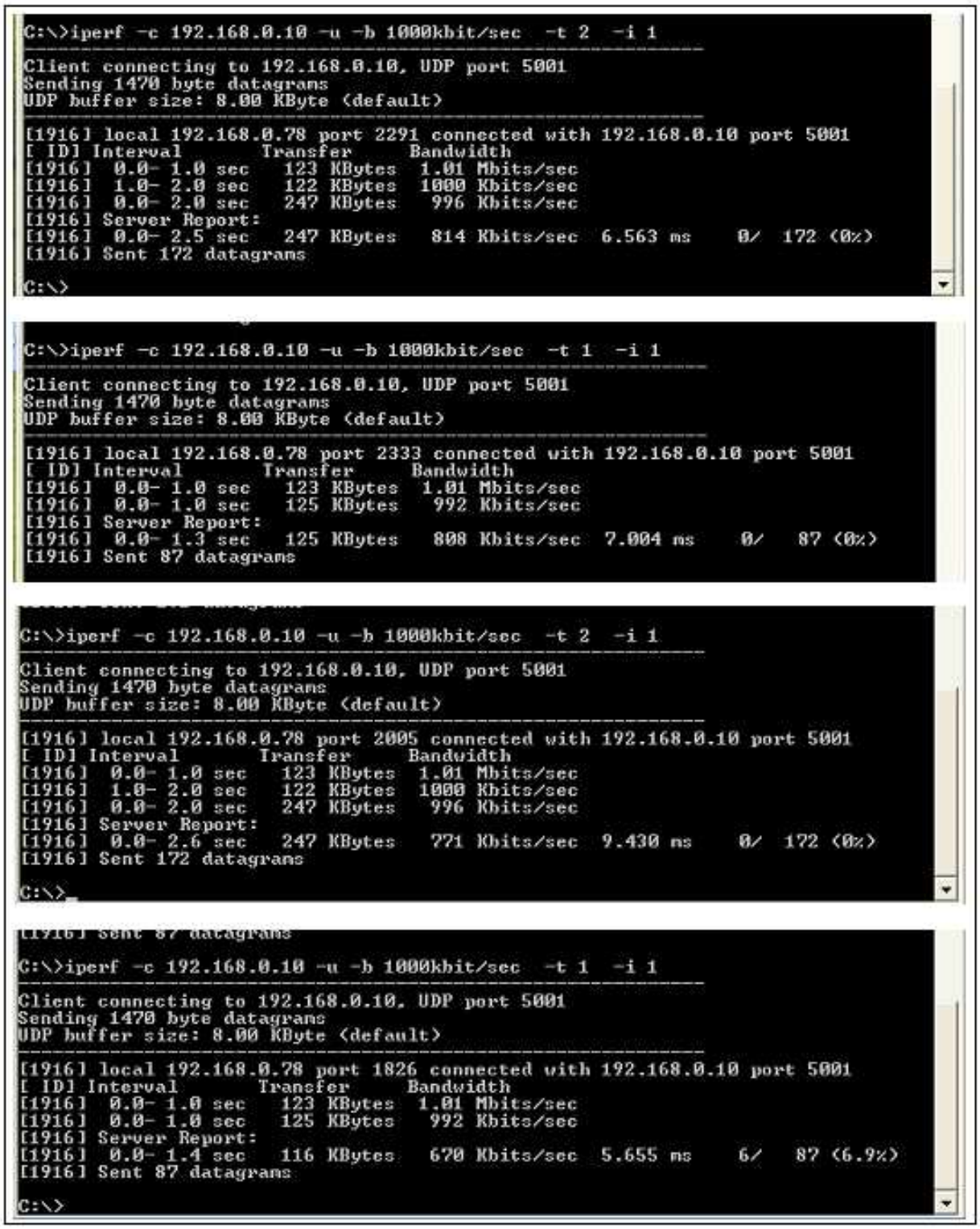
(5-d)

Figure 5: (a-d) Download experiment ,loader increasing in the first stage


Command Prompt
Client connecting to 192.168.0.10, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.0.78 port 2135 connected with 192.168.0.10 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 123 KBytes 1.01 Mbits/sec
[1916] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[1916] 0.0- 2.0 sec 247 KBytes 996 Kbits/sec
[1916] Server Report:
[1916] 0.0- 2.1 sec 247 KBytes 981 Kbits/sec 6.184 ms 0/ 172 (0%)
[1916] Sent 172 datagrams
C:\>iperf -c 192.168.0.10 -u -b 1000kbit/sec -t 2 -i 1
Client connecting to 192.168.0.10, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.0.78 port 1776 connected with 192.168.0.10 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 123 KBytes 1.01 Mbits/sec
[1916] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[1916] 0.0- 2.0 sec 247 KBytes 996 Kbits/sec
[1916] Server Report:
[1916] 0.0- 2.0 sec 212 KBytes 891 Kbits/sec 16.644 ms 24/ 172 (14%)
[1916] Sent 172 datagrams
C:\>
[1916] Sent 427 datagrams
C:\>iperf -c 192.168.0.10 -u -b 1000kbit/sec -t 5 -i 1
Client connecting to 192.168.0.10, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.0.78 port 1676 connected with 192.168.0.10 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 123 KBytes 1.01 Mbits/sec
[1916] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[1916] 2.0- 3.0 sec 122 KBytes 1000 Kbits/sec
[1916] 3.0- 4.0 sec 122 KBytes 1000 Kbits/sec
[1916] 4.0- 5.0 sec 122 KBytes 1000 Kbits/sec
[1916] 0.0- 5.0 sec 613 KBytes 998 Kbits/sec
[1916] Server Report:
[1916] 0.0- 6.0 sec 613 KBytes 841 Kbits/sec 35.940 ms 0/ 427 (0%)
[1916] Sent 427 datagrams

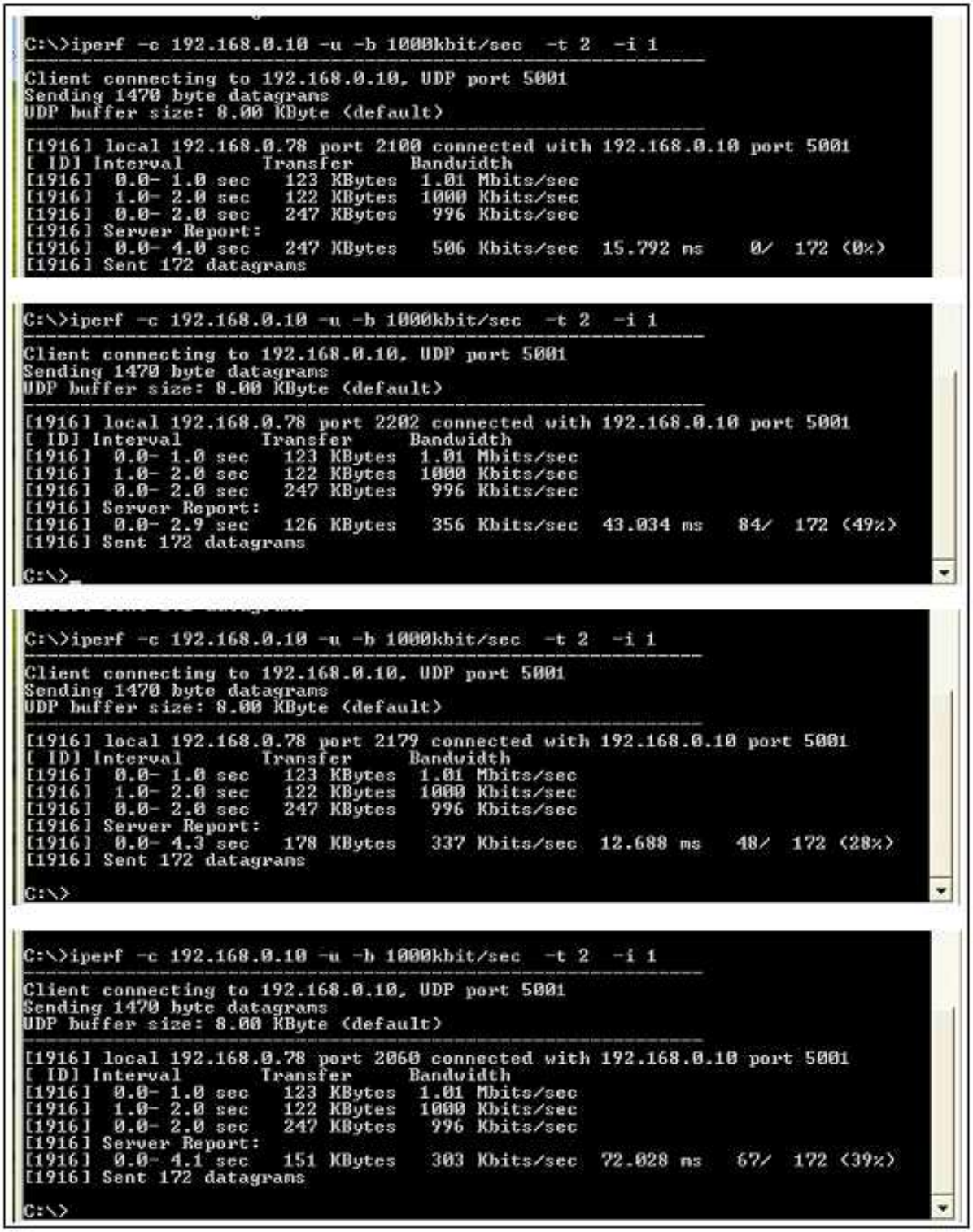
(6-a)

CC

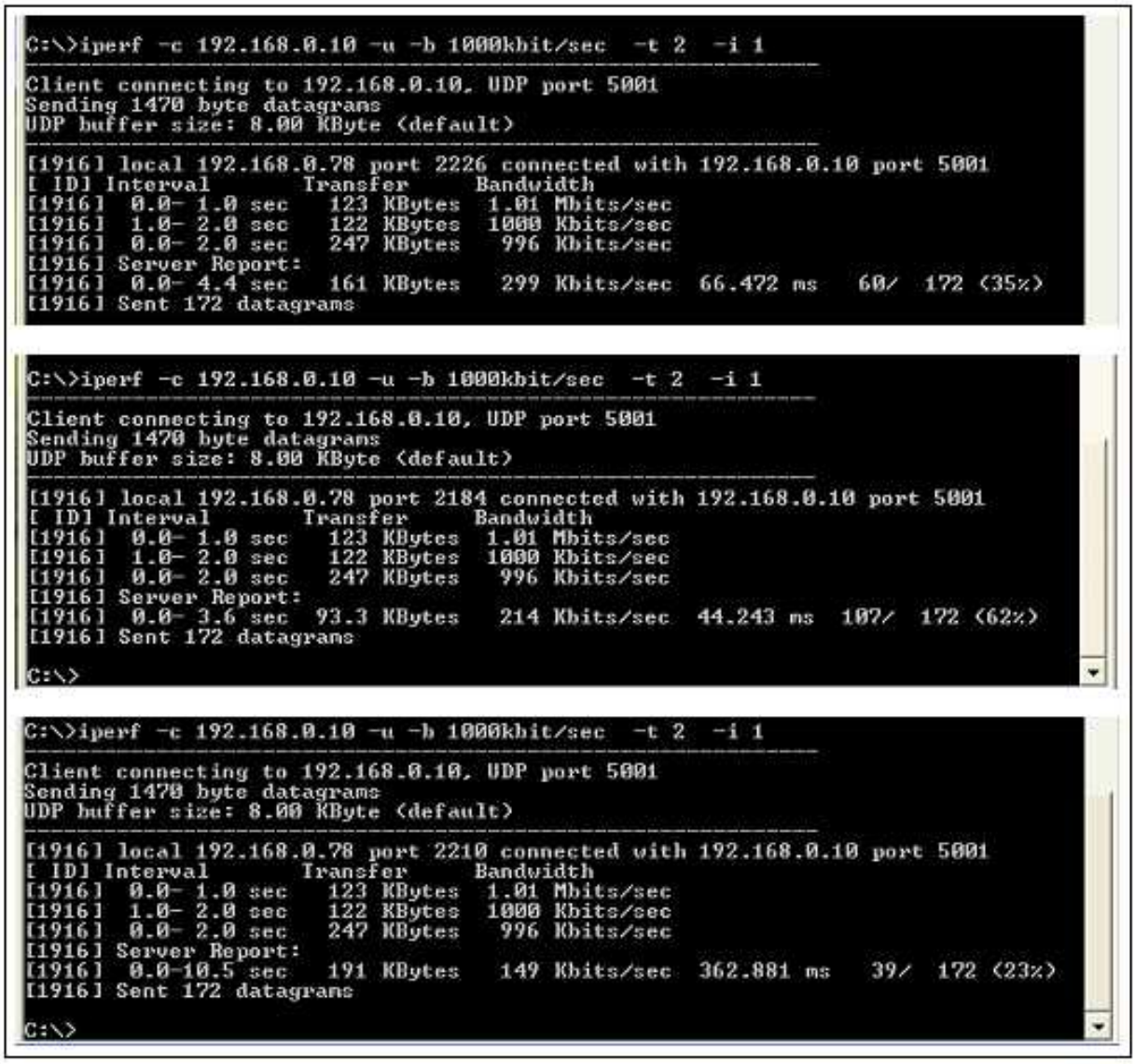

C:\>iperf -c 192.168.0.10 -u -b 1000kbit/sec -t 2 -i 1
Client connecting to 192.168.0.10, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.0.78 port 2291 connected with 192.168.0.10 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 123 KBytes 1.01 Mbits/sec
[1916] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[1916] 0.0- 2.0 sec 247 KBytes 996 Kbits/sec
[1916] Server Report:
[1916] 0.0- 2.5 sec 247 KBytes 814 Kbits/sec 6.563 ms 0/ 172 (0%)
[1916] Sent 172 datagrams
C:\>
C:\>iperf -c 192.168.0.10 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.0.10, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.0.78 port 2333 connected with 192.168.0.10 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 123 KBytes 1.01 Mbits/sec
[1916] 0.0- 1.0 sec 125 KBytes 992 Kbits/sec
[1916] Server Report:
[1916] 0.0- 1.3 sec 125 KBytes 808 Kbits/sec 7.004 ms 0/ 87 (0%)
[1916] Sent 87 datagrams
C:\>iperf -c 192.168.0.10 -u -b 1000kbit/sec -t 2 -i 1
Client connecting to 192.168.0.10, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.0.78 port 2005 connected with 192.168.0.10 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 123 KBytes 1.01 Mbits/sec
[1916] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[1916] 0.0- 2.0 sec 247 KBytes 996 Kbits/sec
[1916] Server Report:
[1916] 0.0- 2.6 sec 247 KBytes 771 Kbits/sec 9.430 ms 0/ 172 (0%)
[1916] Sent 172 datagrams
C:\>
C:\>iperf -c 192.168.0.10 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.0.10, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.0.78 port 1826 connected with 192.168.0.10 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 123 KBytes 1.01 Mbits/sec
[1916] 0.0- 1.0 sec 125 KBytes 992 Kbits/sec
[1916] Server Report:
[1916] 0.0- 1.4 sec 116 KBytes 670 Kbits/sec 5.655 ms 6/ 87 (6.9%)
[1916] Sent 87 datagrams
C:\>

(6-b)

DD

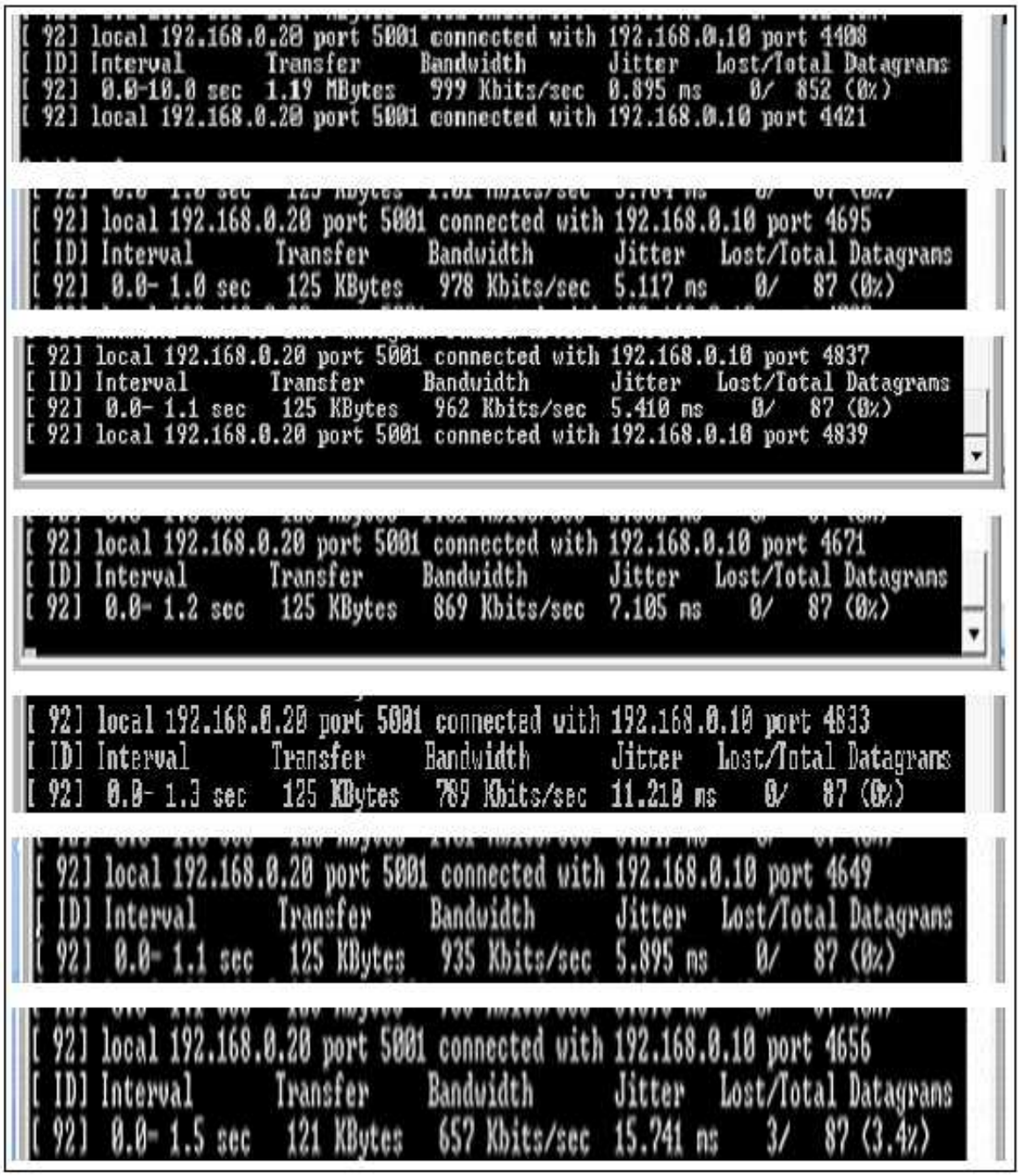

C:\>iperf -c 192.168.0.10 -u -b 1000kbit/sec -t 2 -i 1
Client connecting to 192.168.0.10, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.0.78 port 2100 connected with 192.168.0.10 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 123 KBytes 1.01 Mbits/sec
[1916] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[1916] 0.0- 2.0 sec 247 KBytes 996 Kbits/sec
[1916] Server Report:
[1916] 0.0- 4.0 sec 247 KBytes 506 Kbits/sec 15.792 ms 0/ 172 (0%)
[1916] Sent 172 datagrams
C:\>iperf -c 192.168.0.10 -u -b 1000kbit/sec -t 2 -i 1
Client connecting to 192.168.0.10, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.0.78 port 2202 connected with 192.168.0.10 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 123 KBytes 1.01 Mbits/sec
[1916] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[1916] 0.0- 2.0 sec 247 KBytes 996 Kbits/sec
[1916] Server Report:
[1916] 0.0- 2.9 sec 126 KBytes 356 Kbits/sec 43.034 ms 84/ 172 (49%)
[1916] Sent 172 datagrams
C:\>
C:\>iperf -c 192.168.0.10 -u -b 1000kbit/sec -t 2 -i 1
Client connecting to 192.168.0.10, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.0.78 port 2179 connected with 192.168.0.10 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 123 KBytes 1.01 Mbits/sec
[1916] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[1916] 0.0- 2.0 sec 247 KBytes 996 Kbits/sec
[1916] Server Report:
[1916] 0.0- 4.3 sec 178 KBytes 337 Kbits/sec 12.688 ms 48/ 172 (28%)
[1916] Sent 172 datagrams
C:\>
C:\>iperf -c 192.168.0.10 -u -b 1000kbit/sec -t 2 -i 1
Client connecting to 192.168.0.10, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.0.78 port 2060 connected with 192.168.0.10 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 123 KBytes 1.01 Mbits/sec
[1916] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[1916] 0.0- 2.0 sec 247 KBytes 996 Kbits/sec
[1916] Server Report:
[1916] 0.0- 4.1 sec 151 KBytes 303 Kbits/sec 72.028 ms 67/ 172 (39%)
[1916] Sent 172 datagrams
C:\>

(6-c)

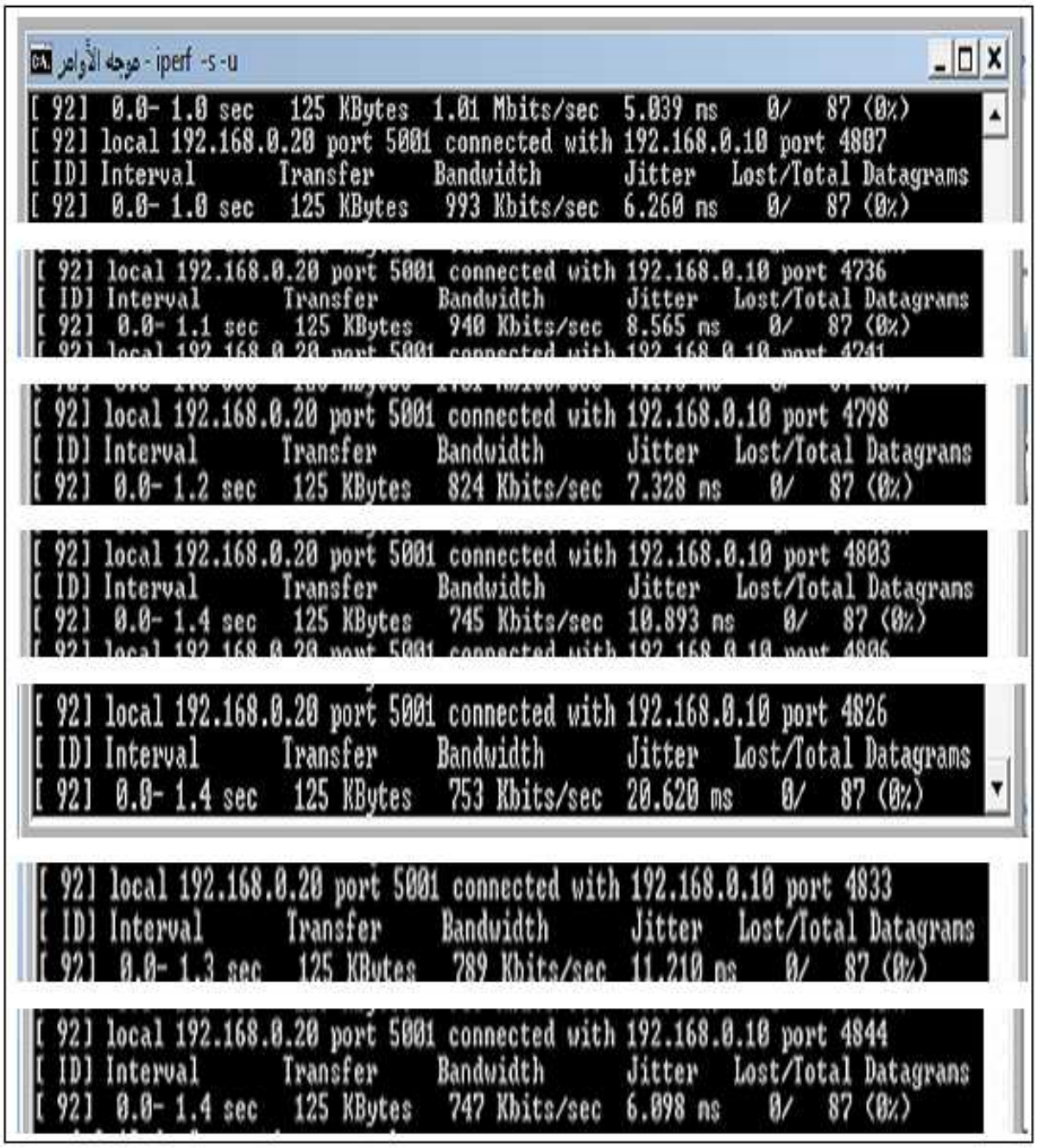


(6-d)

Figure 6: (a-d) Download experiment ,client associates with AP1 in 1st stage

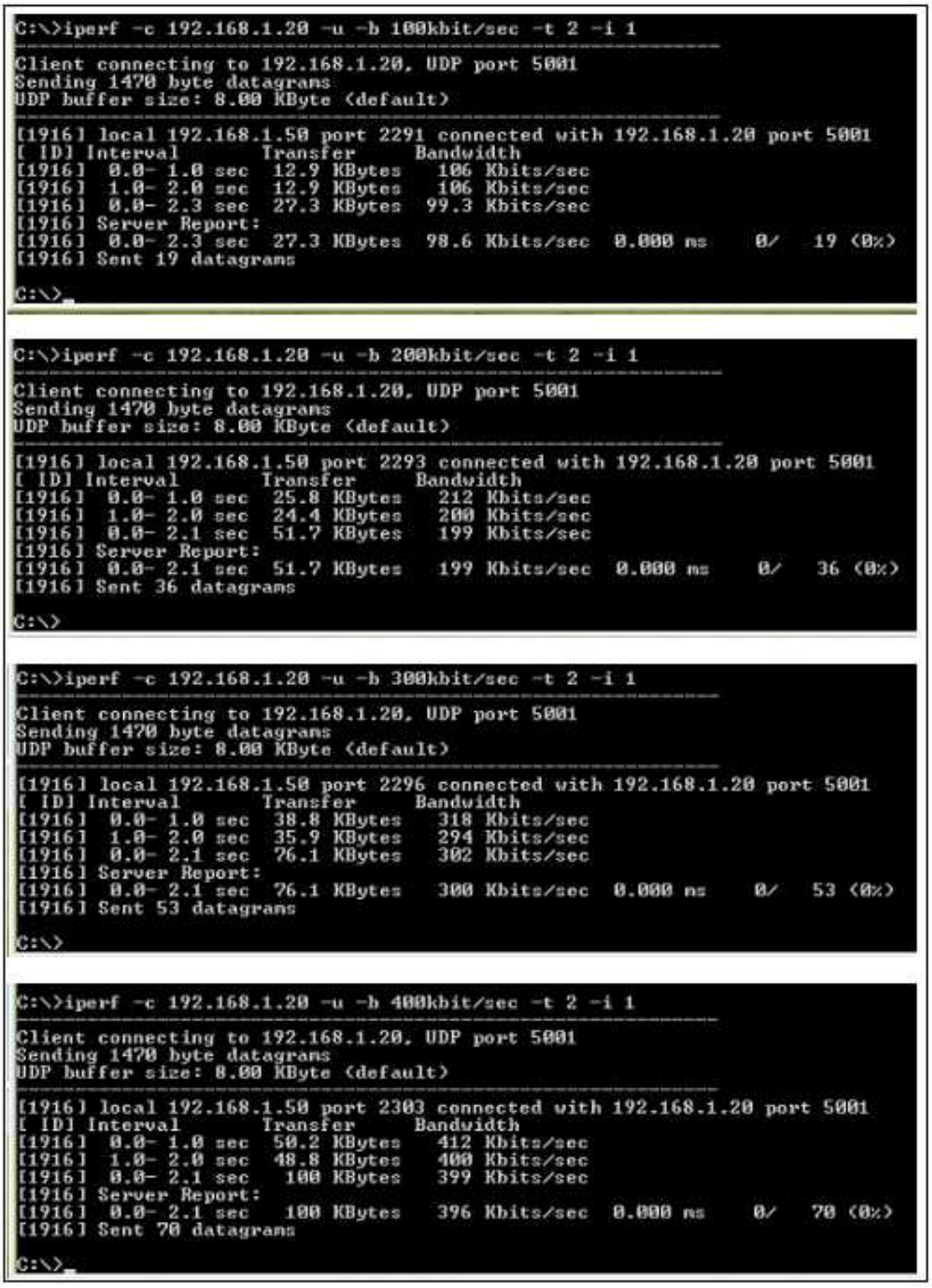

[92] local 192.168.0.20 port 5001 connected with 192.168.0.10 port 4408
[ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
[92] 0.0-10.0 sec 1.19 MBytes 999 Kbits/sec 0.895 ms 0/ 852 (0%)
[92] local 192.168.0.20 port 5001 connected with 192.168.0.10 port 4421
[92] local 192.168.0.20 port 5001 connected with 192.168.0.10 port 4695
[ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
[92] 0.0- 1.0 sec 125 KBytes 978 Kbits/sec 5.117 ms 0/ 87 (0%)
[92] local 192.168.0.20 port 5001 connected with 192.168.0.10 port 4837
[ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
[92] 0.0- 1.1 sec 125 KBytes 962 Kbits/sec 5.410 ms 0/ 87 (0%)
[92] local 192.168.0.20 port 5001 connected with 192.168.0.10 port 4839
[92] local 192.168.0.20 port 5001 connected with 192.168.0.10 port 4671
[ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
[92] 0.0- 1.2 sec 125 KBytes 869 Kbits/sec 7.105 ms 0/ 87 (0%)
[92] local 192.168.0.20 port 5001 connected with 192.168.0.10 port 4833
[ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
[92] 0.0- 1.3 sec 125 KBytes 789 Kbits/sec 11.210 ms 0/ 87 (0%)
[92] local 192.168.0.20 port 5001 connected with 192.168.0.10 port 4649
[ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
[92] 0.0- 1.1 sec 125 KBytes 935 Kbits/sec 5.895 ms 0/ 87 (0%)
[92] local 192.168.0.20 port 5001 connected with 192.168.0.10 port 4656
[ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams
[92] 0.0- 1.5 sec 121 KBytes 657 Kbits/sec 15.741 ms 3/ 87 (3.4%)

(7-a)

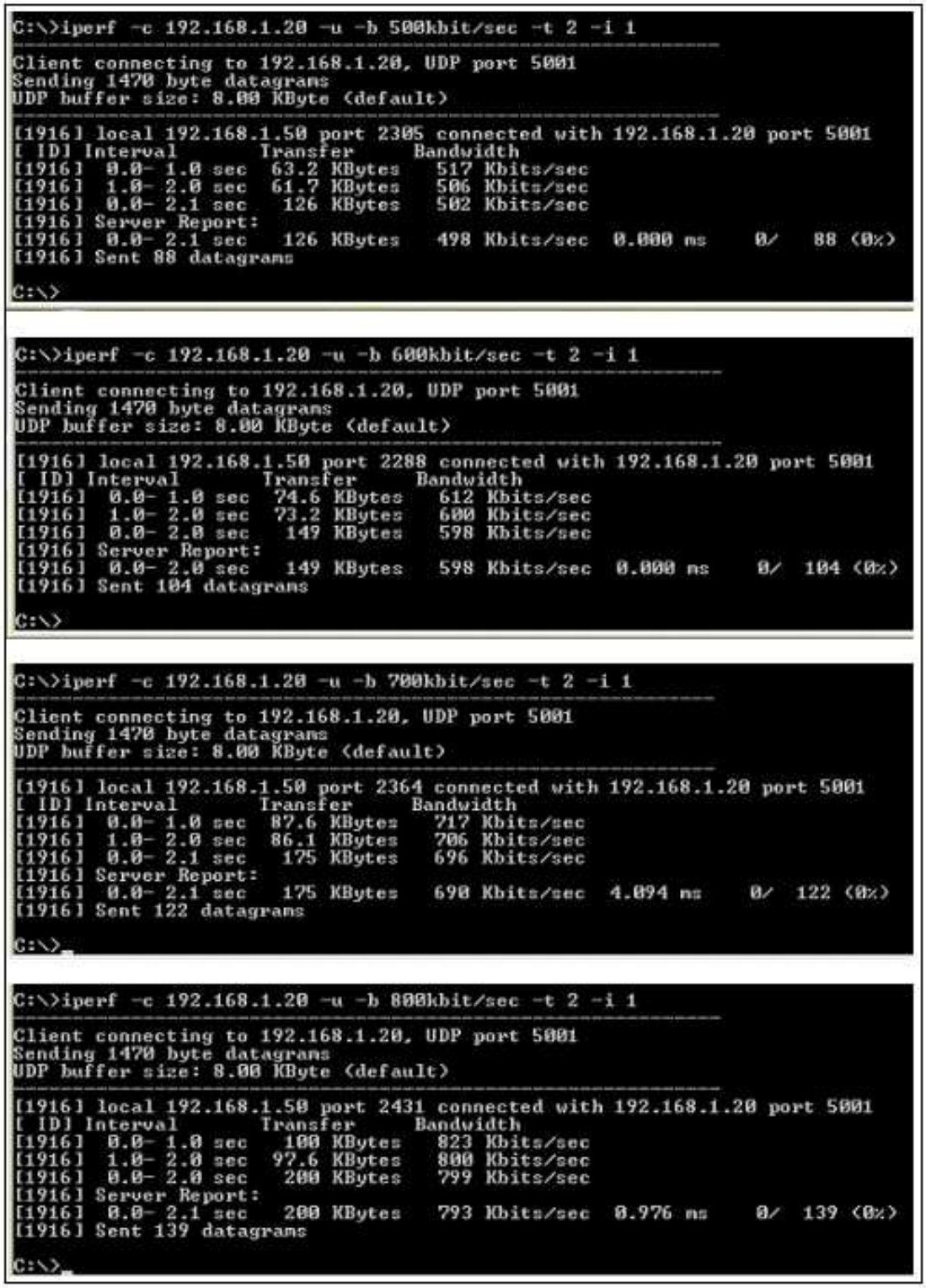


(7-b)

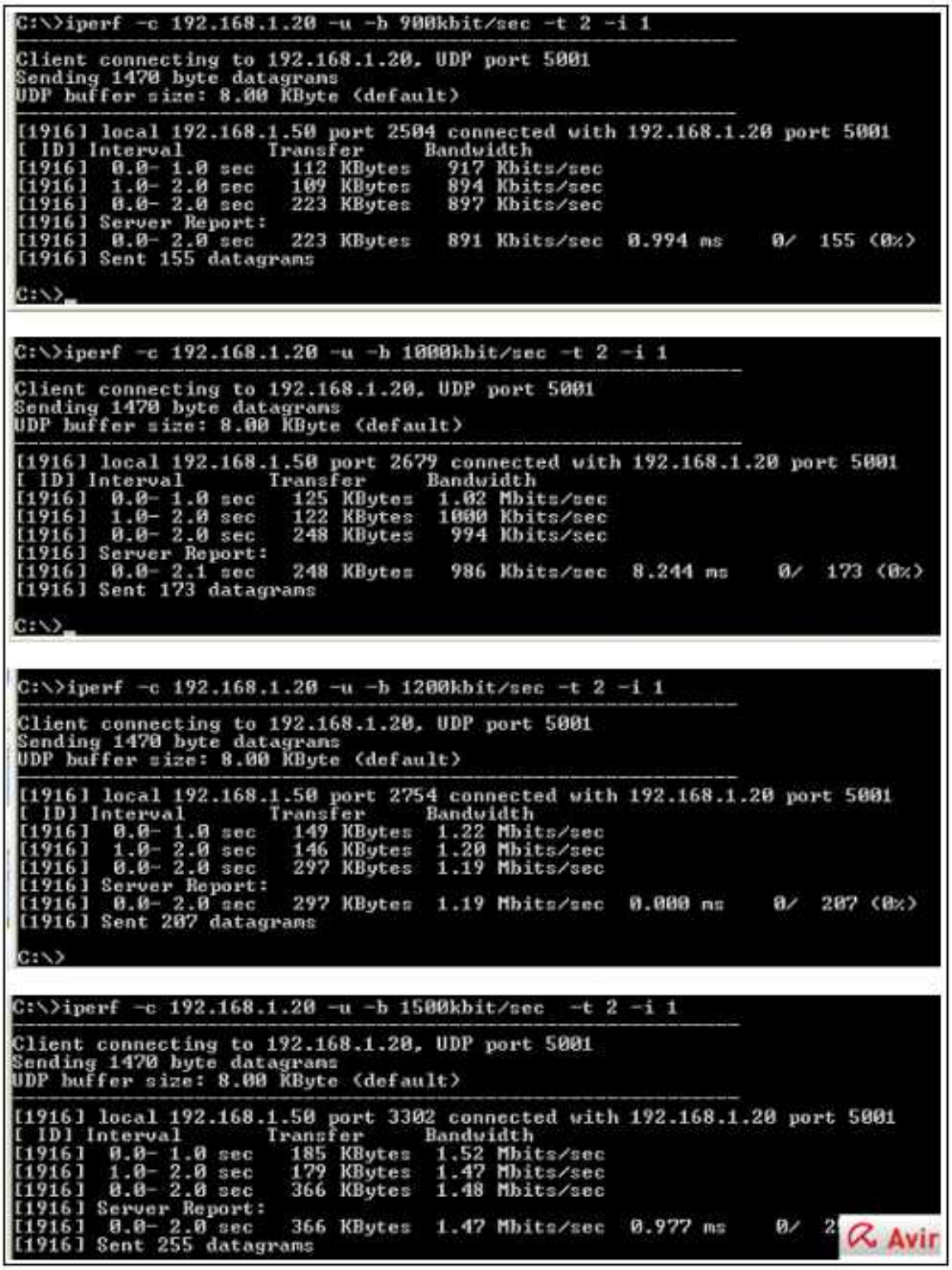
Figure 7: (a-d) Download experiment ,client associates with AP2 in 1st stage


C:\>iperf -c 192.168.1.20 -u -b 100kbit/sec -t 2 -i 1
Client connecting to 192.168.1.20, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.1.50 port 2291 connected with 192.168.1.20 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 12.9 KBytes 106 Kbits/sec
[1916] 1.0- 2.0 sec 12.9 KBytes 106 Kbits/sec
[1916] 0.0- 2.3 sec 27.3 KBytes 99.3 Kbits/sec
[1916] Server Report:
[1916] 0.0- 2.3 sec 27.3 KBytes 98.6 Kbits/sec 0.000 ms 0/ 19 (0%)
[1916] Sent 19 datagrams
C:\>
C:\>iperf -c 192.168.1.20 -u -b 200kbit/sec -t 2 -i 1
Client connecting to 192.168.1.20, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.1.50 port 2293 connected with 192.168.1.20 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 25.8 KBytes 212 Kbits/sec
[1916] 1.0- 2.0 sec 24.4 KBytes 200 Kbits/sec
[1916] 0.0- 2.1 sec 51.7 KBytes 199 Kbits/sec
[1916] Server Report:
[1916] 0.0- 2.1 sec 51.7 KBytes 199 Kbits/sec 0.000 ms 0/ 36 (0%)
[1916] Sent 36 datagrams
C:\>
C:\>iperf -c 192.168.1.20 -u -b 300kbit/sec -t 2 -i 1
Client connecting to 192.168.1.20, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.1.50 port 2296 connected with 192.168.1.20 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 38.8 KBytes 318 Kbits/sec
[1916] 1.0- 2.0 sec 35.9 KBytes 294 Kbits/sec
[1916] 0.0- 2.1 sec 76.1 KBytes 302 Kbits/sec
[1916] Server Report:
[1916] 0.0- 2.1 sec 76.1 KBytes 300 Kbits/sec 0.000 ms 0/ 53 (0%)
[1916] Sent 53 datagrams
C:\>
C:\>iperf -c 192.168.1.20 -u -b 400kbit/sec -t 2 -i 1
Client connecting to 192.168.1.20, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.1.50 port 2303 connected with 192.168.1.20 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 50.2 KBytes 412 Kbits/sec
[1916] 1.0- 2.0 sec 48.8 KBytes 400 Kbits/sec
[1916] 0.0- 2.1 sec 100 KBytes 399 Kbits/sec
[1916] Server Report:
[1916] 0.0- 2.1 sec 100 KBytes 396 Kbits/sec 0.000 ms 0/ 70 (0%)
[1916] Sent 70 datagrams
C:\>

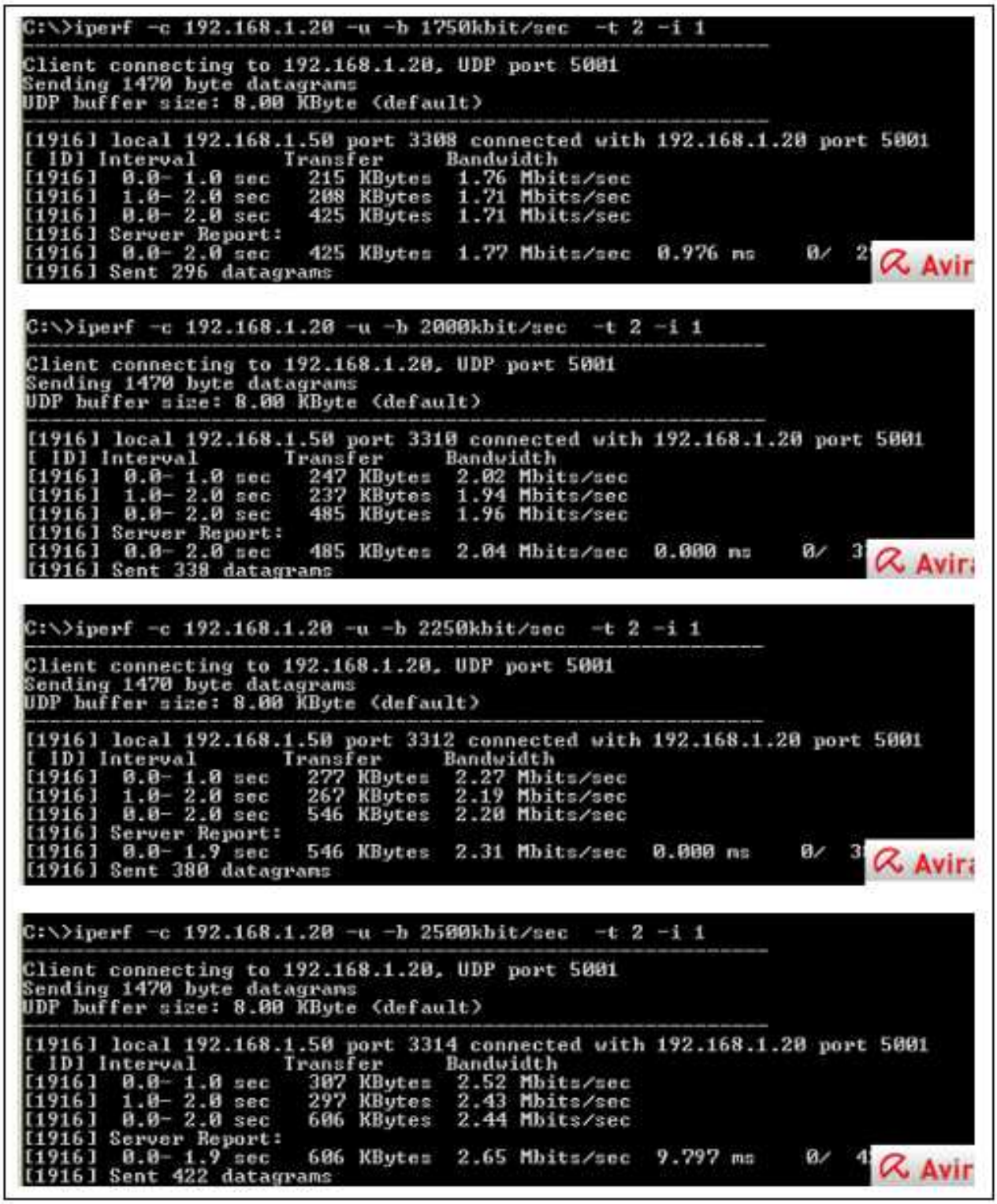
(8-a)


C:\>iperf -c 192.168.1.20 -u -b 500kbit/sec -t 2 -i 1
Client connecting to 192.168.1.20, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.1.50 port 2305 connected with 192.168.1.20 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 63.2 KBytes 517 Kbits/sec
[1916] 1.0- 2.0 sec 61.7 KBytes 506 Kbits/sec
[1916] 0.0- 2.1 sec 126 KBytes 502 Kbits/sec
[1916] Server Report:
[1916] 0.0- 2.1 sec 126 KBytes 498 Kbits/sec 0.000 ms 0/ 88 (0%)
[1916] Sent 88 datagrams
C:\>
C:\>iperf -c 192.168.1.20 -u -b 600kbit/sec -t 2 -i 1
Client connecting to 192.168.1.20, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.1.50 port 2288 connected with 192.168.1.20 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 74.6 KBytes 612 Kbits/sec
[1916] 1.0- 2.0 sec 73.2 KBytes 600 Kbits/sec
[1916] 0.0- 2.0 sec 149 KBytes 598 Kbits/sec
[1916] Server Report:
[1916] 0.0- 2.0 sec 149 KBytes 598 Kbits/sec 0.000 ms 0/ 104 (0%)
[1916] Sent 104 datagrams
C:\>
C:\>iperf -c 192.168.1.20 -u -b 700kbit/sec -t 2 -i 1
Client connecting to 192.168.1.20, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.1.50 port 2364 connected with 192.168.1.20 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 87.6 KBytes 717 Kbits/sec
[1916] 1.0- 2.0 sec 86.1 KBytes 706 Kbits/sec
[1916] 0.0- 2.1 sec 175 KBytes 696 Kbits/sec
[1916] Server Report:
[1916] 0.0- 2.1 sec 175 KBytes 690 Kbits/sec 4.094 ms 0/ 122 (0%)
[1916] Sent 122 datagrams
C:\>
C:\>iperf -c 192.168.1.20 -u -b 800kbit/sec -t 2 -i 1
Client connecting to 192.168.1.20, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.1.50 port 2431 connected with 192.168.1.20 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 100 KBytes 823 Kbits/sec
[1916] 1.0- 2.0 sec 97.6 KBytes 800 Kbits/sec
[1916] 0.0- 2.0 sec 200 KBytes 799 Kbits/sec
[1916] Server Report:
[1916] 0.0- 2.1 sec 200 KBytes 793 Kbits/sec 0.976 ms 0/ 139 (0%)
[1916] Sent 139 datagrams
C:\>

(8-b)


C:\>iperf -c 192.168.1.20 -u -b 900kbit/sec -t 2 -i 1
Client connecting to 192.168.1.20, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.1.50 port 2504 connected with 192.168.1.20 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 112 KBytes 917 Kbits/sec
[1916] 1.0- 2.0 sec 109 KBytes 894 Kbits/sec
[1916] 0.0- 2.0 sec 223 KBytes 897 Kbits/sec
[1916] Server Report:
[1916] 0.0- 2.0 sec 223 KBytes 891 Kbits/sec 0.994 ms 0/ 155 (0%)
[1916] Sent 155 datagrams
C:\>
C:\>iperf -c 192.168.1.20 -u -b 1000kbit/sec -t 2 -i 1
Client connecting to 192.168.1.20, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.1.50 port 2679 connected with 192.168.1.20 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 125 KBytes 1.02 Mbits/sec
[1916] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[1916] 0.0- 2.0 sec 248 KBytes 994 Kbits/sec
[1916] Server Report:
[1916] 0.0- 2.1 sec 248 KBytes 986 Kbits/sec 8.244 ms 0/ 173 (0%)
[1916] Sent 173 datagrams
C:\>
C:\>iperf -c 192.168.1.20 -u -b 1200kbit/sec -t 2 -i 1
Client connecting to 192.168.1.20, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.1.50 port 2754 connected with 192.168.1.20 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 149 KBytes 1.22 Mbits/sec
[1916] 1.0- 2.0 sec 146 KBytes 1.20 Mbits/sec
[1916] 0.0- 2.0 sec 297 KBytes 1.19 Mbits/sec
[1916] Server Report:
[1916] 0.0- 2.0 sec 297 KBytes 1.19 Mbits/sec 0.000 ms 0/ 207 (0%)
[1916] Sent 207 datagrams
C:\>
C:\>iperf -c 192.168.1.20 -u -b 1500kbit/sec -t 2 -i 1
Client connecting to 192.168.1.20, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.1.50 port 3302 connected with 192.168.1.20 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 185 KBytes 1.52 Mbits/sec
[1916] 1.0- 2.0 sec 179 KBytes 1.47 Mbits/sec
[1916] 0.0- 2.0 sec 366 KBytes 1.48 Mbits/sec
[1916] Server Report:
[1916] 0.0- 2.0 sec 366 KBytes 1.47 Mbits/sec 0.977 ms 0/ 2
[1916] Sent 255 datagrams
Avir

(8-c)


C:\>iperf -c 192.168.1.20 -u -b 1750kbit/sec -t 2 -i 1
Client connecting to 192.168.1.20, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.1.50 port 3308 connected with 192.168.1.20 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 215 KBytes 1.76 Mbits/sec
[1916] 1.0- 2.0 sec 208 KBytes 1.71 Mbits/sec
[1916] 0.0- 2.0 sec 425 KBytes 1.71 Mbits/sec
[1916] Server Report:
[1916] 0.0- 2.0 sec 425 KBytes 1.77 Mbits/sec 0.976 ms 0/
[1916] Sent 296 datagrams
C:\>iperf -c 192.168.1.20 -u -b 2000kbit/sec -t 2 -i 1
Client connecting to 192.168.1.20, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.1.50 port 3310 connected with 192.168.1.20 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 247 KBytes 2.02 Mbits/sec
[1916] 1.0- 2.0 sec 237 KBytes 1.94 Mbits/sec
[1916] 0.0- 2.0 sec 485 KBytes 1.96 Mbits/sec
[1916] Server Report:
[1916] 0.0- 2.0 sec 485 KBytes 2.04 Mbits/sec 0.000 ms 0/
[1916] Sent 338 datagrams
C:\>iperf -c 192.168.1.20 -u -b 2250kbit/sec -t 2 -i 1
Client connecting to 192.168.1.20, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.1.50 port 3312 connected with 192.168.1.20 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 277 KBytes 2.27 Mbits/sec
[1916] 1.0- 2.0 sec 267 KBytes 2.19 Mbits/sec
[1916] 0.0- 2.0 sec 546 KBytes 2.20 Mbits/sec
[1916] Server Report:
[1916] 0.0- 1.9 sec 546 KBytes 2.31 Mbits/sec 0.000 ms 0/
[1916] Sent 380 datagrams
C:\>iperf -c 192.168.1.20 -u -b 2500kbit/sec -t 2 -i 1
Client connecting to 192.168.1.20, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.1.50 port 3314 connected with 192.168.1.20 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 307 KBytes 2.52 Mbits/sec
[1916] 1.0- 2.0 sec 297 KBytes 2.43 Mbits/sec
[1916] 0.0- 2.0 sec 606 KBytes 2.44 Mbits/sec
[1916] Server Report:
[1916] 0.0- 1.9 sec 606 KBytes 2.65 Mbits/sec 9.797 ms 0/
[1916] Sent 422 datagrams

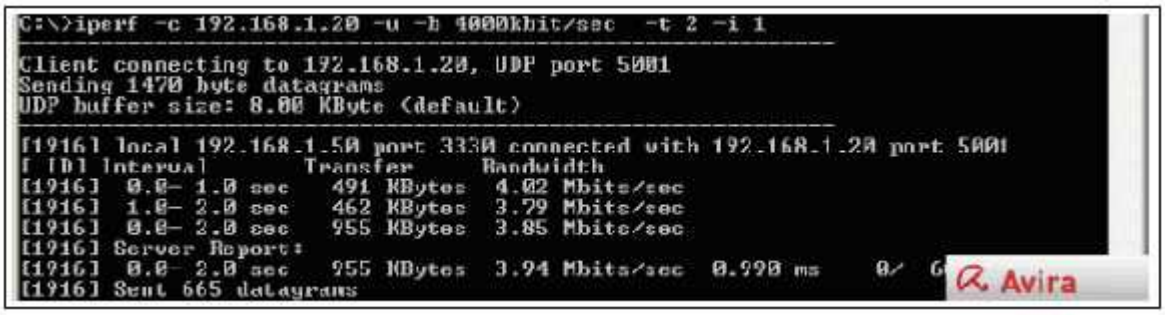
(8-d)

LL


C:\>iperf -c 192.168.1.20 -u -b 2750kbit/sec -t 2 -i 1
Client connecting to 192.168.1.20, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.1.50 port 3317 connected with 192.168.1.20 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 337 KBytes 2.76 Mbits/sec
[1916] 1.0- 2.0 sec 323 KBytes 2.65 Mbits/sec
[1916] 0.0- 2.0 sec 662 KBytes 2.67 Mbits/sec
[1916] Server Report:
[1916] 0.0- 2.0 sec 662 KBytes 2.69 Mbits/sec 7.845 ms 0/ 4
[1916] Sent 461 datagrams
Avir
C:\>iperf -c 192.168.1.20 -u -b 3000kbit/sec -t 2 -i 1
Client connecting to 192.168.1.20, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.1.50 port 3319 connected with 192.168.1.20 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 369 KBytes 3.02 Mbits/sec
[1916] 1.0- 2.0 sec 352 KBytes 2.88 Mbits/sec
[1916] 0.0- 2.0 sec 722 KBytes 2.91 Mbits/sec
[1916] Server Report:
[1916] 0.0- 2.0 sec 722 KBytes 2.98 Mbits/sec 2.858 ms 0/ 5
[1916] Sent 503 datagrams
Avir
C:\>iperf -c 192.168.1.20 -u -b 3250kbit/sec -t 2 -i 1
Client connecting to 192.168.1.20, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.1.50 port 3324 connected with 192.168.1.20 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 399 KBytes 3.27 Mbits/sec
[1916] 1.0- 2.0 sec 380 KBytes 3.12 Mbits/sec
[1916] 0.0- 2.0 sec 781 KBytes 3.15 Mbits/sec
[1916] Server Report:
[1916] 0.0- 2.0 sec 781 KBytes 3.28 Mbits/sec 0.988 ms 0/ 5
[1916] Sent 544 datagrams
Avir
C:\>iperf -c 192.168.1.20 -u -b 3750kbit/sec -t 2 -i 1
Client connecting to 192.168.1.20, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[1916] local 192.168.1.50 port 3328 connected with 192.168.1.20 port 5001
[ID] Interval Transfer Bandwidth
[1916] 0.0- 1.0 sec 459 KBytes 3.76 Mbits/sec
[1916] 1.0- 2.0 sec 439 KBytes 3.60 Mbits/sec
[1916] 0.0- 2.0 sec 900 KBytes 3.63 Mbits/sec
[1916] Server Report:
[1916] 0.0- 2.0 sec 900 KBytes 3.66 Mbits/sec 0.976 ms 0/ 6
[1916] Sent 627 datagrams
Avir

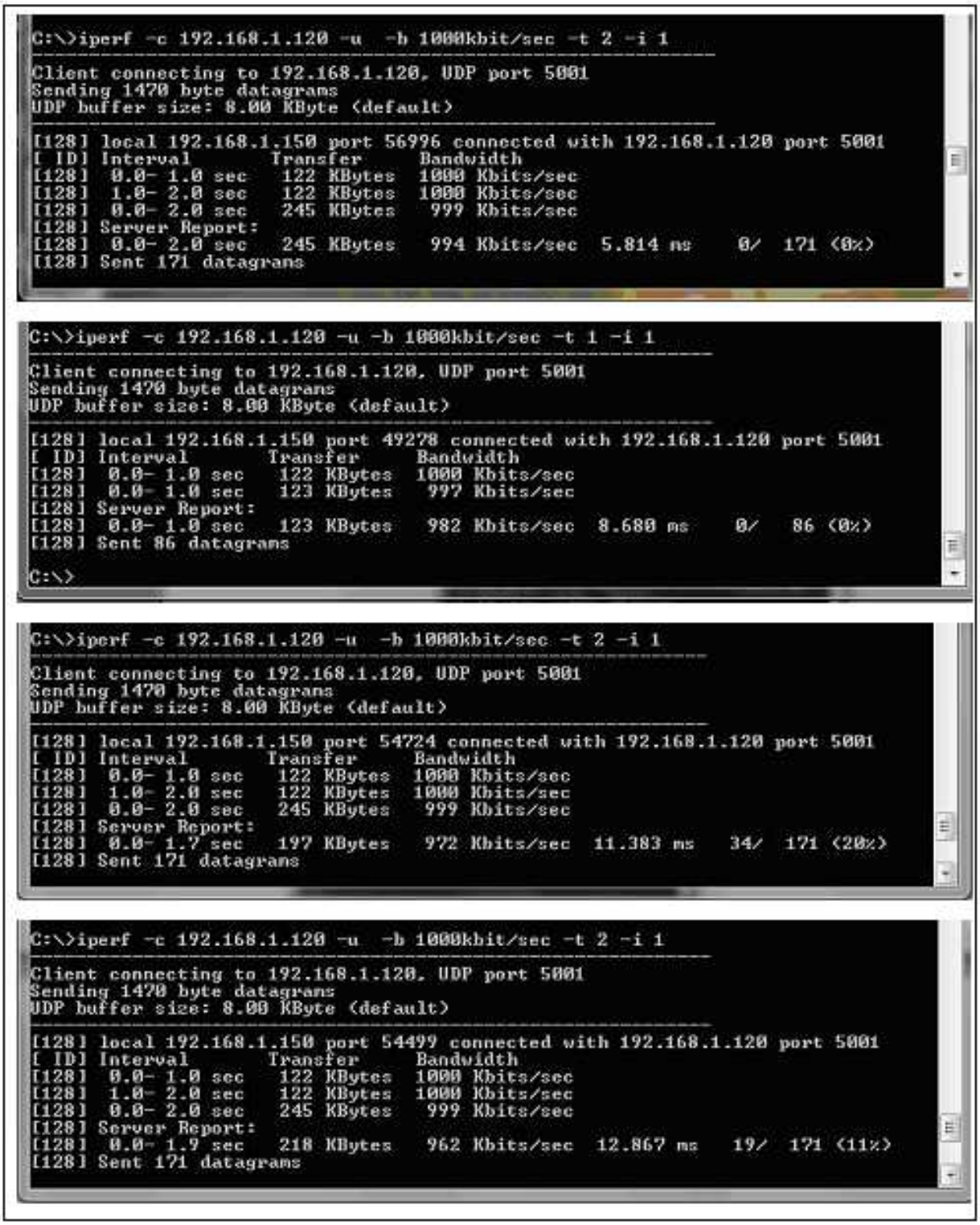
(8-e)

MM



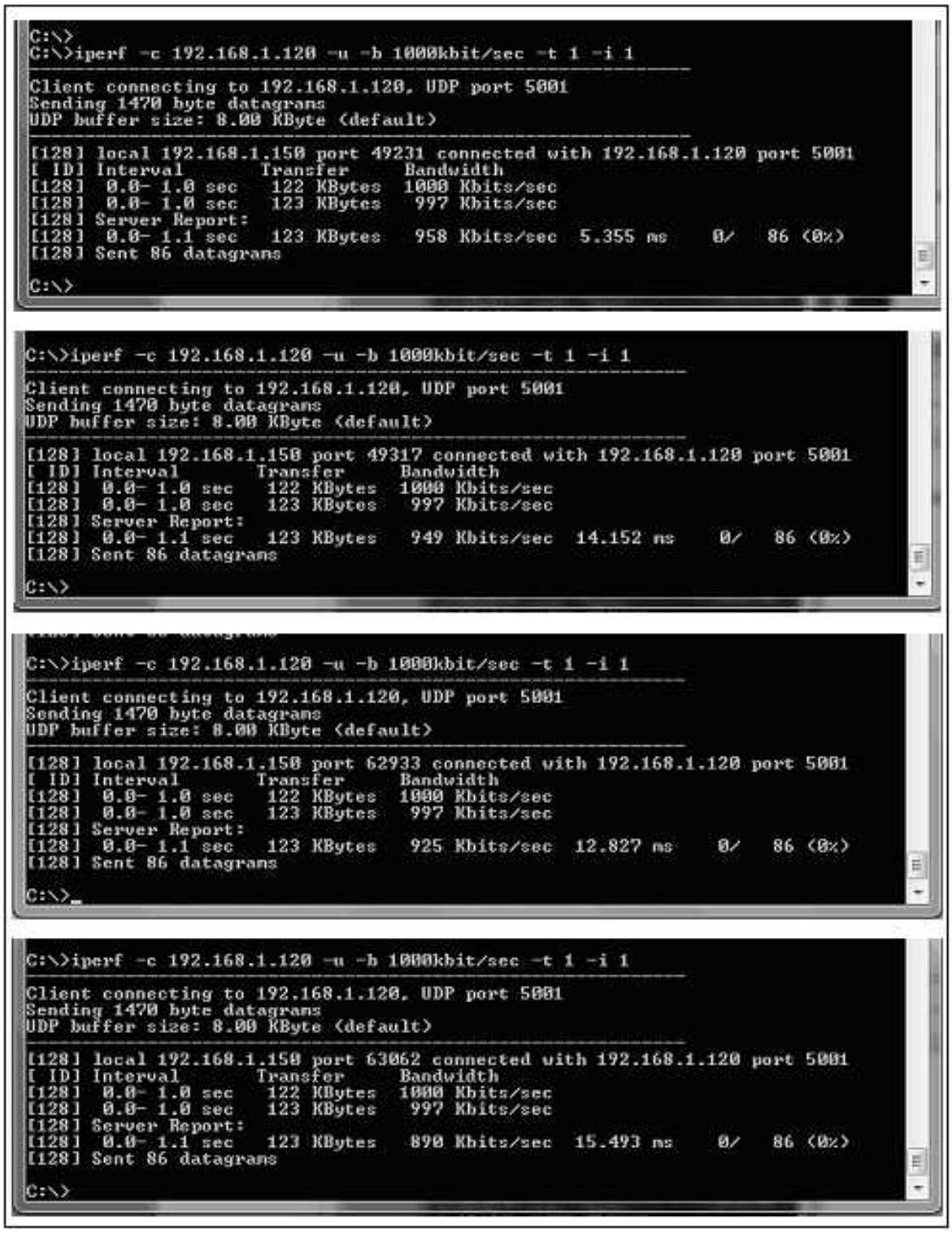
(8-f)

Figure 8: (a-f) Download experiment ,loader increasing in the second stage


C:\>iperf -c 192.168.1.120 -u -b 1000kbit/sec -t 2 -i 1
Client connecting to 192.168.1.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.1.150 port 56996 connected with 192.168.1.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 2.0 sec 245 KBytes 999 Kbits/sec
[128] Server Report:
[128] 0.0- 2.0 sec 245 KBytes 994 Kbits/sec 5.814 ms 0/ 171 (0%)
[128] Sent 171 datagrans
C:\>iperf -c 192.168.1.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.1.120, UDP port 5001
Sending 1470 byte datagrans
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.1.150 port 49278 connected with 192.168.1.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 1.0 sec 123 KBytes 982 Kbits/sec 8.680 ms 0/ 86 (0%)
[128] Sent 86 datagrans
C:\>
C:\>iperf -c 192.168.1.120 -u -b 1000kbit/sec -t 2 -i 1
Client connecting to 192.168.1.120, UDP port 5001
Sending 1470 byte datagrans
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.1.150 port 54724 connected with 192.168.1.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 2.0 sec 245 KBytes 999 Kbits/sec
[128] Server Report:
[128] 0.0- 1.7 sec 197 KBytes 972 Kbits/sec 11.383 ms 34/ 171 (20%)
[128] Sent 171 datagrans
C:\>iperf -c 192.168.1.120 -u -b 1000kbit/sec -t 2 -i 1
Client connecting to 192.168.1.120, UDP port 5001
Sending 1470 byte datagrans
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.1.150 port 54499 connected with 192.168.1.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 2.0 sec 245 KBytes 999 Kbits/sec
[128] Server Report:
[128] 0.0- 1.9 sec 218 KBytes 962 Kbits/sec 12.867 ms 19/ 171 (11%)
[128] Sent 171 datagrams

(9-a)

OO


C:\>
C:\>iperf -c 192.168.1.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.1.120, UDP port 5001
Sending 1470 byte datagrans
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.1.150 port 49231 connected with 192.168.1.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 1.1 sec 123 KBytes 958 Kbits/sec 5.355 ms 0/ 86 (0%)
[128] Sent 86 datagrans
C:\>
C:\>iperf -c 192.168.1.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.1.120, UDP port 5001
Sending 1470 byte datagrans
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.1.150 port 49317 connected with 192.168.1.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 1.1 sec 123 KBytes 949 Kbits/sec 14.152 ms 0/ 86 (0%)
[128] Sent 86 datagrans
C:\>
C:\>iperf -c 192.168.1.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.1.120, UDP port 5001
Sending 1470 byte datagrans
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.1.150 port 62933 connected with 192.168.1.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 1.1 sec 123 KBytes 925 Kbits/sec 12.827 ms 0/ 86 (0%)
[128] Sent 86 datagrans
C:\>_
C:\>iperf -c 192.168.1.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.1.120, UDP port 5001
Sending 1470 byte datagrans
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.1.150 port 63062 connected with 192.168.1.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 1.1 sec 123 KBytes 890 Kbits/sec 15.493 ms 0/ 86 (0%)
[128] Sent 86 datagrans
C:\>
C:\>iperf -c 192.168.1.120 -u -b 1000kbit/sec -t 1 -i 1

(9-b)

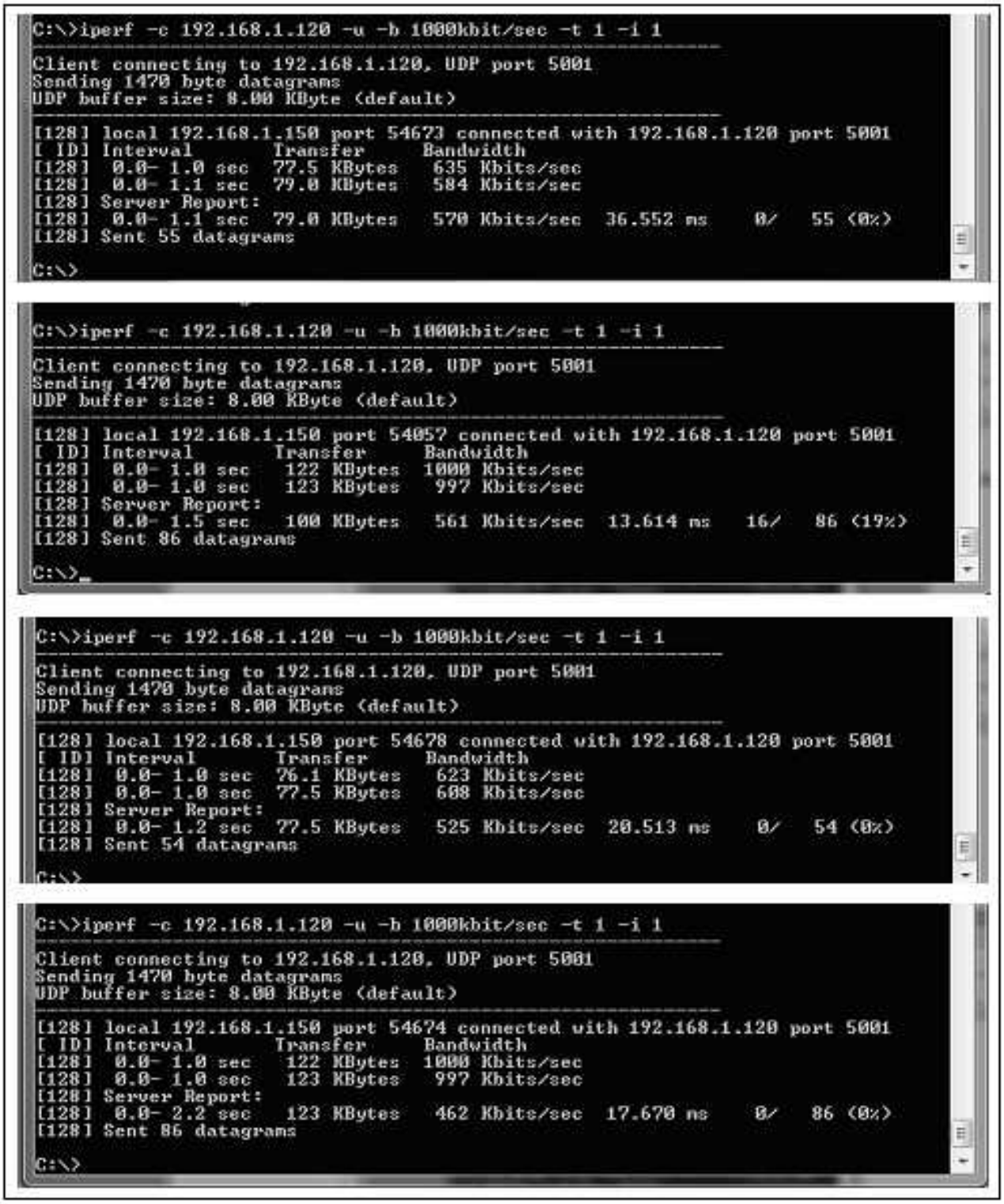

C:\>iperf -c 192.168.1.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.1.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.1.150 port 63011 connected with 192.168.1.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 0.6 sec 60.3 KBytes 880 Kbits/sec 12.973 ms 44/ 86 (51%)
[128] Sent 86 datagrams
C:\>
C:\>iperf -c 192.168.1.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.1.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.1.150 port 54672 connected with 192.168.1.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 0.7 sec 61.7 KBytes 774 Kbits/sec 12.620 ms 42/ 86 (49%)
[128] 0.0- 0.7 sec 1 datagrams received out-of-order
[128] Sent 86 datagrams
C:\>
C:\>iperf -c 192.168.1.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.1.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.1.150 port 54676 connected with 192.168.1.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 106 KBytes 870 Kbits/sec
[128] 0.0- 1.2 sec 108 KBytes 764 Kbits/sec
[128] Server Report:
[128] 0.0- 1.1 sec 108 KBytes 769 Kbits/sec 27.323 ms 0/ 75 (0%)
[128] Sent 75 datagrams
C:\>
C:\>iperf -c 192.168.1.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.1.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.1.150 port 54681 connected with 192.168.1.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 96.2 KBytes 788 Kbits/sec
[128] 0.0- 1.2 sec 97.6 KBytes 693 Kbits/sec
[128] Server Report:
[128] 0.0- 1.1 sec 97.6 KBytes 700 Kbits/sec 30.456 ms 0/ 68 (0%)
[128] Sent 68 datagrams
C:\>

(9-c)


C:\>iperf -c 192.168.1.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.1.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.1.150 port 54692 connected with 192.168.1.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 93.3 KBytes 764 Kbits/sec
[128] 0.0- 1.1 sec 94.7 KBytes 701 Kbits/sec
[128] Server Report:
[128] 0.0- 1.1 sec 94.7 KBytes 699 Kbits/sec 28.581 ms 0/ 66 (0%)
[128] Sent 66 datagrams
C:\>
C:\>iperf -c 192.168.1.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.1.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.1.150 port 63091 connected with 192.168.1.120 port 5001
[ID] Interval Transfer Banduidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 0.9 sec 71.8 KBytes 677 Kbits/sec 21.041 ms 36/ 86 (42%)
[128] Sent 86 datagrams
C:\>iperf -c 192.168.1.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.1.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.1.150 port 54689 connected with 192.168.1.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 109 KBytes 894 Kbits/sec
[128] 0.0- 1.1 sec 111 KBytes 806 Kbits/sec
[128] Server Report:
[128] 0.0- 0.9 sec 74.6 KBytes 655 Kbits/sec 19.596 ms 25/ 77 (32%)
[128] Sent 77 datagrams
C:\>
Command Prompt
C:\>iperf -c 192.168.1.120 -u -b 1000kbit/sec -t 2 -i 1
Client connecting to 192.168.1.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.1.150 port 54843 connected with 192.168.1.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 2.0 sec 245 KBytes 999 Kbits/sec
[128] Server Report:
[128] 0.0- 2.4 sec 194 KBytes 654 Kbits/sec 23.436 ms 36/ 171 (21%)
[128] Sent 171 datagrams

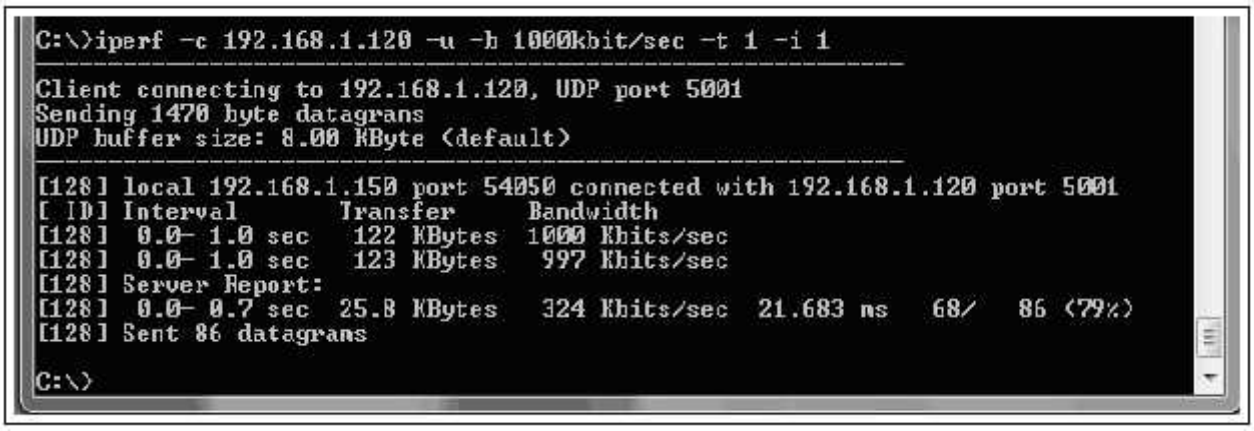
(9-d)

RR


C:\>iperf -c 192.168.1.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.1.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.1.150 port 54673 connected with 192.168.1.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 77.5 KBytes 635 Kbits/sec
[128] 0.0- 1.1 sec 79.0 KBytes 584 Kbits/sec
[128] Server Report:
[128] 0.0- 1.1 sec 79.0 KBytes 570 Kbits/sec 36.552 ms 0/ 55 (0%)
[128] Sent 55 datagrams
C:\>
C:\>iperf -c 192.168.1.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.1.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.1.150 port 54057 connected with 192.168.1.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 1.5 sec 100 KBytes 561 Kbits/sec 13.614 ms 16/ 86 (19%)
[128] Sent 86 datagrams
C:\>
C:\>iperf -c 192.168.1.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.1.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.1.150 port 54678 connected with 192.168.1.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 76.1 KBytes 623 Kbits/sec
[128] 0.0- 1.0 sec 77.5 KBytes 608 Kbits/sec
[128] Server Report:
[128] 0.0- 1.2 sec 77.5 KBytes 525 Kbits/sec 20.513 ms 0/ 54 (0%)
[128] Sent 54 datagrams
C:\>
C:\>iperf -c 192.168.1.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.1.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.1.150 port 54674 connected with 192.168.1.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 2.2 sec 123 KBytes 462 Kbits/sec 17.670 ms 0/ 86 (0%)
[128] Sent 86 datagrams
C:\>

(9-e)

SS



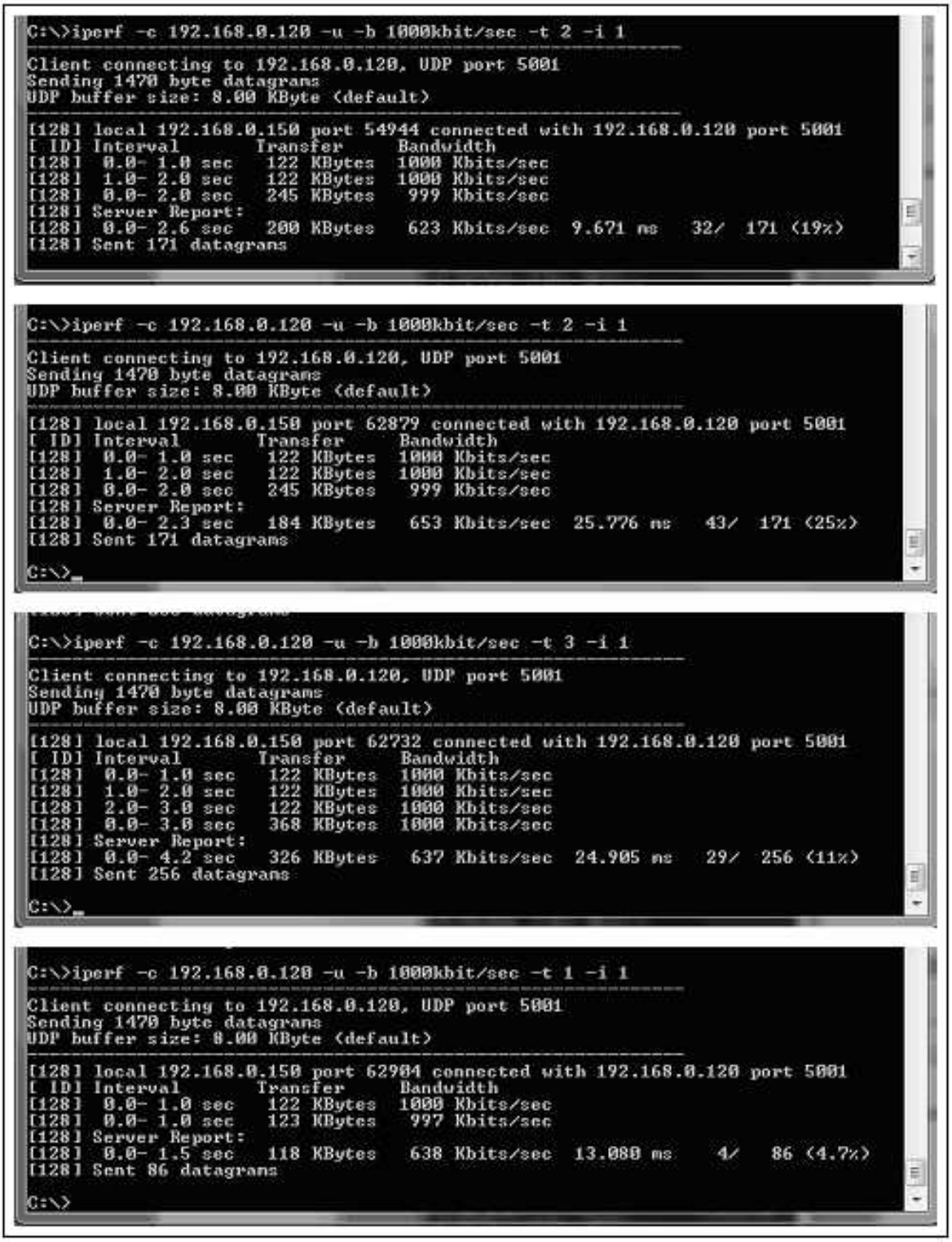
(9-f)

Figure 9: (a-f) Download experiment ,client associates with AP1 in 2nd stage


C:\>iperf -c 192.168.0.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.0.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.150 port 62903 connected with 192.168.0.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 1.5 sec 73.2 KBytes 411 Kbits/sec 16.450 ms 35/ 86 (41%)
[128] Sent 86 datagrams
C:\>_
C:\>iperf -c 192.168.0.120 -u -b 1000kbit/sec -t 2 -i 1
Client connecting to 192.168.0.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.150 port 54510 connected with 192.168.0.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 2.0 sec 245 KBytes 999 Kbits/sec
[128] Server Report:
[128] 0.0- 3.9 sec 244 KBytes 518 Kbits/sec 19.839 ms 1/ 171 (0.58%)
[128] Sent 171 datagrams
C:\>_
C:\>iperf -c 192.168.0.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.0.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.150 port 63100 connected with 192.168.0.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 1.9 sec 121 KBytes 513 Kbits/sec 7.883 ms 2/ 86 (2.3%)
[128] Sent 86 datagrams
C:\>
C:\>iperf -c 192.168.0.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.0.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.150 port 63425 connected with 192.168.0.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 0.2 sec 12.9 KBytes 588 Kbits/sec 4.259 ms 77/ 86 (90%)
[128] Sent 86 datagrams
C:\>_

(10-a)

UU


C:\>iperf -c 192.168.0.120 -u -b 1000kbit/sec -t 2 -i 1
Client connecting to 192.168.0.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.150 port 54944 connected with 192.168.0.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 2.0 sec 245 KBytes 999 Kbits/sec
[128] Server Report:
[128] 0.0- 2.6 sec 200 KBytes 623 Kbits/sec 9.671 ms 32/ 171 (19%)
[128] Sent 171 datagrams
C:\>iperf -c 192.168.0.120 -u -b 1000kbit/sec -t 2 -i 1
Client connecting to 192.168.0.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.150 port 62879 connected with 192.168.0.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 2.0 sec 245 KBytes 999 Kbits/sec
[128] Server Report:
[128] 0.0- 2.3 sec 184 KBytes 653 Kbits/sec 25.776 ms 43/ 171 (25%)
[128] Sent 171 datagrams
C:\>
C:\>iperf -c 192.168.0.120 -u -b 1000kbit/sec -t 3 -i 1
Client connecting to 192.168.0.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.150 port 62732 connected with 192.168.0.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[128] 2.0- 3.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 3.0 sec 368 KBytes 1000 Kbits/sec
[128] Server Report:
[128] 0.0- 4.2 sec 326 KBytes 637 Kbits/sec 24.905 ms 29/ 256 (11%)
[128] Sent 256 datagrams
C:\>
C:\>iperf -c 192.168.0.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.0.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.150 port 62904 connected with 192.168.0.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 1.5 sec 118 KBytes 638 Kbits/sec 13.080 ms 4/ 86 (4.7%)
[128] Sent 86 datagrams
C:\>

(10-b)

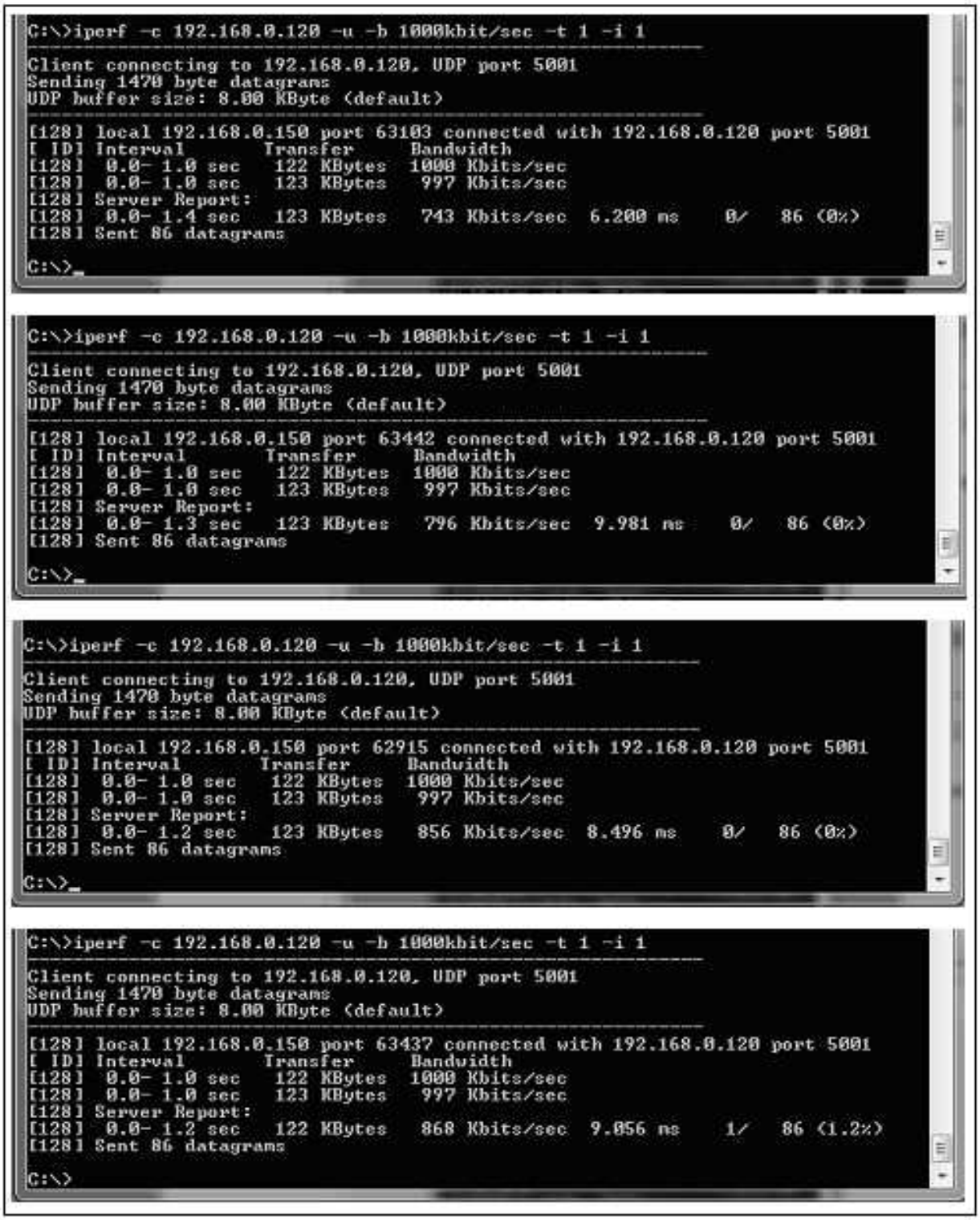

C:\>iperf -c 192.168.0.120 -u -b 1000kbit/sec -t 2 -i 1
Client connecting to 192.168.0.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.150 port 54771 connected with 192.168.0.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 2.0 sec 245 KBytes 999 Kbits/sec
[128] Server Report:
[128] 0.0- 2.8 sec 224 KBytes 651 Kbits/sec 51.825 ms 15/ 171 (8.8%)
[128] Sent 171 datagrans
C:\>
C:\>iperf -c 192.168.0.120 -u -b 1000kbit/sec -t 2 -i 1
Client connecting to 192.168.0.120, UDP port 5001
Sending 1470 byte datagrans
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.150 port 54771 connected with 192.168.0.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 2.0 sec 245 KBytes 999 Kbits/sec
[128] Server Report:
[128] 0.0- 2.8 sec 224 KBytes 651 Kbits/sec 51.825 ms 15/ 171 (8.8%)
[128] Sent 171 datagrans
C:\>
C:\>iperf -c 192.168.0.120 -u -b 1000kbit/sec -t 2 -i 1
Client connecting to 192.168.0.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.150 port 54941 connected with 192.168.0.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 1.0- 2.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 2.0 sec 245 KBytes 999 Kbits/sec
[128] Server Report:
[128] 0.0- 2.8 sec 240 KBytes 693 Kbits/sec 21.084 ms 4/ 171 (2.3%)
[128] Sent 171 datagrams
C:\>
C:\>iperf -c 192.168.0.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.0.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.150 port 63115 connected with 192.168.0.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 1.4 sec 123 KBytes 715 Kbits/sec 10.047 ms 0/ 86 (0%)
[128] Sent 86 datagrans
C:\>

(10-c)

WW

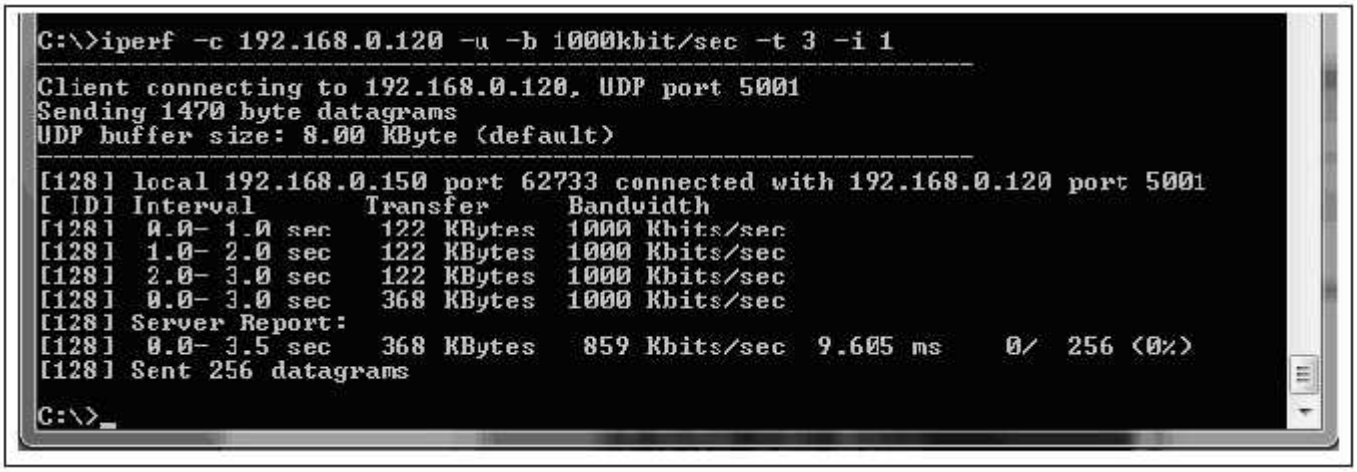

C:\>iperf -c 192.168.0.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.0.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.150 port 63105 connected with 192.168.0.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 1.4 sec 123 KBytes 738 Kbits/sec 6.477 ms 0/ 86 (0%)
[128] Sent 86 datagrams
C:\>_
C:\>iperf -c 192.168.0.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.0.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.150 port 54635 connected with 192.168.0.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 1.4 sec 123 KBytes 719 Kbits/sec 18.430 ms 0/ 86 (0%)
[128] Sent 86 datagrams
C:\>
C:\>iperf -c 192.168.0.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.0.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.150 port 62911 connected with 192.168.0.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 1.4 sec 122 KBytes 733 Kbits/sec 13.735 ms 1/ 86 (1.2%)
[128] Sent 86 datagrams
C:\>
C:\>iperf -c 192.168.0.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.0.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.150 port 54727 connected with 192.168.0.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 1.4 sec 123 KBytes 735 Kbits/sec 8.212 ms 0/ 86 (0%)
[128] Sent 86 datagrams
C:\>_

(10-d)


C:\>iperf -c 192.168.0.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.0.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.150 port 63103 connected with 192.168.0.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 1.4 sec 123 KBytes 743 Kbits/sec 6.200 ms 0/ 86 (0%)
[128] Sent 86 datagrams
C:\>_
C:\>iperf -c 192.168.0.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.0.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.150 port 63442 connected with 192.168.0.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 1.3 sec 123 KBytes 796 Kbits/sec 9.981 ms 0/ 86 (0%)
[128] Sent 86 datagrams
C:\>_
C:\>iperf -c 192.168.0.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.0.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.150 port 62915 connected with 192.168.0.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 1.2 sec 123 KBytes 856 Kbits/sec 8.496 ms 0/ 86 (0%)
[128] Sent 86 datagrams
C:\>_
C:\>iperf -c 192.168.0.120 -u -b 1000kbit/sec -t 1 -i 1
Client connecting to 192.168.0.120, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size: 8.00 KByte (default)
[128] local 192.168.0.150 port 63437 connected with 192.168.0.120 port 5001
[ID] Interval Transfer Bandwidth
[128] 0.0- 1.0 sec 122 KBytes 1000 Kbits/sec
[128] 0.0- 1.0 sec 123 KBytes 997 Kbits/sec
[128] Server Report:
[128] 0.0- 1.2 sec 122 KBytes 868 Kbits/sec 9.056 ms 1/ 86 (1.2%)
[128] Sent 86 datagrams
C:\>

(10-e)

YY



(10-f)

Figure 9: (a-f) Download experiment ,client associates with AP2 in 2nd stage

ZZ