Analysis and Performance Measurement of Adaptive Modulation and Coding

Presented By,

Scott Lye Carr Ken (scottlye@ieee.org)
Tan Shee Eng (setan@ieee.org)
Siew Zhan Wei (zwsiew@ieee.org)
Yew Hoe Tung (htyew@ums.edu.my)
Kenneth Teo Tze Kin (ktkteo@ieee.org)
Outline

1.0 Introduction
2.0 Objective
3.0 Methodology
4.0 Simulations
5.0 Discussion and Results
6.0 Conclusion
1.0 Introduction

• **Wireless Communication** – Current state – room for more improvement, spectrally efficient techniques, adaptive communications.

• **Challenges** – Fast Fading that will cause outages, communication environment has reflective objects – unpredictable, time-varying channel characteristics.

• **Adaptive Modulation and Coding (AMC)** – Improves the wireless link quality in noisy situations - adjusting transmission parameters (e.g. transmit power, modulation scheme, coding rate)

• **Channel State Information** – the receiver side or transmitter side, in most cases, receiver estimates the signal then feedback to transmitter.

• **Examples** – IEEE 802.11 can support different data rates according to link characteristics, CDMA 2000, HSDPA etc..
2.0 Objective

- This paper’s **objective** is:
  - To describe an AMC scheme which utilizes a simple moments based SNR estimator and punctured convolution coding for spectral and quality improvement for the wireless channel
  - To examine the effects of adapting only modulation and adapting modulation + coding
3.0 Methodology

- Based on channel quality (SNR), transmitter adapts to different modulation schemes and coding rate.
- The information is passed back to the transmitter via a feedback channel.
- Mode assumption: Errorless and delay free feedback – important to ensure errorless signalling between TX and RX. (coded and fast feedback channels)
4.0 Simulation

\[ E_b N_0 / \text{BER relationship for uncoded and coded cases.} \]
4.0 Simulation

<table>
<thead>
<tr>
<th>MCS, n</th>
<th>Modulation</th>
<th>Rate, Rs, Bits/Hz</th>
<th>Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>hold</td>
<td>-</td>
<td>$E_b/N_0 &lt; 7.0 \text{dB}$</td>
</tr>
<tr>
<td>1</td>
<td>QPSK</td>
<td>-</td>
<td>$7.0 \text{dB} \leq E_b/N_0 &lt; 10.5 \text{dB}$</td>
</tr>
<tr>
<td>2</td>
<td>8-PSK</td>
<td>-</td>
<td>$10.5 \text{dB} \leq E_b/N_0 &lt; 15.0 \text{dB}$</td>
</tr>
<tr>
<td>3</td>
<td>16-PSK</td>
<td>-</td>
<td>$15.0 \text{dB} \leq E_b/N_0 &lt; 19.8 \text{dB}$</td>
</tr>
<tr>
<td>4</td>
<td>32-PSK</td>
<td>-</td>
<td>$19.8 \text{dB} \leq E_b/N_0 &lt; 24.7 \text{dB}$</td>
</tr>
<tr>
<td>5</td>
<td>64-PSK</td>
<td>-</td>
<td>$24.7 \text{dB} \leq E_b/N_0 &lt; \infty$</td>
</tr>
</tbody>
</table>

Thresholds obtained from BER curves
### 4.0 Simulation

<table>
<thead>
<tr>
<th>MCS, n</th>
<th>Time duration distribution</th>
<th>With weight of SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$P_0 = \int_1^5 \frac{1}{100} e^{-\gamma/100} d\gamma = 0.0388$</td>
<td>$0.0388 \times 0 = 0$</td>
</tr>
<tr>
<td>1</td>
<td>$P_{QPSK} = \int_{11.22}^5 \frac{1}{100} e^{-\gamma/100} d\gamma = 0.0574$</td>
<td>$0.0574 \times 2 = 0.1148$</td>
</tr>
<tr>
<td>2</td>
<td>$P_{8PSK} = \int_{11.2}^{31.6} \frac{1}{100} e^{-\gamma/100} d\gamma = 0.1648$</td>
<td>$0.1648 \times 3 = 0.4944$</td>
</tr>
<tr>
<td>3</td>
<td>$P_{16PSK} = \int_{31.6}^{95.5} \frac{1}{100} e^{-\gamma/100} d\gamma = 0.3442$</td>
<td>$0.3442 \times 4 = 1.3768$</td>
</tr>
<tr>
<td>4</td>
<td>$P_{32PSK} = \int_{95.5}^{295.1} \frac{1}{100} e^{-\gamma/100} d\gamma = 0.3325$</td>
<td>$0.3325 \times 5 = 1.6125$</td>
</tr>
<tr>
<td>5</td>
<td>$P_{64PSK} = \int_{295.1}^{\infty} \frac{1}{100} e^{-\gamma/100} d\gamma = 0.0523$</td>
<td>$0.0523 \times 6 = 0.3138$</td>
</tr>
</tbody>
</table>

Average Spectral Efficiency @ $\bar{\gamma}_x = 20\text{dB}$: 3.9123 bps/Hz

Distribution of various modulation and coding schemes
5.0 Results & Discussions

Average spectral efficiency for coded and uncoded AMC
5.0 Results & Discussions (con’t)

Normalized mean square error of M2M4 SNR estimator
5.0 Results & Discussions (con’t)

PER of both Adaptive Modulation with Coding and without Coding
5.0 Results & Discussions (con’t)

(a) Image transmitted over a fixed favorable AWGN, SNR = 10 dB (same as original).

(b) Image transmitted over a range of random SNR values.

(c) Image received using AMC technique.
6.0 Conclusion

• Adaptive Modulation and coding is a powerful method to overcome fading channels.

• The extra advantage offered by coding will give a robust transmission system if designed properly.

• A balanced variable coded system is necessary to achieve minimum target BER with optimum spectral efficiency.

• For future work, more wireless channel models will be tested on different configurations of variable rate and coding AMC. Furthermore, predictive channel estimation can be incorporated as a feasible solution to the delay impact on AMC systems.
Thank You