Introduction to Wireless Networks

Chapter 7: Introduction to Heterogeneous Networks and ALL-IP Networks

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Outline

- Trend on Wireless/Cellular Networks
- Heterogeneous Wireless Networks
  - Datacom: Wireless Networks
  - Telecom: Cellular Networks
- Some Research Issues
  - Interworking Architecture
  - Mobility Management
  - QoS Guarantee
  - Security/AAA
- Conclusions
Cellular Networks (1/2)

- 1G: analog systems
  - AMPS, NMT, TACS
- 2/2+G: digital systems
  - GSM, CDMA
  - GPRS, EGDE
- 3G: IMT-2000
  - W-CDMA (UMTS)
  - CDMA2000
- Beyond 3G
  - All-IP architecture
- 4G
  - Heterogeneous networks
- 5G
  - ???
Cellular Networks (2/2)

Maximal data rate

- ISDN: 64 kb/s
- HSCSD: 9.6 kb/s
- GPRS: 57.6 (115.2) kb/s
- EDGE: 171.2 kb/s
- UTRA: 553.6 kb/s
- UMTS: 1920 kb/s
Wireless Networks (1/2)

  - ([http://www.ieee802.org/15/pub/TG4.html](http://www.ieee802.org/15/pub/TG4.html))
  - Communication between computers, mobile telephones, and other portable devices
  - Derive from the Bluetooth Spec.
  - 721 kb/s or up to 20 Mb/s in the 2.4 GHz band

- 802.11 Wireless LAN
  - ([http://grouper.ieee.org/groups/802/11/](http://grouper.ieee.org/groups/802/11/))
  - 1 or 2 Mb/s with infrared
  - 1 or 2 Mb/s with the frequency hopping spread spectrum in the 2.4 GHz band
MICAz - 2.4 GHz IEEE 804.15.4/ZigBee™ Compliant Mote

(http://www.xbow.com/)
Wireless Networks (2/2)

- Up to 11 Mb/s with the direct sequence spread spectrum in the 2.4 GHz band (802.11b) (Wi-Fi Standard)
- Up to 20 (54) Mb/s with the orthogonal frequency division multiplexing in the 2.4 GHz band (802.11g)
- Up to 54 Mb/s with the orthogonal frequency division multiplexing in the 5-6 GHz band (802.11a)

802.16 Wireless MAN (WiMax)
- [WiMax Forum](http://www.wimaxforum.org/home)
- Broadband wireless access standards
- Link commercial/residential buildings to core networks
- Ranges of bands
  - 5-6 GHz, 2-11 GHz, 10-66 GHz
Next-generation Wireless Internet

(1/2)

- Heterogeneous Networks
  - Including different access networks
    - GPRS, WLAN, MANET (mobile ad hoc)
  - Vertical/Horizontal handoffs
- All-IP Architecture and Connectivity
- Terminals with Software-Based Radio Interfaces
Example IP-based 4G/Next G/… network

- PSTN, CS core
- SS7 signalling
- IP-based core
- GSM
- BSC
- MSC
- SGSN
- router
- Internet
- broadcast
- access points
- private WPAN
- private WLAN
- firewall, GGSN, gateway
- server farm, gateways, proxies
- gateways
- firewall
- GGSN
- gateway
- broadcast
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- UMTS
Next-generation Wireless Internet
(2/2)
All-IP Architecture

- **Advantages**
  - Integrated voice and data stack at end devices
  - Simpler signaling architecture
  - Lower operations and network management cost

- **Disadvantages**
  - IP headers waste wireless bandwidth
  - More complex terminals
  - Larger latency
  - Requires QoS support for packet voice
Integrated WLAN and Cellular Data Networks

- Integrated WLAN and Cellular Data Networks
  - A cellular data network can provide relatively low speed data service (up to 115.2Kbps with GPRS and 2Mbps with 3G system) over a large coverage area. On the other hand, WLAN provides high-speed data service (up to 11 Mbps with 802.11b and 54Mbps with 802.11a) over a geographically small area. An integrated network combines these two kind of data networks.
  - A kind of Heterogeneous Networks
Integration

- UMTS (or GPRS) vs. WLAN
  - Coverage
    - UMTS (several kilometers) > WLAN (several hundred meters)
  - Data rate
    - WLAN (up to 54Mbps) > UMTS (up to 2Mbps when static) > GPRS (up to 115.2K bps)

- There is a strong need for interworking mechanism between WLANs and cellular data networks

- We discuss integrated UMTS/WLAN heterogeneous networks
Integration of Heterogeneous Networks

MANET

WLAN

Connection/Mobility Management

QoS Guarantee

Security/AAA
Scenario: Integration
Scenario: Connection/Mobility

Mobile IP

Hybrid Ad Hoc Routing
Scenario: Authentication

SIM-based Authentication
Scenario: End-to-End QoS

- GPRS Network
- SIP/RSVP/DiffServ
- Ad Hoc Network
- WLAN Network
Research Issues in Heterogeneous Networks

- Security/AAA
- Interworking Operation
- ALL-IP Core, IP Mobility
- QoS Guarantee
- Connection/Mobility
Interworking Architectures

- There needs an interworking mechanisms, which effectively combine WLANs and cellular data network into integrated wireless data environment capable of ubiquitous data service and very high data rates in hotspot locations.

- The European Telecommunications Standards Institute (ETSI) specifies two coupling mechanisms:
  - A Tight Coupling Architecture
  - A Loose Coupling Architecture

- **Loose coupling**: WLAN data traffic goes directly to the external packet data networks (PDN)
- **Tight coupling**: WLAN data traffic goes through GPRS core networks
Loose Coupling

- WLAN is deployed as an access network complementary to the GPRS network
- Standard IETF-based protocols for AAA and mobility (e.g. Mobile IP)
- Need a common billing system
A GPRS Reference Diagram Showing the WLAN Coupling Points
WLAN-GPRS Integration with Loose Coupling

- **Radio access network (UTRAN/GPRS RAN)**
- **HLR (AuC)**
- **GPRS core**
- **FA**
- **SGSN**
- **GGSN**
- **CAG**
- **HA**
- **Feature servers**
- **Operator's IP network**
- **Firewall**
- **Billing mediator**
- **Billing system**
- **Internet**
- **WLAN network**
- **Double-mode MS**
- **AP**
- **AAA**

**Abbreviations:**
- CAG: Cellular access gateway
- CG: Charging gateway
- HLR: Home location register
- AuC: Authentication center
- SGSN: Serving GPRS support node
- GGSN: Gateway GPRS support node
- AAA: Authentication, authorization, accounting
- FA: Foreign agent
- HA: Home agent
Tight Coupling

- WLAN is connected to the GPRS core network as any other radio access network (RAN)
- WLAN is considered like any other GPRS routing area (RA)
- Reuse of GPRS infrastructure/AAA
Tight coupling over Gb
## Loose vs. Tight (1/2)

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<tr>
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<th>Tight coupling</th>
<th>Loose coupling</th>
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<tbody>
<tr>
<td>Authentication</td>
<td>Reuse GPRS auth. and ciphering key</td>
<td>Cellular Access Gateway to provide SIM-based auth. interworking</td>
</tr>
<tr>
<td>Accounting</td>
<td>Reuse GPRS accounting</td>
<td>Billing mediator to provide common accounting</td>
</tr>
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<td>WLAN-Cellular mobility</td>
<td>SGSN (call anchor), Intra-SGSN handoff</td>
<td>Home agent (call anchor), Mobile IP handoff</td>
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<td>Context transfer</td>
<td>Fine-grained context information (e.g. QoS Parameters)</td>
<td>Limited context transfer</td>
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## Loose vs. Tight (2/2)

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<tr>
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<th>Tight coupling</th>
<th>Loose coupling</th>
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<tbody>
<tr>
<td>System engineering</td>
<td>Impact of high-speed WLAN on GGSN</td>
<td>Engineered separately</td>
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<tr>
<td>New development</td>
<td>WLAN terminal, WLAN or SGSN modification</td>
<td>Cellular access gateway, billing mediator</td>
</tr>
<tr>
<td>Standardization</td>
<td>New interface in the SGSN</td>
<td>EAP-SIM, EAP-AKA (Extensible Authentication Protocol)</td>
</tr>
<tr>
<td>Target usage</td>
<td>Cellular operators owns WLAN</td>
<td>Applies more broadly</td>
</tr>
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<td></td>
<td>Limited apps. when ISPs are different</td>
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Mobility Management: Overview

- **Location Management**
  - **Goal**: record the current location
  - **Approach**: HLR/VLR (cellular networks), Mobile IP, SIP (wireless networks)

- **Handoff Management**
  - **Goal**: keep network connectivity during handoff
  - **Approach**: hard, soft, seamless
Mobility Management: Research Issues

- IPv4 and IPv6 Integration
- Mobile IP + NAT
- Mobility over GPRS/WLAN/Ad Hoc Networks
- Seamless Handoff
- Handoff Prediction
- Handoff Decision in Vertical Handoffs
GPRS/WLAN Mobility

- **Gateway Approach**
  - HA locates in the dedicated gateway
  - GGSN and HA are connected via Gi interface

- **NAT Problem**
  - Mobile IP assumes uniquely routable IP address for all component, but it is not if they behind the NAT
WLAN/Ad Hoc Mobility

- Some researchers integrate and implement Mobile IP on mobile ad hoc networks, which enables mobile hosts (MH) ubiquitously to access Internet services such as WWW, FTP, Email.

- We modify Mobile IP protocol
  - By relaxing one-hop restriction
  - By using N-hop agent advertisements
Hybrid Networking

- Group Management
- Route Discovery
Integrated Services Models (IntServ)
- Reservation-based, per-flow
- Hard guarantee
- RSVP (resource reservation protocol)

Differentiated Services Models (DiffServ)
- Reservation-less, per-packet
- Soft guarantee
- DSCP (DiffServ code point), PHB (Per-Hop Behavior)
UMTS QoS

contention/contention-free priority: 0~7

Guaranteed/Control Load
4 classes (12 subclasses)
Security/AAA: Overview

- In order to enhance security of the IEEE 802.11 standard, 802.11i is being developed.
- 802.11i includes the mechanisms:
  - Enhanced encryption to WEP (Wired Equivalent Privacy)
  - Enhanced authentication based on 802.1x
- 802.1x defines a mechanism for port based network access control to provide compatible authentication and authorization protocols for devices interconnected by IEEE 802 LANs.
Mobile IP over WLAN Security

- 802.11 Security by 802.1x and Radius
Conclusions

- Next-generation wireless Internet would be heterogeneous networks
  - GPRS/3G, WLAN, MANET
- Integration of heterogeneous networks is a challenge
- Various key issues should be addressed
  - security, QoS, energy efficient, mobility, geolocation, etc.
Homework #7:

1. What’s the difference of WLAN-GPRS Integration by “loose coupling” and “tight coupling”?
2. What’s key futures of ALL-IP networks?