A Distribution System for Large Scale IEEE 802.11 Wireless LANs

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Our lost area from above

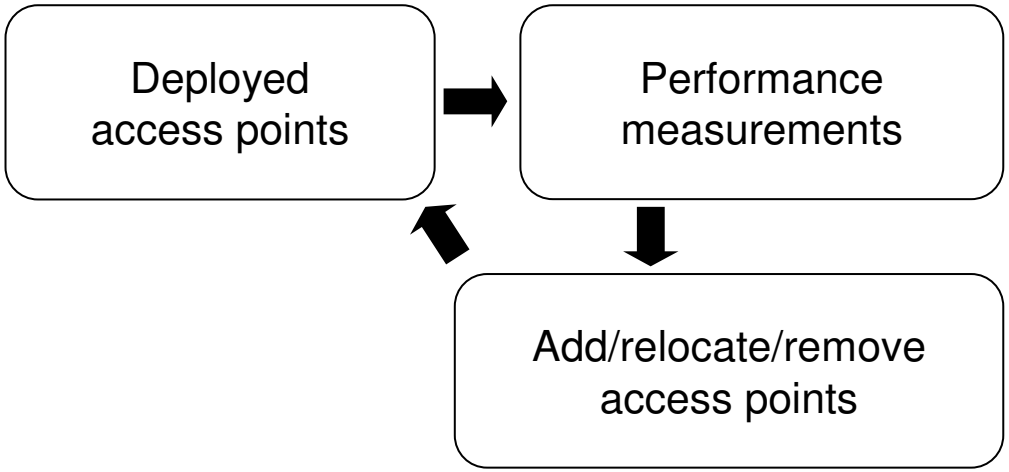
The land area is about 150 million square kilometers

Could be covered by 300 million 802.11 access points

How to cover this area?

- A priori planning impossible
  - Independent owners of access points
  - Unlicensed spectrum, no permission needed
  - Radio propagation planning
  - Traffic demand forecasting
- Rely on existing growth of coverage
  - Shipments: some 10's of million units per year
  - Promote self-organization
    - Coordinate AP's into larger WLAN's
    - Steer growth towards uncovered areas
    - Provide incentives to share AP's
  - Promote open access to all public networks
    - Access bought in time or data units

Incremental deployment



- Start with initial coverage
  - Existing deployments that form the WLAN
- Monitor how well the infrastructure performs
  - Air-time usage and throughput
  - Users' positions with respect to installed APs
- Suggest relocations, removals and additions
  - Two growth components
    - Individual owners primarily meeting one's own need
    - Public owners meeting general need (free or at cost)
- Integrate new AP's into the existing infrastructure
  - Monitor how well the infrastructure performs…

Advantages

- Organic growth
  - Unlicensed spectrum
    - Anyone can deploy infrastructure on own or leased sites
  - No need for subscriptions
    - Capacity bought in small units
    - Business operators compete on price and QoS
- Continuous innovation
  - Services available via the Internet
    - Not in radio access network
  - No 3G, 4G … with long standardization cycles
    - IEEE 802.11 shorter cycles, standards leave room for add ons
  - Users select network access based on application needs and policies
    - Competitive drive for more coverage and better service
- Incentives
  - Private needs
    - Companies, organizations and individuals
    - Public use of surplus capacity
  - Business opportunities
    - Dense user population – high demand and competition
      - Baseline service or leading edge
    - Sparse population – low demand, first mover advantage
  - Add-on to primary business
    - Coffee shops, camping sites, ski resorts, …

From APs to a WLAN

- Roaming and handover
  - Seamless
  - Load balancing (forced handover)
- Resource allocation
  - Space, power, frequency
  - QoS support
- Management
  - Configuration
  - Performance
  - Security
  - Reliability
- Sharing of infrastructure
  - Incentive schemes and business models
  - Resolution of inter-WLAN interference

Need for a new distribution system!

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Outline of remainder

- IP-based distribution system
- The architecture and self-configuration
- Routing and mobility support
- Performance issues
- Summary and future work

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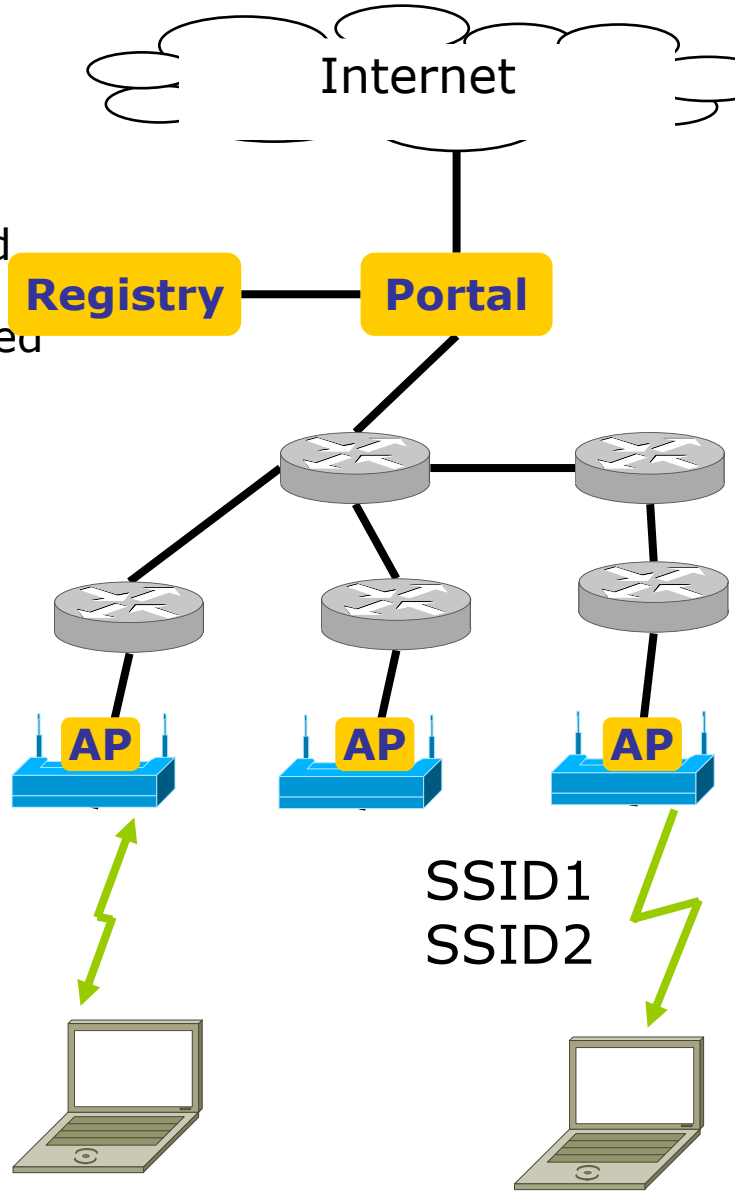
Distribution system

- Radio-access network for WLAN
  - Not standardized in IEEE 802.11
  - IEEE 802.3 mostly used
    - Limits the composition
- IP-based distribution system
  - One IP-based overlay network
    - Intermediate routers not affected
    - APs in different IP networks
  - Smooth handoff at link layer
  - No need for Mobile IP
  - Self-configuration
  - Load balancing amongst APs
  - Allows APs to be shared by different WLANS

Architecture

- Registry for self-configuration
  - Stores IP addresses of all APs in WLAN
  - Informs new AP of WLAN name and portal IP address
  - Not time critical and could be located anywhere
- Portal
  - Gateway to WLAN
    - Routes traffic between APs and the Internet
    - Relies on IP tunneling to form overlay
  - Associates stations to WLAN
    - MAC and IP addresses, APs IP address
- Modifications to APs
  - Wired side
    - Protocol for AP registration and station association with portal
    - IP-within-IP encapsulation
    - Routing within DS
  - Wireless side
    - Announce more than one name (if shared)



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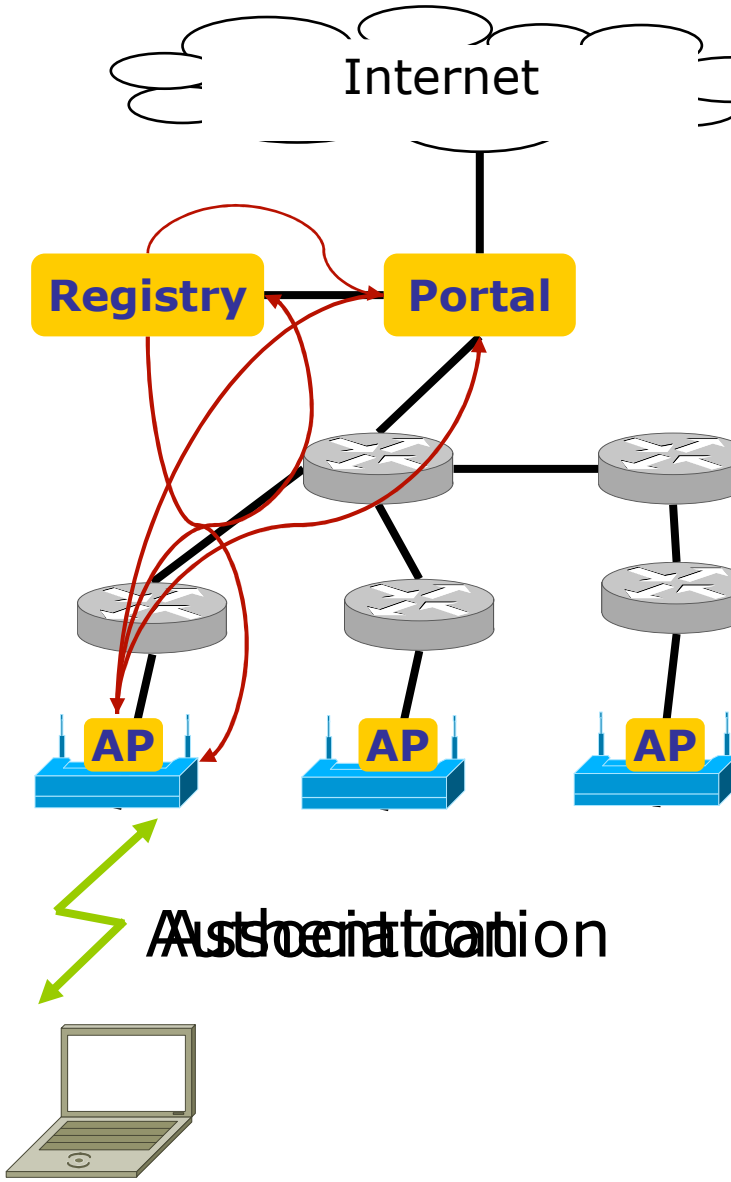
Self-configuration

- New AP contacts the registry
  - Reachable at known IP address
  - Provides own IP address and MAC address for wireless side
- The registry provides
  - Acceptance of registration
  - WLAN name to broadcast
  - Network address and mask
  - IP address of the portal
  - The AP's IP address to the portal
- Station registration
  - Authenticates with AP
  - Association with AP
  - AP notifies portal
    - Station's MAC address
    - AP's IP address
  - Portal confirms association
  - Station obtains IP address
    - DHCP server at portal
    - Informs portal



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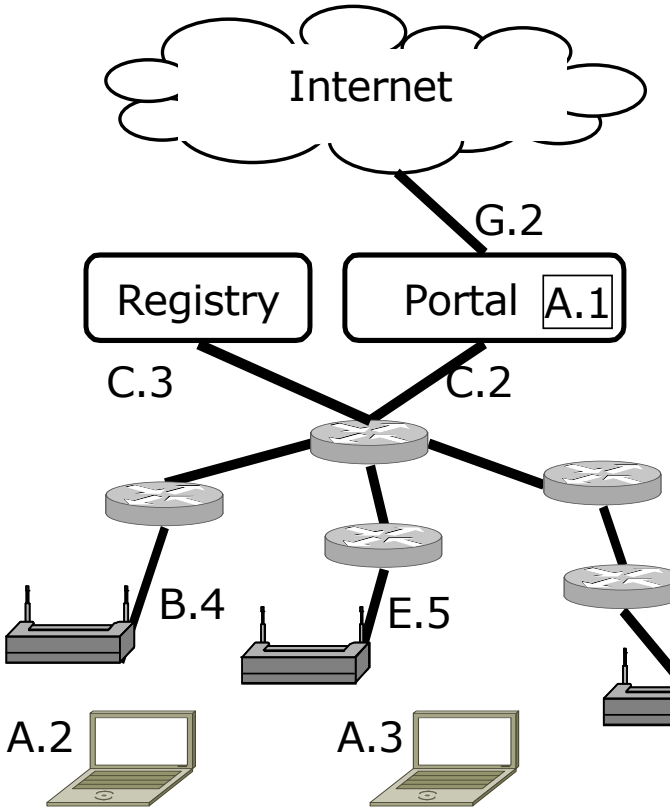
Routing in the DS

- All IP addresses with common prefix
  - All wireless stations in the WLAN
  - Portal
- Uplink
  - Station sends IP packet in 802.11 frame
  - AP decides if frame is for WLAN
    - Based on IP address
    - Destinations outside WLAN sent to portal
  - To find station within WLAN
    - AP contacts portal
    - Gets IP address of AP where receiver is associated
    - Caches the answer, portal records it
  - AP encapsulates 802.11 frame in IP packet and sends it
    - Receiving AP extracts frame
    - Frame forwarded to receiving station



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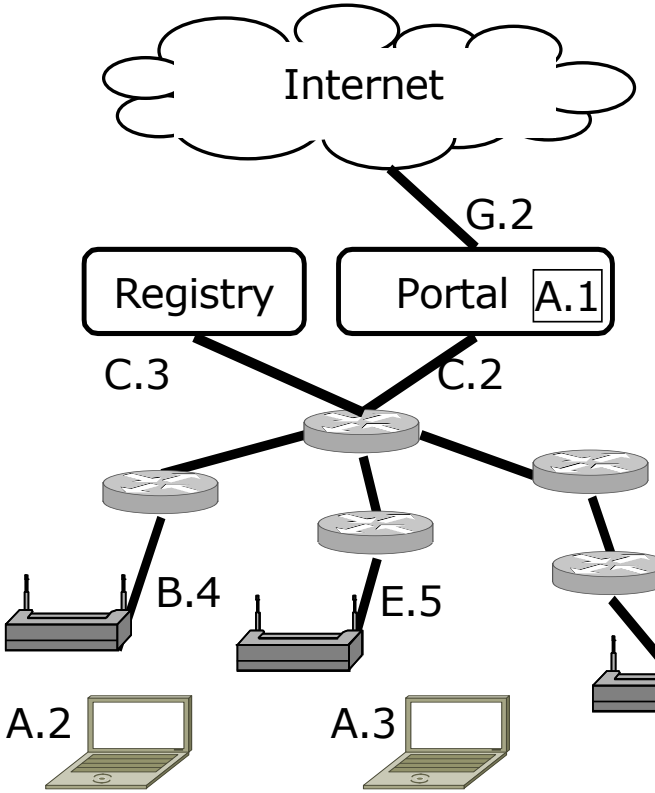
Routing in the DS

- Downlink
  - From portal to AP
    - Encapsulation of IP packet
  - From AP to AP
    - Frame within IP packet
  - Distinguished by protocol field
- Handoff
  - Stations follow standard 802.11 procedure
  - Re-association
    - New AP informs portal of move
    - Portal updates routing
    - Informs APs that have forwarded frames to the station



Performance issues

- The distribution system fully implemented and tested
  - Scalability hard to test experimentally
- Registration of access points
  - Slow process and not delay sensitive
- Association of stations at portal
  - Critical for short association times
  - Update of next-hop information in the portals FIB
- Address lookup at portal
  - MAC to IP address
    - To find AP where receiver is associated
    - For first frame from AP to given receiver
  - IP address of incoming packets
    - To find AP where receiver is associated
- Scalability depends on
  - Number of stations in the WLAN
  - Number of APs in the WLAN
  - Address lookup scheme
    - 60 million packet lookups per second on a Pentium 4, 2.8 GHz, computer for a real traffic trace [Fu et al.]

Summary and future work

- IP-based distribution systems
  - Retains link-level benefits
    - Fast handovers
    - Load balancing
  - Self-configuring
    - Registry serving incoming APs
  - Stations remain unaffected
    - Only APs, registry and portal
  - Sharing possible of APs between WLANs
  - Performance a matter of dimensioning
    - Little difference from normal address lookup
- Future work
  - Large-scale test bed
  - Inclusion of wireless routers in concept
  - Incorporation in wireless content distribution system

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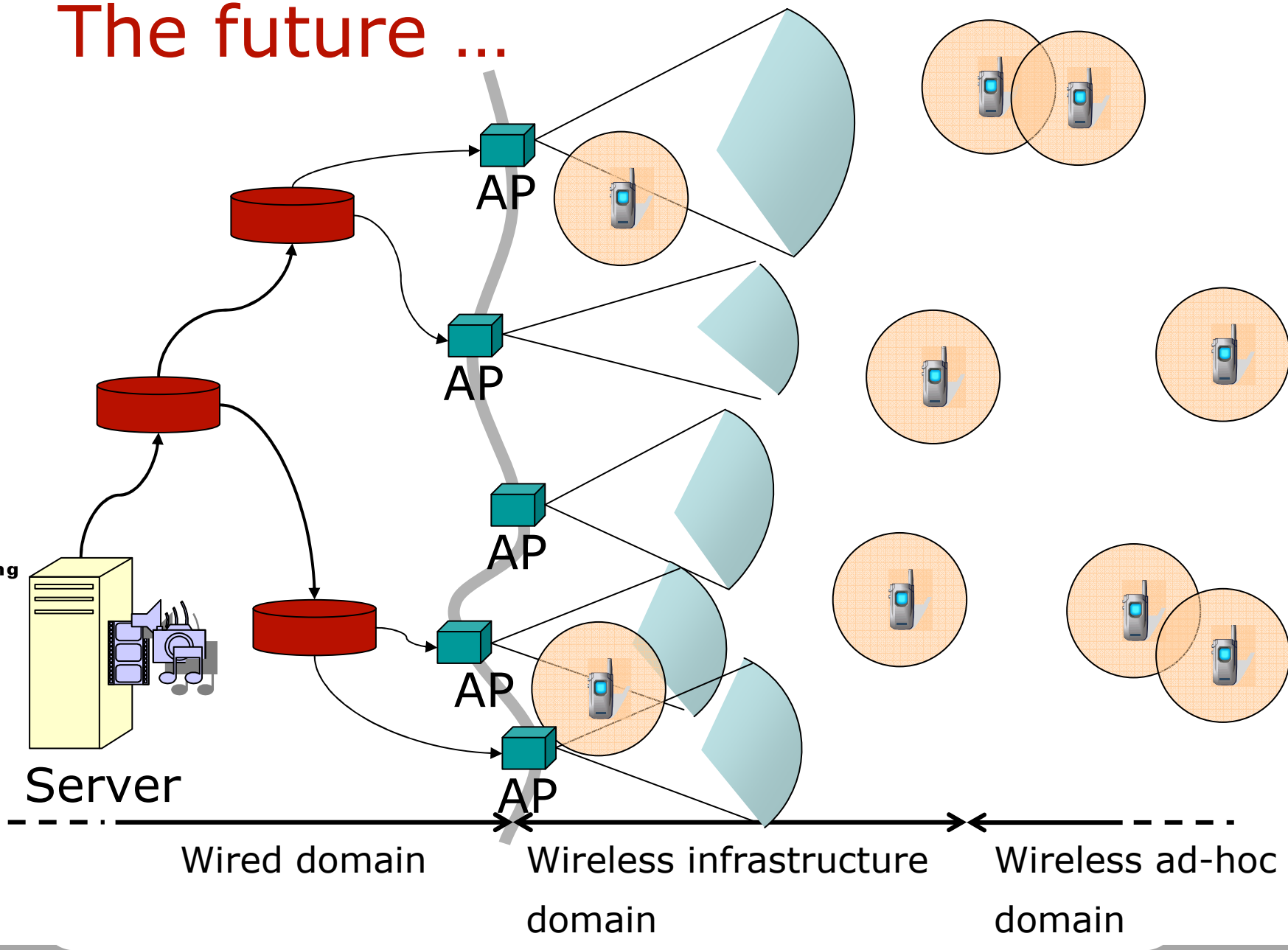
The future …



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