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In this issue of CCNEWS, the topics covered are:

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USE OF TCP/IP ON METU CAMPUS-WIDE BACKBONE NETWORK

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1. Introduction

Installation of METU campus-wide backbone network has been completed by the end of November 1990. This backbone network spans over the campus by providing 120 access points in 15 buildings. The backbone network, having a speed of 16 Mbit/Sec, utilizes Token-Ring (IEEE 802.5) Fiber-Optic technology.

Departmental networks (LANs) and host computers will soon be connected to the backbone network. The key question is: *'How all these different types of computers (PCs, workstations, mini and mainframe computers, etc.) and their operating systems will be able to communicate with one another ?'.*

As a solution to the connectivity problem, this article will present a de-facto standard protocol, so-called ***'Transmission Control Protocol / Internet Protocol (TCP/IP)'*** and its future use on METU campus-wide backbone network (METU-NET).

2. What is TCP/IP ?

A network architecture is typically comprised of a set of layered protocols. The ISO Reference Model for Open Systems Interconnection (OSI) is the world-wide standard layered communication network architecture [1]. Layered protocols have a basic characteristic called ***'peer protocol interaction'***, in which a particular protocol layer maintains a conversation with its counterpart at the other end.

TCP/IP is a set of layered protocols that have evolved from the research community of DARPA (Defence Advanced Research Project Agency) [2,3,4]. Its development efforts go back to the beginning of 1970s.

TCP (Transmission Control Protocol) and IP (Internet Protocol) corresponds to the Transport Layer and the Network Layer of OSI Reference Model respectively. The **Internet Protocol (IP)** is responsible for routing packets of information between network

stations, while the **Transmission Control Protocol (TCP)** provides an end-to-end reliable data stream service between applications.

3. Services Running on Top of TCP/IP

There are three standard services that run on top of TCP/IP protocols. These are :

1. Simple Mail Transfer Protocol (SMTP)
2. File Transfer Protocol (FTP)
3. Telnet Virtual Terminal Protocol (TELNET)

The *Simple Mail Transfer protocol (SMTP)* is used for exchanging electronic mail between the end users of host computers [7].

The *File Transfer Protocol (FTP)* is used for transferring files between host computers, by utilizing a mechanism of commands and replies [8].

The *Telnet Virtual Terminal Protocol (TELNET)* is the remote terminal access protocol [9]. It allows the use of a terminal (or even a terminal server) on one host to interact with a program on another host, so that remote login to another host computer would be possible.

One can easily develop other applications that can run on TCP. TCP provides interfaces, called sockets, for such applications. TCP/IP protocol stack itself, applications running on TCP/IP protocols, and its relation to OSI reference model is shown in Figure-1.

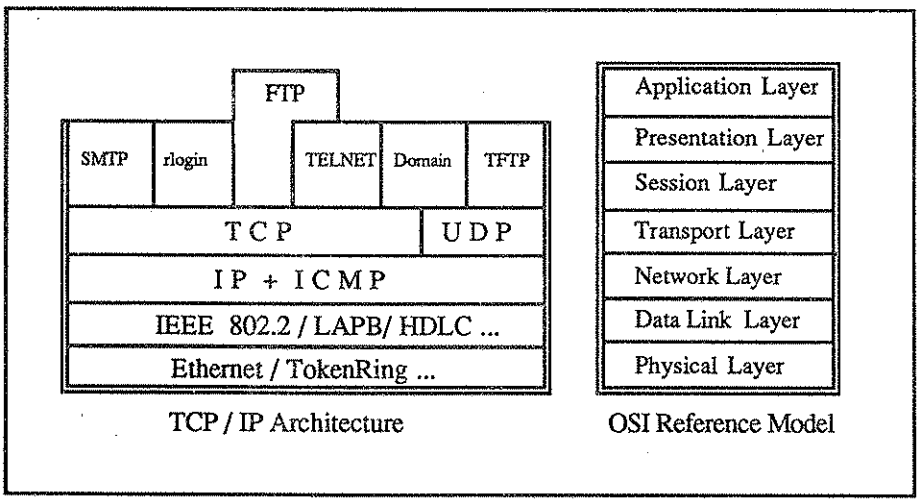

Figure 1. TCP/IP Communication Architecture and its relation to OSI Reference Model

4. Internet Addresses

Each host on the Internet is assigned a unique 32-Bit Internet address that is used by the IP layer of the network for communication with that host. This IP address is usually represented in dotted decimal form. IP addresses are centrally controlled throughout the world by the Internet Network Information Center (NIC).

Conceptually, each IP address is a pair ***(net-id,host-id)*** where net-id identifies a network and host-id identifies a host on that network. IP addresses have 3 classes: A, B and C.

Class A addresses, which are usually assigned to very large networks, can accommodate more than 65536 hosts in each network. It allocates 7 bits to net-id and 24 bits to host-id.

Class B addresses, which are used for intermediate size networks, allow between 256 and 65536 hosts in each network. 14 bits are used for the net-id and 16 bits for the host-id. METU was assigned a B-class address (144.122.0.0) by the Internet Network Information Center (NIC).

Class C addresses, which have less than 256 hosts on each network, allocate 21 bits to the net-id and only 8 bits to the host-id.

The use of net-id and host-id fields on each class of IP addresses is shown in Figure-2.

5. Domain Names and Mapping them to IP Addresses

While using the facilities of the network, IP addresses in dotted decimal form is quite impractical to be used by a network user. More meaningful names should be used for higher level entities (i.e. machines, file servers etc.). There are a few different approaches for assigning names to machines. In the Internet, hierarchical machine names are assigned according to the structure of organizations that obtain authority for parts of the name space, not according to the structure of the physical network interconnections.

Internet uses a hierarchical naming scheme known as ***domain names*** [5]. A domain name consists of a sequence of subnames separated by a delimiter character, the period (*'.'*). The domain naming system simply calls each section a label. Thus the domain name, *'math.metu.edu.tr'* contains four labels *tr*, *edu*, *metu*, and *math*. Any suffix of labels in a domain name is called a domain.

In the above example, the lowest level domain is *math.metu.edu.tr* (Mathematics Department), next to lowest level is *metu.edu.tr* (Middle East Technical University), the second level domain is *edu.tr* (Education and Research Network), and the top level domain is *tr* (Turkey).

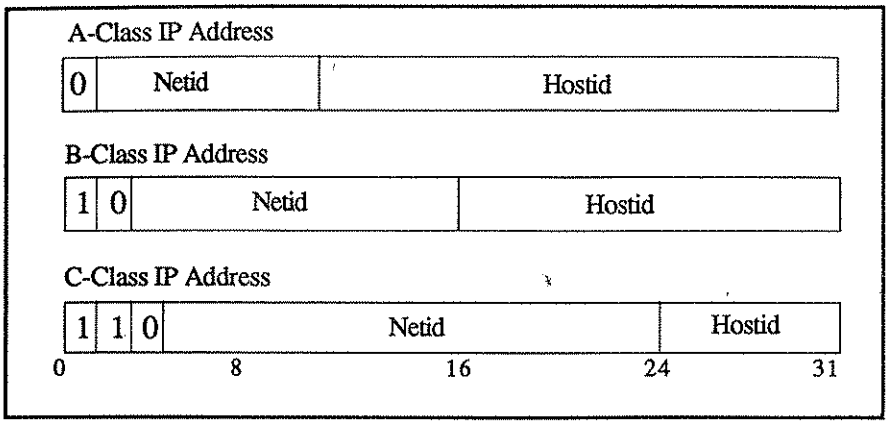

Figure 2. IP Address Structure

The Internet scheme for mapping names to addresses consists of independent cooperative systems called *name servers*. A name server is a server program that supplies name-to-address translation, mapping from domain names to Internet addresses.

6. Use of TCP/IP on METU Campus

6.1. Subnetting on METU-NET

As we all know, METU is a campus university and there will be many separate departmental networks (LANs) that will be connected on a backbone LAN. The backbone LAN uses fiber-optic Token-Ring (16 Mbit/Sec) technology, and is named as **'METU-NET'**.

For the assignment of IP addresses to departmental networks and machines (hosts), an hierarchical approach will be used. This technique that we will use on *METU-NET* to allow a single network address to span multiple physical networks, is called *'subnet addressing'* or *'subnet routing'*. This is the most general technique and it has been standardized and have been used by many organizations including educational institutions (MIT, Stanford University, etc.). Subnetting further divides the host-id field into two parts, namely, *subnet-id* and *host-id*. We shall use our well-established departmental codes for subnet-ids (e.g. 67 for Electrical Engineering, 30 for Physics etc.).

METU has a single, class B IP network address that is assigned by the Internet Network Information Center: **'144.122.0.0'**. This B-Class address will be shared by the departments of METU. The first and second decimal numbers of the METU's IP address are fixed (i.e. 144.122). It is being planned to use 8-bit subnet addressing on *METU-NET*, which will provide us with 255 subnets (departmental networks) and each subnet will have up to 254 hosts. If a department needs to have more than one subnet, an additional subnet

number will be assigned. The third decimal number will be used for subnet-id (i.e. departmental code). The fourth decimal number of the IP address will be used by the departments for their hosts that are to be hooked to departmental LAN.

The assignment of the subnet-ids over the *METU-NET* will be controlled and managed by METUCC, while the assignment of host-ids over the departmental network will be done by the departments' local management. However, the general guidelines for the assignment of host-ids within the departmental networks should be consulted with METUCC. Whenever departments complete their departmental networks' physical setup, they should apply to Computer Center (METUCC) to register IP addresses for their departmental networks.

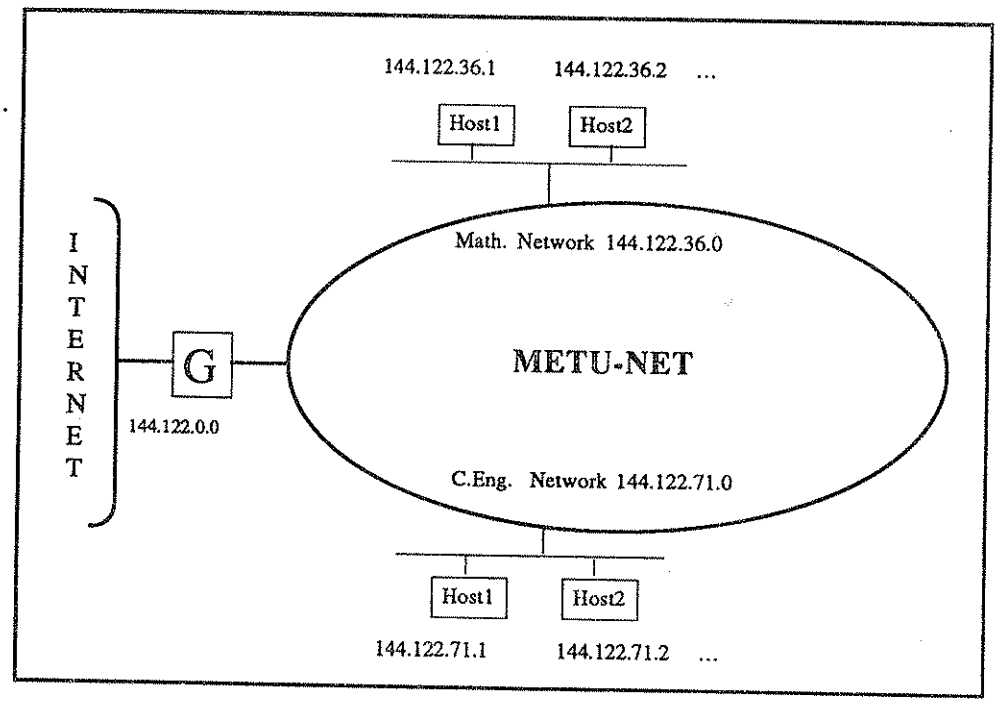

Figure 3. Subnetting on METU-NET

Now, let us explain subnetting on *METU-NET* with the following example. Department of Mathematics and department of Computer Engineering have their departmental LANs that are to be connected to *METU-NET*. Departmental network of Mathematics is assigned the IP address '144.122.36.0' (the zero in the field of host-id identifies the subnet), and department of Computer Engineering is assigned the IP address '144.122.71.0'. Figure-3 shows this configuration.

METU-NET will eventually be connected to the Internet by a local gateway. It is currently being planned that the gateway will be our IBM 3090 machine. Only the local gateway (IBM 3090) will know that there are several departmental networks and how to route traffic among them; core gateways route all traffic as if there is a single network (144.122.0.0).

All gateways, except G, treat destinations on *METU-NET* equally. All the packets having destination addresses starting with 144.122 will be routed to our local gateway. Once a packet reaches G, it must be sent across the physical network *(METU-NET)* to its destination. To choose a physical network, G examines the third octet of the destination address and routes datagrams with value 36 to the network labelled 144.122.36.0 and those with value 71 to the network labelled 144.122.71.0.

6.2. Assigning Domain Names.

The alternatives for the structure of the domain names in Turkey is currently being discussed within the TUVAKA (Turkish Universities and Research Institutions Network) technical group. The top-level domain name for Turkey will be ***'.TR'***. The ongoing discussions are for the second-level domain names. One view defends the idea that there will be different communities in the whole network, therefore, the second-level domain name should indicate the type of the community (e.g. *'EDU.TR'* for Educational Network, *'GOV.TR'* for Government Network, *'MIL.TR'* for Military Network, etc.). The other view is in favour of the idea that the institution name should follow the top-level domain (e.g. *'METU.TR'*).

No matter what the results of this discussions will be, an hierarchical domain name system will be used in our University as well as in the country. Departments of our University will use their department names immediately following the METU suffix. For instance, Department of Physics could be identified as *'physics.metu.edu.tr'* (or *'physics.metu.tr'*). Departments having more host computers or even LANs can also use an additional level of domain names (e.g. *'lan1.physics.metu.edu.tr'*).

The departmental level domain names that will be used on the *METU-NET* will be assigned centrally by the METUCC, therefore, those names should be registered by contacting with the METUCC. Those departments wishing to participate in the *METU-NET* by using the described networking scheme, are required to run TCP/IP software and a domain name server on their departmental network.

7. Conclusion

TCP/IP is today's widely used networking protocol. It can be easily run on any type of machine and operating system without making a big investment. Although the OSI Reference Model is the ultimate goal, it is still in the development phase and not ready for immediate use. TCP/IP remains the only viable solution to interoperability problem.

Using TCP/IP protocols would be the most appropriate and the cheapest solution for the interconnection of the computing resources located in the METU campus. It is also a very good tool for accessing the computing resources on remote locations.

TCP/IP must be considered as the most viable alternative for those departments planning to hook their computing resources on to the *(METU-NET)* backbone network. This type of solution would provide departments' users with the full connectivity features.

IP addresses and domain names for METU campus are centrally managed by the METUCC. Those departments, planning for network connectivity, should contact with METUCC for obtaining their departmental IP addresses and domain names. Departments will also be requested to run a minimum configuration of software for participating in such a networking environment.

REFERENCES

[1] International Organization for Standardization, ***'Information Processing Systems, Open Systems Interconnection, Basic Reference Model'***, ISO 7498-1984, 1984.

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[5] Mockapetris P., ***'Domain Names - Concepts and Facilities'***, RFC 882, USC Information Sciences Institute, Marina del Ray, California, 1983.

[6] Comer D., ***'Internetworking With TCP/IP- Principles, Protocols, and Architecture'***, Prentice Hall, 1988.

[7] RFC 821 Simple Mail Transfer Protocol (SMTP)

[8] RFC 959 File Transfer Protocol (FTP)

[9] RFC 854 Telnet Virtual Terminal Protocol (TELNET)

*Electronic copies of RFCs are available at SRI-NIC.ARPA