

PROGRAMMA  
ARCHITETTURE AVANZATE DI NETWORKING E SISTEMI WIRELESS  
(ADVANCED NETWORK ARCHITECTURES AND WIRELESS SYSTEMS)  
A.A. 2005/2006

QOS-AWARE APPLICATION REQUIREMENTS

- ✓ Elastic and Real-Time Applications
- ✓ Taxonomy of Real-Time Applications
  - Tolerant and Intolerant
  - Adaptive and Nonadaptive
  - Delay Adaptive and Rate Adaptive

INTEGRATED SERVICES MODEL (INTSERV)

- ✓ Service Classes
  - Guaranteed QoS Service
  - Controlled Load Service
- ✓ IntServ Mechanisms
  - Flow Descriptor
  - Admission Control
  - Resource Reservation
  - Packet Classifier
  - Packet Scheduler
- ✓ Resource reSerVation Protocol (RSVP)
- ✓ RSVP Overview
  - Routing Protocol Independent
  - Sender Advertisements
  - Receiver-Issued Reservations
  - Soft State Design
- ✓ RSVP Versus Conventional Signalling Protocols
- ✓ RSVP Setup Messages
  - PATH Message
  - RESV Message
- ✓ An IntServ Implementation Framework
- ✓ IntServ Scalability Issues

DIFFERENTIATED SERVICES MODEL (DIFFSERV)

- ✓ Basic Principles
  - Resource allocation to aggregated traffic rather than individual flows
  - Guarantees by provisioning rather than reservation
  - Classification and marking on the edge and class-based forwarding in the core

- Define forwarding behaviors not services
- ✓ Service and Forwarding Treatment Concepts
- ✓ Per-Hop Behavior
- ✓ Service Level Agreement (SLA) and Traffic Conditioning Agreement (TCA) concepts
- ✓ DiffServ Architectural Model
  - Classifier
  - (Re)Marker
  - Meter
  - Shaper
  - Dropper
  - Scheduler
- ✓ Per-Hop Behavior
  - Default PHB
  - Class-selector PHB
  - Expedited Forwarding (EF) PHB
  - Assured Forwarding (AF) PHB

#### NETWORK CALCULUS BASIC ELEMENTS

- ✓ What is Network Calculus?
- ✓ Backlog and Virtual Delay
- ✓ Arrival Curve Concept
- ✓ Min-Plus Convolution and its Properties
- ✓ Arrival Curves and Min-Plus Convolution
- ✓ Service Curve Concept
- ✓ Backlog and Delay Bounds
- ✓ Relationship Among the various Functions
- ✓ The Composition Theorem
- ✓ Tandem of Routers
- ✓ Pay Burst Only Once
- ✓ Concatenation of GPS Routers
- ✓ The Packetizer

#### PACKET SCHEDULING ALGORITHMS

- ✓ Network and Traffic Models
- ✓ Desirable Properties of a Scheduler
  - isolation of flows
  - end-to-end delay guarantees for individual flows
  - high utilization of the output link bandwidth
  - fairness
  - simplicity of Implementation
  - scalability

- ✓ First Road Map for Scheduling Algorithms
  - Work conserving and non-work conserving
  - Sorted priority and frame based
- ✓ FIFO, Priority Queueing, Round Robin scheduling and Weighted Round Robin scheduling algorithms
- ✓ Generalized Processor Sharing (GPS) scheduling algorithm
- ✓ GPS Properties
- ✓ Approximating GPS with Weighted Fair Queueing (WFQ)
- ✓ Time Complexity of WFQ
- ✓ WFQ Service Curve Offered to a Flow
- ✓ WFQ and IntServ
- ✓ Concatenation of WFQ Routers
- ✓ Reservation Setup with RSVP
- ✓ packet Approximation of GPS
  - Sequence Number Computation
  - Virtual Time computation
- ✓ Worst-case Fair weighted Fair Queueing ( $WF^2Q$ )
- ✓ Deficit Round Robin (DRR)
- ✓ DRR Time Complexity

#### MULTIPROTOCOL LABEL SWITCHING (MPLS)

- ✓ Factors which led to the development of MPLS
  - Integration of IP over ATM
  - Extending Routing Functionality
- ✓ Basic MPLS Concepts
  - Control and Forwarding in Traditional IP Routing
  - Forwarding Equivalent Classes (FEC)
  - Conventional IP Routing Reformulated
- ✓ MPLS Architecture
  - Control Component (Plane)
  - Data or Forwarding Component (Plane)
- ✓ MPLS Forwarding Component
  - Frame-mode MPLS Operation
  - Cell-mode MPLS Operation
  - Label Stack
- ✓ MPLS Control Component
  - Label Assignment and Allocation
- ✓ From Label Switching to Label Switched Paths
- ✓ Penultimate hop popping
- ✓ LDP - Label Distribution Protocol
- ✓ MPLS Loop Detection and Prevention
- ✓ MPLS Support of IntServ and DiffServ

- ✓ Constrained-Based Routing
- ✓ Type of Constraints
- ✓ Constrained Shortest Path First (CSPF)
- ✓ Support for constraint-based routing
- ✓ MPLS explicit routing capability
  - RSVP Extensions
  - CR-LDP (Constrained Routing)
  - OSPF Extensions
- ✓ Application to
  - Traffic Engineering
  - Fast Rerouting
  - QoS

#### VPN - VIRTUAL PRIVATE NETWORKS

- ✓ What is a VPN?
- ✓ VPN Implementation Technologies
- ✓ VPN Topology Characterization
  - Hub-and-spoke topology
  - Redundant hub-and-spoke topology
  - Partial mesh topology
  - Hybrid topology
- ✓ VPN Business Categorization
  - Intranet VPN
  - Extranet VPN
- ✓ Peer-to-peer VPN Model
- ✓ MPLS/VPN Architecture
- ✓ Overlapping VPN
- ✓ Route Target
- ✓ Propagation of VPN Routing Information in the Provider Network
  - BGP Extended Community Attribute
  - Configuration of Import and Export Policies
- ✓ Characteristics of the mechanism used by BGP/MPLS VPN to control intersite connectivity
- ✓ VPN-IP Addresses
  - Route Distinguisher (RD)
  - RD usage in an MPLS/VPN
- ✓ Multiple Customer Within the Same VPN
- ✓ Enhanced BGP Decision Process for VPN-IPv4 Prefixes
- ✓ Impact of Complex VPN Topologies on Virtual Routing Tables
- ✓ Advanced MPLS/VPN Topologies

## QUALITY OF SERVICE (QoS) SUPPORT IN WIRELESS NETWORKS

- ✓ A Taxonomy of Wireless Networks
- ✓ Wireless as an Access Technology
- ✓ Wireless Technology Application Areas
- ✓ Traditional WLAN Topologies
- ✓ WiFi Hot Spots
- ✓ QoS Provisioning in Wireless Networks
- ✓ Wireless Link Characteristics
- ✓ Impact on QoS
- ✓ MAC and QoS

## IEEE 802.11 STANDARD

- ✓ IEEE 802.11 Standard Scope
- ✓ PHY Modes and Rates
- ✓ Basic Service Set (BSS)
- ✓ Extended Service Set (ESS)

## IEEE 802.11 MAC

- ✓ Distributed Coordination Function (DCF)
- ✓ Exponential Backoff
- ✓ DCF with RTS/CTS
- ✓ Extended IFS (EIFS)
- ✓ MAC Overhead and PHY Rates
- ✓ Point Coordination Function (PCF)
- ✓ PCF Polling Management
- ✓ QoS Support in Legacy IEEE 802.11
- ✓ QoS Enhancement to 802.11
- ✓ QoS Basic Service Set (QBSS)

## IEEE 802.11e MAC

- ✓ Transmission Opportunity (TXOP)
- ✓ Enhanced Distributed Channel Access
- ✓ EDCA Service Model
- ✓ HCF Controlled Channel Access (HCCA)
- ✓ QoS Negotiation and Association
- ✓ Controlled Access Period (CAP)
- ✓ Scheduling Requirements
- ✓ From the Standard
  - Not Defined in the Standard
  - The Reference Scheduler

## BROADBAND WIRELESS ACCESS

- ✓ Broadband Wireless Access Goals
- ✓ IEEE 802.16 Standards
- ✓ Reference Topology
- ✓ Physical Layer (802.16 WirelessMAN-SC)
  - Burst Transmission - Single Carrier Modulation)
  - Time Division Duplexing (TDD)
  - Frequency Division Duplexing (FDD)
  - Adaptive PHY
- ✓ IEEE 802.16 MAC
- ✓ TDD Downlink Subframe
- ✓ FDD Downlink Subframe
- ✓ FDD Support for Half-Duplex Stations
- ✓ Uplink Subframe
- ✓ Bandwidth Requests (Per Connection)
- ✓ Grants (Per Subscriber Station)
- ✓ QoS Support
- ✓ Scheduling Services
  - Unsolicited Grant Service (UGS)
  - Real-Time Polling Service (rtPS)
  - Non- Real-Time Polling Service (nrtPS)
  - Best Effort Service

## UMTS - roots, status and perspectives

- ✓ Radio basics
  - Access modes
  - Code division multiple access
- ✓ Radio resource management
  - Structure and use of the physical channels
  - Logical channel definition
  - Code management
- ✓ Core network, mobility and switching
  - Architecture
  - Protocol scheme
  - Basic functions, handover call set-up, location update
- ✓ Network and Service control
- ✓ Engineering issues
  - Radio coverage and dimensioning
  - Frequency allocation
  - Access network

## SIMULATION

- ✓ Analyzing a network through simulation
- ✓ Discrete event simulators
- ✓ Preparing the input: random number generation
- ✓ Steady-state properties
- ✓ Estimating the confidence of the output
- ✓ The Network Simulator ns2
  - Overview
  - Interacting with ns2
  - Writing code for ns2