### Project
IEEE 802.20 Working Group on Mobile Broadband Wireless Access
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### Title
A Vision of an IP-based Cellular Network

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### Re:
802.20 Presentation

### Abstract
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### Purpose
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### Release
A Vision of an IP-based Cellular Network

M. Scott Corson
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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

MBWA Air Interface

Operator IP-based Network

Autonomous Base Stations

Back End Systems

Gateway

Public Internet

Mobility Agents

Mobility Management

User Devices
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 \textit{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

Handoffs driven by air interface considerations
Inter-technology AAA Roaming

Typically ‘policy-based’ handoffs
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

HA

IPx->COA1

Register
IPx->COA1

FA

COA1

MS

Home=IPx

Public Internet

Border Gateway(s)

Private IP Domain

Remote Web

Router

Base Station
Mobile IP Handoff

- HA
- IPx->COA1
- FA
- COA1
- COA2
- Router
- Base Station
- Remote Web
- Public Internet
- Border Gateway(s)
- Private IP Domain
- Mobile IP Handoff
Mobile IP Handoff

HA

Remote Web

Public Internet

Border Gateway(s)

Private IP Domain

Router

Base Station

FA

COA1

FA

COA2

MS

IPx->COA1

IPx->COA2

Register

IPx->COA2

FA COA1

FA COA2
An Enhanced Mobile IP Handoff

*True Make-Before-Break*

- Binding Update
- IP Context Transfer
- Handoff Indication
- MIP Registration + Old FA Ext.
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

How do you like my new wireless PDA?

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

IP-aware Allocation, Fine-grained Control, Variable Burst Rates, Variable Durations
VoIP Service Support

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

Efficient – Low latency air link
Simple – Voice treated as data

PSTN/Cellular
Telephone

Media Gateway

QoS Assured (Provisioning)

Managed IP Domain

SIP

Best Effort (Variable Voice Quality)

QoS Assured (Provisioning)

Router

Public Internet

MS

MS

MS

MS

MS
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