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White Paper

4.5G Backhaul Transformation

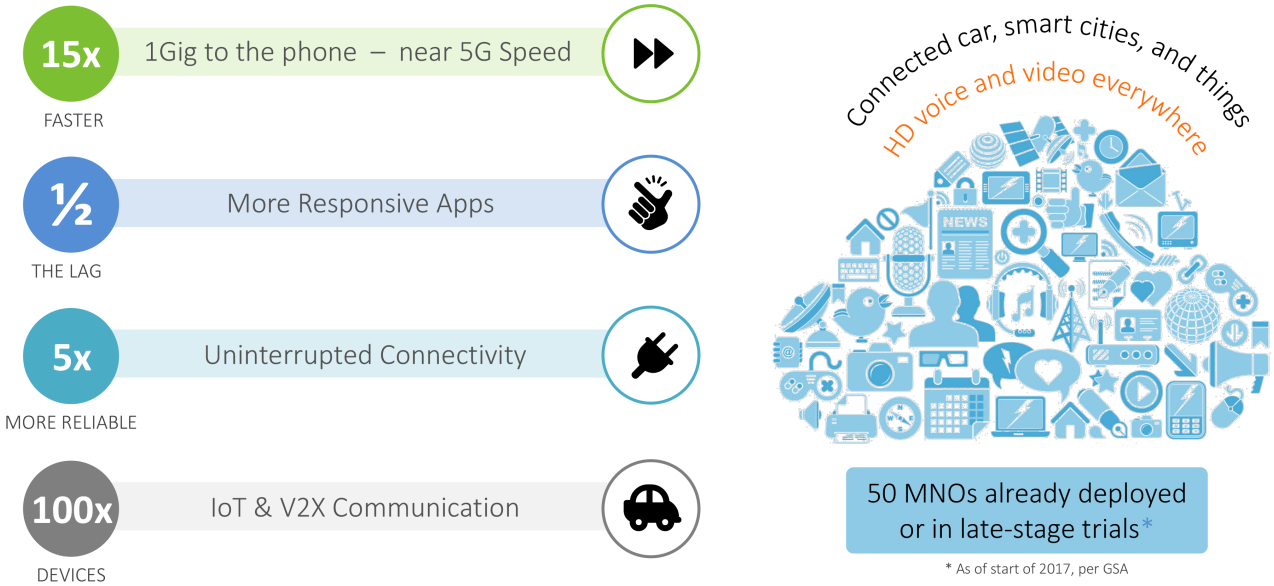
Connecting and assuring the next mobile network transition

Organizations like the GSMA, 3GPP, and NGMN hope to get to 5G commercial viability by 2020. However, a complete 5G deployment is complex, and involves full virtualization of the network, implementation of network slicing, and closed-loop feedback using machine learning. In the meantime, 4.5G has emerged as a short-term, relatively straightforward way to bring many of 5G's benefits to subscribers, well before 5G's business case can be agreed upon.

4.5G brings dramatic increases in speed and offers strong competitive differentiation—but doesn't require the full complexity of 5G's multi-access edge computing and virtualized RAN and core. Deployment of 4.5G—also referred to variously as Gigabit LTE, 4GX, or 4G+—is well underway by operators and vendors. Essentially, it's a radio upgrade: a way to get more juice out of existing mobile spectrum.

Unofficially (and not endorsed by the 3GPP), 4.5G is the consumer-oriented marketing term for LTE-Advanced Pro, as defined by 3GPP release 13 (current) and release 14 (coming). In addition to 'faster LTE,' 4.5G also introduces the first standardized IoT protocols including LTE-M (machine-to-machine/M2M) and a 50% reduction in latency to handsets.

4.5G ● GIGABIT LTE ARRIVES



Compared with the vision for 5G, 4.5G introduces significant, but still incremental, improvements to data speeds and connection reliability.

As of June 2016, almost 50 operators globally had trialled, deployed, or commercially launched LTE-A Pro technologies (source: Global mobile Suppliers Association/GSA). At that time, commercial services were available in Australia (Telstra), South Korea (SK Telecom), Thailand (AIS, True) and Turkey (Turkcell, Turk Telecom, Vodafone), benefitting users with:

- Better network coverage, few cell-edge effects
- HD Voice and video "everywhere"
- Gigabit mobile broadband
- IoT (connected car, smart cities, etc.)

4.5G, The Next Step Toward 5G

How will the success of 4.5 and 5G be measured? The chart below shows key performance indicators (KPIs) likely to be the yardstick for these next generation of services (traffic density, throughput, latency, reliability) along with some of the proposed specific numbers associated with them. Corresponding KPIs for 4.5G provide context for how significant 5G is expected to be, and how mobile networks will get there.

At present, even deploying 4.5G networks and managing the services they support—which require a new level of flexibility, both in terms of relationships between infrastructure owners and service providers, and the architecture involved—can be quite challenging. For example, it takes a carefully thought-out strategy to create 4.5G networks that are cost efficient (with low total cost of ownership/TCO) to maintain even in low-ARPU areas, and to deploy sufficiently flexible architecture that's energy efficient and easily upgradable.

THE 4.5G BOOST ON THE PATH TO 5G

		4G	4.5G	5G
		LTE • 3GPP Rel 11	LTE-A Pro • Rel 13/14	Rel 15
Traffic Density	Mbps/km^2	-	100 x	1000 x
Throughput [Mbps]	Peak	75	1000	3000
	Typical	20	300	1000
	Change	-	15 x	50 x
Latency	Round Trip	12 ms	5 ms	1 ms
	Change	-	2.4 x	12 x
Reliability	Availability	95%	99.9%	99.99%
	Downtime	4320 sec/day	860 sec/day	< 8 sec/day
	Change	-	5 x	550 x

While it doesn't deliver the significant, revolutionary service performance of 5G, 4.5G nonetheless represents an important boost on the way to the next generation of mobile communications.

What it Takes to Deliver 4.5G

Enhancements afforded by LTE-A and LTE-A Pro are realized through improved spectral efficiency (RAN upgrades) and support for unlicensed spectrum and Wi-Fi aggregation to augment bandwidth. Technically, neither LTE-A or LTE-A Pro require any form of virtualization or software-defined networking (SDN), or new radio spectrum. However, in practice, implementing the standards does require some virtualization applied to RAN, radio network controller (RNC), EPC, and cloud-RAN (C-RAN).

4.5G • WHAT'S NEW?

LTE-A and LTA-A Pro Are "Lightweight" Compared With 5G

- Enhancements realized through greatly improved spectral efficiency: RAN upgrades
- Support for unlicensed spectrum and Wi-Fi aggregation further augments bandwidth.

	Dual Connectivity (CoMP)	3D Beam Forming (via MIMO)	Carrier Aggregation (CA)	Unlicensed Bands (LAA)	Proximity Services (ProSe)	New Spectrum (e.g mmWave)	Requires SDN, MEC, NFV
5G	✓	✓	12	✓	✓	✓	✓
4.5G	✓	✓	5	✓	✓		

Required for Ultra-Low Latency, High Availability Apps and Network Slicing

5G is the first non-cellular mobile architecture

5G will take mobile communications in a new direction, away from traditional cellular architecture; ultra-low latency, high availability apps, and network slicing demands a different approach.

5G will take this to a whole different level by adding new spectrum, SDN, mobile edge computing (MEC), and network functions virtualization (NFV). Even as they are in the midst of 4.5G development, operators are now beginning to invest in higher frequency spectrum (e.g. sub-6GHz and millimeter wave/mmWave+), massive multiple-input/multiple-output (MIMO) radios, and other technologies that cannot be used for 4.5G but are required for 5G.

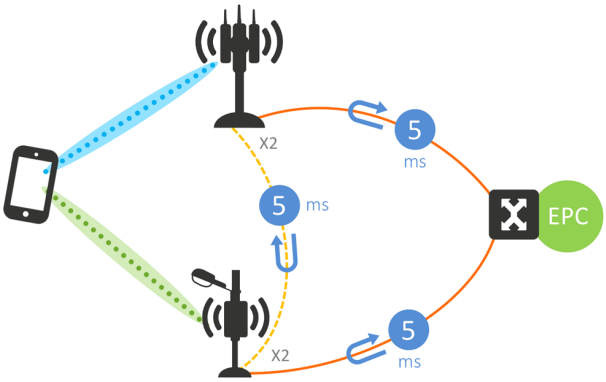
Shortcuts to Lower Latency

Broadly speaking, 4.5G backhaul means 10 times faster connectivity with latency cut in half, achieved through direct inter-tower communications for 5ms or less round-trip time. Going from evolved packet core (EPC) to tower and back in 5ms or less means 2.5ms each way, leaving no margin for processing delays at the EPC. Instead, service level agreements (SLAs) target 2ms each way for a 20% margin. Therefore, shortcuts—new direct connections—between towers will often be necessary to meet performance targets.

Another implication of 4.5G latency requirements is that these connections can no longer be effectively measured using router-based methods, which aren't accurate enough. Instead, virtualized instrumentation or network interface devices (NIDs) are required. We discuss measurement solutions a bit further along in this paper.

Meeting 4.5G latency requirements involves inter-tower connectivity.

4.5G BACKHAUL



Inter-tower latency requirements mean that new, direct 'shortcut' connections may be required.

Otherwise existing links need to achieve ~1ms one-way latency.

10x FASTER — 10 Gig to the Tower

½ THE LATENCY — 2ms One-Way Delay SLAs

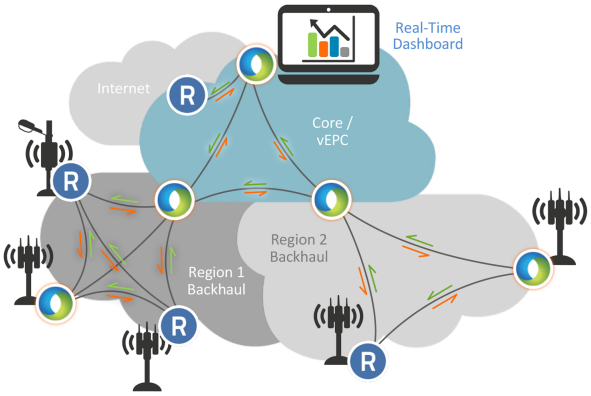
2x MORE LINKS — Inter-Tower Connect (X2)

Double the Links

As backhaul demand increases by 10-fold, the impact is significant for mobile network operators (MNOs). Think of it this way: instead of 30Mbps to each handset, you now have 300Mpbs! In a typical mobile network at peak traffic periods, GbE links to cell sites are already approaching 60% utilization. The logical conclusion is that, to keep up, operators must move to 10GbE connectivity. This is a big opportunity for wholesale access providers, and requires MNOs to invest in new cell site equipment.

As touched on already, direct Layer 2 or Layer 3 connections between towers therefore become important—as cell sites communicate with each other, coordinating transmission to mobile devices. This effectively doubles the number of logical backhaul connections, and doubles the complexity involved in managing backhaul networks; all of those links—logical and physical— must be performance monitored to ensure they meet stricter SLAs. Again, that is only possible using virtualized instrumentation or NIDs to test between sites.

4.5G BACKHAUL PERFORMANCE MONITORING



Industry's most comprehensive 1-way metrics, including microsecond-level 1-way latency

NFV test points – offer hub-and-spoke and inter-tower (full mesh) monitoring

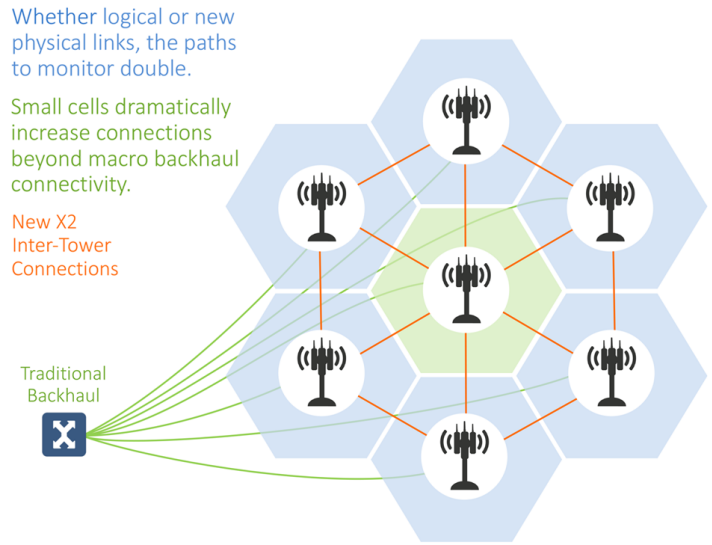
Standards-based test reflectors in network elements

Requirements:

- < 2µs precision to monitor 2ms one-way SLAs
- Tower-to-tower testing vs. hub-and-spoke
- 10Gbps service activation test (SAT) capabilities
- 10Gbps line rates for inline solutions
- Double the scalability required vs. LTE

Accedian's SkyLIGHT VCX controller and ant Modules provides the distributed, precise, comprehensive performance monitoring capabilities needed to assure 4.5G services.

X2 • DOUBLING BACKHAUL LINKS



Inter-tower communications and the use of small cells for additional bandwidth and coverage double the number of backhaul links to monitor.

Performance Monitoring: The Next Generation

The increased complexity of 4.5G networks brings some specific requirements that render traditional, reactive, passive monitoring insufficient. Of most relevance to the discussion here:

- High precision measurements—less than 20 microseconds (µ) for 2ms one-way SLAs
- The ability to precisely test between towers rather than hub-and-spoke at the EPC

While the required precision is challenging, the need to test between sites is a show-stopper for centralized monitoring solutions that work fine in hub-and-spoke configurations, but have no way to generate test traffic between sites. The NFV-performance monitoring capabilities offered by Accedian's SkyLIGHT VCX (NFV-based performance assurance controller) paired with 10GbE ant Modules fill in this new visibility gap by allowing accurate testing over the X2 tower-to-tower interface. As a virtualized, software solution, SkyLIGHT VCX can be deployed on a hosted cloud resources or on a commercial off-the-shelf server. Accedian ant Modules can be installed at any network location where local wire-speed processing is required to perform accurate testing, at a fraction of the cost of a 10GbE NID.

This elegant, efficient solution makes possible the automated control, performance optimization, and predictive network analytics needed for large-scale 4.5G deployments.