Intelligent Radio Resource Management for Heterogeneous Wireless Networks

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• Introduction
  - RRM
  - Handoff
  - HO algorithms

• Research outline
  - Existing Problems
  - Proposed idea
  - Pattern recognition
  - Application
  - Project idea
  - Simulation environment
  - Simulated scenario
  - Classification
  - Results
Radio Resource Management (RRM)

New Call Admission → Admission Control → Proper Layer and cell selection → Channel Allocation Admission Check

Our Project Basis

Handoff Algorithm

Handoff out Condition Check? → Proper Layer and cell selection → Channel Allocation Hand-in Check

Power control
Definition

The mechanism that transfers an ongoing call from one cell to another as a user moves thru’ the coverage area of a cellular system.

** HO -> Acronym for Handover/Handoff
Handoff

Handoff Architectures

Handoff Procedures

H.O Control

1) network-controlled
2) mobile assisted
3) mobile - Controlled

H.O methodology

Hard H.O
Seamless H.O
Soft H.O

H.O Technology

Horizontal H.O
GSM
AMPS

Vertical H.O
Multitier Overlay
Mobile IP

Handoff Algorithms

Handoff Metrics

RSS
Path Loss
SIR
BER

H.O Performance Measure

Call Blocking
H.O Blocking
H.O Rate
Delay
Call Dropping
etc

Handoff Algorithms

Decision Time Algorithms

Hypothesis Test Prediction
Dynamic Prog
Neural Networks
Fuzzy Logic
Pattern Recognition

Hysteresis
Threshold
Dwell Timer
Averaging Window
Distance
Velocity
Traffic

Call Blocking
H.O Blocking
H.O Rate
Delay
Call Dropping
etc

Handoff

TOHOKU UNIVERSITY
Overlay Cellular Structure concept for next generation wireless networks
Vertical Handoff

- Metropolitan Area Network (MAN): WiMAX 802.16 REVd → WiMAX 802.16e
- Mobile Phone: 2G → 2.5G → 3G → 4G
- Local Area Network (LAN): WiFi 802.11a/b/g → WiFi Higher Security and QoS → WiFi High Speed
- Personal Area Network (PAN): Bluetooth V1.1 → Bluetooth V2.0 → UWB Standard for Specific Type → UWB Standard for Universal → UWB Wireless USB → UWB Wireless 1394
Different Algorithms

Traditional Methods

🌟 Absolute Signal Strength
🌟 Absolute Signal Strength with threshold
🌟 Absolute Signal Strength with Hysteresis
🌟 Absolute Signal Strength with Hysteresis and Threshold
🌟 Optimal Algorithm
🌟 These Algorithms Plus Dwell Timer
Emerging Techniques

• Prediction based algorithms
• distance based algorithms (using GPS)
• fuzzy logic based algorithms
• neural networks based algorithms
• pattern recognition based algorithms
• Genetic algorithms (For DCA optimization, etc)
Vertical Handoff

• Network point of view (upper network layers)
  Delay and throughput analysis, UDP, TCP, IP transmission

• Communication point of view (physical layer)
  Radio propagation details (RSS, SIR, BER)
A Handoff to the upper layer and its latency (Network point of view)

\[ L = L_D + L_P + L_N + L_F \]

- \( L_D \) is the latency during which the mobile discovers that it must hand off to a new wireless overlay.
- \( L_P \) is the latency for the mobile to power on the upper or lower network interface.
- \( L_N \) is the latency for the mobile to inform the new BS to start forwarding data to the mobile.
- \( L_F \) is the latency for the BS to send the first data packet across the new network to the mobile.

\[ L_D + L_N \rightarrow \text{Dominant} \]
Existing problems

• Ping pong effect
  (increasing network signalling, power loss, HO dropping and connection blocking probability)

• Crossover point
  (increasing interference, delay)
Reducing Handoff Latency
(Communication point of view)
Comparison of traditional and intelligent Algorithms

Mobile IP H.O between GPRS and WLAN

Simple RSS-based and NN-based Algorithms for H.O from WLAN to GPRS
Proposed idea

Using pattern recognition based on received signal samples to predict user location and decide on vertical handoff considering estimated user location

→ Fewer ping pong

→ More exact crossover point
Pattern recognition application

\[
P = \begin{bmatrix}
\text{SSI vector of 1st base station} \\
\text{SSI vector of 2nd base station} \\
\vdots \\
\text{SSI vector of Mst base station}
\end{bmatrix}
\]
Pattern recognition application

\[ M(P^{(c)}, P_0) = \frac{1}{N_PM} \min_{l=1,2,...,L} \sum_{m=1}^{M} \sum_{n=1}^{N_P} (P^{(c)}_{l,m,n} - P_{0,m,n})^2 \]
L: A Pattern Class Stretch Consisting Of Four Heterogeneous Signal Samples

$$\xi^{ik} = \begin{bmatrix} \xi_{0}^{ik}, \xi_{1}^{ik}, \ldots, \xi_{N_{max} - 1}^{ik} \end{bmatrix}^T$$

$$C = \left[ \frac{N_{max}}{N_w} \right]$$
Classifier Structure

\[ (PNN) \]

\[ y_n = e^{-\frac{\|X-W_n\|^2}{\sigma_{\text{PNN}}^2}} \]

\[ Y_l = \{ y_n : l_n = l \}, \quad n = 1, 2, \ldots, P \]

\[ z_l = \sum_{y_n \in Y_l} y_n, \quad l = 1, 2, \ldots, C \]
Simulation Environment

Simulation Model
- Cell Model
- Traffic Model
- Propagation Model
- Mobility Model

Discrete time step simulation model

Path Loss
- Slow Fading
- Fast Fading
## Defined values

<table>
<thead>
<tr>
<th></th>
<th>Microcell</th>
<th>Macrocell</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cell radius (m)</strong></td>
<td>250</td>
<td>2500</td>
</tr>
<tr>
<td><strong>Carrier frequency (MHz)</strong></td>
<td>900</td>
<td>2400</td>
</tr>
<tr>
<td><strong>Number of clusters</strong></td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td><strong>Attenuation at 1 meter distance (dB)</strong></td>
<td>-40</td>
<td>-31</td>
</tr>
<tr>
<td><strong>Thermal noise floor (dBm) ( N_0 )</strong></td>
<td>-118</td>
<td>-118</td>
</tr>
<tr>
<td><strong>Distance attenuation coefficient</strong></td>
<td>3.3</td>
<td>4</td>
</tr>
<tr>
<td><strong>Standard deviation for the log-normal fading in(dB)</strong></td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td><strong>Log-normal correlation down link</strong></td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Log-normal fading correlation distance (m) ( d_0 )</strong></td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>
Simplified flowchart of simulation program for a general case (single layer)

Constant profile definition
1-mobile user specifications profile
2-overlay cellular structure
3-radio propagation characteristics

Dynamic variables initiation
crerayslmap ()
crelognmap ()
crechanplan ()
mobmove ()
crecells ()

Terminate ()
1-Naturally terminated
2-Dropped ones due to link degradation
mrequest ()
Dynamic variables cleaning
(removing infinite values)
pathgain ()
userayslmap ()
handoff ()
assign ()
transmitul ()
transmitdl ()
collect iteration’s results
Simulated scenario
Proposed techniques for classification

1- Ascending and descending data set sorting
2- magnitude factor
3- adaptive averaging

<table>
<thead>
<tr>
<th>Parameter (varies)</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probabilistic NN bias</td>
<td>0.83(PNN) 0.083(Nearest neighbor case)</td>
</tr>
<tr>
<td>Block Length</td>
<td>80 – 50 – 40 – 20</td>
</tr>
<tr>
<td>Magnitude factor</td>
<td>0.95 – 0.96 – 0.97 – 0.98 – 0.99 – 1</td>
</tr>
</tbody>
</table>
Minimum distance algorithm

<table>
<thead>
<tr>
<th>Without sorting</th>
<th>With sorting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seq1 = [WLAN (2 4 18)]</td>
<td>Seq4 = [WLAN (2 3 4 17 18)]</td>
</tr>
<tr>
<td>Seq2 = [WLAN (2 4 18) UMTS (2 3)]</td>
<td>Seq5 = [WLAN (2 3 4 17 18) UMTS (2 3)]</td>
</tr>
<tr>
<td>Seq3 = [WLAN (1 5 7 15)]</td>
<td>Seq6 = [UMTS (1 2 3)]</td>
</tr>
</tbody>
</table>
PNN algorithm

<table>
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<th>Seq1</th>
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<td>[UMTS (1 2 3)]</td>
</tr>
</tbody>
</table>

Error probability for different BS sequences:
- **With sorting**
- **Without sorting**
Comparing classification precision for two algorithms

Seq=[WLAN2 WLAN4 WLAN18]  Averaging window size=15
Thank You