

# Computer Networks

## -An Introduction

Lecture-1

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# Interaction Points

- About the focus of the course
- How shall this course be conducted?
- Resources & Timelines for the course
- What is a Computer Network and why do we need it?
- Basic types of Computer Networks and Internetworks
- Select References to the literature
- Summary

# About the Focus of the Course

This course aims at:

- Learning about the basics of Computer Networking
- **Developing an ability to:**
  - Conceptualize a simple network,
  - **Design an elementary network,**
  - Simulate and build a multi-protocol network,
  - **Configure a simple network,**
  - Analyze a give network design &
  - **Diagnose issues / problems associated with a simple state-of-the-art Network / Internetwork**

# The Course Plan

- Methodology to be used:
  - 40 Classroom lectures (three per week, as per the provided course handout)
  - Learning Reinforcements through:
    - Online Discussion Forum (at Nalanda)
    - Case-studies interlaced with design discussions (in classroom)
    - Mini-project (with four-part submission schedule): 30%
    - Self-study assignments <for learning enhancement at appropriate points of time, no evaluation weightage>
    - Two tests <closed book> 20% each
    - Quizzes <without any evaluation weightage>
    - Comprehensive Examination <Open Book> 30%

# Resources for the Course

- **Course Home Page:**

- [URL: http://discovery.bits-pilani.ac.in/rahul/CompNet](http://discovery.bits-pilani.ac.in/rahul/CompNet)
- This page shall have the original slides developed by me for a group of lectures on related topics <to be updated after lectures on a particular topic are over>.
- This page may also have my topic-wise lecture notes in electronic form (PDF / html) hereafter referred as online lecture notes <to be updated at the end of every month>.

- **Course Forum at the Nalanda open-learning portal:**

- [URL: http://nalanda.bits-pilani.ac.in](http://nalanda.bits-pilani.ac.in)
- This page shall carry links to:
  - Discussion Forum
  - Reading advisories
  - Challenges for bright students <meant for self-learning, no evaluation weightage>
  - Occasional Links to News items of contemporary relevance to the topic under discussion
  - Laboratory tips developed with the help of student volunteers

- **IntraBITS Page for Course:**

- <http://intraBITS.bits-pilani.ac.in> <to be operational around January 21, 2011 >
- This page shall carry additional external reference material for exclusive internal use by students, notices and report/code upload facility,
- Mid-Sem marks and grades and End-Sem Marks
- Indicative Solutions to Test / Quiz / Compre. Exam papers

# Additional Resources for the Course

- Digital Library resources:
  - As accessible from the <http://library.bits-pilani.ac.in> < including relevant online IEEE / ACM journals / magazines / standards & e-books as advised through Reading Advisories>>
  - Access to select complete E-books via Books 24x7
- Laboratory resources:
  - Fixed and Mobile Networking equipment located at
    - IBM Laboratory for Open Source Computing,
    - Microsoft Laboratory for Mobile Computing and
    - Relevant networking apparatus as and when allowed by the IPC Unit at the Cisco Advanced Networking Laboratory
- Chamber Consultation Hours:
  - Monday: 1700 – 1800 Hrs.

# What is a Computer Network?

- *A Computer Network is an interconnected group of autonomous computing nodes which can meaningfully and (preferably) controllably communicate with one-another.*
  - Such communication *requires* presence of *one or more sets of rules and conventions* which are *encoded as commands and their corresponding responses*.
  - Such *rules and conventions* that allow meaningful and unambiguous communication between members of a Computer Network are collectively called *Network Protocols*.
- In real-life networks, often a set of related functions are handled by a group of closely tied protocols which constitute a *Protocol Family* (also known as a *Protocol Suite*).

# Defining a Computer Network

- Defining a Computer Network
  - A Computer Network is an interconnected group of autonomous computing nodes which:
    - Use a well-defined, mutually-agreed set of rules and conventions known as Protocols,
    - Interact with one-another, if duly authenticated and authorized, meaningfully;
    - Allow resource-sharing preferably in a predictable and controllable manner.
- Autonomous computing node
  - A computer / node that has its own processing capabilities and that does not act under the control of any other computer / is known as an Autonomous Computer or an Autonomous Computing Node.
  - It should NOT be confused with the traditional Dumb Terminals in centralized computing environments.



# Elements involved in a Network / Internetwork

- **Nodes**
  - Regular computing nodes
  - Network extension / interconnection devices
- **Network Interfaces**
  - NICs / On-board Chips
  - Wireless interfaces
  - Wireline interfaces
- **Links**
  - Wireline links
  - Wireless links
- **Strategies, Algorithms & Protocols:**  
H/W, S/W, F/W level implementations

Nodes: where processing and communication capabilities co-exist

Hosts: end / intermediate nodes where all levels / layers including those belonging to applications exist

# Applications of Computer Networks

- Numerous applications of computer networking are possible.
- Some of the most popular ones include:
  - Electronic Mail
  - Web-browsing
  - Digital Libraries
  - Video-on-Demand
  - File Transfer
  - Video / Audio Conferencing / Immersive Telepresence
  - Social Networking
  - Web-Services
  - E-Commerce & Mobile Commerce

# Types of Computer Networks (1 of 2)

- Spread, size, inter-node-distance and purpose based classification:
  - **Personal Area Networks (PANs): Often, Wireless: Wireless Personal Area Networks (WPANs)**
  - Local Area Networks (LANs): Wireline LANs (LANs) & Wireless LANs (WLANs)
  - **Metropolitan Area Networks (MANs): Wireline and Wireless MANs**
  - Wide Area Networks (WANs): Wireline / Wireless, Fixed / Mobile, Planet-wide / Interplanetary
  - **Sensor Networks (SNs) & Wireless Sensor Networks (WSNs)**
  - Storage Area Networks / System Area Networks (SANs)
  - **Body Area Networks (BANs)**
  - Car Area Networks (CANs)

# Types of Computer Networks (2 of 2)

- **Virtualization-based classification:**
  - Virtual Local Area Networks (VLANs)
  - **Virtual Private Networks (VPNs)**
  - Overlay Networks

# Conventional Classification of Computer Networks

- **Class One: Function-based classification**
  - Data Networks
  - **Voice Networks**
  - Multimedia Networks .....
- **Class Two: Location-and-Distance-based classification**
  - Personal Area Networks (PANs)
  - **Local Area Networks (LANs)**
  - Metropolitan Area Networks (MANs)
  - **Wide Area Networks (WANs) ....**
- **Class Three: Forwarding-based classification**
  - Switched Networks
    - **Circuit-Switched Networks**
    - Packet-Switched Networks
  - **Shared Networks**
  - Hybrid Networks
- **Class Four: Ownership-based classification**
  - Public Networks
  - **Private Networks**
  - Virtual Private Networks

# Local Area Networks (LANs)

- The term LAN stands for Local Area Network.
- The term 'local area' in the world of networking usually refers to:
  - a geographically contiguous area
    - in which the inter-node distance is lesser than or equal to one kilometer.
- LANs are always owned by a single entity (an organization or individual)
- Examples of popular LAN technologies include the Ethernet in wired (wireline) category and Wi-Fi in the wireless category

# Local Area Networks ...

- A LAN is local in the sense that it is installed in a local location like a local office, a laboratory, a building or a campus.
- Although, normally, in a LAN, the inter-node distance does not exceed a kilometer; in most of the real-life situations, it is far less than this ceiling.

# Interconnection of nodes / interfaces / networks

- **Media-based interconnection perspective**
  - Guided / Unguided
  - Noisy / Noiseless
  - Broadcast / Non-broadcast
- **Link-based interconnection perspective**
  - Secure / Insecure
  - Logical / Physical
  - Point-to-Point / Multi-point
- **Physical Links**: those entities that provide physical path (direct paths between neighbouring nodes (point-to-point / point-to-multi-point) for data delivery over guided or unguided media
- **Logical Links**: an abstraction showing the logical path of data delivery at layers higher than the physical layer



# Personal Area Networks (PANs)

- The term PAN stands for Personal Area Network.
- Typically these networks are small in size, belong to a single person and are limited to his / her environment within a small area *like* his room, body or garden etc.
- **PANS** mostly use short-range wireless technologies for interconnecting various nodes that comprise them.

# Local Area Internetwork / Intranet

- Traditionally, a Campus Internetwork is a campus-wide internetwork of individual LANs which may be geographically spread over the part or whole of a single campus. This sometimes called campus intranet.
- In common practice, the entire campus internetwork including its communication subnet is wholly owned by a single organization or institution.
- Usually, the campus internetworks use LAN technology; however, it is possible to use WAN technology, when so desirable.
- The latter may be desirable in some cases when the campus is very large and comprises of a vast set of buildings spread over it. Protocols used in both of these cases at the lower layers, are, generally, different.

# Metropolitan Area Networks (MANs)

- The term MAN stands for Metropolitan Area Network.
- A computer network that is not usually owned by a single organization / entity and that is spread over a metropolitan city area is called a Metropolitan Area Network.
- Normally, in a MAN, the inter-node distance does not exceed ten kilometers. This, however, is not a hard-and-fast rule.

# Wide Area Networks (WANs)

- The term WAN stands for Wide Area Network.
- A computer network that is not usually owned by a single organization / entity and that is spread over an area larger than that of any city of operation is called a Wide Area Network .
- *A WAN may be spread over several cities / towns, a state, a country or even a continent.*
- In many a cases, when people say WAN, they actually mean Wide Area Internetwork (WAI), however!

# Comparing Computer Networks with Distributed Systems

- Terms Computer Network and Distributed System must NOT be used interchangeably since:
  - In the former, locations and elements of network remain visible to the user;
  - In the latter, the underlying network remains transparent to the user who sees the system as a uni-processor.
- Similar differences can be cited in case of Network Operating Systems and Distributed Operating Systems.

# Summary of the Concepts learnt so far:

Definition and applications of networks

Types / Classes of Networks

Physical & Logical / Virtual links

Need for Network Protocols

How networks facilitate distributed & mobile computing

# Concluding remarks

- Networking support of some kind is already inside most of the operating systems we use today in variety of forms on Notebooks, Laptops, Workstations and Servers. All Smartphones and several set-top boxes support it too.
- **Subsequent lectures shall introduce you to the following topics:**
  - Internetworks
  - Network Architectures
  - Performance
  - Quality of Service
  - Reliability
  - Security

Any question please?

*Thank you for your kind attention!*

For further details, you may contact at:

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**or visit:**

Home: <http://www.bits-pilani.ac.in/~rahul/>



# References

- *Larry L. Peterson & Bruce S. Davie: Computer Networks: A Systems Approach, Fourth Edition, Morgan Kaufmann / Elsevier, New Delhi, 2007. <System design approach>*
- *S. Keshav: Computer Networking: An Engineering Approach, Pearson Education, New Delhi, 1997.*
- *A. S. Tanenbaum: Computer Networks, Fourth Edition, Pearson Education, New Delhi, 2003. <Conceptual Approach>*
- *Y. Zheng and S. Akhtar: Networks for Computer Scientists and Engineers, Oxford University Press, New York, 2002. <Structural approach>*
- *A. Leon Garcia and I. Widjaja: Communication Networks: Fundamental Concepts and Key Architectures, Second Edition, Tata McGraw-Hill, New Delhi, 2004.*
- *Mohammed G. Gouda: Elements of Network Protocol Design, Wiley Student Edition, John Wiley & Sons (Pte.) Ltd., Singapore, 2004.*
- *Thomas G. Robertazzi: Computer Networks and Systems: Queuing Theory and Performance Evaluation, Third Edition, Springer-Verlag, New York, 2000. <Analytical approach>*

# Next Interaction Points

- **Examples of Types of Applications benefitting from Networking**
  - hard real-time, soft real-time, non-real-time / best-effort / delay-tolerant applications / services <with examples>
  - **case-study movie**
  - Constituent networking components of a smart room setup
- **The Internet & its Evolution**
- About Internet Architecture
- **Who decides about the Internet?**
- The Internet versus the World-Wide Web
- **Protocols, Layers, Interfaces, Virtual Communication and Services**
- Select References to the literature
- **Questions and Answers / Summary**



# Examples of Types of Applications benefitting from Networking

- **Types of applications & services:**
  - hard real-time applications & services,
  - **soft real-time applications & services,**
  - non-real-time / best-effort / delay-tolerant applications / services
- **Examples of each kind of applications and services**
- About the significance of application-driven and economics-constrained nature of network system design approaches
- **Case-study of the Networking aspects of the *Microsoft Easy Living Research Experiment***



# It is the Internet today?

- Wide Area Network of variety of networks
- Global
- Public
- Not transparent, as yet
- Hybrid topology but largely hierarchical
- No single controller
- Internet Society (ISoc) oversees, assists --- does not control
- QoS, Security continue to have issues – partly at least
- Web, mail, commerce, education, entertainment, sharing continue to dominate its application space



# Architecture of the Internet

- Originally, it was a point-to-point WAN.
- Original architecture that led to ARPANET has evolved over the years that have passed by.
- It is loosely hierarchical.
- Currently, Internet architecture is largely governed by the IAB of the ISoc.
- Has many sub-organs which facilitate evolution and coordinated maintenance of the Internet.
- IESG steers the ISoc in a general way the engineering issues are resolved.
- IETF workgroups do the ground work and by a democratic process helps community in building up engineering solutions through IETF drafts and standards (RFCs) etc.



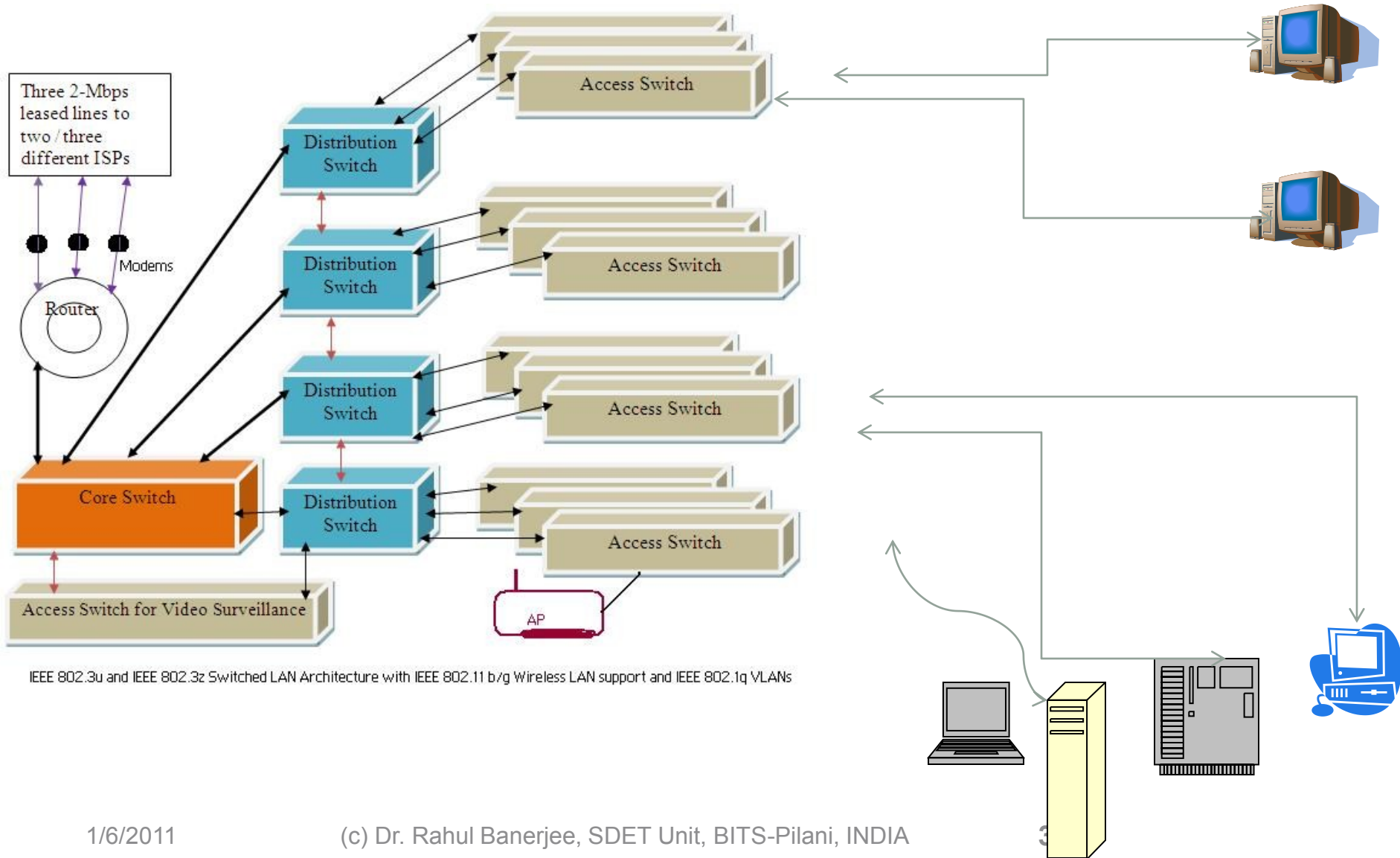
# Of the Internet, Intranet and Extranet

- The Global Public Internetwork: The Internet
- The Wholly Owned / Private Internetwork: Intranet
- The Hybrid Internetwork-- private networks / internetworks connected through the Internet: Extranet

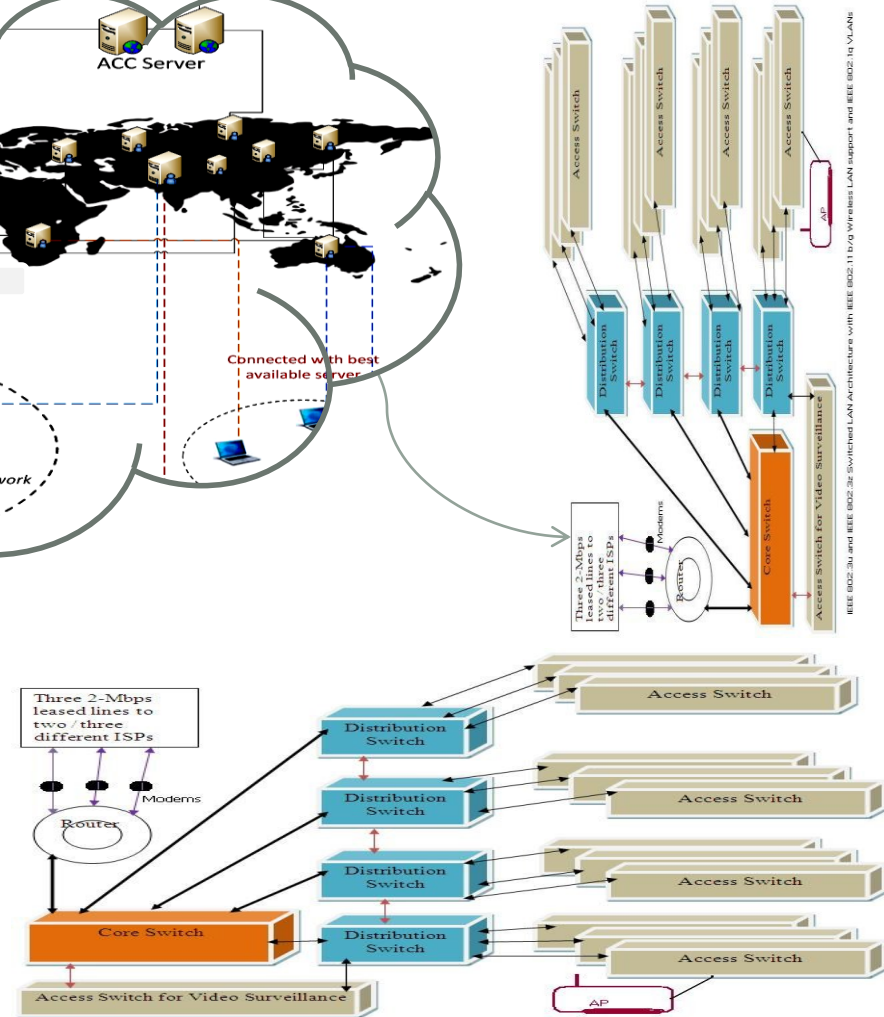
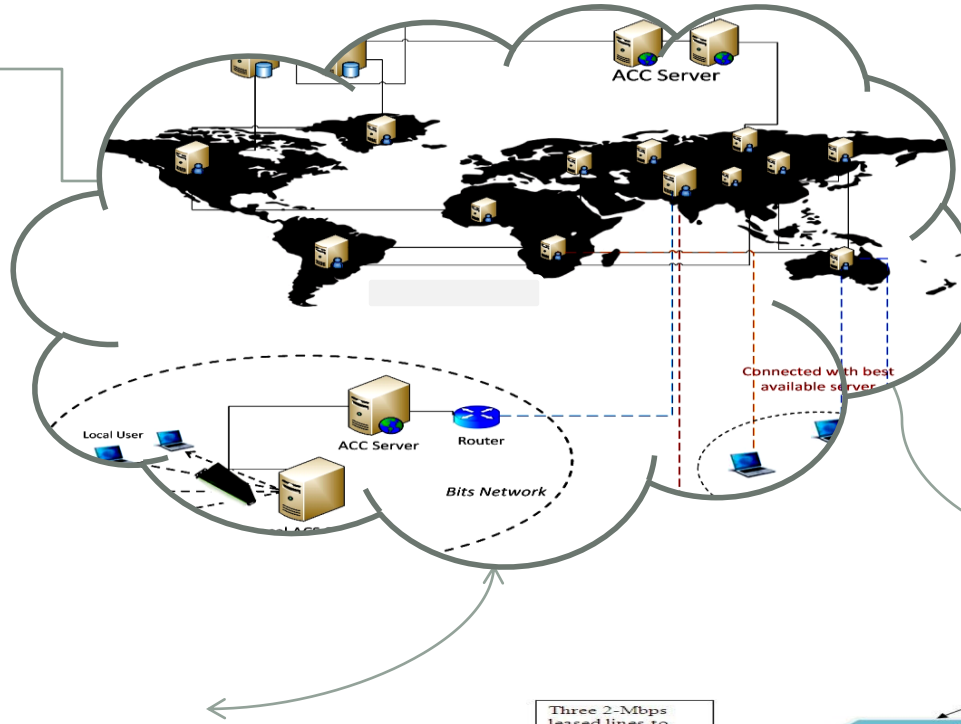
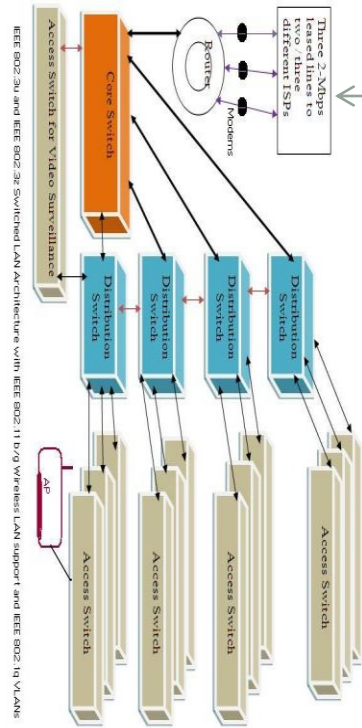
*In the early stages of development, technologies used for the internetworks of all type were essentially the same, except probably at the lowest level. This situation is rapidly changing.*



# An Example of a Computer Network



# It is an Internetwork?



IEEE 802.3u and IEEE 802.3e Switched LAN Architecture with IEEE 802.11 b/g Wireless LAN support and IEEE 802.1q VLANs





# Some Terms Related to Networks

- Channel <application-level logical / virtual communication path>
- Services: Functionalities provided by a layer / protocol / entity
- Interfaces: Peer-to-Peer / Layer-to-Layer / entity-to-entity
- Service Access Points: defined addresses / ports through which data / parameters are passed
- Tunneling <Encapsulation & Decapsulation>



# Summary

- **Intranet:** Completely private network of networks
  - Wireline
  - **Wireless**
    - Fixed
    - **Mobile**
  - Hybrid
- **The Internet:** Global public network of networks
  - Wireline
  - **Wireless**
    - Fixed
    - **Mobile**
  - Hybrid
- **Extranet:** Intranets interconnected via the Internet