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## What Have We Learned?

1. Network Concepts and Architectures
2. Communication Protocols
   (e.g. TCP/IP,Bluetooth)
3. Doing Useful Work on a Network

How?

•Lectures,

•Reading and programming

•Project & presentations (30% of total grade)

•Exams (20% for exam 1 + 30% for final).

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## Main Focus of This Semester

1. Principles and concepts of networking
2. TCP/IP Architecture
   - Internet
3. Ethernet LAN
4. Wireless Communication
   - Bluetooth
5. Network performance analysis

## Introduction: Summary

Covered materials!

- Internet overview
- what's a protocol?
- network edge, core, access network
  - packet-switching versus circuit-switching
- access net, physical media
- performance: loss, delay
- layering and service models

You now have:

- context, overview, "feel" of networking
- more depth, detailed understanding of networking



## Application Layer

- Application architectures
  - client-server
  - P2P
- application service requirements:
  - reliability, bandwidth, delay
- Internet transport service model
  - connection-oriented, reliable: TCP
  - unreliable, datagrams: UDP

- specific protocols:
  - HTTP
  - Bluetooth and Zigbee
  - iSCSI, FC
- Networked Storage Applications



## Application Layer

Most importantly: learned about *protocols*

- typical request/reply message exchange:
  - client requests info or service
  - server responds with data, status code
- message formats:
  - headers: fields giving info about data
  - data: info being communicated

- control vs. data msgs
- centralized vs. decentralized
- stateless vs. stateful
- reliable vs. unreliable msg transfer
- "complexity at network edge"



## Transport Layer

Our goals:

- understand principles behind transport layer services:
  - multiplexing/ demultiplexing
  - reliable data transfer
  - flow control
  - congestion control
- learn about transport layer protocols in the Internet:
  - UDP: connectionless transport, (read yourselves)
  - TCP: connection-oriented transport
  - TCP congestion control

## Principles of Congestion Control

Congestion:

- informally: "too many sources sending too much data too fast for *network* to handle"
- different from flow control!
- manifestations:
  - lost packets (buffer overflow at routers)
  - long delays (queueing in router buffers)
- a top-10 problem!
- Delay and performance analysis



## Network Layer

- Forwarding and routing
- Virtual circuit and datagram networks
- What's inside a router
- Router architectures
- Routing algorithms
  - Link state
  - Distance Vector
- IP protocol



## Wireless and Bluetooth protocol

- Bluetooth Protocol Stack
  - Physical Layer
  - Baseband
  - Link Manager Protocol (LMP)
  - L2CAP
  - RFCOMM
- BlueZ
  - Full source code is available under the GPL
  - Socket based interfaces
  - Simple API for development tasks
  - Access to all Bluetooth host layers



## Link Access and LAN Protocols

- ***Link layer services***
  - Framing, access, reliable delivery, flow control
- ***Shared Medium Access*** (multiple access control MAC)
  - Static allocation: channel partitioning
  - Random access: Slotted, CSMA/CD, CSMA/CA
  - Taking turns: token passing protocol
  - Delay analysis of a LAN
- ***CSMA/CD and Ethernet:***



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## Network Security

- Security Issues and requirements
- Traditional Encryptions
- DES
- Public Key encryption
- Firewalls
- Application gateways.