Quality of Service Guarantees in Mobile Computing

- Introduction
- QoS Parameters
- Architectural and Internetworking Issues
- Traffic Classes at the Transport Layer

Introduction

- ❒ Mobile Users
  - ⌧Personal Digital Assistants
    - Palmtop computers with wireless communications technology
    - Able to access data and other services while on the move
  - ⌧High Data Rates
    - Between 1-2Mbps per mobile user
  - ⌧Microcellular Network Architecture
    - Geographical region divided into microcells
    - Diameter of the order of hundreds of meters
    - Central host machine within the cell serve as a gateway to the wired networks - Mobile Support Station (MSS)

Introduction

- ❐ Issues need to be considered:
  - ⌧Design of efficient network architectures to support mobility
  - ⌧Protocols to provide uninterrupted service to mobile users
  - ⌧Maintaining quality of service guarantees for applications
  - ⌧Renegotiating these guarantees during the lifetime of a connection
- ❐ Unique features of the mobile computing environment
  - ⌧Guarantee of QoS:
    - Unpredictability of their motion
  - ⌧Maintaining seamless connection
    - Mobility of users
    - Brief blackout periods

QoS Parameters

- Quality of Service Parameters:
  - Delay & jitter bounds
  - Minimum & maximum bandwidth requirements
  - Maximum loss bound, etc.
- Two additional QoS parameters
  - Essential to specify grades of service for mobile users

Graceful Degradation Service

- Service degradation
  - When many users with open connections enter a cell
  - Total requested bandwidth exceeds the cell's capacity
  - How to allocate the limited bandwidth among all the users
- One scheme
  - Prioritize all the open connections &
  - Penalize the least priority connections first.
  - Problems:
    - Not always possible to rank-order all the different applications.
    - "Low priority" connections may lose all connections.

Loss Profile

- Loss Profile
  - Require users to specify, during connection setup,
    - A preferred way in which data can be discarded in the event that bandwidth requirements within a cell exceed the available bandwidth.
  - Used in conjunction with other QoS parameters.
  - Acceptable loss behavior
    - Service-provider specify for their respective services
    - Channel allocation policies try to follow this type of loss behavior

Seamless Communication

- Goal
  - Users do not see any breaks in service.
- Group idea
  - Mobile use in cell Ci
  - Collection of cells surrounding Ci - Gi
    - The current group of the mobile user.
  - Message destined for the mobile user is multicast to all the cells in Gi.
  - Predictive buffering
    - Anticipating the arrival of the mobile user
    - Prebuffering

Seamless Communication

- Shape and composition of a group determined by
  - Set of neighboring cells that can be accessed from the present one;
  - The speed at which the mobile user moves between cells.
  - The direction of motion.
- QoS Parameter: Probability of Seamless Communication
  - Drawback
    - Enormous overhead - storage space required at MSS.
  - Predict future movements of a mobile user
    - Estimate the latency of the user in a cell, begin prebuffering at neighboring cells only after a certain amount of time.
    - Restrict the group membership based on observed user behavior.

Seamless Communication

- Implications for Network Design
  - Able to track users as they move.
  - Predict future position of the users in order to define groups.
  - MSS nodes cannot implement loss profiles.
  - Individual MSS node is unaware of the past history of a connection.

Architectural and Internetworking Issues

- Network Design Issues
  - ☒Develop a mobile network architecture that provides a simple way to satisfy the QoS requirements of diverse applications.
  - ☒Mobile network as an extension of ATM networks
    - Architecture and protocols compatible with ATM
    - Minimum protocol processing at the interface
    - Several drawbacks:
      - Situation1:
        - » Close connections - undesirable
        - » Renegotiate QoS parameters - undesirable
      - ATM cells be delivered out-of-order
      - No support for deciding appropriate multicast groups as users move about.
      - Paths needs to be updated (i.e., modify tables in ATM switches.)

Architectural and Internetworking Issues

- Our Approach
  - Three-level hierarchy:
    - Lowest level - MH
    - Next level - MSS - one to each cell
      - Provide MH with connectivity to the underlying network and to one another.
    - MSSs controlled by an assigned supervisor machine - Supervisor Host (SH)
      - Connected to the wired network
      - Handles most of the routing and other protocol details
      - Maintains connections for MH
      - Handles flow-control
      - Responsible for maintaining negotiated QoS

Architectural and Internetworking Issues

☒Several Advantages:

- SH tracks users within its domain and maintains group information for each user.
  - Communication between SH and MH takes place via packets containing sequence numbers. (Handle duplicate or out-of-order data)
- QoS parameters set for the mobile part of the connection (between MH and SH) and another defined for the high-speed fixed network.
  - Loss profile implemented transparent to the fixed network.
  - SH responsible for deciding which parts of a data stream to discard based upon user specified loss profiles.
  - SH manages all aspects of a user connection so long as the user is within its domain.

Architectural and Internetworking Issues

- Proposed Architecture
  - Average density of mobile users per microcell
  - Cellular network architecture
    - Microcells - diameter of the order of 100m
    - Picocells - diameter of the order of 10m
    - Advantage of a smaller cell size
      - Higher throughput
      - Greater frequency reuse
      - Low-power transmitters
    - Drawback
      - Faster inter-cell user mobility
      - Host of routing, tracking and hand-off problems.

Architectural and Internetworking Issues

☒Difference from traditional microcellular architectures

- Network intelligence implemented in MSS nodes.
  - Not scalable
- Three-level hierarchy do much more than switching and tracking.
  - SH maintain QoS guarantees for mobile users.
  - MSS and SH responsible for flow-control.
  - More cost effective and easily scalable.

Architectural and Internetworking Issues

- Internetworking
  - IPIP (“IP-within-IP”) protocol.
  - VIP (Virtual Internet Protocol)
- Connection management
  - Sequence number
  - MSS nodes - communication devices with large caches.
  - Connection maintenance - responsibility of the SH

Architectural and Internetworking Issues

- Architectural support for satisfying QoS requirements
  - Connection between the MH and a fixed host broken into:
    - MH and SH
    - SH and fixed host.
  - Shield fixed nodes from idiosyncrasies of the mobile environment.
  - Handoffs between two SHs
    - First approach
      - old SH anticipates the move and informs the new SH who then begins negotiations
    - Second approach
      - set up static connections between neighboring SHs

Traffic Classes at the Transport Layer

- Advantage of providing different traffic classes for the mobile environment:
  - SH responsible for translating between the framing protocol of the mobile environment and the high-speed network environment.
  - Ability to provide users with differential service based on the type of application.
  - SH behaves as the end-point for the service from the point of view of the service provider.
  - Renegotiation of QoS handled between MH and SH

Traffic Classes at the Transport Layer

- Connectionless Service
  - Like UDP, no guarantee of correct delivery.
- Connection-oriented Service
  - Guaranteed in-order delivery of packets.
- Variable Bit-Rate - Priority
  - Tries to provide bounded delay and bounded loss service.
  - Best-effort service class.
- Constant Bit-Rate - Priority
  - Best effort guarantee with increasing losses as the available bandwidth shrinks.
- Constant Bit-Rate - Critical
  - Low bit-rate service takes priority over all others and suffers no loss or queueing delays.