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Evolution of Network Technologies and its Impact on Traffic Engineering

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ITU/ITC Regional Seminar on Network Evolution to Next Generation Networks
and Fixed Mobile Convergence for CEE, CIS and Baltic States
Moscow, April 27-30, 2004

Outline

1 Network Developments

2 Service Developments

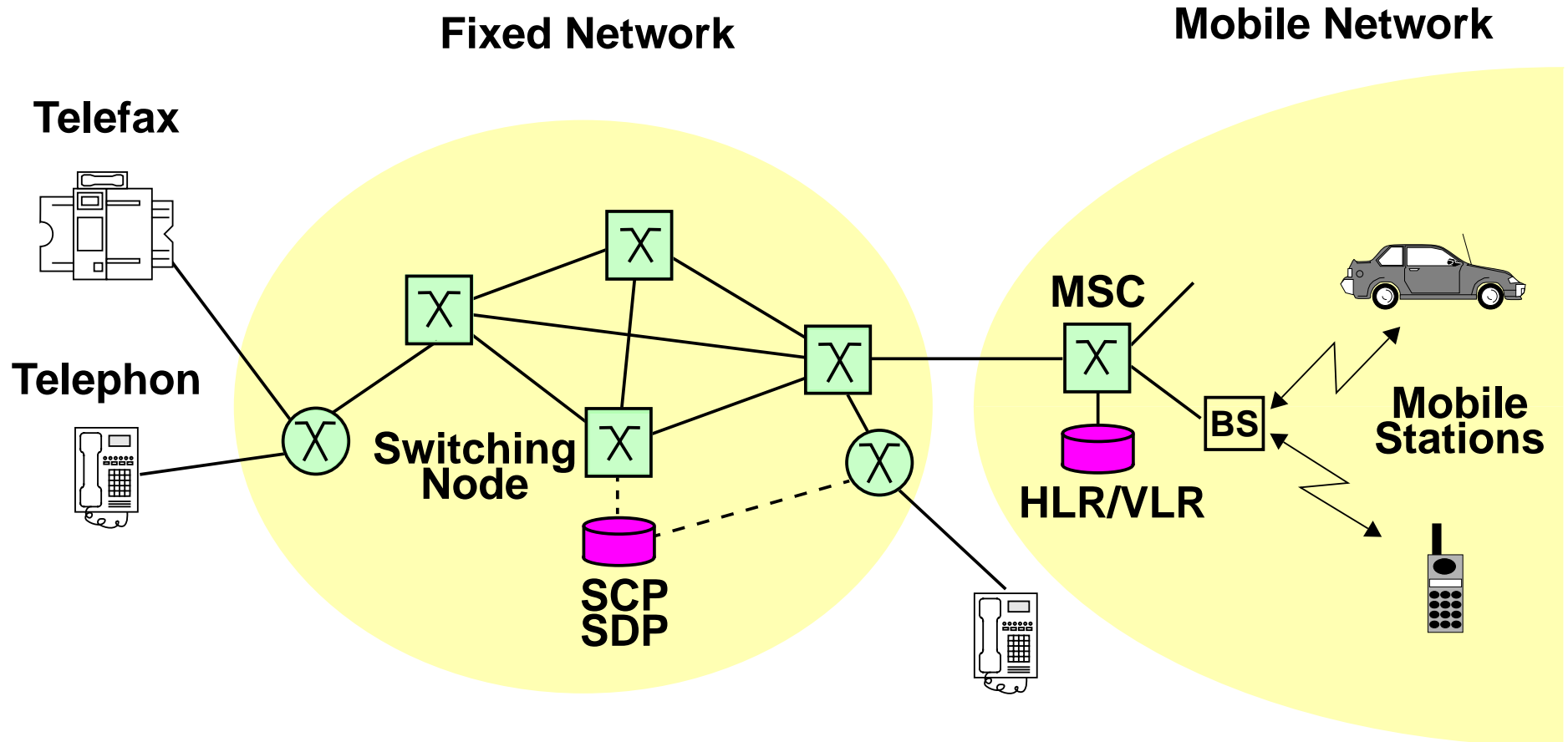
3 Quality of Service

4 Conclusion: General Observations and Research Areas

1 Network Developments

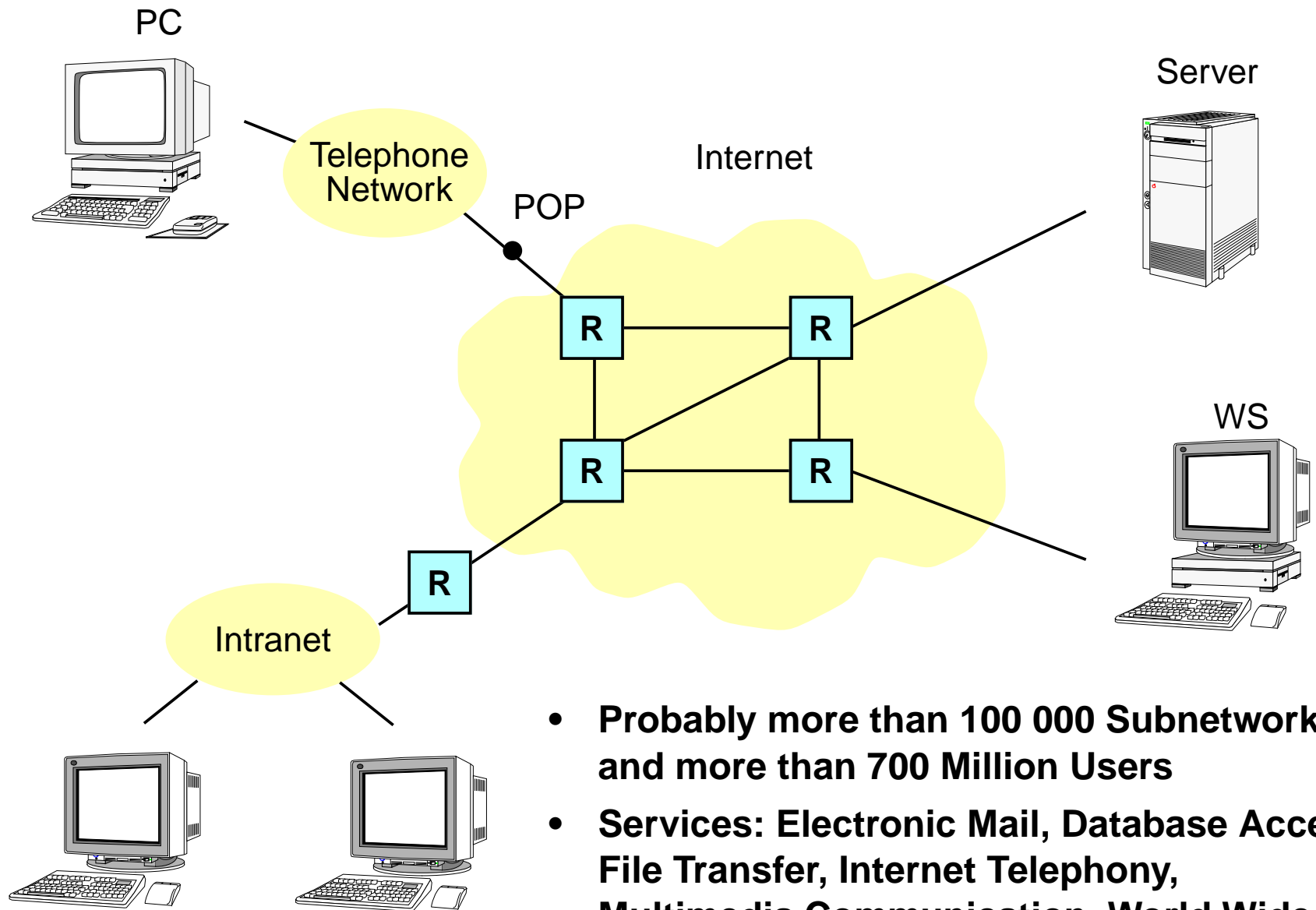
- **Telecommunication Networks**
- **Computer Communication Networks**
- **Technological Developments**

Telecommunication Networks



- 1200 Million Subscribers (Fixed Network) Annual Growth 10%
- 1400 Million Subscribers (Mobile Networks) Annual Growth 50%
- Intelligent Network Services (IN)

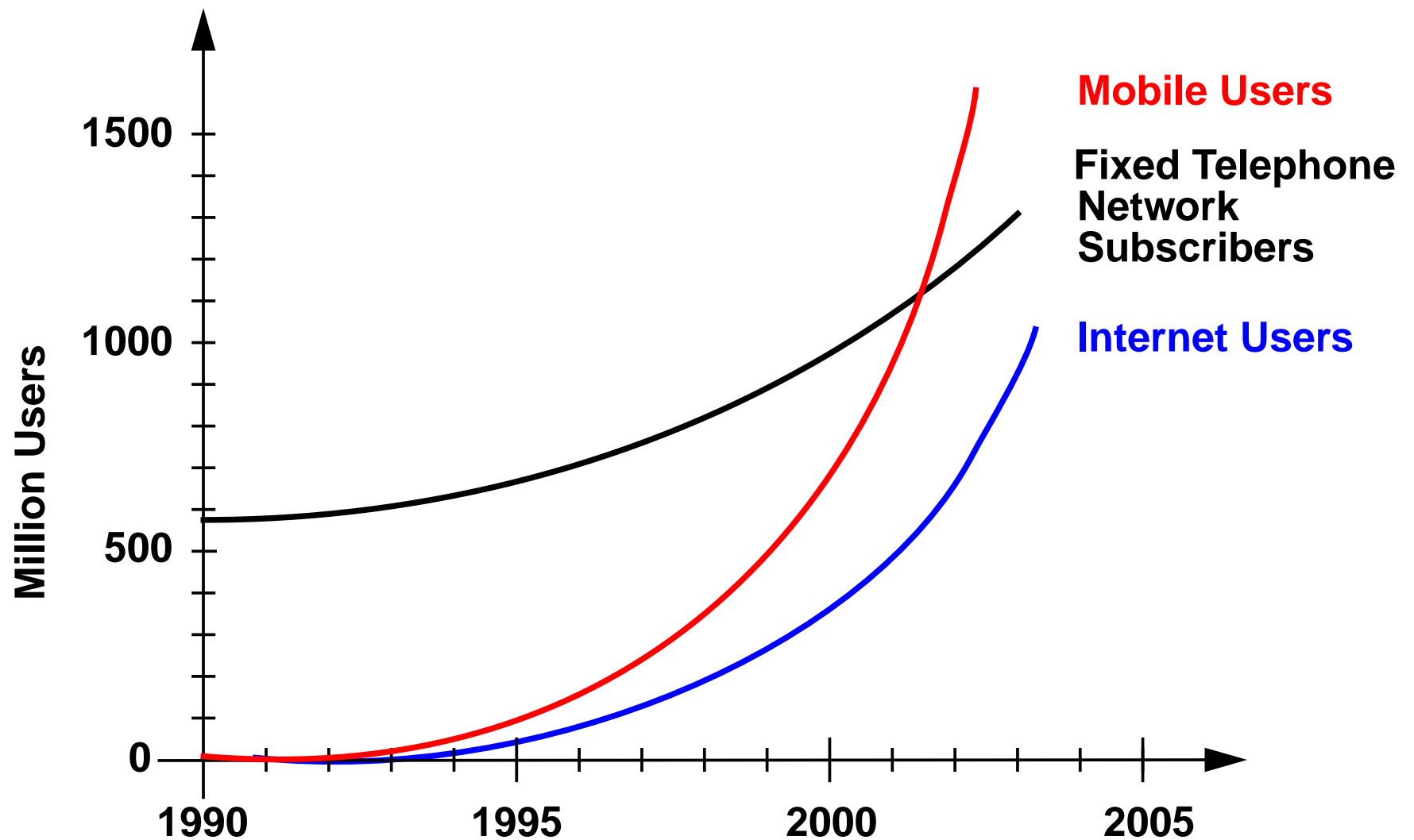
Computer Communication Networks



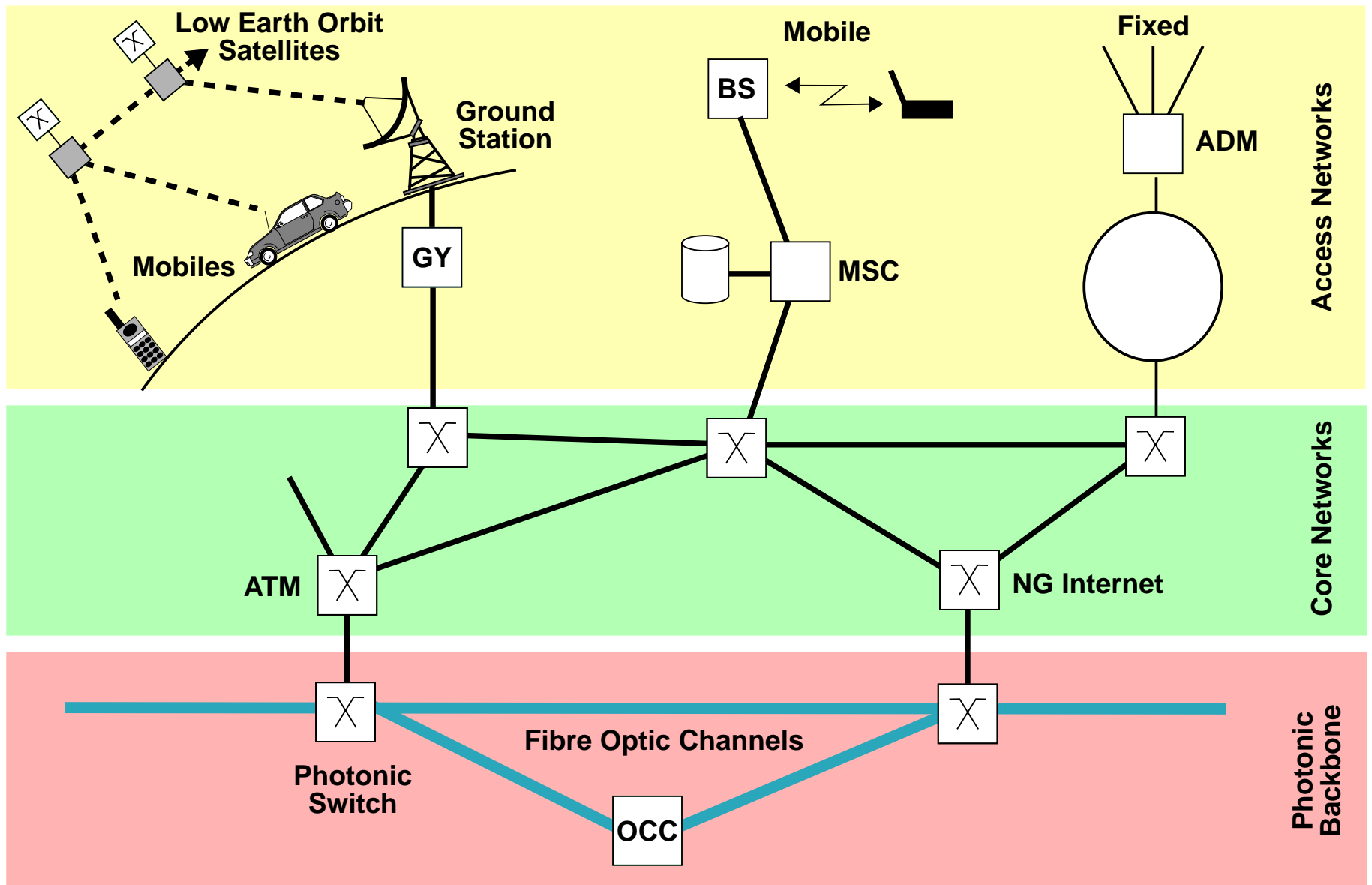
- **Probably more than 100 000 Subnetworks and more than 700 Million Users**
- **Services: Electronic Mail, Database Access, File Transfer, Internet Telephony, Multimedia Communication, World Wide Web, Peer-to-Peer**

Development of User Numbers

Source: ITU News 2/2002



Technological Developments



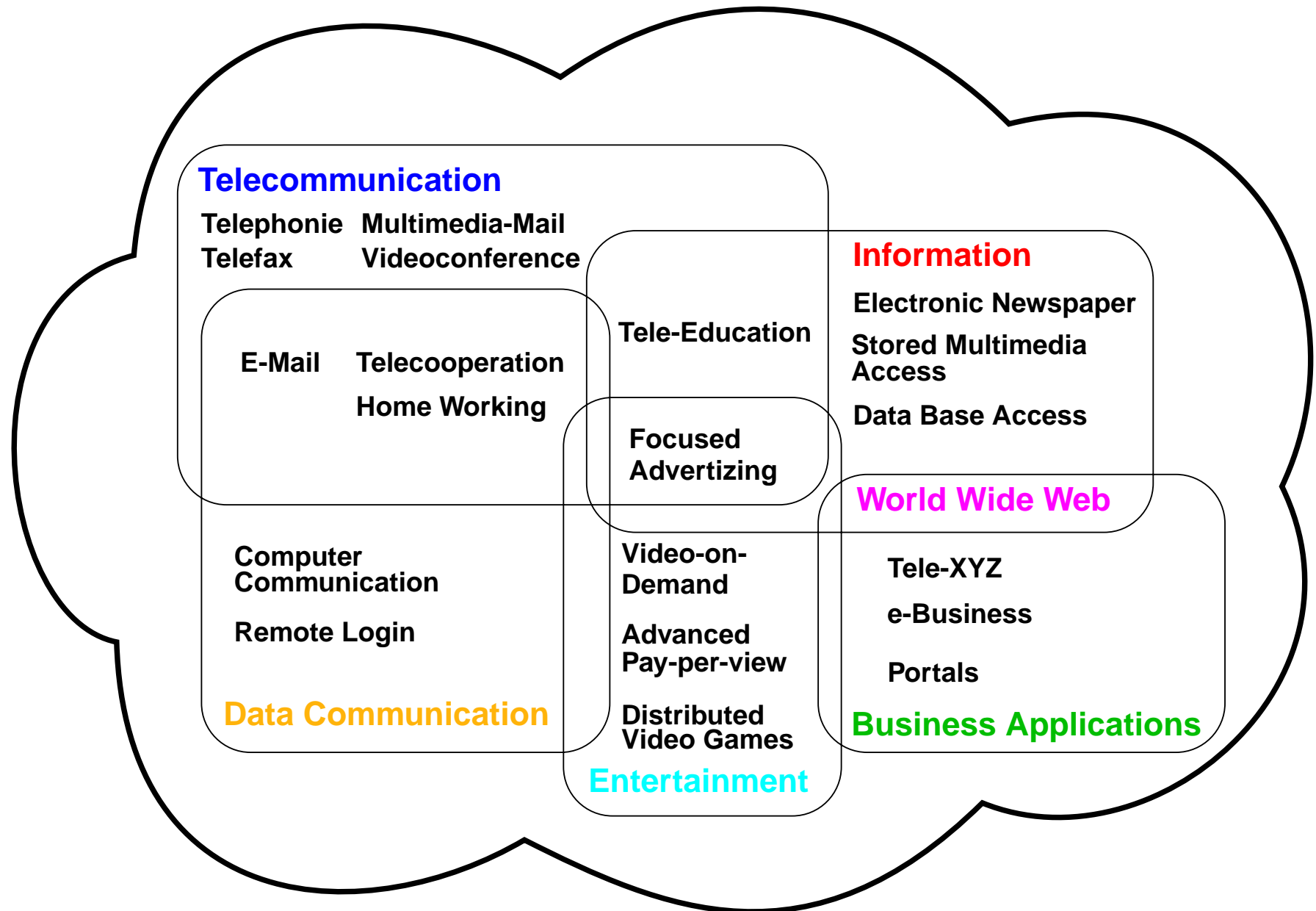
1 Network Developments

- **Telecommunication Networks**
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2 Service Developments

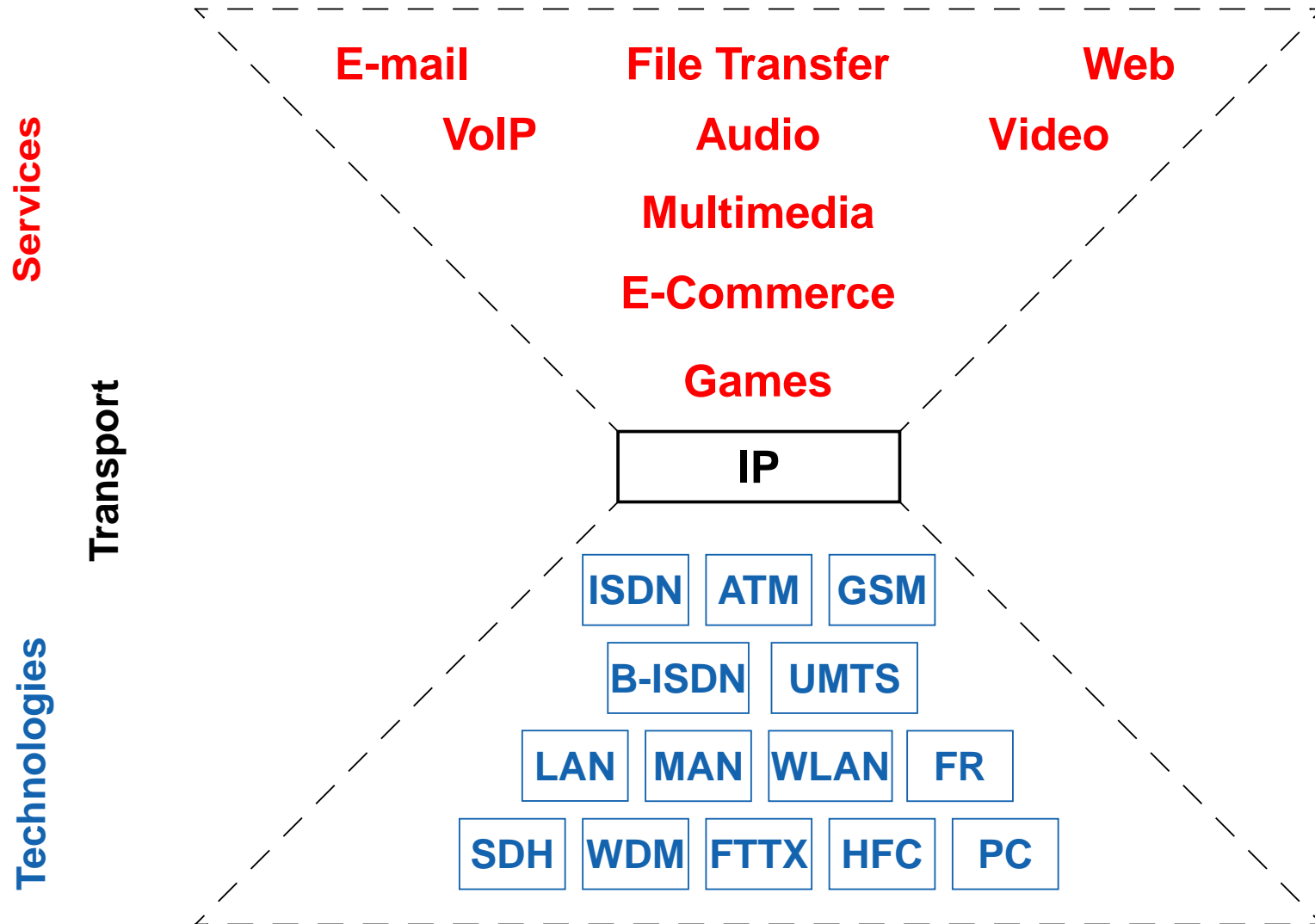
- **Service Categories**
- **Service and Technology Convergence**
- **Application Scenarios**

Service Categories



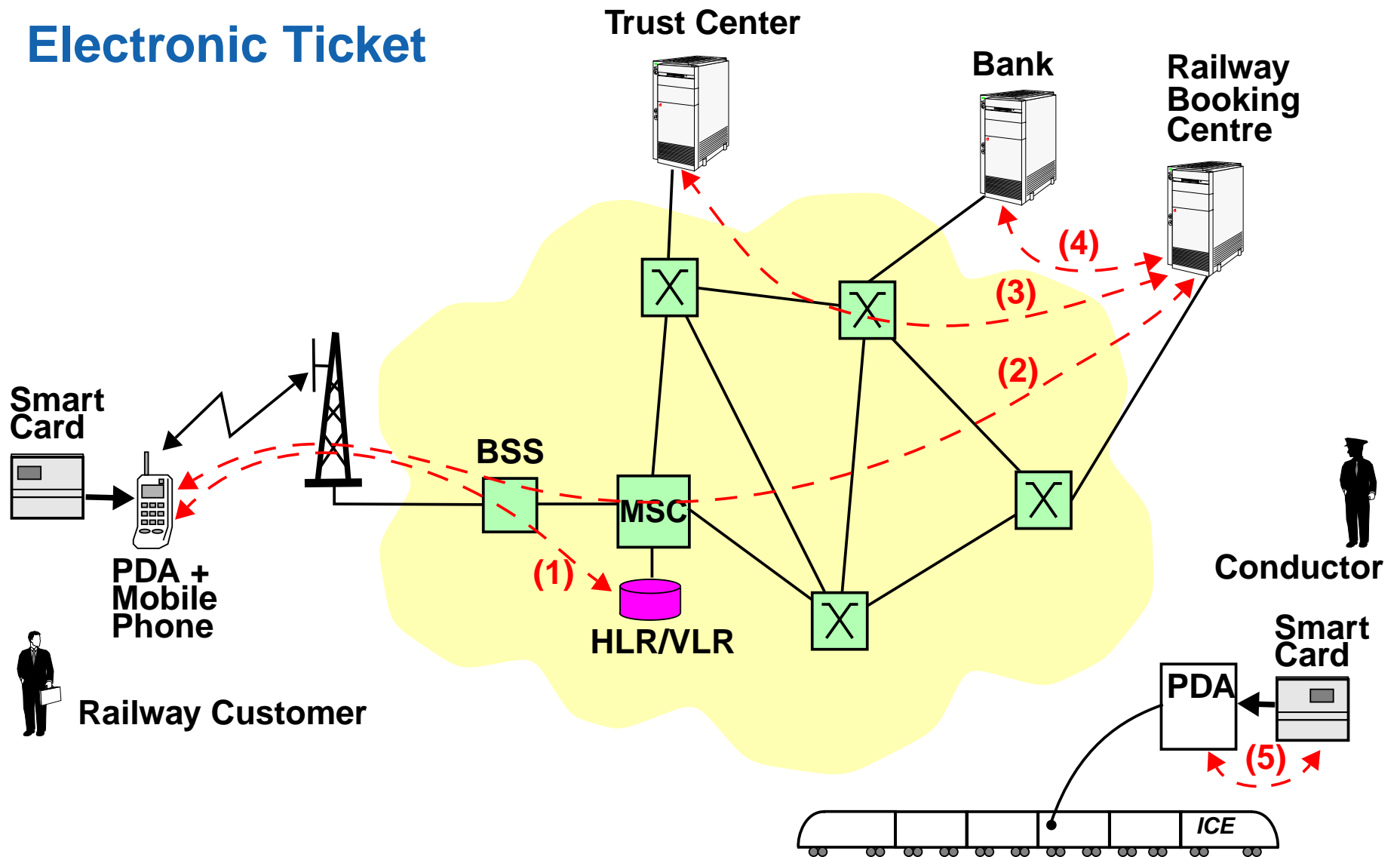
Development Scenario

Service and Technology Convergence



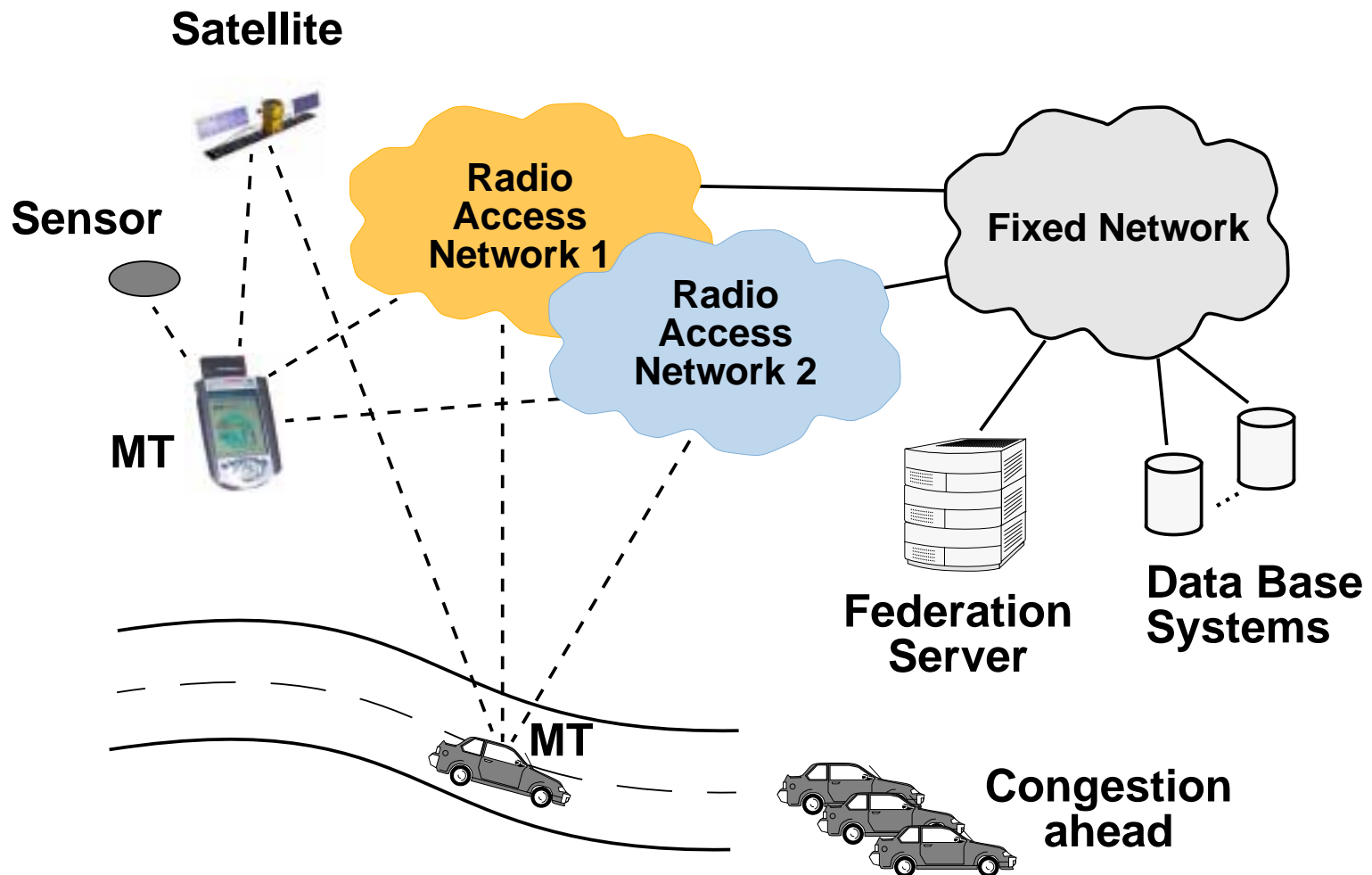
Application Scenario

Electronic Ticket



Application Scenario

Navigation Support



1 Network Developments

- **Telecommunication Networks**
- **Computer Communication Networks**
- **Technological Developments**

2 Service Developments

- **Service Categories**
- **Service and Technology Convergence**
- **Application Scenarios**

3 Quality of Service (QoS)

- **Definition of QoS**
- **Traditional Solutions**
- **Challenges for New Services**

Quality-of-Service (QoS) Definition

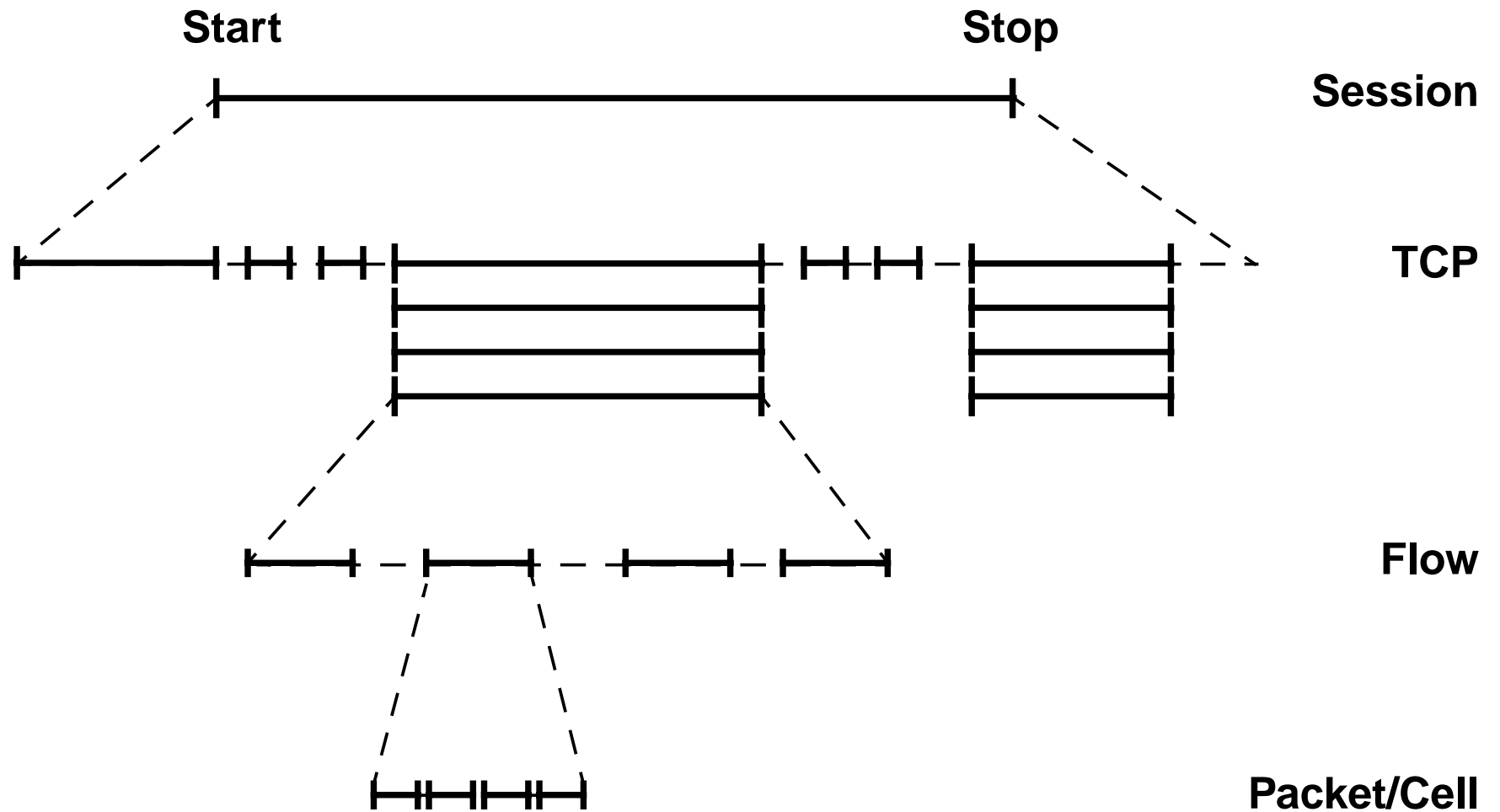
- QoS:** Entirety of all features characterizing the perception of a service (application) at the user level ("user perceivable criteria")
- Features:**
- Delay (average, peak, distribution, percentile, ...) of information
 - Loss (average, peak) of information or of a connection
 - Resolution, audibility, ... of information content
 - Reliability, dependability, availability, accountability, security of service
- Quantifiable QoS (Q2S):** Measurable value ("Metric") in the widest sense

Factors Influencing QoS

Factor	Reason
<ul style="list-style-type: none">• Source Traffic	Coding Scheme, Human Factors
<ul style="list-style-type: none">• Network Resources	Capacity Limits, Network Planning
<ul style="list-style-type: none">• Operational Strategies	Resource Management
<ul style="list-style-type: none">• Network Management	Fault Detection, Resilience

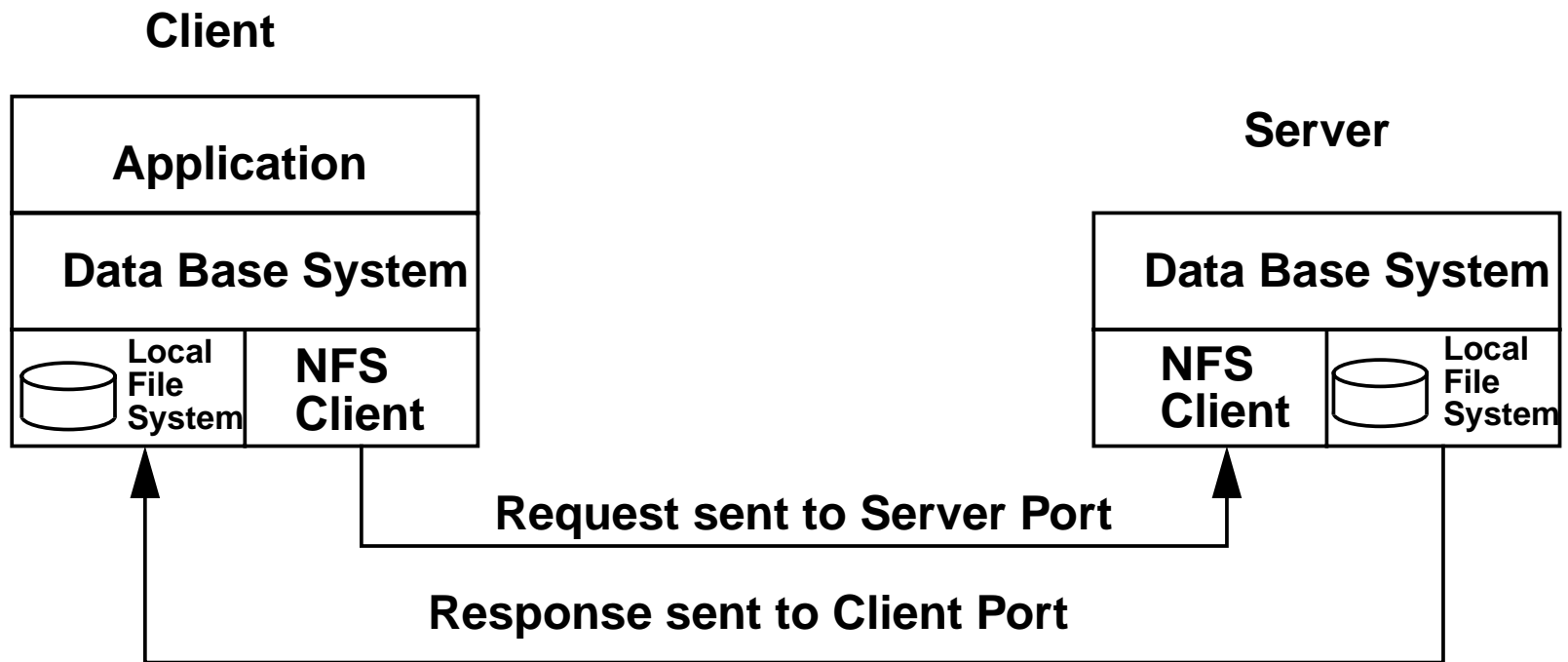
Examples

Multi-Level Source Model for IP-Applications

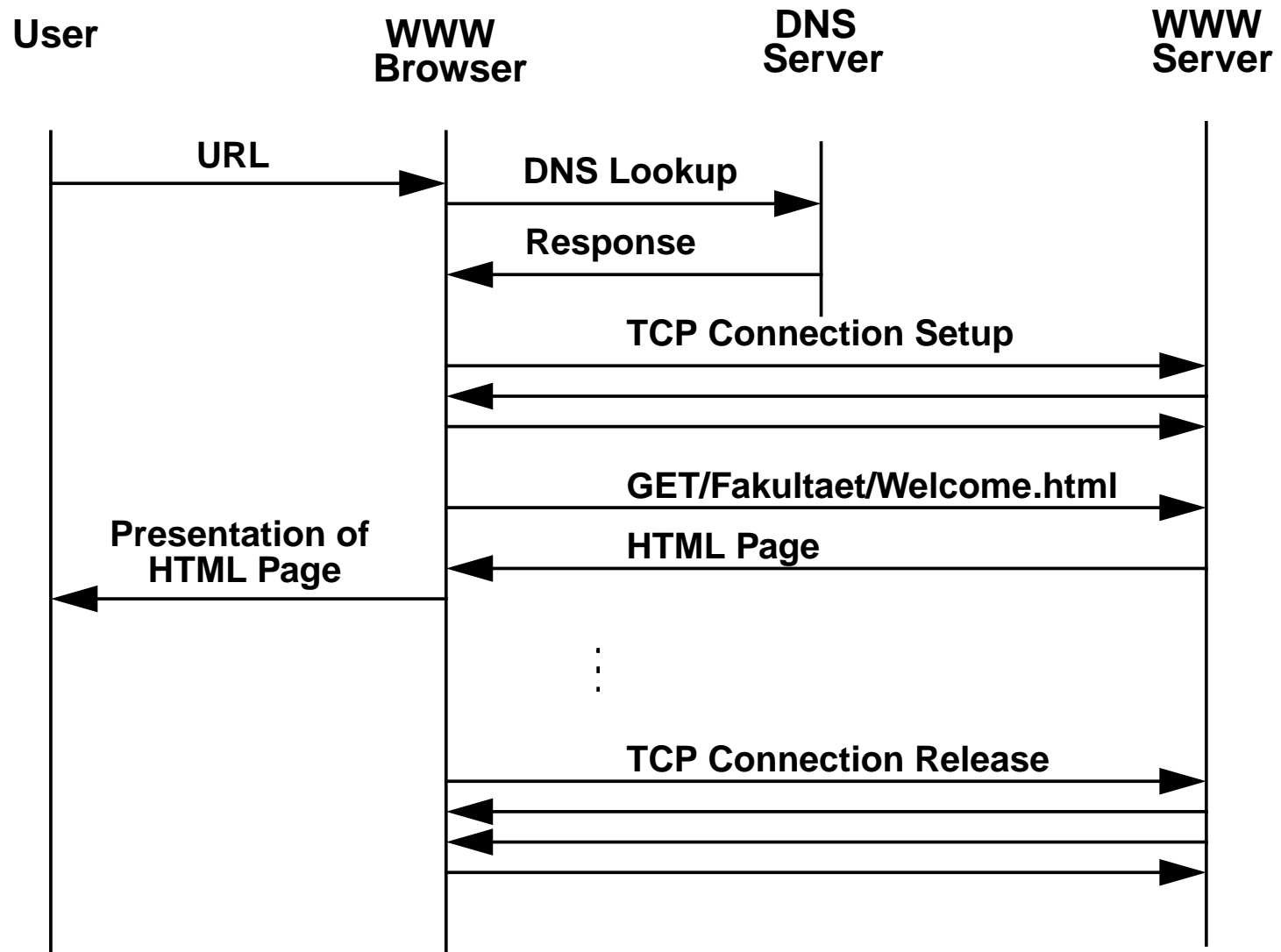


Client-Server Communication

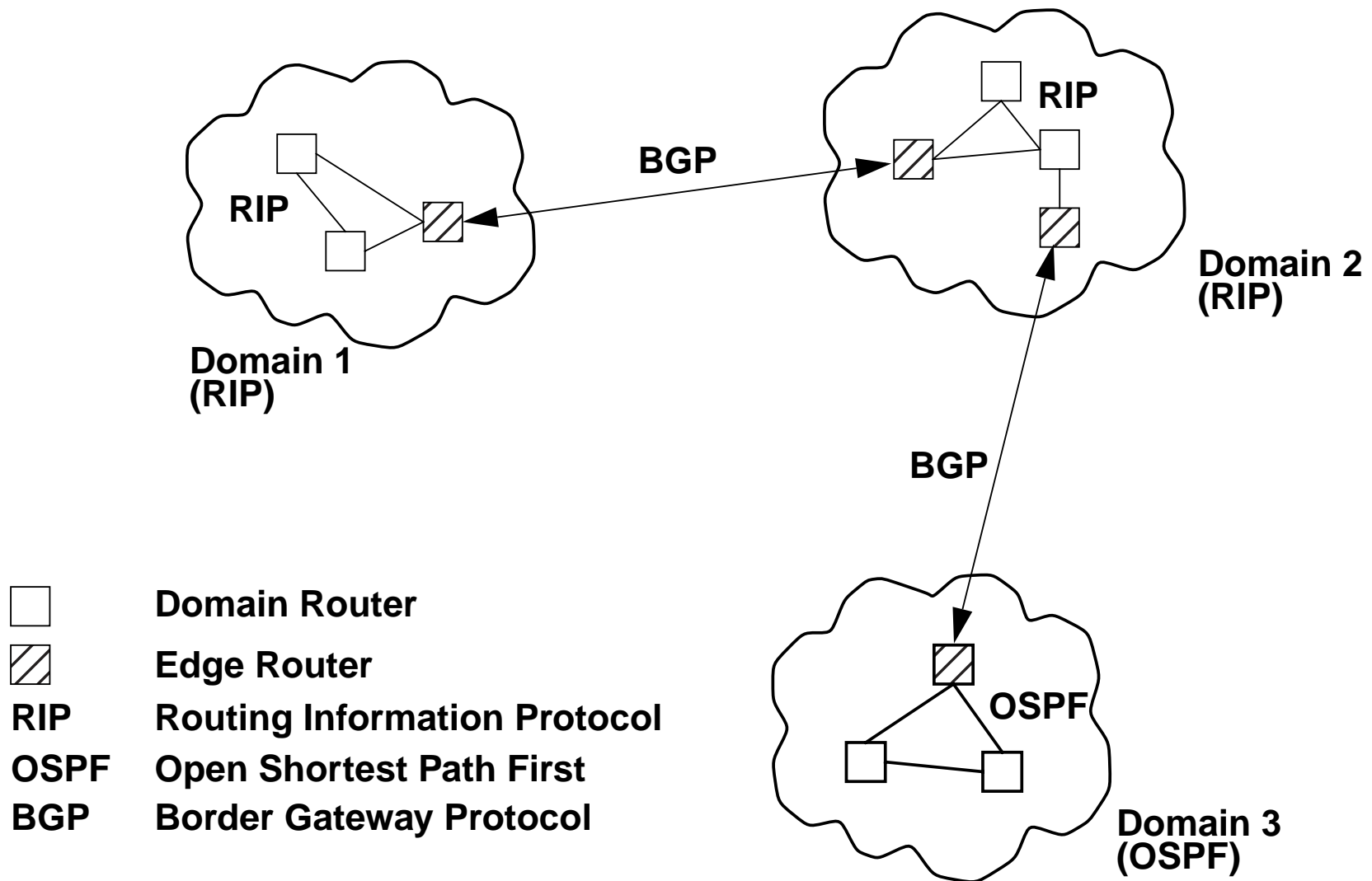
Example: Network File System (NFS)



HTTP Application

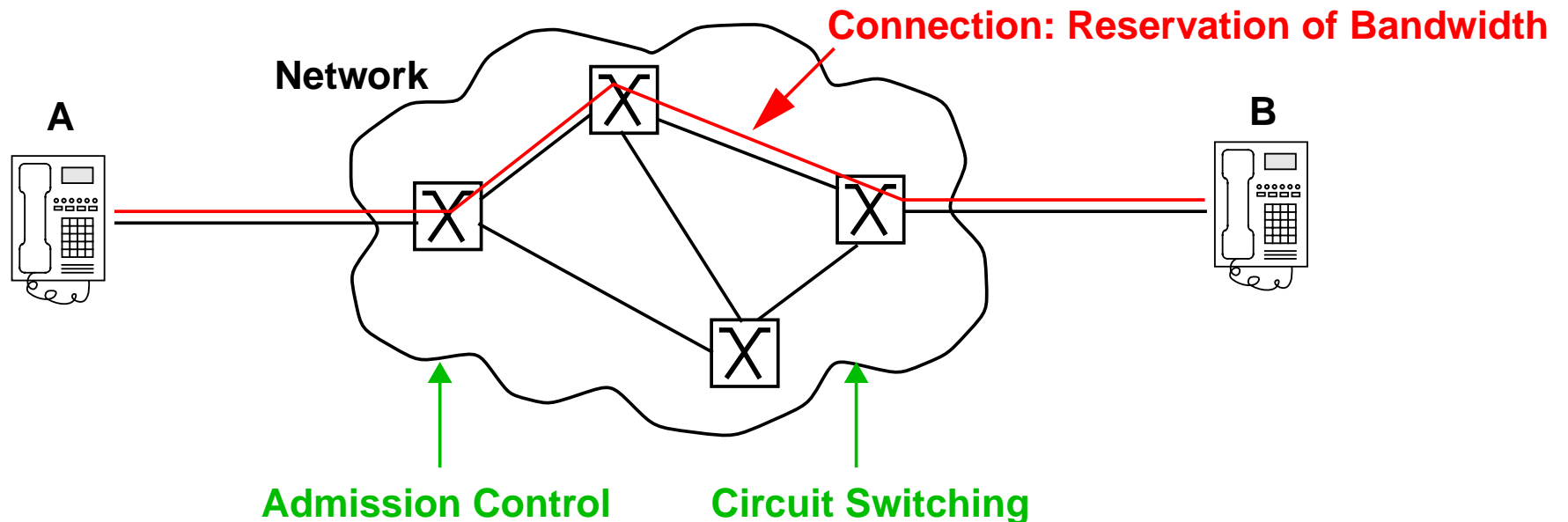


Internet Routing



Traditional Solutions

Example 1: Telecommunication Services

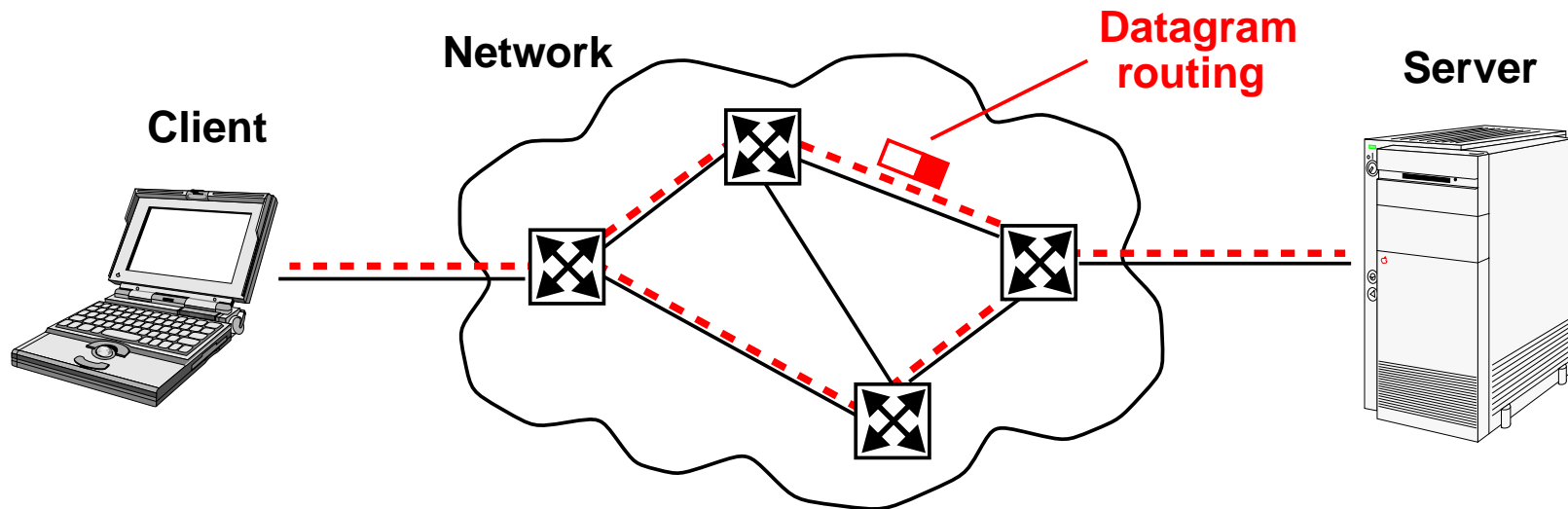


Traditional Solution is not feasible for many new applications due to:

- **Variable bitrate sources (burst traffic)**
- **Overhead for connection management (delay, state management, ...)**
- **Integration of many services with quite different characteristics**
- **Inflexibility with respect to adaptation to application requirements**
- **Cost**

Traditional Solutions

Example 2: Internet



"Best Effort Service": No admission control
No resource reservation
Unpredictable delays and losses

BES is not feasible for many new applications due to:

- No guarantees on QoS

Traffic Classes in the IntServ-Model

- **Guaranteed Service** (similar to CBR and rt-VBR)
- **Controlled Load Service** (similar to nrt-VBR)
- **Best Effort Service** (similar to UBR)

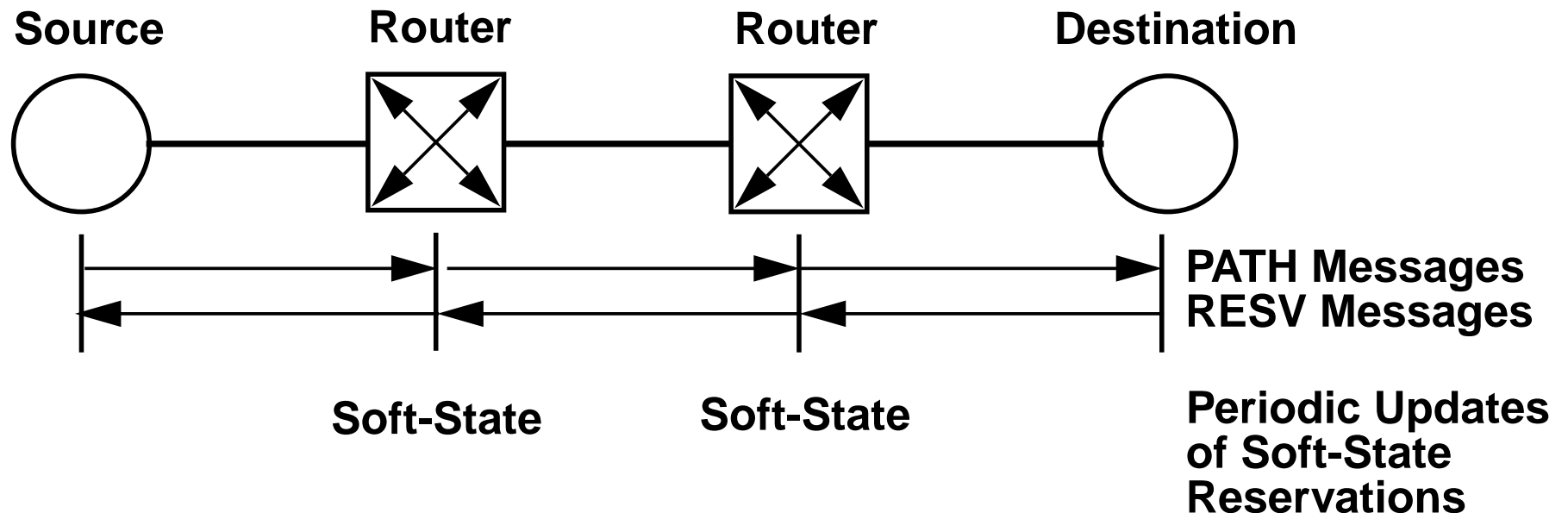
Use of RSVP

Traffic Classes in the DiffServ-Model

- **Expedited Forwarding** (Premium Service)
- **Assured Forwarding with different Priorities**

Hop-by-Hop Control

IntServ-Model



Flow Description by

Flow Specifications (FlowSpec)

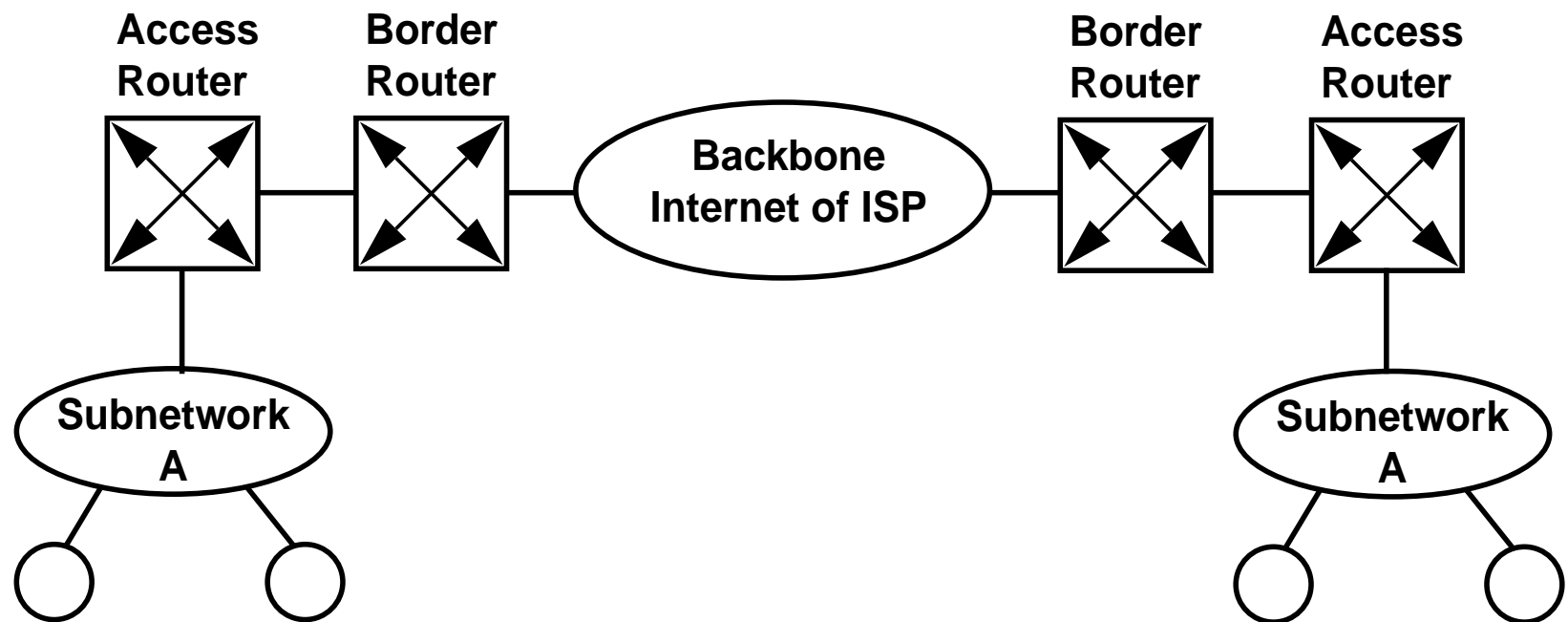
Service Class

Reserve Specification (RSpec)

Traffic Specification (TSpec)

Filter Specification (FilterSpec)

DiffServ Model



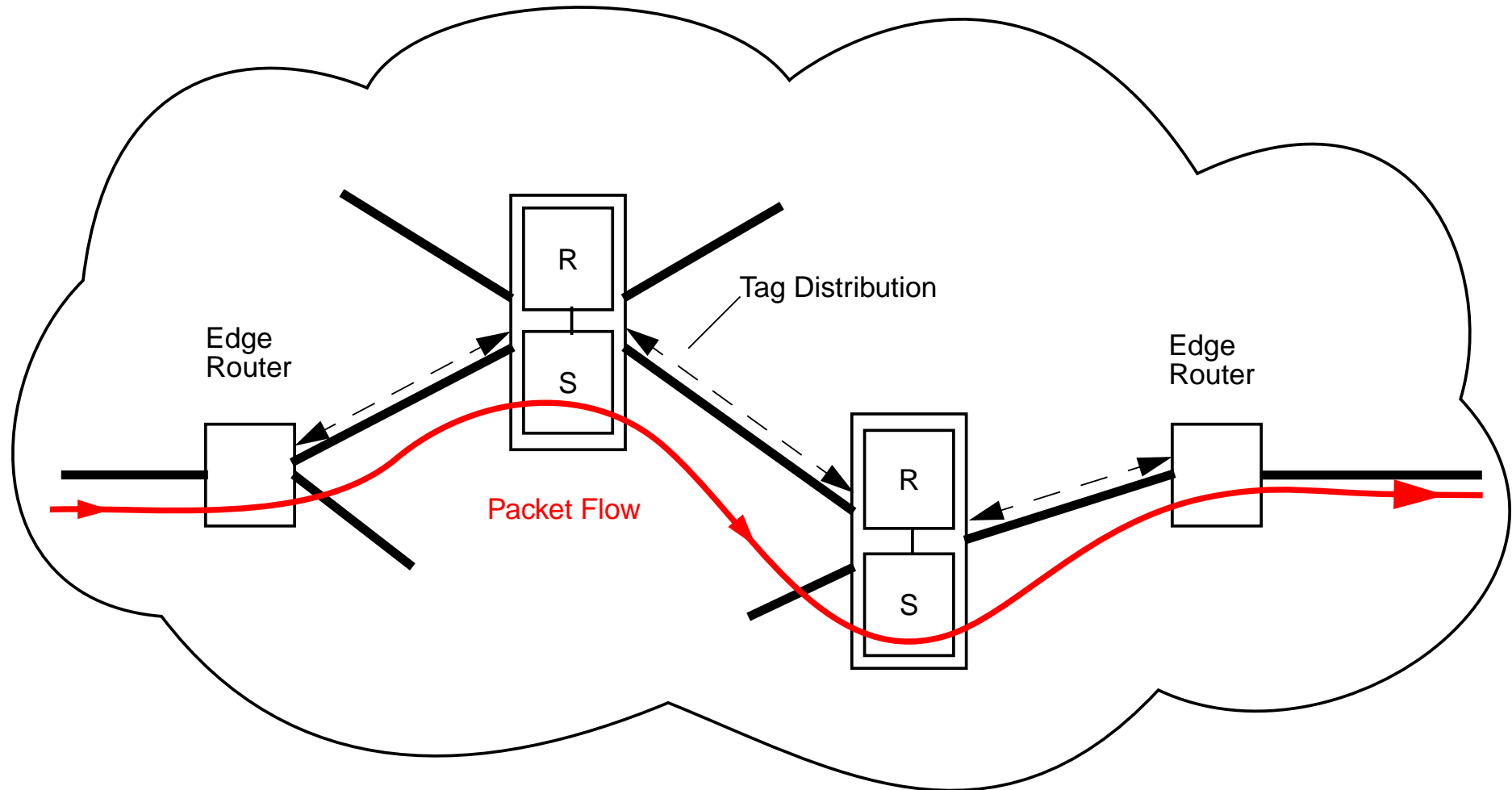
Negotiation of max. Bitrate between User and ISP for Aggregated Traffic Volumes
Classification of Traffic Class by Access Routers

Premium Service: Separate Queues and Prioritized Transport provide virtual leased Line Service
Policing Function by Border Router

Assured Service: Use of Priority to provide QoS for short Bursts
Policing Function and Packet Dropping by Border Router
Appropriate Dimensioning of Transmission Resources by ISP

Per Hop Behaviour (PHB) Routing, Marking of IP Packets within DS-Field

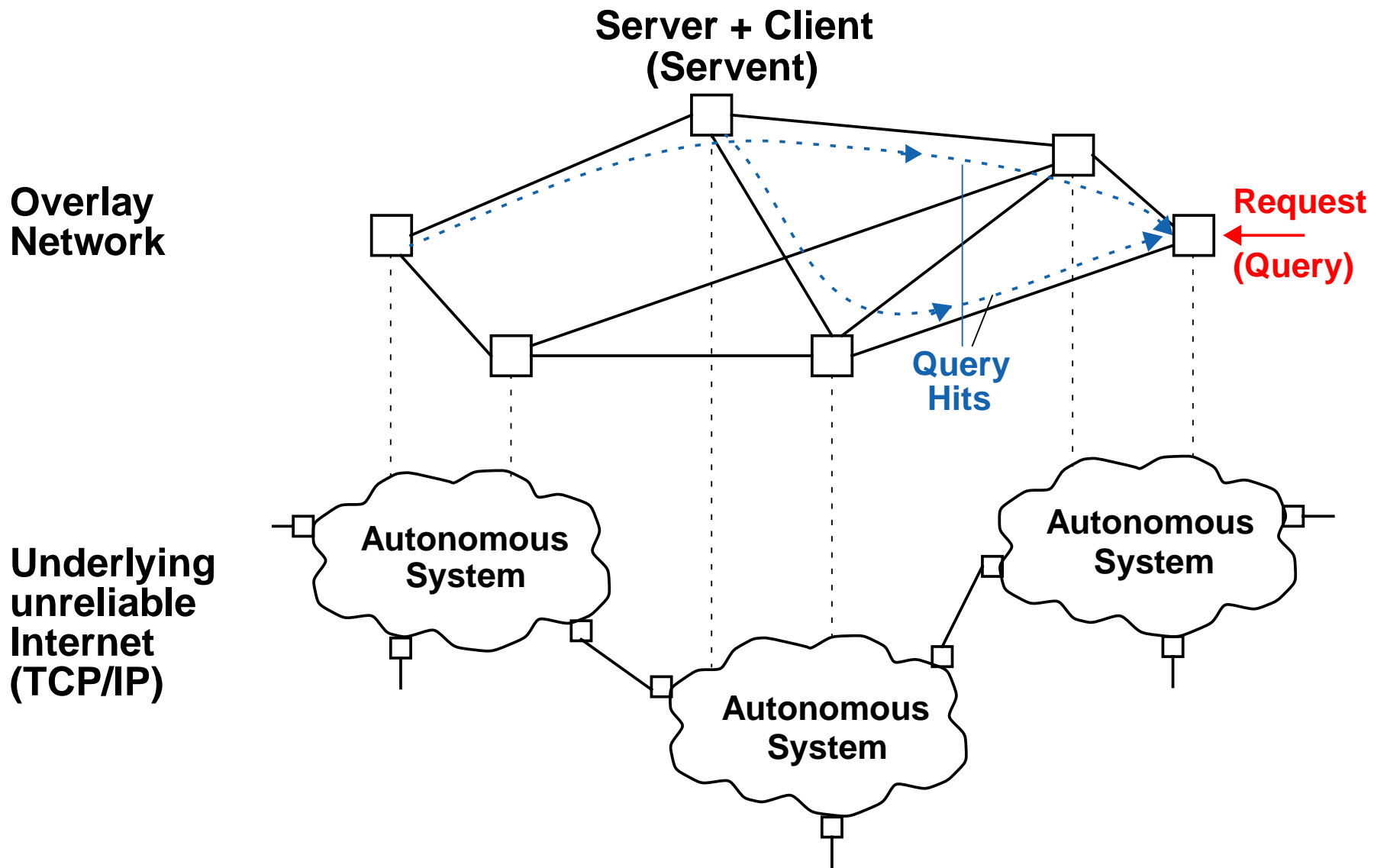
Tag Switching



- **Detection of flows**
- **Assignment of flow labels**
- **Fast switching along pathes**

➔ **State-based switching**

Peer-to-Peer File Sharing



Challenges of NG Internet with Respect to QoS

- **Tremendous increase in bandwidth demand in mobile and fixed networks for new applications**
Ahead: Japan and Rep. of Korea (70/60 % mobile Internet users; US/Europe < 10%)
Asia-Pacific Region leading in broadband penetration
- **Rapid decrease of internat. bandw. pricing from 111 TUSD (1998) to 10 TUSD (2002) for US-Japan 1Mbps link per year**
- **NG Internet Technology and broadband access**
- **Fast routing algorithms**
- **Convergence of Internet and Mobility**
- **Adaptive traffic control (e.g., for Peer-to-Peer applications)**
- **Negotiable QoS Levels and QoS guarantees**
- **Accounting and charging for highly variable bitrate services**
- **Ubiquitous computing and ad hoc communication networks**
- **Adaptation of source coding and network traffic control**
- **QoS across multiple layers and heterogeneous network technologies**

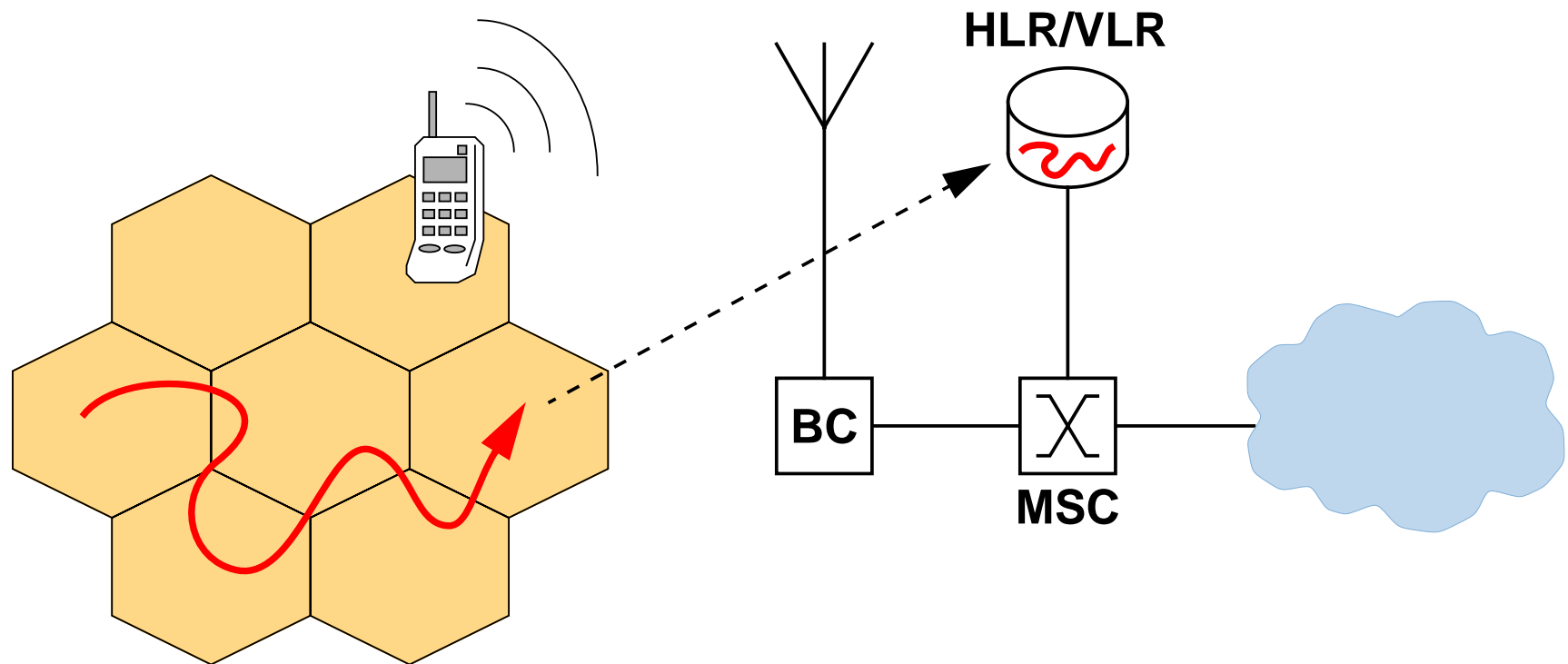
Architectures & Protocols

- **Unified Communication based on IPv6**
- **Communication across different Networks**
- **Mobility Management based on Mobile IP Concepts**
- **Dynamic Address Management**
- **Horizontal and Vertical Handover**
- **Integration of Ad Hoc Networks (infrastructureless)**
- **Middleware Concepts**
Abstraction from Underlying Network Infrastructures
- **Design & Implementation**
- **Standardization**

Mobility

- **Modelling of Mobility of Users and Data**
- **Modelling of (Communication) Traffic
-spatial and temporal**
- **Disconnected Operation (information Caching and Fuelling)**
- **Predictive Information Provision (Hoarding)**
- **Simulation Methods for Mobility**
- **Performance**

Example



- **Tracking of Location May Cause Severe Privacy Problems**
- **Similar Problems Arise from Recording of User Activities**

Research Topics - Security & Privacy

- **Protection Against Concatenation between Location Data and User Identity**
- **Methods:**
 - Pseudonymization
 - Authentication
 - Multilateral Security concepts:
Negotiation of Protection Aims and Strengths
 - Accountability and Non-Repudiation
 - Integrity
- **Security Protocol Design**

Conclusion (1): General Observations

- **Change of Paradigms in the Communication Sector**
 - heterogeneous network technologies, broad spectrum of applications
 - trend directs to IP-based network and transport protocols
 - technology push and market pull
- **Success Factors**
 - time to market
 - open platforms
 - user acceptance
- **Design Processes**
 - limited development periods
 - specialization and limitation to core competences ("make or buy?")
 - design automation, design platforms and tools
- **Standardization and Quality**
 - proprietary solutions vs. open platforms
 - need for standardization
 - product quality and quality of service

Conclusion (2): Research Areas

- **Integration of the various Network Technologies**
 - fixed, mobile and ad hoc networks
 - internet and photonic technologies
 - support of autoconfiguration and manageability
- **Platforms**
 - advanced middleware concepts
 - service creation support
 - application programming interfaces
- **New Application Paradigms**
 - location and context based services
 - nomadic communications and ubiquitous computing
 - overlay networks
- **New Business Models**
 - micropayment
 - quality of service
 - scalable security