Computer Networks

-An Introduction

Lecture-3

January 12, 2011

Rahul Banerjee, *PhD (CSE)*
Professor
Department of Computer Science
Birla Institute of Technology & Science, Pilani, INDIA
Email: rahul@bits-pilani.ac.in / Rahul.Banerjee.CSE@gmail.com
Home Page: http://www.bits-pilani.ac.in/~rahul/

Interaction Points

- What is the Internet today?
- Architecture of the current Internet
- Introduction to Internetworks
- Classes / types Internetworks
- Select References to the literature
- Summary

What 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.

Introducing Some Terms Related to Networks

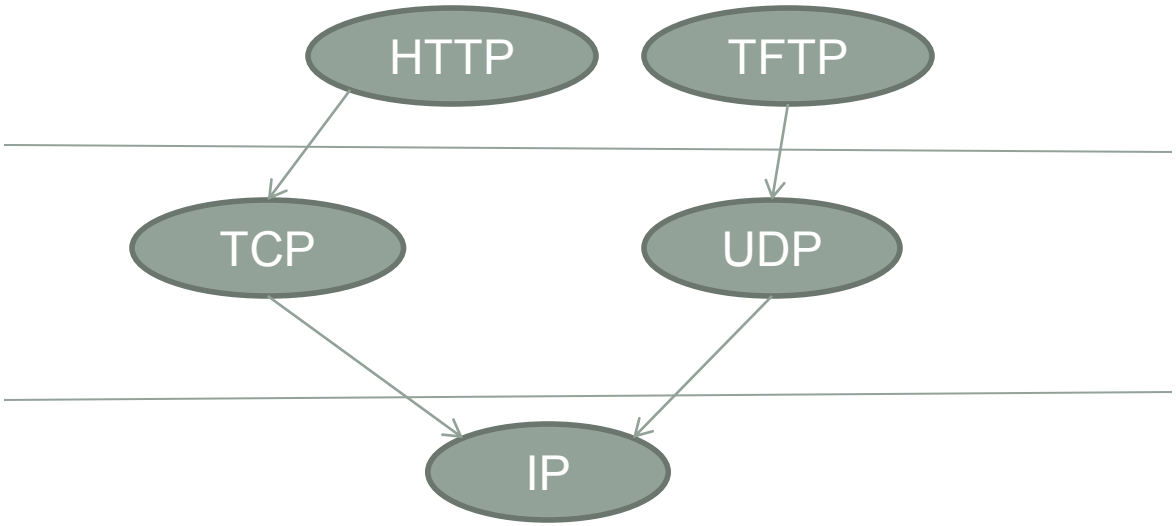
- Channel <application-level logical / virtual communication path>
- Services: Functionalities provided by a layer / protocol / entity
- Interfaces: Peer-to-Peer / Layer-to-Layer / entity-to-entity
- Service Access Points: defined addresses / ports through which data / parameters are passed
- Tunneling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

What do we mean by a Network Protocol?

- Perspective-1:
  - A Network Protocol is a set of rules and conventions leading to a set of pre-defined requests / commands and responses for any meaningful communication / exchange of control / information / both
- Perspective-2:
  - A Network Protocol may also be viewed as abstract interfaces in terms of operations associated with an interface definition in the context of one or more services on offer along with the set of parameters, form, format, message types, meanings associated with the messages and even mechanism of handling select kinds of possible failures.
- Perspective-3:
  - A Network Protocol may be seen as a pair of modules implementing the interfaces between two layers or peers

Protocol Graphs

- A graph showing interrelation of various collaborating protocols at different levels is called a Protocol Graph.
- In a protocol graph, each protocol is represented as a node.



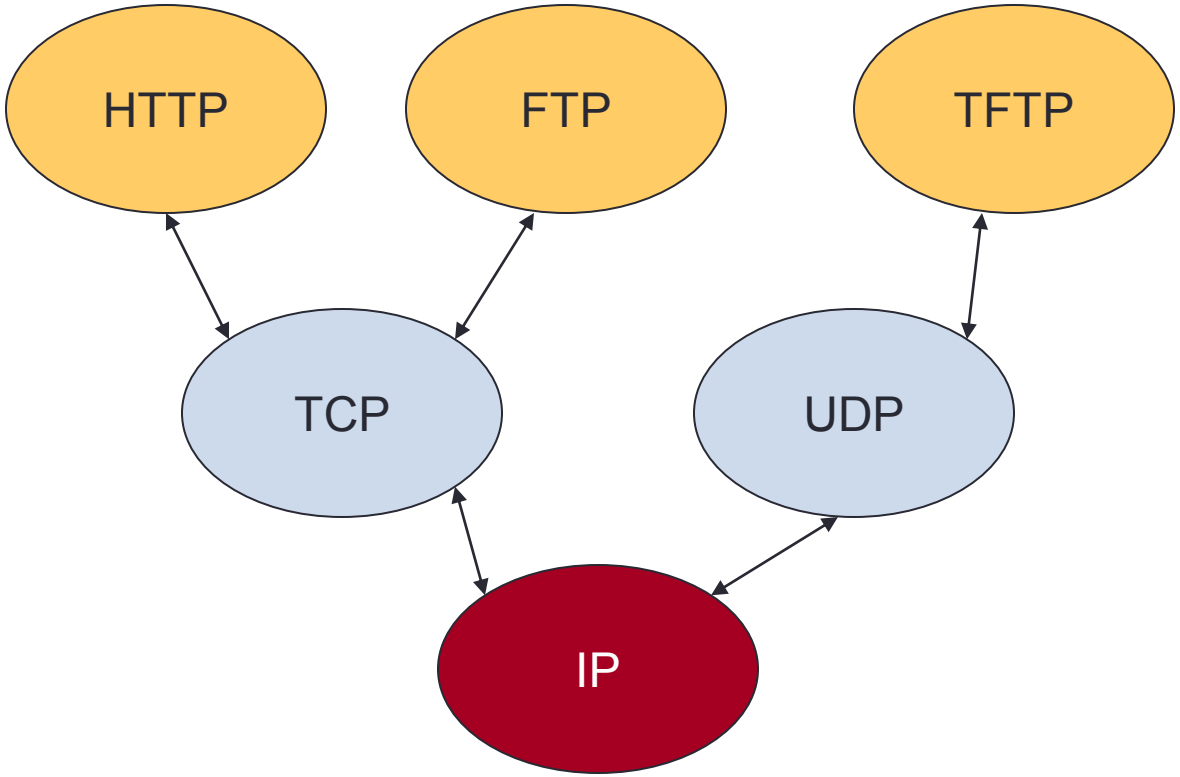
Protocol Representation

- There exist numerous schemes of representation of a given Protocol.
- One common way to specify a Protocol is to represent it as a State Transition Diagram.

Protocol Validation

- A Protocol needs to be proven correct before it is implemented.
- There exist quite a few ways of formal and semi-formal verification of Protocols.
- One common technique is to first represent a protocol a State Transition Diagram and then examine it for its ‘completeness’, ‘reachability’ and / or points of weakness etc.

xample of a Simple Protocol Graph as applicable to the Internet



An Example Protocol

- Let's take one of the simplest situations in which there exist two network nodes N1 and N2 interconnected through a bi-directional communication link.

- Let's assume that that it is required that primarily N1 would be sending the data to N2 using a simple mechanism over this link and only one unit of data (frame) would travel at a time over the link.

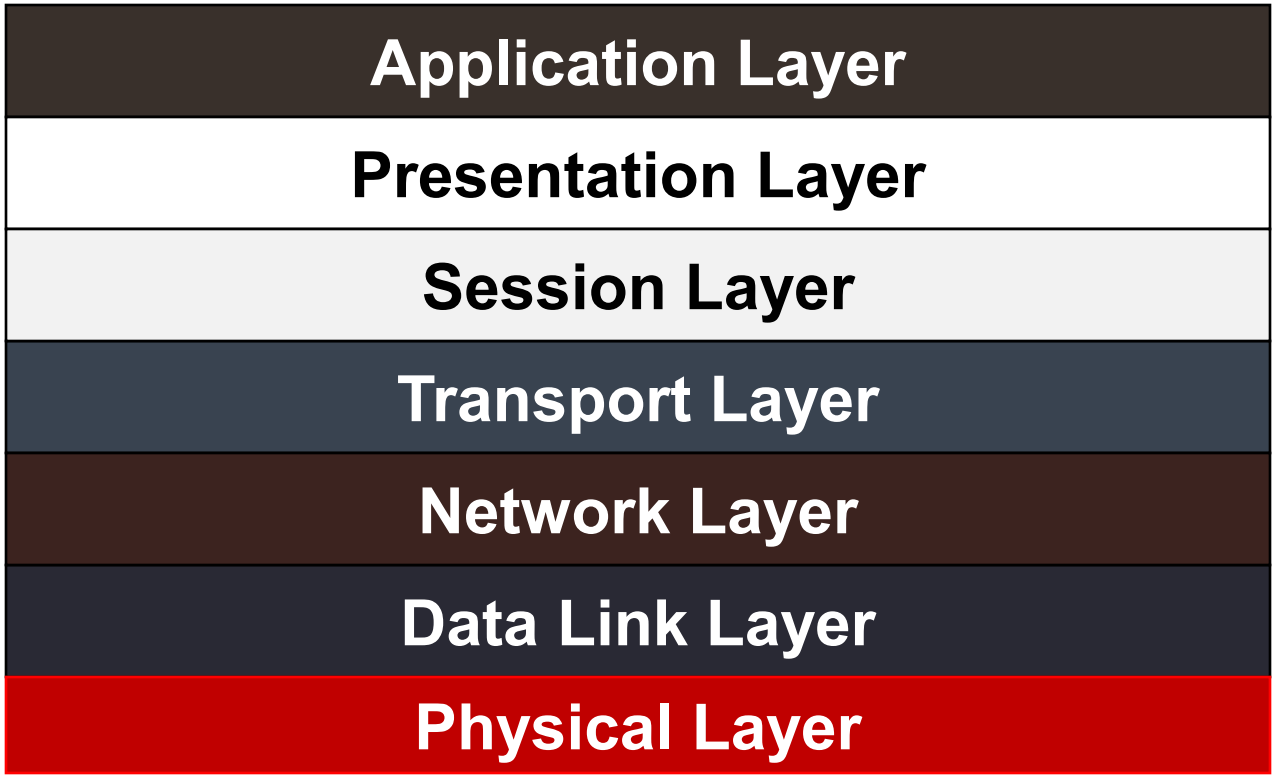
A Few Measures of Network Performance

- *Performance Measures*
  - *Available Performance*
  - *Measured Performance*
- *Bandwidth:*
  - *Width of the usable / allotted Frequency band*
  - *Rate of data transfer in bits per second*
    - *Throughput: Actual measured rate of achievable data transfer in bits per second*
    - *Bandwidth has often a value greater than that of the Throughput*
- *Round-Trip Time (RTT)*
- *Latency: Delays of various kinds*
- *'Delay x Bandwidth' metric*
- *Quality of Service*

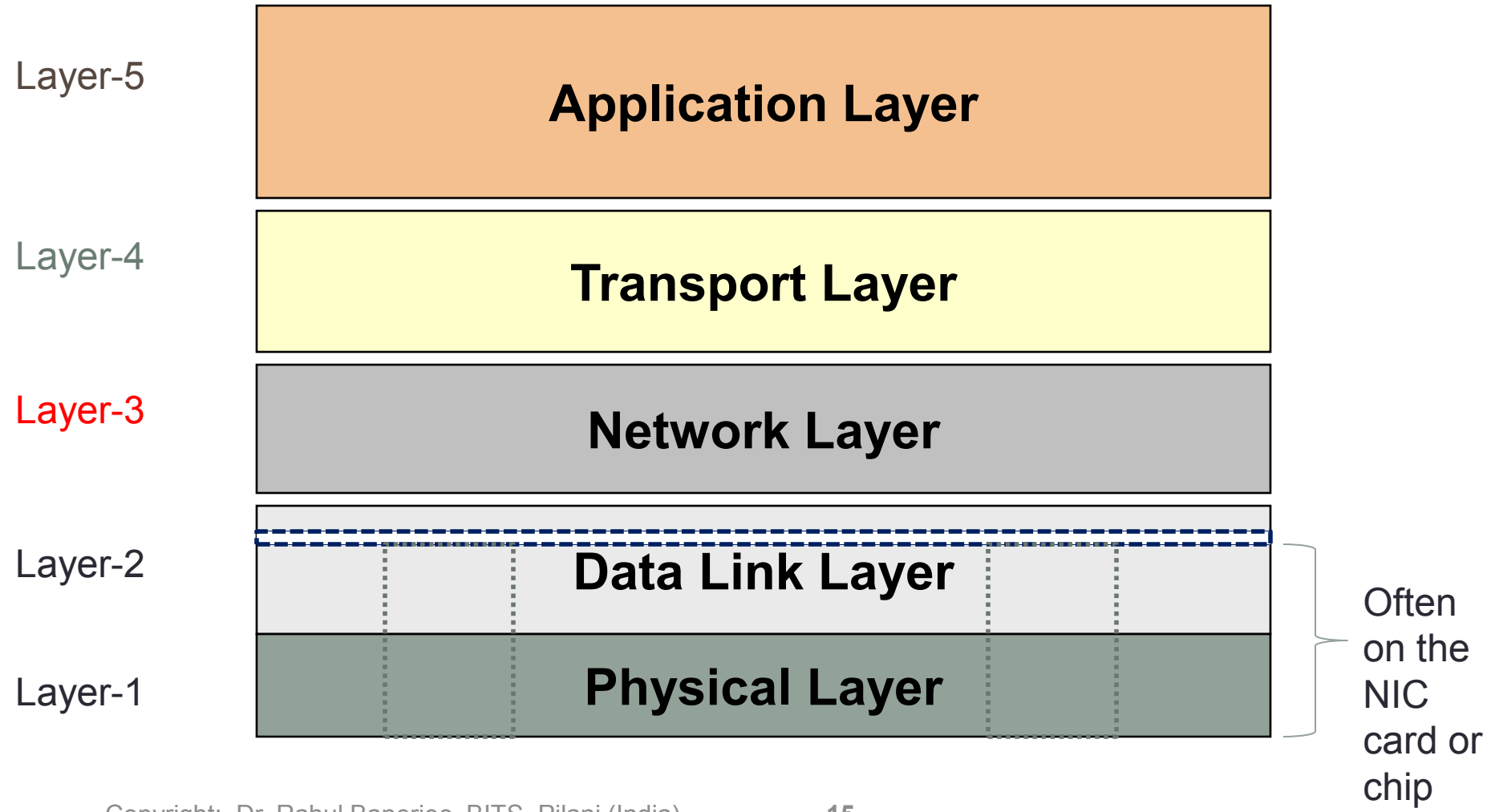
Network Architecture & Reference Models

- Architecture versus Reference Model: A simplistic perspective:
  - Network Architecture:
    - It may be seen as a detailed *generic blueprint* with unambiguous definitions of *services*, *interfaces*, *organization* and defined *protocols* that helps in design and implementation of a set of relevant protocol stack / suite based network / internetwork
  - Network Reference Model:
    - It is the same as the architecture minus the specifically defined readily usable protocols.
- Examples:
  - TCP/IP Architecture
  - OSI Reference Model & OSI Architecture

The ISO OSI Reference Model



A Hypothetical Network Reference Model for Easy Conceptual Understanding



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 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

Any question please?

Thank you for your kind attention!

For further details, you may contact at:

E-mail: rahul@bits-pilani.ac.in / rahul.banerjee.cse@gmail.com

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

amples 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*

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