

3G/4G/5G Small Cell Deployments over HFC

Lindsay Broadband Analysis

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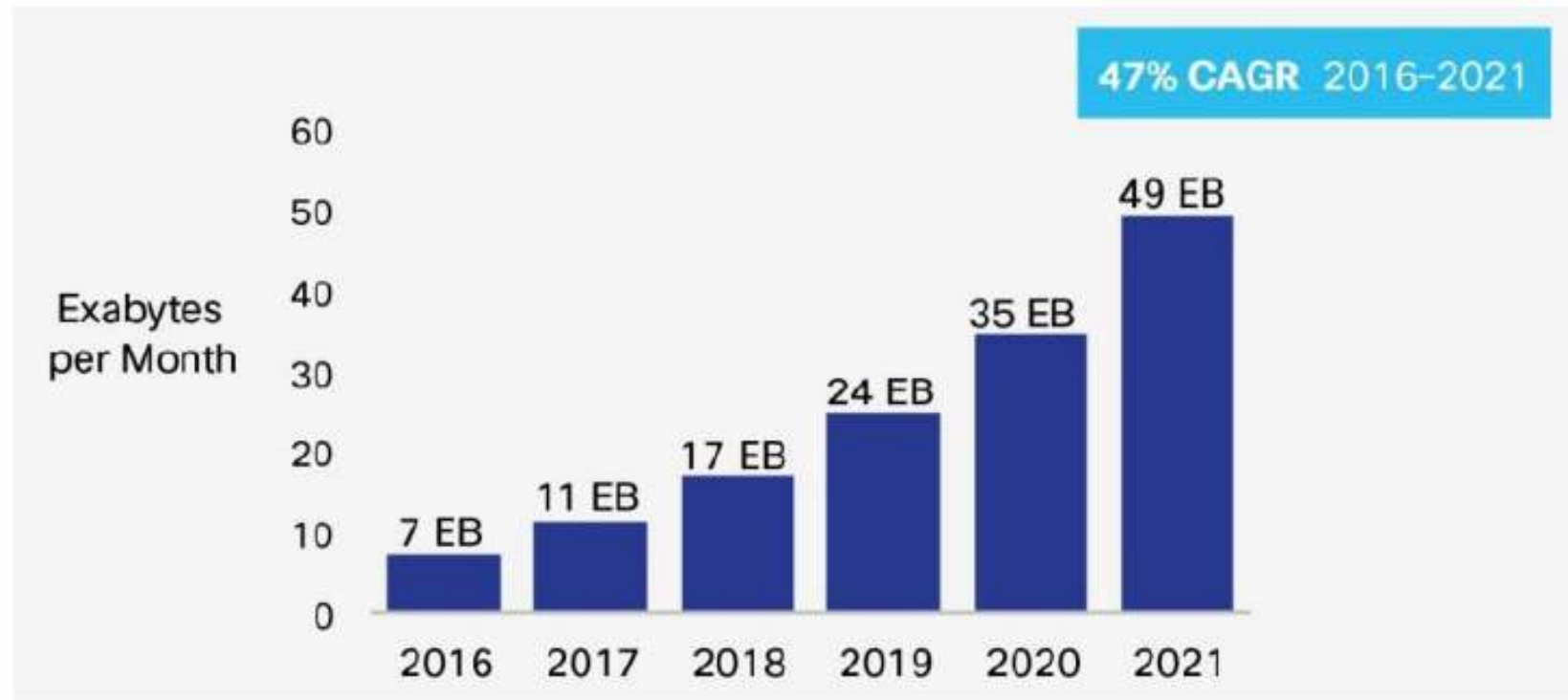
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Introduction

As wireless networks evolve from 4G/LTE to 5G, small cells will play a critical role in delivering the high bandwidth, low-latency connections required by the myriad of potential 5G use cases. With regulators opening up new low, mid & high-band millimeter wave (mmWave) spectrum for 5G, MSOs are uniquely positioned to create ultra-dense 5G wireless networks by leveraging their existing Hybrid Fiber Coax (HFC) networks & emerging technologies such as Full Duplex DOCSIS® (FDX) & Distributed Access Architectures (DAA). Our objective for this presentation is to show how Lindsay's products can enable MSOs to deploy small cells in a rapid & cost effective manner leveraging their existing networks.

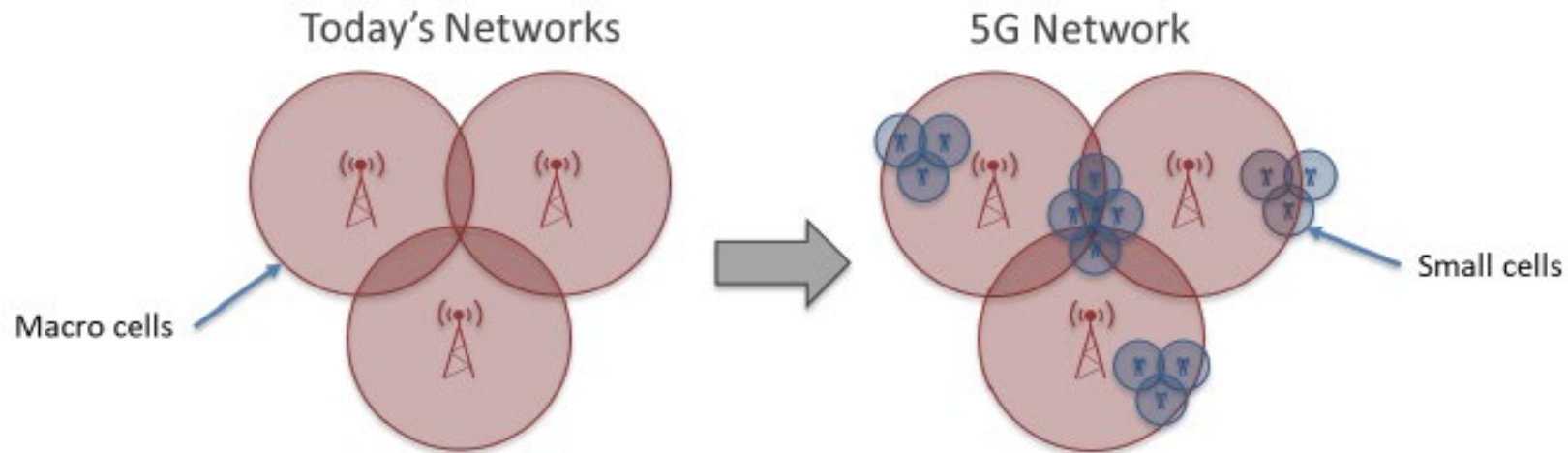
Future 5G Traffic Demand Projections



1 - Global Mobile Data Traffic (Source: Cisco Visual Networking Index 2017)

Network Densification & Small Cells

While 5G opens up a world of new use cases, it also comes with a number of important implications. One that represents both a challenge and an opportunity, particularly for MSOs, is network densification. That is, to realize the higher data rates & area traffic capacities promised by 5G, operators will need to deploy much denser network topologies using small cells. The figure below illustrates the transition that needs to be made from today's networks, which are larger composed of macro cells, to 5G networks of the future with the targeted deployment of small cells.



- Network Densification

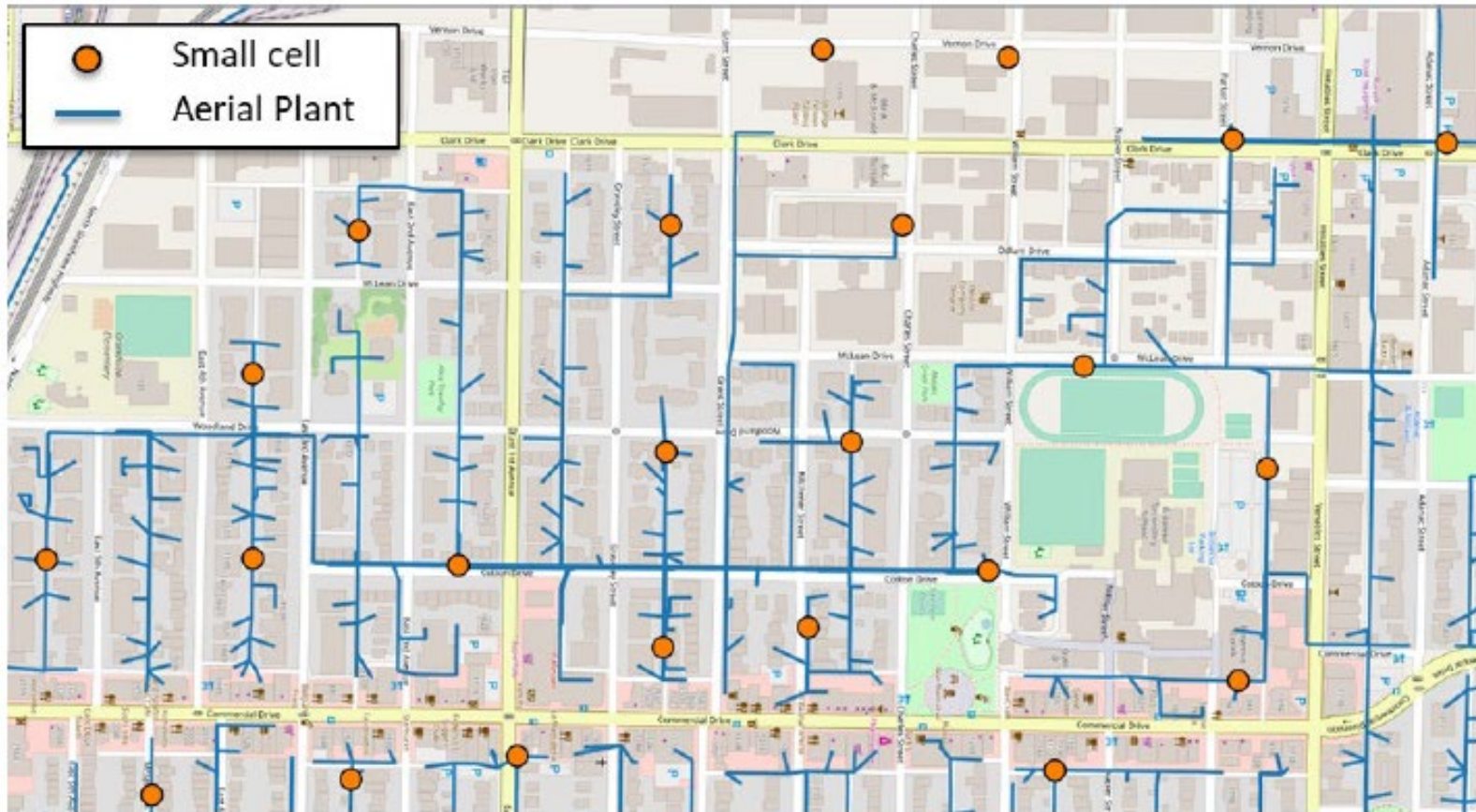
Challenges & Opportunities (Site Acquisition)

There is no doubt site acquisition & everything that implies is by far the biggest challenge MNOs will have to deal with when thinking of high density networks. Government permits, hydro projects & construction of the new site are only a few of the tasks to consider per site. On the contrary, the opportunity for the cable industry is to leverage their existing Wi-Fi® hotspot and/or existing HFC infrastructure to deploy 4G/5G small cells. With access rights to millions of public Wi-Fi hotspots, often in prime “beach front” properties, the cable industry is uniquely positioned to capitalize on this opportunity, either as a wireless player or a wholesale provider to existing MNOs.



Challenges & Opportunities

Overlapping Wireless Needs with Existing HFC Networks



Strand-Mount 4G Small Cell Deployments

Challenges & Opportunities

Backhaul Options (DOCSIS, Fiber, PON)

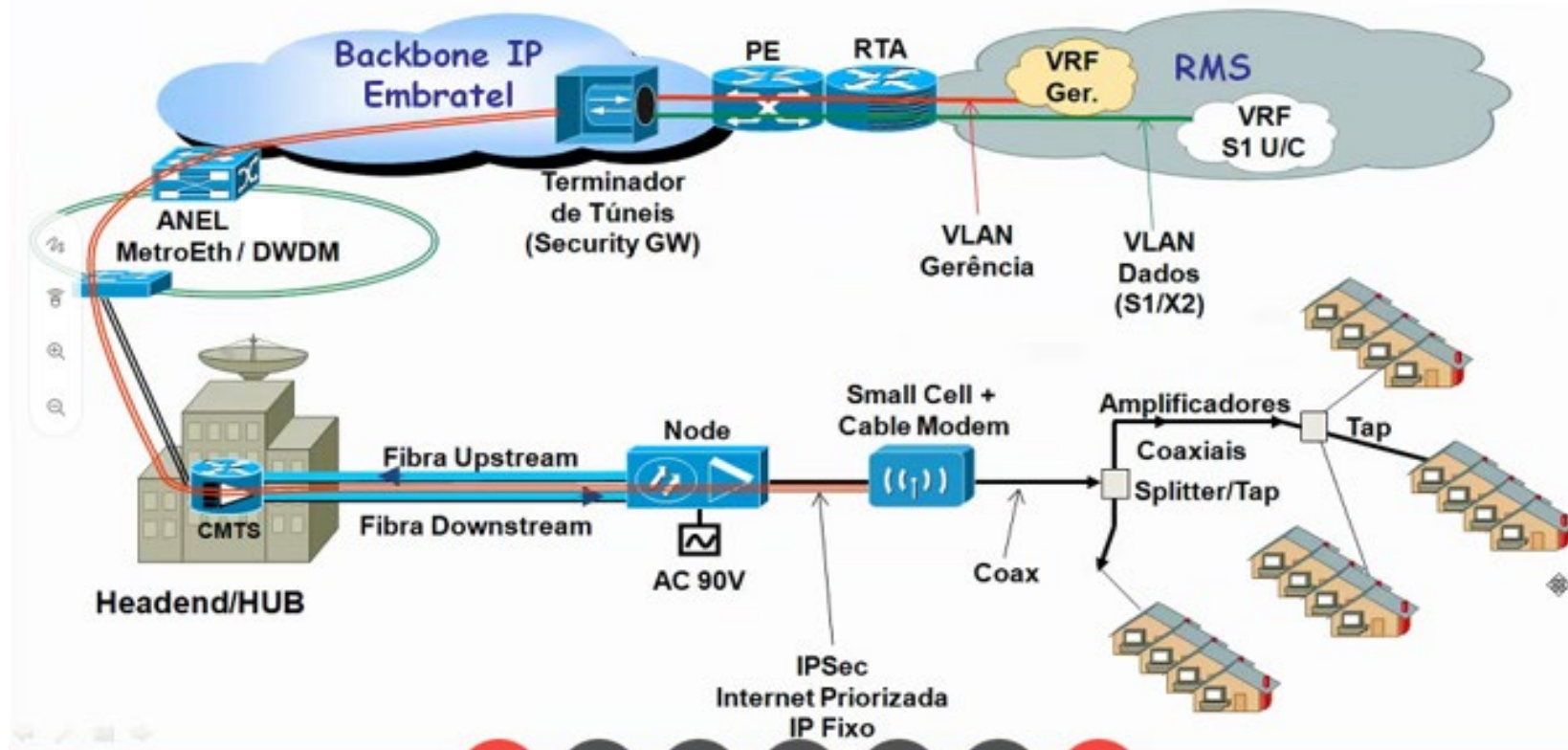


Traditionally in 3G deployments with Macro cells, only fiber optic connections & microwave links are considered. Now with 4G / 5G networks, DOCSIS 3.1 & PON are very reliable options allowing gigabit connectivity. Additionally, aspects such as the complementary traffic peaks of wireless/cable TV networks must be considered. Typically the traffic peaks of the DOCSIS network do not coincide with the traffic peaks of the mobile network

Challenges & Opportunities

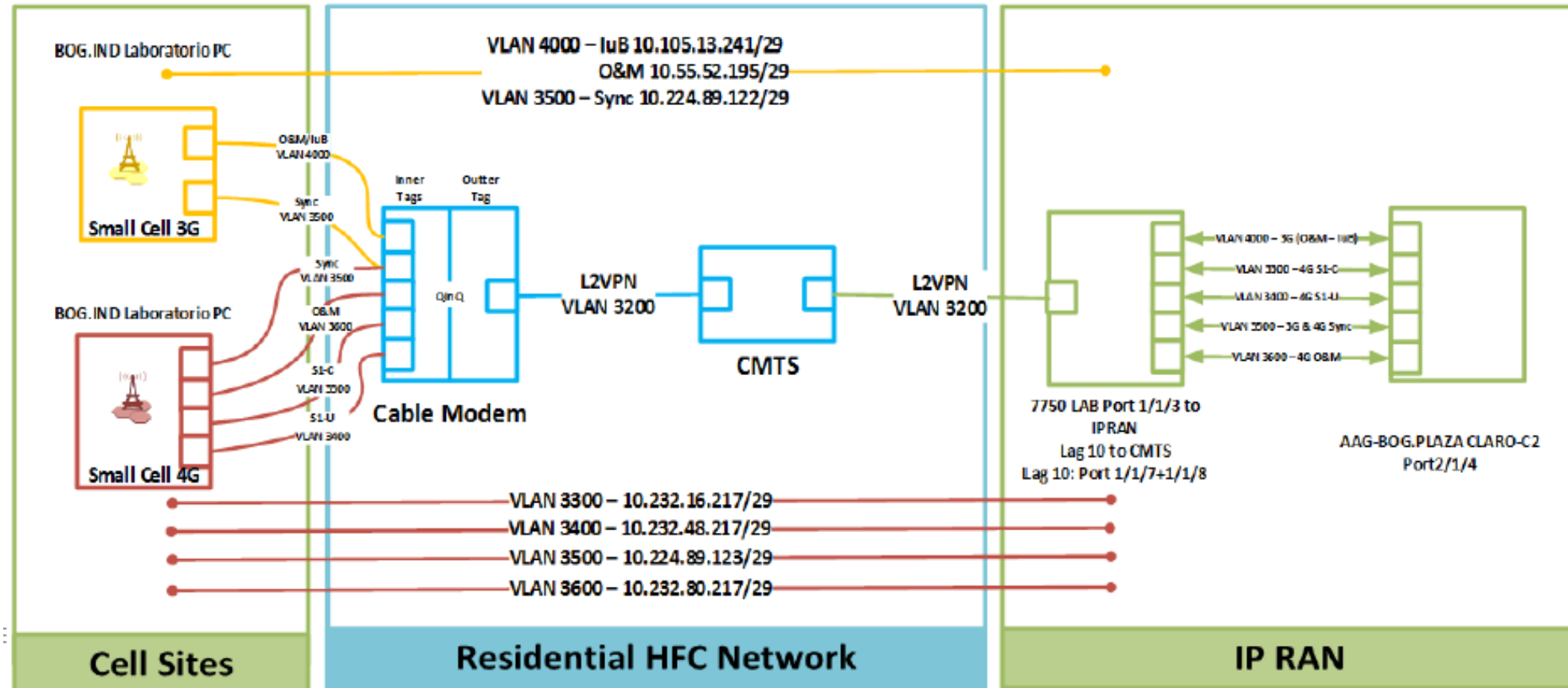
Network Architectures (Ipsec Tunnel)

Small Cell Architecture over HFC



Challenges & Opportunities

Network Architectures (BoDOCSIS)



Challenges & Opportunities

Synchronization (IEEE 1588)

IP Addresses Security IP Interfaces Quality of Service **Timing over Packet** NTP Sync Application Addresses RTT Measurement IP Security IPv4 Routing IPv6 Routing

Frequency synchronization (In use)
Phase synchronization

☒ In use

ToP selection mode: IEEE-1588-2008

Sync message rate: 16 times/second

PTP domain number: 0 [0...255]

Accepted clock classes: 6,7,13,14 [6, 7, 13, 14] ⓘ

Announce message requesting: ☒ From all masters
☐ From active and higher priority masters

Master switching time: 225 s

ToP masters:

Address	Priority 1 [0...255]	Priority 2 [0...255]	
10.229.125.138	0	0	<input type="checkbox"/>
<Enter address>			<input type="checkbox"/>

Status of ToP masters:

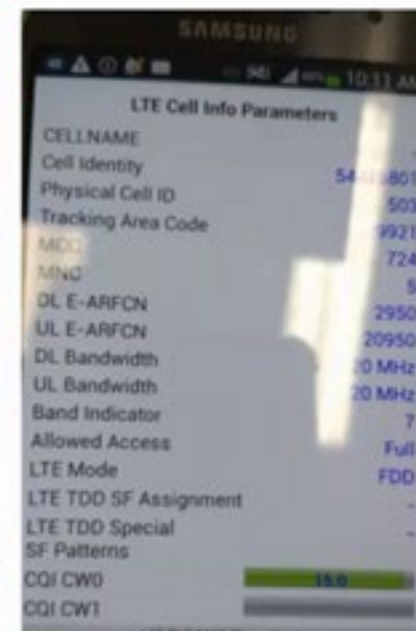
Address	Active master	Clock state	Lock status	Clock quality	Received priority 1	Received priority 2
10.229.125.138	Yes	Accurate	Locked	6	128	128

Real Deployment Metrics

Small Cell Integration Over HFC Backhaul

Test Results – Phase 2A – Lindsay Gateway

Test Case	Results
Attach Procedure	Traces next slides
Latency	79 ms
Throughput	28 Mbps
	9.9 Mbps
Mobility Test	Traces next slides
Web Browsing	Pass
Video Streaming	https://photos.app.goo.gl/QZwbdvNFCe9C6wUL8



DL/UL Throughput is limited by the CMTS Profile (30/10Mbps DL/UL)

Real Deployment Metrics

Small Cell Integration Over HFC Backhaul Test Results – Phase 2A – Lindsay Gateway – Attach Procedure

Attach Request

Default Bearer Established

Destination	Protocol	Length	Tag	e-RAB-ID	qci	Info
10.108.213.129	SLAP/NAS-	168				1d-InitialUEMessage Attach request , PDN connectivity request
10.159.210.18	SLAP/NAS-	100				SACK 1d-downlinkNASTransport
10.108.213.129	SLAP/NAS-	196				SACK 1d-uplinkNASTransport
10.159.210.18	SLAP/NAS-	340				9 1d-InitialContextSetup, InitialContextSetupRequest (DTAP) (TP)
10.108.213.129	SLAP	108		5		SACK 1d-InitialContextSetup, InitialContextSetupResponse
10.108.213.129	SLAP	132				1d-UECapabilityInfoIndicationUECapabilityInformation
10.108.213.129	SLAP/NAS-	132				1d-uplinkNASTransport
10.159.210.18	SLAP/NAS-	120				SACK 1d-downlinkNASTransport
10.159.210.18	SLAP/NAS-	104				1d-downlinkNASTransport
10.108.213.129	SLAP	132				1d-eNBConfigurationTransfer
10.129.213.129	SLAP	132				1d-eNBConfigurationTransfer
10.108.213.129	SLAP	132				1d-eNBConfigurationTransfer
10.129.213.129	SLAP	132				1d-eNBConfigurationTransfer
10.159.210.18	SLAP	64				1d-ErrorIndication
10.159.210.18	SLAP	152				1d-MMEConfigurationTransferId-MMEConfigurationTransfer
10.159.210.18	SLAP	92				1d-MMEConfigurationTransfer
10.159.210.18	SLAP	152				1d-MMEConfigurationTransferId-MMEConfigurationTransfer
10.108.213.129	SLAP	132				1d-eNBConfigurationTransfer

Packet Details:

```
<Open Type Length: 10>
  value
    E-RABSetupItemContextSetup
      <0... .. Extension Bit: False>
      <0... .. Optional Field Bit: False (if-Extensions is NOT present)>
      <0... .. Extension Present Bit: False>
      e-RAB-ID: 5
      <0... .. Extension Present Bit: False>
      <Bit String Length: 32>
      transportLayerAddress: 0a9fd12 [bit length 32, 0000 1010 1001 1111 1101 0010 0001 0010 decimal value 178246162]
      transportLayerAddress(IPv4): 10.159.210.18 (10.159.210.18)
      GTP-TEID: 00000349
```

Attach procedure successfully performed

Real Deployment Metrics

Small Cell Integration Over HFC Backhaul

Test Results – Phase 2A – Lindsay Gateway – Mobility Test

G-NetTrack v9.0

Operator:

MCC:724 MNC:05 TAC:29921
eNB:212800 CELLID:1/503 Type:LTE
RSRP:-53 RSRQ:-6 SNR:16.6 CQI:- RSSI:-63
Longitude:-- Latitude:--
Speed:-- -- Accuracy:GPS off
Height:-- Altitude:-- Ground:0m
UL: 0 kbps DL: 0 kbps
Data: -LTE DATA
Serving time: 1652 sec

Time	LAC	Node	CELLID	Level	Qual	Type	Serv,s
10:11:35	29921	212800	1	-53	-6	4G	4998
11:39:14	34521	2121	60481	-61	-	3G	7
11:39:21	44521	212746	3	-122	-20	4G	70
11:40:36	44521	211812	3	-88	-12	4G	113
11:42:36	29921	212800	1	-114	-10	4G	

Small Cell FlexiZone – PCI 503 / eNB Id 212800

**4G Neighbor Lists Automatically Created
ANR Feature
(Small Cell ↔ Macro eNB's)**

UE Attached to Small Cell 4G

Handover from Small Cell 4G to Macro 3G

Handover from Macro 3G to Macro 4G

Handover from Macro 4G to Macro 4G

Handover Macro 4G to Small Cell 4G

Handovers Successfully Performed From/To Several Layers/Technologies (4G → 3G → 4G → 4G)

4G Neighbor Lists Automatically Created (Small Cell ↔ Macro eNB's)

Lindsay's Gateways (Power Only)

LBPS-250-DC = 250 Watts, 2 Outputs DC

LBPS-250-AC = 250 Watts, 2 Outputs AC

LBPS-400-DC = 400 Watts, 4 Outputs DC

LBPS-250-AC = 400 Watts, 4 Outputs AC



Lindsay's Gateways (Power & DOCSIS)

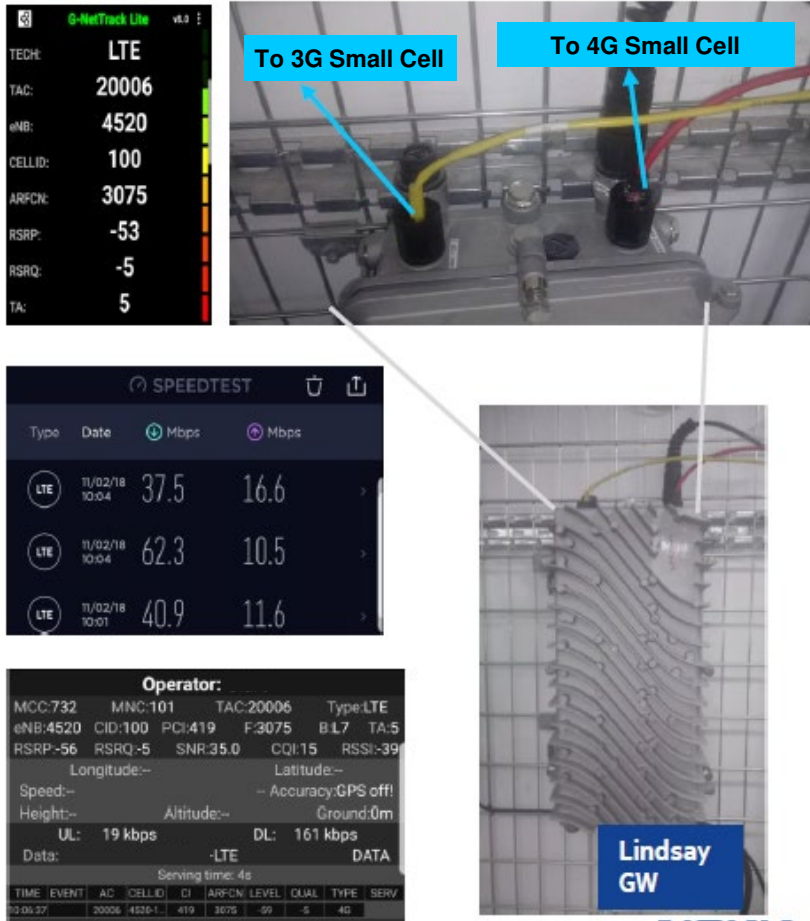
LBDG-250-DC = 250 Watts, 1 Output DC + 1 GigE Port

LBDG-250-AC = 250 Watts, 1 Output AC + 1 GigE Port

LBDG-400-AC-2 = 400 Watts, 2 Output AC + 2 GigE Ports

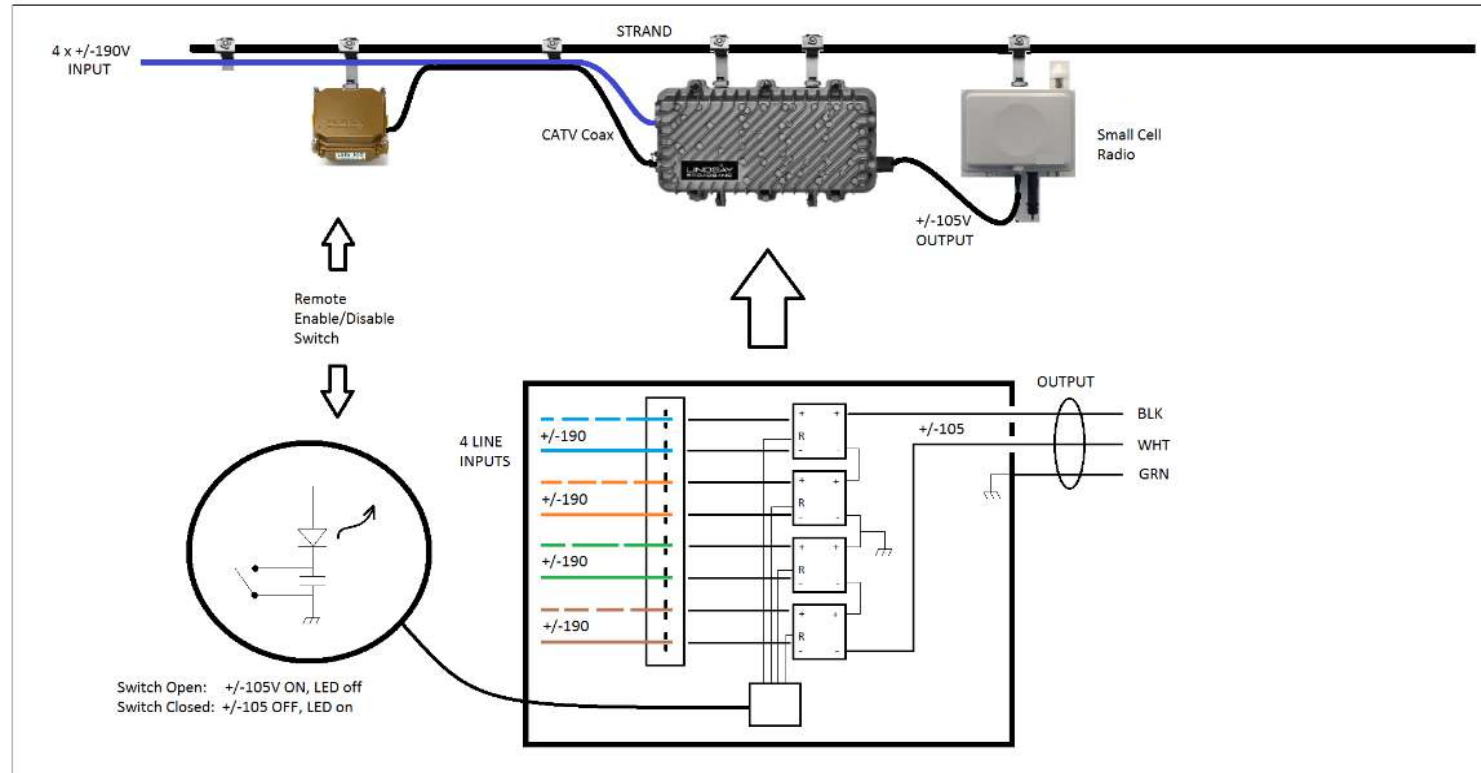


Lindsay's Gateways (Power & DOCSIS)



Pictures show a Lindsay Gateway LBDG-400-AC-2 in a lab environment being used to power & backhaul 3G & 4G Nokia small cells. The gateway integrates a DOCSIS 3.1 cable modem enabling enough bandwidth for both radios to operate simultaneously. BoDOCSIS implements 6 VLANs for different traffic segmentation.

New Powering Options over Twisted Pairs



Lindsay recently developed a new family of gateways to power small cells leveraging twisted pair networks. This new gateway takes +/- 190 VDC (380 VDC) already present on most twisted pair networks & turns it into +/- 110 VDC (220 VDC).

New Powering Options over Twisted Pairs



Pictures show a Lindsay 4TP-PSU deployment powering small cell radios. The backhaul of the cell is handled via fiber optics.

Thank you

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