Frame-Relays Among the Private LANs of Iraqi Universities

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Received on:17/12/2015 & Accepted on:29/9/2016

ABSTRACT

Frame Relay (FR) was one of the most popular wide area networks (WANs) services deployed over the past few decades. FR is a high-performance WAN protocol that operates at the data link layer. FR is an example of a packet-switched technology, where the end stations are enabled to dynamically share the network medium and the allocated bandwidth. In a sequel, due to such attributes further to the lower cost and privacy (security), it is deployed widely in various organizations, companies, banks, or institutions as a main backbone technology to connect their local area networks (LANs) over different sites. In this work, the utilisation of FR technology among the LANs of some Iraqi universities is presented. Consequently, bandwidth-on-demand will be provided for the end and intermediate systems of each individual LANs. In addition, ports and expensive communications facilities that are required to interconnect the devices of these LANs are reduced. The configuration of frame relay among routers has been simulated using a Packet tracer, which is one of the professional software that can be utilized to implement networks along with their technologies.

Keywords: Frame Relay (FR), local area networks (LANs), wide area networks (WANs).

INTRODUCTION

In general, a network can be defined as a set of nodes connected via communication links. Basically, a node is any device capable of sending and/or receiving data to/from other nodes on the network, such as a computer, printer, or any other. According to its area that covers, networks can be classified into two main types; Local Area Networks (LANs) and Wide Area Networks (WAN). A LAN connects some hosts in a single office, building, or campus and it is usually privately owned. Whereas, a WAN is an interconnection of LANs [1, 2, 3]. There are various protocols that can be employed to establish WAN connection, such as high-level data link control (HDLC) protocol, integrated services digital network (ISDN), point-to-point protocol (PPP), Point-to-Point Protocol over Ethernet (PPPoE), Multiprotocol Label Switching (MPLS) protocol, Cable, digital subscriber line (DSL), Asynchronous Transfer Mode (ATM), Cellular 3G/4G/5G, very small aperture terminal (VSAT), Metro Ethernet and Frame Relay (FR) protocols. In addition, vertual private network (VPN) can be utilised as a WAN technology [4, 5].

Since the begning of the 1990s, the popularity of frame relay (FR) is increased as a WAN networking technology. Therefore, expert groups have been worked hardly based on standarazation to describ and to discuss the FR in details. Consequently, FR has recieved a great attention in the past and in the recent studies. J. Thibodeau [6] introduced a comprehensive frame relay glossary by providing the following. The main issue of developping FRs are based on their benefits. In order to avoid congestion among various nodes, FRs are switched data among vrious nodes are based on the

https://doi.org/10.30684/etj.34.14A.5
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addressing mechanism that is utilized based on the standards for communication purpose and to convey the status of various connections.

Moreover, an overview of frame relay services and technology along with their evolution and standardization is introduced in [7] . Data transfer and connection control protocols in frame relay along with thier applications in networks are discussed . Wheras, [8] discussed the internetworking of frame relays among with the asynchronous transfer mode (ATM) cell relay service. Evolution scenario for the interworking of FR and ATM cell relay networks and services introduced based on the standards-based methodology and the major open issues. For the sake of clarityand based on the relevant referenced standards, the functional requirement configurations of the permanent virtual connection service (PVCS) between the frame relay service (FRS), ATM and broadband integrated services digital network (B-ISDN) is prodided in [9]. In addition, the advantages of utilizing frame-relays over the private networks are illustrated in [10]. Such a work concluded that the employment of frame-relays accross the private networks will reduce the ports number and the latency further to provide bandwidth-on-demand.

This works provides a good source of information for the researchers about a frame relay (FR), which is one of the most professional protocol that has been used efficiently with WANs. Moreover, a FR is employed to introduce a robust network to connect all Iraqi universities. The data link connection identifier (DLCI) addressing is employed to communicate a single device directly or indirectly to other devices of other LANs. For the sake of simplicity, the configuration of frame relay over such a network using Packet tracer instructions is also illustrated.

The rest of this paper is organized as follows. Section 2 illustrates the aspects that are considered to use the FRs over ATM technology. A good resource of information about the frame relay (FR) Technology is presented in Section 3. The implementation of the proposed network among some Iraqi universities is introduced in Section 4. Then, Section 5 configures the FR technology over such a network. Lastly, Section 6 concludes the paper.

Frame Relay (FR) vs. Asynchronous Transfer Mode (ATM) Technologies

Based on the open systems connection (OSI) conceptual model, frames encapsulation during the transmission between two endpoints is controlled by the data link layer. The main technologies working on the data link layer are ATM and FR. The applications of each individual technique are employed depending on their advantages and disadvantages.

For ATM technique, the communication between any two nodes is established via a virtual circuit based on a connection oriented protocol. Consequently, when the data transfer starts, a fixed route should be established between two points. In addition, ATM performs an asynchronous operation in time division multiplexing. In conventional time division multiplexing, despite data is not available, the synchronization bytes are transferred. In contrast, in ATM technique, the cells are quantized and transmitted only when data is available for transmission. ATM cells size is 53 bytes (48 bytes of ATM payload and 5 bytes header). Owing to such features of ATM technique, a good quality of services (QoS) is provided for transmitting voice, image and video data over single network connection. In the sequel, the convenient hardware implementation of ATM leads to faster processing and switching operations when used over the SONET/SDH backbone of the ISDN [11].

On the other hand, FR is a connection oriented technique that utilizes a virtual circuit (VC) to switch frames (packets of data) among points of wide area networks (WANs). Where each individual frame is constructed from two parts: ‘Actual data’ and the ‘frame relay header’. Such a mechanism of frames transferring is more efficient than ATM due to the flexibility of changing their packet size. Consequently, FR is currently used over a variety of networks. Practically, FRs are connected with other points via ‘Ports’ by utilizing the unique address of each port. This means that the FRs is capable of creating multiple redundant virtual connections among various routers without needing to multiple physical links. In a sequel, a good interconnect medium between different types of network points with different speeds is achieved over networks that used FRs [12].

Interestingly, the differences between FRs and ATM, in terms of controlling techniques, data size, network types, can be listed as follows; 1) Variable packet sizes depending on the type of information are sent with FRs whereas fixed size packets (53 bytes) are used for data communication ATM technique. 2) Contrast to ATM which is used within a single LAN, FR is used to connect separated LANs. 3) FR is a software controlled scheme, whereas ATM is a hardware controlled scheme. Thus, FR is less expensive and upgrading is easier than ATM. 4) Finally, due to the variable packet size, FR transmits frames efficiently with low overhead. However, for high speed transmission, fixed packet can be useful for handling video and image traffic but the overhead of transmission methodology is increased.

Basics of a Frame Relay (FR)

Over the past few decades, FR deployed widely with most popular owing to its relatively lower cost. Spreading packet-switched network is provided for different customers at the same time. Moreover, a portion of dedicated bandwidth is employed for each user by using FR. Furthermore, in the case of an individual user needs more bandwidth, FR works to provide the unused resources of other users.

FR is a high-speed communications technology used throughout the world to connect LANs, Internet and even voice applications. Basically, as a response for the need for a cheaper alternative to leased lines, FR was developed. Technically, WAN network information is divided into frames (a group packets) by FR. Then each individual frame is forwarded to its destination depending on the frame label. Because FR uses a connection-oriented approach, its service provider typically assigns Data Link Connection Identifiers (DLCIs) values, which are used on interfaces to distinguish between different VCs. Many DLCIs are often affiliated with FR because of one multipoint FR interface can terminate many VCs. Network resources are allocated on each connection by providing a portion of dedicated bandwidth to each user. If the resources are available, the dedicated bandwidth can be exceeded by the user. Based on the required speed and bandwidth, access rate and committed information rate (CIR) are availabl as separate bandwidth specifications for a FR. For the application that required FR interface to transmit at the maximum speed, the Access rate is utilized. Whereas, CIR is used when the maximum bandwidth of data guaranteed to be delivered [13].

Frame Relay Encapsulation Types

On Cisco routers, the encapsulation type should be configured on serial interfaces. Basically, there are two encapsulation types; Cisco and IETF (Internet Engineering Task Force). Cisco encapsulation is a Cisco proprietary with 4-bytes header as a default. This means that it cannot be used in the FR network with different vender’s routers. The contents of Cisco encapsulation frame is depicted in Fig. 1.

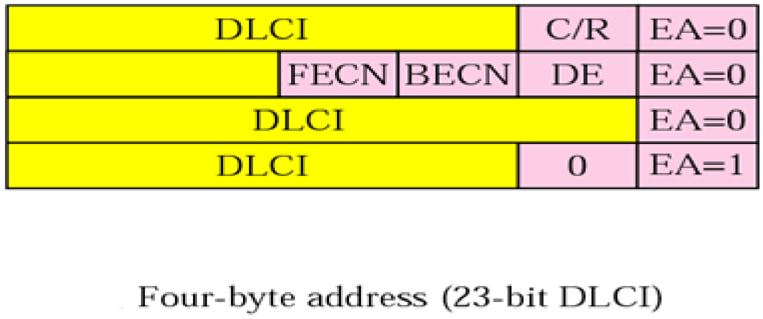


Figure (1): Cisco FR Encapsulation Frame

On the other hand, IETF-type encapsulation is used if different venders devices are connected via Frame Relay. Consequently, FR encapsulation should be the same on both ends. The IETF's frame is divided into many parts, as shown in Fig. 2 [14].

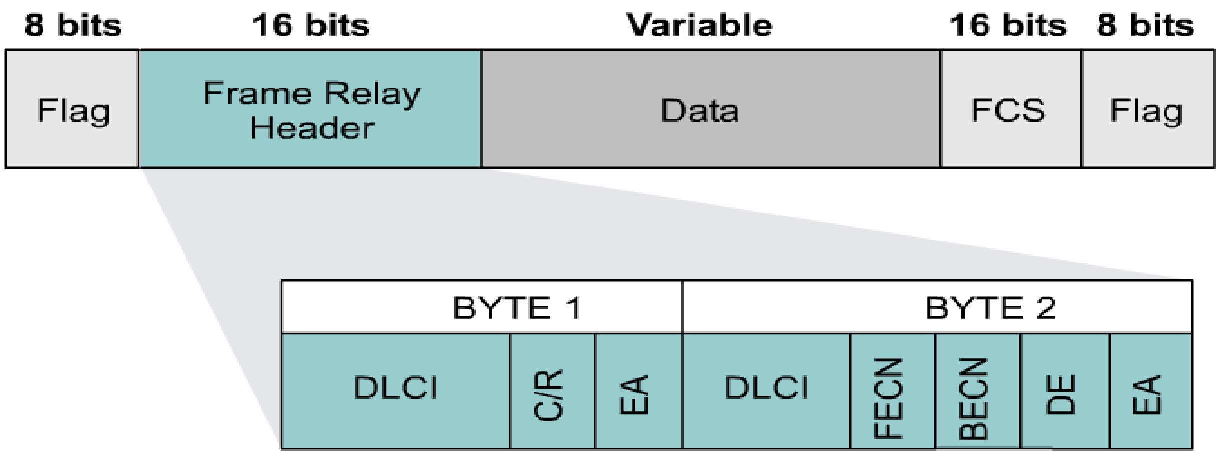


Figure. 2: IETF FR Encapsulation Frame

Where the contents of such a frame can be defined as in Table 1.

Table 1: IEFT Frame-Relay Encapsulation Frame Content Definitions [2].

Field	Definition
Flags	Delimits the beginning and end of the frame. The value of this field is always the same and is represented either as the hexadecimal number 7E or the binary number 01111110.
DLCI	The 10-bit DLCI value represents the virtual connection between the DTE device and the switch.
C/R	The C/R is the bit that follows the most significant DLCI byte in the Address field. The C/R bit is not currently defined.
Extended Address (EA):	The EA is used to indicate whether the byte in which the EA value is 1 is the last addressing field. If the value is 1, then the current byte is determined to be the last DLCI octet. Although current Frame Relay implementations all use a two-octet DLCI, this capability does allow for longer DLCIs to be used in the future.
Data	Contains encapsulated upper-layer data. Each frame in this variable-length field includes a user data or payload field that will vary in length up to 16,000 octets. This field serves to transport the higher-layer protocol packet (PDU) through a Frame Relay network.
FCS	Frame Check Sequence. Ensures the integrity of transmitted data. This value is computed by the source device and verified by the receiver to ensure integrity of transmission.
FECN	Forward explicit congestion notification (FECN) is a single bit field that is set to a value of 1 by a frame relay switch to indicate to a destination DTE device, such as a router, that congestion was experienced. DTE devices receiving frames with the FECN bit set can request higher-level protocols take flow control action as appropriate.
BECN	Backward explicit congestion notification (BECN) is a single bit field that is set to a value of 1 by a frame relay switch to notify the sending DTE device that congestion avoidance procedures should be initiated. If the router receives any BECNs during the current time interval, it may decrease the transmit rate by 25%.
DE	Discard eligibility (DE) is a bit set by the DTE device, such as a router, to indicate that the marked frame is of lesser importance relative to other frames being transmitted. Frames that are marked as "discard eligible" should be discarded before other frames if congestion occurs. The DE bit is set on oversubscribed traffic.

For example, the encapsulation type for one serial interface (s0) of TIKRIT university router can be simply configured using Packet Tracer as:

TIKRIT(config)# int s0

TIKRIT(config-if)# encap fr ?

ietf Use RFC1490 encapsulation <cr>

Unless IETF is manually chosen, the default encapsulation option is Cisco. Whoever, the encapsulation type should be the same on both ends of FR.

Virtual Circuits

Basically, VCs are the circuits that are their ends are logically or indirectly connected. Thus, in FR networks, VC can be simply defined as the connection between two data terminal equipment (DTE) through a FR network. Consequently, the bandwidth can be shared among multiple users and any single site can be connected with any other sites without using multiple dedicated physical lines. VCs can be established in two ways; Switched virtual circuits (SVCs) and Permanent virtual circuits (PVCs). As shown in Fig. 3, SVCs is similar to a phone call, where VC is established during data transmission, whereas it is dismantled when the data transmission is completed.

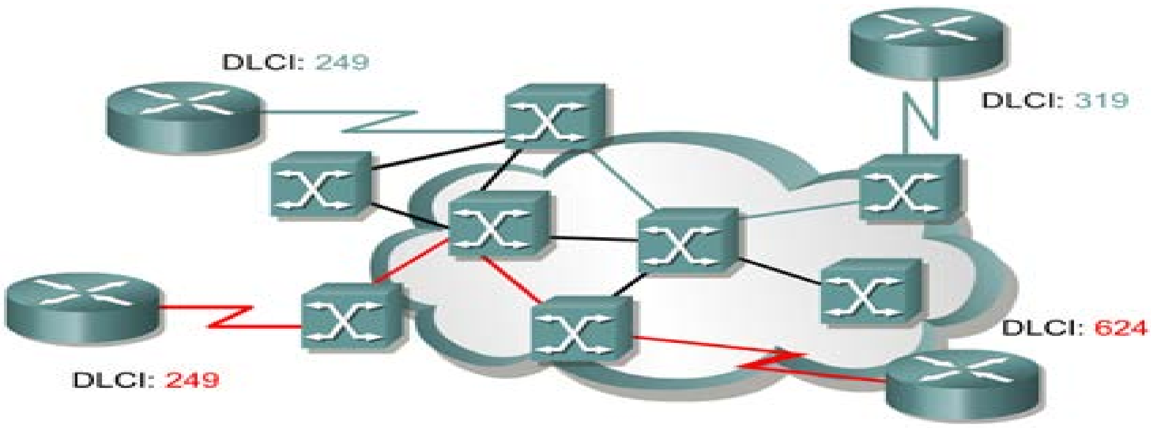


Figure. 3: Switched virtual circuits (SVCs)

On the other hand, the most common type in use today is the PVCs. As shown in Fig. 3, the permanent feature of such a type means that the VCs among nodes are still established as long as the bill is paid.

Data Link Connection Identifiers (DLCIs)

DLCIs are number for a permanent or switched virtual circuit located in the frame header over a frame relay network. Practically, the DLCI field identifies which logical path of data travelling depending on the CIR associated with each DLCI. Interestingly, a known DLCI can be transferred to an IP address using an inverse ARP (IARP). A DLCI number can be simply configured to a sub-interface of TIKRIT router, as example, as in the following:

TIKRIT(config-if)# fr int-dlci ? // <16-1007> Define a DLCI as part of the current sub interface.

TIKRIT(config-if)# fr int-dlci 16

Local Management Interface (LMI)

The communication between the DTE devices, such as routers, and the DCE devices, such as FR switches can established using LMI. LMI tells routers when a FR PVC is available by exchanging the status messages. Basically, on Cisco equipments, there are three different formates of LMI message: Cisco, American National Standards Institute (ANSI), and Q.933A (which equivalent to International Telecommunication Union- Telecommunication Satandarazation Sector (ITU-T) standard that can be execute by Q.933a) [2]. The VC status should be determined before sending a LMI information to the routers on a FR encapsulated interface.There are three state of VCs; Active state, inactive state and deleted state.

Sub-interface

An approach of using a single serial interface to connect multiple VCs, where each logically has its own separate interface, is called sub-interface. Consequently, by using multiplexing, a single hardware interface will be shared by several sub interfaces, as shown in Fig. 4. There are two types of sub interfaces; Point-to-point and multipoint.

For such types of sub-interfaces, multiple DLCIs can not be associated with a single point-to-point sub interface. Furthermore, FR map statements and Inverse-Address resolution Protocol (ARP) can not be used. In contrast, the FR interface DLCI statement can be used for both point-to-point and multipoint.

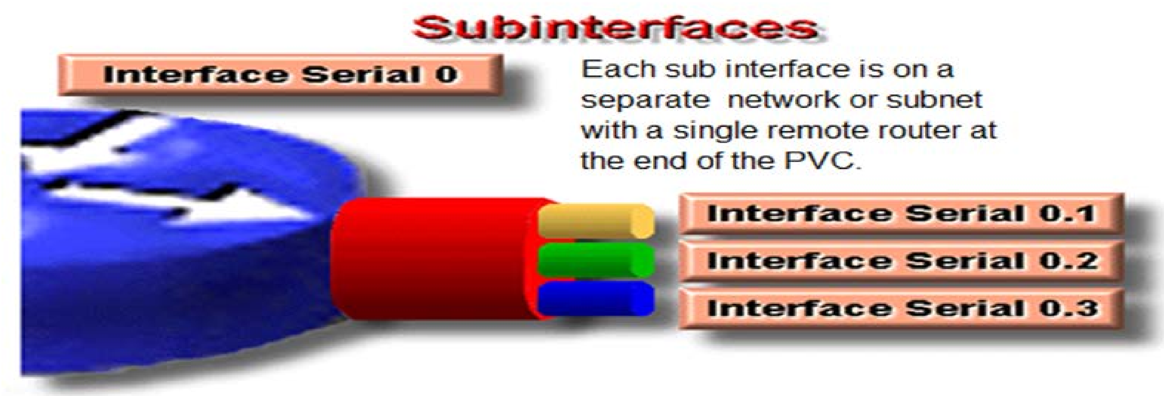


Figure (4): point-to-point sub interface

On the other hand, multipoint interface is employed when the star topology is used by using one router at the center of VCs that are using a single subnet for all other router's serial interfaces that are connected to the FR cloud, as shown in Fig. 5. As clearly noticed, in order to easily administer the interfaces, the sub interface number matches the DLCI number.

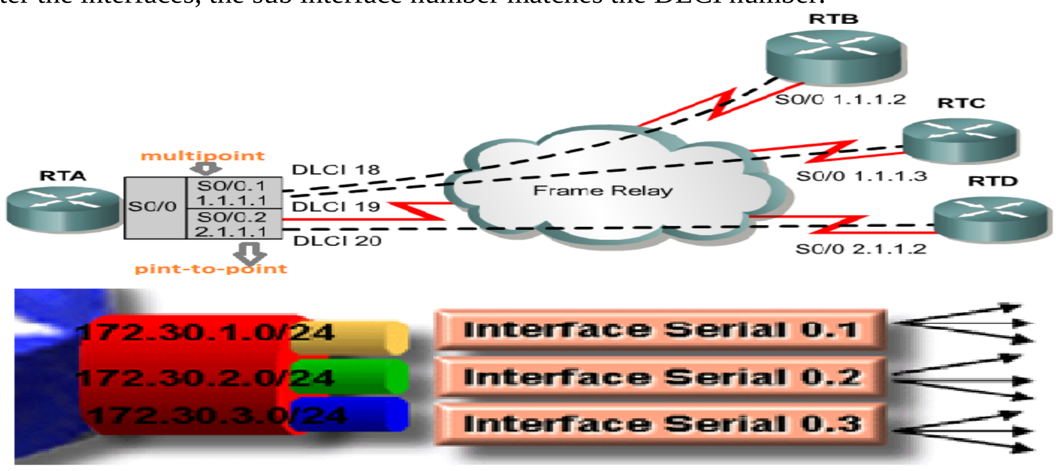


Figure (5): multipoint sub interface

Implementation of the Proposed Network

As shown in Fig. 6, the implemented network represents a group of Iraqi Universities that are communicated with each other, either directly or indirectly through the Ministry of Higher Education (MOHE). WAN technology, which is utilized to connect different LANs, is the FR. The configuration of FR that is established among the suggested networks based on the following needs:

- Permit each university to directly communicate with the MOHE. As example, Tikrit University sends and receives any data (decision or information) to/from the MOHE.
- Universities to communicate with each other need to go through the MOHE and then to the destination university, except any two universities which we make direct connection between them, as illustrated in Table 2.

Table: 2 Iraqi Universities Network Connections Specifications

No.	University	Directly Connected To	Indirectly Connect To
1	Baghdad	MOHE, Mustansiriyah and Technology	Anbar, Basra, Kirkuk, Mosul, and Tikrit
2	Mustansiriyah	MOHE, Baghdad, and Technology	Anbar, Basra, Kirkuk, Mosul, and Tikrit
3	Anbar	MOHE	Al-Mustansiriya, Baghdad, Basra, Kirkuk, Mosul, Technology, and Tikrit
4	Technology	MOHE, Baghdad and Mustansiriyah	Anbar, Basra, , Kirkuk, Mosul, and Tikrit
5	Basra	MOHE	Mustansiriyah, Anbar, Baghdad, Basra, Mosul, Technology, and Tikrit
6	Kirkuk	MOHE and Tikrit	Mustansiriyah, Anbar, Baghdad, Basra, Mosul, and Technology
7	Mosul	MOHE	Mustansiriyah, Anbar, Baghdad, Basra, Kirkuk, Technology and Tikrit
8	Tikrit	MOHE and Kirkuk	Mustansiriyah, Anbar, Baghdad, Basra and Mosul

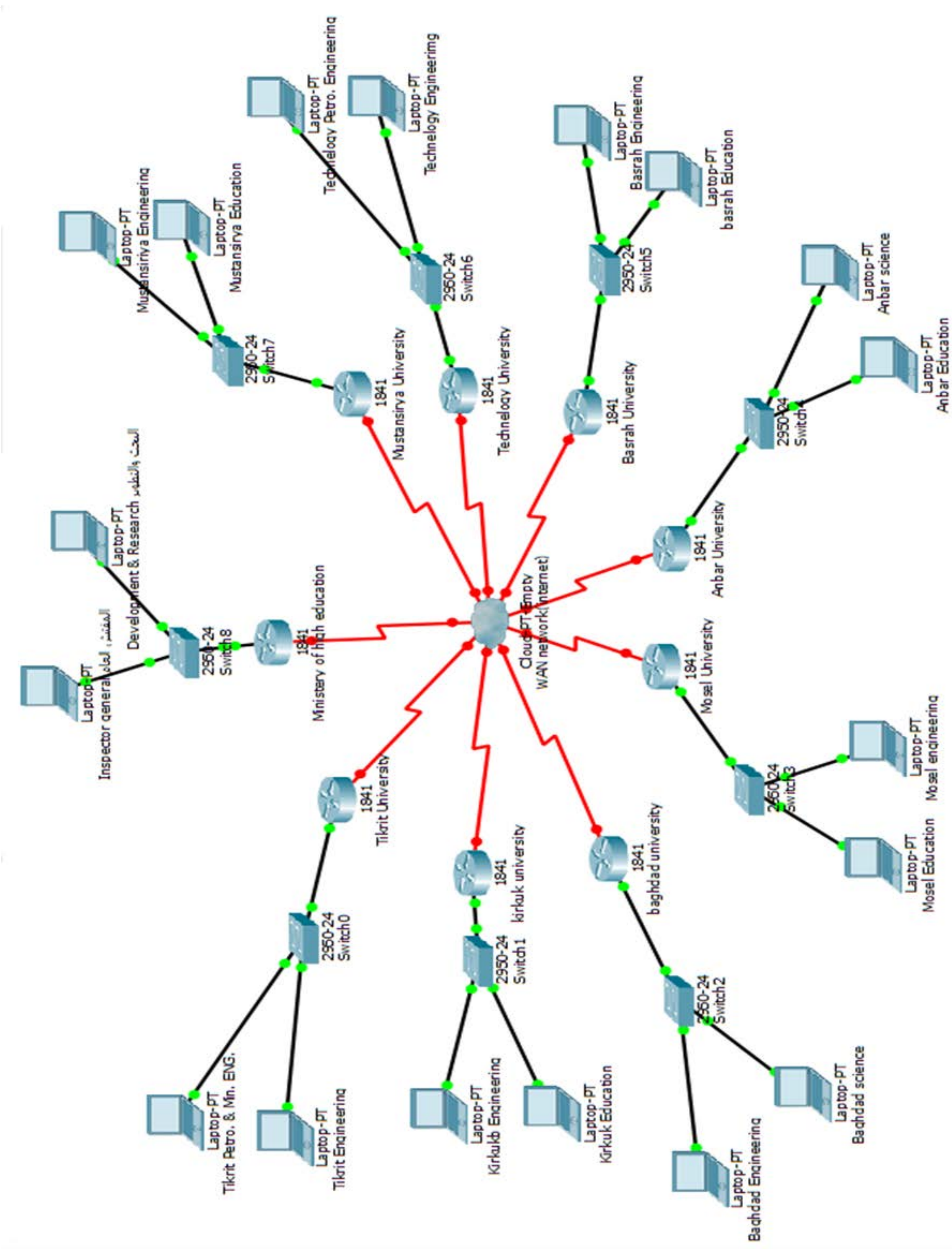
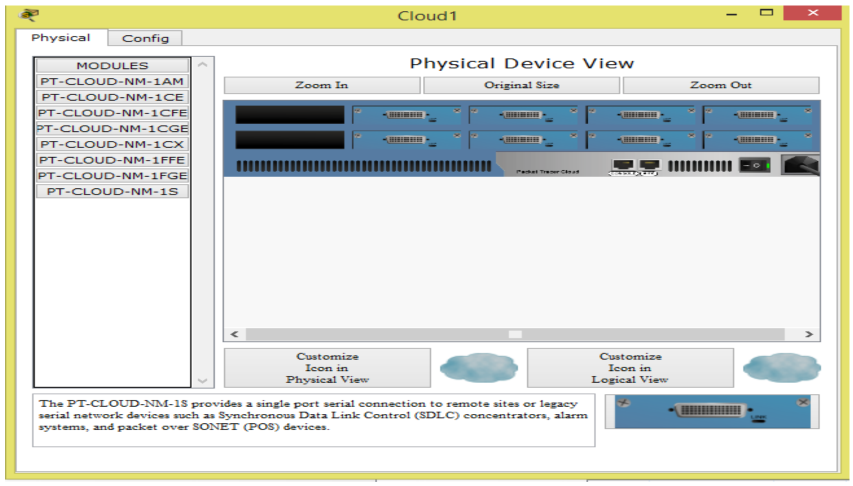


Figure. 6: WAN of some Iraqi universities.

Network Devices Programming

WAN Emulation

1. Adding serial interface ports equal to the number of routers which are connected to them, as shown in Fig. 7.



Figure(7). WAN Emulation "Adding Serial Interface Ports"

2. Giving DLCI number for each serial interface, as depicted in Fig.8.

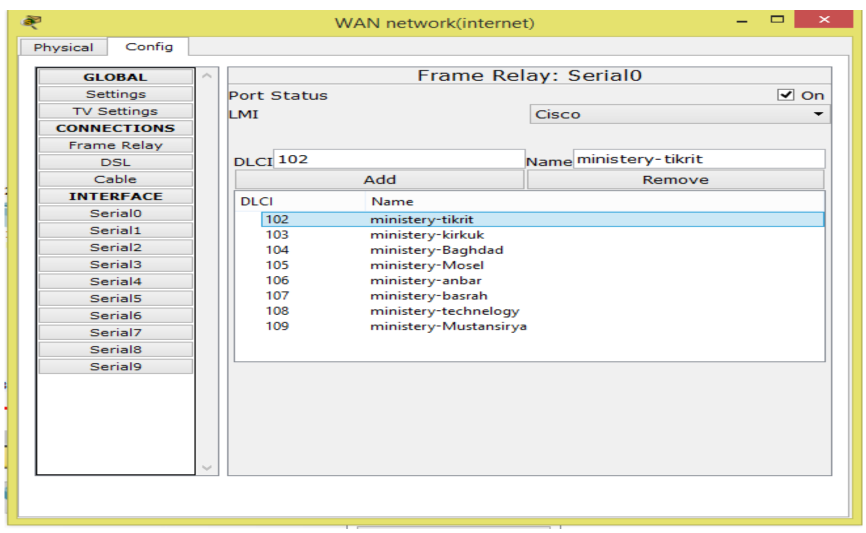


Figure (8). WAN Emulation "Adding DLCIs"

3. Connecting each serial interface (router) to each other by their DLCI using FR, as illustrated in Fig. 9.

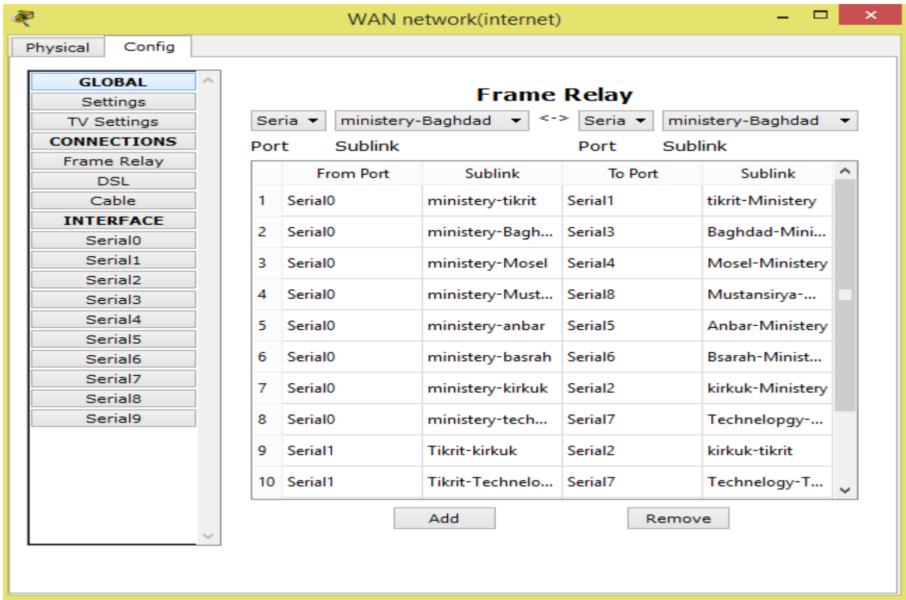


Figure (9). WAN Emulation "Frame Relay Connecting"

Router:

1. Adding serial interface ports, as shown in Fig. 10.

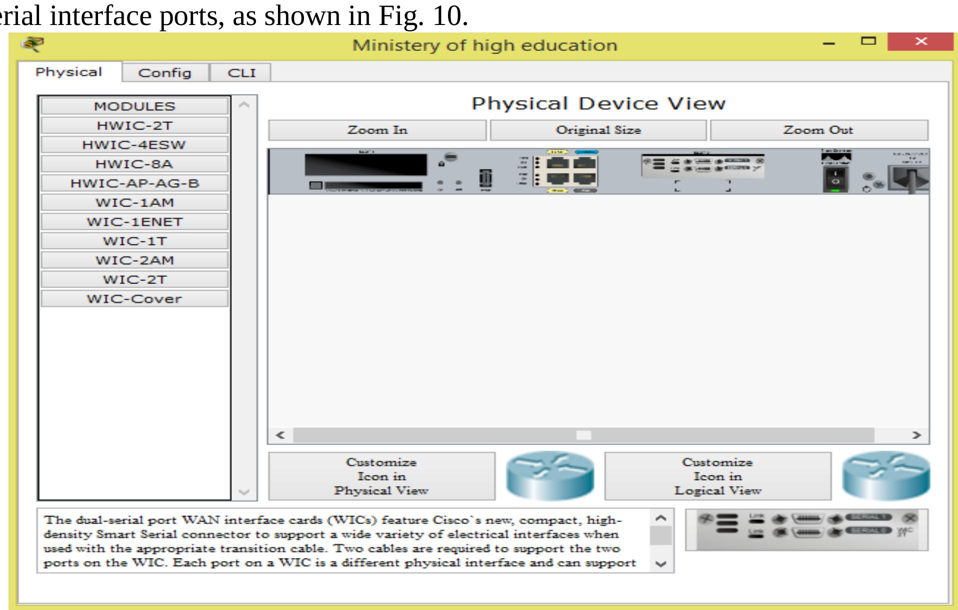


Figure (10). Router "Adding Serial ports"

2.Programing the router

A. Serial interface Configuration

- MOHE Router which directly connected to all others

MOHE>en

```
MOHE #conf term
MOHE(config)#int S0/0/0
MOHE(config-if)#ip add 30.30.30.1 255.255.255.0
MOHE(config-if)#no sh
MOHE(config-if)#
MOHE(config-if)#enc fr
MOHE(config-if)#
```

- Some routers are directly connected to some and indirectly connected to others.

  For indirectly connected we need the frame Relay mapping instruction as follow. Tikrit University router (TIKRIT) is taken as example:

```
TIKRIT>en
TIKRIT#conf term
TIKRIT(config)#int S0/0/0
TIKRIT(config-if)#ip add 30.30.30.2 255.255.255.0
TIKRIT(config-if)#no sh
TIKRIT(config-if)#
TIKRIT(config-if)#encap fr
TIKRIT(config-if)#
TIKRIT(config-if)#fr map ip 30.30.30.4 201
TIKRIT(config-if)#fr map ip 30.30.30.5 201
TIKRIT(config-if)#fr map ip 30.30.30.6 201
TIKRIT(config-if)#fr map ip 30.30.30.7 201
TIKRIT(config-if)#fr map ip 30.30.30.9 201
```

B. Fast Eathernet Configuration

The configuration of fast ethernet ports of MOHE router will be as in the following:

```
MOHE(config)#int F0/0
MOHE(config-if)#ip add 170.170.1.1 255.255.255.0
MOHE(config-if)#no sh
MOHE(config-if)#
```

End Devices:

Giving each device its own IP with its gateway, as shown in Fig. 11.

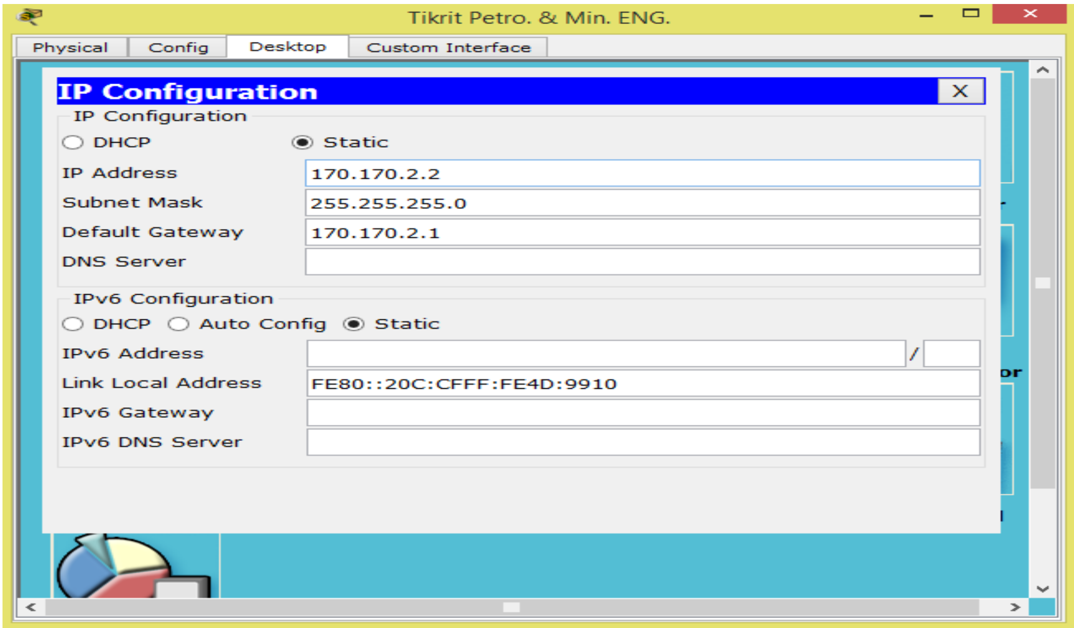


Figure.(11). End Devices "Laptops" Programing

CONCLUSIONS

In this paper, the Frame relays (FRs), which is one of high-performance WAN protocols that operate at the data link layer, are used to connect some Iraqi universities. The configuration of FR over routers is depicted using packet tracer software, which is a simple and an efficient software that can be used to implement any networks along with their technologies. The implementation of a relatively lower cost FR technology among Iraqi universities provides a high level of security (privacy) for the information of the colleges or departments of these universities. Furthermore, such a technology provides a bandwidth-on-demand, which appears as having more bandwidth available than they physically have dedicated for each university.

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