

COMS3200

COMS3200/COMS7201 Week 1 – Introduction, Network Models

School of Information Technology and Electrical Engineering
The University of Queensland

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Overview

- Course Profile
 - Brief Overview
 - You should obtain and read a copy
- Course Introduction
- Networks Introduction
- Network Models

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Teaching Staff

- Prof. Neil Bergmann
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- Email:
 - coms3200@itee.uq.edu.au
 - (Or substitute [coms7201](#) in place of [coms3200](#) above)
- Tutors:
 - Tuts:
 - Pracs: Wei Yin

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Purpose of COMS3200/7201

- Computer Networking Concepts
 - Topologies, Functions, Architectures
 - OSI model, Internet model
 - Data transmission techniques
 - High speed networks
- Distributed Applications
 - Programming networked applications
- Understand Acronyms...

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Assumed Background

- Prerequisites (paraphrasing course catalog):
 - COMP2303
- OR
- COMP1500/CSSE1001
AND
● COMP1300/2300/2302
- Our assumptions:
 - You should be able to program (C or Java)
 - You should know the basics of how computers work
- Incompatible:
 - COMS2000, CS233, CS332, CS334, CS336
- Target audience:
 - 3rd year Information Technology and Engineering students

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Relationship to COMP2303

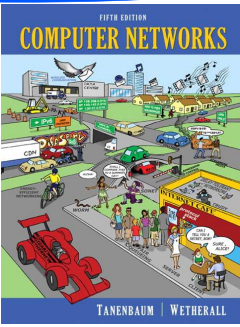
- COMP2303 = Network and OS Principles (first offered Semester 1, 2005)
- COMS3200 assumes that students have taken COMP2303
- However...
 - there will be some repeated material from COMP2303 (~5 to 10%)
 - In general, COMS3200 will cover concepts in greater depth than COMP2303
 - COMS3200 programming assignments can be done using C or Java

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Textbook

- Textbook
 - Tanenbaum, Wetherall, "Computer Networks", 5th ed., Prentice Hall, 2011.
- Highly recommended that you obtain a copy
- Lecture slides, will be available on the web
 - Not everything presented at lectures will be on the web



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Teaching Activities

- 5 contact hours – 3L1T1P
- Lectures
 - Tuesday 12-2pm
 - Friday 12-1pm
- Tutorials (start in week 2)
 - Tuesday 9 am,
 - Friday 11 am

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Teaching Activities (cont)

- Pracs (start in week 5)
 - Monday 10 am, 78-110
 - Monday 11 am, 78-110
 - Tuesday 10am, 78-110
 - Tuesday 2pm, 78-110
- For consultation about assignments, plus assignment 3 marking
- Sign-on (tuts, pracs) via mySI-net
- Significant self-study required

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Lecture Outline

Week	Topic
1	Introduction, Network models No lecture on Friday
2	Interprocess Communication No lecture on Friday
3	TCP/UDP
4	Physical Layer
5	Data Link Layer
6	Medium Access
7	Medium Access, Internetworking, Network layer
8	Network Layer: Internet protocol (IP), Routing
9	Network Layer: Routing, Multicast
10	Multimedia Protocols and Applications No lecture on Friday
11	Network Security
12	Quality of Service
13	Revision No lecture on Friday

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Tutorials & Pracs

- Tutorials
 - Start next week
 - Questions provided the week before
 - Read the recommended readings
 - Attempt questions **before** tutorial
 - Questions discussed in tutorials
 - Attendance encouraged
 - Questions indicative of exam questions
- Pracs
 - Start in week 5
 - Assistance for programming assignments (and marking of assignment 3)

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Assessment

- Three Assignments (40%)
 - 1: Interprocess communication and network programming (16%)
 - 2: Network Application (17%)
 - 3: Networking Applications Lab (7%)
- Final Exam (60%) – open book
- Overall mark is a sum of assignment and exam marks
- Final Grade based on overall mark:

Final Grade	Required Overall Mark	
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7	≥ 85	≥ 88
6	≥ 75	≥ 78
5	≥ 65	≥ 68
4	≥ 50	≥ 50

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References

On many slides

- T number = page number in Tanenbaum (5th ed)
- (occasionally - PD number = page number in Peterson and Davie)
 - Note
 - Not necessarily complete
 - Subject may be covered elsewhere too
 - Absence of reference doesn't mean material not covered
 - Not necessarily representative
 - Other material in text important too
 - Figures taken from
 - Tanenbaum
 - Peterson & Davie
 - Other sources, as referenced

e.g. T-23 13

Lecture 1
Introduction to Networking, Network Models

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 The University of Queensland

Outline

- Reiteration from COMP2303:
 - What is a network?
 - Network structures
 - Protocols & Services
- Network models
- Who's who in Networking

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Expected Learning Outcomes

- After this week's lecture, associated readings and Tutorial 1, you should...
 - Be able to describe various network structures
 - Be able to describe the layers in the OSI and TCP/IP reference models and the issues dealt with at each layer
 - Understand the reasons for the differences between the two models

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What is a Network

- Networks provides **connectivity** between **nodes** over some **link** (or links)
- **Nodes**
 - hosts (computation nodes)
 - e.g. computers and other devices
 - routers (switching nodes)
- **Link**: physical medium
 - Various technologies, e.g. twisted pair wire, air
 - Various scales, e.g. room to planet sized
 - Various topologies
 - Point to point
 - Multiple access (broadcast)

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Network Structure – Routers and Hosts

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Why Use Computer Networks?

- Resource sharing
 - software, data, databases, equipment remotely accessible
- High Reliability
 - Alternative sources of supply
- Economy
 - Small computers have better price/performance than large computers
- Communication
 - Email, WWW, Instant Messaging, Chat
- Personal reasons
 - Access to information, entertainment
- Commerce
 - Business-to-business, business-to-consumer

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Scale of computer networks

Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	
100 m	Building	Local area network
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	
1000 km	Continent	Wide area network
10,000 km	Planet	

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Network Hardware

- Personal area networks
- Local area networks
- Metropolitan area networks
- Wide area networks
- The internet

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Personal Area Network

Bluetooth PAN configuration

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Local Area Networks

Wireless and wired LANs

(a) 802.11. (b) Switched Ethernet

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Metropolitan Area Networks

A metropolitan area network based on cable TV

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Wide Area Networks (1)

WAN that connects three branch offices in Australia

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Wide Area Networks (2)

WAN using a virtual private network

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Wide Area Networks (3)

WAN using an ISP network.

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Point-to-Point Networks

- Pairs of nodes linked together - links have two ends
 - e.g. twisted pair cable, fibre-optic cable, microwave link
- Also called **store-and-forward** or **packet-switched** networks
- Packets sent from origin router to destination router via intermediate routers
 - **Packet** = short message (with destination address)
- Examples
 - Most WANS
 - Modern LANs (e.g. switched ethernet)

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Possible Point-to-Point Topologies

Star Ring Tree Complete Intersecting Rings Irregular

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Multiple Access (Broadcast) Networks

- Single channel shared by all hosts
- Each host checks each packet's destination address
 - reject packets where address doesn't match
- Broadcast subnets also support **broadcast mode**
 - packet addressed to all destinations
- **Multicasting**
 - packets sent to a particular subset of hosts
- Examples
 - Early LANs, e.g. original Ethernet
 - Satellite based networks

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Broadcast Network Topologies

The diagram illustrates four broadcast network topologies:

- Bus:** A horizontal line with five computer icons connected to it.
- Ring:** A circular arrangement of five computer icons connected in a loop.
- Satellite:** A satellite in orbit with three ground stations on the ground.
- Radio:** A radio tower with three ground stations.

- Issues
 - Which host broadcasts?
 - If only one, which one?
 - Static or dynamic allocation

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Networks of Networks

- An *internetwork* (**internet**) is an interconnected set of networks.
 - The Global IP **Internet** (uppercase "I") is the most famous example of an internet (lowercase "i")

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Network vs. Distributed System

- What's the difference?
- Network: interconnected collection of autonomous computers
- Distributed system:
 - Existence of multiple autonomous computers not visible to user
 - Virtual machine

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Network Software

- Protocol hierarchies
- Design issues for the layers
- Connection-oriented versus connectionless service
- Service primitives
- Relationship of services to protocols

Protocols

- Definition: Set of procedures designed to achieve some higher purpose, sometimes in adverse circumstances
- In communications:
 - Set of rules governing exchange of data between two entities
- Distinction between service and protocol

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Key Elements of a Protocol

What's in a protocol?

- Syntax
 - Data format
 - Signal levels
- Semantics
 - Meaning of data, e.g. control information
- Timing
 - Speed matching, sequencing

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Protocol Hierarchies

- To reduce *design* complexity, most networks organized as series of layers or levels
- Purpose of layer
 - Offer services to higher layers
 - Shield higher layers from implementation details

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Protocol Hierarchies (cont)

The philosopher-translator-secretary architecture

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Virtual Protocols

- No data directly transferred between peer entities
- Each layer passes data and control information to layer below, until reach lowest layer
- Actual communication occurs via physical medium

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Headers and Enveloping

- Header
 - Additional information attached to a message unit by a protocol
- Protocol worries about header, not message
- Like placing a message in an envelope
- Layered protocols -> nested envelopes
- Some protocols might add a *tail* also

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Headers and Enveloping (cont.)

Source machine Destination machine

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Network Architecture

- Definition: A set of layers and protocols
- Must contain enough information to build
- Some protocol architectures do not specify interfaces, only protocols
 - In such cases interfaces can differ on different machines
- Protocol Stack
 - Set of protocols used by a certain system, one protocol per layer

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Entities

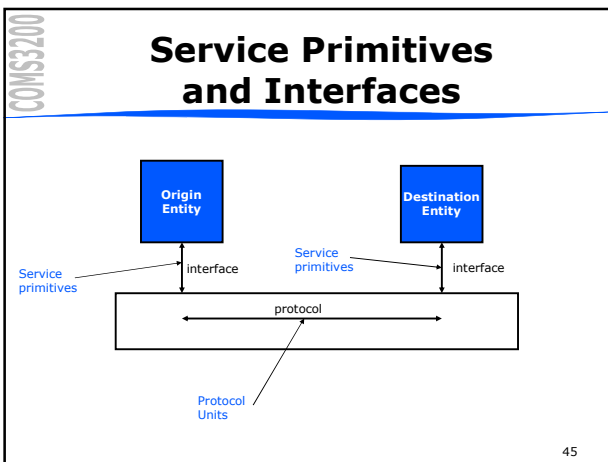
- Definition: Active elements in each layer
 - Can be software (e.g. process)
 - Can be hardware (e.g. integrated circuit)
- Peer entities
 - Same layer – different machines
 - Sometimes called *peer processes*

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Service vs. Protocol

- **Service** – set of operations provided by layer to layer above
 - **Service primitives**
 - Operations available to user or other entity
 - Service user is level n+1
 - Service provider is level n
 - e.g. 3 uses 2, 2 uses 1
- **Protocol** – rules governing format and meaning of frames/packets/messages exchanged by peer entities

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Service Categories

- Connection
 - Connection-oriented
 - Connectionless
- Reliability
 - Reliable
 - Unreliable

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Connection-Oriented and Connectionless Service

- Connection-oriented
 - Modeled after telephone system
 - Service user
 - establishes connection
 - uses connection
 - releases connection
- Connectionless
 - Modeled after postal system
 - Each message
 - contains full destination address
 - routed through system independently

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Connection-Oriented Versus Connectionless Service

	Service	Example
Connection-oriented	Reliable message stream	Sequence of pages
	Reliable byte stream	Movie download
Connection-less	Unreliable connection	Voice over IP
	Unreliable datagram	Electronic junk mail
	Acknowledged datagram	Text messaging
	Request-reply	Database query

Six different types of service

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Example Service Primitives

Six service primitives that provide a simple connection-oriented service

Primitive	Meaning
LISTEN	Block waiting for an incoming connection
CONNECT	Establish a connection with a waiting peer
ACCEPT	Accept an incoming connection from a peer
RECEIVE	Block waiting for an incoming message
SEND	Send a message to the peer
DISCONNECT	Terminate a connection

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Service Primitives

A simple client-server interaction using acknowledged datagrams

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Reliability

- Services can be reliable or unreliable
- Reliable
 - receiver needs to acknowledge receipt
- Unreliable
 - No acknowledgement necessary

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Network models

- Models for network architectures and protocols:
 - OSI reference model
 - TCP/IP reference model
 - Differences

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OSI Reference Model (OSIRM)

- OSI = Open Systems Interconnection
 - Title for set of computer communication standards, developed by ISO (International Standards Organisation)
- Goal
 - Provision of communication services between computers of different origin
- Reference model
 - Partitioned the problem into discrete layers
 - Work started 1977
 - First step towards standardized protocols

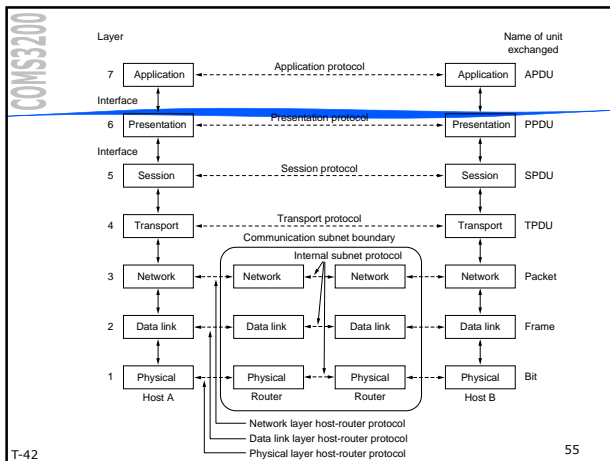
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OSIRM – Design Principles

- Create layer where need abstraction
- Each layer should perform well defined function
- Keep possible protocols in mind
- Minimize information flow between layer boundaries
- Not too few layers
- Not too many layers

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1. Physical Layer

- Concerned with
 - Bit transmission
- Issues:
 - Volts, microseconds
 - Connectors, pins, cables
 - Mechanical, electrical
 - Activating, using, deactivating circuit
- Not perfect – bits can be corrupted
 - noise, burst error, catastrophic

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2. Data-Link Layer

- Concerned with:
 - Reliable transmission of frames (bit sequences)
 - Overcoming unreliability of physical layer
- Issues:
 - Acknowledgements
 - Error detection / correction
 - Lost / damaged / duplicate frames
 - Traffic regulation
 - Channel access (Broadcast networks)
 - Medium-access sub-layer

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3. Network Layer

- Concerned with:
 - Routing of packets, i.e. determining sequence of links
- Issues:
 - Routing tables/algorithms
 - Static / dynamic
 - Congestion control
 - Accounting (\$)

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Think...

- What does the network layer do in broadcast networks?

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4. Transport Layer

- Concerned with
 - End-to-end communication
- Issues
 - Breaking messages into smaller chunks
 - Connection management
 - Multiplexing
 - Upward
 - Downward
 - Different transport connections (service qualities)
 - e.g. error-free end-to-end channel
 - Flow control

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5. Session Layer

- Concerned with
 - Allow pair of users to establish *session*
- Issues
 - Kind of dialogue – half/full duplex
 - Token management
 - operation exclusivity
 - Synchronisation
 - e.g. file transfer checkpointing

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6. Presentation Layer

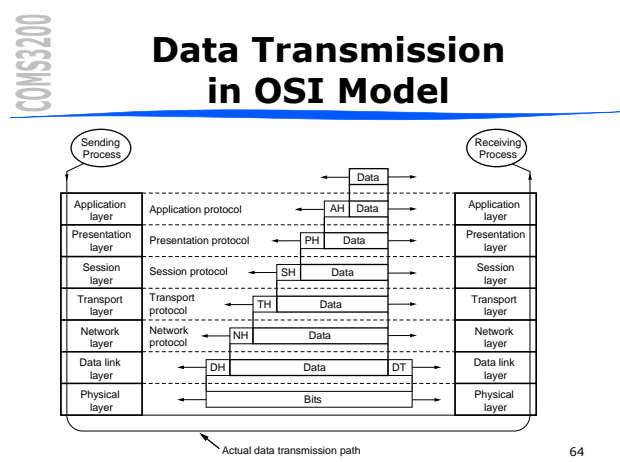
- Concerned with:
 - Data Representation
 - Preservation of *semantics* despite differences in *syntax*
- Issues:
 - Representations for
 - characters, integers, strings etc
 - Compression
 - Encryption

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7. Application Layer

- Concerned with:
 - Providing services to end-user
 - Range of applications
- Examples:
 - HTTP for WWW
 - File transfer and management (FTAM)
 - Email
 - Network virtual terminal
 - Directory services

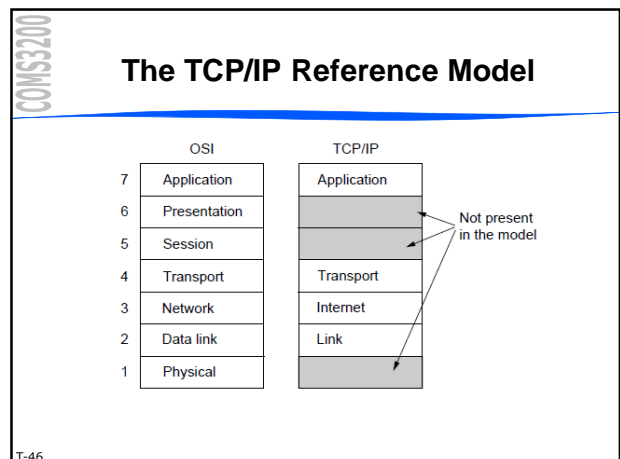
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TCP/IP Reference Model

- from ARPANET
 - ancestor of the Internet
- Named after two primary protocols
- Goals
 - Connect multiple networks together
 - Survive loss of subnets
 - Flexible

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The TCP/IP Reference Model (2)

The TCP/IP reference model with some protocols we will study

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The model we will use

5	Application
4	Transport
3	Network
2	Link
1	Physical

The reference model used in the lectures and textbook

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Comparison: OSI & TCP/IP Models

- Many similarities
- Differences
 - Number of layers
 - OSI distinguishes Services, Interfaces, Protocols
 - Protocols in OSI better hidden
 - OSIRM devised before protocols whereas TCP/IP protocols came first
 - TCP/IP model not useful for describing other networks

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OSI Model & Protocols - Critique

- OSI
 - Model – useful, but not adopted
 - Protocols – failed
- Why?
 - Timing – TCP/IP already in use
 - Too complex
 - Bad implementations
 - Politics
 - Not for free

T-46 to 48

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OSI Model Bad Timing

The apocalypse of the two elephants

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TCP/IP Model & Protocols - Critique

- Protocols
 - Widely used and popular
- Problems
 - No clear boundary between services, interfaces, protocol
 - Not general
 - Host-to-network layer is really interface
 - Doesn't distinguish (or mention) physical and data-link layers
 - Some protocols ad hoc – particularly old ones e.g. Telnet

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Example Networks

- Internet
- Third-generation mobile phone networks
- Wireless LANs: 802.11
- RFID and sensor networks

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Architecture of the Internet

Overview of the Internet architecture

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Third-Generation Mobile Phone Networks (1)

Cellular design of mobile phone networks

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Third-Generation Mobile Phone Networks (2)

Architecture of the UMTS 3G mobile phone network

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Third-Generation Mobile Phone Networks (3)

Mobile phone handover (a) before, (b) after.

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Wireless LANs: 802.11 (1)

(a) Wireless network with an access point
(b) Ad hoc network

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Wireless LANs: 802.11 (2)

Multipath fading

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Wireless LANs: 802.11 (3)

The range of a single radio may not cover the entire system

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RFID and Sensor Networks (1)

RFID used to network everyday objects.

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RFID and Sensor Networks (2)

Multihop topology of a sensor network

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Network Standardization

- Who's Who in telecommunications
- Who's Who in international standards
- Who's Who in internet standards

Who's who in Telecommunications?

- Service providers
 - In US: > 3000 phone companies (wired, mobile, inter-exchange carriers)
 - In Australia (see www.acma.gov.au, www.tjo.com.au)
 - many licensed telecommunications carriers
 - many Telephone and Internet Service Providers
- Many countries
 - Government monopoly (PTTs)
- Need standards
 - Why?

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ITU

- International Telecommunication Union
 - Job – standardize international telecommunications
 - Sectors
 - ITU-R (radiocommunications)
 - ITU-T (telecommunications) - was CCITT
 - ITU-D (development)
- ITU-T makes recommendations about telephone, telegraph and data communication interfaces
 - e.g. V-series modem standards (e.g. V.34)
- Composed of
 - study groups/working parties/expert teams

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Who's Who in Standards?

- ISO = International Standards Organisation
- Composed of national standards bodies
 - ANSI (American National Standards Institute)
 - Standards Australia
 - etc
- Deals with everything
 - Over 200 Technical Committees (TCs)
 - TC #1 (screw threads)
 - TC #97 (Information Processing) now replaced by JTC-1 (Joint TC with IEC)
- Each TC has Subcommittees (SCs)
- SCs have Working groups (WGs)

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Who else is important in Standards?

- NIST = US National Institute of Standards and Technology
- IEEE = Institute of Electrical and Electronics Engineers
- Standards come in two types
 - De facto
 - Just happened (e.g. IBM-PC)
 - De jure
 - Formal process

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Internet Standards

- Much more informal process
- IAB (Internet Architecture Board)
- IRTF (Internet Research Task Force)
- IETF (Internet Engineering Task Force)
- IESG (Internet Engineering Steering Grp)
- Documents known as RFCs (Request for Comment)
 - Proposed Standard -> Draft Standard -> Internet Standard
- Web standards – World Wide Web Consortium (W3C)

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Readings

- Tanenbaum (5th ed), Chapter 1.
- Other references
 - www.iso.ch
 - www.jtc1.org
 - www.iab.org
 - www.ietf.org

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What YOU should do in the next week

- Obtain textbook (highly recommended)
- Do readings for week 1
- Sign-up for a tutorial & prac session
- Attempt Tutorial 1
- Do readings for week 2
 - RPC: Tanenbaum pages 5th ed: 543-546
 - (4th ed: 526-529)

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