Cellular and Wireless Offloading

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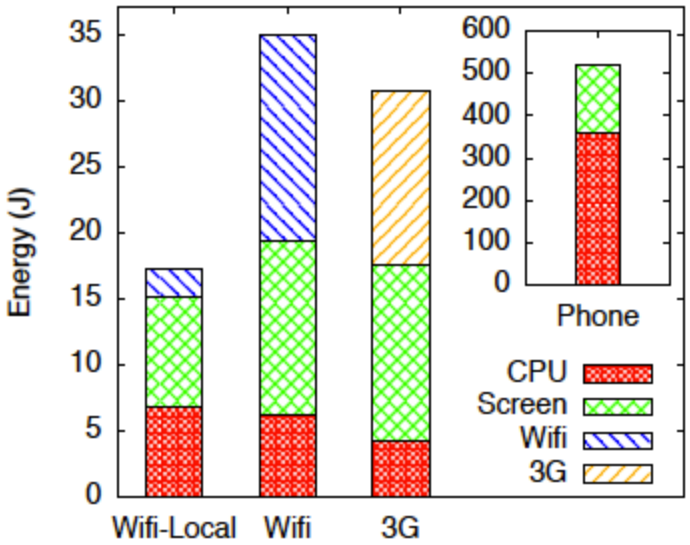
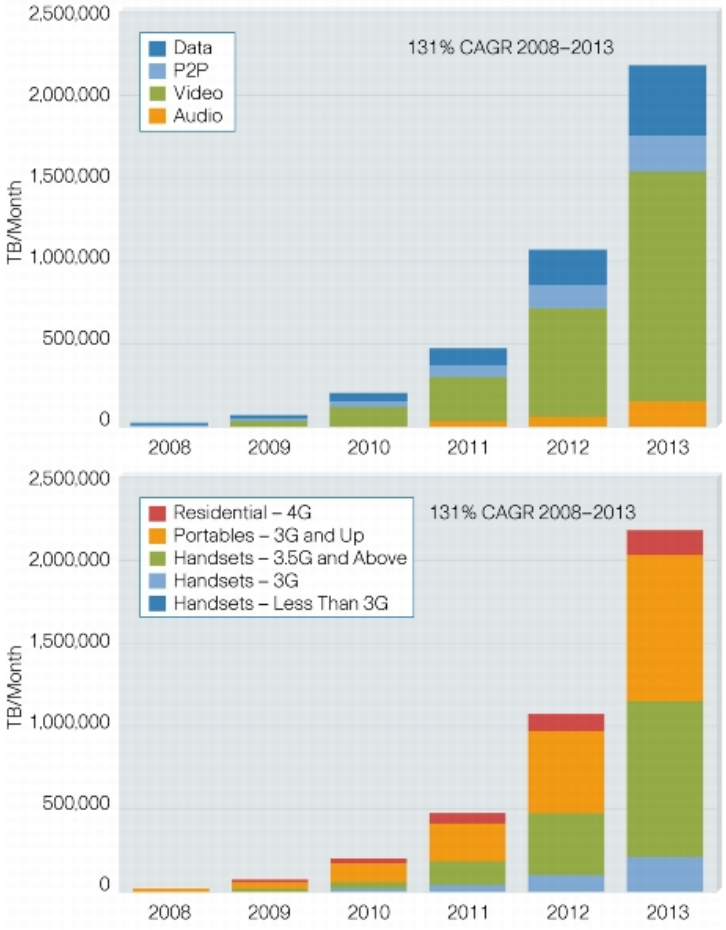
Making the Most of Mobile, Cambridge UK, 24 September 2012

Mobile Offloading

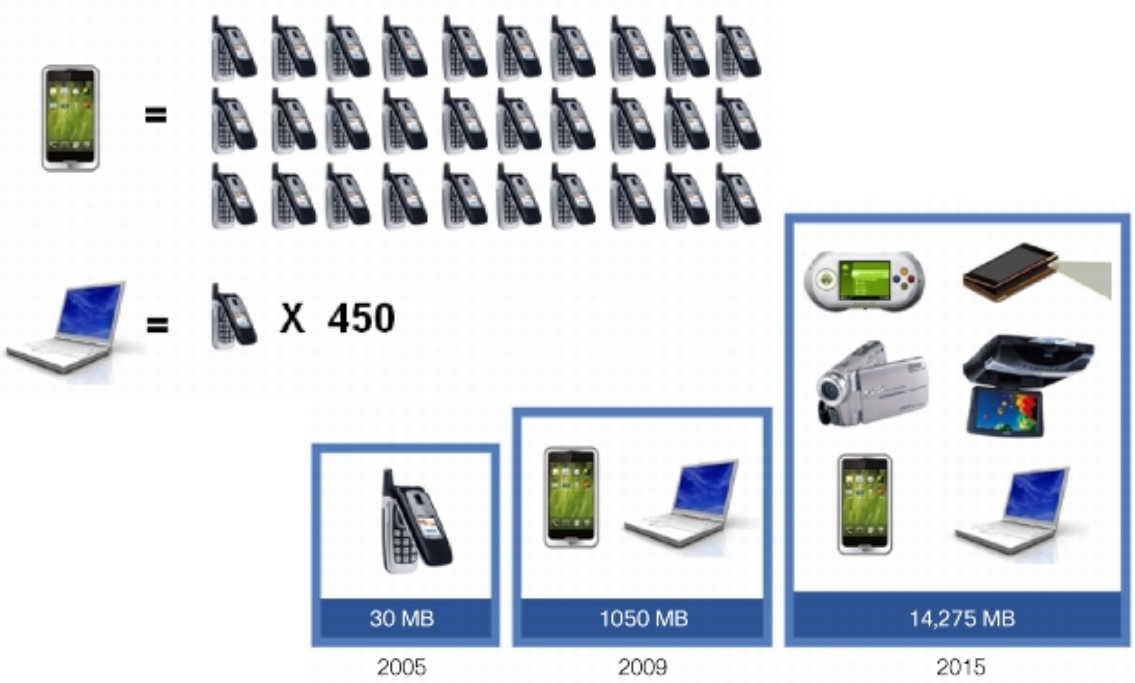
- Data offloading
  - Migrate data from one congested network to another network
- Computation offloading
  - Migrate expensive computational process from mobile to server/cloud to improve performance and enhance battery life



Celluar Data Traffic Explosion



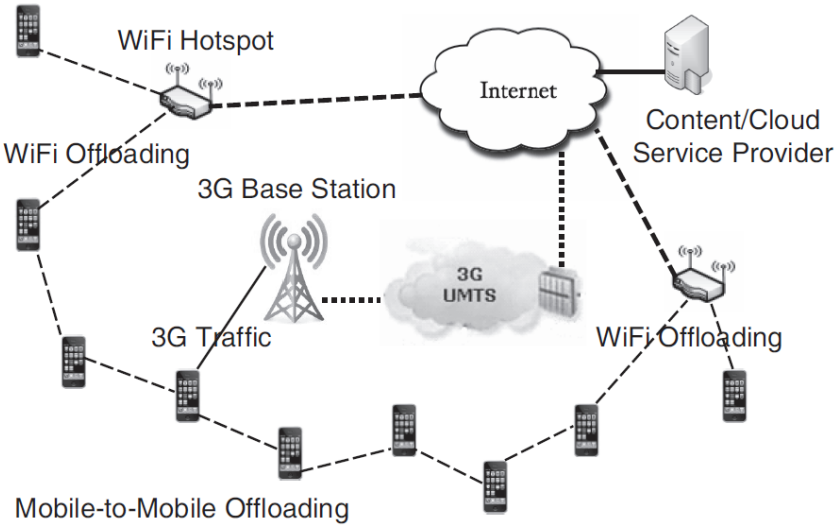
- 2008 to 2013, CAGR 131%
  - over 2 exabytes per month
- 2005 to 2012, a thousand-fold
  - Half time compared to fixed traffic



- 64% of the world's mobile traffic will be video by 2013
- Mobile broadband handsets and laptop aircards
  - over 80% of global mobile traffic by 2013
- Mobile flat rate
  - Additional traffic will not bring additional revenue

MADNet Design and Architecture

- Metropolitan Advanced Delivery Network
  - Cellular networks
  - WiFi networks
  - Mobile-to-Mobile communications
- Offload cellular data traffic to WiFi and opportunistic communications

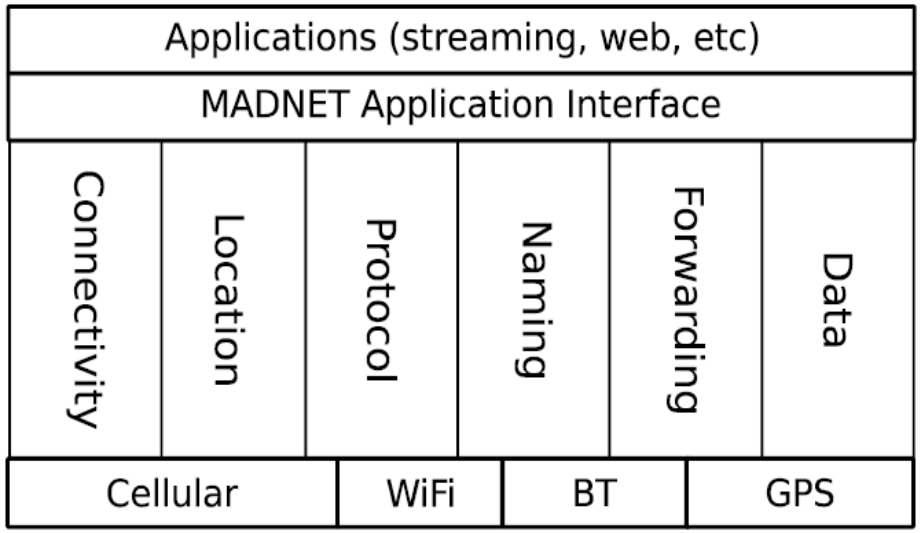


City Speed	Berlin driving	Chicago walking	Baltimore driving
Detected APs	4421	4588	3418
APs without encryption	351 (7.9%)	775 (16.9%)	621 (18.2%)
APs granting IP addresses	12 (0.27%)	18 (0.39%)	6 (0.18%)
Accessible APs	0 (0.0%)	7 (0.15%)	1 (0.03%)

- Design principle – A deployable architecture that utilizes available technologies to aggregate the power of mobile social networks, opportunistic communications, and collaborations among celluar operators, WiFi providers, and mobile users

MADNet Essentials

- Major modules
- Connectivity – control underlying accesses
- Location – provide positioning support via GPS, cellular tower, WiFi beacons
- Protocol – data transfer
- Naming & Forwarding – data relay
- Data – assemble and aggregate data from different connections

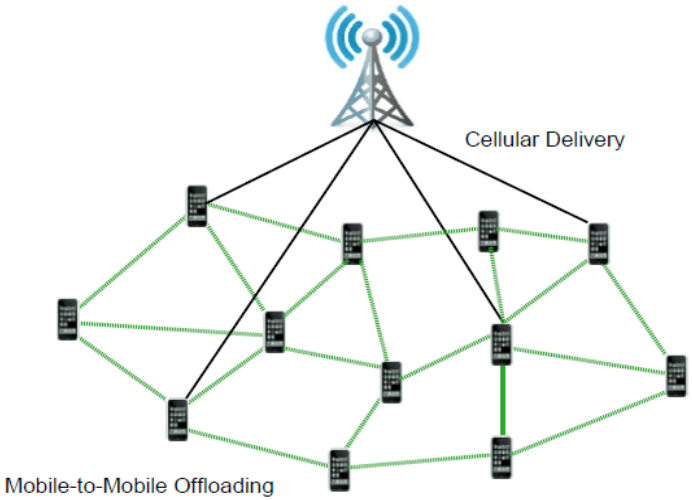


MADNet Key Components

- Research directions
  - Mobile social networks and opportunistic data dissemination
  - Opportunistic city-wide WiFi offloading
  - Energy-aware design for smartphones

Mobile Social Networks (MoSoNet)

- Data dissemination approach for cellular data offloading via mobile social participation
- Design
  - MoSoNet based target-set selection
  - Three proposed algorithms: greedy, heuristic, random
  - Utilize BT for discovery and WiFi for data transmission to improve performance and energy saving
- Key findings
  - Active participation is crucial – up to 81.42% traffic can be offloaded with active users
  - Heuristic algorithm exploiting the regularity of human mobility is close to greedy algorithm with best performance

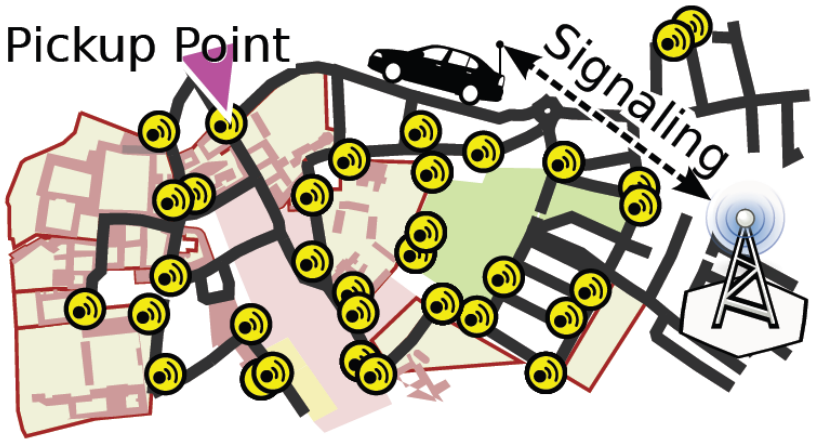


Mobile subscribers

Social graph of corresponding mobile users

Opportunistic City-Wide WiFi Offloading

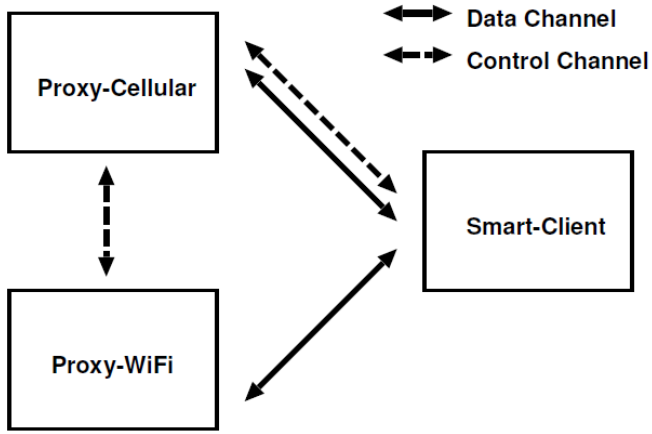
- Delay-tolerant approach for opportunistic WiFi-based data offloading
- Design
  - Signaling and pickup for downlink traffic
  - Peer relay for uplink traffic
- Key findings
  - Delivery performance improves even with sparse WiFi networks
  - Only few hundreds WiFi Aps are needed to offload up to 50% cellular data traffic in an area of 313.83 km^2
  - Delay tolerant nature of bulk data content, including video streaming, is good for mobile offloading
  - MADNet design is scalable



Signaling and pickup method

Energy-Aware Design for Smartphones

- Dedicated to smartphones in terms of energy saving, mobility, and collaboration of mobile operators, WiFi providers and mobile users
- Design
  - Energy-aware offload decision algorithm
  - Mobility and offload capacity prediction
  - Content prefetching for full utilization of WiFi access
  - WiFi fingerprint-based localization for energy saving
- > 80% Energy Saving
- Can tolerate small errors of mobility prediction



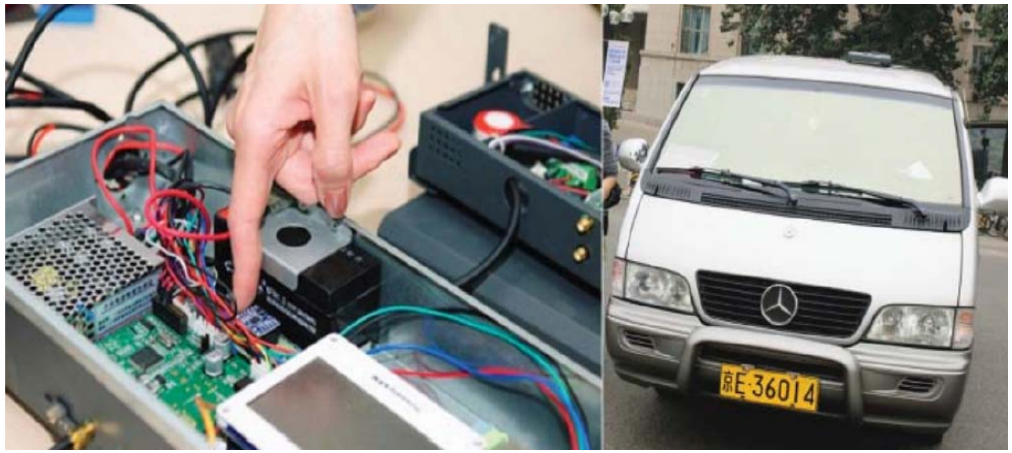
Collaborative components and communication channels

	C_W	B_{3G}	B_W	E_{oo}	E_{3G}	E_W	Saving
	MB	Mbps	Mbps	Joule	Joule	Joule	%
East	27.2	0.8	3.5	3.4	292.8	39.3	85.28
West	22.9	0.8	3.2	3.5	256.4	38.9	83.70

Estimated energy saving of field experiment

UrbanTracking: Real Time Trace Collection

- Number of vehicles
  - 27,000 participating Beijing taxis&bus
- Devices for trace collecting: GPS receivers and GPRS modules
  - GPS: collect the taxis locations and timestamps
  - GPRS: report the records every 15 seconds
- The specific collected information
  - the taxi's ID,
  - longitude and latitude
  - timestamps
  - instant speed
  - heading



- Our Beijing trace is the largest vehicular data trace available.

GlobalSense: Planet-scale mobility using public webcam

Region	# of Cameras	Duration	Interval	Records	Database Size	Routes
Bangalore	160	30/Nov/10 - 01/Mar/11	180 sec	2.8 million	357 GB	
Beaufort	70	30/Nov/10 - 01/Mar/11	30 sec.	24.2 million	1150 GB	
Connecticut	1120	21/Nov/10- 20/Jan/11	20 sec.	10 million	435 GB	74,801
Georgia	1200	30/Nov/10 - 02/Feb/11	60 sec.	32 million	1400 GB	
London	182	11/Oct/10 - 22/Nov/10	60 sec.	3 million	201 GB	32,580
London(BBC)	400	30/Nov/10 - 01/Mar/11	60 sec.	20 million	1050 GB	
New york	1160	20/Oct/10 - 13/Jan/11	15 sec.	26 million	1200 GB	
Seattle	121	30/Nov/10 - 01/Mar/11	60 sec.	8.2 million	600 GB	7,656
Sydney	67	11/Oct/10 - 05/Dec/10	30 sec.	4 million	350 GB	4,422
Toronto	189	21/Nov/10 - 20/Jan/11	30 sec.	5 million	325 GB	43,055
Washington	240	30/Nov/10 - 01/Mar/11	60 sec.	5 million	400 GB	59,809
Total	**4909**	**-**	**-**	**140.2 million**	**7468 GB**	**114,942**

- Vehicular images captured from 10 regions
- Total 4,909 cameras monitored for 4-6 months
- Over 140 M images captured and processed, ~7.5 TB data

Thank You!

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