Comparing Metro-Area Cellular and WiFi Performance

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Motivation and Research Questions

Mobile handheld devices and apps are becoming more and more bandwidth-hungry

WiFi and cellular access technologies offer compelling — and rather different — connectivity options for mobile users

How do performance characteristics of WiFi and cellular compare in diverse environments and conditions?

- What are relative performance differences between WiFi and cellular access?
- How does performance depend on metro area? Region within metro area?
- How does performance vary temporally? How consistent is performance for users over time?
- What specific features in the data differentiate observed performance characteristics?

Approach

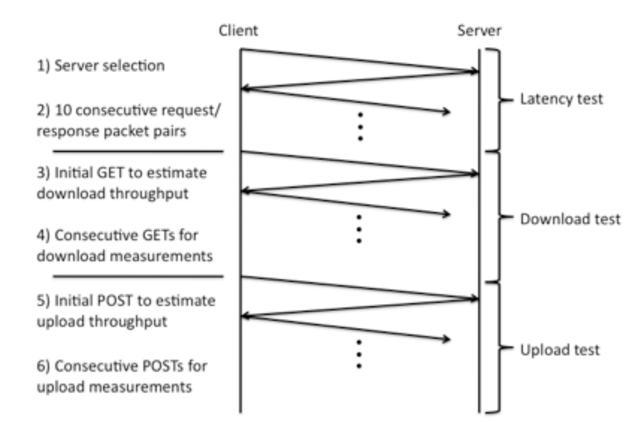
Analyze 15 weeks of crowd-sourced wireless performance data provided by Speedtest.net*

- Speedtest is operated by Ookla, Inc., and is one of the most popular performance testing applications available online
- The testing method that Speedtest employs was evaluated to be one of the most accurate end-host-based methods (Bauer *et al.*, 2010)
- Performance tests initiated from iOS and Android apps
- Data collected from 15 metro areas in which there are Speedtest servers
- Data include timestamp, client IP address, device type and OS, client geographic coordinates, server name and coordinates, access type (WiFi or cellular; possibly detailed cellular access type), latency measurement, and upload/download throughput measurements

* Thanks to Ookla, Inc. and Andrew Bassett for generous access to the Speedtest performance data

	Cellular	WiFi
Range from Tower / Base Station	Kilometers	Meters
Maximum Throughput Rates	Varies widely based on access technology; typically hundreds of kb/s through single- and multi- Mb/s	Common rates are 11 Mb/s, 54 Mb/s, and 300 Mb/s
Wired backhaul connectivity	Service provider network through, e.g., a Gateway GPRS Support Node	Typically cable or DSL for residential access; varies for non-residential access
Cost to User	Pay per maximum amount of data transferred over a unit time	Pay per unit time at a given rate tier, usually with an upper limit on data transferred

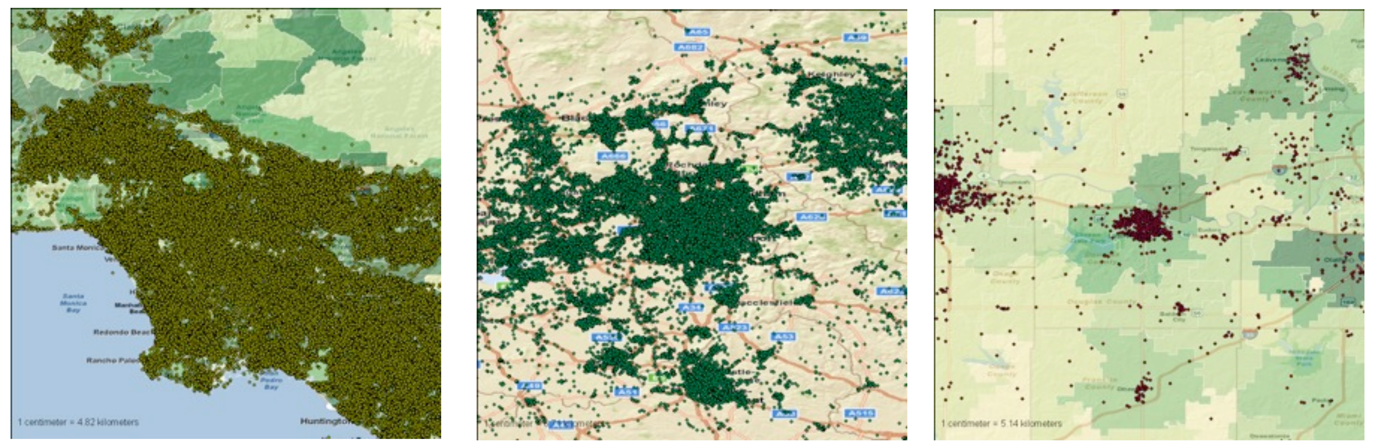
Speedtest Testing Method



Initial Results and Future Work

- Absolute performance of WiFi is better than cellular in most areas, and WiFi exhibits higher degree of performance consistency than cellular
- WiFi latency measurements are significantly lower than cellular latencies, but consistency of cellular latency is generally better than WiFi
- Larger metro areas generally exhibit better performance than smaller areas
- Access providers often exhibit similar performance consistency results across all offered access methods in a given metro region
- Significantly lower performance consistency results for these wireless access measurements than has been reported for wired access in prior work (Sundaresan *et al.*, 2011)
- LTE cellular access offers throughputs on par with WiFi, but performance consistency is not as good
- Standard diurnal patterns are evident in our measurements; performance during off-peak hours is marginally better than performance during peak hours
- Significant variability in performance measures across subregions for different metro areas

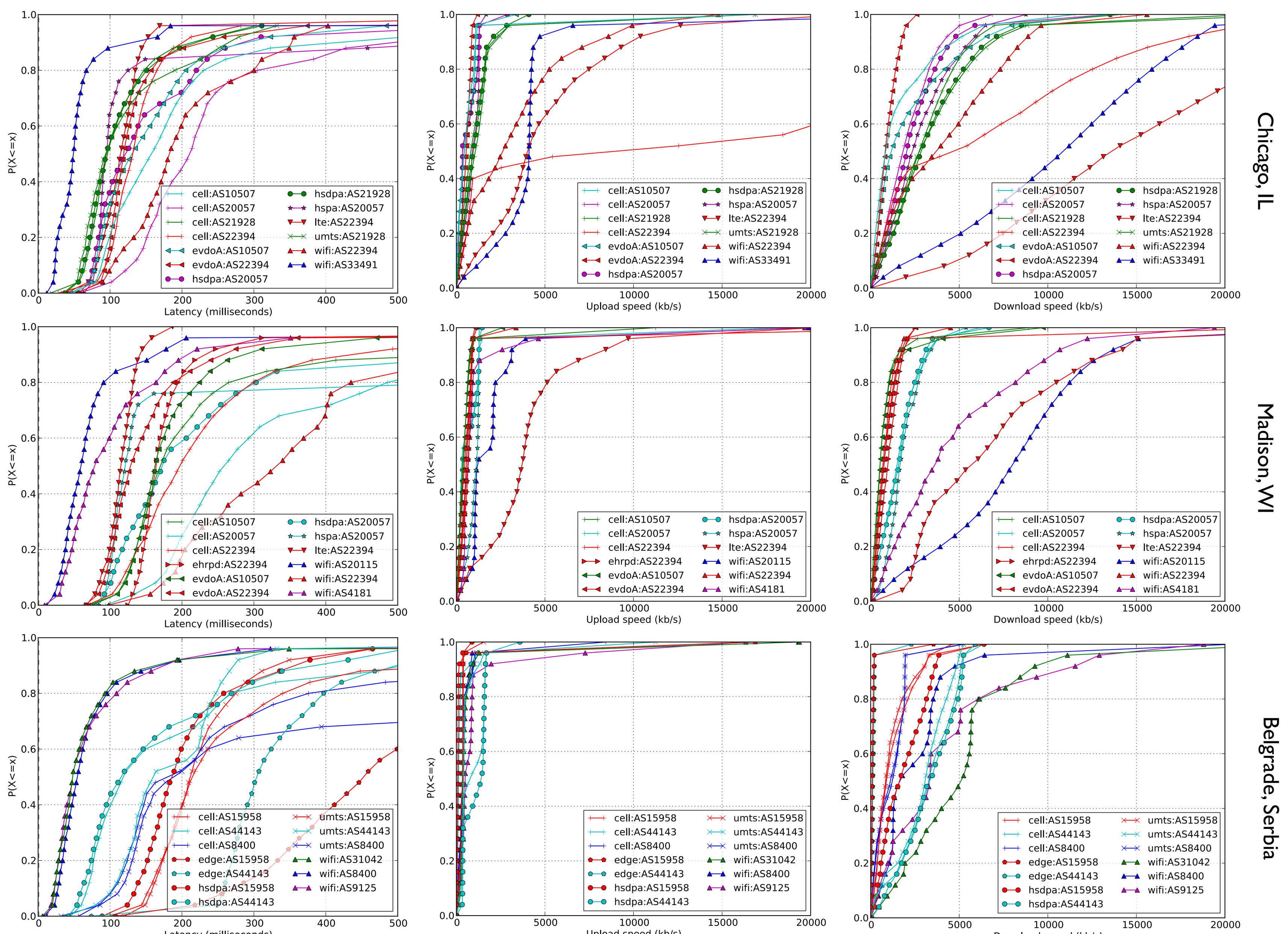
Our next steps are to examine additional metro areas, consider related datasets such as cellular tower locations and weather, and continue to work toward developing a better understanding of root causes for observed performance.



WiFi test locations for Los Angeles, CA (left), Manchester UK (center) and Lawrence, KS (right)

General Performance Characteristics

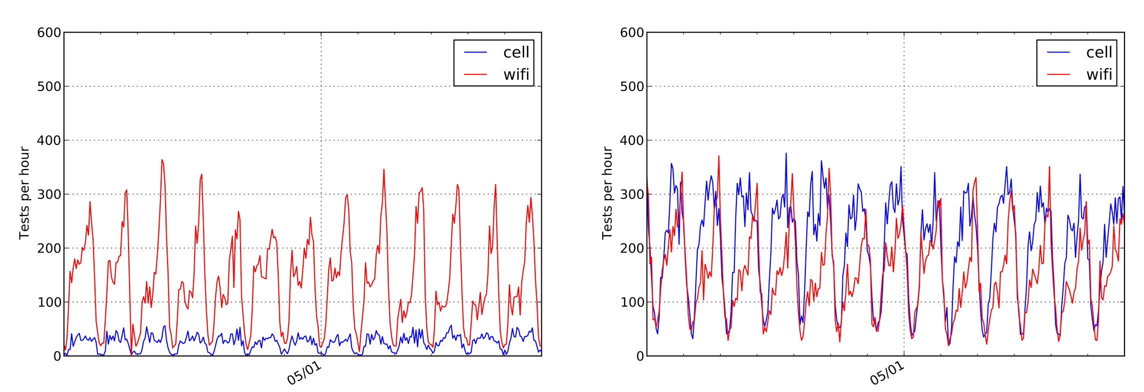
	Demographic Information		iOS			Android			Cellular			WiFi		
Metro Areas	Population	Annual PCI	Unique Handsets	WiFi tests	Cellular tests	Unique Handsets	WiFi tests	Cellular tests	Median Latency (millisec)	Median Upload (kb/s)	Median Download (kb/s)	Median Latency (millisec)	Median Upload (kb/s)	Median Download (kb/s)
New York, NY	18.9M	$50.8K	89,356	246,222	78,729	97,994	100,794	353,784	159	772	1678	54	2020	7040
Los Angeles, CA	12.8M	$45.9K	150,804	425,197	105.901	174,221	181,928	606,564	165	715	1262	64	1022	5556
Chicago, IL	9.5M	$51.0K	27,018	62.997	12,084	41,482	34,437	104,667	122	802	2250	53	3530	7770
Columbia, SC	768K	$41.7K	4,931	11,553	3,138	6,779	6,331	18,975	183	708	1276	120	446	4286
Syracuse, NY	663K	$39.8K	6,122	16,801	3,627	5,165	6,808	9,898	171	683	1143	73	985	7914
Madison, WI	569K	$49.2K	8,549	23,995	3,853	6,718	9,625	14,012	184	478	895	69	1064	5742
Jackson, TN	115K	$36.6K	5,117	13,742	3,034	2,645	3,894	5,655	226	429	792	107	930	3171
Lawrence, KS	111K	$37.5K	3,231	8,164	1,893	3,917	4,058	11,498	250	554	1182	113	908	4623
Missoula, MT	109K	$34.4K	860	2,479	604	526	872	806	314	479	747	115	731	3579
Manchester, UK	2.2M	$41.4K	80,211	291,564	30,810	32,221	82,700	37,767	221	396	1077	92	745	4717
Brussels, BE	1.8M	$45.2K	22,624	48,085	11,033	4,311	7,192	3,964	203	326	902	67	1397	8171
Belgrade, SB	1.6M	$6.0K	3,849	11,606	1,477	9,599	18,865	13,101	226	351	884	52	389	2952
Palembang, iD	1.5M	$2.0K	415	743	621	504	756	749	348	76	256	179	239	457
Almaty, KZ	1.4M	$6.9K	1,949	4,821	1,674	903	1,097	1,947	194	374	783	77	829	1855
Ulaanbaatar, MN	1.1M	$1.6K	673	1,861	275	340	621	289	216	154	960	67	846	975



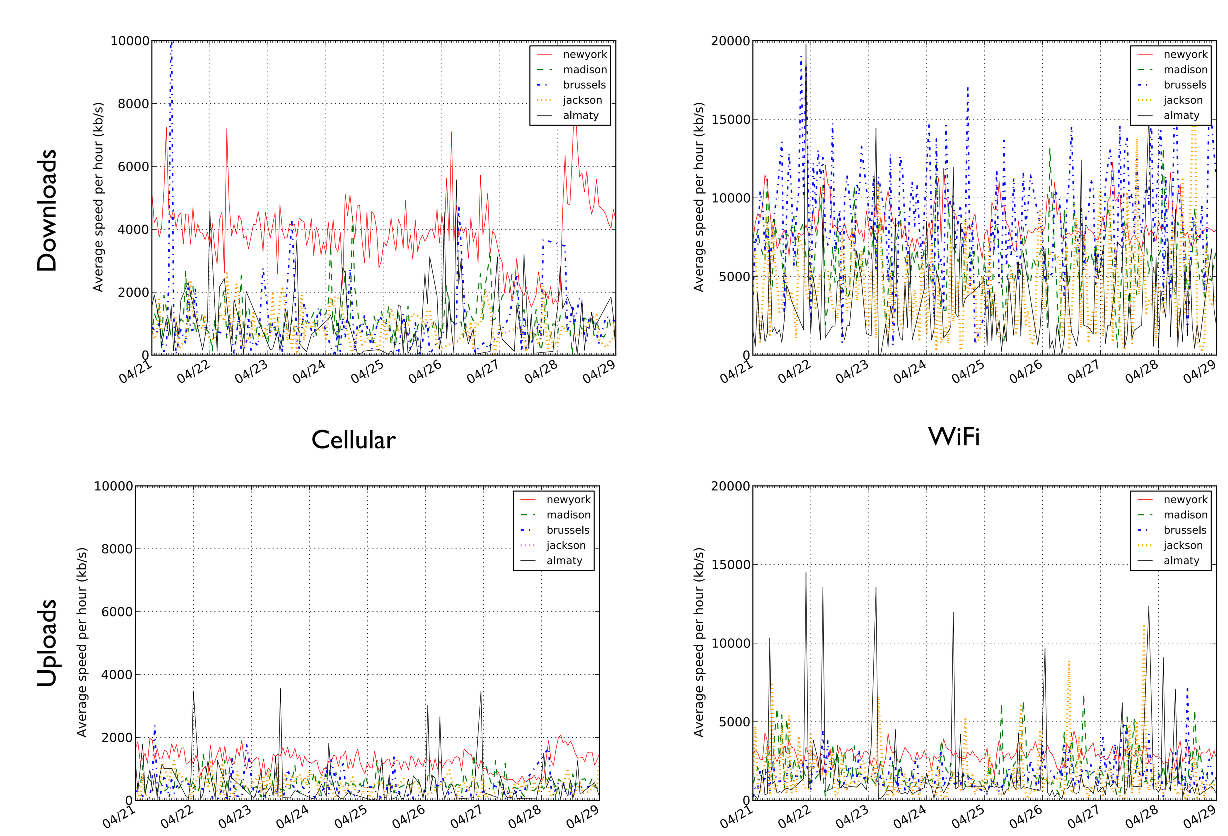
CDFs of latency (left), upload speed (center), and download speed (right) for three representative metro areas.

Absolute WiFi performance is better than cellular access, and performance consistency of WiFi throughput is generally better than cellular. However, cellular latency performance exhibits more consistency than WiFi, which is likely due to overbuffering at residential WiFi access devices. Local providers exhibit similar performance consistency characteristics, suggesting that the same backhaul infrastructure is used to support various access technologies. Performance consistency for wireless is markedly lower than for wired broadband access, as reported in prior research by Sundaresan et al., 2011.

Temporal Performance Characteristics



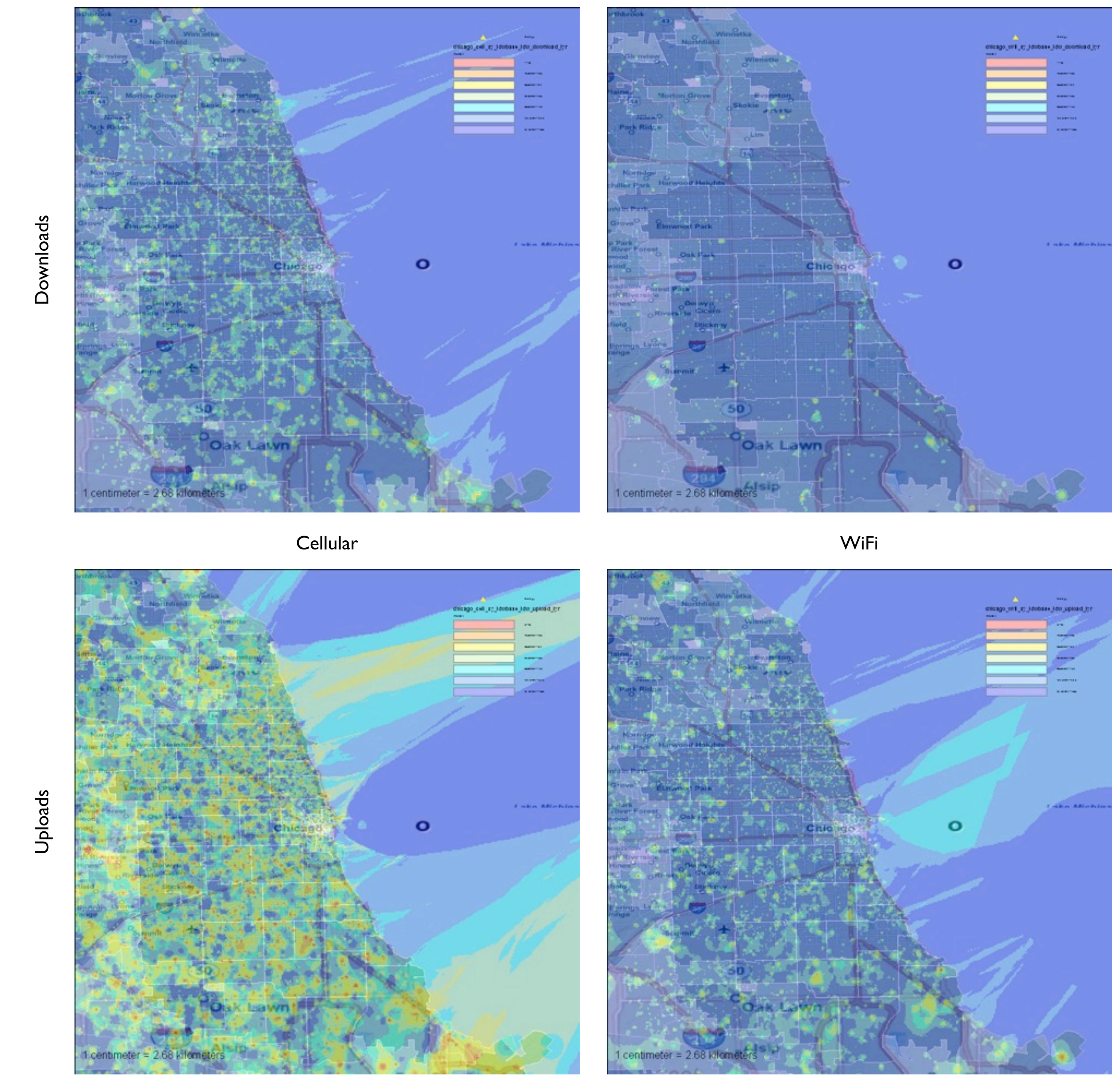
Cellular and WiFi tests per hour for Manchester, UK (left) and New York, NY (right)



Average hourly performance for cellular and WiFi uploads and downloads for 5 representative metro areas during the week April 21-April 29, 2011

We find higher throughput performance over time for larger metro areas, suggesting that service providers expend more effort to engineer networks in populous areas. We observe standard diurnal access patterns, and find some evidence for higher performance during off-peak hours and lower performance during peak hours.

Spatial Performance Characteristics



Inverse distance weighting performance interpolation plots for WiFi and cellular uploads and downloads in Chicago, IL.

We observe a high degree of spatial variability, with some metro areas exhibiting performance degradation as one moves away from the metro area center. Observed performance differences are likely due to cellular tower and WiFi base station placement, density of placements, and local contention.