DoCoMo USA Labs

4G Access Network Architectures

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Outline

- Current trends in access networks.
- Multihop architecture for 4G?
- The IP hourglass and access networks.
- Access points as IP architectural elements.
- Summary.

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Current Trends in Access Networks

Problems with 3G

- UMTS deployments stalling.
  - High license costs.
  - High infrastructure costs.
- cdma2000 deployments proceeding, business prospects uncertain.
  - Lower infrastructure costs.
  - Will business data drive the need for higher bandwidth?
    - And hopefully some revenue…
- WLAN potential high but there are uncertainties.
  - Limited coverage area.
  - Power problems.
  - Not suitable for high speed mobility.
  - Will the hotspot business model succeed?

What's Needed for 4G?

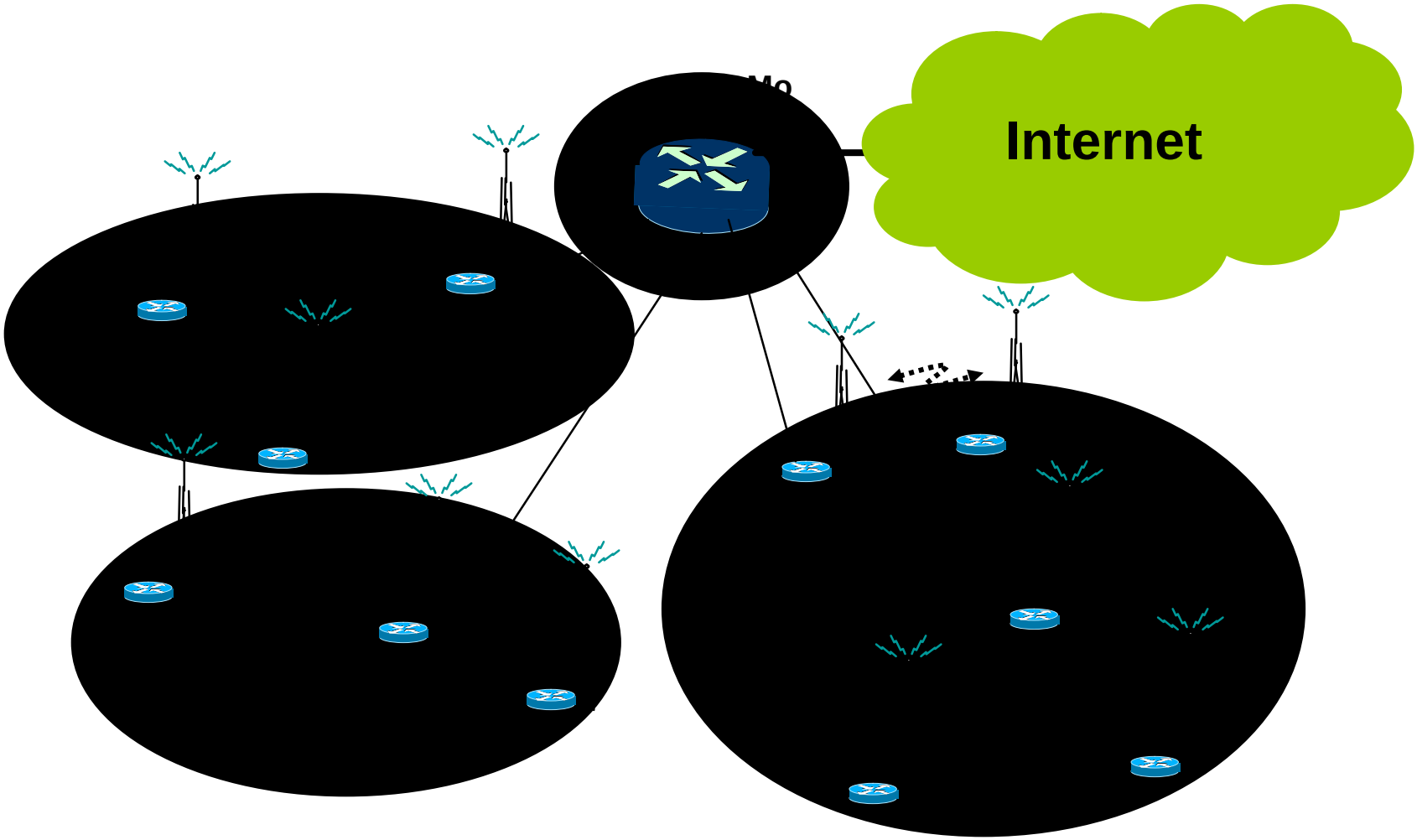
- Cheaper access point deployment cost.
  - 90% of access network deployment cost is in the radio access points.
  - 10% is in the network.
- Cheaper network costs.
  - Combined voice/data for VoIP to the mobile terminal.
  - Removes need for dual circuit-switched/packet switched backbone.
  - Reduction in network operating costs.
- IP friendly radio protocol.
  - 3G latency too high (200-300 ms) for VoIP.
  - Is high per mobile terminal bandwidth really necessary?

High Bandwidth 4G

- ITU-R targeting standard for 100 mbps downlink/50 mbps uplink aggregate bandwidth by 2010/2012.
  - Radically increased cell capacity.
  - Support millions of small, sensor devices.
- Traditional cellular architecture will require 300-500 MHz.
- Bandwidth allocation problems.
  - Impossible to allocate below 5 GHz.
  - Difficult around 5 GHz.
  - Probably around 10 GHz.
- Line of sight effects become important.
  - Requires many more access points.
  - Wired network access difficult.
  - Corresponding cost increase with traditional cellular architecture.
- Is a multihop architecture a viable alternative?

Multihop Architecture

Example Multihop Architecture

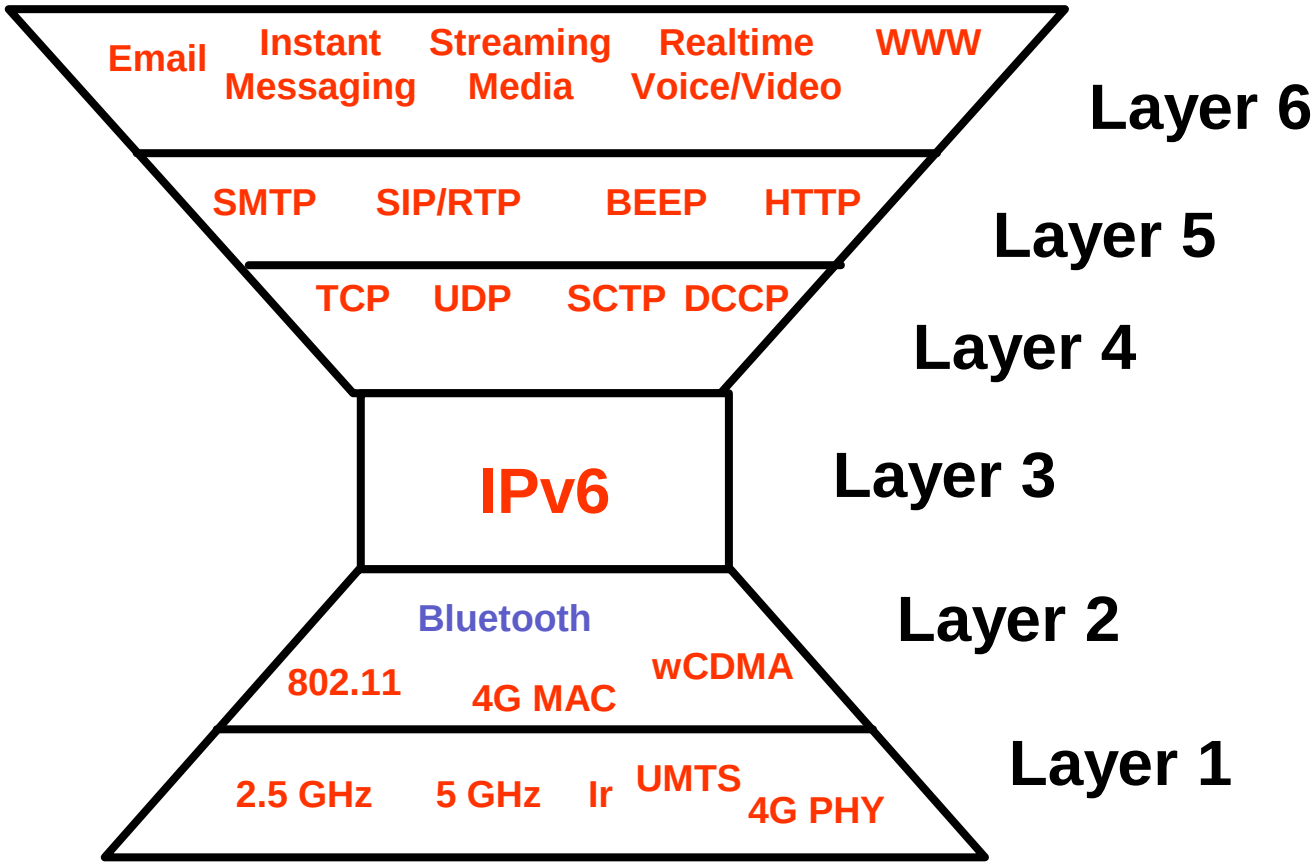


Multihop Architecture

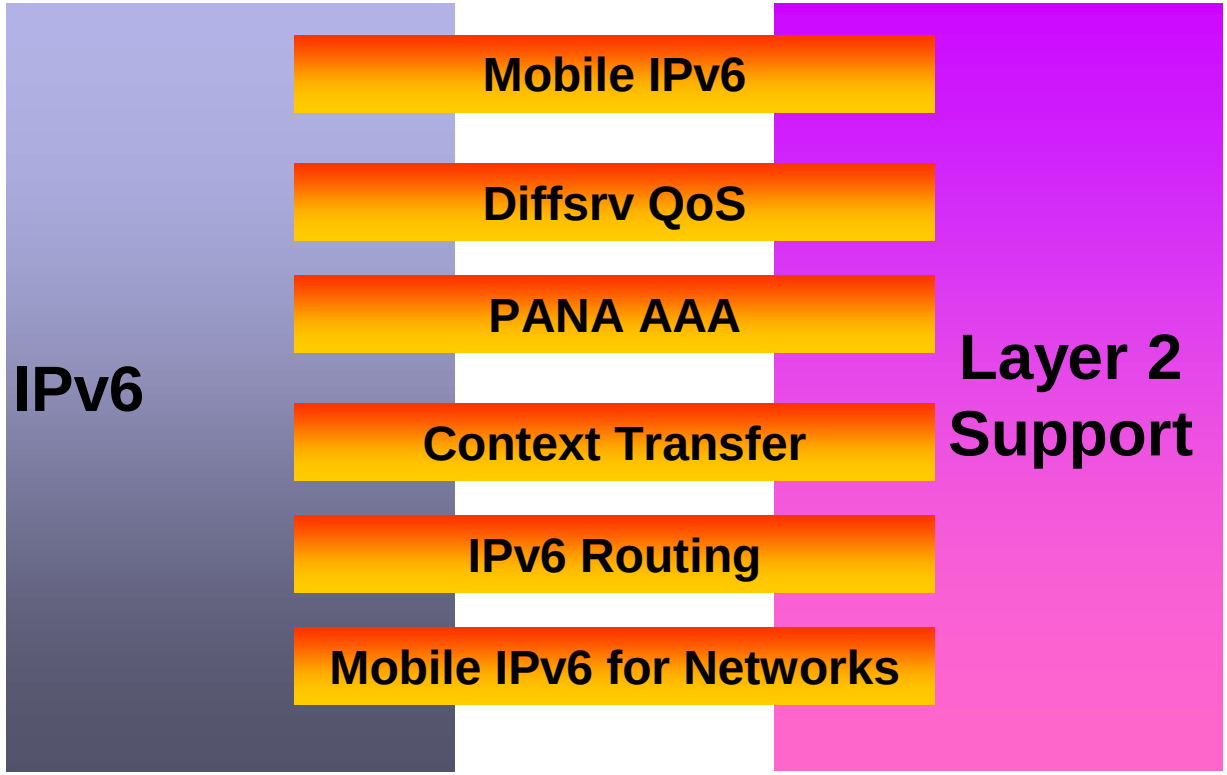
- Property owners can install their own access points.
  - Spreads infrastructure cost.
- Reduced network access operational cost.
  - Backbone access through wireless.
  - Wired access through DSL at aggregation points.
- Ad hoc-like characteristics:
  - Access points configure into access network.
  - Some access points may be moving (bus, train).
- Multihop also could reduce costs in heterogeneous 3G networks.
  - 802.11 to GPRS for example.
- Can multihop deliver low latency, real time IP?

The IP Hourglass

IP as the Unifying Abstraction



The IP Waist and Wireless Layer 2



Example 1: Handover Triggers

- Mobile IP movement detection depends only on Layer 3 information – slow!
  - Router Advertisement Layer 3 beacon
  - ICMP Redirect
  - ICMP Host Not Found
- Idea: synchronize Mobile IP handover with Layer 2 link change.
- Handover triggers:
  - Prehandover notification
  - Link down
  - Link up
- Problem: existing wireless link protocols don't entirely fit the model.

Example 2: AAA to Host

- AAA is more important in wireless because medium is broadcast.
- Existing wireless protocols use Layer 2 AAA.
  - Complex interaction with IP AAA.
- Example 802.11
  - Association.Request/Reply
  - 802.1x
  - Required on each access point handover!
- Idea: Split AAA into two:
  - Initial Layer 2 phase for link access authorization only.
  - Subsequent Layer 3 phase with IP for off-link access.
  - PANA, Diameter for Layer 3 common for multiple Layer 2 protocols.
- Problem: existing wireless link protocols don't fit this model.
  - 802.1x

Barriers

- IP over Wired doesn't need any special Layer 2 support.
  - Except for path MTU discovery.
- Changing AAA requires inter-standardization group co-operation.
- IETF participants concerned exclusively with wired networks see Layer 2 triggers as a network management issue.
  - Proposed use of SNMP.
  - Too slow and complex for real time handover.
- PANA, Diameter only address part of the problem.
  - The other part is simplifying 802.11 authentication.

Access Points as IP Devices

Recognizing Access Points as IP Layer Devices

- In 4G networks, some multihop devices will be access points only, others will be routers.
- In heterogeneous 3G networks, cheap, simple access points can provide a more cost effective deployment scenario.
- IETF view: access points are Layer 2 devices, therefore, they can be ignored by IETF.
- But access points have important IP layer functions.
  - Not visible to the host.

IP Layer Functions of Access Points

- Tunnel end points for fast IP handover.
- Provide routers with radio link information:
  - Triggers for handover if router handles the tunnel.
  - Radio quality information for QoS if router handles.
- Network Access Server (NAS) for AAA.
- Distributed radio resource management.

Summary

- Research in 4G networks should seek to address the problems that cropped up in 3G networks.
  - Don’t do high bandwidth, etc. just for the sake of doing new technology.
- 4G wireless protocols may require multihop due to high frequency.
  - Multihop can reduces costs in heterogeneous 3G networks too.
- Coordinating Layer 2 and IP necessary for fast, efficient wireless IP service.
- Barriers to standardization in wired network culture, inter-standardization co-ordination.
- Multihop, cheap access points may provide a more cost effective deployment than traditional cellular architectures.