Next-Generation Communication Networks: Services and Challenges

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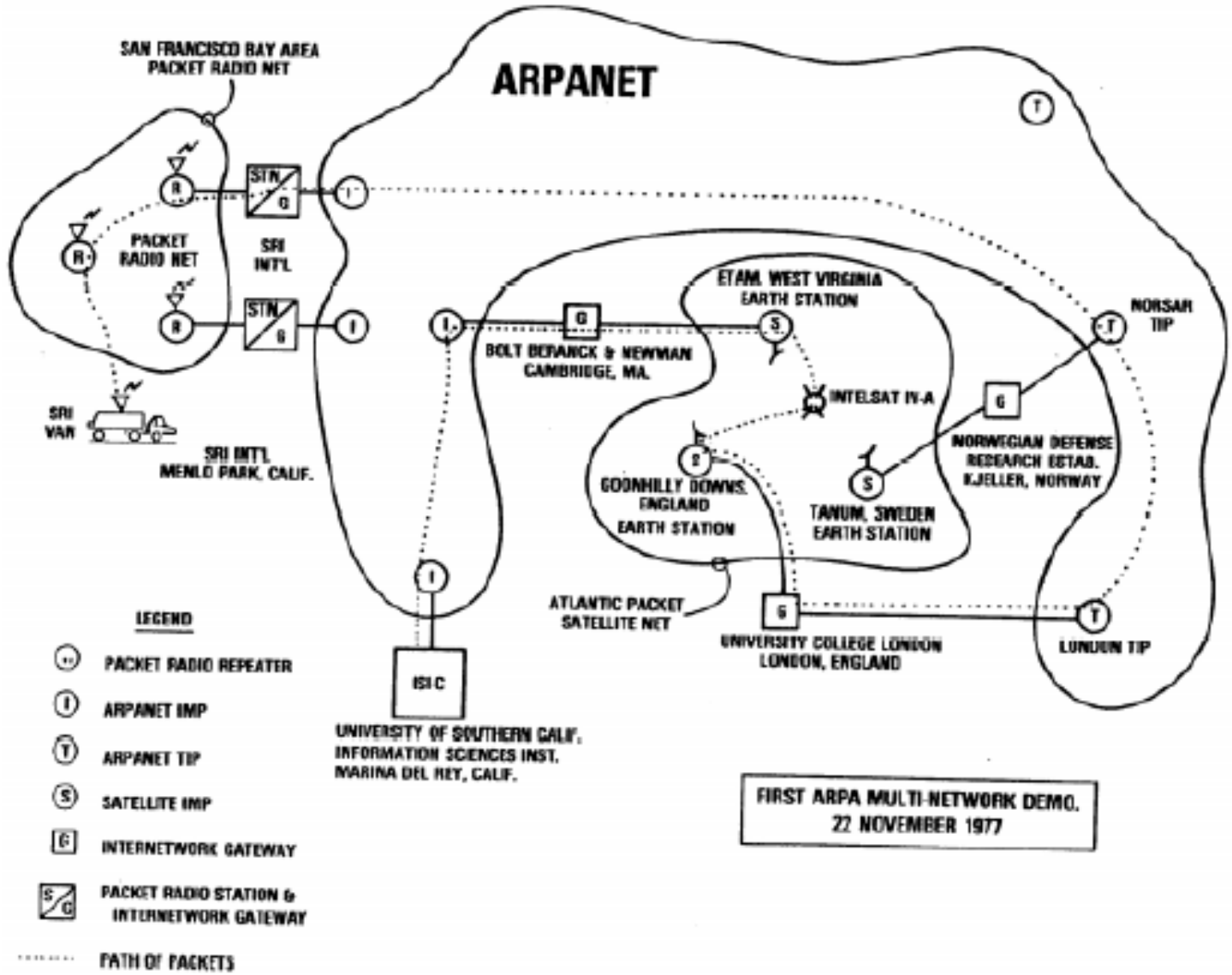
Outline

- Next-Generation Internet
- Broadband Applications
- Global Information Network
- Access Technologies
- Technical Challenges
- Standards
- Conclusions

ARPANET


ARPANET
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INTELSAT IV-A
GOONHILLY DOWNS, ENGLAND EARTH STATION
TANUM, SWEDEN EARTH STATION
NORWEGIAN DEFENSE RESEARCH ESTAB. KJELLER, NORWAY
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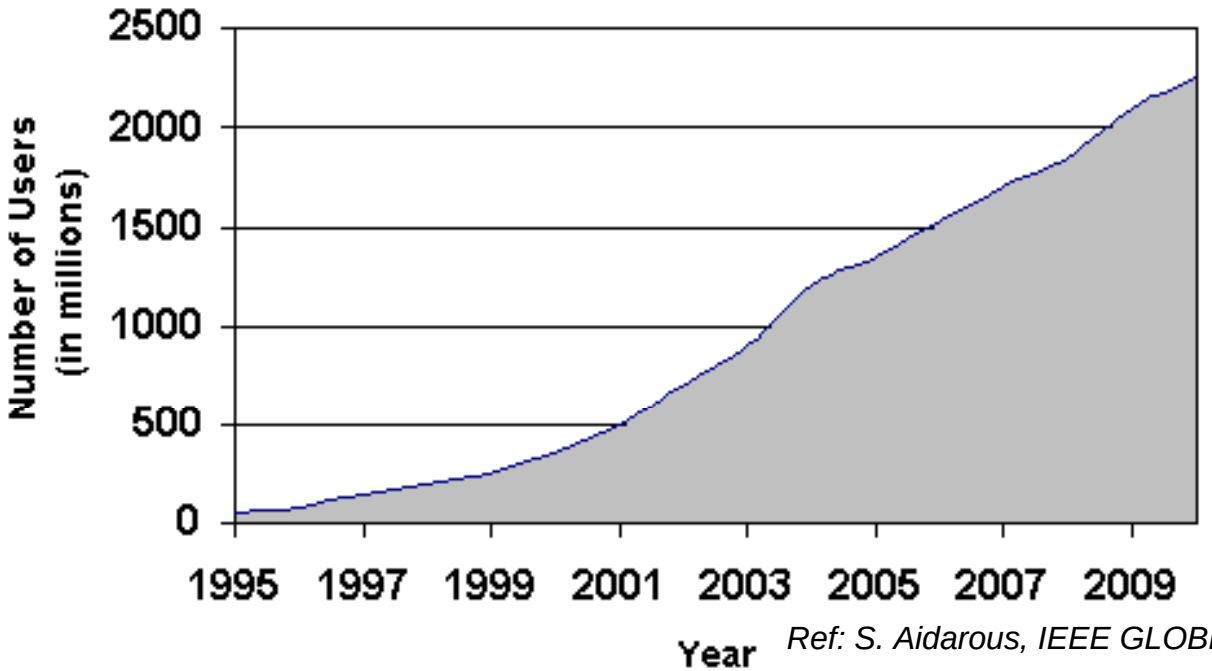
PACKET RADIO STATION & INTERNETWORK GATEWAY
PATH OF PACKETS
FIRST ARPA MULTI-NETWORK DEMO. 22 NOVEMBER 1977

Internet Growth



Ref: S. Aidarous, IEEE GLOBECOM 2001

- 75% of Traffic Web Based
- 3.6 million websites with 300-700 million web pages
- Traffic Consists of 80 % data and 20 % voice

Projections are based on earlier market studies.

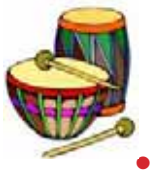
Next-Generation Internet – Abilene

Reference:
http://www.internet2.edu/presentations/spring03/20030410-Abilene-Corbato.pdf

- Consortium consisting of 221 members from universities and research labs as of April 2003.
- Current network is OC-192c (10 Gbps) backbone DWDM technology and advanced high-performance routers.
- Goals are to - increase the capacity of 10 Gbps; implement IPv6 and support IPv4; provide 97.9% to 99.99% reliability.

What is Broadband?

- **International Telecommunications Union (ITU) definition**
  - ITU-T I.113 recommends broadband as transmission capacity that is *faster* than primary rate ISDN, at 1.5 or 2.0 Mbps.
  - In 80s broadband is considered to be up to 144 Kbps (ISDN).
  - During the past five years, around 250 Kbps and upwards are regarded as broadband (DSL and cable modem).



- **Canadian National Broadband Task Force study**
  - National definitions range from 200 Kbps to 30 Mbps among the 14 countries studied.
- **Other definitions**
  - Jupiter Communications: at least 256 Kbps.
  - Federal Full broadband lines are lines with information carrying capability in excess of 200 Kbps in both directions, simultaneously.
  - Jonathan Taplin CEO of the Intertainer, the video-on-demand service - "...if you offer something called 'broadband' it has to be 750 Kbps...“ just like Federal Trade Commission Control of Octane in Gasoline. Not a bad idea for the administration to think about.

No internationally agreed definition of broadband.

What is Broadband Cont'd

- "Broadband should be a national imperative for this country in the 21st century, just like putting a man on the moon was an imperative in the last century"
  - John Chambers, President and CEO, Cisco

- "The FCC's definition of broadband, anything over 200 Kbps, is very realistic. 100 Mbps to the home will never happen"
  - Charles Hoffman, CEO, Covad

- "Three hundred or 400 Kbps is not real broadband. When you get to 5 or 10 Mbps, that's real broadband, going to 100."
  - Craig Barrett, President and CEO, Intel

Source: Network World, 11/18/02

Need for a national and international broadband policy.

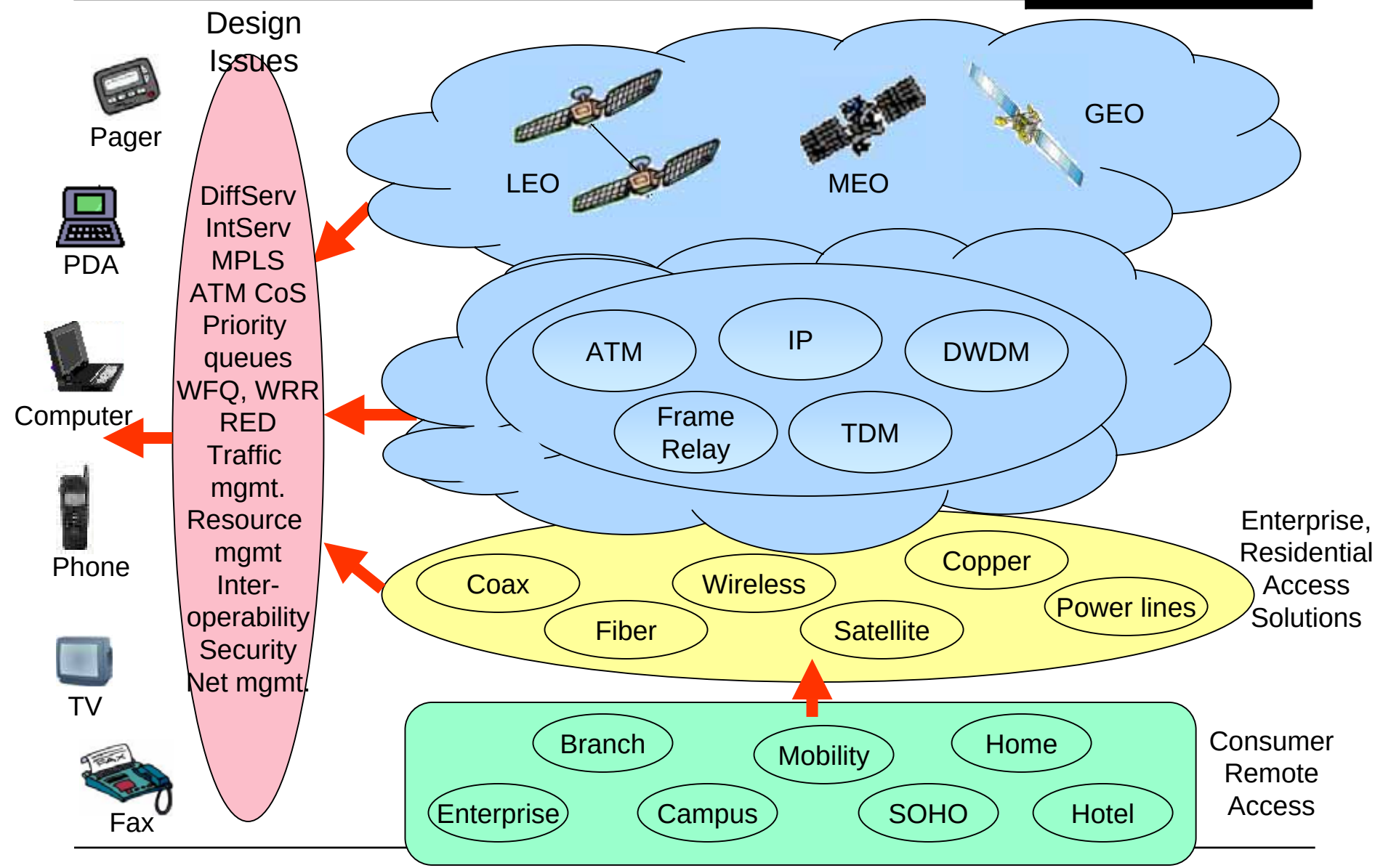
Broadband Applications

- **Content Distribution Services**
  - Network or CATV Distribution
  - Direct to the Home TV and Interact TV
  - Video/Audio streaming multicast
    - online gaming, downloading movies
  - Video on Demand
  - Medical imaging
  - Distance learning
- **Broadband Access**
  - High Speed Internet Access
  - Web TV and e-commerce
  - Enterprise Virtual Private Networks
  - MAN and WAN connectivity
- **Corporate Network Applications**
  - Virtual Private Network
  - Local Area Network interconnections
  - Bandwidth on Demand
  - Disaster recovery

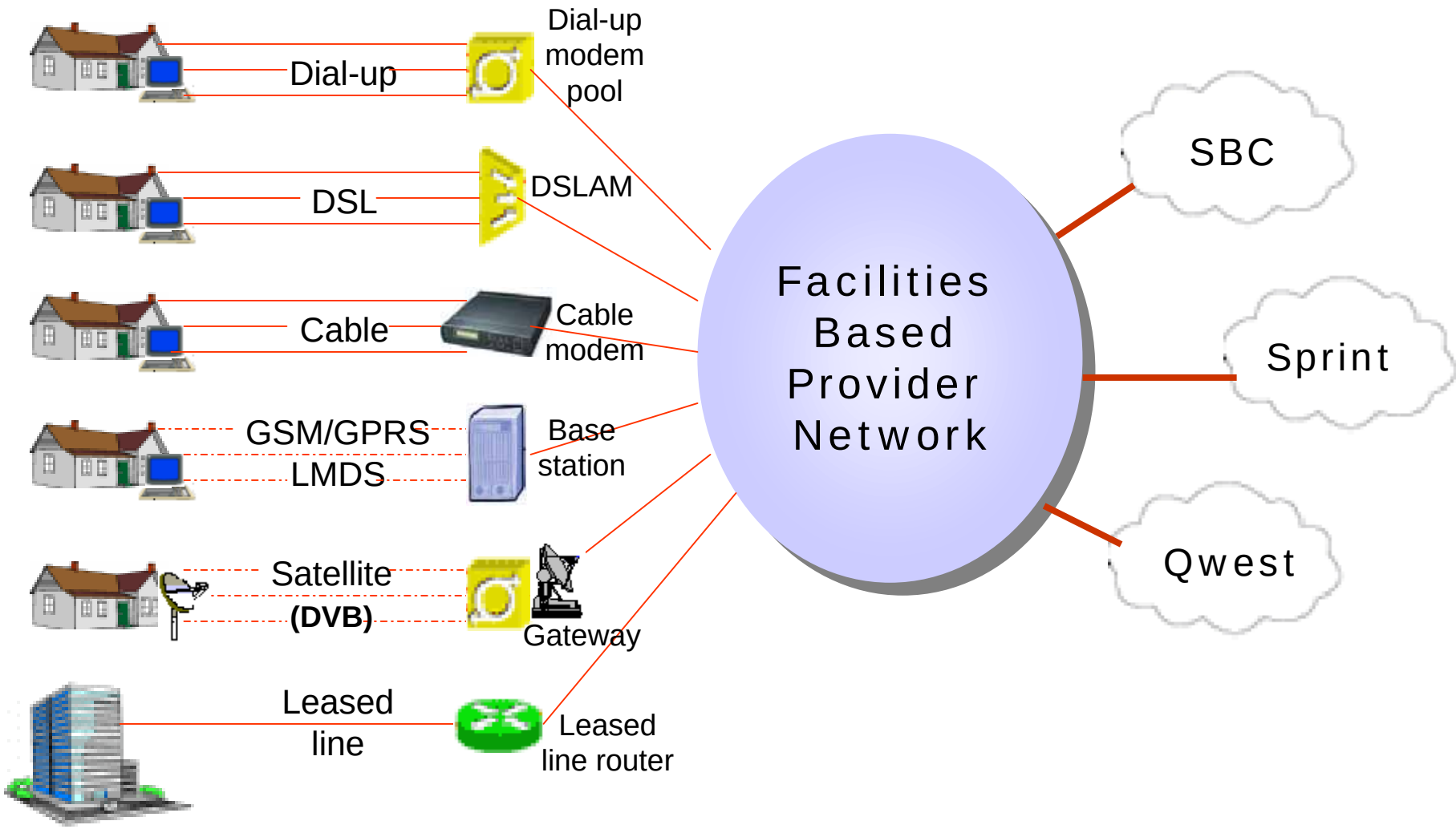
Broadband Applications Cont'd

- **Multimedia Corporate Services**
  - Executive briefings
  - Product launches
  - Supply chain communications
  - Investor relations
- **VSAT Services**
  - Provision bandwidth on demand
  - Frame relay like services
  - Corporate private networks
- **Voice and Data Trunk Services**
  - Transoceanic Telephony
  - IP Transport and ISP Access
  - Video, Audio and Data File Transfer

Global Network Infrastructure and Technologies



Broadband Access Technologies



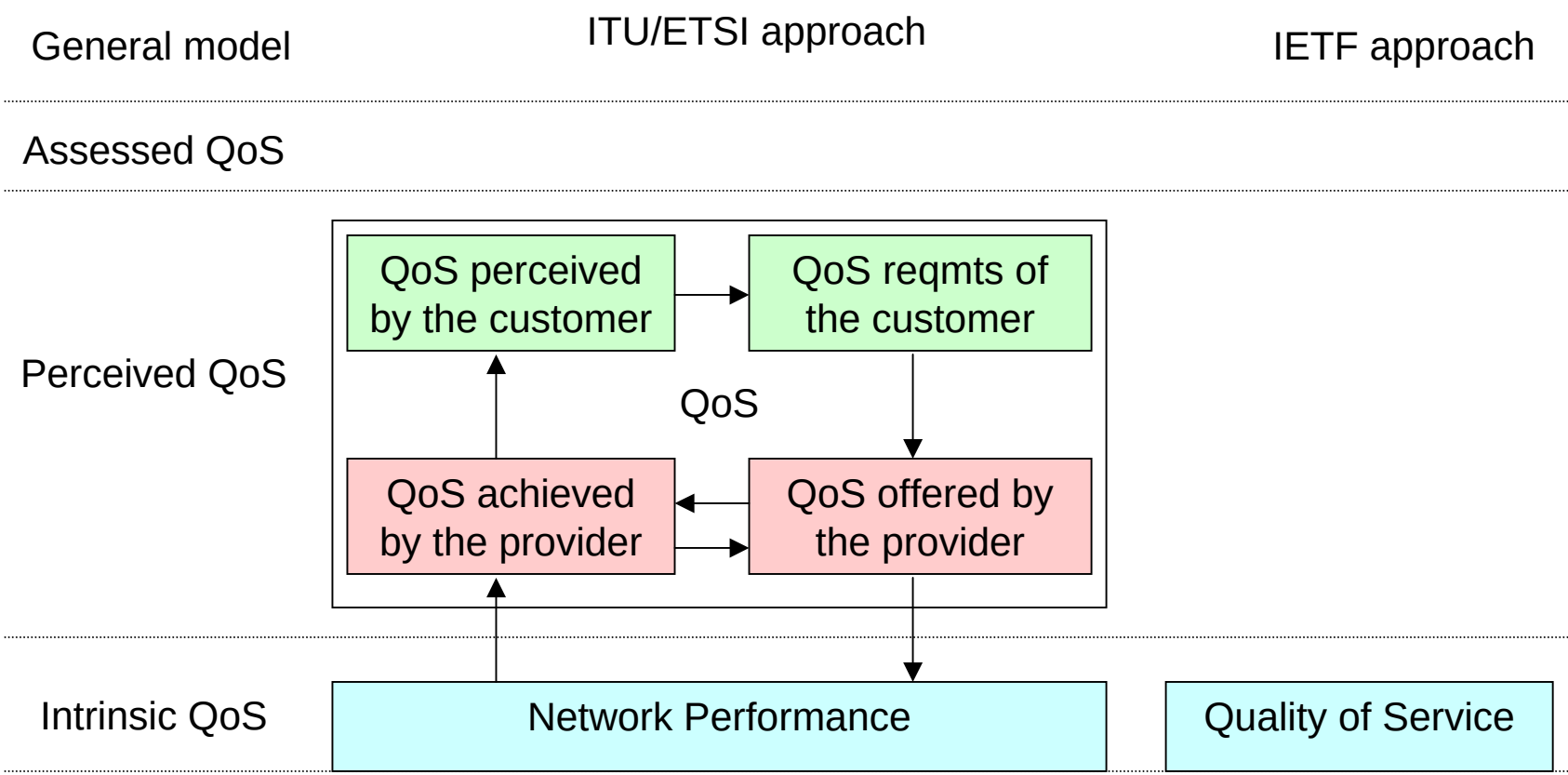
Access Technologies Comparison Cont'd

Access Method	Speed	Market Potential
Satellite	Up: < 1-2 Mbps Down: 45-50Mbps	High growth revenue: $1.45 Billion By 2006 for CDD services
Cable Modem	320 kbps up to 10 Mbps; 30 to 40 Mbps	4.2 million subscribers in 2001 to 21 million subscribers in 2006
DSL	Up: 1.5 Mbps Down: 8 Mbps	• 3.8 million subscribers in 2001 to 20.7 million subscribers in 2006 •Revenue growth from $3 billion in 2001 to $11.2 billion in 2006
Wireless	UP:1.5 Mbps Downstream: 30Mbps	•160,000 in 2001 to 750,000 subs in 2006 • Revenue growth from $480 million in 2001 to over $3.3 billion in 2006
Fiber to the Home	UP:10 Mbps Downstream: 50Mbps	• 840,000 sites by 2006

What is Quality of Service (QoS)?

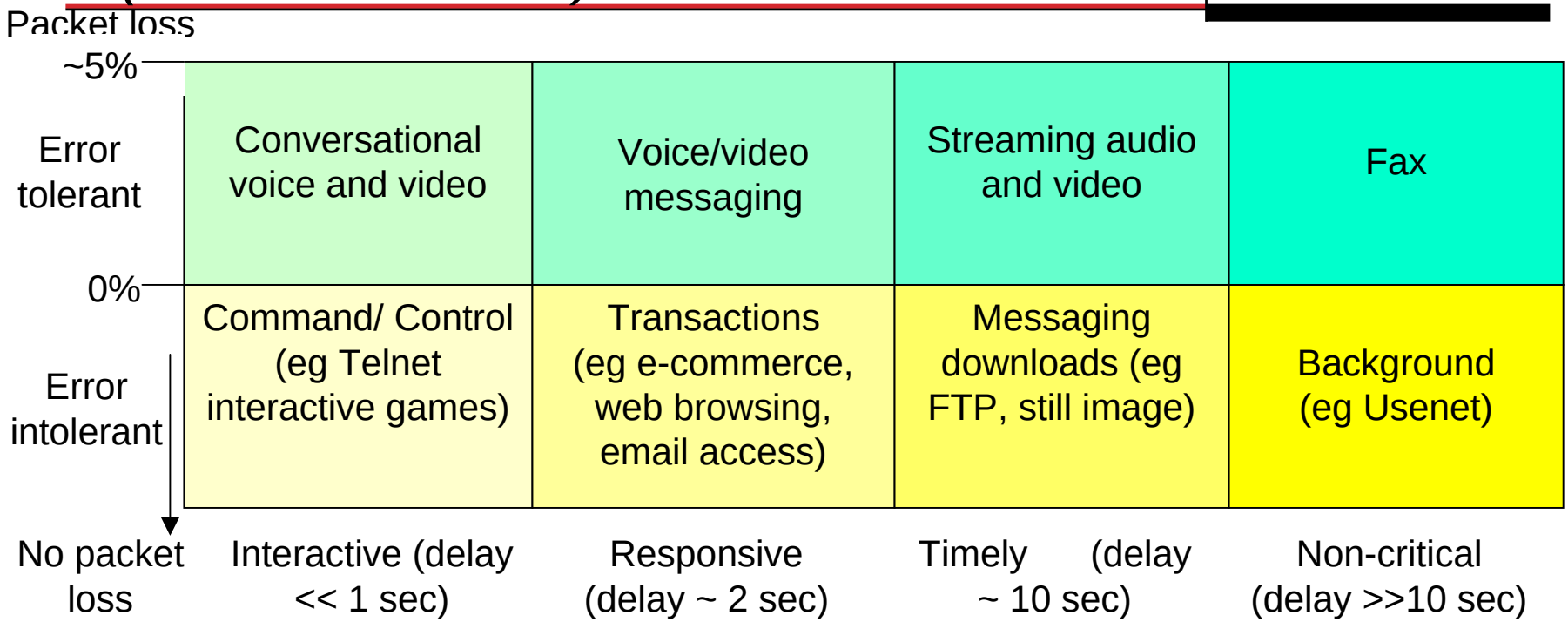
- Ability of a network element to have some level of assurance that its traffic and service requirements can be satisfied.
- Requires cooperation of all network layers and every network element
- ISO 8402 QoS definition
  - "the totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs."
- ITU-T Recommendation E.800 QoS definition
  - "the collective effect of service performance which determine the degree of satisfaction of a user of the service"
- ITU-T Recommendations on QoS
  - ITU-T I.350 and ITU-T Y.1540 - network performance and network interface-to-network interface QoS.
  - ITU-T Y.1541 - 6 classes of applications and application QoS objectives

QoS model: ITU/ETSI and IETF Approaches



QoS definition ranges from user's perception of the service to a set of connection parameters necessary to achieve particular service quality.

Application QoS Requirements (ITU-T G.1010)



- **Throughput***:* maximal data transfer rate that can be sustained between two end points, e.g., average rate, peak rate, minimum rate.
- **Delay:** time for a packet to be transported from the sender to the receiver.
- **Jitter***:* variation in end-to-end transit delay.
- **Information loss***:* ratio of the number of undelivered packets/cells to the total number of sent packets/cells.
- **Reliability***:* percentage of network availability depending upon various environmental parameters such as rain and atmospherics.

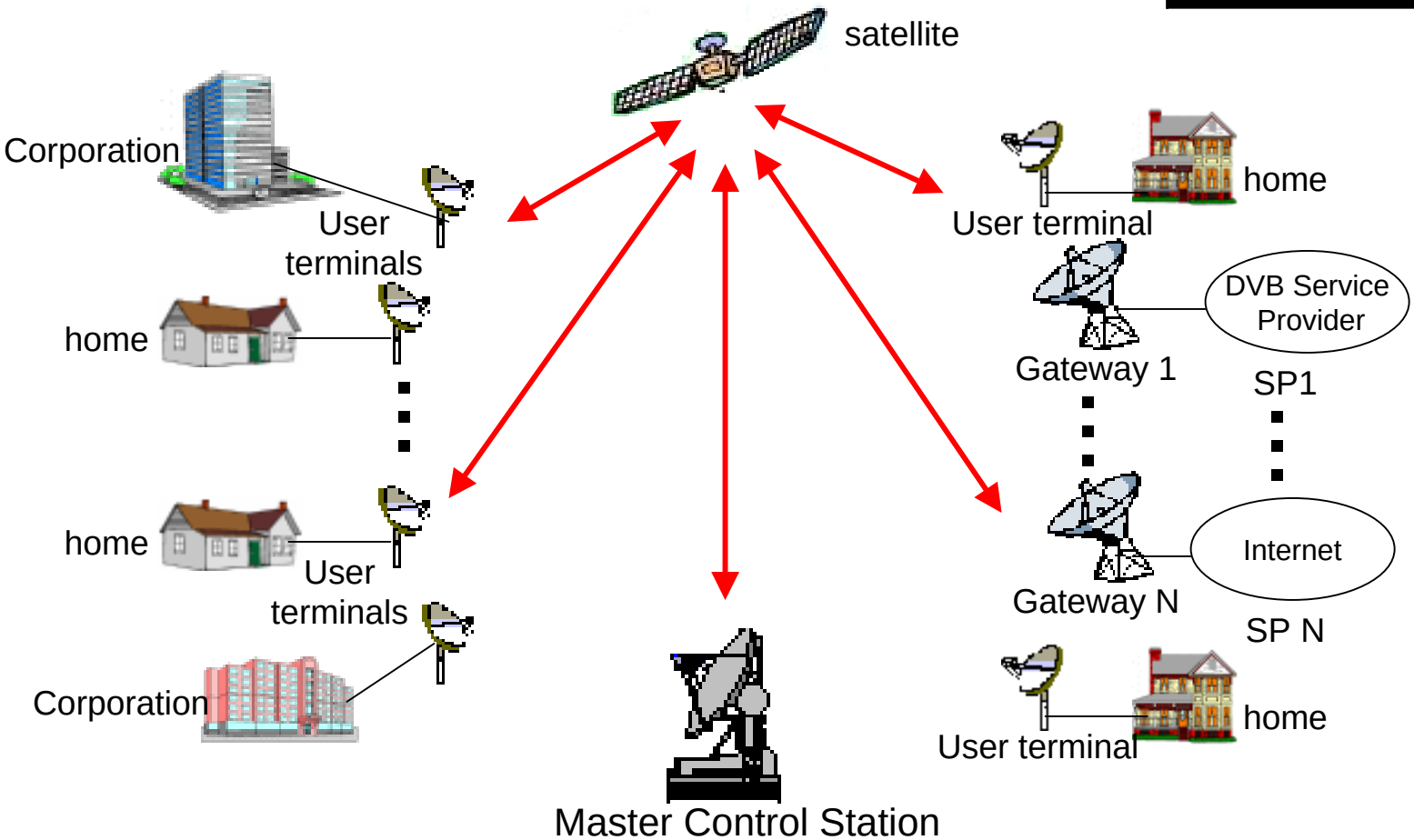
IP QoS – Fundamental Issues

- IP QoS architectures and objectives are influenced by proper selection of the following
  - **Services and applications**
  - **Transport layer protocols**
  - **Security algorithms**
  - **Flow and congestion control**
  - **Buffering and queue management – drop policies**
  - **Multicasting protocols**
  - **Routing and addressing schemes**
  - **Media Access Control protocols**
  - **Bandwidth allocation and bandwidth-on-demand algorithms**
  - **Interfaces, protocols, air interfaces**
  - **Interoperability networks and policies**
  - **Network control and management**

QoS Mechanisms

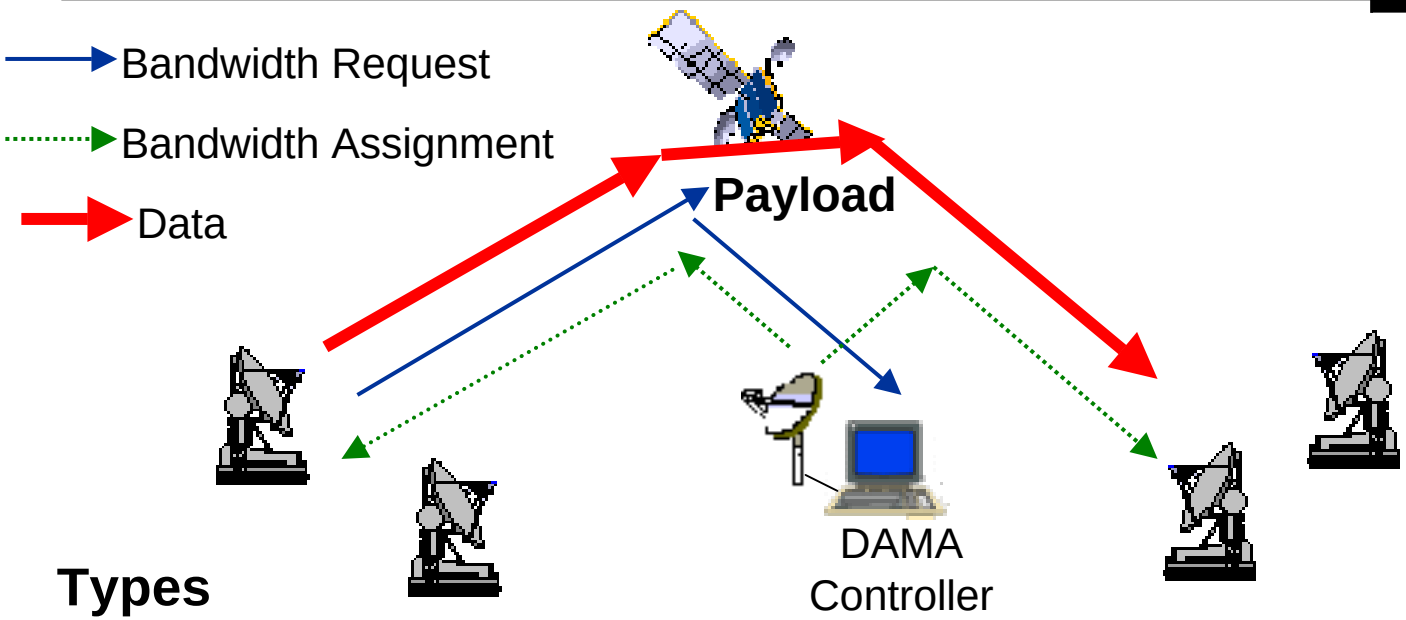
- **Integrated Services – IntServ**
  - ReSerVation Protocol (RSVP) reservation mechanism
  - Guaranteed load service
  - Controlled load service
- **Differentiated Services – DiffServ**
  - Nodal behaviors
  - Class of service
  - RSVP lite or LDP
- **MPLS Traffic Engineering**
  - Packet oriented and codepoint based
  - Packet forwarding
  - Constraint based/Explicit routing
  - Aggregate flow setup

Satellite IP Network Example



- Gateway provides interface to Internet - Service providers, PEP implementation, and security.
- Master control station provides overall control functions of the network – capacity allocation and transmission scheduling.

DAMA Concept



Types

- Circuit switching
- Packet switching
- ATM switch
- Onboard uplink
- Ground-based

Advantages

- Efficient resource utilization
- Dynamic traffic adaptability
- Reduced access and end-to-end delay
- Accommodates priority traffic

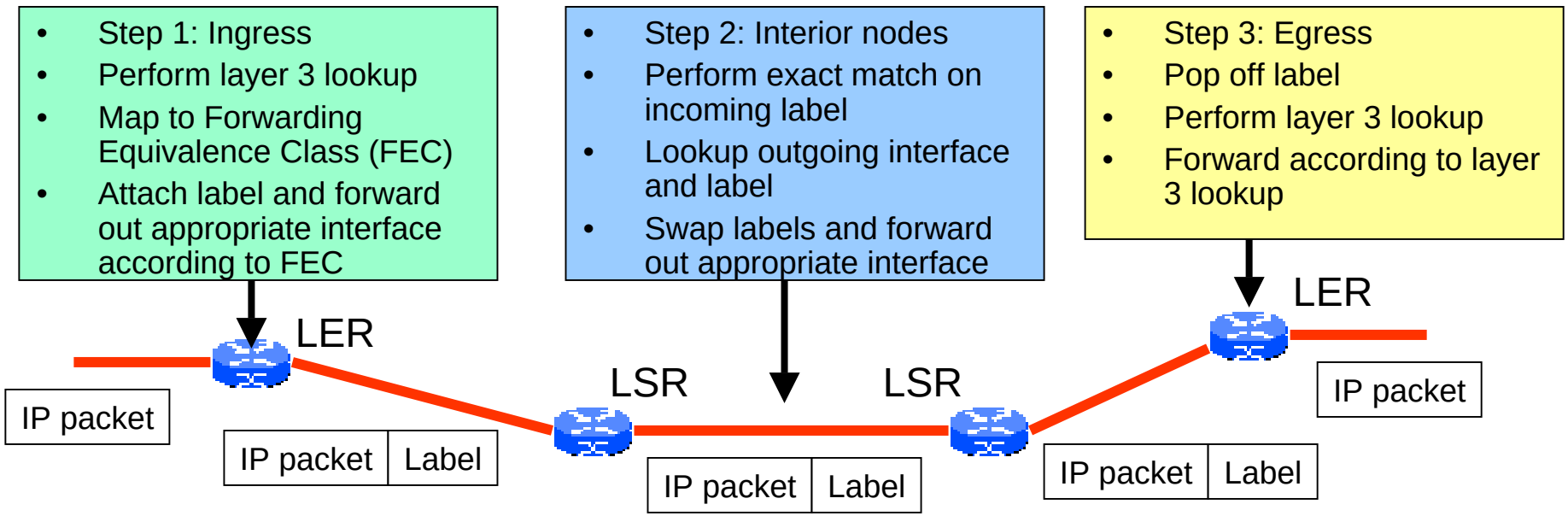
Performance-cost tradeoffs depends on the selection of the DAMA architecture.

Traffic Management Issues

- **Fairness**: Traffic sources should be treated according to some fairness criteria like max-min fairness or proportional fairness.
- **Efficient Resource Utilization**: Available resources e.g., network buffers, network links bandwidths, processing capabilities, proxy servers, should be efficiently utilized.
- **Bounded Queuing Delay**: According to application QoS requirements, there should be low buffer delays and no excessive packet loss.
- **Stability**: Transmission rates of the sources should not fluctuate in steady state.
- **Fast Transient Response**: Traffic sources should react rapidly to changing network conditions like sudden congestion.
- **Scalability**: The traffic management algorithms must be scalable to large numbers of users. Few million users are typical in satellite IP networks.

Multi Protocol Label Switching (MPLS)

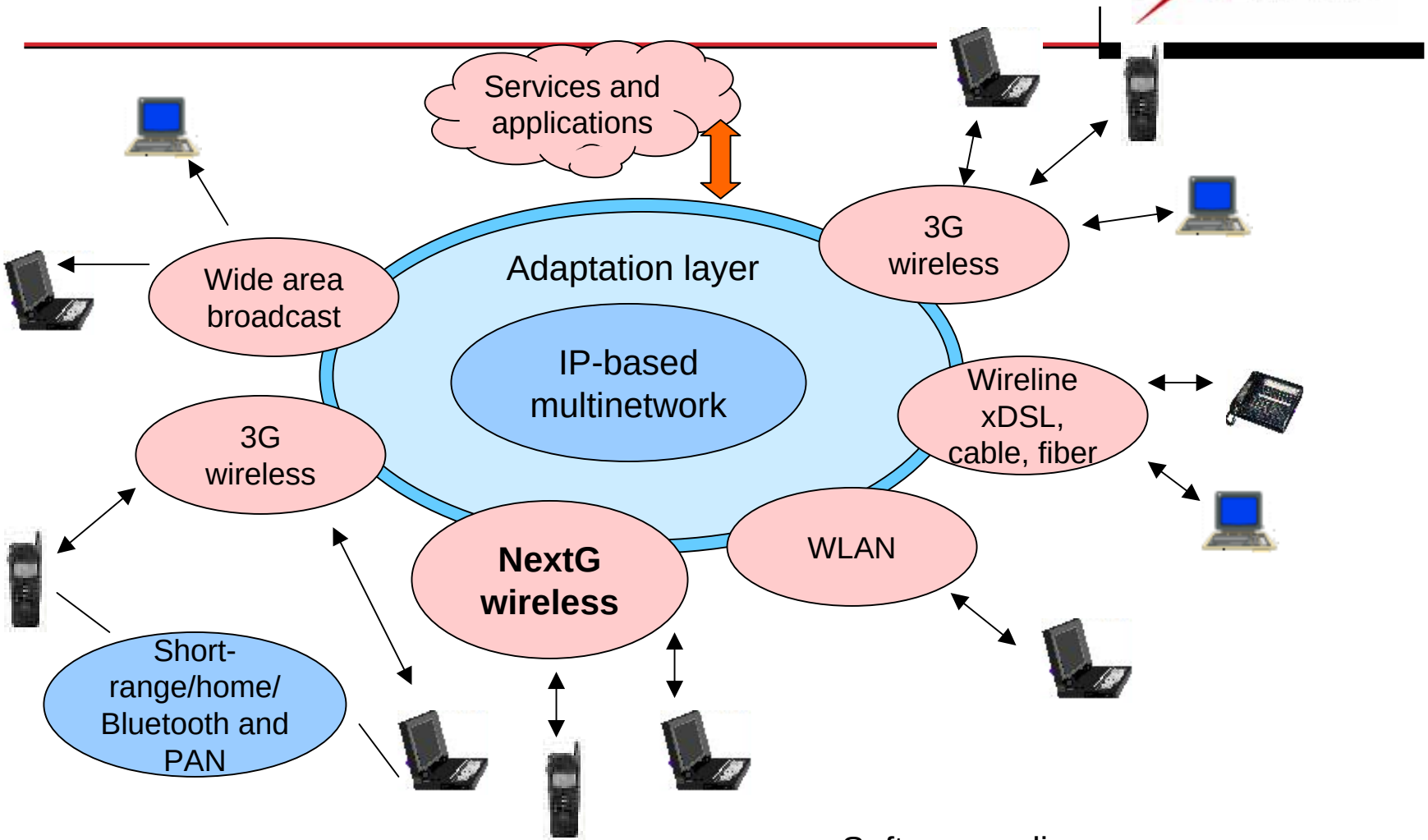
- MPLS uses IP routing protocols to control a connection oriented layer-2 switch
- Explicit Routing: Sets up explicit routes using Label Switched paths (LSP) without making changes to IP routing architecture
- Signaling, Admission Control, Routing: Each LSP can have priority, preemption, policing, and overbooking



LER – Label Edge Router
LSR – Label Switch Router

MPLS involves routing at the edges, switching in the core

Next-Generation Wireless Network

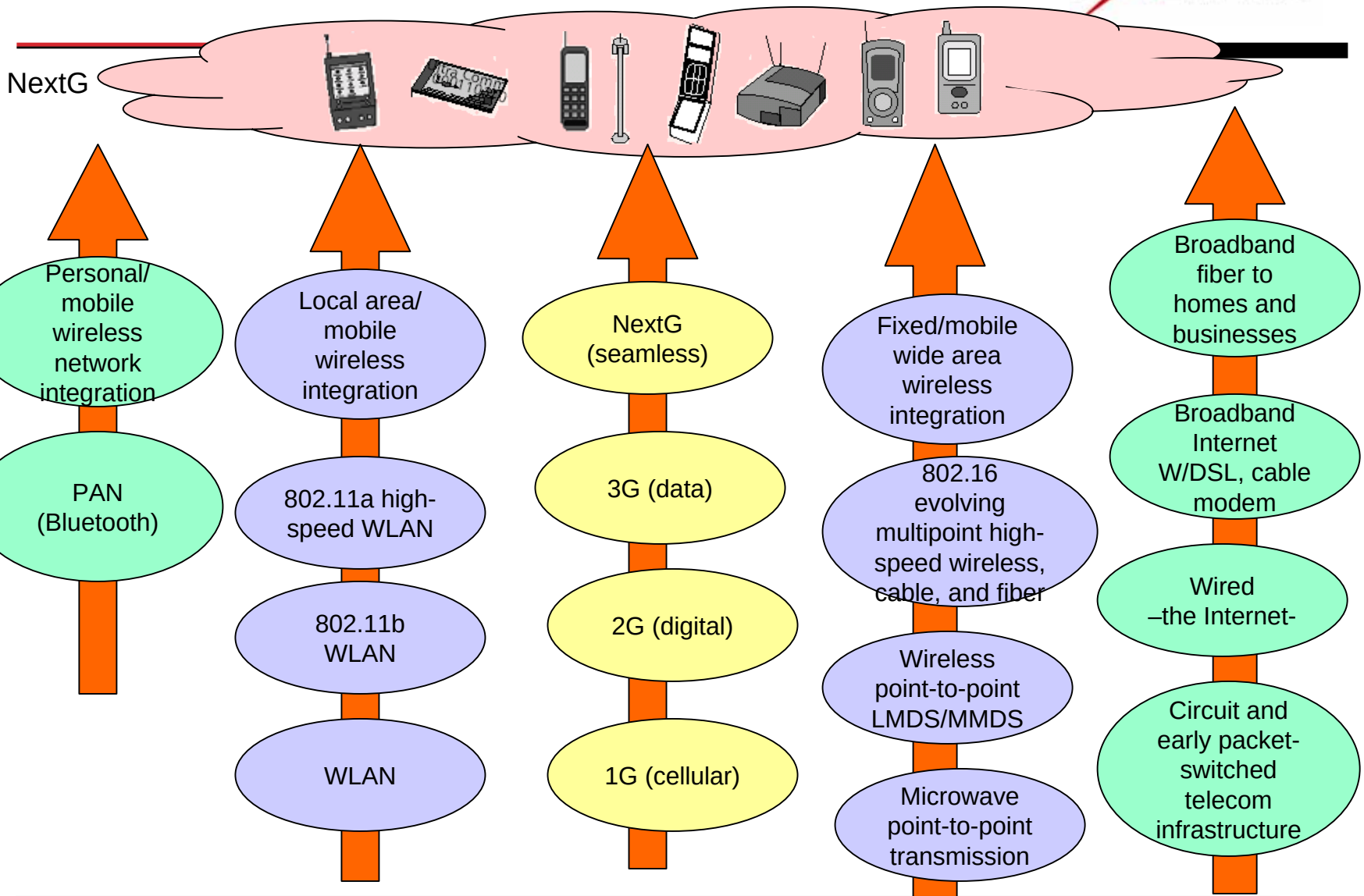


- Ultraconnectivity
- Flexible networks
- Adaptive resource management

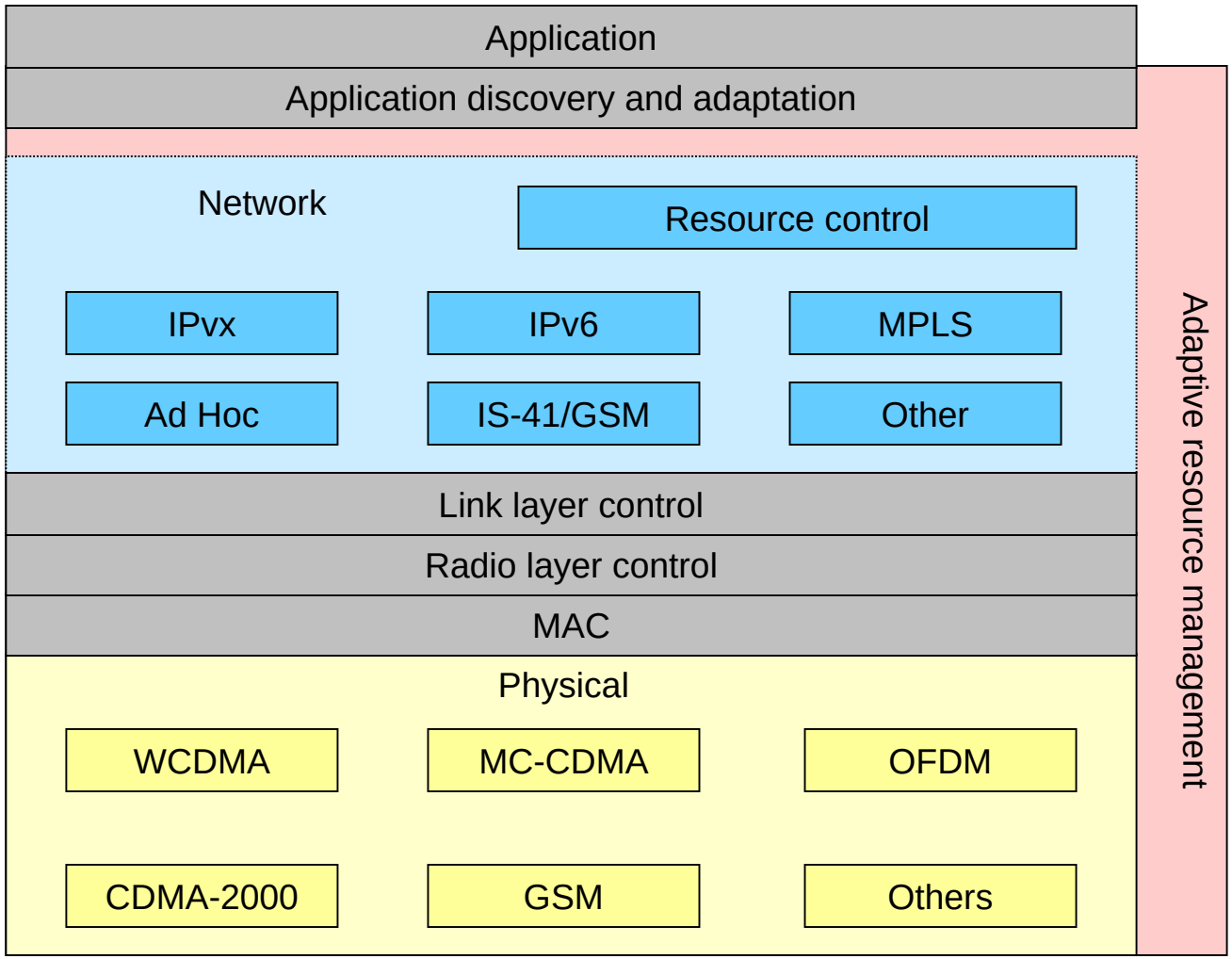
- Software radios
- Adaptive waveforms – modulation and coding
- Quality of Service

Next-Generation Wireless Network Technologies

HARRIS

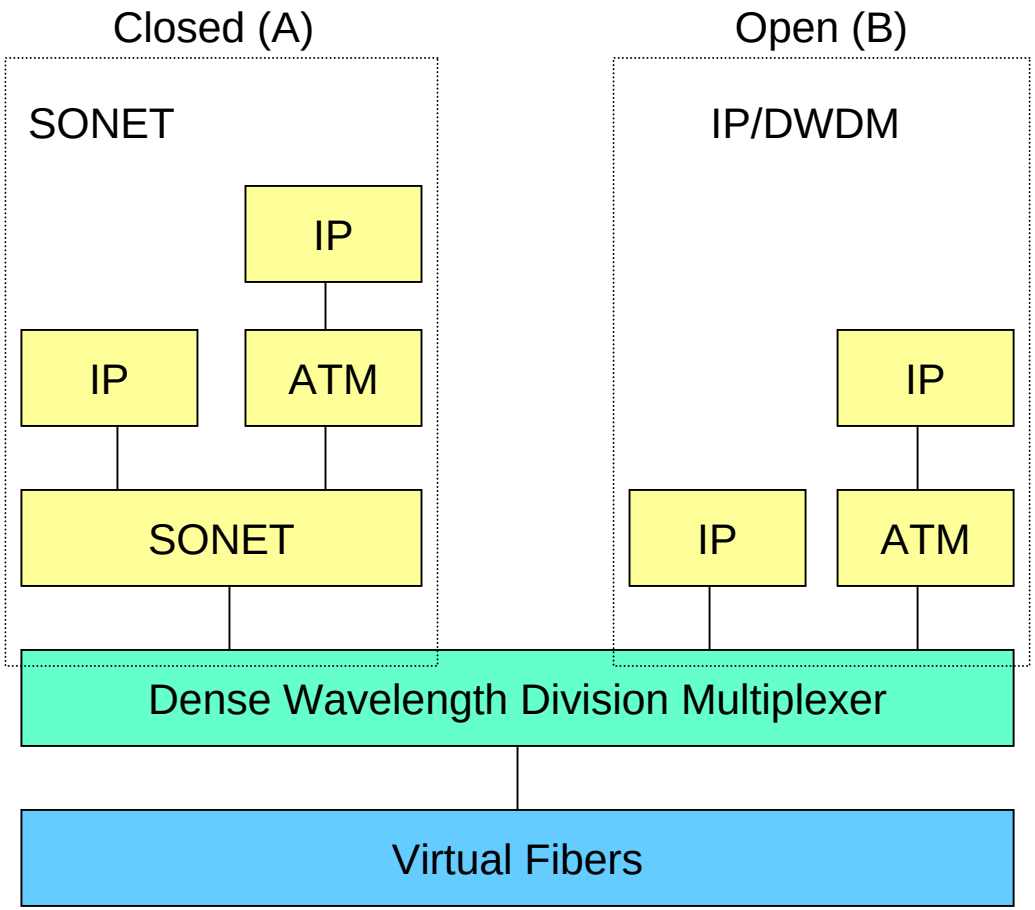


Adaptive multilayer protocol architecture example



- Adaptation of services and applications
- Dynamic resource management
- Allocation of spectrum
- Dynamic multiple access

IP over DWDM



- DWDM layer has two approaches
  - SONET centric and generic
- It is an open architecture – can be used with any TDM architecture

Interoperability Issue Example: Satellite Link Characteristics Affecting TCP

- Latency
  - Propagation delay is dominant part in broadband satellite links
  - Large variations of RTT may lead to false timeouts and transmissions
- Link Impairments
  - Multipath, interference, fading, rain attenuation and shadowing are the various impairments affecting satellite link
- Bandwidth Asymmetry
  - Bandwidth asymmetry in terms of forward to the return channels exist anywhere in the order of 10:1 or more exists in satellite access networks
- Multiple Segment Loss
  - In geostationary satellite networks, TCP senders and receivers with limited congestion/receive windows will not be able to use the available bandwidth Those that can also increase their probability of a multiple segment loss within a single window
- RTT Fairness
  - A short RTT connection will unfairly capture a larger portion of the network bandwidth than a large RTT connection particularly in the presence of congestion and subsequent loss

IPSec Issues in Satellite Network

- End-to-end IPSec can run simultaneously with techniques such as PEPs and Network Address Translation (NAT).
- IPSec cannot support multicast.
- IPSec requires that the same encryption rules must be applied on both ends.
- Tunnel mode of IPSec leads to critical overhead and a large number of signaling messages.

Standards

- ITU-T Study Group 15
- ITU-T Study Group 13
- ITU-R Study Group 4B
- ITU-R Study Group 8D
- IETF
- IEEE 802.11, .15, .16
- ETSI – BMS, DVB
- MPLS Forum
- ATM Forum
- DSL Forum
- TIA
- ……..

Conclusions

- Global communication networks consists of access and core networks utilizing transport technologies frame relay, ATM, IP, and optical.
- Future multimedia services and applications demand high bandwidth and guaranteed delay bounds and jitter performance.
- End-to-end Quality of Service including security is a critical element.
- Interoperable protocols and standards must be developed to realize global information infrastructure.

Twenty years from now when people look back on the systems of today I'm sure that they'll shake their heads in bemusement and say, "What were they thinking?"

- Robert W. Lucky