STRATEGY ANALYTICS INSIGHT

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Small Cells Taking Off, Need Fiber Backhaul Soon

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JDSU

Snapshot

Mobile Broadband traffic growth accelerated by video demand is now driving the deployment of LTE small cells in urban hot zones and indoor venues. Carrier Aggregation with LTE-Advanced (LTE-A), WiFi roaming and Local Breakout will all accelerate the need for smart high bandwidth broadband backhaul capacity. Within two years this will dramatically increase the use of fiber backhaul for multiple high capacity clusters of small cells.

As small cell deployment finally takes off in 2014 and 2015 new requirements are emerging for backhaul transport with increased peak bandwidth. Fiber connectivity for small cells – especially where Gigabit Ethernet backhaul can be shared with commercial users – will be demanded soon.

Analysis: Key Drivers for Small Cell Growth and Backhaul Capacity

The key factor driving the demand for LTE capacity and small cells is mobile broadband traffic growth worldwide that demands new capacity over existing spectrum. New cost effective small cells are finally being deployed at an accelerating rate in late 2014 and 2015 but backhaul for these small cells still presents challenges.

Requirements for LTE small cells include premium backhaul performance and throughput even for the two earliest LTE Use Cases. So we expect small cell backhaul to cross the ***'Fiber Threshold'*** due to:

- Aggregated Traffic from clusters of small cells
- LTE Carrier Aggregation
- Shared backhaul transport capacity for WiFi Roaming and Local Breakout

Traffic Growth Demands New Bandwidth

Mobile Traffic is escalating dramatically over the next five years as smartphone penetration passes 60 percent in most of the world and video and other applications demand increasing bandwidth over both 3G and 4G networks.

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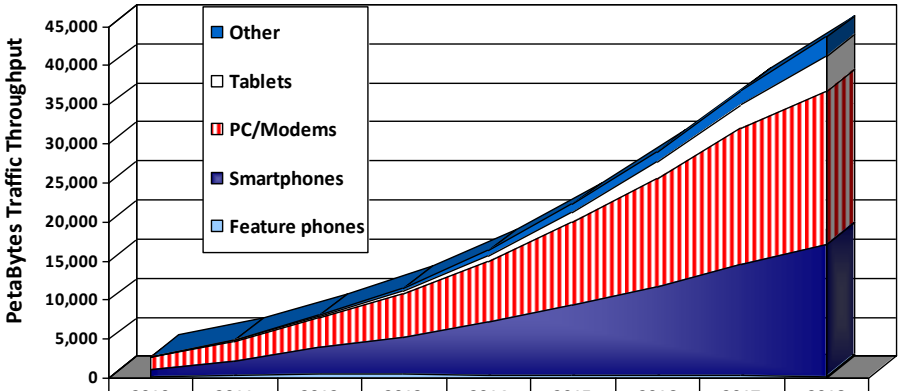
Chart 1. Growth of Applications on Modems and Smartphones drive Bandwidth Worldwide

Mobile Data Traffic Explosion PetaBytes (PB) Worldwide



	2010	2011	2012	2013	2014	2015	2016	2017	2018
Other	52	112	217	372	640	970	1,392	1,945	2,392
Tablets	7	47	161	386	758	1,317	2,067	3,001	4,486
PC/Modems	1,497	2,490	3,785	5,512	7,786	10,565	13,831	17,485	19,673
Smartphones	975	1,905	3,394	4,735	6,671	8,980	11,385	14,205	16,838
Feature phones	147	328	487	486	430	414	338	280	236

Source: Strategy Analytics 'Traffic Forecasts by Device'

Mobile network bandwidth and signaling demands are projected to continue to increase rapidly. Smartphones and tablets spearheaded dramatic applications growth and they will be followed by a flood of new connected mobile sources - from connected car systems, wearables and sensor networks to high bandwidth M2M real time control systems. Network resources will be increasingly taxed both by bandwidth-hungry applications like broadcast and streaming video and by increasingly intensive signaling traffic e.g. to support VoLTE and 3G voice interworking.

Small Cells will be essential to provide the Required Capacity

Small cells or '***spatial reuse'*** will play a major role alongside LTE's '***new spectrum'*** and LTE-A '***spectral efficiency'*** to meet this dramatic growth in capacity demand. But to make small cells cost effective they must be deployed for the right 'Use Cases' with the right backhaul capacity at low cost.

How do we Define Small cells?

Small Cells can be defined most easily by transmission power and the cell radius they are engineered to support. Below are definitions of cell types in terms of their power and size - including WiFi for comparison.

Chart 2. Definition of Small Cells by Power & Approximate Radius

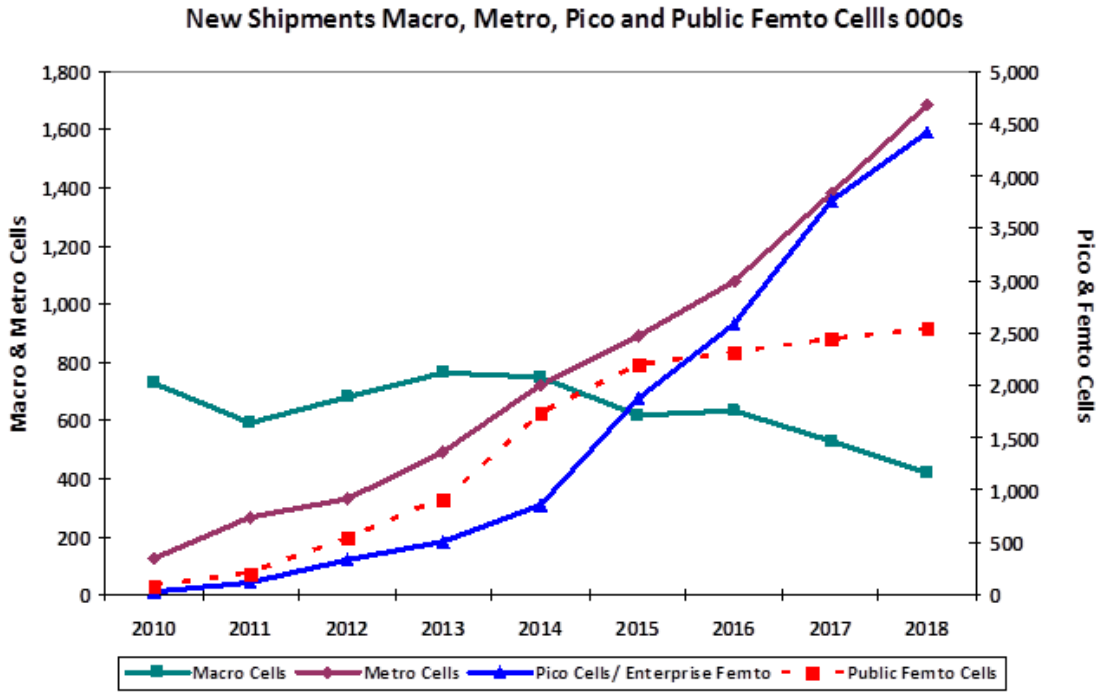
Cell Type	Typical Power	Typical Radius
WiFi	10 mW - 400 mW	10 to 100 meters
Outdoor Femto	2 mW– 250 mW	10 to 100 meters
Pico	250 mW – 1 W	20 to 200 meters
Metro/Microcell	1 to 10 W – Generally ~2 W	200 meters - 2 kilometers
Macro Cells	10 to 50+ W	8 to 30 kilometers

Key: mW – MilliWatts, W – Watts ***Source: Strategy Analytics***

Small Cell Deployment will accelerate from 2014 onwards

After a year of hiatus as operational processes, use cases and chipsets for small cell were finalized Strategy Analytics expects the deployment of both Enterprise and venue focused Pico Small Cells (Blue) and Metro Cells (Purple) to take off in 2014 and 2015. The chart below shows Strategy Analytics most recent projections for shipments of new Macro, Metro, Pico and Public femto cells through 2018.

Chart 3. Macro, Metro, Pico and Public Femto Cell Shipments will Accelerate through 2018



Source: Strategy Analytics

Note that in the above chart Pico cells include indoor enterprise and public venue small cells that are a coordinated part of the Mobile Operator's HetNet. Femto Cells are defined as those that merely avoid Interference with the HetNet.

LTE Small Cells introduce New Requirements

LTE Small Cells have several unique requirements for visibility, real time response and key data analytics that historically were not as important in 3G networks or networks not connected by packet based IP transport. New LTE/4G requirements - very low latency for X2 cell handoff, E2E S1 and Diameter signaling, link by link visibility in the RAN beyond the router, lower layer transport and network monitoring, pro-active (rather than passive) Network Management, upper layer Service Awareness, increased complexity created by Self Organizing Networking (SON) and real time virtualization under Software Defined Networking (SDN) demand new functionality.

LTE small cell demand increases the need for real-time signaling and delivery, e.g. for X2 inter-cell handover or for Service Level Agreement (SLA) guarantees. Monitoring and managing backhaul for small cells is an increasing challenge as networks need to meet the new performance demands of low latency signaling and bursty traffic. Additional challenges are created for small cell backhaul by changing topology as the backhaul network evolves from hub and spoke to a 'partial mesh' with redundant paths for backhaul connectivity and real time load management.

This increased **backhaul complexity is exacerbated by several additional factors:**

- **Increased bandwidth and connectivity between cell sites** and associated **cost to *activate*** *a large number of backhaul links*
- ***Increased processing at the Edge due to new and embedded functionality***
- ***Burstier network traffic with less predictable spikes*** since small cells do **not** benefit from the 'law of large numbers' and traffic fluctuates far more than in larger cells
- ***Need for more dynamic network reconfiguration to share (and steer) traffic load across multiple network links as traffic fluctuates*** **-** to ensure consistent Quality of Service (QoS) for all end users

As the number of small cells increases the topology of the backhaul network is expected to expand and evolve from hub and spoke to a partial mesh as shown below. This offers redundant backhaul options that can also share traffic dynamically at peak periods. Visibility of every link becomes essential for operators to manage even these 'partial mesh' networks.

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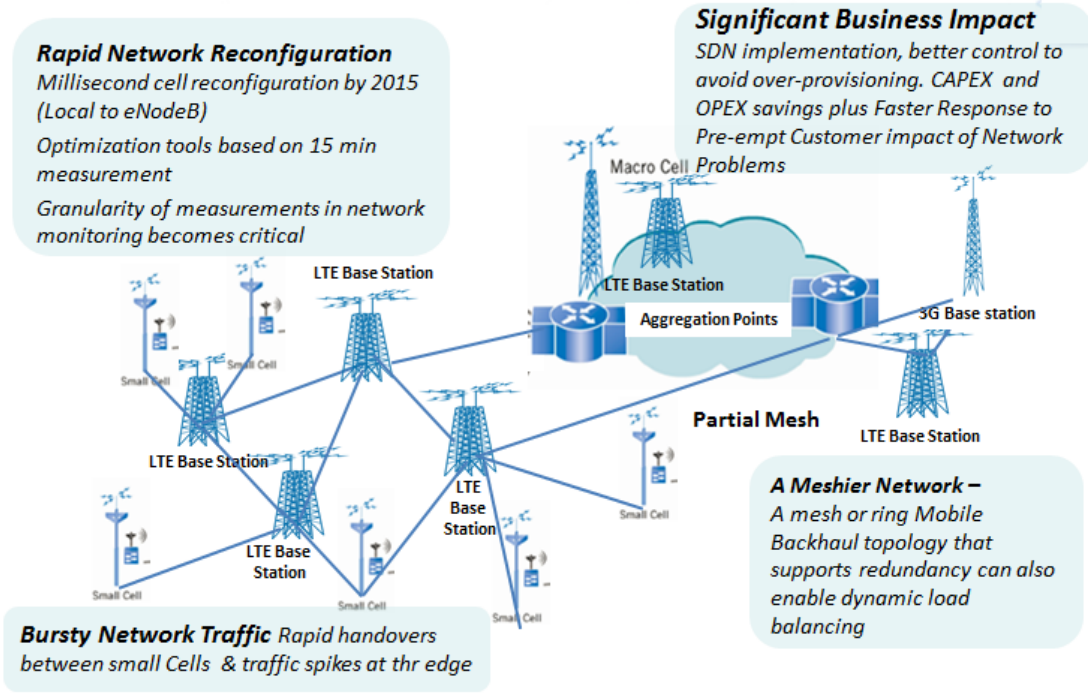
Chart 4. Number of Backhaul Interconnections and Aggregation Points Changes Topology



Source: Strategy Analytics

Two particular Small Cell Use Cases are part of early LTE Deployments

Based on Strategy Analytics research there are two specific Use Cases where early LTE deployments will need small cells for capacity or coverage. The chart below provides some preliminary estimates of the relative magnitude of these two Use Cases and their market timing.

Chart 5. Magnitude of Two Key Use Cases

Use Case	Location/Area	Backhaul Signal, Capacity Need	QoS	Backhaul Technology	Market Timing	Est. Units Deployed by 2017 (Millions)
A. For Capacity	Urban Hot Zone - congested outdoor locations, intersections	HIGH	Medium	Wireless/Fiber to Cell, fiber for aggregation	2014-2015	>5 Million
B. For Coverage	Indoor Venues – Corporate Offices, Public Malls etc.	Medium	Medium	Fiber	2015-2017	>5 Million

Source: Strategy Analytics

These specific Use Cases are described below. We expect both cases to evolve rapidly to require fiber backhaul within the next two years.

- **Use Case A. Dense Urban 'Hot Zones'**

  In dense urban 'Hot Zones' small cells add cost-effective capacity to Macro Cells, optimize 3G spectrum use to support 4G refarming and will soon support WiFi Offload under operator control. Hot Zones such as Times Square in New York require significant and ever increasing capacity that exceeds normal Macro Cell availability. Small cells can be deployed in manageable *'groupings'* or 'clusters' that can leverage X2 'pole to pole' communications for assisted handover with direct low latency signaling between each other or to the shared eNodeB. A single macro carrier deployment and out of band Pico Cell deployment would be typical.

  According to a large Tier 1 operator "X2 is a must for urban small cells". Fiber is virtually essential to deliver very low latency connectivity within these clusters and back to the eNodeB, and fiber capacity from the Macro cell is highly desirable if not yet essential.

- **Use Case B. Indoor Venues, Office Buildings, Campuses and Venues e.g. Shopping Malls**

  In these locations small cells are needed to provide coverage and in-building penetration that Macro Cells cannot. Operators are beginning to offer managed or shared services with small cells that generally require a fiber broadband connection for backhaul. For corporate customers offering Service Level Agreements (SLAs) for hybrid fixed and mobile Virtual Private Networks (VPNs) can be lucrative for the operator but they will require premium monitoring to deliver high performance LTE.

Increasing Operator Use of Fiber for Small Cell Backhaul – the 'Fiber Threshold'

As small cell deployments accelerate in late 2014 and 2015 the backhaul and technology requirements will change. Initially fiber connectivity for small cells will be used only where fiber is readily available. Today new fiber deployment for small cell connectivity is often viewed as too costly. **Over time as small cell capacity and processing requirements escalate they will cross the 'Fiber Threshold'.**

> *Over time as small cell capacity and processing requirements escalate they will cross the **'Fiber Threshold'.***

Today fiber would generally be deployed where a specific location requires over 1 Gbps of throughput but Strategy Analytics anticipates that for the reasons listed above the 'Fiber Threshold' for small cell backhaul will fall to about 200 Mbps of aggregate LTE throughput – at least in areas *where existing fiber is less than a kilometer from the new cell site* and especially where Gigabit Ethernet over Fiber can be shared with commercial users.

Many Mobile Operators have already stated that they will use fiber for mobile backhaul wherever they can. As they plan small cell deployments operators should consider choosing fiber for multiple reasons where:

- Throughput per small cell will exceed the 'Fiber Threshold' in the next 18 months - from 200 Mbps to 1Gbps
- Bandwidth load management over multiple paths will soon become feasible in a ring or partial mesh topologies
- Fiber deployment is easy to justify in relation to the total cost of ownership through attractive leasing deals or shared Ethernet over Fiber.

Today although existing fiber is often re-used for backhaul, the last 15-30 meters to the small cells are likely to be new – due to their sheer numbers and placement. Initially backhaul transport for small cells will be a mix of wireless - point to point and often multipoint microwave, copper - especially where VDSL is available for short distances - and **fiber for about 40 percent of the locations**. The final choice will depend on what is available at each location and what can be made available for the best Total Cost of Operations (TCO).

Value of Ethernet over Fiber

Ethernet over Fiber provides the ideal backhaul transport for LTE small cells since it leverages:

- Partial (or Full) **Mesh Connectivity**
- On-Demand **Burstable Bandwidth**
- **Inherent Redundancy when deployed on fiber ring**
- **Standard** third party leasing agreements
- **Efficient Network Sharing with commercial users**

In addition ***Ethernet itself offers value added capabilities for Carrier Service Mapping as well as Quality and Class of Service Monitoring and SLA enforcement*** per user with standard termination and easy integration – especially for Use Case B (above).

It is important to note that the fiber required for small cell backhaul is standard commercial broadband fiber transport that is available as a 'Gigabit Ethernet' and 'Carrier Ethernet' service; and can therefore be shared commercially - 100 Mbps at a time - by multiple enterprise and operator applications to reduce initial deployment costs and support burstable rates for peak loads. This is in contrast to the ***dedicated dark fiber '***fronthaul' that is required to run CPRI for Cloud RAN (C-RAN) or for Remote Radio Heads (RRHs) which is likely to be far more costly. CPRI 'fronthaul' installations today are very difficult to share***.***

We believe that in the longer term as fiber vendors implement SDN and fixed service transport vendors support rapid reconfiguration Ethernet over fiber backhaul will provide the best scalable capacity and redundancy, at the lowest CAPEX and OPEX per Gigabyte (GB).

*Carrier Aggregation and WiFi Integration with Small Cells will together push multiple small cell configurations over the **'Fiber Threshold'** leading to a dramatic expansion of fiber to the edge of the network.*

Unfortunately, however - even for mobile operators that are part of fixed Telco service provider - new fiber backhaul will appear on financial statements as a large OPEX expense i.e. as a ***recurring leasing cost***.

So while Microwave systems may represent a large initial CAPEX, operators often prefer fixed assets which they can depreciate that live well beyond their depreciable life. This improves their reported Return on Investment (ROI). A new business model is needed that would allow mobile operators to capitalize their long term fiber leases for mobile backhaul to obviate this financial reporting problem.

Crossing the 'Fiber Threshold'

The 'Fiber Threshold' for backhaul therefore will vary with each deployment. But bandwidth per cell 'cluster' is expected to escalate rapidly and ***many small cell clusters are expected to cross the critical 200 Mbps breakeven 'Fiber Threshold' during 2015 and 2016***, especially as:

(i) ***LTE-Advanced (LTE-A)*** with 3GPP Release 10 - for Carrier Aggregation will be deployed rapidly in the near future

(ii) Many small cells will be deployed with ***integrated 802.11 ac WiFi Access points for video and other traffic Offload***

- **(i) LTE-Advanced (LTE-A) Carrier Aggregation will accelerate Fiber backhaul for Small Cells**

When planning backhaul capacity for LTE small cells it is essential to provide adequate backhaul not just for average traffic loads – minimum backhaul – but for peak traffic periods. For small cells peak 'burst rates' can require backhaul throughput that is 6 to 8 times the average level. This is especially true if Carrier Aggregation enables user applications to grab multiple channels simultaneously. Operators are definitely planning to deploy LTE-Advanced with **Carrier Aggregation will push aggressively during 2015 and 2016 and this multiple small cell configurations over the *'Fiber Threshold'* leading to a dramatic expansion of fiber to the edge of the network.**

Video Growth and WiFi Integration followed by LTE-A Carrier Aggregation will demand Fiber Backhaul.

Operators need to prepare for this bandwidth explosion today. The chart below shows the likely initial timeframes for backhaul throughput to cross the 'Fiber Threshold' - Green areas in chart below indicate crossing of the **'Fiber Threshold'**. Darker Green are full Fiber speeds.

Chart 6. Required Backhaul Rates for small cell sites- Mbps (MB) and Gbps (GB)

Backhaul	Technology	2014	2015	2016	2017
Minimum backhaul per cluster (Average Traffic)	LTE	80 MB	80 MB	120 MB	120 MB
	LTE-A	200 MB	200 MB	400 MB	400 MB
Backhaul Required per cluster to support Peak Traffic	LTE	240 MB	240 MB	360 MB	360 MB
	LTE-A	600 MB	600 MB	1.2 GB	1.2 GB

Source: Strategy Analytics Estimates

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Traffic Growth driven by Video and WiFi Integration with Small Cells will be followed by LTE-Advanced Carrier Aggregation that will demand Fiber Backhaul

- **(ii) Small Cell Backhaul Capacity will Increasingly Share Transport with WiFi**

  Between 50 and 70% of mobile data traffic today uses WiFi as the air interface, and most smartphone, tablets and notebooks are equipped with WiFi. Some operators have chosen to offload data users to WiFi even before full integration of the WiFi into the mobile network.

  Video Traffic represents over half of Mobile Device traffic today but much of it already travels over WiFi. As WiFi Access points are integrated with small cells and monetized, even mobile device users watching video over WiFi will share the same fiber backhaul as small cells at the same location - dramatically increasing the shared backhaul required.

  As WiFi networks evolve, it is becoming possible to integrate WiFi fully into Radio Resources Management (RRM) - offering seamless roaming, intelligent access type selection, session mobility and common Customer Experience Management (CEM). Operators will also be able to optimize the user experience and create brand value with a variety of flexible new business models for seamless location aware services.

  Integrated LTE/WiFi small-cells will require almost twice the backhaul of small cells alone pushing backhaul requirements into Gbps range and over the 'Fiber Threshold'.

Implications

As mobile data demands escalate, LTE small cells will become an integral part of operators' network rollout. The advent of LTE-Advanced Carrier Aggregation and integrated WiFi in high-traffic urban and indoor scenarios will push small cell backhaul over the 'Fiber Threshold'.

Small cells will multiply the complexity and processing required at edge of the network by a factor of at least 10X and the number of backhaul links could increase dramatically as self-organizing 'clusters' and 'meshier' network topologies evolve. New mechanisms are expected to streamline backhaul service activation and pro-actively monitor and manage these networks.

Contact Information

To explore this topic in more detail or to hear how our solutions (Workshops, Presentations, Consulting engagements, annual multi-client services) can support you please contact us www.strategyanalytics.com/solutions.html

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