OF FRAMES, SHARED HUBS, BRIDGES AND L-2 SWITCHES

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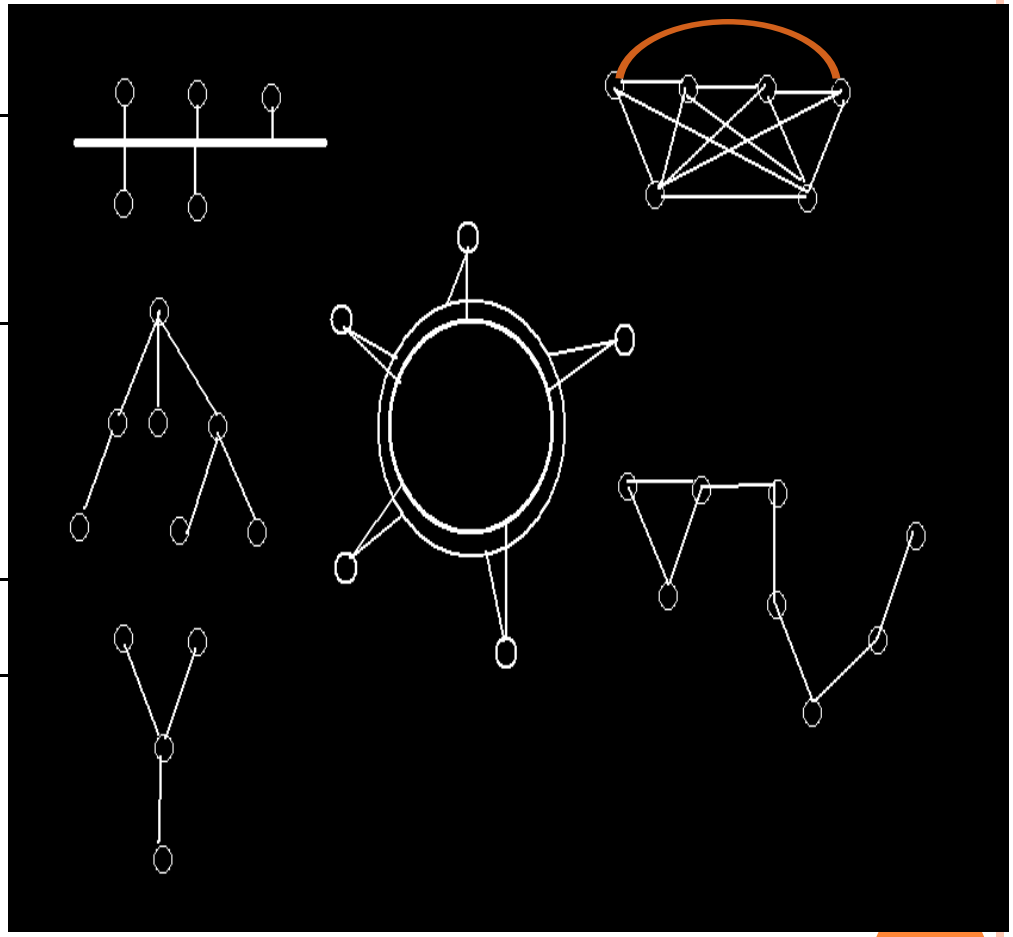
INTERACTION GOALS

- Introduction to the Building Blocks of Networks
- Understanding Frames
- Shared Hubs, Bridges, L-2 Switches
- Inside the Layer-2 Switches
- The IEEE 802.x standards
- Summary of the Concepts Learnt

NETWORK TOPOLOGIES REVISITED

- Bus Topology
  - Shared
  - Switched
- Tree Topology
- Ring Topology
  - Single
  - Double
- Star Topology
- Irregular Topology
- Complete Topology



NETWORK BUILDING BLOCKS

- Nodes: where processing and communication capabilities co-exist
- Physical Links: those entities that provide physical path (direct paths between neighboring 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
- Hosts: end / intermediate nodes where all levels / layers including those belonging to applications exist

NETWORK BUILDING BLOCKS

- Shared Hubs: where L1 and L2 layers / levels exist with ability to handle and deliver L2-protocol data unit (frame) over a shared medium
- Bridges: where L1 and L2 layers / levels exist with L2-protocol data unit (frame) processing and forwarding
- Switches: where L1 and L2 and / or L3 (sometimes even higher) layers / levels exist with L2 and / or L3-protocol data unit (frame / packet) processing, switched routing , forwarding

NETWORK BUILDING BLOCKS

- Repeaters: where L1 layer / level exist with L1-protocol data unit (raw bits) regeneration and onward transmission
- Gateways: where two or more different networks meet and may require protocol / message translation capabilities
- Routers: where L1, L2 and L3 layers / levels exist with L3-protocol data unit (packet) processing, routing and forwarding
- Clouds: abstraction of node connectivity in the networking context

DATA LINK LAYER REVISITED

- Data Link Layer consists of two sub-layers:
  - Media Access Control (MAC) sub-layer &
  - Logical Link Control (LLC) sub-layer.
- Major Issues involved in the design of the Data Link Layer include:
  - Which services are to be provided to each of the adjacent layers?
  - Exactly when to provide these services?
  - How to provide them?
  - To whom should they be provided?

CLASSES OF LAYER-2 PROTOCOLS

Basic Categories:

- Point to Point DLC Protocols
- Point to Multi-point DLC Protocols
- Half Duplex DLC Protocols
- Full Duplex DLC Protocols

… and many more!

LAYER-2 DATA UNITS: FRAMES

- Frame
  - The unit of Data as expressed at the Data Link Layer *(Layer-2 of the Hypothetical model used for instruction)* is conventionally called a Frame.
- Frames can take different formats and sizes depending upon the protocol in question
- Frames do include fields like synchronization, addressing, payload, control-information etc.

- Frame Forwarding
  - The process of moving frames from one port to another in a switching hub.

FRAMES: FACTORS THAT MATTER!

- Synchronization: Transmitter & Receiver need to be in sync
- Start Delimiter: Required to mark starting bit
- End Delimiter: Required to mark the end bit
- Control Information: Information suggesting data handling and interpretation
- Error Detection / Correction / Retransmission
- Flow Control: Required for avoiding data loss due to overflow at receiving end
- Data Length: Needed if data-field is not of fixed size

SOME MORE TERMS OF RELEVANCE

- Collision Domain
  - The set of all stations connected to a network where faithful detection of a collision can occur.
  - A collision domain terminates at a switch port.
- Late Collision
  - A failure of the network in which the collision indication arrives too late in the frame transmission to be automatically dealt with by the medium access control (MAC) Protocol.
  - The defective frame may not be detected by all stations requiring that the application layer detect and retransmit the lost frame, resulting in greatly reduced throughput.
- CRC
  - Cyclic Redundancy Check is an error-checking technique used to ensure the fidelity of received data.

ROUTING / FORWARDING / SWITCHING OF FRAMES

- Frame Routing and / or Forwarding: <Size: Fixed / Variable> *Bridge style*
  - Store-in-entirety first and forward later
  - All nodes on each side form their respective collision domains

- Frame Routing and / or Switching: <Size: Fixed / Variable> *Switch style*
  - Store header first and begin switching without waiting for payload's arrival
  - Uses no or smaller collision domains, where applicable

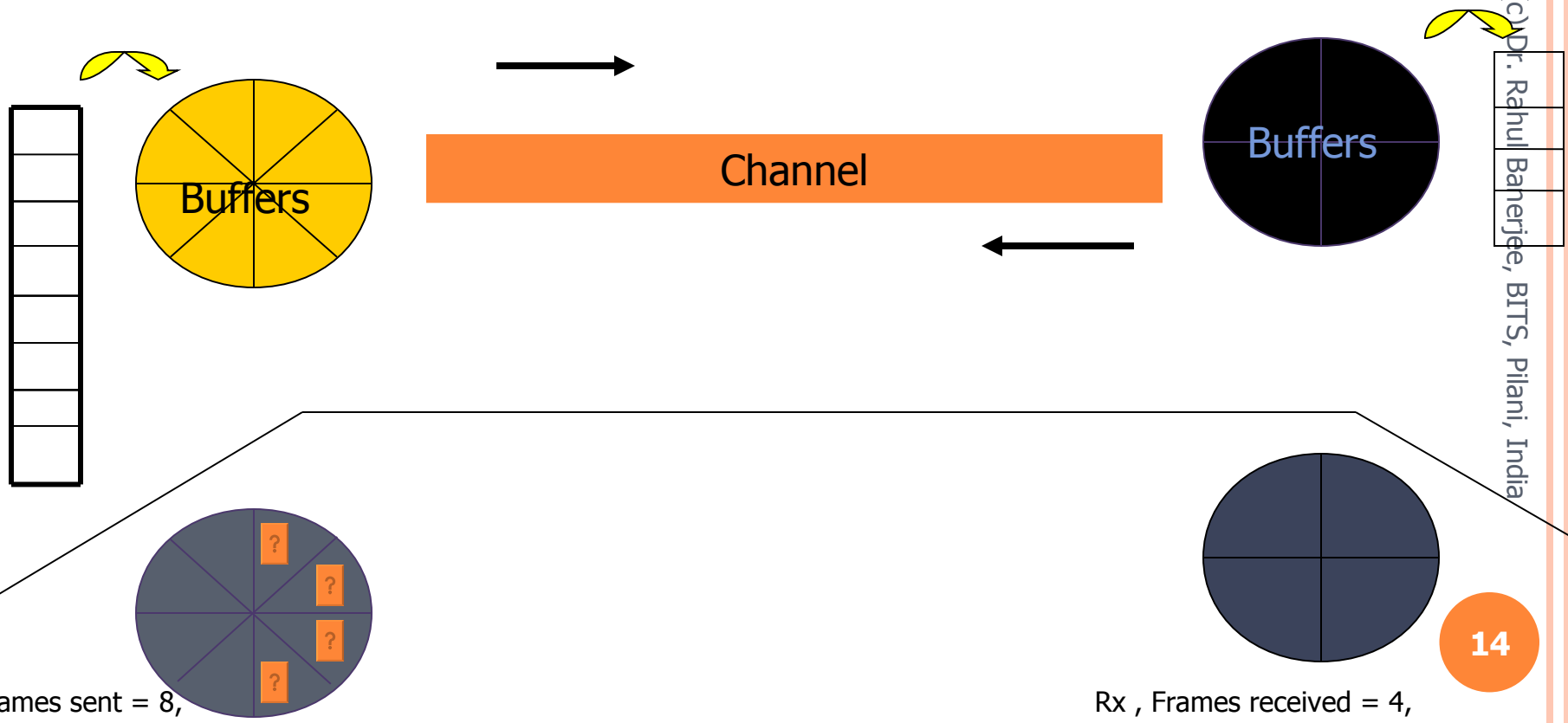
SWITCHING FABRIC, NETWORK PROCESSORS AND THE SEMANTIC GAP

- Switching Fabric
  - High-speed Physical mechanism that allows the backplanes to execute low-latency switching
- Channels
  - Process-to-Process abstraction / view
  - Request-Response abstraction / view
  - Message-Stream abstraction / view
- Network Processors
  - Specialized network nodes optimized for functions like switching / routing / forwarding / provisioning etc.
- Semantic Gap
  - Gap between services / functionalities / features expected by applications and the capabilities of the networking technology

DATA FRAMES, ACKNOWLEDGEMENT FRAMES AND BUFFERS: AN EXAMPLE

Frames Ready to be sent at Transmitter = 8

Frames Ready to be received at Receiver = 4



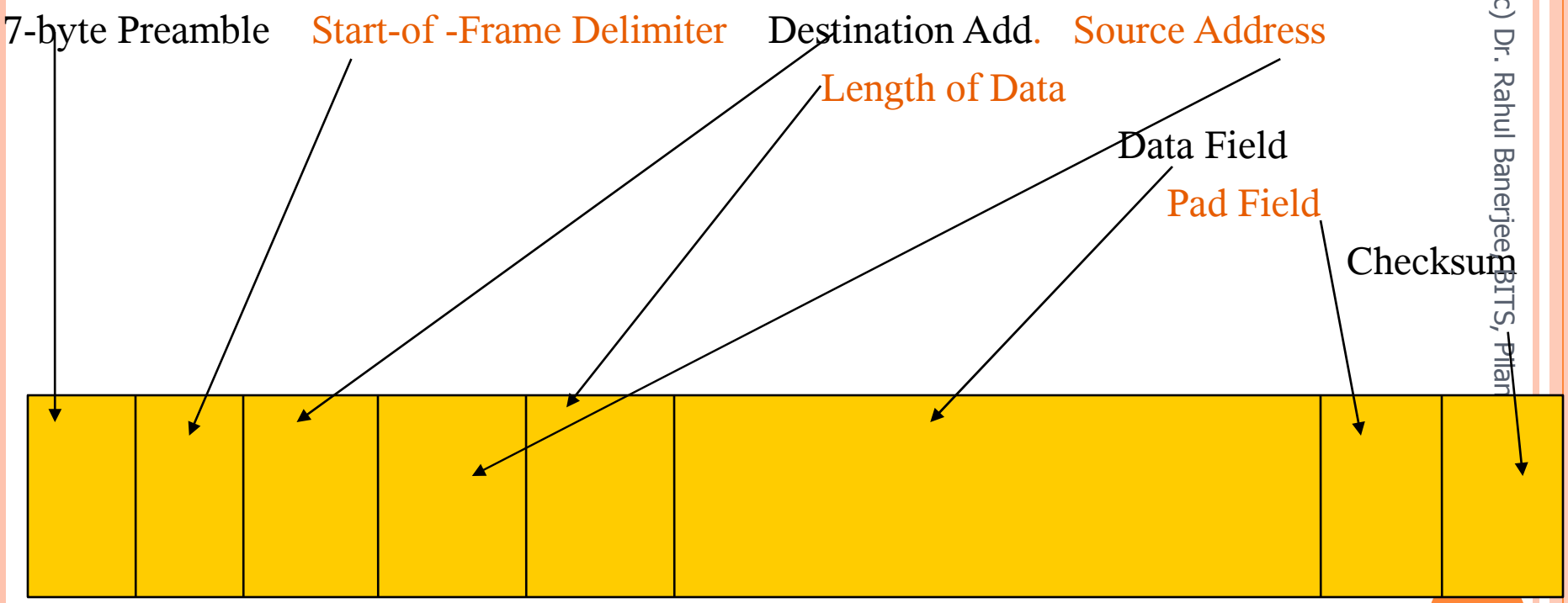
Frames sent = 8,

4 awaiting acknowledgement

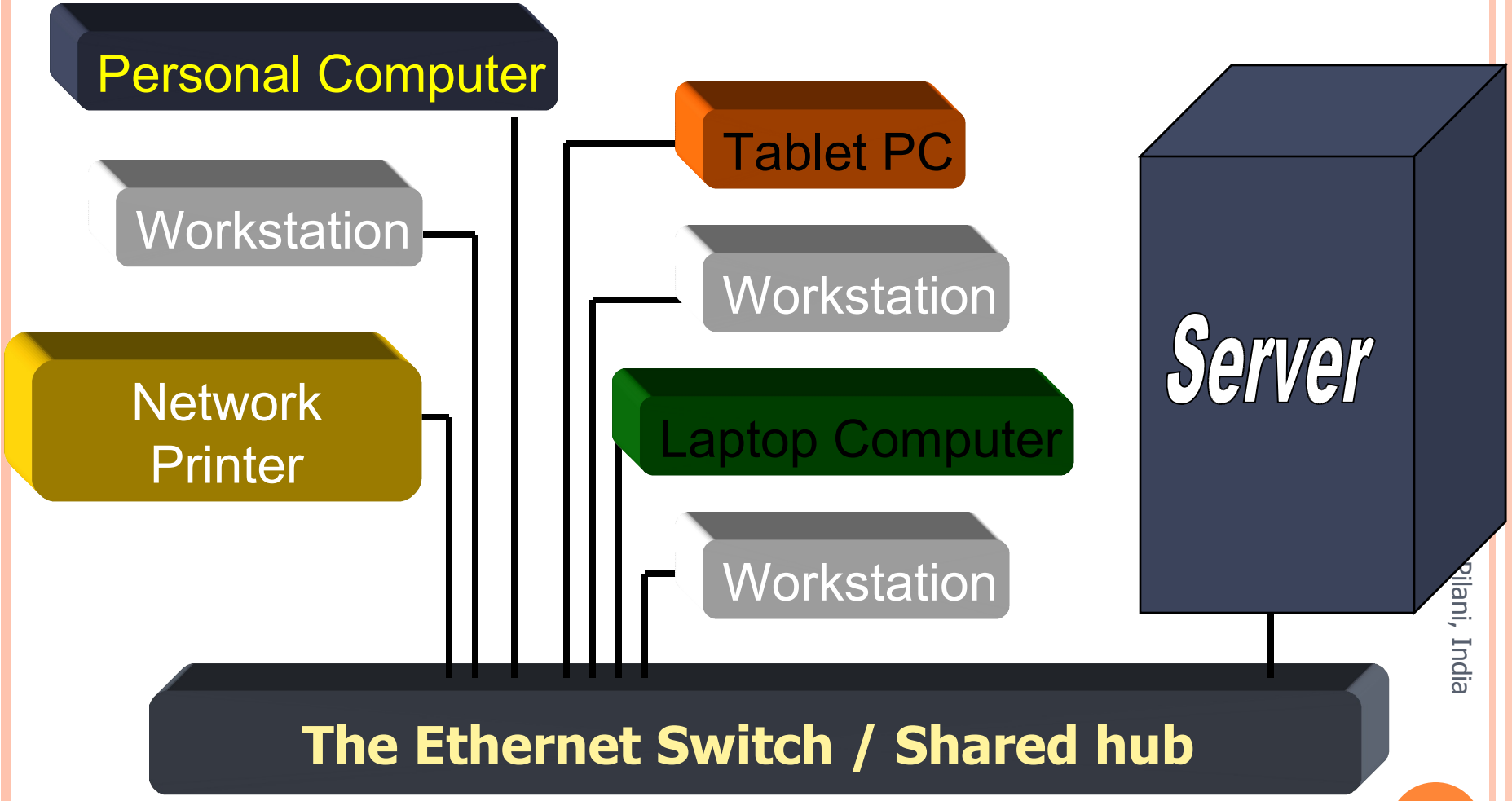
Rx , Frames received = 4,

Group ACKs yet to be sent

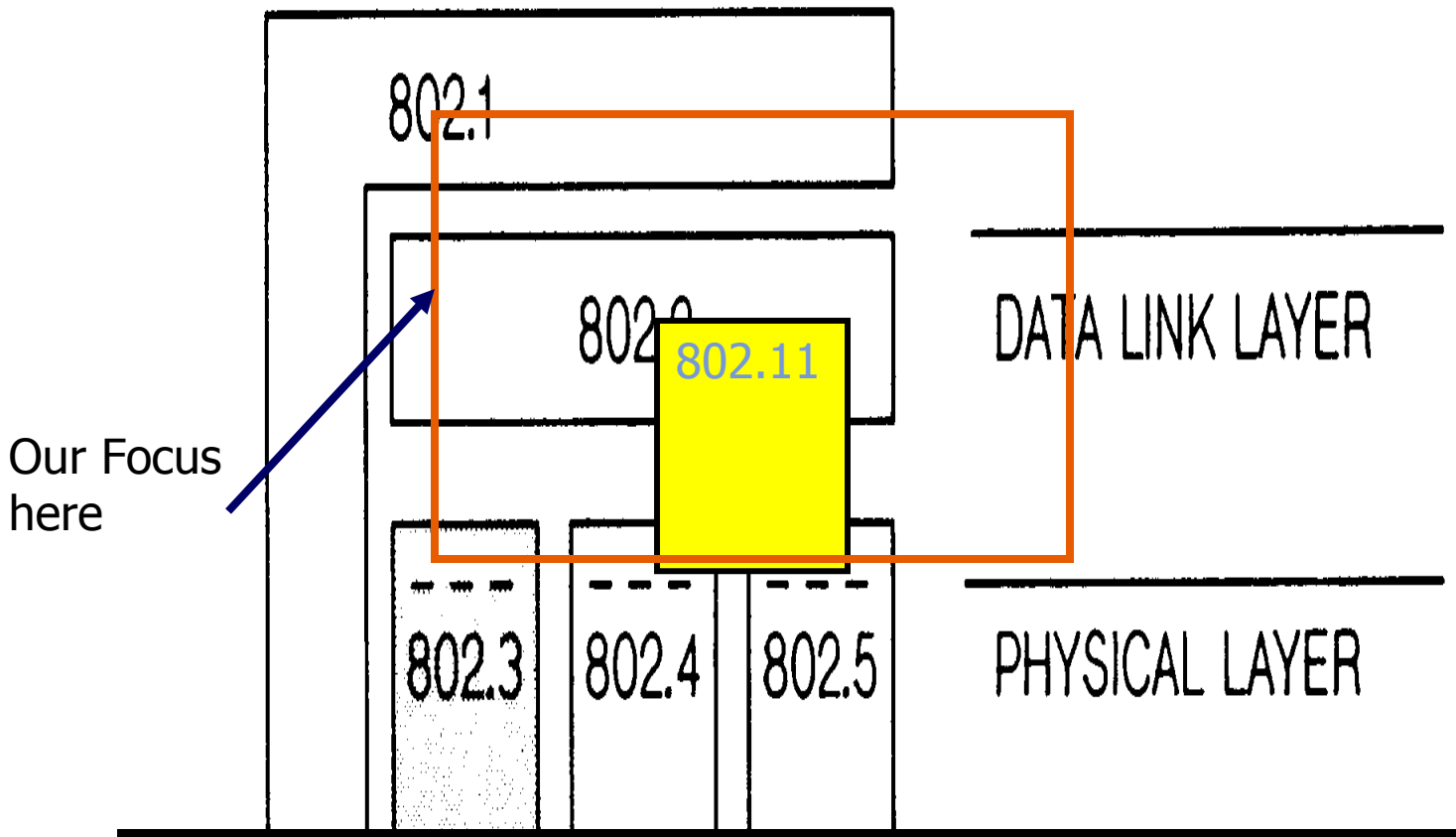
A SAMPLE FRAME FORMAT (IEEE 802.3)



AN ETHERNET LAN



THE IEEE 802.X ARCHITECTURE AND SPECIFICATIONS REVISITED



Based on IEEE documents with instructional modifications

THE IEEE 802 BRIDGES

- As discussed earlier, in case two networks differ at the DLL and lower levels, they can be connected by using a Bridge.
- Thus, theoretically, a *Bridge* is an *interconnection device* that has two layers (DLL and PL) and that can map two different DLL Frame formats onto each other (thereby providing support for *frame translation* on demand).
- Many of today's Switches also dual as Bridges.

THE IEEE 802 BRIDGES ...

- The IEEE 802 Bridges offer the basic functionality of the Bridges defined above; and, also extend it in some specific ways.
- Two basic types of Bridges are:
  - Half Bridges
  - Full Bridges
- Another classification of Bridges may look like:
  - Transparent Bridges
  - Source Routing Bridges

TRANSPARENT BRIDGES

- A Transparent Bridge is also known as a Spanning Tree Bridge or a Plug-and-Play Bridge.
- Design Goals of a Transparent Bridge:
  - No manual configuration should be required for using the bridge.
  - No hardware / software changes should ne necessary for operation.
  - There should be automatic detection, address-location and periodic review of the internetwork status.
  - Promiscuous Mode operation should be supported by default.

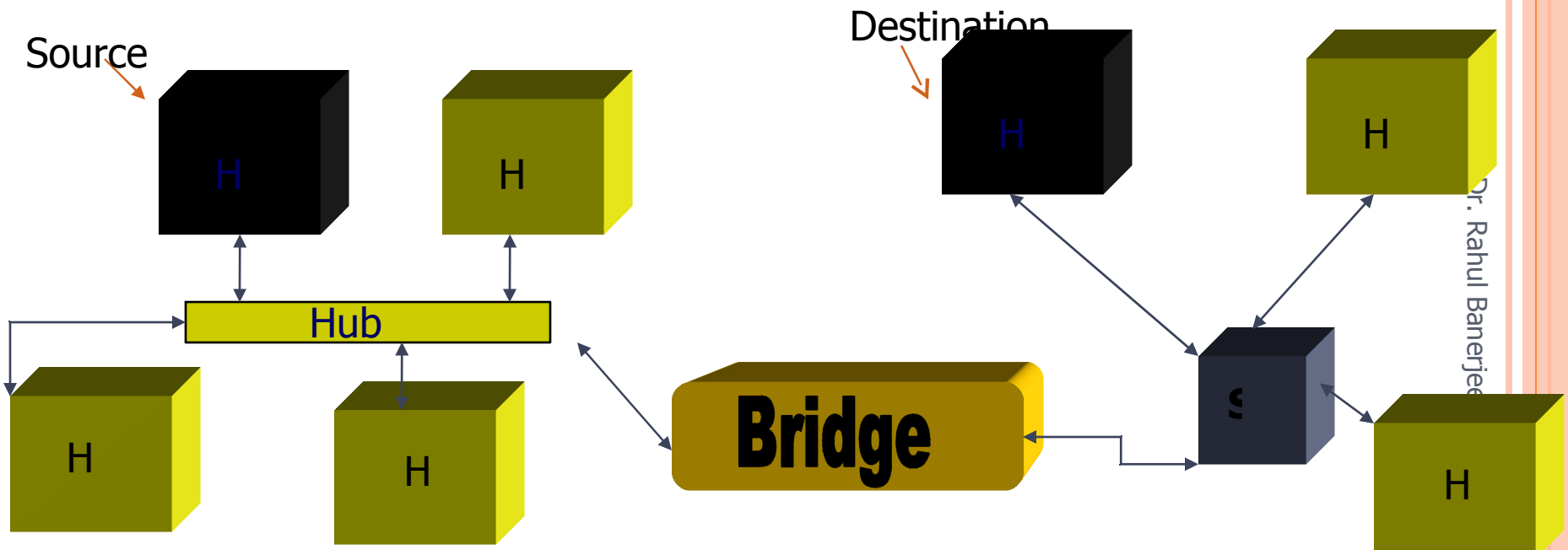
OPERATION OF THE TRANSPARENT BRIDGES

- A Transparent Bridge accepts all Frames that it receives from the attached networks.
- Frames destined for a station on same LAN from which they originate are immediately discarded by the bridge.
- Only those Frames which are destined to reach other LAN(s) are processed further for the purpose of Forwarding.
- The forwarding decision is based on the current status of the local hash table maintained by the bridge in question.
- This hash table is periodically refreshed by the bridge at preset regular intervals (in order to take into account any network node / switch etc. that might have come up or gone down in the mean time).

OPERATION OF THE TRANSPARENT BRIDGES …

- When the network first comes up, this table is empty. It is gradually filled in by means of exploration.
- The basic schemes that helps in building up this table at the start up and later update at said intervals are:
  - Flooding and
  - Backward Learning Algorithm
- Periodic flushing of the table contents may be 'selective purge' or 'purge-all' type.

OPERATION OF A BRIDGE WITH TWO LANS



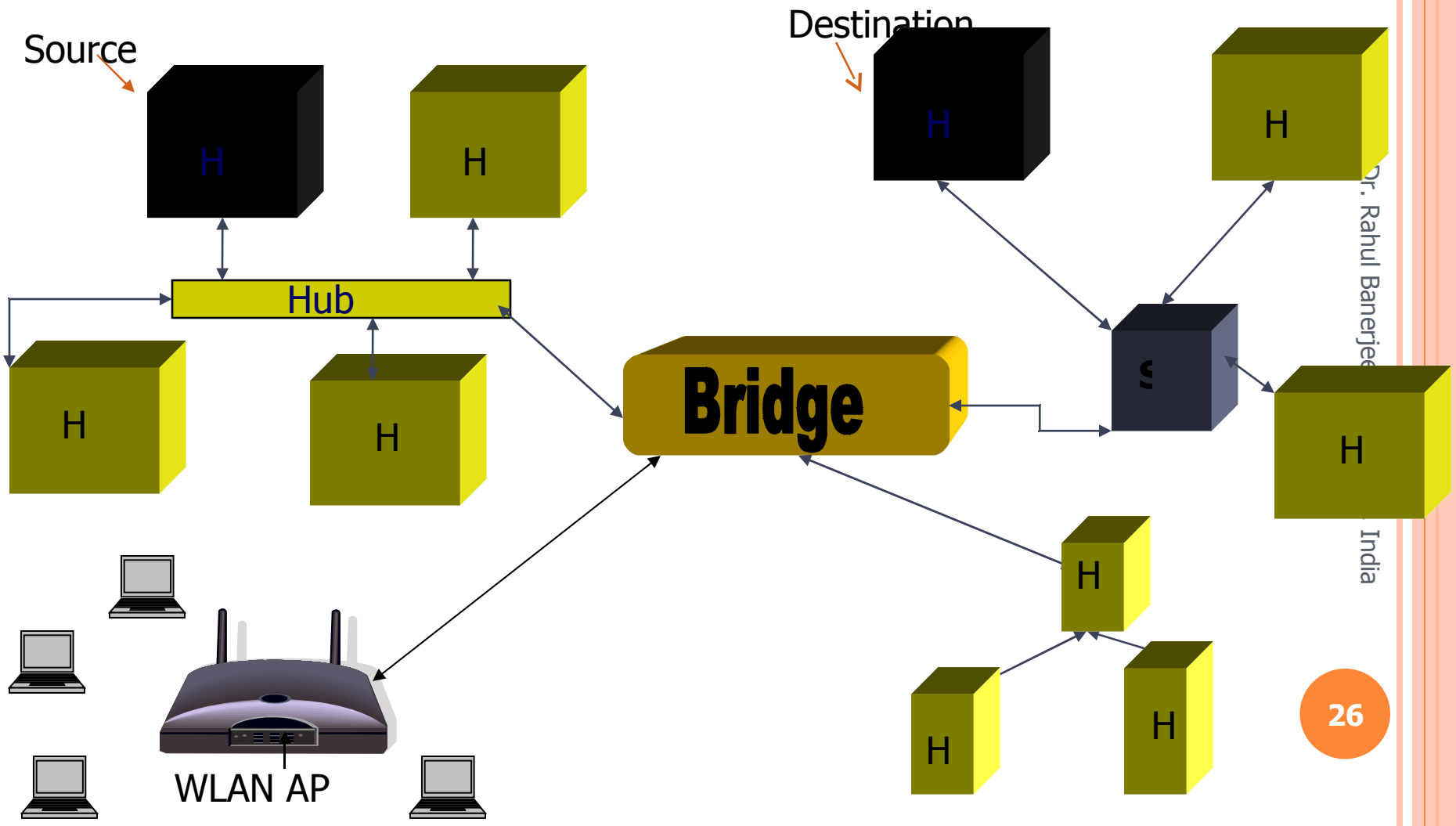
SOURCE ROUTING BRIDGES

- What is Source Routing?
  - It may be defined as a scheme of bridging two or more LANs in such a way that the bridge may perform the traditional job of format translation etc. while the onus of deciding a route between two nodes (Source and Destination nodes) and failure handling remains on the Hosts themselves.
  - Here, each Host is supposed to be aware of the fact that it is sending a message to another host on the same LAN or a different LAN.
  - In the latter case, the high order bit of the address is set to 1.
  - Also, routing details are provided in this case within the header itself.

SOURCE ROUTING BRIDGES …

- What is Source Routing …
  - Each bridge has a 4-bit Identification Number whereas each LAN has a 12-bit Identification Number.
  - Although, like the Transparent Bridges, even the Source Routing Bridges operate in promiscuous mode (by default), they simply discard any frame meant for a destination on the originating LAN.
  - This scheme requires the Hosts to discover location of Destination Hosts and routes leading to them. This is accomplished by broadcasting Discovery Frames.
- Such bridges can be implemented in terms of:
  - Hardware
  - Software
  - Partly in Hardware and partly in software

OPERATION OF A BRIDGE WITH FOUR LANS



INSIDE A SWITCH

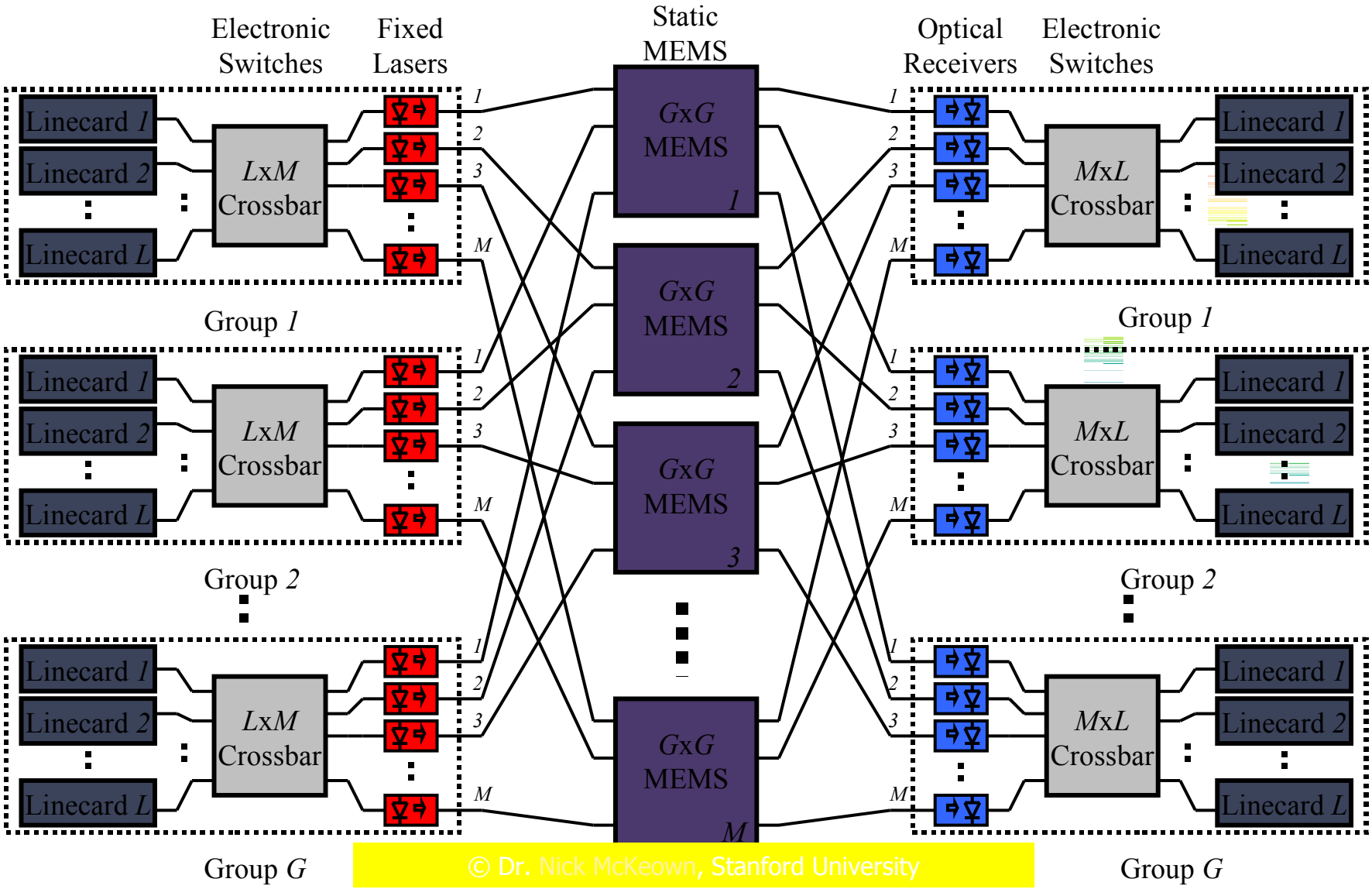
- Elements of a Layer-2 Switch
  - Processors (Front-end Processors on Line Cards) for Frame Routing
  - Multiple Buffers for Multiple Queues
  - Shared I/O Bus or Ring (1st / 2nd Gen.) / Switching Fabric (3rd Gen.)
  - I/P Line Controllers (ILC)
  - O/P Line Controllers (OLC)

INSIDE A SWITCH FABRIC

- A Switch Fabric is a set of switching elements and links capable of transferring a data unit from any input port to any output port.
- Types of a Layer-2 Switch Fabric
  - Crossbar Fabrics
  - Broadcast Fabrics
  - Switching Element based Fabrics
  - Banyan Fabrics
  - Sorting & Merging Fabrics
  - Batcher-Banyan Fabrics

  And, other types are emerging …

An Example of a Hybrid Switching Fabric



SOME COMMON LAYER-2 SWITCHES

Cisco L2 Managed Switches

SOME COMMON LAYER-2 SWITCHES

D-Link

SOME COMMON LAYER-2 SWITCHES

SOME MORE COMMON SWITCHES

Cisco Catalyst 3750 Series
Switches

CISCO CATALYST 4500 SERIES OF SWITCHES

Cisco Catalyst 4500 Series Switches

(Used in several places in the Institute as Distribution Switches)

CISCO CATALYST 6500 SERIES OF SWITCHES

Cisco Catalyst 6500 Series Switches

(One of these is OUR Core Switch located in the IPC System Room)

INSIDE THE CISCO 6500 SWITCH (OUR CORE SWITCH LOCATED AT THE IPC SYSTEM ROOM)

- Cisco Catalyst 6500 Series Switch offers:
  - high availability
  - integrated security
  - support for converged applications
  - excellent operational efficiency
  - Scalability
  - investment protection for medium-sized business

INSIDE CISCO 6500 SWITCH

- Support for Converged Applications:
  - embedded real-time monitoring of VoIP call quality;
  - the Cisco Communication Media Module, which allows to connect TDM and analog devices to the IP network
  - a wireless LAN services module to simplify deployment and management of WLAN infrastructure
  - an Application-Oriented Networking (AON) Module to provide message-level routing, visibility, and security.
  - Additional converged applications support includes high-density 802.3af Power over Ethernet with intelligent power management, advanced IP multicast, and Quality of Service features.

INSIDE CISCO 6500 SWITCH

- Excellent Operational Efficiency:
  - The Catalyst 6500 Series with Cisco IOS Software Modula simplifies software changes and enables process-level policy control
  - Embedded Event Manager (EEM) allows you to create automated policies to ease management
  - Encapsulated Remote SPAN (ERSPAN) enables centralized analysis of remote traffic across L3 boundaries
  - network virtualization features such as MPLS, VRF-lite, and firewall virtualization provide efficient network segmentation.

INSIDE CISCO 6500 SWITCH

- Scalability and Flexibility:
  - The Catalyst 6500 Series currently supports up to 288 Class 3 (15.4W) Power over Ethernet (PoE) devices
  - up to 1152 10/100-Mbps, 576 10/100/1000-Mbps, or
  - 32 10-Gbps Ethernet ports in a single chassis, and
  - system scalability up to 720 Gbps, providing 40 Gbps/slot (half-duplex)
  - Additional choices include 3, 4, 6, 9, and 13-slot chassis options and several WAN interface module options.

INSIDE CISCO 6500 SWITCH

- Long-Term Investment Protection:
  - It offers several daughter-card options for incremental upgrades and backward compatibility to support multiple generations of interface modules.

INSIDE CISCO 6500 SWITCH

High Availability:

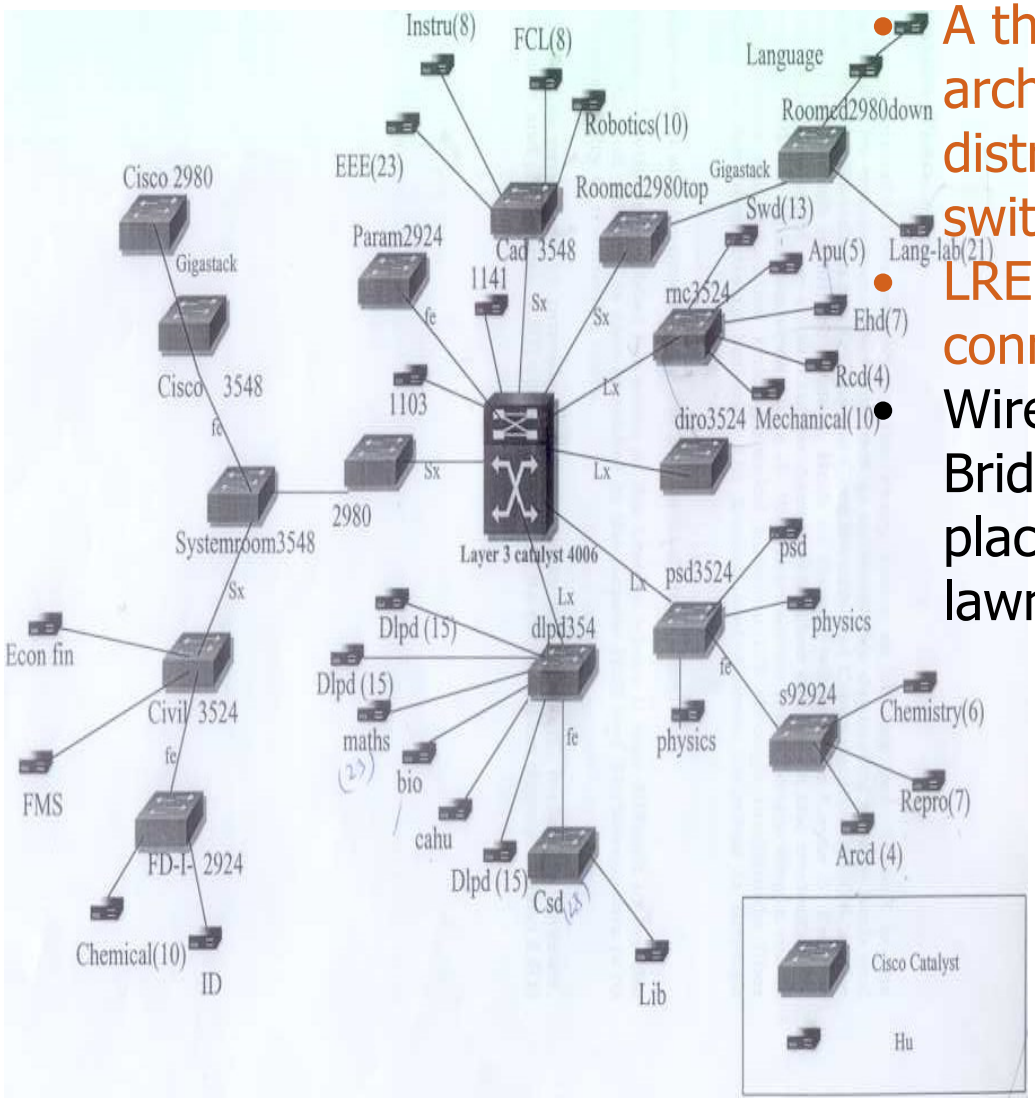
- The Catalyst 6500 Series with Cisco IOS Software Modularity enables subsystem In-Service Software Upgrades (ISSU) and stateful process restarts
- Generic Online Diagnostics (GOLD) proactively detect hardware and software faults
- Non-Stop Forwarding and Stateful SwitchOver (NSF/SSO) delivers application and service continuity
- redundant system components provide hardware-level resiliency

INSIDE CISCO 6500 SWITCH

Integrated Security:

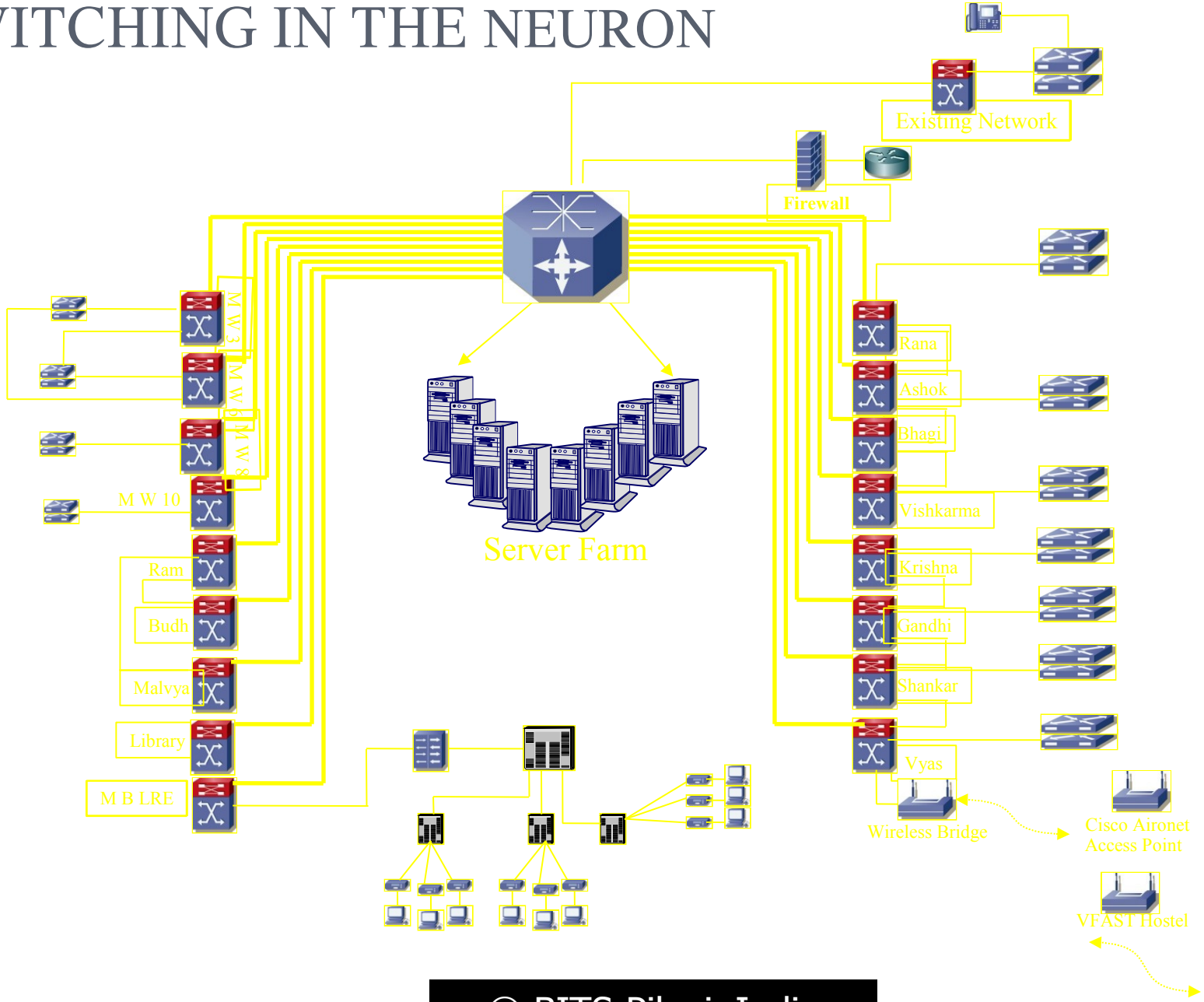
- These switches include:
  - multiple Denial-of-service (DoS) attack mitigation mechanisms
  - integrated security service modules for high-performance threat protection and secure connectivity
  - Man-in-the-middle attack mitigation innovations to protect against IP phone call eavesdropping
  - Identity-Based Networking Services (IBNS) to control network access.

SWITCHED / BRIDGES VIEW OF THE BITS NETWORK

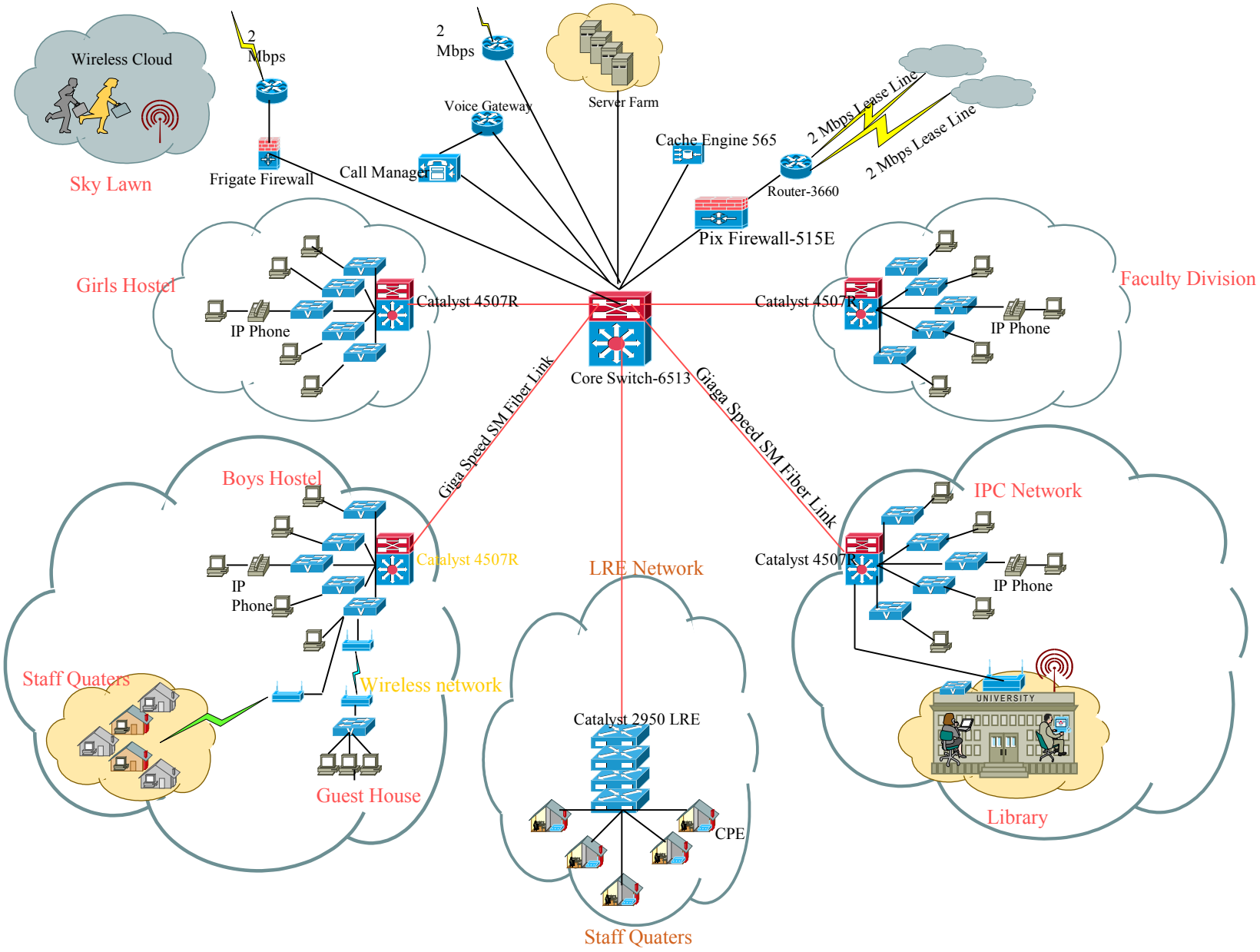


- A three-tier network architecture (Using core, distribution and access switches)
- LRE (Long Range Ethernet) connectivity for Staff Quarters
- Wireless Access Points and Bridges (IEEE 802.11b) in many places (library, NCC area, Sky lawns etc.)

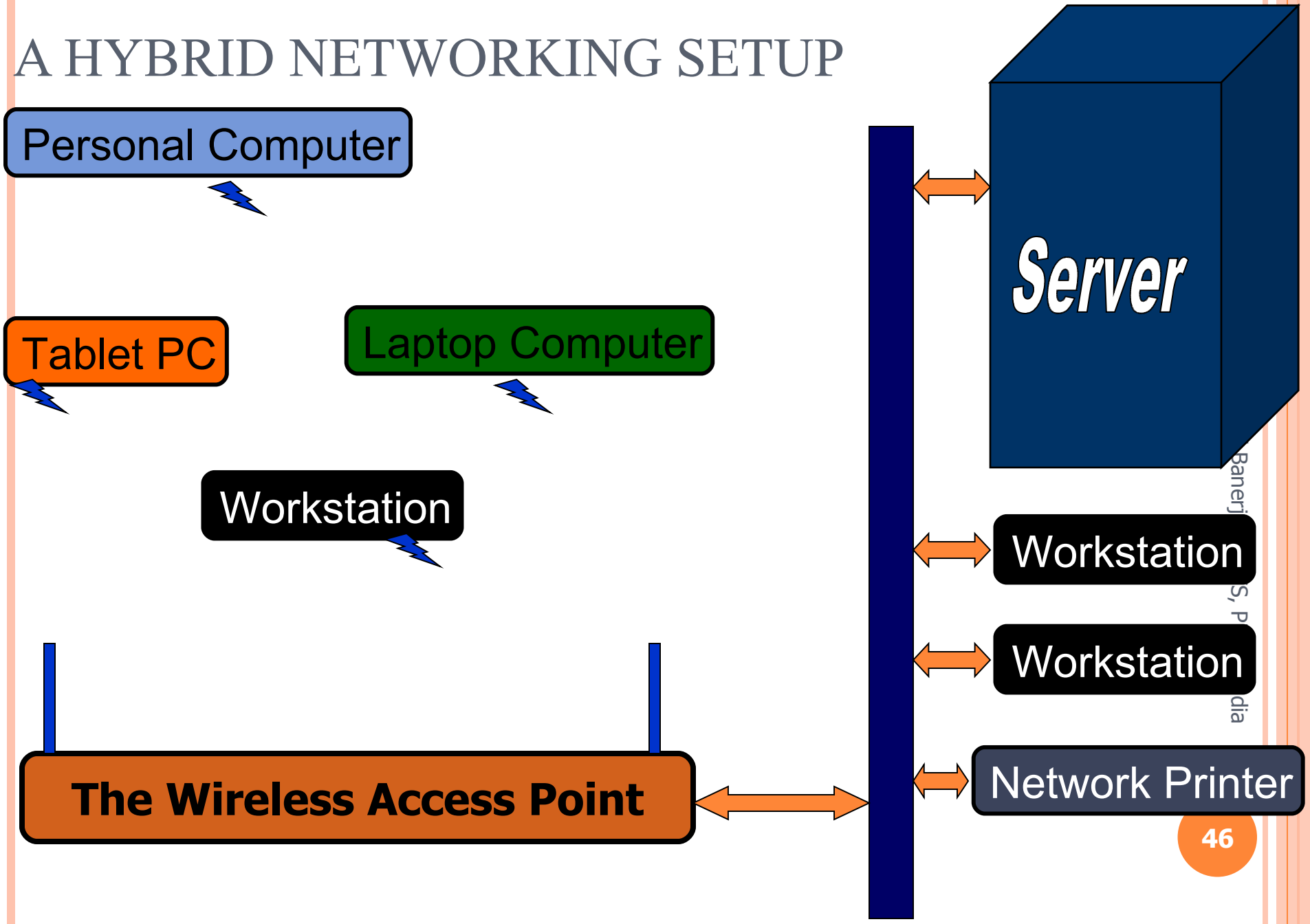
SWITCHING IN THE NEURON



Another view



A HYBRID NETWORKING SETUP



HOW DO THE SOURCE ROUTING BRIDGES COMPARE TO THE TRANSPARENT BRIDGES?

Bridges may be compared with respect to:

- Transparency
- Location of Complexity
- Configurability
- Connection-orientation
- Routing
- Location Discovery
- Failure Handling
- Optimality

UNIT SUMMARY

- Bridges provide connectivity and where required protocol translation at Layer-2.
- Wireless LANs can be quickly set up.
- WLANs may not suffice for high-speed operations.
- Not all situations favour a wireless network
- There do exist certain difference between theory and practice in wireless networking that need attention.
- Bridges provide connectivity and where required protocol translation at Layer-2.

UNIT SUMMARY

- Packet Switching is more cost effective than Circuit Switching primarily since the latter allows resource monopolization and therefore charges users time-wise and distance-wise instead of charging them according to actual traffic and its quality.
- While the term ‘cloud’ roughly abstracts ‘networked / connected nodes’; the term ‘channel’ abstracts ‘protocol-level functionalities / application-specific services’.
- Networks, like many others, need to scale to be cost-effective.
- The term ‘Semantic Gap’ refers to the perceived gap between the application’s / user’s expectancy and the network technology’s capability.

REFERENCES 1 OF 4

- *Larry L. Peterson & Bruce S. Davie*: Computer Networks: A Systems Approach, Fourth Edition, Morgan Kaufmann / Elsevier, New Delhi, 2007. <*System design approach*>
- *A. S. Tanenbaum:* Computer Networks, Fourth Edition, Pearson Education, New Delhi, 2003. <*Conceptual Approach*>
- *Mohaamed G. Gouda:* Elements of Network Protocol Design, Wiley Student Edition, John Wiley & Sons (Pte.) Ltd., Singapore, 2004.

REFERENCES 2 OF 3

- *Thomas G. Robertazzi:* Computer Networks and Systems: Queuing Theory and Performance Evaluation, Third Edition, Springer-Verlag, New York, 2000. <*Analytical approach*>
- *S. Keshav:* Computer Networking: An Engineering Approach, Pearson Education, New Delhi, 1997.

REFERENCES 3 OF 3

- *A. Leon Garcia and I. Widjaja:* Communication Networks: Fundamental Concepts and Key Architectures, Second Edition, Tata McGraw-Hill, New Delhi, 2004.
- *Y. Zheng and S. Akhtar:* Networks for Computer Scientists and Engineers, Oxford University Press, New York, 2002. <*Structural approach*>

ANY QUESTIONS PLEASE?

Thank you!