Mobile Computing and Wireless Communications
Short Tutorial and R&D Trends

• Mobile Applications
• Mobile Computing Platforms
• Wireless Networks
• Security, Management, & Integration

Amjad Umar, Ph.D.

University of Pennsylvania
Fordham Grad School of Business
NGE Solutions, Inc
umar@amjadumar.com
Framework for Discussion: The Building Blocks

Drivers

Mobile Business, Government, and Life
Mobile Computing Applications

Mobile Computing Platforms
(Wireless Middleware, Mobile IP)

Wireless Networks
(Wireless LANs, Cellular Networks, Satellites, Wireless Local Loops)

Enablers

• Wireless Business, Regulations, and Standards
• Architectures and Integration
• Wireless Security
• Management and Support

Research and development in every building block
Mobile Computing Applications

• Mobile computing applications
  – Wireless messaging (e.g., SMS, MMS, Blackberry)
  – Mobile ecommerce (M-Commerce) and its variants
    • Positional commerce \((p\)-commerce\).
    • Voice commerce \((v\)-commerce\).
    • Television commerce \((T\)-Commerce\).
  – Mobile ebusiness applications (MEBAs), e.g., M-CRM, M-portal
  – Specialized applications
    • Location sensitive apps (LBS – Loc based services)
    • Wireless sensor network apps
    • Mobile Adhoc applications (e.g., VANET)

• Possible areas of R&D:
  – Adding mobility and positional features as additional dimension of the existing applications
  – Developing fundamentally new apps
Supporting M-Apps: Mobile Computing Platforms

Mobile Device
(Cell Phone, PDA, Pocket PC)

Local Platform Services

Application

Middleware Services

Network Transport Services

Server
(Web Server, eMail server, Mainframe)

Middleware Services

Application

Local Platform Services

Network Transport Services

Physical Wireless Network
(Antennas, Transceivers, Base Stations, Cellular Networks, 802.11 LANs, Satellites)
Mobile Computing Platforms

- Mobile operating systems
  - Palm OS
  - Windows CE
  - Symbian OS
- Mobile database managers
- Mobile transaction managers
- Utilities for mobile devices
- Wireless Middleware (information hiding versus information providing)
- Wireless Gateways: Collection of Middleware services
- Mobile Application Servers
- Research and development in every aspect
Many players
- WAP
- iMode
- J2ME
- BREW
- MMIT (Visual Studio)

Industry activity
- Open Mobility Alliance
Mobile IP – The Roaming in Wireless Internet World

Research issues:
- Can Mobile IP replace roaming
- Security issues
- Performance issues

Flash OFDM
Uses Mobile IP
For cellular networks

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Different type of wireless networks support mobile computing applications and platforms
- Wireless Personal Area Networks (Bluetooth, Sensors, UWB, Zigbees)
- Wireless LANs (802.11 family)
- Fixed Wireless Local loops (Wimax)
- Cellular networks
  - 1G to 5G
- Satellite systems

Many Research Issues: short list
- Lower level issues (e.g., signaling, error correction, smart antennas)
- Mobile Adhoc Networks
- Voice over 802.11
### Research and Development issues unique to wireless
- Frequency allocation (efficient frequency utilization)
- Multiple Access (CDMA vs TDMA)
- Location services (Data rate versus speed of mobile devices)
- Error correction (e.g., Turbo codes)
- Signalling and encoding (PCM versus Delta code modulation)
- Antenna design (smart antennas)

<table>
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<tr>
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<th>Local Area Networks (LANs)</th>
<th>Metropolitan Area Networks (MANs)</th>
<th>Wide Area Networks (WANs)</th>
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<tr>
<td><strong>Wired</strong></td>
<td>Wired LANs</td>
<td>Wired MANs</td>
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<td>Ethernet (10-100 Mbps, 150 to 500 meters)</td>
<td>FDDI (100 Mbps, 50 Kilometers)</td>
<td>ATM (44 Mbps to 140 Mbps)</td>
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<td>Token Ring (4-16 Mbps, 200 to 500 meters)</td>
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<td>Frame Relay (44 Mbps)</td>
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<td><strong>Wireless</strong></td>
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<td>Wireless MANs</td>
<td>Wireless WANs</td>
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<td></td>
<td>Bluetooth (1 Mbps, 10 meters)</td>
<td>wireless local loops (10 Mbps, 100 Kilometers)</td>
<td>Current GSM systems at 9.6Kbps, future 3G systems at 2 Mbps</td>
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<td>IEEE 802.11 LANs (2-11 Mbps, 100 meters)</td>
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Wireless PANs: Home Networking

Players:
- Bluetooth
- Sensor networks
- UWB
- 802.11
- Zigbees

xDSL, cable, ISDN, or other

= Wireless Adapter

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Wireless Sensor Networks

Network of Tiny Sensors

Network of Powerful Sensors

Powerful server

Many R&D efforts

Sensor = mote

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802.11 Family LANs

- X, Y, Z are access points for the wireless Ethernet LANs
- A, B, C, D are student laptops

- 11a, 11b, 11g, 11n, 11i – security
- 11e – QoS
Interesting applications

Wireless Local Loops

Narrowband – telephony services
Broadband – high-speed data service

Intertoll Trunks

Toll Connecting Trunks

Intercall Trunks

Local Control Office

Toll Connecting Trunks

Inter-Exchange Switch
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Cellular Networks

Public Switched Telephone Network (PSTN)

Mobile Telephone Switching Center (MTSC)

Cell 1

Cell 2

Mobile User

Cordless connection

Wired connection

Base Transceiver Station (BTS)

HLR = Home Location Register

VLR = Visitor Location Register

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Evolution: 1G to 5G

Data Rates

- 1G (<1Kbps)
- 2G (9.6Kbps)
- 2.5G (10-150Kbps)
- 3G (144Kbps to 2Mbps)
- 4-5G (10 Mbps+)

Years

1980 1990 2000 2010

Research Issues
- Mobility vs data rate
- Error correction
- Intelligent Antennas
- Intelligent radio

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Satellite Communications

GEO = 35,000 km, 250 ms delay
LEO = 4,000 km, 20 ms delay
MEO = 10,000 km, 50 ms delay
Research Issue: Deep Space Networking

Deep Space Link (> 1 Million Miles)

- Extreme Attenuation – can be 10 billion times weaker than with a commercial GEO satellite
- Extreme delays: 15 minutes to/from Mars, 13 hours to/from Voyager-1
- Noise: Celestial events, atmospheric conditions, other spacecraft

Geo-Link (22,300 Miles)
Other issues

• Security
• Management and support
• Integration and Convergence (IMS)
Wireless Security – The Big Picture

Unique issues:
- Medium
- Mobility
- Audits and Controls

Latest Security Technologies
- Cryptographic techniques
- Managing digital certificates and PKI
- Secure payment systems
- Significant research developments

External Factors
- Intruder/attacker/assault Threats
- Privacy and confidentiality laws
- Consumer/customer attitudes

Organizational Requirements
- Survivability and Tolerance
- Requirements
- QoS Requirements
- Budgetary and policy restrictions

Physical Assets
- Humans
- Buildings
- Other corporate assets (e.g., planes, trains, and automobiles)

IT Assets
- Applications and automated services
- Databases, files
- Computing platforms
- Middleware (e.g., web servers)
- Networks (hardware, routing software)
User View (PIA4)

Privacy

- assure privacy of information (i.e., no one other than the authorized people can see the information) in storage or transmission

Integrity

- the integrity of information (i.e., no unauthorized modification)

Authentication:

- identify for certain who is communicating with you

Authorization (Access control):

- determine what access rights that person has.

Accountability (Auditing):

- assure that you can tell who did what when and convince yourself that the system keeps its security promises.

- Includes non-repudiation (NR) -- the ability to provide proof of the origin or delivery of data.

- NR protects the sender against a false denial by the recipient that the data has been received. Also protects the recipient against false denial by the sender that the data has been sent.

- a receiver cannot say that he/she never received the data or the sender cannot say that he/she never sent any data

Availability: access to system when a user needs it

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Security Design: higher level services to compensate for lower layers

Tradeoffs in performance and security

Attack Trees for Risk Analysis

Security patterns for security design

Unique: MANET Security

Sample Wireless Security Technologies

- 802.11 security (WEP)
- Cellular network security
- Satellite link security
- WiMax and FSO security
- Mobile Adhoc Network security

Applications

Middleware

TCP/IP

Wireless Link

- SET for transaction security
- S/MIME and PGP for secure email
- Java security (sandboxes)
- Database security

- SSL and TLS
- WAP security (WTLS)
- Web security (HTTPS, PICS, HTTP Headers)
- Proxy server security

- IPSEC and wireless VPN
- Mobile IP

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Risk Analysis Through Attack Tree

Goal: Break into a Database

- Learn the ID/PW
  - Find the ID/PW written down
  - Steal ID/PW by Using sniffer on Logon session

- Tap the database access after logon
  - Guess ID/PW
  - Wired access

- Steal a backup copy of database
  - Bribe the database administrator

- Wireless access

I = Impossible
P = Possible
Privacy Issues Due to Mobility

Public Switched Telephone Network (PSTN)

Mobile Telephone Switching Center (MTSC)

- HLR = Home Location Register
- VLR = Visitor Location Register

Base Transceiver Station (BTS)

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Wireless Security Patterns -- Example

0. No security (starbuck)
1. No physical net security (server ID/PW)
2. No physical net security (server ID/PW + encryption)
3. Physical net security at APs (optional server ID/PW + encryption)
Management and Support Issues

- Specific issues in managing mobile networks and wireless apps
- Five key areas (FCAPS) in wireless net management:
  - Fault management
  - Capacity management
  - Accounting(access) management
  - Performance management
  - Security management
- FCAPS at all layers of a stack (network, middleware, apps)
- Fault management for wireless (diagnosing APs, BTS, etc)
- Security is the main area of concern
STRATEGIC PLANNING
• Business Strategy Analysis
• Analyzing Business Processes and Business Workflows
• Mobile Application Identification and Selection.

ORGANIZING/STAFFING
  • Mobile Virtual Teams
  • Mobile Real-time Enterprises

MONITORING AND CONTROL
• Wireless fault and performance management
• Wireless Security and configuration management

CAPABILITY EVALUATION
• Wireless Infrastructure Planning
• Capacity Planning & Traffic Engineering
• Resource and Cost Estimation

DEVELOPMENT AND DEPLOYMENT
• Mobile application development
• Wireless infrastructure development
• Outsourcing the Wireless Infrastructure

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Example Scenario:

- Anna in a taxi calls Andrew on her cell phone to discuss a construction project.
- To explain the project, she shows videos of the project on the phone so that both can see what is going on.
- Anna invites other colleagues from office to join the discussion.
- The users make wireless phone calls, run videos, and conference call with wired users.
- This happens even though 802.11 LAN signals fade and GPRS wireless WAN takes over.
Integration Framework

- **M-Business and Mobile Applications (SMS, MMS, Voice, M-commerce)**
- **Mobile Computing Platforms**
  - Wireless Middleware (WAP, I-Mode, J2ME)
  - Mobile Platform Services (Mobile OS, Utilities)
- **Wireless Internet and Mobile IP**
  - Roaming Support through Mobile IP
  - Network interfaces
  - Handoffs
  - Multirate cards

- Provide consistent user interfaces for seamless operations.
- Shield the app. developers from the network heterogeneities.

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IP Multimedia Systems (IMS)

History and Background
- The 3GPP system was designed to be backward compatible with the existing GSM circuit switched infrastructure.
- The costs to procure and maintain the very proprietary hardware of circuit switched systems are very high.
- So 3GPP system slowly evolved towards an all-IP core network.
  - Circuit switched infrastructure will be outdated and replaced by IP-based hardware, open, scalable, and cheaper to procure and maintain, due to a more competitive market.
  - Most of new services and applications developed in the market place are IP based.
- IP multimedia subsystem (IMS) introduced to handle classical circuit switched services (like voice) over IP and to handle all multimedia services provided to a subscriber.
- IMS uses the Session Initiation Protocol (SIP) to setup, maintain and terminate voice and multimedia sessions.
IMS- High Level View

- **Service/Application Layer (may be 2 layers)**
  - SIP App Server
  - HLR
  - Parlay/OSA Gateway
  - SS7 SCP

- **IMS Layer (Control Layer)**
  - CSCF (Call Signal Control Function)
  - MRF
  - MGCF
  - MRF = Media Resource Function
  - MGCF = Media Gateway Control Function

- **Access/transport Layer**
  - Backbone (IPV6/IPv4)
  - 2.5G
  - Wired Networks
  - 3G
  - WLAN

**Abbreviations**
- SIP: Session Initiation Protocol
- HLR: Home Location Register
- SS7: Signaling System 7
- CSCF: Call Session Control Function
- MRF: Media Resource Function
- MGCF: Media Gateway Control Function
- 2.5G: Second Generation
- Wired Networks: Wired Communication Networks
- 3G: Third Generation
- WLAN: Wireless Local Area Network
IMS (Additional Details)

• Part of the vision for evolving mobile networks beyond GSM.
• Original formulation (3GPP R5) represented an approach to delivering "Internet services" over GPRS.
• This vision was later updated for support of networks other than GPRS, such as Wireless LAN, CDMA2000 and fixed line.
• To ease the integration with the Internet, IMS uses IETF protocols such as Session Initiation Protocol (SIP).
IMS Reality Check

- IMS is getting too complex -- requires large investment and slow adoption
- Some debate about the motivation for adoption of IMS by carriers – it allows the carriers to control the SIP connections – thus kill the toll free VOIP (e.g., skype)
- ITU-NGN vision looks very much like IMS, raising the question: is NGN = IMS?
Concluding Comment

Building blocks provide a good framework for R&D trends

Drivers

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- Mobile Computing Applications
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