



innovate

achieve

lead

BITS Pilani

Pilani | Dubai | Goa | Hyderabad



Computer Networks

Lecture-1

Rahul Banerjee, PhD (CSE)

Professor, Department of Computer Science & Information Systems

E-mail: rahul@bits-pilani.ac.in

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:
 - 42 Classroom lectures (three per week, as per the provided course handout)
- Learning Reinforcements through:
 - Online Discussion Forum (at the Nalanda learning management system: <http://nalanda.bits-pilani.ac.in/>)
 - Case-studies interlaced with design discussions (in classroom)
 - Mini-project / Investigative Project / Laboratory Experiments: 25%
 - Self-study assignments <for learning enhancement at appropriate points of time, no evaluation weightage>
 - Only ONE Test: Mid-Semester Test <closed book> 30%
 - Quizzes <Open Book / Open Notes> 5%
 - Comprehensive Examination <Open Book: 20%, Closed Book: 20%> 30%

<You are allowed to carry Laptops/Notebooks/Netbooks/Tablets/iPads etc. with wireless access disabled in classrooms as well as in open-book examinations and quizzes>

Resources for the Course

- **Course Home Page:**

- URL: <http://universe.bits-pilani.ac.in/pilani/rahulbanerjee/ComputerNetworks>
- This page shall have the original slides <in PDF> developed by me for a group of lectures on related topics <to be updated after lectures on a particular topic are over>.

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

- URL: <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
 - Indicative Solutions to Test / Quiz / Compre. Exam papers

- **IntraBITS Page for Course:**

- <http://intraBITS.bits-pilani.ac.in> <January 15, 2012 onward>

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
- Chamber Consultation Hours:
 - Tuesday: 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

- **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

Concluding remarks

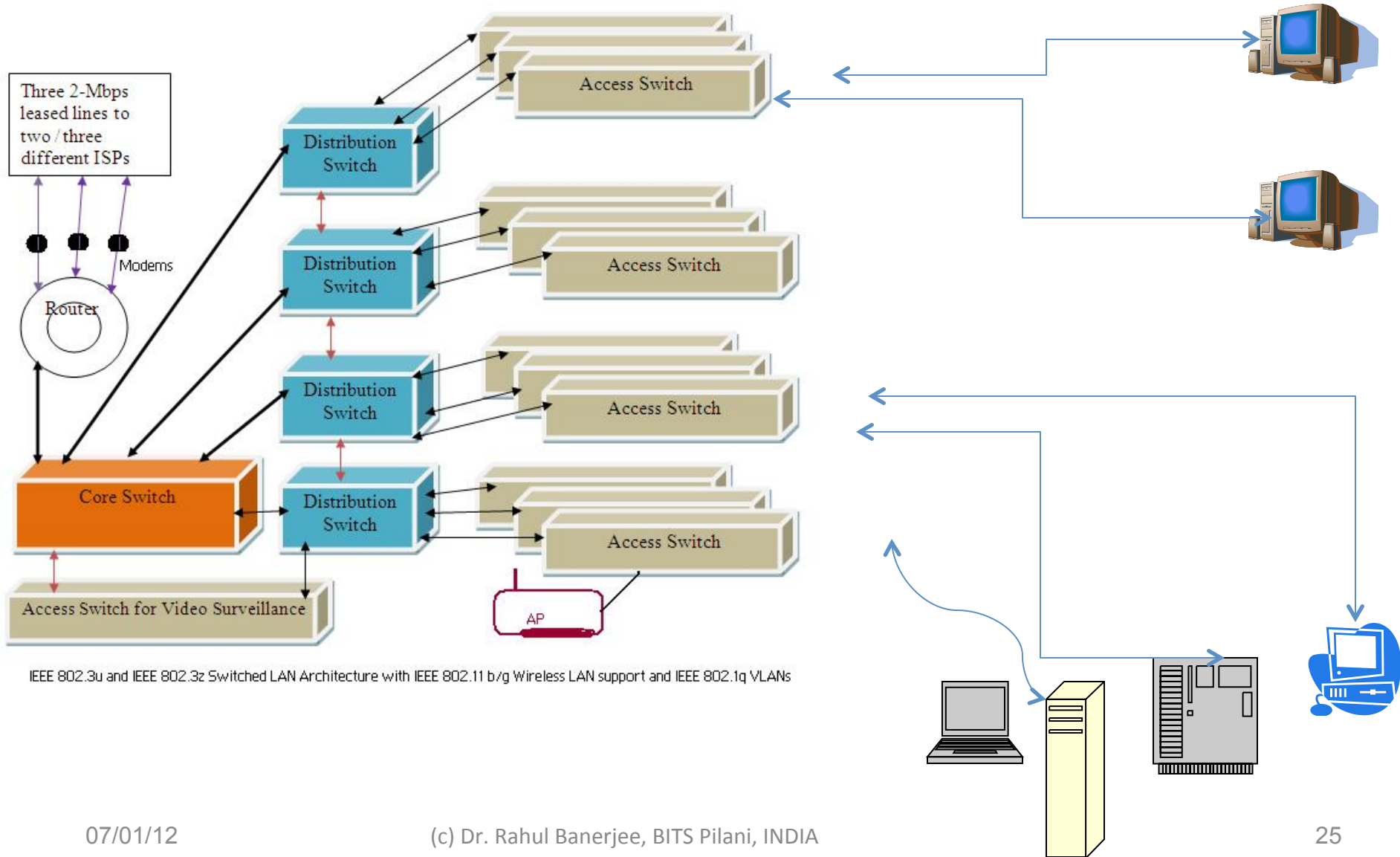
- Networking support of some kind is already inside most of the operating systems we use today in variety of forms on Notebooks, Laptops, Workstations and Servers. All Smart-phones and several set-top boxes support it too.
- **Subsequent lectures shall introduce you to the following topics:**
 - Internetworks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

References

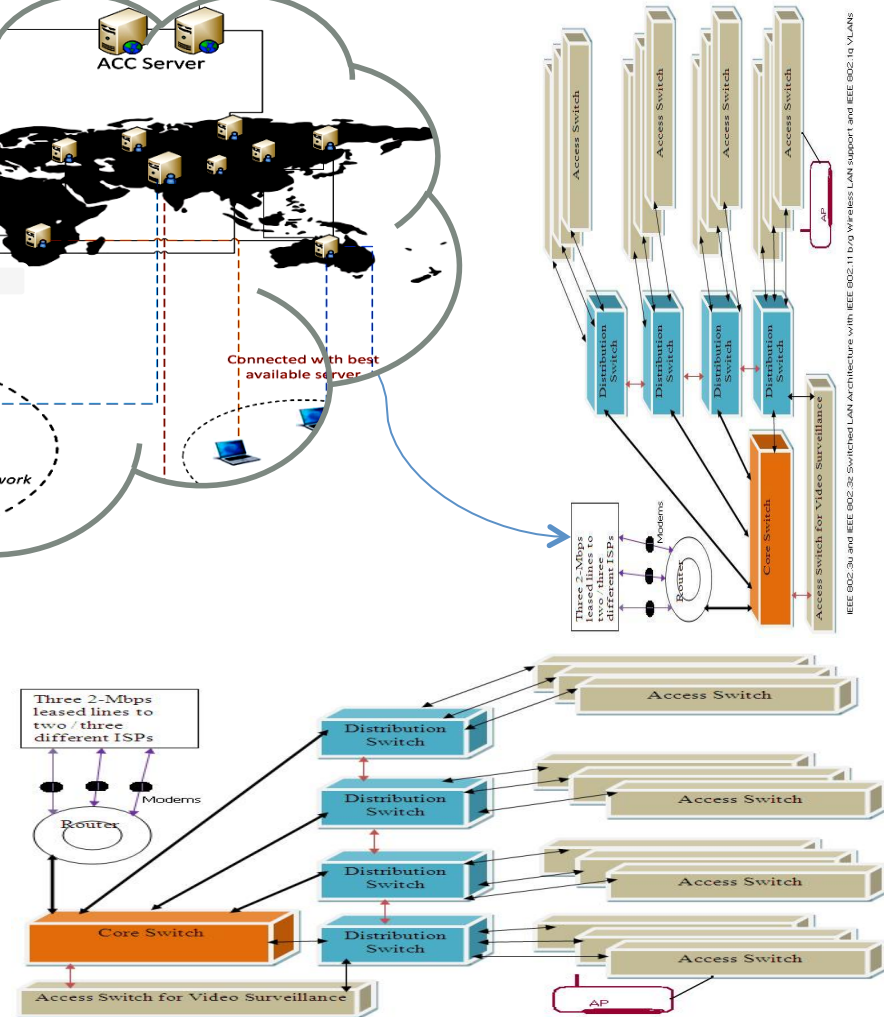
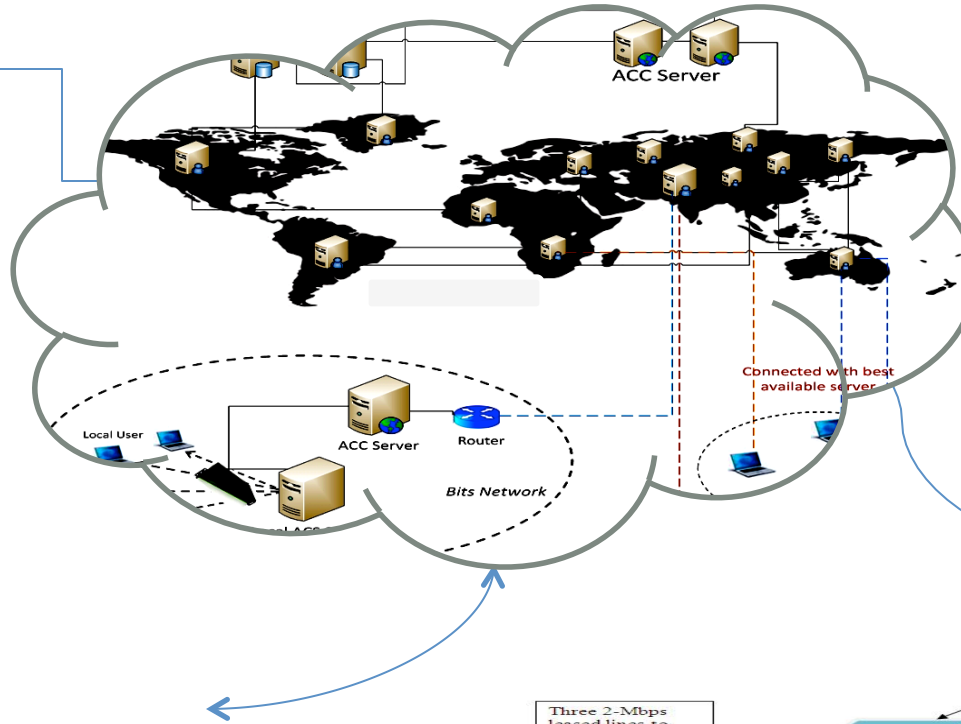
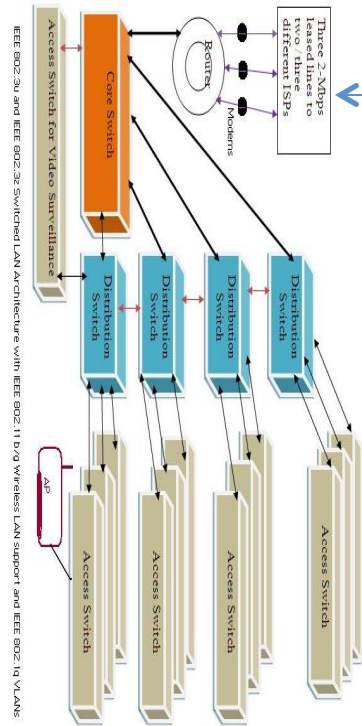
- *Larry L. Peterson & Bruce S. Davie: Computer Networks: A Systems Approach, Fifth Edition, Morgan Kaufmann / Elsevier, New Delhi, 2011. <System design approach>*
- *S. Keshav: Computer Networking: An Engineering Approach, Pearson Education, New Delhi, 1997.*
- *A. S. Tanenbaum: Computer Networks, Fifth Edition, Pearson Education, New Delhi, 2012. <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>*



An Example of a Computer Network



What is an Internetwork?



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

Project BITS-Connect 2.0



The Immersive Tele-presence Rooms

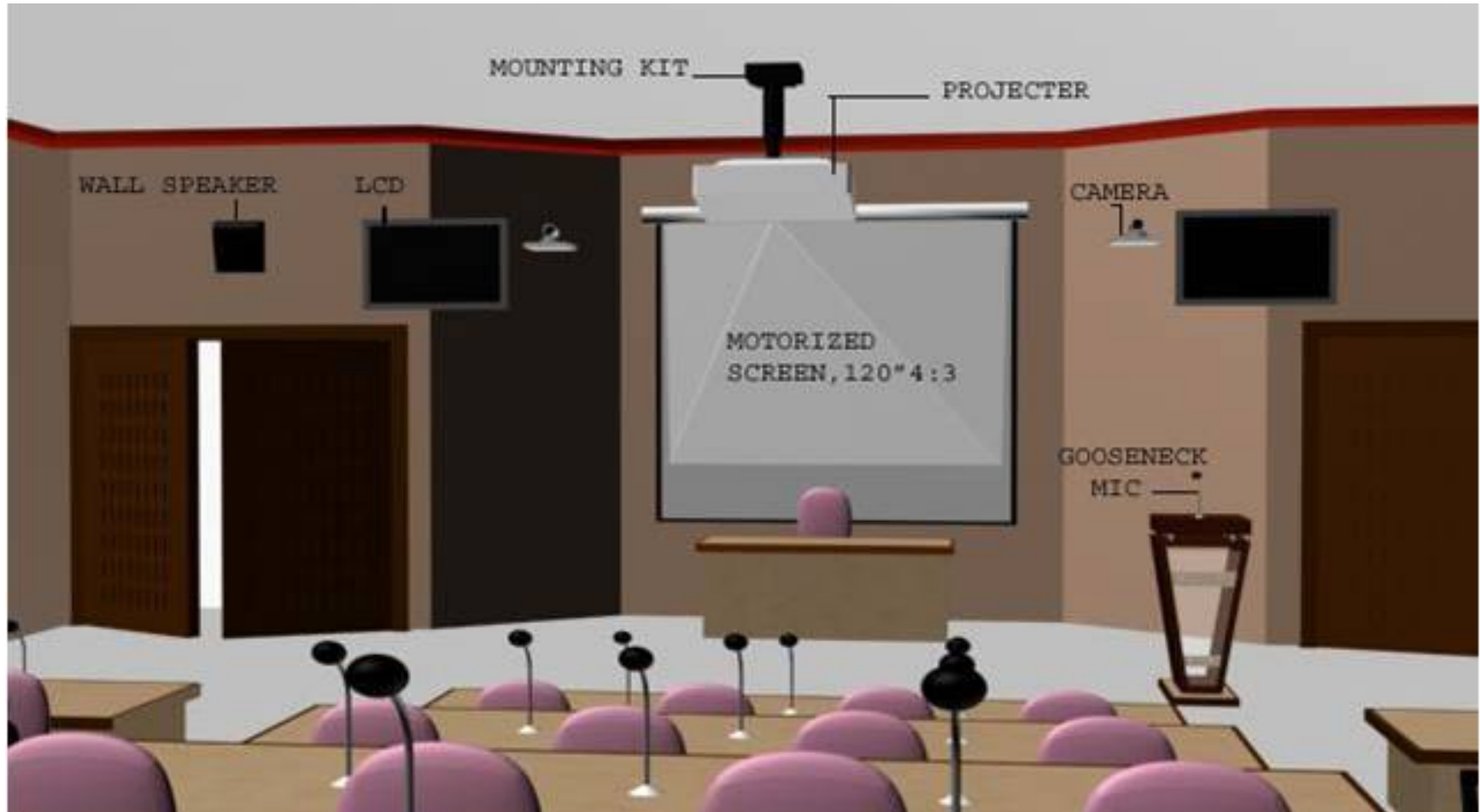
- This is how an 18-seater immersive tele-presence room would look like at the Pilani campus.
- All other campuses shall be equipped with one-row of six seats instead of two rows shown here.
- Chancellor's office shall be equipped with one two-seater system



Project BITS-Connect 2.0



Four 200-seater Classrooms in various campuses to have Integrated HD VC



Project BITS-Connect 2.0

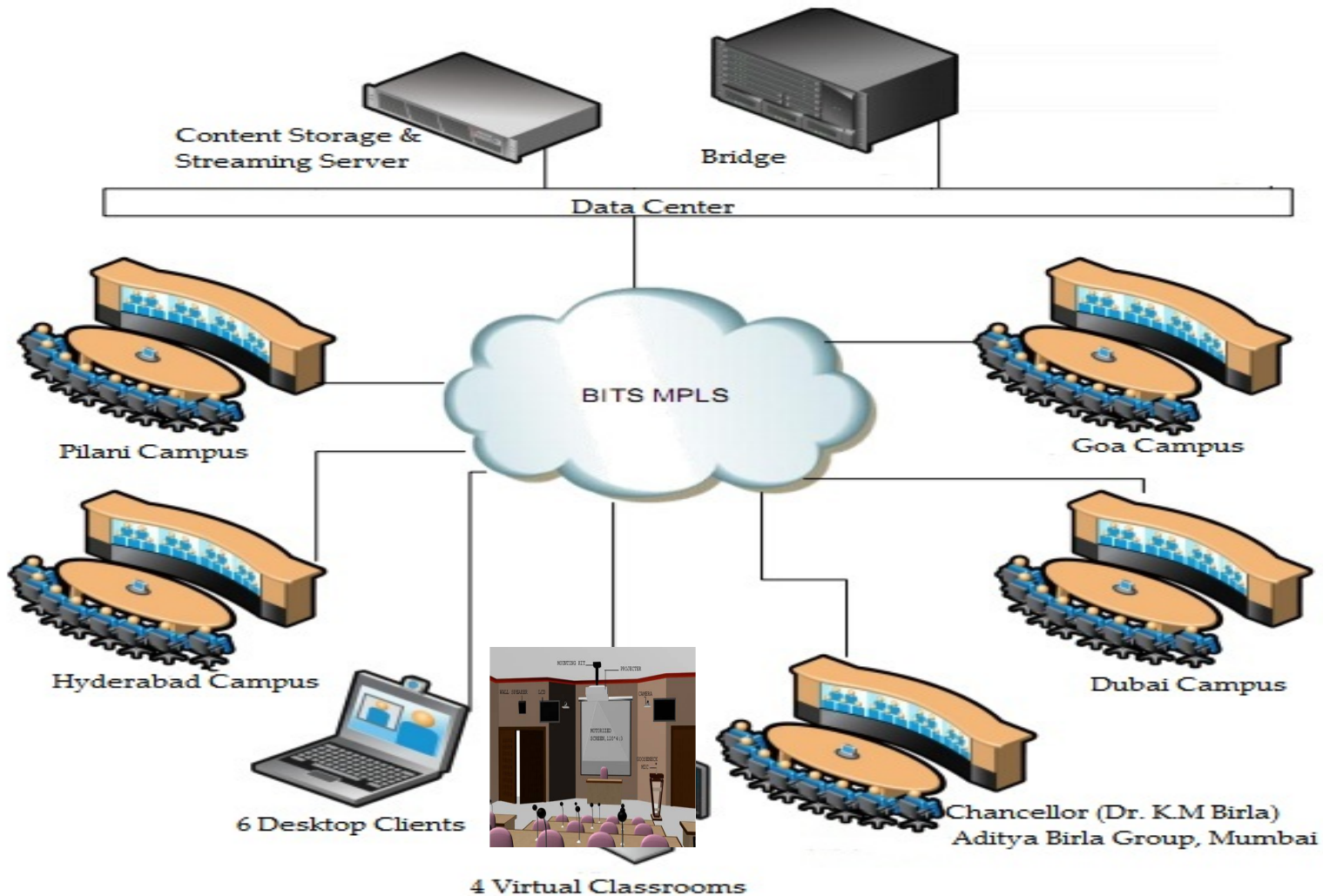


- For the Vice Chancellor, four Campus Directors, DD: desktop units



VC or Any Director in Any campus can talk to one-another right from their chambers.

Project BITS-Connect 2.0





Thank you for your kind attention!

BITS Pilani

Pilani | Dubai | Goa | Hyderabad

Rahul Banerjee