When Will Small Cells Be Deployed: A Case Study of Critical Strategic Planning Options for Mobile Network Operators.

This case study was designed to help answer important questions related to small cell deployments. Demand for mobile data services is expanding at a rate ranging between 30-60% per year. Subscribers have a choice between many different plans and mobile devices. Networks feature multiple technologies (e.g. 2G/GSM, 3G/HSPA, 4G/LTE) operating in different frequency bands. All this has combined to increase the complexity of technology planning. Outdoor compact base stations operating at low elevation above ground using licensed frequency spectrum form small cells that work to fill the projected gap between the supply and demand of mobile data capacity. This case study serves to illustrate some strategic options to consider when making small cell buildout decisions. It builds on numerical models to answer a fundamental question: when are outdoor small cells needed? It also illustrates the factors that impact the number of required small cells, the effects of Wi-Fi offload and other strategic technology options such as spectrum.

Canada – Key Wireless Facts:

- Wireless coverage reaches 99% of pop.
- 13,000 wireless antenna sites
- 60% of all sites are shared
- 40% of sites are located on buildings other than towers
- Up to 40% – 50% of mobile data is consumed at home

Source: CWTA

Toronto – Basic Facts:

Populations (2011): 2,615,060
Area: 630 km^2 (240 sq mi)
Density: 4,149/km^2 (10,750/sq mi)

Source: Statistics Canada, City of Toronto

Canadian Operators – Subscriber Base:

Rogers	9,437,000	Wind	590,438
Bell	7,681,032	MTS	497,367
TELUS	7,670,000	Videotron	402,600
SaskTel	607,659	Total	26,886,096
Penetration			83%
Smartphone penetration (% of postpaid)			62%

Source: CWTA, 2012

Scenario Description: The analysis focuses on the downtown core of Toronto, Canada's most populous city. The area measures 7 km^2 and houses over 77 thousand residents in addition to tens of thousands of commuters who flock to this area on a daily basis to work in many corporate offices, particularly in the financial sector, government, hospitality, retail, and other service industries. The area is selected because the subscriber density is highest. One expects small cells to be required in this area before other, less dense areas (although this is not necessarily true because density improves the economies of competing techniques such as DAS, cloud-RAN and WiFi).

The area is covered by a total of 59 three-sectored macrocells for a total of 177 sectors, as shown in Figure 1, and five microcells at height lower than 15 m. All macrocells can operate both LTE and 3G HSPA technologies.

Today, a total of 95 MHz full duplex spectrum is held by the wireless operator in 800, 1700, and 1900 MHz bands. There is potential to acquire additional spectrum in 700 MHz following the planned auction in November 2013. The frequency allocation also raises the important

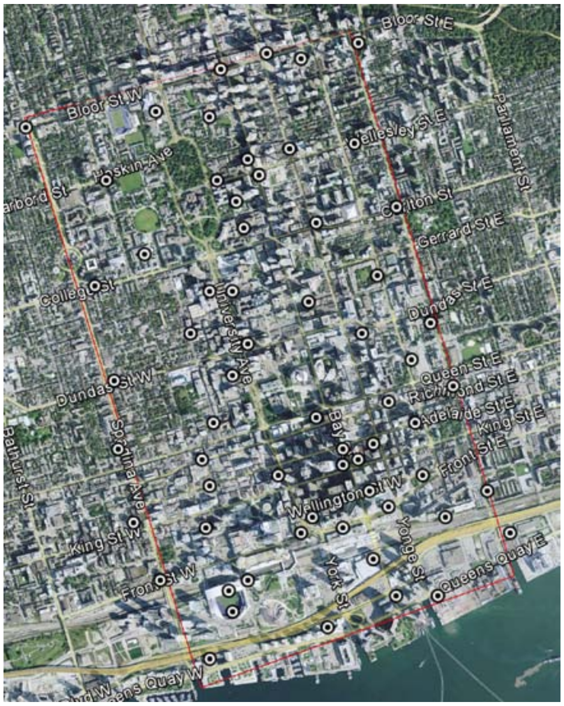

Figure 1 Total of 59 three-sectored macrocell sites and 5 microcells serve downtown core outlined by red boundary line.

issue of using 2.5 MHz allocations for HSPA services in bands such as 800 MHz which has 2x12.5 MHz allocation resulting in inefficient use of spectrum with the 5 MHz HSPA+ channel allocation. We have not considered the added capacity resulting from such a feature should it become available. The importance of this feature will come to play in future spectrum refarming plans.

Subscriber Profile: The analysis considers a mix of subscribers (postpaid, prepaid), types of mobile devices (smartphones, feature phones, tablets, laptops, and M2M devices), and technologies (HSPA, LTE) as shown in Figure 2. Operator market differentiation strategies have a great impact on the type of subscribers and the carried traffic. Hence, they are incorporated into the model.

Traffic consumption: Demand for capacity follows defined patterns characteristic of the type of subscriber and device type. An example is shown in Table 1 which shows significant data usage in smartphones over feature phones. Tablets consume 2.4 times the traffic of smartphones while laptop average just over 7 times the amount used by a smartphone. The traffic volume per device type as percentage of aggregate network traffic varies between operators and regions. For example, laptop traffic in Europe accounts for 50-80% of the total traffic while in North America, can be a few percent[1]. In our scenario, smartphone

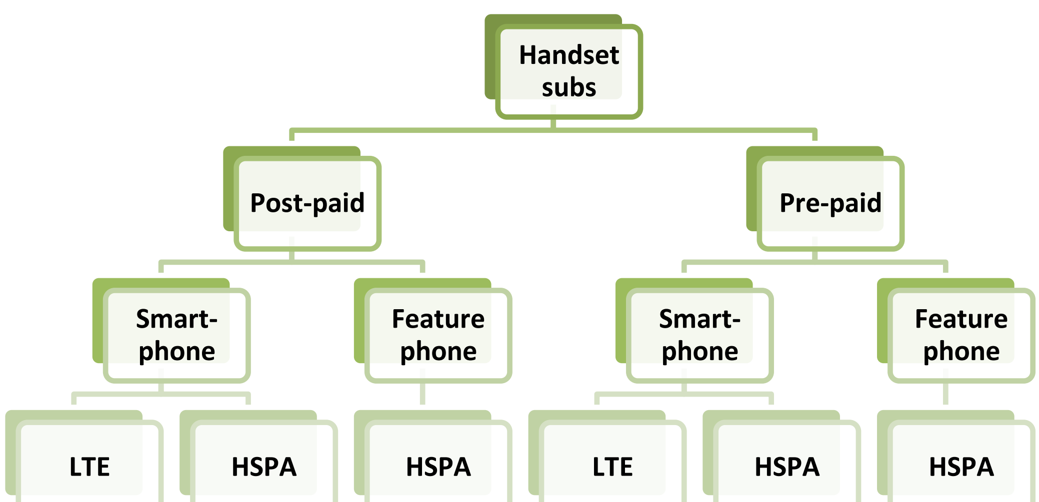

Figure 2 Subscriber profile hierarchy for handsets.

traffic remains the predominant type of traffic for the duration of the analysis period as shown in Figure 3.

Table 1 Cumulative average traffic growth rate (2012-2017) and traffic multiples normalized to that of a smartphone[2].

	CAGR ('12-'17)	Traffic
Non-Smartphones	35%	0.02
Smartphones	81%	1
Laptops	31%	7.36
Tablets	113%	2.4
M2M	89%	0.18

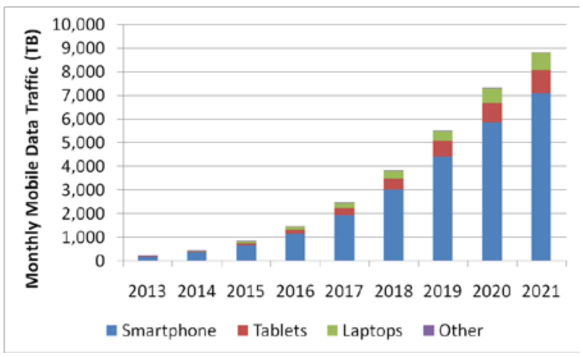

Figure 3 Total network traffic per device type.

Technology Migration & Offload Strategies: LTE provides about twice the spectral efficiency than HSPA. This advantage is expected to increase with the deployment of LTE-Advanced where a host of features (for example, eICIC, high-order MIMO, and receiver interference cancellation) would increase the spectral efficiency of LTE systems beyond the current downlink average of 1.8 b/s/Hz. From this isolated perspective, it is in the interest of the network operator to expand LTE coverage. In this case study, we assume the operator will turn off data services on the HSPA network in 2019 as shown in Figure 4. Furthermore, Wi-Fi offload and the deployment of in-building systems such as DAS and cloud-RAN solutions work to reduce mobile network traffic. Market analyst estimate that as much as 85% of mobile data consumption occurs indoors. The proliferation of these techniques will have a large impact on the strategies implemented by MNOs to address shortage of network capacity and consequently the deployment timelines of small cells.

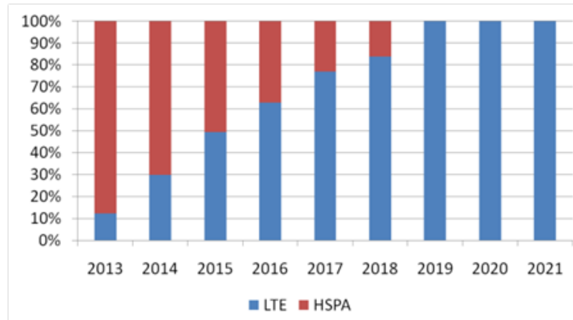

Figure 4 Subscriber distribution between HSPA and LTE.

Capacity Supply and Demand: Figure 5 shows the aggregate network capacity supply and demand. The HSPA network is managed appropriately to maintain sufficient offered capacity to meet demand. However, in the LTE network, demand for capacity will outstrip supply in 2017. This is when small cells will need to be introduced.

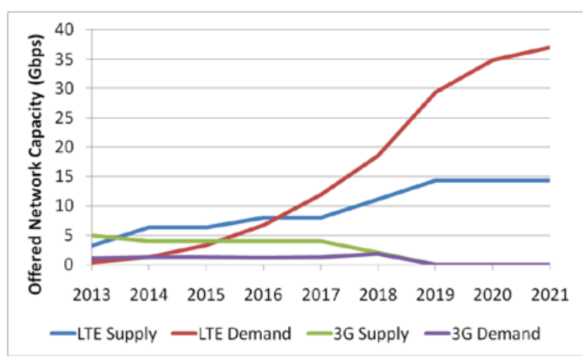

Figure 5 Network capacity supply and demand.

Number of Small Cells: The deployment of outdoor small cells is achieved through a methodical approach. By identifying the location of traffic concentration, the operator deploys small cells incrementally to relieve congested macrocells. Figure 6 shows the cumulative number of small cells which includes a ramped-up factor for in-building traffic offload. Two scenarios are considered: small cells with 10 MHz and 20 MHz channel bandwidth. While 20 MHz channelization provides higher capacity, the limited coverage area of small cells may not allow the operator to derive the full benefits of the larger channelization.

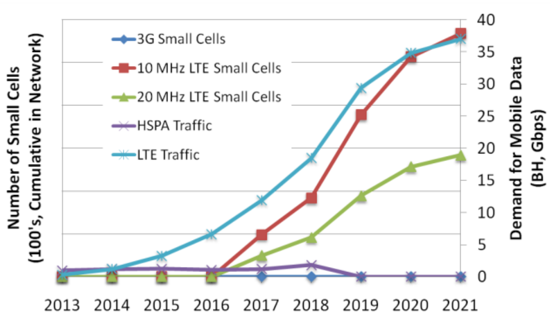

Figure 6 Busy hour demand for capacity and cumulative number of small cells required to equalize capacity supply with demand.

Summary: Outdoor small cells are one solution to address capacity deficit in wireless networks among a host of solutions at the disposal of the network operator. The deployment timelines for outdoor small cell base stations, if they are to happen on large scale, have to be considered in a manner that is line with operator greater business objectives and market differentiation. Capacity control levers at the disposal of operators include the acquisition of spectrum for LTE services, and spectrum refarming; migration to LTE from older less efficient technologies and implementation of roadmap to support LTE-Advanced features; deployment of Wi-Fi, DAS, and Cloud RAN offload; implementation of data plans and fair-use policies to cap demand for data services; and deployment of caching techniques to reduce the carried traffic. As a result, predicting when small cells will be deployed will vary from one region to another, and within a region from one operator to another.

Acronyms

DAS	**Distributed antenna system**
eICIC	**Enhanced intercell interference coordination**
GSM	**Global systems for mobiles**
HSPA	**High speed packet access**
LTE	**Long term evolution**
M2M	**Machine to machine**
MIMO	**Multiple input multiple output**
MNO	**Mobile network operator**
RAN	**Radio access network**

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[1] Akamai, The State of the Internet, Vol. 5, No. 4, 4th Quarter, 2012 report.

[2] Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2012–2017. February 2013.

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