

Information Security 3
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Module 59
Review - 1

So in this module we will actually do a quick review of the different network concepts that we had discussed so that it will actually act as a summary of the different concepts that are very critical for us to remember in going forward and learning more about them, so we started originally with a definition of the internet in terms of like what are the different components of the internet like defining the end systems, defining what is a network application. We talked about that the communication links that really connect my network application running host with my end systems like a server and then we talked and defined about

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What's the Internet: "nuts and bolts" view

- millions of connected computing devices: *hosts = end systems*
- running *network apps*
- *communication links*
 - ❖ fiber, copper, radio, satellite
 - ❖ transmission rate = *bandwidth*
- *routers*: forward packets (chunks of data)

(C): James F. Kurose and Keith W. Ross

Things like bandwidth right, So then we had a look at what exactly is a protocol, we defined a protocol as means of communication that is usually used between two different devices in my network topology right,

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What's the Internet: a service view

- **communication infrastructure** enables distributed applications:
 - ❖ Web, email, games, e-commerce, file sharing
- **communication services** provided to apps:
 - ❖ Connectionless unreliable
 - ❖ connection-oriented reliable

(C): James F. Kurose and Keith W. Ross

The diagram shows a network of routers and hosts. A dashed line separates the network into two parts: the top part represents communication infrastructure (routers and hosts), and the bottom part represents communication services (hosts and routers).

Then we defined network form the point of view of service where we talked about a connection oriented service.

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A closer look at network structure:

- **network edge:** applications and hosts
- **network core:**
 - ❖ routers
 - ❖ network of networks
- **access networks, physical media:** communication links

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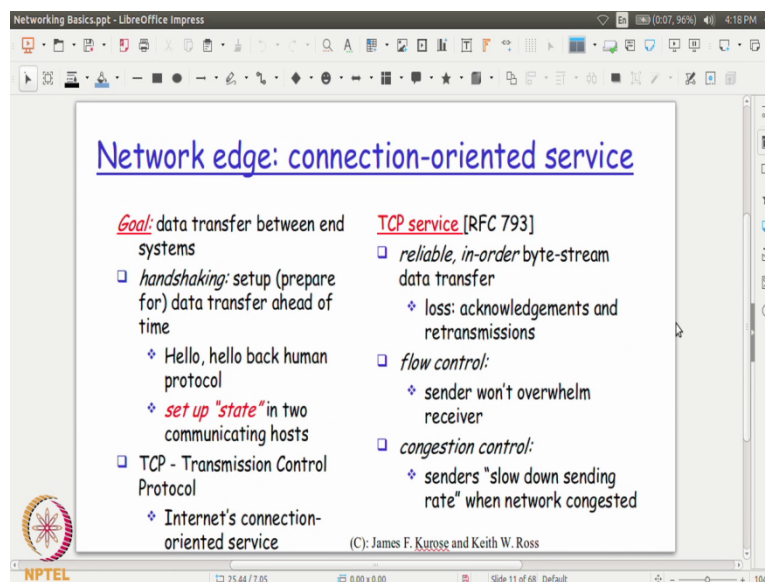
The diagram shows a network of routers and hosts. A dashed line separates the network into two parts: the top part represents network edge (applications and hosts), and the bottom part represents network core (routers and network of networks).

And a connectionless service, A connection oriented Service basically we mentioned about establishment of a connection between the two end systems where is in a connectionless service we talked about the data getting exchanged without going into the over heads of a connection

establishment right, then we had a look at the network edge and the network core wherein we defined a network topology a network edge we talked about how it is constituted by my applications.

Which are running as part of my client systems or my server systems and then we also defined a client and a server in this concept, whereas a network core was basically the devices, a set of devices that are basically part of the heart of my network right, so like the routers, the switches and the different kinds of devices,

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The image shows a screenshot of a presentation slide titled "Network edge: connection-oriented service". The slide is displayed in a LibreOffice Impress window. The slide content is as follows:

- Goal:** data transfer between end systems
- handshaking:** setup (prepare for) data transfer ahead of time
 - ❖ Hello, hello back human protocol
 - ❖ **set up "state"** in two communicating hosts
- TCP - Transmission Control Protocol**
 - ❖ Internet's connection-oriented service
- TCP service [RFC 793]**
 - ❖ **reliable, in-order** byte-stream data transfer
 - ❖ loss: acknowledgements and retransmissions
 - ❖ **flow control:**
 - ❖ sender won't overwhelm receiver
 - ❖ **congestion control:**
 - ❖ senders "slow down sending rate" when network congested

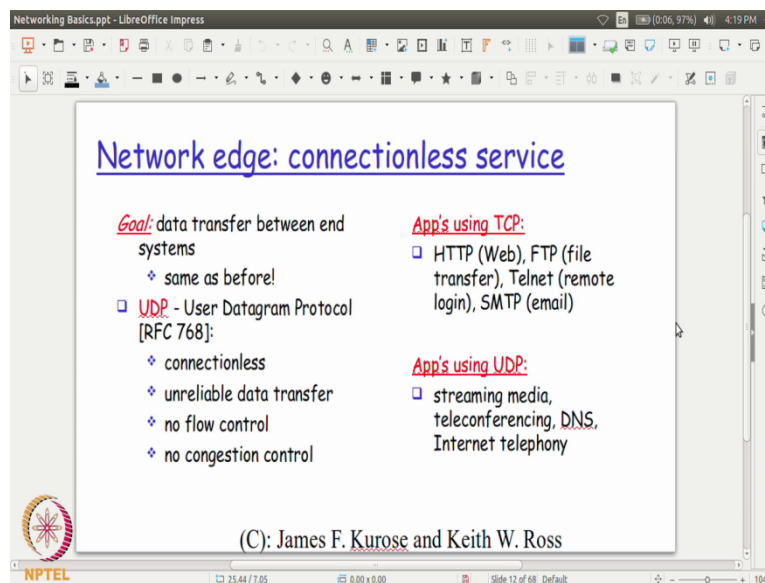
At the bottom of the slide, it says "(C): James F. Kurose and Keith W. Ross". The NPTEL logo is visible in the bottom left corner of the slide. The presentation software interface shows the slide is 11 of 68, with a zoom level of 104%.

So we differentiated the end systems of the client and the server in the network edge and then we talked about what exactly is a TCP service. And what kind of features that a TCP service is providing, so TCP is basically providing a reliable in order bite stream, it provides flow control, it provides congestion control,

so when we say reliable in order bite stream we are talking of the exact amount of data in the same order with the sender has sent to be received by the receiver right, so when we talk of flow control we are basically talking of a mechanism where the sender is not overwhelming the receiver so that essentially the amount of data.

That other end is able to receive only that much amount of data is actually been sent to the receiver sent to the other side at any point in time where as the congestion control is a mechanism to take care of any kind of congestion on the network at any instant of time right, so these are the different services that my TCP is Actually providing.

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The image shows a screenshot of a presentation slide titled "Network edge: connectionless service". The slide is displayed in a LibreOffice Impress window. The slide content is as follows:

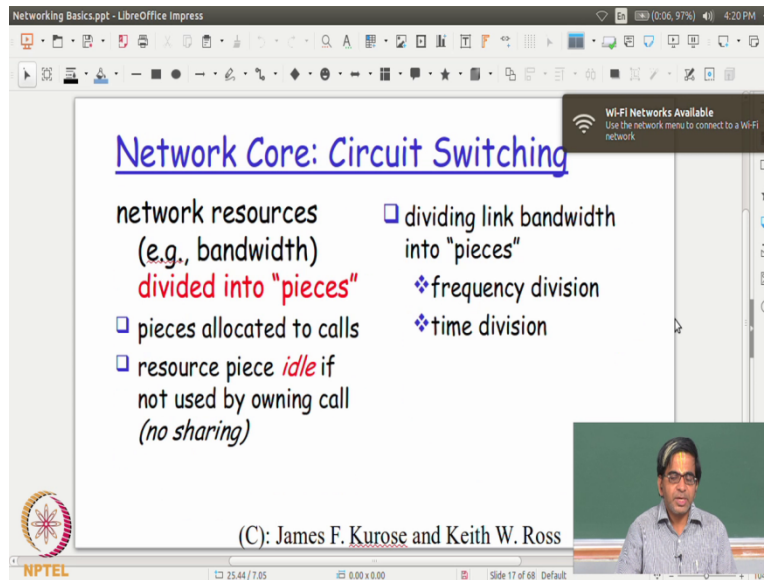
- Goal: data transfer between end systems
 - same as before!
- UDP - User Datagram Protocol [RFC 768]:
 - connectionless
 - unreliable data transfer
 - no flow control
 - no congestion control
- App's using TCP:
 - HTTP (Web), FTP (file transfer), Telnet (remote login), SMTP (email)
- App's using UDP:
 - streaming media, teleconferencing, DNS, Internet telephony

At the bottom of the slide, it says "(C): James F. Kurose and Keith W. Ross". The NPTEL logo is visible in the bottom left corner of the slide area. The presentation window title is "Networking Basics.ppt - LibreOffice Impress". The status bar at the bottom shows "Slide 12 of 68 Default" and "100%" zoom.

Now UDP is basically providing a connectionless unreliable data transfer, there is no flow control or congestion control provided in UDP.

And any kind of traffic that is actually latency sensitive right, like my audio video data or dns kind of a traffic or network management like my snmp related kind of traffic all make use of the UDP protocol right, whereas all other things like http and so on which requires 100% reliability they make use of the the TCP protocol,

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The image shows a screenshot of a presentation slide titled "Network Core: Circuit Switching". The slide content is as follows:

- network resources (e.g., bandwidth) **divided into "pieces"**
- pieces allocated to calls
- resource piece *idle* if not used by owning call (*no sharing*)
- dividing link bandwidth into "pieces"
 - frequency division
 - time division

At the bottom of the slide, it says "(C): James F. Kurose and Keith W. Ross". There is also an NPTEL logo in the bottom left corner and a small video inset of a speaker in the bottom right corner. The slide is displayed in a LibreOffice Impress window.

So then we talked about really circuit switching and data. Packet switching part of it, in circuit switching we talked about FDM versus TDM a frequency division multiplexing with a time division multiplexing, we saw the different advantages of the packet switching as compared to the the circuit switching part of it and saw the reasons behind why in today's network world at the backbone the IP protocol which is predominantly running is using the packet switching approach which is basically what gives me the maximum optimal utilization of my network backbone right,

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The slide is titled "Residential access: point to point access" in blue text. It contains two main sections: "Dialup via modem" and "ADSL: asymmetric digital subscriber line". The "Dialup via modem" section lists: up to 56Kbps direct access to router (often less), and "Can't surf and phone at same time: can't be 'always on'". The "ADSL" section lists: up to 1 Mbps upstream (today typically < 256 kbps), up to 8 Mbps downstream (today typically < 1 Mbps), and FDMA: 50 kHz - 1 MHz for downstream, 4 kHz - 50 kHz for upstream, and 0 kHz - 4 kHz for ordinary telephone. A diagram shows two computers connected to a central router via telephone lines. The NPTEL logo is in the bottom left corner. The footer shows "Slide 25 of 68 Default" and "104%" zoom.

Residential access: point to point access

- **Dialup via modem**
 - ❖ up to 56Kbps direct access to router (often less)
 - ❖ Can't surf and phone at same time: can't be "always on"
- **ADSL: asymmetric digital subscriber line**
 - ❖ up to 1 Mbps upstream (today typically < 256 kbps)
 - ❖ up to 8 Mbps downstream (today typically < 1 Mbps)
 - ❖ **FDMA**: 50 kHz - 1 MHz for downstream
4 kHz - 50 kHz for upstream
0 kHz - 4 kHz for ordinary telephone

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Then we looked at the physical media we had different media discussion about right from a dial up modem to adsl

(Refer Slide Time: 04:31)

The slide is titled "Company access: local area networks" in blue text. It contains two main sections: "company/univ local area network (LAN) connects end system to edge router" and "Ethernet:". The "Ethernet:" section lists: "shared or dedicated link connects end system and router" and "10 Mbs, 100Mbps, Gigabit Ethernet". A diagram shows a central router connected to multiple computers and servers. The NPTEL logo is in the bottom left corner. The footer shows "Slide 26 of 68 Default" and "104%" zoom.

Company access: local area networks

- company/univ **local area network (LAN)** connects end system to edge router
- **Ethernet:**
 - ❖ shared or dedicated link connects end system and router
 - ❖ 10 Mbs, 100Mbps, Gigabit Ethernet

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To talking about Ethernet.

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Wireless access networks

- shared *wireless access network* connects end system to router
 - ❖ via base station aka "access point"
- **wireless LANs:**
 - ❖ 802.11b/g (WiFi): 11 or 54 Mbps
- **wider-area wireless access**
 - ❖ provided by telco operator
 - ❖ 3G ~ 384 kbps
 - ❖ GPRS in Europe/US

router
base station
mobile hosts

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And then came to the wireless access networks, we talked about the kind of limitations that a wireless access network

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Home networks

Typical home network components:

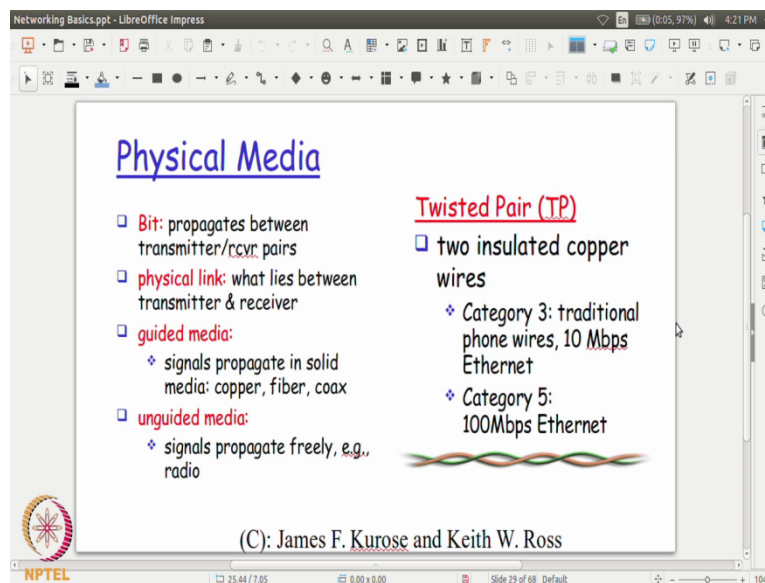
- ADSL or cable modem
- router/firewall/NAT
- Ethernet
- wireless access point

point to/from cable headend
cable modem
router/firewall
Ethernet
wireless access point
wireless laptops

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Typically has and discussed in detail about how a typical home network will be connected with right, so what are the different kinds of components that are there in the home network and what each of these components are suppose to do and what kind of responsibilities they are really having.

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The image shows a screenshot of a presentation slide from a LibreOffice Impress window. The window title is "Networking Basics.ppt - LibreOffice Impress". The slide content is as follows:

- Physical Media**
 - **Bit:** propagates between transmitter/rcvr pairs
 - **physical link:** what lies between transmitter & receiver
 - **guided media:**
 - ❖ signals propagate in solid media: copper, fiber, coax
 - **unguided media:**
 - ❖ signals propagate freely, e.g., radio
- Twisted Pair (TP)**
 - two insulated copper wires
 - ❖ Category 3: traditional phone wires, 10 Mbps Ethernet
 - ❖ Category 5: 100Mbps Ethernet

At the bottom of the slide, there is a copyright notice: "(C): James F. Kurose and Keith W. Ross". Below the text, there is a small graphic of a twisted pair of wires. The presentation software interface includes a toolbar at the top and a status bar at the bottom showing "NPTEL", "25.44 / 7.05", "0.00 x 0.00", "Slide 29 of 68", "Default", and "104%".

Then going into the physical media, we talked about the different types of physical media that I have right from a twisted pair

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Networking Basics.ppt - LibreOffice Impress


Physical Media: coax, fiber

Coaxial cable:

- two concentric copper conductors
- bidirectional
- baseband:
 - ❖ single channel on cable
 - ❖ legacy Ethernet
- broadband:
 - ❖ multiple channels on cable
 - ❖ HFC

Fiber optic cable:

- glass fiber carrying light pulses, each pulse a bit
- high-speed operation:
 - ❖ high-speed point-to-point transmission (e.g., 10's-100's Gps)
- low error rate: repeaters spaced far apart; immune to electromagnetic noise



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To a coaxial cable to a fiber optic cable, we talked about the capabilities of each of those different physical media.

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Networking Basics.ppt - LibreOffice Impress

Physical media: radio

Radio link types:

- signal carried in electromagnetic spectrum
- no physical "wire"
- bidirectional
- propagation environment effects:
 - ❖ reflection
 - ❖ obstruction by objects
 - ❖ interference

Radio link types:

- terrestrial microwave
 - ❖ e.g. up to 45 Mbps channels
- LAN (e.g., Wifi)
 - ❖ 11Mbps, 54 Mbps
- wide-area (e.g., cellular)
 - ❖ e.g. 3G: hundreds of kbps
- satellite
 - ❖ Kbps to 45Mbps channel (or multiple smaller channels)
 - ❖ 270 msec end-end delay
 - ❖ geosynchronous versus low altitude

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And then we were discussed very briefly about the different types of radio links also that is available like from a terrestrial microwave to a satellite link right, then we went into the different levels of ISP where we defined ISP, a tier one, tier two, tier three.

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Networking Basics.ppt - LibreOffice Impress

Internet structure: network of networks

- "Tier-2" ISPs: smaller (often regional) ISPs
 - ✦ Connect to one or more tier-1 ISPs, possibly other tier-2 ISPs

Tier-2 ISP pays tier-1 ISP for connectivity to rest of Internet
 □ tier-2 ISP is customer of tier-1 provider

Tier-2 ISPs also peer privately with each other, interconnect at NAP

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And talked about the coordinating points being referred to as a network access point for the connectivity between the two different ISP's at at a single level or between a higher level ISP to a lower level ISP right,

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Networking Basics.ppt - LibreOffice Impress

How do loss and delay occur?

packets *queue* in router buffers

- packet arrival rate to link exceeds output link capacity
- packets queue, wait for turn

packet being transmitted (delay)

packets queueing (delay)

free (available) buffers: arriving packets dropped (loss) if no free buffers

NPTEL 25.44 / 7.05 0.00 x 0.00 Slide 39 of 68 Default 104%

So then we started talking about the different types of delays that could potentially happen on a per packet basis, as it goes from a source to the destination across these different ISP's right,

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Four sources of packet delay

- 1. **nodal processing:**
 - ❖ check bit errors
 - ❖ determine output link
- 2. **queuing**
 - ❖ time waiting at output link for transmission
 - ❖ depends on congestion level of router

The diagram shows two computers, A and B, connected to a central node. The node is divided into sections for 'nodal processing' and 'queuing'. A packet is shown moving from the node to a destination, with labels for 'transmission' and 'propagation' along the link.

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That is talked about the application called trace row when we which basically gave us the complete delay duration for a packet to go from a source to the destination as it travels through the different ISP's right,

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Nodal delay

$$d_{proc} = d_{processing} + d_{queue} + d_{trans} + d_{prop}$$

- ❖ typically a few microseconds or less
- d_{queue} = queuing delay
 - ❖ depends on congestion
- d_{trans} = transmission delay
 - ❖ = L/R , significant for low-speed links
- d_{prop} = propagation delay
 - ❖ a few microseconds to hundreds of msec

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So we talked about the nodal delay and then we saw with the tray suit application

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"Real" Internet delays and routes

traceroute: gaia.cs.umass.edu to www.eurecom.fr

Three delay measurements from gaia.cs.umass.edu to cs-gw.cs.umass.edu

```
1  cs-gw (128.119.240.254) 1 ms 1 ms 2 ms
2  border1-rt-fa5-1-0.gw.umass.edu (128.119.3.145) 1 ms 1 ms 2 ms
3  chl-vbns.gw.umass.edu (128.119.3.130) 6 ms 5 ms 5 ms
4  j11-atl-0-0-19.wor.vbns.net (204.147.132.129) 16 ms 11 ms 13 ms
5  j11-so7-0-0-0.waa.vbns.net (204.147.136.136) 21 ms 18 ms 18 ms
6  abilene-vbns.abilene.ucalid.edu (198.32.11.9) 22 ms 18 ms 22 ms
7  nycm-wash.abilene.ucalid.edu (198.32.8.46) 22 ms 22 ms 22 ms
8  62.40.103.253 (62.40.103.253) 104 ms 109 ms 106 ms
9  de2-1.de1.de.geant.net (62.40.96.129) 109 ms 102 ms 104 ms
10 de.fr1.fr.geant.net (62.40.96.50) 113 ms 121 ms 114 ms
11 renater-gw.fr1.fr.geant.net (62.40.103.54) 112 ms 114 ms 112 ms
12 nio-n2.cssi.renater.fr (193.51.206.13) 111 ms 114 ms 116 ms
13 nice.cssi.renater.fr (195.220.98.102) 123 ms 126 ms 124 ms
14 c12-nice.cssi.renater.fr (195.220.98.110) 126 ms 126 ms 124 ms
15 eurecom-valbonne.c12.fr.net (193.48.50.54) 135 ms 128 ms 133 ms
16 194.214.211.25 (194.214.211.25) 126 ms 128 ms 126 ms
17 ***
18 ***
19 fantasia.eurecom.fr (193.55.113.142) 132 ms 128 ms 136 ms
```

trans-oceanic link

* means no response (probe lost, router not re

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How this nodal delay is actually calculated and then displayed out as part of the output of this application right,

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Packet loss

- ❑ queue (aka buffer) preceding link in buffer has finite capacity
- ❑ when packet arrives to full queue, packet is dropped (aka lost)
- ❑ lost packet may be retransmitted by previous node, by source end system, or not retransmitted at all

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So then we defined about the packet loss.

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The slide is titled "Protocol Layers" in blue. It contains the following text:

- Networks are complex!
- many "pieces":
 - hosts
 - routers
 - links of various media
 - applications
 - protocols
 - hardware, software

Question:
Is there any hope of *organizing* structure of network?
Or at least our discussion of networks?

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The slide also features an NPTEL logo in the bottom left corner and a status bar at the bottom with the text "Slide 48 of 68 Default".

And went it to the definition of the protocol layers.

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The slide is titled "Organization of air travel" in blue. It contains the following text:

- a series of steps

The steps are arranged in two columns, connected by lines to form a continuous path:

- ticket (purchase)
- baggage (check)
- gates (load)
- runway takeoff
- airplane routing
- runway landing
- airplane routing
- gates (unload)
- baggage (claim)
- ticket (complain)

(C): James F. Kurose and Keith W. Ross

The slide also features an NPTEL logo in the bottom left corner and a status bar at the bottom with the text "Slide 49 of 68 Default".

Where we looked at in a example of a typical I mean we looked at in an analogy of how we can actually talk about the different network layers and compare it with the typical air travel that we actually do right from purchasing the ticket at our source to coming out of the final destination after collecting our baggage at the end of our air travel right,

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The slide is titled "Why layering?" in blue text. Below the title, it says "Dealing with complex systems:" followed by a list of four points, each starting with a blue square bullet. The first point is "explicit structure allows identification, relationship of complex system's pieces" with a sub-point "layered reference model for discussion". The second point is "modularization eases maintenance, updating of system" with sub-points "change of implementation of layer's service transparent to rest of system" and "e.g., change in gate procedure doesn't affect rest of system". The third point is "layering considered harmful?". At the bottom, it says "(C): James F. Kurose and Keith W. Ross". There is a small video inset of a man in the bottom right corner of the slide area.

Why layering?

Dealing with complex systems:

- explicit structure allows identification, relationship of complex system's pieces
 - ❖ layered **reference model** for discussion
- modularization eases maintenance, updating of system
 - ❖ change of implementation of layer's service transparent to rest of system
 - ❖ e.g., change in gate procedure doesn't affect rest of system
- layering considered harmful?

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So the layering concept for that network stack was introduced

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The slide is titled "Internet protocol stack" in blue text. Below the title, it lists five layers with descriptions and examples. To the right of the text is a vertical stack of five boxes labeled "application", "transport", "network", "link", and "physical". At the bottom, it says "(C): James F. Kurose and Keith W. Ross".

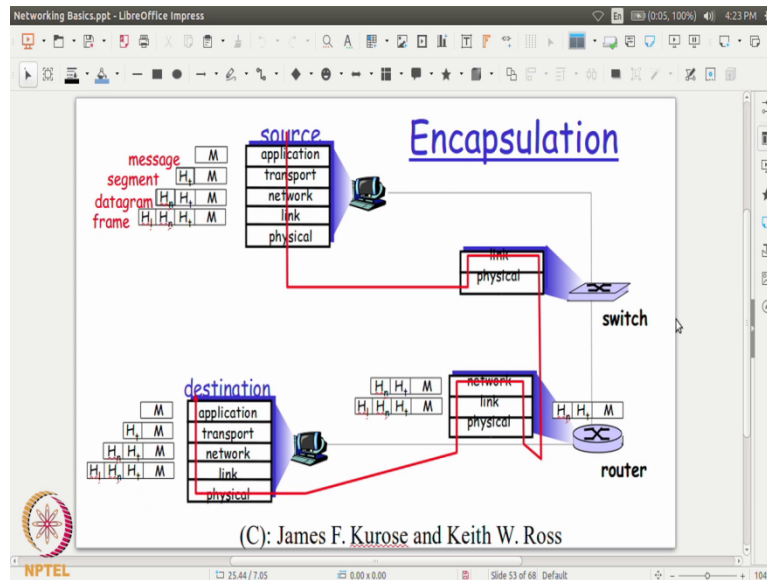
Internet protocol stack

- **application**: supporting network applications
 - ❖ FTP, SMTP, HTTP
- **transport**: process-process data transfer
 - ❖ TCP, UDP
- **network**: routing of datagrams from source to destination
 - ❖ IP, routing protocols
- **link**: data transfer between neighboring network elements
 - ❖ PPP, Ethernet
- **physical**: bits "on the wire"

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And then we discussed in detail about the five different layers along with the responsibilities for each of them

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Where in we clearly talked about the packet encapsulation and de-capsulation and discussed how a packet from a higher level application goes.

Through and gets sort of encapsulated with the lower level headers as if goes through across each of the layers in my network stack down below till it reaches a physical level and then at the the destination side how it gets de-capsulated for the final application to receive the original message that was sent out by the application right, so then we started looking at the different types of devices like an hub, a switch and how they basically work in terms of a switch becoming a self, a managed switch.

By doing a self learning, how does it do a self learning and sort of build the switch table we looked with the couple of examples and then understood, then we try to compare the different types of devices with respect to the benefits in each of them.

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Networking Basics.ppt - LibreOffice Impress

Switches: dedicated access

- Switch with many interfaces
- Hosts have direct connection to switch
- No collisions; full duplex

Switching: A-to-A' and B-to-B' simultaneously, no collisions

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Networking Basics.ppt - LibreOffice Impress

Institutional network

to external network router switch mail server web server IP subnet hub hub hub

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So that we could identify what device

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Switches vs. Routers

- both store-and-forward devices
 - routers: network layer devices (examine network layer headers)
 - switches are link layer devices
- routers maintain routing tables, implement routing algorithms

Diagram illustrating a network topology with Hosts, Bridge, Router, and Host, showing packet flow and IP addresses (1-5).

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To be actually

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Summary comparison

	<u>hubs</u>	<u>routers</u>	<u>switches</u>
traffic isolation	no	yes	yes
plug & play	yes	no	yes
optimal routing	no	yes	no
cut through	yes	no	yes

(C): James F. Kurose and Keith W. Ross

Making use of in different types of our requirements right, so this is basically what we actually covered as part of our networking basics, so the idea behind this discussion was to slowly introduce you to the concept of a networking world, especially the jargons that are typically employed there, the terminologies that are typically employed there to serve as a sort of an

appetizer for you to basically get into more details subsequently right, so this set of modules on networking should have hopefully given you a a basic level of foundation for you to understand the different terminologies especially when somebody is talking to you in the networking domain right.

So that was basically the the objective of having this set of modules in our discussion as part of this certification which will come in handy for you in our subsequent discussions on the various tools as part of information security.

Thank you.