Wake on Wireless: An Event Driven Energy Saving Strategy for Battery Operated Devices

Eugene Shih
Massachusetts Institute of Technology Cambridge

Paramvir Bahl & Michael J. Sinclair
Microsoft Research One Microsoft Way Redmond

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Outline

- INTRODUCTION
- WAKE-ON-WIRELESS
- SYSTEM PERFORMANCE
- ALTERNATIVE STRATEGIES
- CONCLUSION
INTRODUCTION (1/4)

• Cellular phones has increased over the past few years.
  – Integrate phone technology with PDA-like
    • Universal Communicator (UCoM)
INTRODUCTION (2/4)

- The Problem of Power Consumption

Figure 1: Standby lifetime of an iPAQ with an IEEE 802.11b card in PS/CAM modes compared to lifetime of a cell phone. The cell phone lifetime was computed assuming a constant power drain. The other curves were determined by monitoring the battery level.
INTRODUCTION (3/4)

• Bridging the Energy Gap
  – Battery lifetimes must be comparable to that of cellular phones.
  – The time interval between phone calls is large
    • Eliminating this waste can improve the lifetime.
  – Proposed that when a UCoM device
    • is not actively used that it and its wireless network card be powered off.
    • is powered on only when there is an incoming or outgoing call or when the user needs to use the PDA for other purposes.
INTRODUCTION(4/4)

• *Wake-on-wireless*
  – separate the control channel from the data channel.
    • control channel using a low-power radio.
  – achieve an increase of 115% of standby time
Wake-on-wireless is to eliminate the power consumed when a IEEE 802.11b-enabled device is idle.
- By adding a second, low-power channel.
**WAKE-ON-WIRELESS (2/7)**

- System Architecture and Components

Figure 5: The UCoM System Components and Architecture.
Figure 6: Call Setup
WAKE-ON-WIRELESS (4/7)

- Hardware Implementation - MiniBrick

**Figure 7:** The Minibrick and COMPAQ iPAQ are integrated together into a single package to form the UCOM Client Device.

**Figure 9:** The MiniBrick PCB. The front of the MiniBrick includes sensors, a pager, and the RFM TR1000. The back of the MiniBrick contains an accelerometer, the PIC processor (under accelerometer), and a temperature sensor.

**Figure 10:** Two SmartBrick devices.
WAKE-ON-WIRELESS (5/7)

- Software Implementation
  - Packet Format

| PREAMBLE | DEST_TYPE | DEST_ID | SRC_TYPE | SRC_ID | DATA_SIZE | DATA | CRC |

- **CRC**: cyclic redundancy check code

- MiniBrick Modes of Operation
  - Autonomous Mode and
    - Broadcast the 68-bit message ten times, which takes approximately 7 to 8 ms.
    - Immediately switch the radio into a receive mode and wait for 20 ms for a response.
    - If no WAKEUP message is heard, then go to sleep for 300 ms.
  - Command-Driven Mode.
WAKE-ON-WIRELESS (6/7)

- Autonomous & Command-Driven Mode State Diagram

- Setup MINIBRICK
- Transmit (8ms)
- Sleep (300ms)
- Wait and Receive (20ms)
- Turn IPaq on
- IPaq turn off
- IPaq still on?
- Received wakeup from proxy?
- No message

(Command-Driven Mode => Brick off)
WAKE-ON-WIRELESS(7/7)

– SmartBrick Modes of Operation
  • uSbrickGetId:
  • uSbrickTransmit:
  • uSbrickReceive:
Table 3: The power consumption of the UCoM device in three different modes. In standby mode, we take the power consumed by the iPAQ during standby mode and add the average power consumed by the MiniBrick during Autonomous Mode.

<table>
<thead>
<tr>
<th>iPAQ mode</th>
<th>MiniBrick mode</th>
<th>Power consumed (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTIVE</td>
<td>Off</td>
<td>2.92</td>
</tr>
<tr>
<td>ATTEMPT</td>
<td>Off</td>
<td>2.92</td>
</tr>
<tr>
<td>STANDBY</td>
<td>Autonomous</td>
<td>0.114</td>
</tr>
</tbody>
</table>

Figure 14: Cellular phone usage profiles of two different users over a period of one day. From both of these profiles, one can see that the phone spends the majority of the time in standby mode. Alice spent a 82 minutes on the phone and Bob spent 80 minutes.
Figure 16: The lifetime of the UCoM device using a low-power channel (LPC) compared to the lifetime of the UCoM device with an IEEE 802.11b card only.
Table 6: Power consumption of Bluetooth radios, n/a = not available.

<table>
<thead>
<tr>
<th></th>
<th>Xircom Credit Card Bluetooth Adapter</th>
<th>Silicon Wave SiW1502</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleep (mW)</td>
<td>n/a</td>
<td>20</td>
</tr>
<tr>
<td>Transmit (mW)</td>
<td>250</td>
<td>140</td>
</tr>
<tr>
<td>Receive (mW)</td>
<td>263</td>
<td>160</td>
</tr>
<tr>
<td>Idle (mW)</td>
<td>140</td>
<td>n/a</td>
</tr>
</tbody>
</table>

![Graph showing battery lifetime comparison](image-url)
CONCLUSION

• By adding a second, low power channel of lower complexity and capability
  – lower energy consumption and longer lifetimes can be achieved.