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Abstract		
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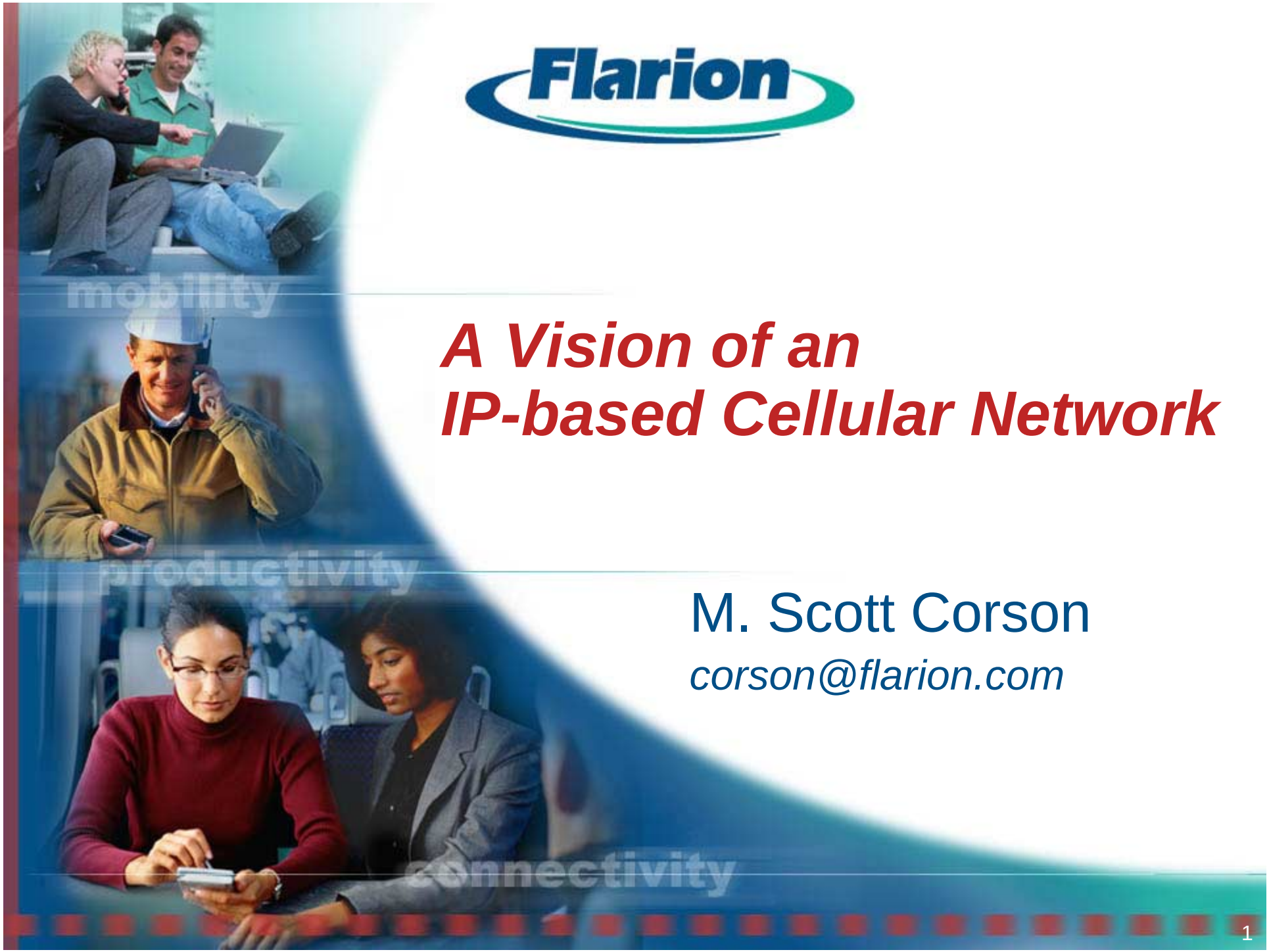

A Vision of an IP-based Cellular Network

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A message to the networking community...

Wireless need NOT be different

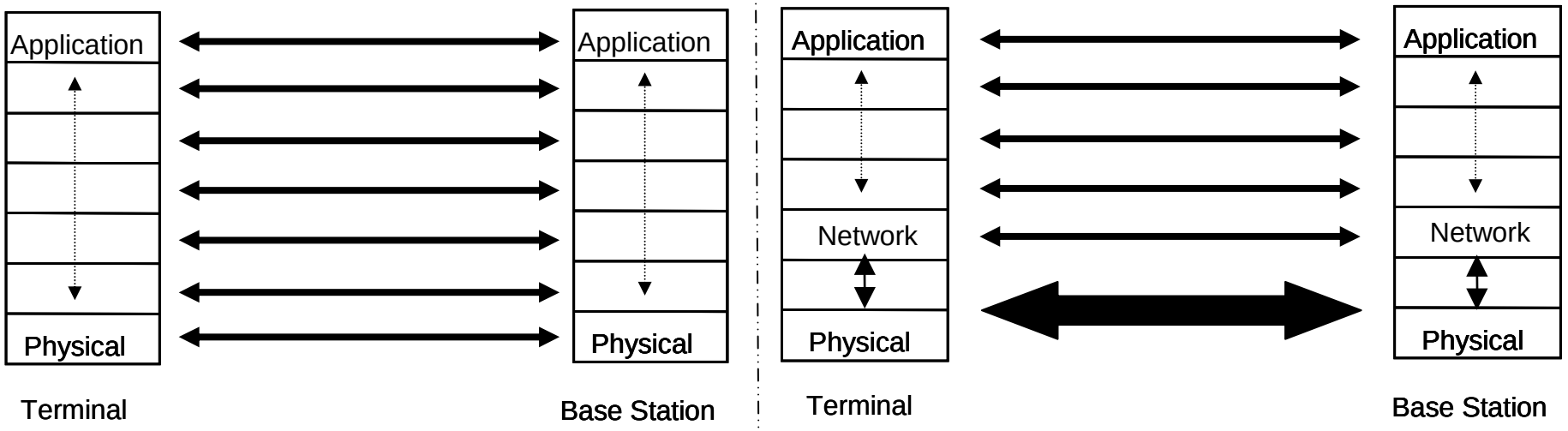
System Design Objective

- Data Access must be *cost-effective*
  - Efficient Data Network
    - IP technology
  - Efficient Data Air Interface
    - MBWA

System Design Philosophy

- Optimize for IP-based data delivery and networking
  - Vertically-integrated design of layers 1-3 (physical, link, network)
  - Horizontally-layered design of layers 3-7 (IETF standards compliant)

Layering
Vertically-integrated L1-L3 design

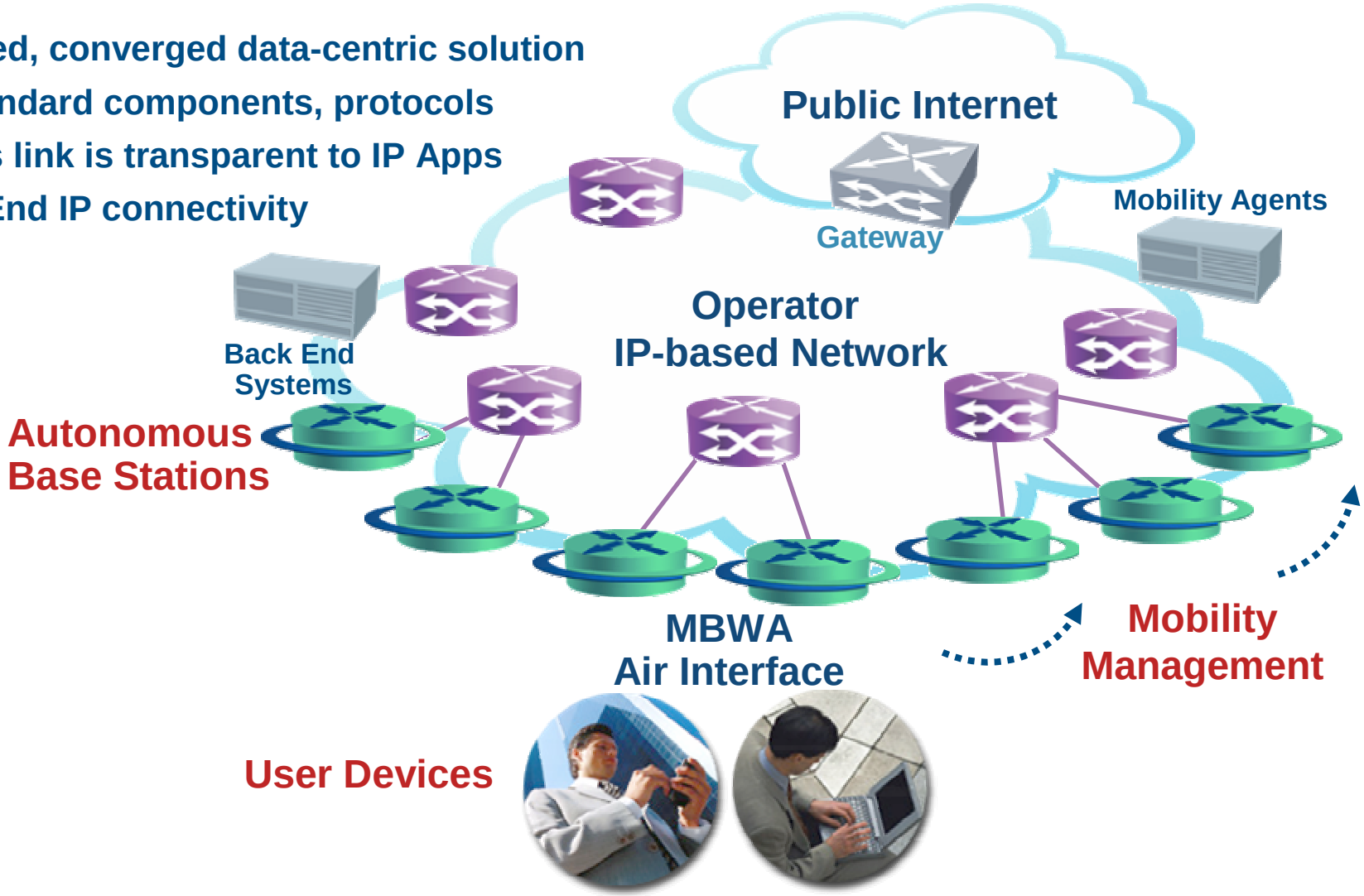


(a) Horizontally Layered Design of Traditional Data Networks

(b) Integrated L1-3 Design of IP-based Cellular Networks

A True All-IP Network

- Optimized, converged data-centric solution
- IETF standard components, protocols
- Wireless link is transparent to IP Apps
- End-to-End IP connectivity



Enabling a Mobile Internet

- Cellular now just like any other form of broadband Internet Access, e.g.:
  - DSL
  - Cable
  - Leased Lines
  - Ethernet
- Simply allow the IP protocol suite to use link layer capabilities and control their resources

Simply Deliver Native IP Traffic

- MBWA air interface viewed merely as another link in an inter-network
  - IP protocols and apps flow across link *without* modification
    - e.g. TCP works on standard, unmodified IP host stacks as in wired networks
  - Development required for a new MBWA air link minimized
    - exploit all existing IP features / capabilities
    - simply map IP over the MBWA link layer

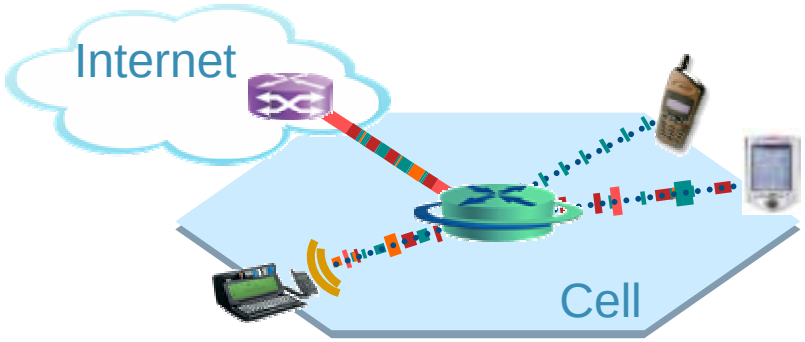
Access Network Architecture

- For a MBWA network, this implies:
  - Base Station is an IP Router
    - Access Router
  - Mobile is an IP Host
    - Apps may or may not be mobility-aware

Asynchronous Base Stations

- IP networks are fundamentally ‘asynchronous’
  - IP flows are *unidirectional*
  - network links operate *independently*
    - same should hold for MBWA links
- MBWA air interface operation should be asynchronous between cells
  - no requirement for timing or frequency synchronization
    - no GPS requirement
  - enables *backhaul-agnostic* base stations
    - T1, GigE, ATM, Microwave...
  - flexible, scalable architecture

Base Station as IP Access Router



- The base station should be an IP Router
  - One or more wireless interfaces (sectors)
  - One or more wired interfaces (backhaul)
  - Controls network access to services
  - Direct application of IP QoS mechanisms on air and backhaul interfaces
  - Native delivery of IP multicast to base station and over the air

IP Application Impact on MBWA Design

- Air Interface
  - ‘Data-centric’
    - e.g. voice as data
  - Reasonably ‘Symmetric’
    - increasing movement towards peer-to-peer IP Apps over time
      - voice, push-to-talk, messaging, gaming, etc.
  - ‘Interactive’ data exchange
    - real-time, reliable data at very low latency

Desirable Air Interface Properties

- Packet-switched
  - Native IP packets over air (e.g. no PPP)
- Broadcast Downlink Capability
  - Efficient IP Multicast Support
- IP QoS control at Base Station
  - Fine-grained, flexible bandwidth allocation with full statistical multiplexing gains on both uplink and downlink

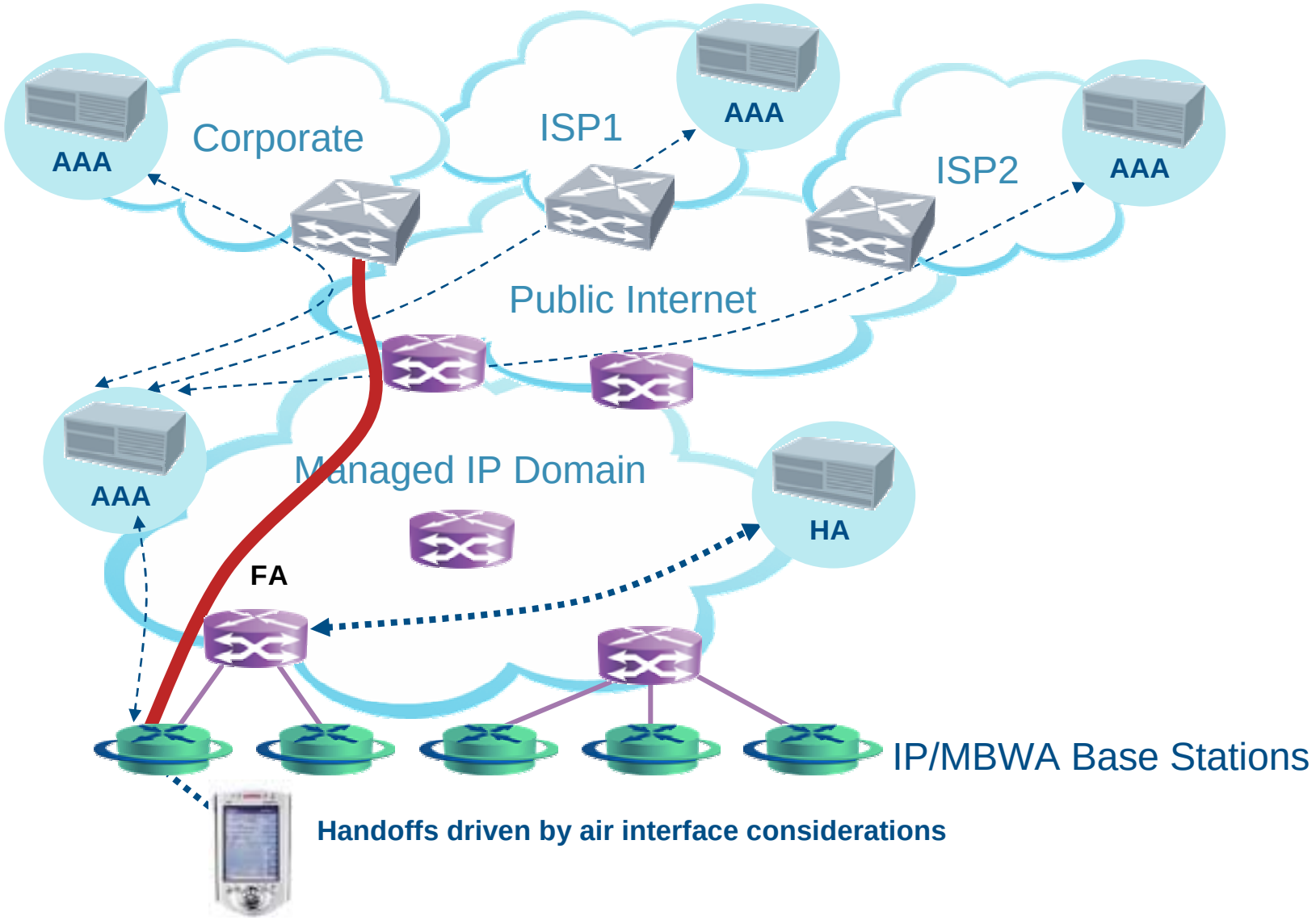
Desired System Capabilities

- IP-based Signaling/Data Traffic
  - Connectivity Management
    - Access Control
    - Forwarding
    - Handoff
    - Paging
  - Quality of Service
  - Session Control
  - Multicast

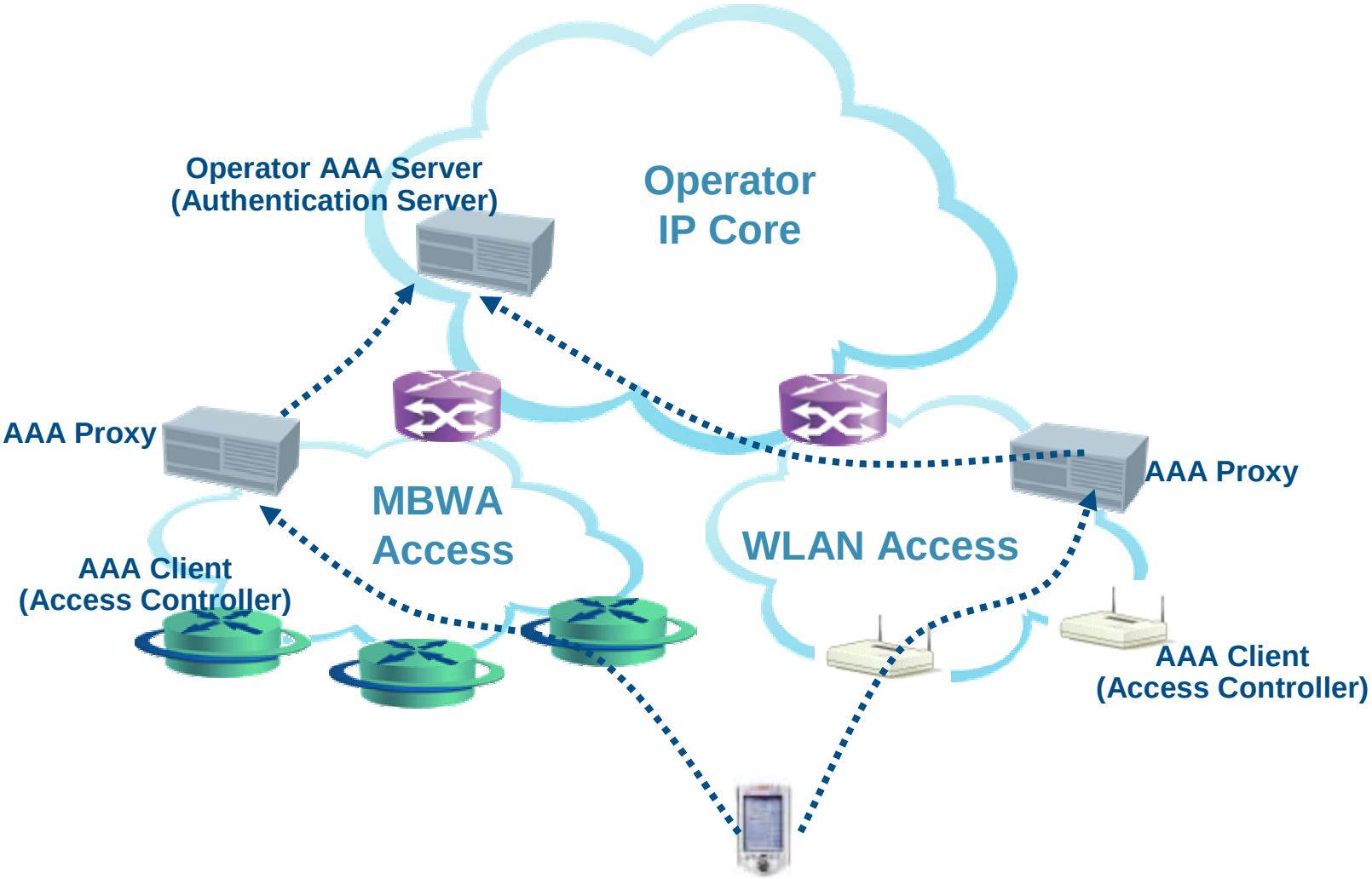
AAA Access Control Advantages

- AAA-based Access Control plane
- The IP base station can simply use IP Authentication, Authorization and Accounting (AAA) to support all user access

AAA Roaming/Mobility Models



Inter-technology AAA Roaming



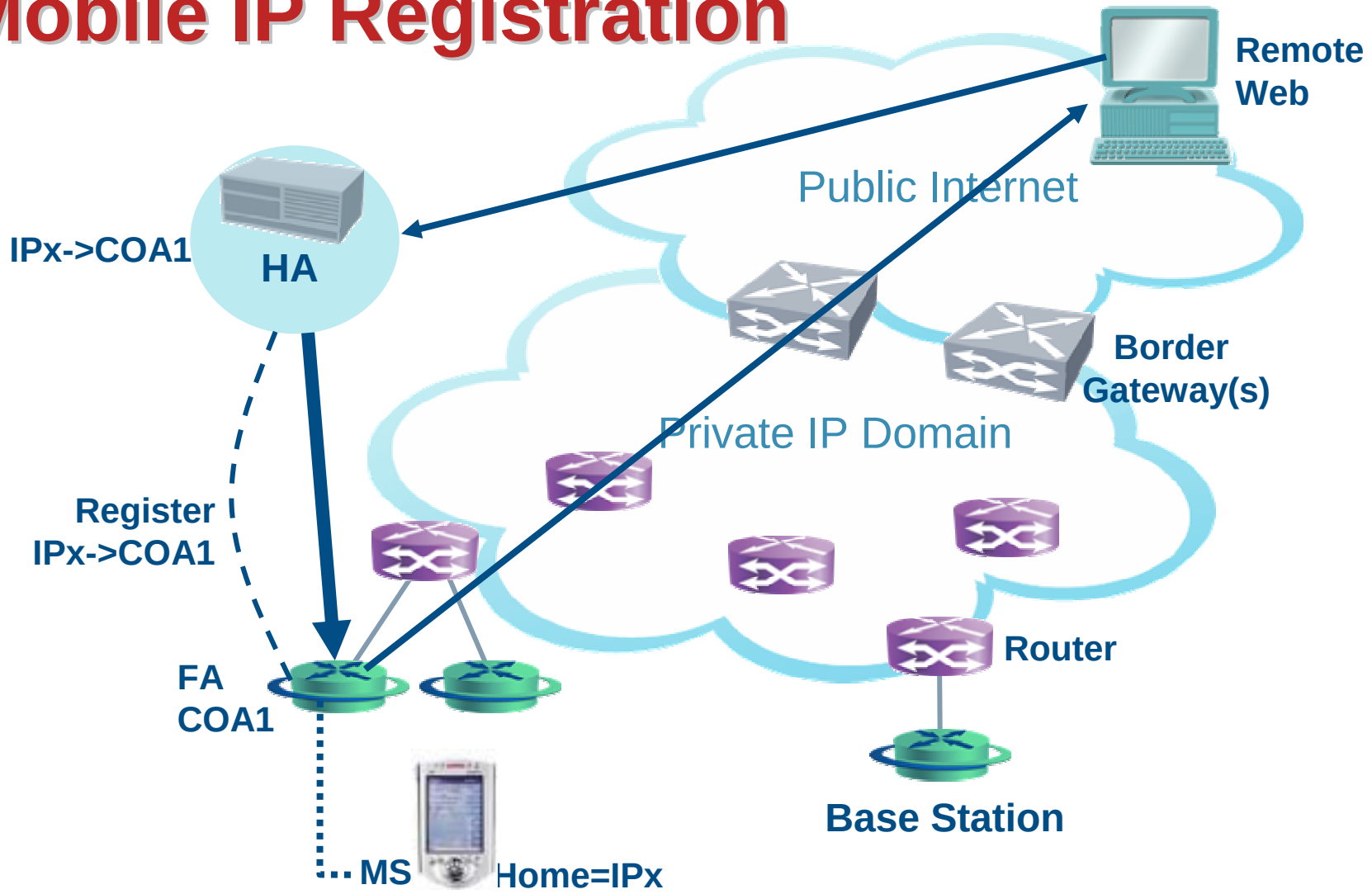
Mobility Management Architecture

- Mobile IP-based Forwarding
- Mobile IP-based Handoff
- Paging

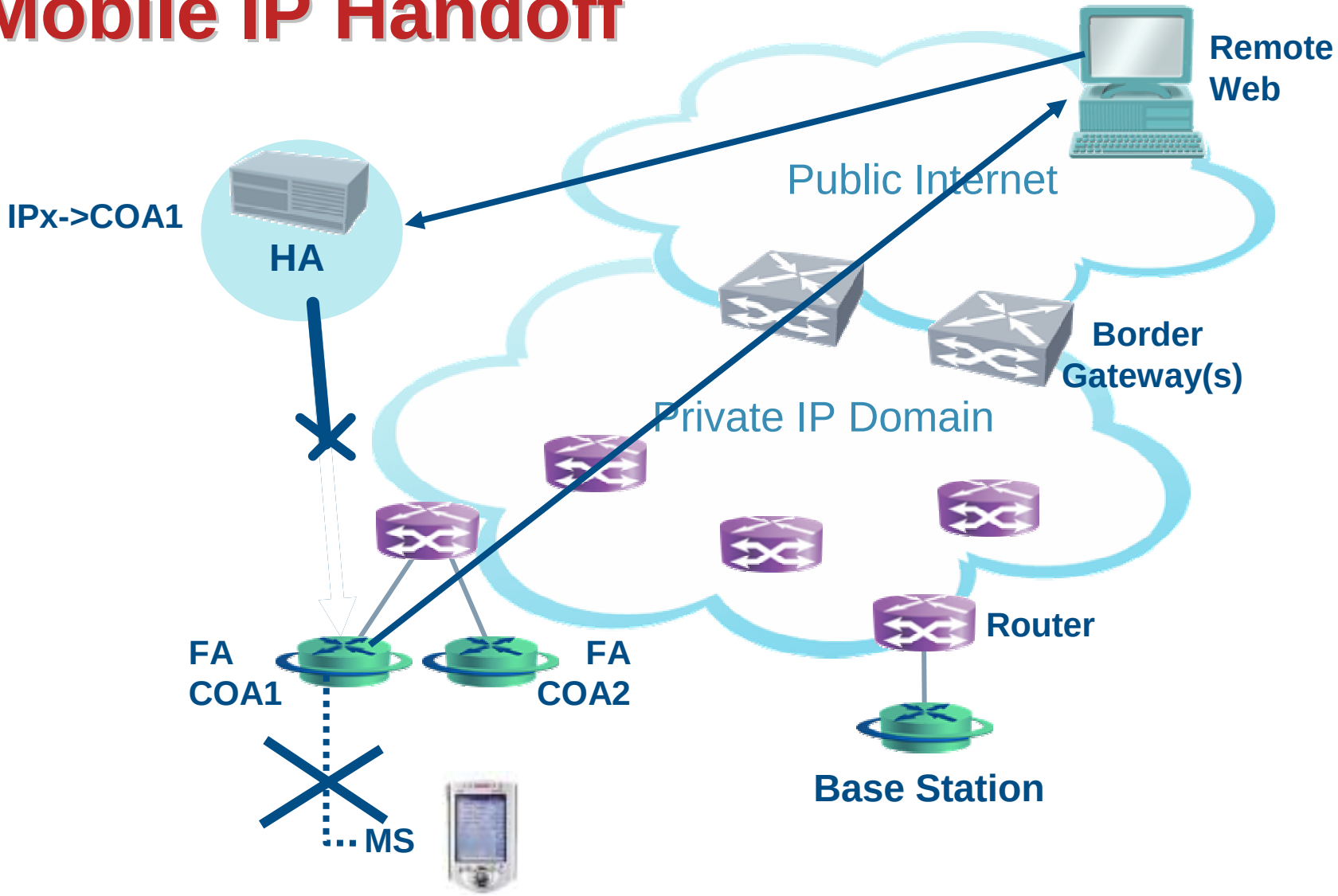
Mobile IP Features

- Provides a framework for mobility management
- Tunnel-based redirection and forwarding between IP subnets (MBWA cells)
- Enables transparent network layer mobility (i.e. no address change)

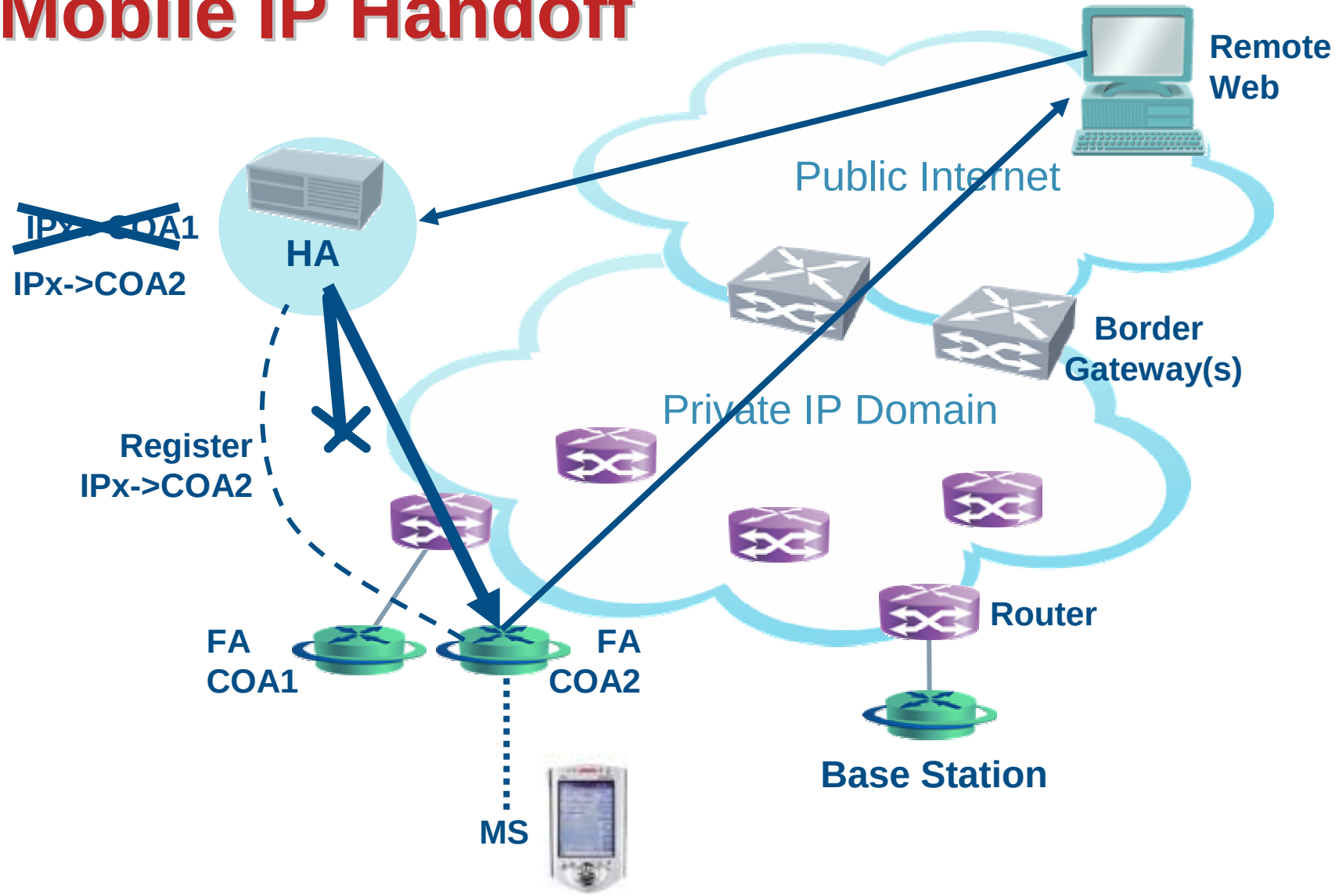
Mobile IP Registration



Mobile IP Handoff

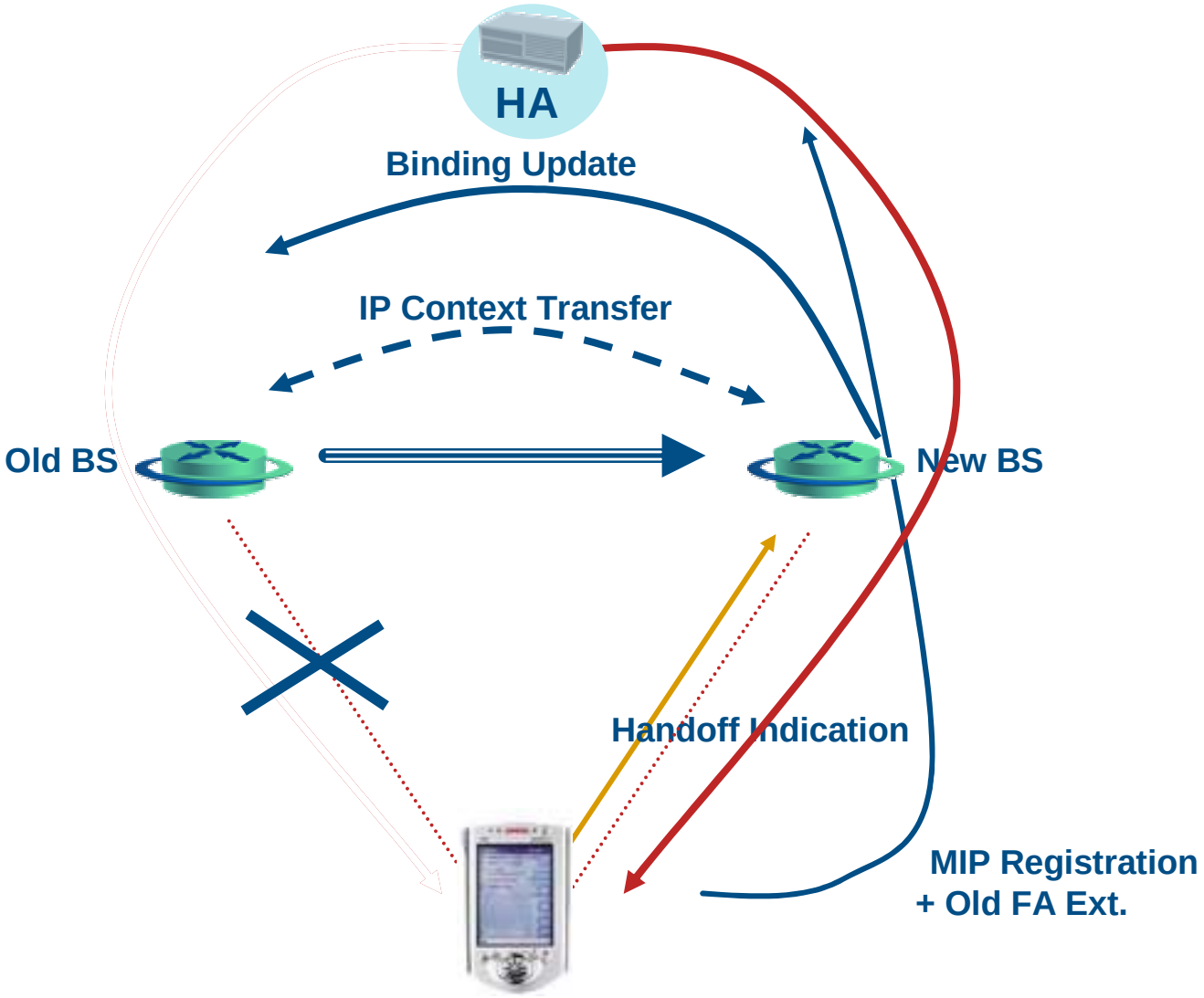


Mobile IP Handoff



An Enhanced Mobile IP Handoff

True Make-Before-Break



Desirable Features for Enhanced Handoff

- Interoperable
  - HA runs Mobile IP
  - HA can run in standard routers
- Seamless to the user
  - Minimum packet loss and latency
- Robust
  - Reactive Mobile IP-based mechanism

Motivation for Paging

Small lightweight devices

+

Long operational lifetime

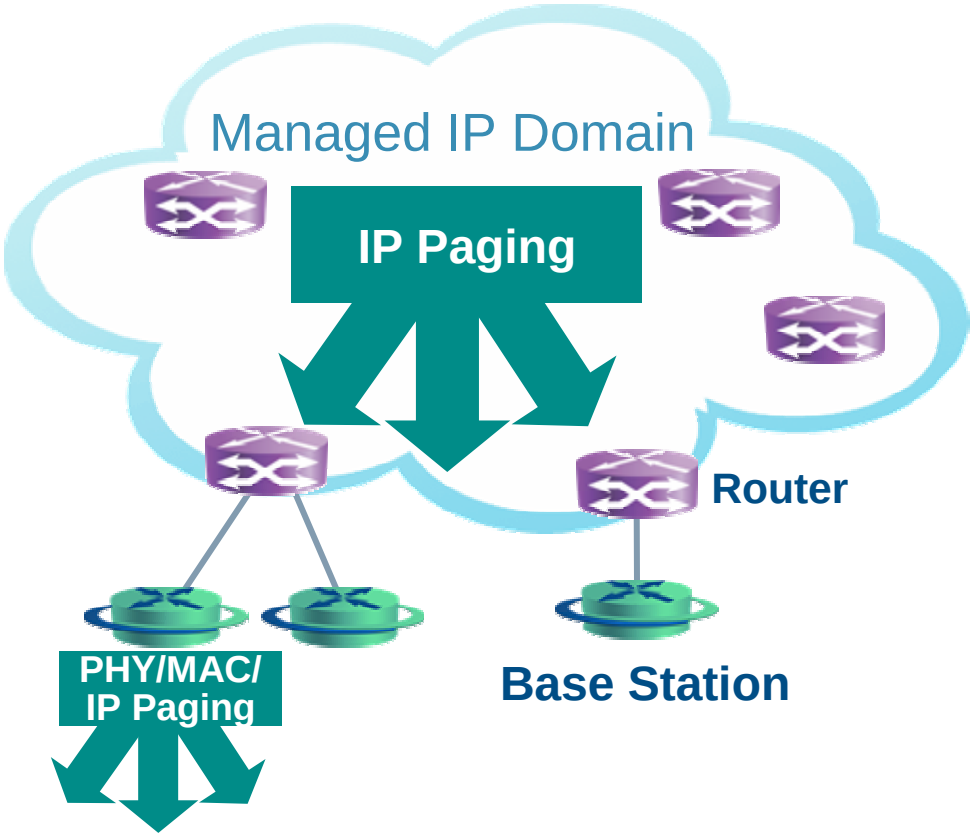
Power Conservation + Always-on reachability → Paging Support

Desirable Paging Operation

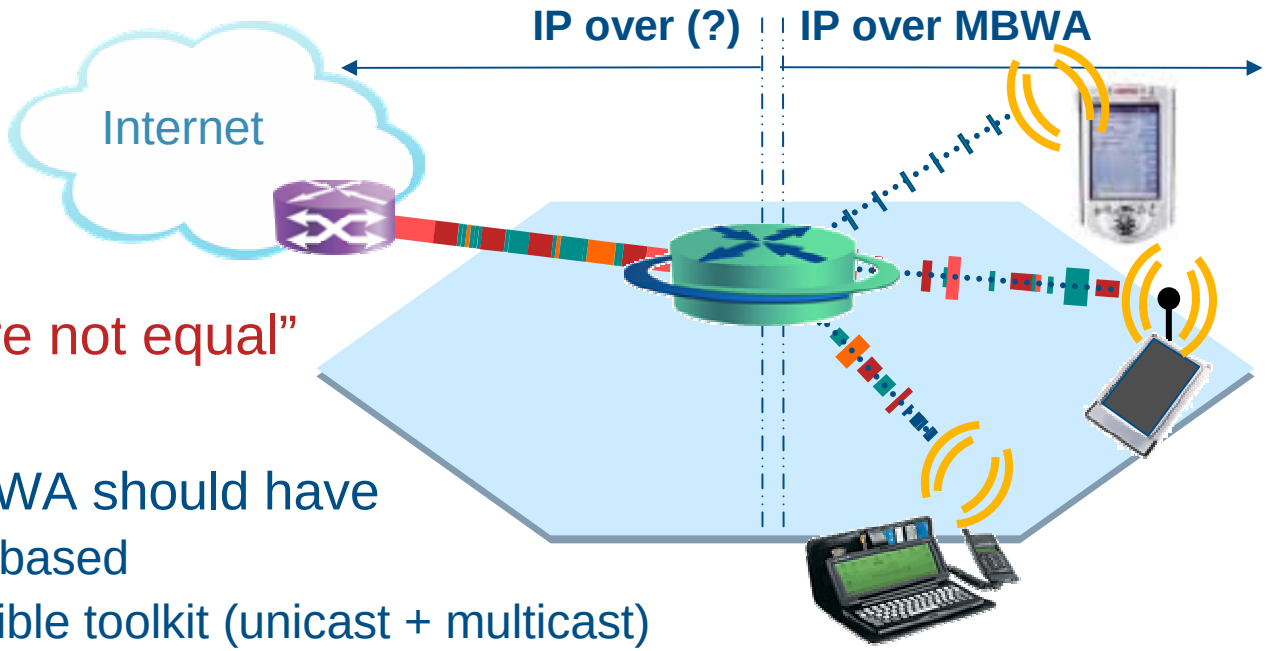
- Between “Active” sessions, mobile should enter “Sleep” mode to reduce power consumption.
- While in Sleep mode, mobile should periodically listen for pages that indicate need to return to Active mode.

An IP-based Paging Approach

- **IP-based page signaling to base stations**
- **PHY/MAC/IP layer paging within a cell/sector**



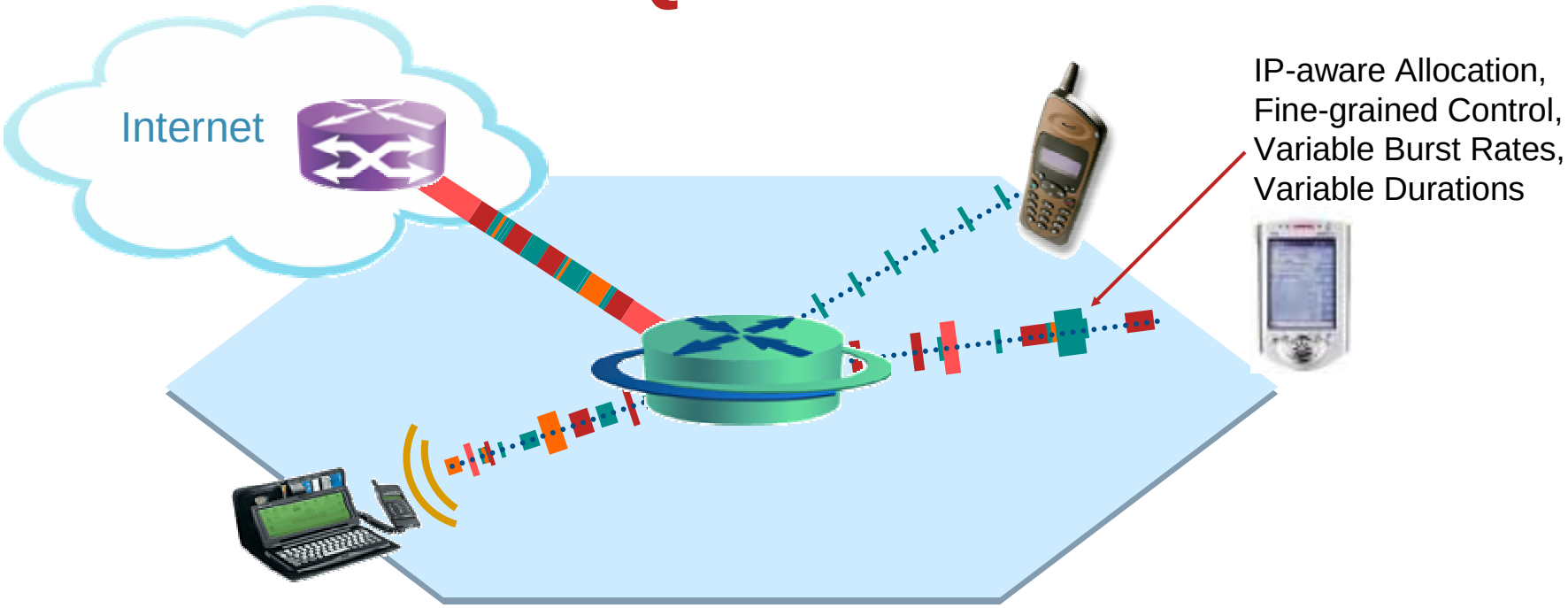
QoS: Maximizing Spectrum Utility



"All packets are not equal"

- IP over MBWA should have
  - DiffServ-based
  - Rich flexible toolkit (unicast + multicast)
- Joint optimization of QoS scheduling across IP, MAC and PHY layer constraints

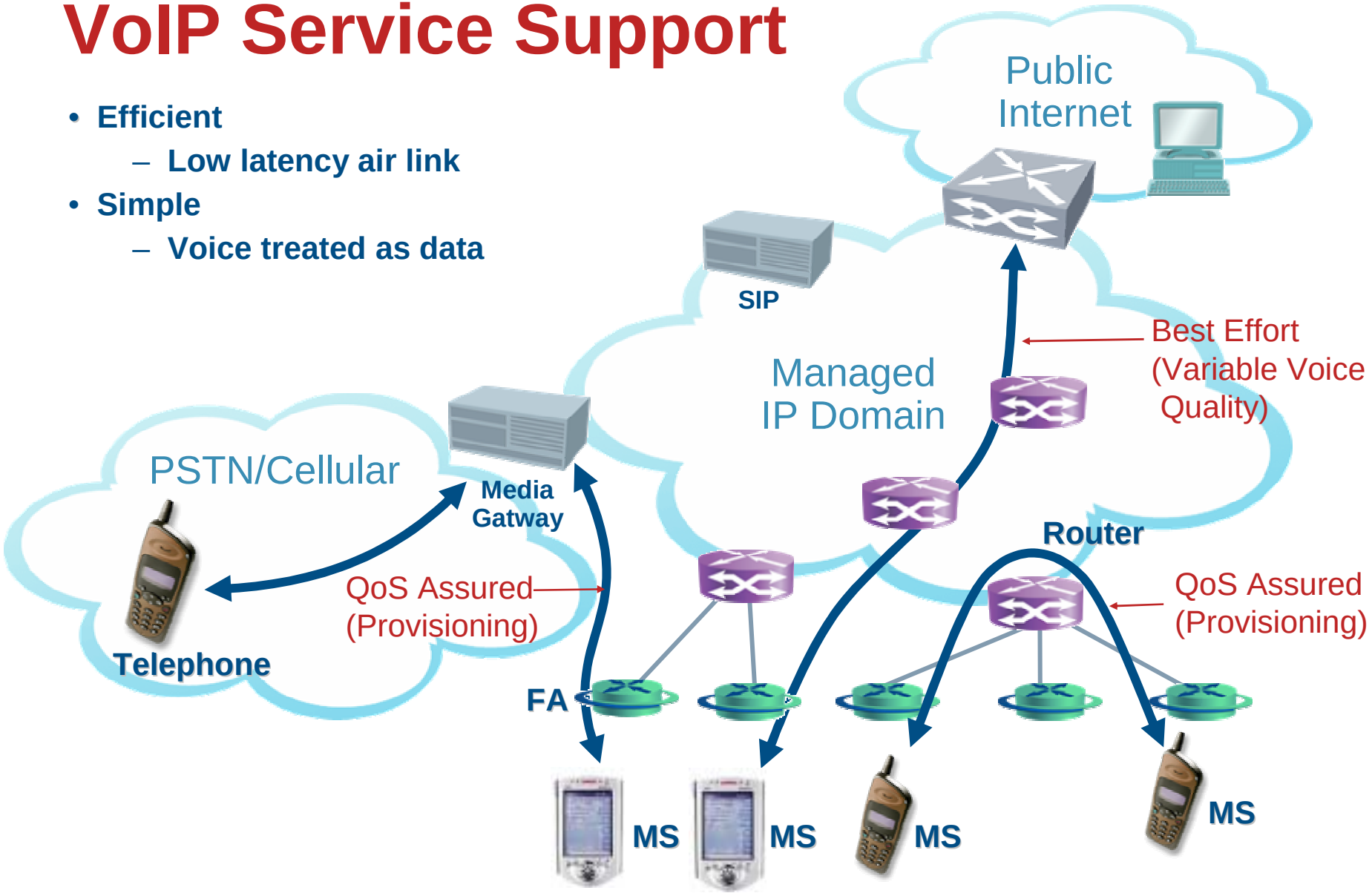
Enablers for IP QoS ‘Over the Air’



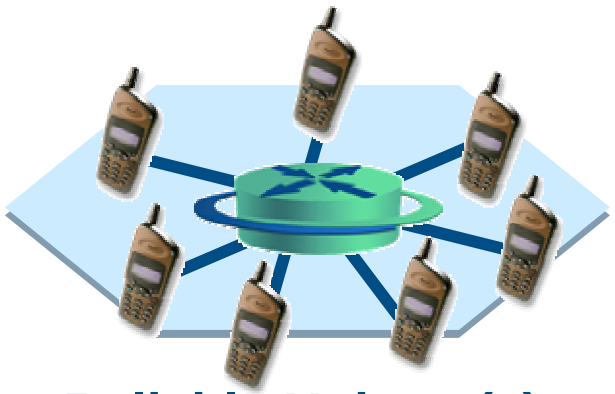
- **Multiple ‘wire-like’ links**
  - **Reliable, low latency air links**
  - **Broadband user feel**
- **Fully-scheduled, air resource**
- **Link layer Multicast/Broadcast**

VoIP Service Support

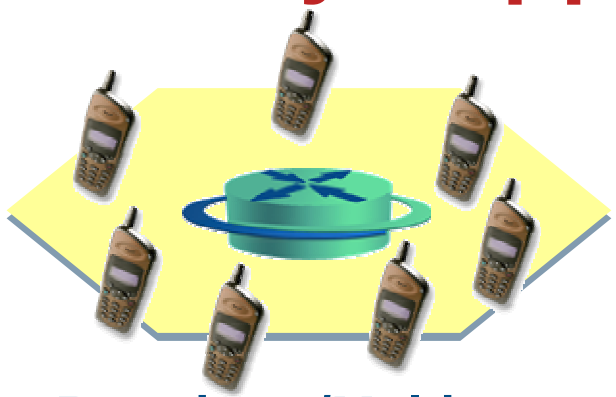
- **Efficient**
  - **Low latency air link**
- **Simple**
  - **Voice treated as data**



IP Multicast Delivery Support



Reliable Unicast(s)



Broadcast/Multicast

Mixed Delivery

- IP Multicast Delivery options
  - Reliable unicasts (point-to-multipoint)
  - Low-loss, broadcast/multicast
- Scheduling freedom (mixed delivery)
  - A mobile may simultaneously receive unicast and multicast data
- Ideal for push-to-talk, interactive gaming, video, focused advertisements, subscription services, etc.

Interactive Services

- SIP and IPv6 return the Internet to its peer-to-peer origins, enabling voice, gaming, etc.
  - support for interactive Apps and future data services requires an air interface that can handle **many** small messages very quickly
    - requires a fast, efficient MAC layer under QoS control that can handle a **large** number of users

Summary

- An ideal IP-based Cellular Network suggests an air interface that:
  - enables use of standard IP core technology
  - enables autonomous IP base stations
  - adapts Wireless to the Internet (not vice-versa)
    - existing IP protocols/apps work without modification
    - mobile and fixed Internet realms remain the same
  - maximizes spectrum utility, not just bits/hertz