Goals and Objectives

- Understand state-of-the-art in network protocols, architectures, and applications
- Process of networking research
  - Constraints and thought processes for networking research
  - Problem Formulation—Approach—Analysis—Results
Lecture Topics

**Traditional**
- Layering
- Internet architecture
- Routing (IP)
- Transport (TCP)
- Queue management (FQ, RED)
- Naming (DNS)

**Recent Topics**
- Botnets
- Datacenter Networking
- Multicast
- Mobility/Wireless
- Network Energy
- Network Debugging
- Overlay Networks
- P2P applications

Modified from F08 based on feedback from last year’s class: QoS, SensorNets, “Future Network” Architecture eliminated

What is the Objective of Networking?

- Communication between applications on different computers
- What the application needs/demands
  - Traditional view: traffic data rate, pattern (bursty or constant bit rate), target (multipoint or single destination, mobile or fixed)
  - New application-orientation
    - Overlays/DHTs/Indirection
    - Policy Awareness
    - “Programmable” Networks
Packet Switching

- Interleave packets from different sources
  - Statistical multiplexing to use resources on demand
  - Supports multiple applications types
  - Accommodates bursty traffic via queues

- Store and forward
  - Packets are self contained units
  - Can use alternate paths – reordering
  - Effects of contention: congestion and delay

- Semester readings on Fair Queuing, Router Congestion Control

Extensions to the Network

- New kinds of networks within the Internet
  - Local Area: Enterprise, Datacenter
  - Mobile
  - Wireless/Broadcast
  - Names vs. Addresses/Content Distribution
  - BotNets

- Semester readings on Enterprise/Datacenter networks, Roofnet/Broadcast, Ad hoc routing, CDNs, DHTs/I3, etc.
Extensions to the Network Architecture

- **Naming**
  - DNS as an Overlay Network
  - Problems with Host-to-IP Address bindings
  - Problems with Service-to-Host bindings
  - Solutions based on the idea of an extra level of indirection: flat identifiers plus resolution based on DHT lookup
  - Semester readings on DNS, DHTs/i3, etc.

- **Forwarding**
  - Problems with Internet routing
  - Beyond point-to-point routing: broadcast, multicast, mobility, etc.
  - Indirection schemes and intermediaries (e.g., “policy aware switching”) to implement new forms of forwarding
  - Semester readings on Internet topology, multicast, wireless, i3, policy-aware switching, network measurement
Enterprise/Datacenter Networks

- Large number of nodes within a single administrative
  - New approaches for name-to-address mapping and network management, e.g., floodless
  - New challenges for local-area transport, e.g., incast
  - New routing algorithms, e.g., parallel paths between nodes
- Course readings: Floodless, VL2, Portland, In-cast, etc.

Protocols

- Module in layered structure
- Set of rules governing communication between network elements (applications, hosts, routers)
- Protocols define:
  - Interface to higher layers (API)
  - Interface to peer
    - Format and order of messages
    - Actions taken on receipt of a message
Layering Characteristics

• Each layer relies on services from layer below and exports services to layer above
• Interface defines interaction
• Hides implementation - layers can change without disturbing other layers (black box)

Application-Oriented Networking

• All kinds of new application-specific routing and transport layers
  • Name-to-address mapping as routing, e.g., DHTs, I3
  • Content distribution
  • Overlay networks
  • Active/programmable networks
• Layering and E2E assumptions questioned and revised
Energy Considerations

• Energy proportionality applied to compute and switch nodes
  • Protocol implications for allowing nodes to sleep—protocol proxies
  • Low power switch ports
• Service placement based on energy price arbitrage
• Course readings: Electricity Bill, Art of Idleness

Network Security

• Many challenges remain
  • Authenticated sender and receiver
  • Trust management
  • E2E secure payloads
  • Manage malicious behaviors, e.g., botnets
• Course readings: botnet detection
Quo Vadis Networking?

- New architecture for the Next Generation
  - New naming and forwarding as foundation
  - Security and authenticity from first principles
  - Application-oriented networking
- Refocus from wide-area to local-area
  - Unified telephony and data, wired/wireless
  - Datacenters for web and batch parallel apps
  - O(10,000) node DC and enterprise networks
  - New addressing, transport opportunities

What Next?

- Today
  - Course evaluations next
  - Research Project Poster Session – 3-4 PM in 465 Soda
- Thursday, 10 December: Quiz #2
  - 405 Soda, 2-3:30 PM
- Monday, 15 December: 5 PM Project Reports
  - Specification on the web, 5-15 pages