

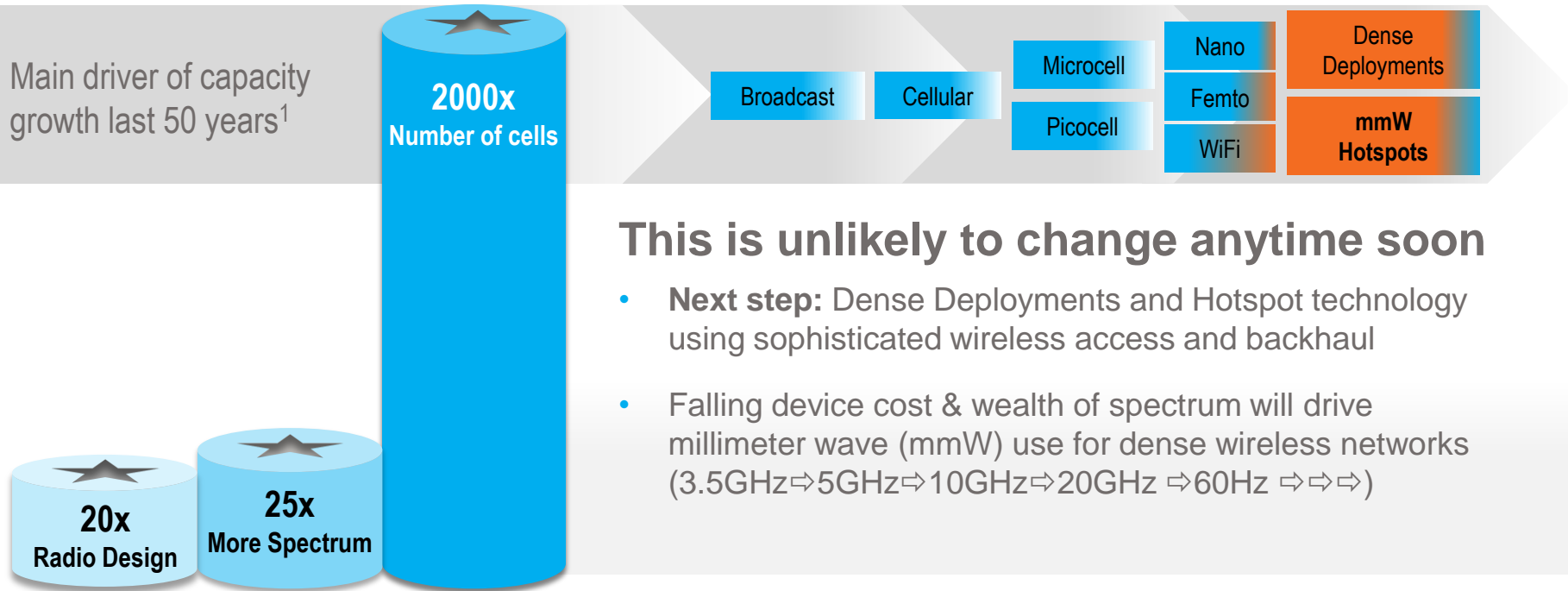
5G Millimeter Wave Hotspots

MWC 2013

The Relentless Move To Small & Smaller Cell Solutions

It has always been about making the network more efficient

Main driver of capacity growth last 50 years¹



This is unlikely to change anytime soon

- **Next step:** Dense Deployments and Hotspot technology using sophisticated wireless access and backhaul
- Falling device cost & wealth of spectrum will drive millimeter wave (mmW) use for dense wireless networks (3.5GHz⇒5GHz⇒10GHz⇒20GHz ⇒60Hz ⇒⇒⇒)

All driving us to a world of ubiquitous connectivity

¹ Source: Agilent, 2008 (Coopers Law)

The Bandwidth Crunch – Small cells are only part of the solution

A Conjecture on year 2020 spectrum requirements...

	Average Speeds ¹	Population Density	Devices/ Person	Busy Hour	Required Area Capacity
2013	0.8Mbps	x 4984/km ²	x 1.20	x 15%	0.71Gbps/km ²
2016	2.9Mbps	x 5191/km ²	x 1.40	x 20%	4.2Gbps/km ²
2020	30Mbps	x 5477/km ²	x 1.70	x 25%	69.8Gbps/km ²

Assuming only the performance of LTE-A today¹ at 500m cell size

- In 2016 we might need 317MHz of spectrum
- **By 2020 we might need more than 5GHz!**
- ***Only mmW bands can support this demand***



Smaller Cells sounds simple, but what about spectrum for backhaul?
Small Cell Interference problems?

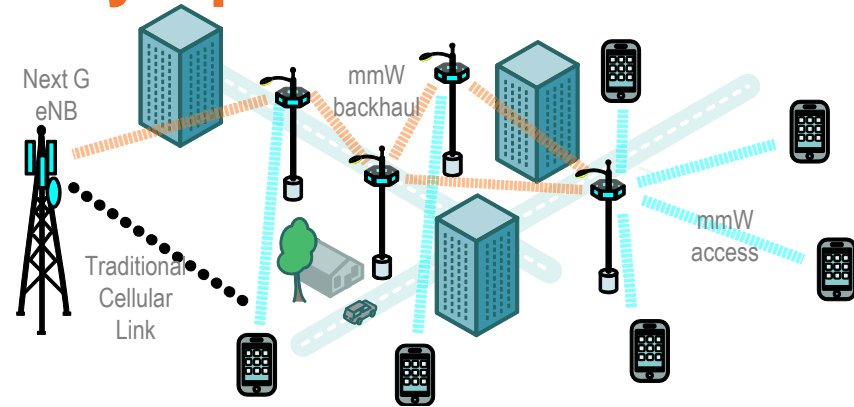
¹Cisco VNI 2012 ² 3GPP TR 36.913 (Microcellular model: 2.6b/s/Hz/Cell, ISD=500m, 4x2MIMO) – Assumes perfect trunking efficiencies

Small Cells meet High Frequency Spectrum

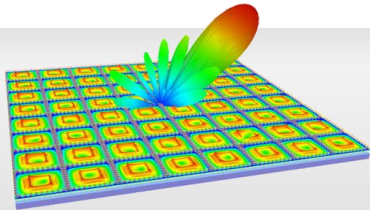
mmWave Hotspots (mmH)

Higher frequency backhaul and access solutions to solve the future wireless capacity problem

- 500X capacity growth by 2020!



Leverage mmW radios which are becoming commercially available



Enable wireless backhaul

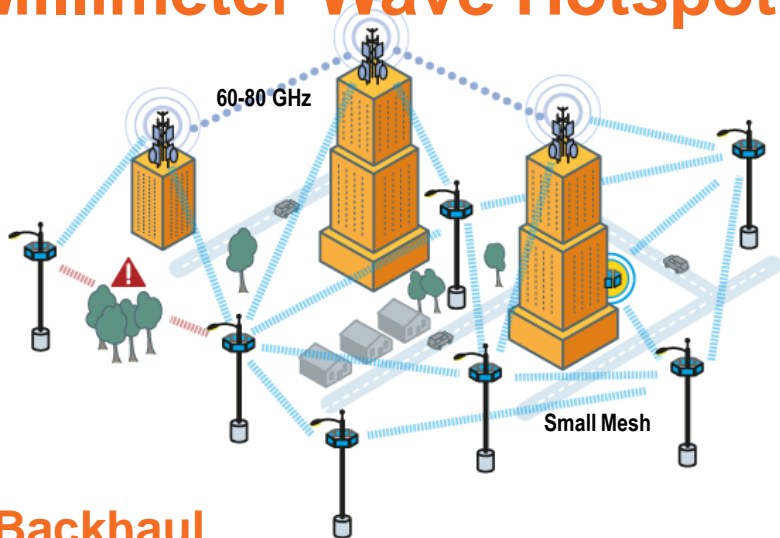
Extend mmW MAC/PHY and add directional mesh networking to provide high capacity, low cost backhaul solution

Extend support to Access links and integrate with 3GPP

Adapt 3GPP RAN Architecture to support multi-RAT mmW

Full mmH Architecture

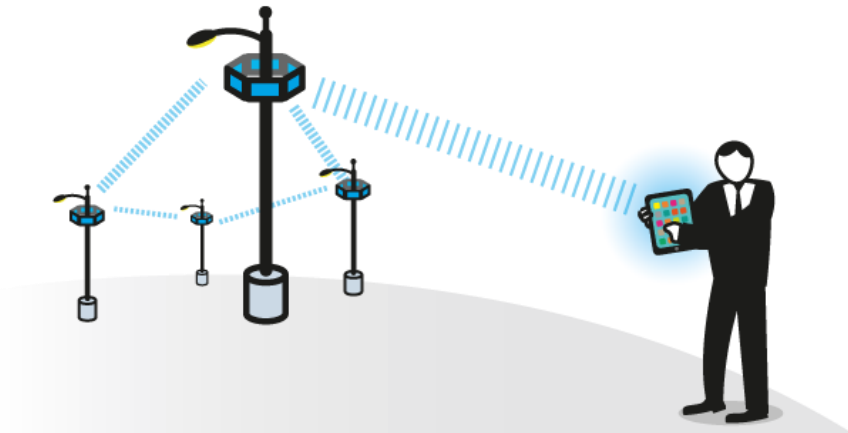
Millimeter Wave Hotspot Use Cases



Backhaul

- Backhaul is a top priority for small cell deployments
 - 80% of small cells will have wireless backhaul
 - Cost of fiber is ~4x greater than wireless (cumulative CAPEX/OPEX)
- Small Cell mesh inter-connectivity over ~150m
 - Large indoor and outdoor public spaces

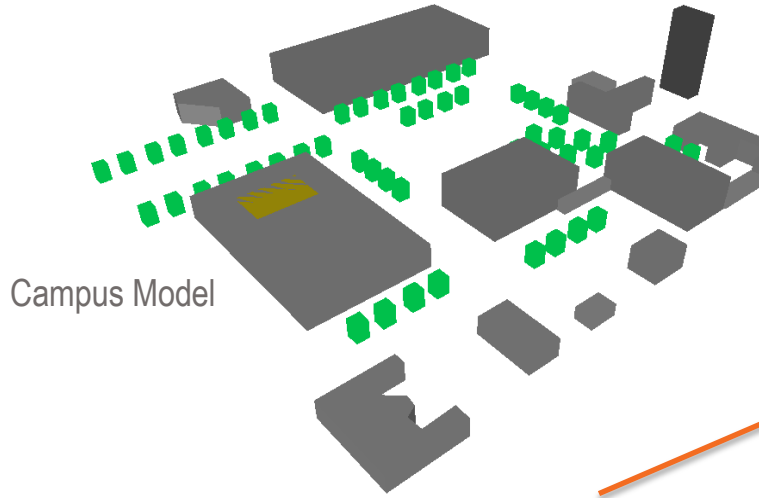
¹ABI reports that by 2017 80% of all small cells will have a wireless backhaul solution



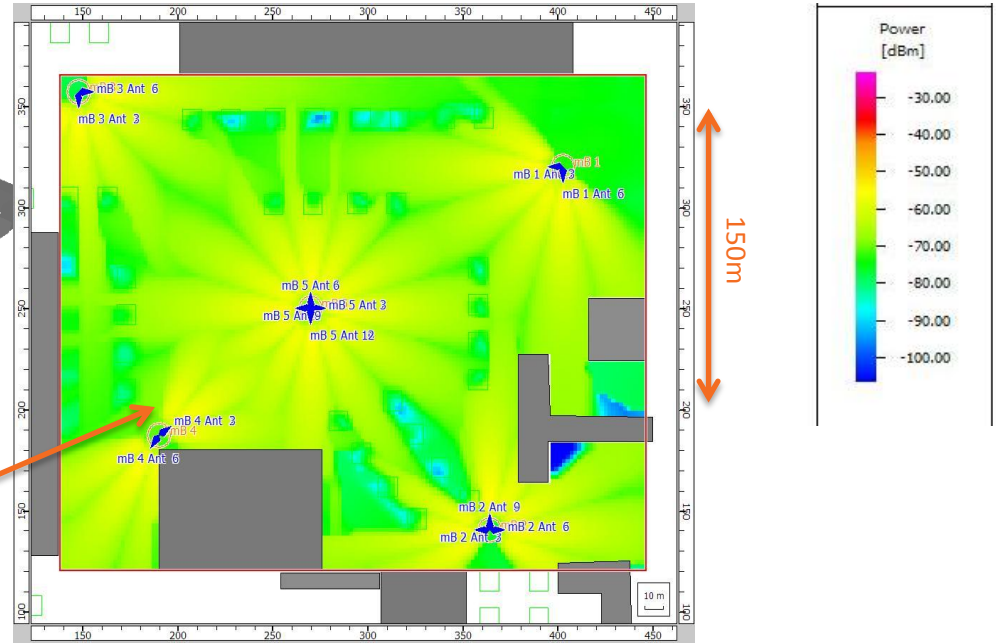
Access

- Access link capacity needs to grow to support 80% CAGR in data demand
- Radio integration into devices has already begun, enabling mmW bands for small cell access
 - Initially for cable replacement in 2013, longer term for access
 - By 2016, mmW will be in 1/3 of 802.11 shipments¹

100x over today's small cell capacity, yielding 50Gbps/km²



Ray tracing software computes power, delay, and AoA information for each grid point



- Goal of 50 Gbps/km² can be met, with excess capacity useable for wireless backhaul
- 90% coverage demonstrated in most scenarios (Campus and Urban models)
- 150m inter-site distances is reasonable