Urban Activity Dynamics
Sensing Places Through Network Antennas

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February, 2008
Overview:

Introduction

WiFi 802.11 MhZ on the MIT campus

GSM 900/1800 MhZ in the City of Rome

Conclusions
802.11 Mhz

MIT

WiFi signals VS

1. Academic buildings
2. Residential Buildings
3. Service Buildings
MIT campus, Cambridge, MA 02139:
168 acres, 190 buildings, 10,320 students and 9,414 employees

MIT wireless network coverage:
All academic and residential buildings, most service buildings, 3056 WiFi hotspots
Analysis of 3056 unique WiFi access points on campus:

Total network activity on campus:
Average WiFi use by building type
First three eigenvectors:
Relationship between the obtained three clusters & the official MIT categorization of buildings into ACADEMIC / RESIDENTIAL / SERVICE

3 WiFi clusters: 3 official MIT building types:

Correlation: 60.66%
Cluster 1: dominated by daytime usage, highest consumption of WiFi on weekdays typically occurs around 1 pm, activity declines steeply after 4pm. Such a pattern seems characteristic to academic working spaces.

Cluster 2: More stable throughout the day showing minor peaks around 9am in the morning and 11pm in the evening. Unlike in the previous cluster, weekend usage is quite similar to weekday usage, which well matches our assumption of its residential nature.

Cluster 3: Rather than showing peak activity during working hours, as we would expect with service buildings, peaks occur instead around 10am and more sharply right before midnight. This suggests that the third cluster might not in fact characterize service spaces, but instead activity spaces that resemble more to residential areas but have higher average usage rates.
900 / 1800 MhZ

ROME

GSM signals

VS

1. population distribution
2. Service distribution
3. Employment distribution?
398 cells covering the urban area within the city's ring-road
Typical raw Erlang values for the 3 largest clusters

3 largest clusters:
- 16 clusters
- 25 clusters

Plot of PNS_A_Rl, symbol used is 'o'.

16 clusters
25 clusters
Residential distribution in Rome (data: Census 2000)

Business distribution in Rome (Yellow Pages data, approx. 50,000 businesses)
Typical demographic and business values for the 3 largest clusters

<table>
<thead>
<tr>
<th></th>
<th>Cluster 1</th>
<th>Cluster 2</th>
<th>Cluster 3</th>
</tr>
</thead>
<tbody>
<tr>
<td># people aged 0-9</td>
<td>301.75</td>
<td>757.71</td>
<td>203.15</td>
</tr>
<tr>
<td># people aged 10-19</td>
<td>319.26</td>
<td>738.91</td>
<td>205.32</td>
</tr>
<tr>
<td># people aged 20-65</td>
<td>2316.03</td>
<td>6065.22</td>
<td>1943.77</td>
</tr>
<tr>
<td># people aged &gt;65</td>
<td>695.77</td>
<td>2198.90</td>
<td>617.15</td>
</tr>
<tr>
<td>Government Services</td>
<td>2.70</td>
<td>5.19</td>
<td>8.91</td>
</tr>
<tr>
<td>Clothing &amp; Accessories</td>
<td>6.14</td>
<td>19.18</td>
<td>36.18</td>
</tr>
<tr>
<td>Recreation &amp; Hobbies</td>
<td>2.99</td>
<td>9.33</td>
<td>9.73</td>
</tr>
<tr>
<td>Transportation</td>
<td>8.98</td>
<td>25.36</td>
<td>13.64</td>
</tr>
<tr>
<td>Household Goods</td>
<td>7.80</td>
<td>26.71</td>
<td>23.36</td>
</tr>
<tr>
<td>Travel</td>
<td>2.34</td>
<td>6.47</td>
<td>8.09</td>
</tr>
<tr>
<td>Hotels &amp; Accommodation</td>
<td>2.90</td>
<td>3.17</td>
<td>18.73</td>
</tr>
<tr>
<td>Food</td>
<td>4.72</td>
<td>17.57</td>
<td>14.82</td>
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<tr>
<td>Health Services</td>
<td>7.57</td>
<td>28.13</td>
<td>18.55</td>
</tr>
<tr>
<td>Other Personal Services &amp; Goods</td>
<td>1.66</td>
<td>6.15</td>
<td>6.45</td>
</tr>
<tr>
<td>High-end Retail</td>
<td>3.27</td>
<td>10.03</td>
<td>29.73</td>
</tr>
<tr>
<td>Financial Services</td>
<td>3.24</td>
<td>6.68</td>
<td>10.45</td>
</tr>
<tr>
<td>Bars &amp; Restaurants</td>
<td>8.58</td>
<td>22.19</td>
<td>49.36</td>
</tr>
<tr>
<td>Beauty</td>
<td>5.56</td>
<td>20.85</td>
<td>16.73</td>
</tr>
<tr>
<td>Entertainment &amp; Culture</td>
<td>0.98</td>
<td>2.06</td>
<td>7.73</td>
</tr>
<tr>
<td>Churches &amp; Religious Buildings</td>
<td>3.31</td>
<td>5.22</td>
<td>8.64</td>
</tr>
<tr>
<td>Business Services</td>
<td>1.96</td>
<td>5.67</td>
<td>6.36</td>
</tr>
<tr>
<td>Daily Retail &amp; Services</td>
<td>1.51</td>
<td>5.65</td>
<td>5.09</td>
</tr>
</tbody>
</table>

**Cluster 1:** least amount of businesses but more residents than cluster 3. These seem to be the relatively lower density residential areas of Rome.

**Cluster 2:** more residents than the other two clusters, less overall businesses than cluster 3, but more transportation, food, health, beauty and daily retail establishments. Cluster 2 thus seems to represent typical dense residential areas, as shown in the residential distribution map previously.

**Cluster 3:** highest amount of businesses, most notably hotels, restaurants, business services, government services and specialized retail, but the least amount of residents. This suggests that cluster 3 characterizes dense CBD neighborhoods where few people live.
Residential distribution in Rome (data: Census 2000)

Business distribution in Rome (Yellow Pages data, approx. 50,000 businesses)

Demographic & Business clusters

Erlang clusters
Correlation: **63.14%**

Other correlations for the 3 largest clusters:

- Erlang VS businesses: **60.05%**
- Erlang VS census: **51.29%**
- Census VS businesses: **74.75%**
Conclusions:

• Correspondence between antenna usage patterns and the demographic and functional characteristics of location.

• This suggests that the gross functional and demographic indicators of urban areas could be approximated from the mere consumption statistics of wireless networks.

• Despite a generally good match, the correspondence between traditional land categorizations and wireless activity patterns is not exact, and should not be. The traditional categories of space usage typically describe the permanent aspects of places - their land use, the number of businesses, jobs or residents. The wireless network usage, on the other hand, reflects people’s temporary presence and communications behavior in these spaces.

• Employment data needed in addition to residential distribution & business distribution.
Thank you!

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