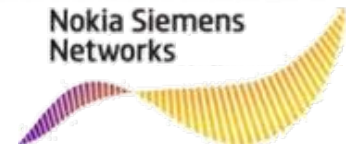# Dense RAN: Handling Interference in a Dense City Environment

GTI workshop, Tokyo

Dr. Phil Fleming, Head of Radio Technology & Engineering

NSN Concepts for High Density City Environment

Stadiums are challenging venues that test wireless data systems

The solutions depend on the penetration of smartphones and the density of the crowd

- Light to medium ➡ Add more macrocell capacity
- Medium to heavy ➡ Macros and picocell clusters over ethernet
- Heavy++ load ➡ Dense RAN using Macros/picos and PicoRRH over fiber w/BB pooling to eliminate the cell edge
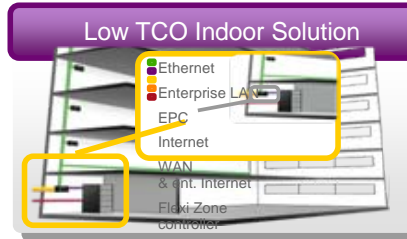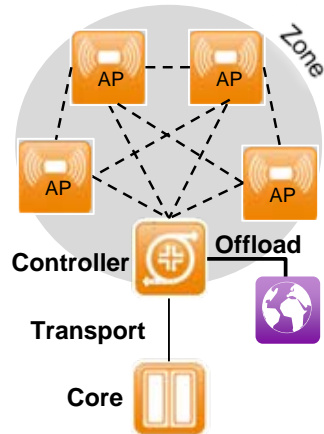
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Spectrum of Architectures
to Supplement Macrocells and *Eliminate the Cell Edge*

Flexi Zone AP 6

FZ AP 1 NLOS · FZ AP 2 NLOS · FZ AP 8 NLOS · FZ AP 7 NLOS · FZ AP 1 NLOS · FZ AP 1 NLOS

Looking SW from Macro antenna on 200N

IP Backhaul;
Delay Tolerant >10ms
Including Wireless

AP-Cluster 12-15

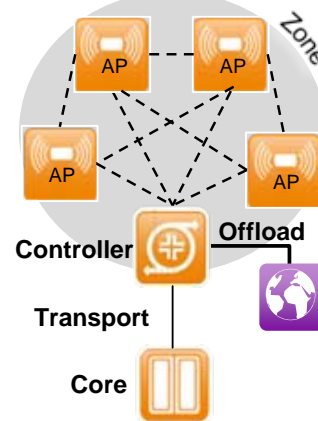**Low TCO Indoor Solution**

Ethernet
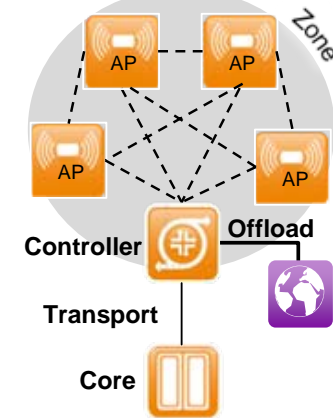Enterprise LAN
EPC
Internet
WAN & ent. Internet
Flexi Zone controller

IP Backhaul;
In-building/Enterprise
Wiring, Network
(CAT5, Switching/Routing)
Latency ~10ms

Fiber-Interconnect
Dense AP/RRH
<1ms latency

Urban Street

Zone

AP — AP
AP — AP

Controller · Offload
Transport
Core

Indoor

Zone

AP — AP
AP — AP

Controller · Offload
Transport
Core

Dense RAN

Zone

AP — AP
AP — AP

Controller · Offload
Transport
Core

increasing user density

DistributedScheduler Packet-based Coordination

Centralized scheduler Joint Receiver/Transmitter

Ethernet/Wireless BH + picoAP
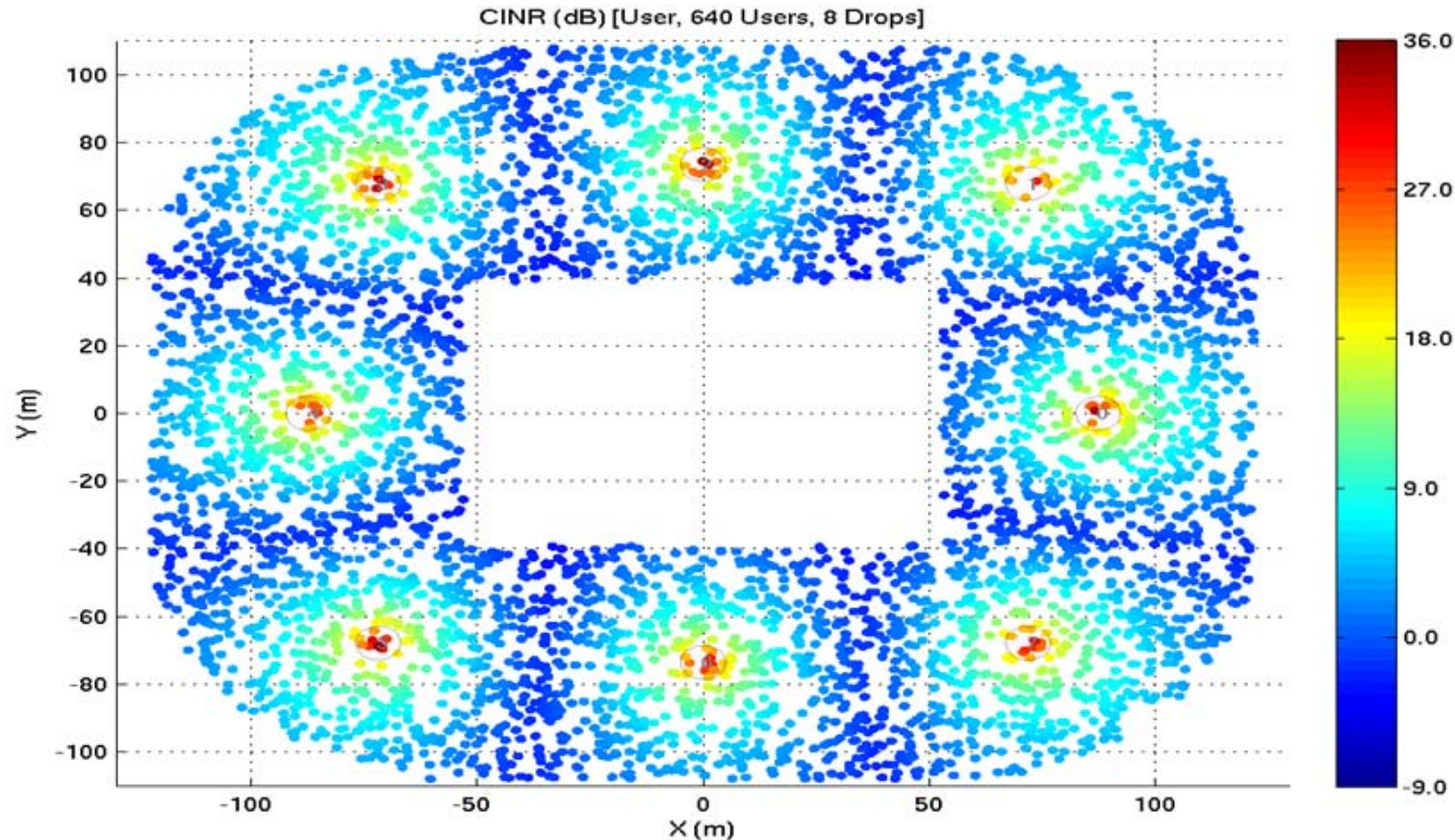
Fiber + picoRRH

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Dense RAN solutions

- Stadiums have the densest population of smart phones in the world
- Up to 100,000 fans sending videos to friends and watching highlights on *Youtube*
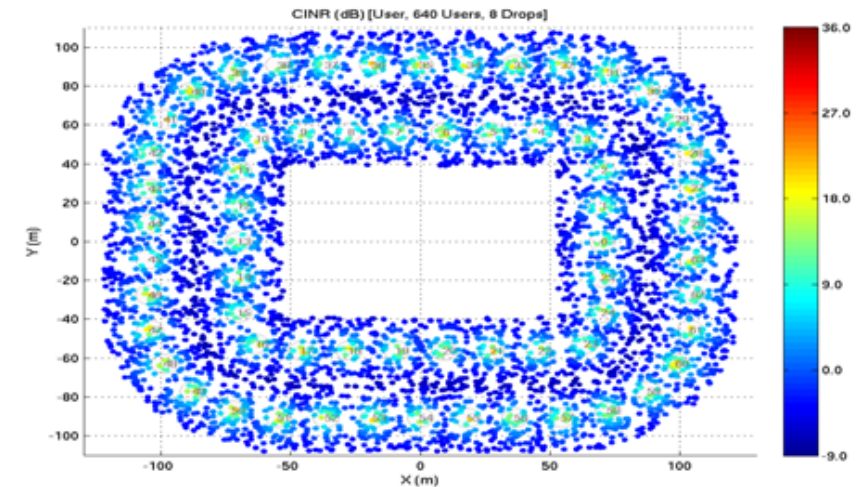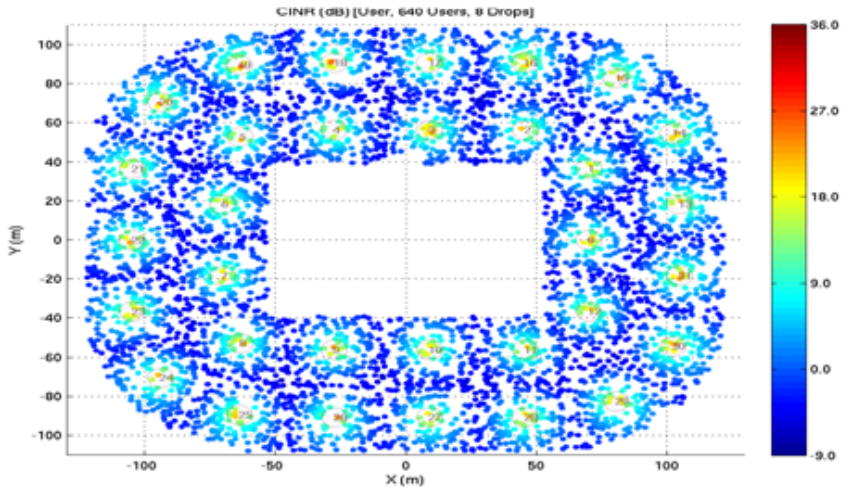- Many small (unobtrusive) low power cells over fiber or Ethernet
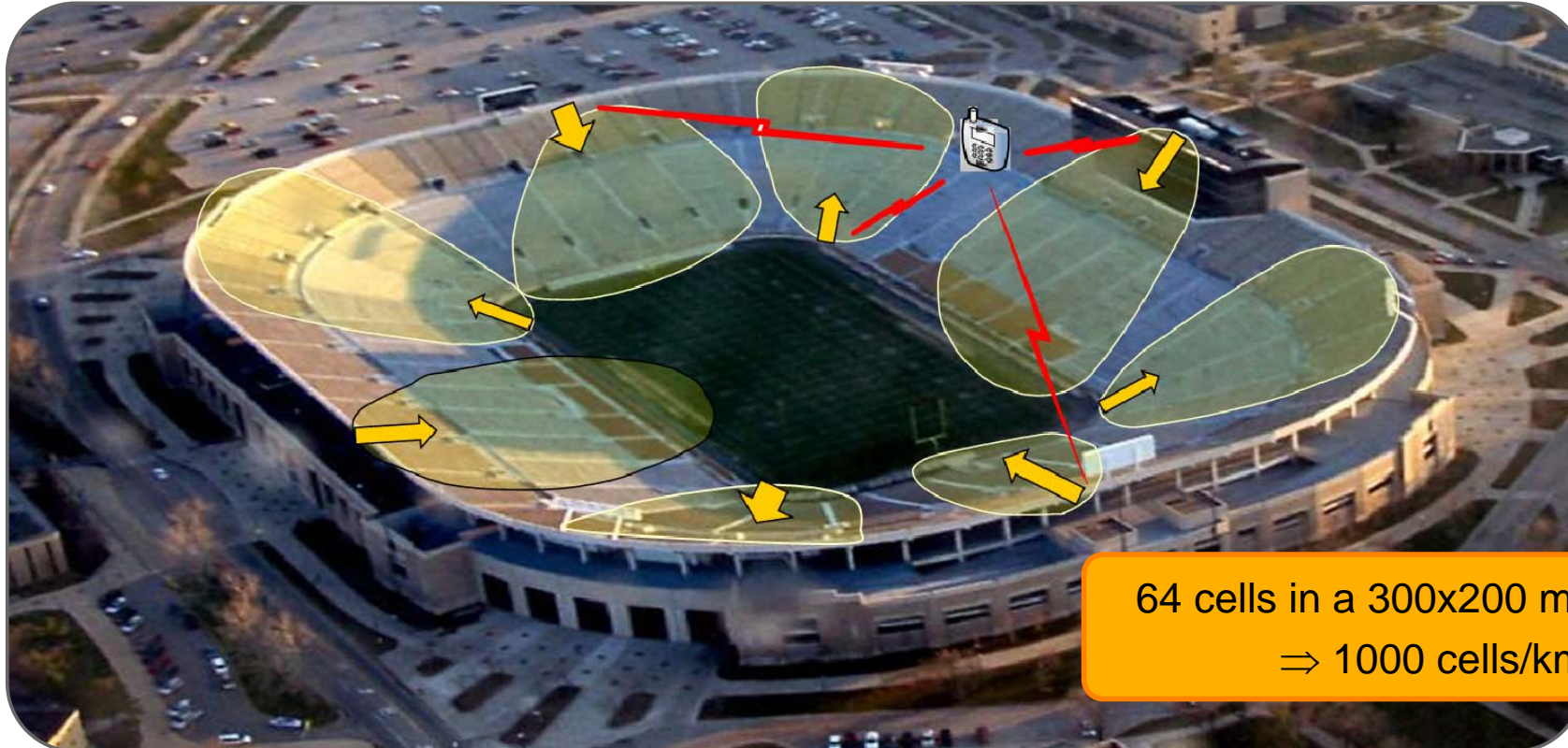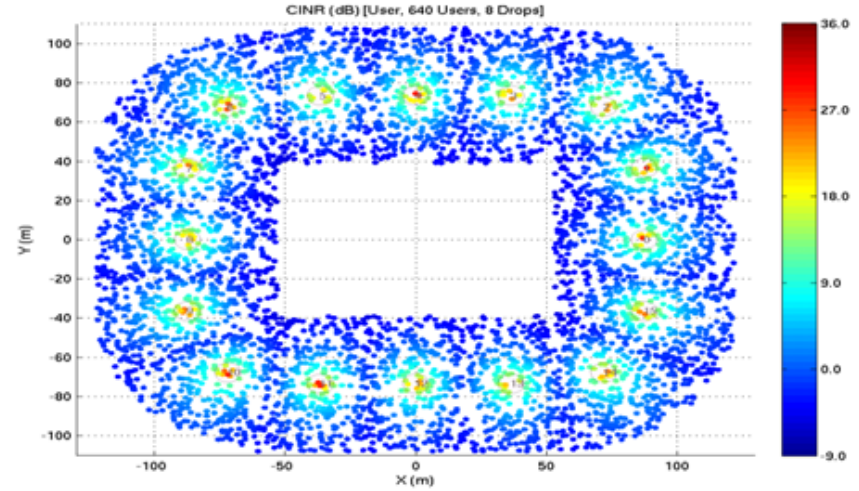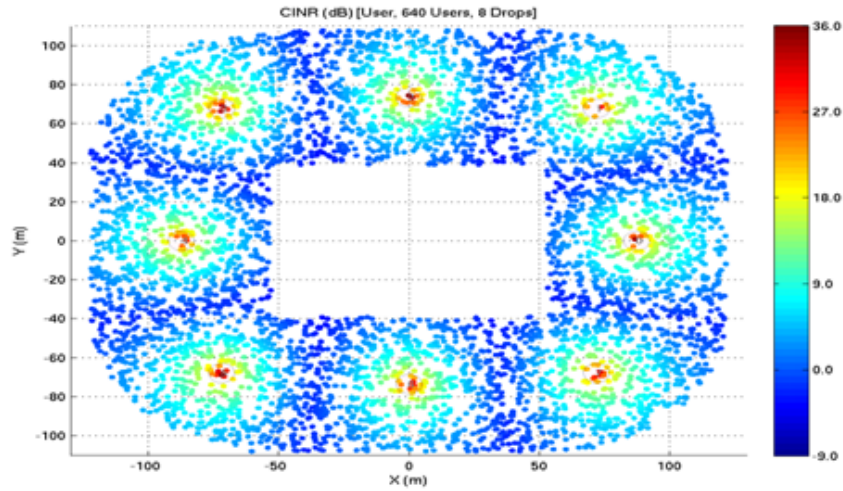

64 cells in a 300x200 m^2 stadium
$\Rightarrow$ 1000 cells/km^2!

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The user's signal quality degrades as more cells are added to the stadium
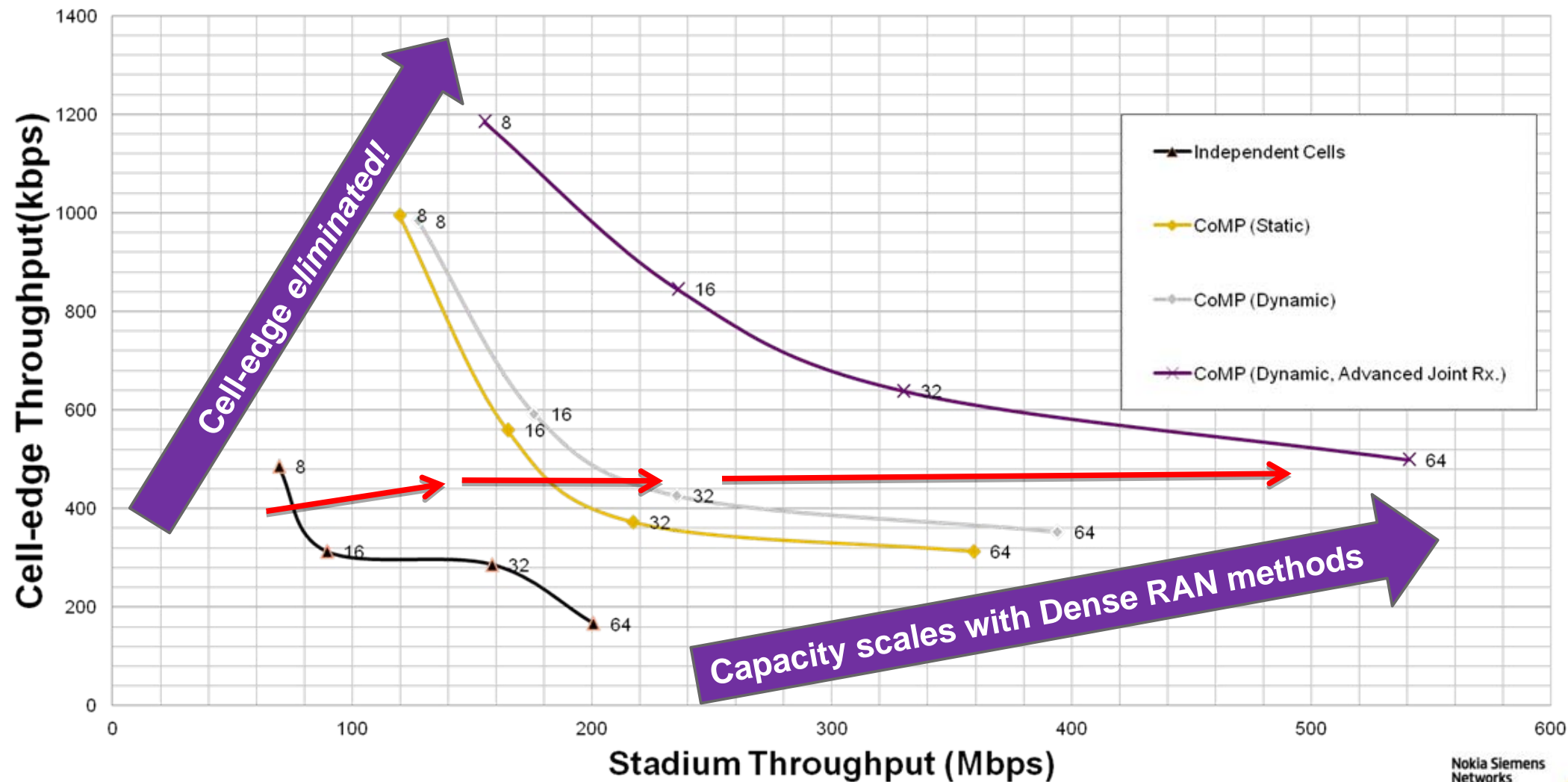

CINR (dB) [User, 640 Users, 8 Drops]

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The user's signal quality degrades as more cells are added to the stadium

The *Interference Dimensionality* Problem

Stadium capacity increases with more cells *but not proportionally*

Dense user population
⇒ Dense cells
⇒ More interference and
⇒ More interferers!
⇒ Higher *Interference Dimension*

20 MHz TD-LTE
■ Stadium [Mbps]
■ Cell edge [kbps]

Cell edge throughput *decreases* with more cells

8 cells   16 cells   32 cells   64 cells

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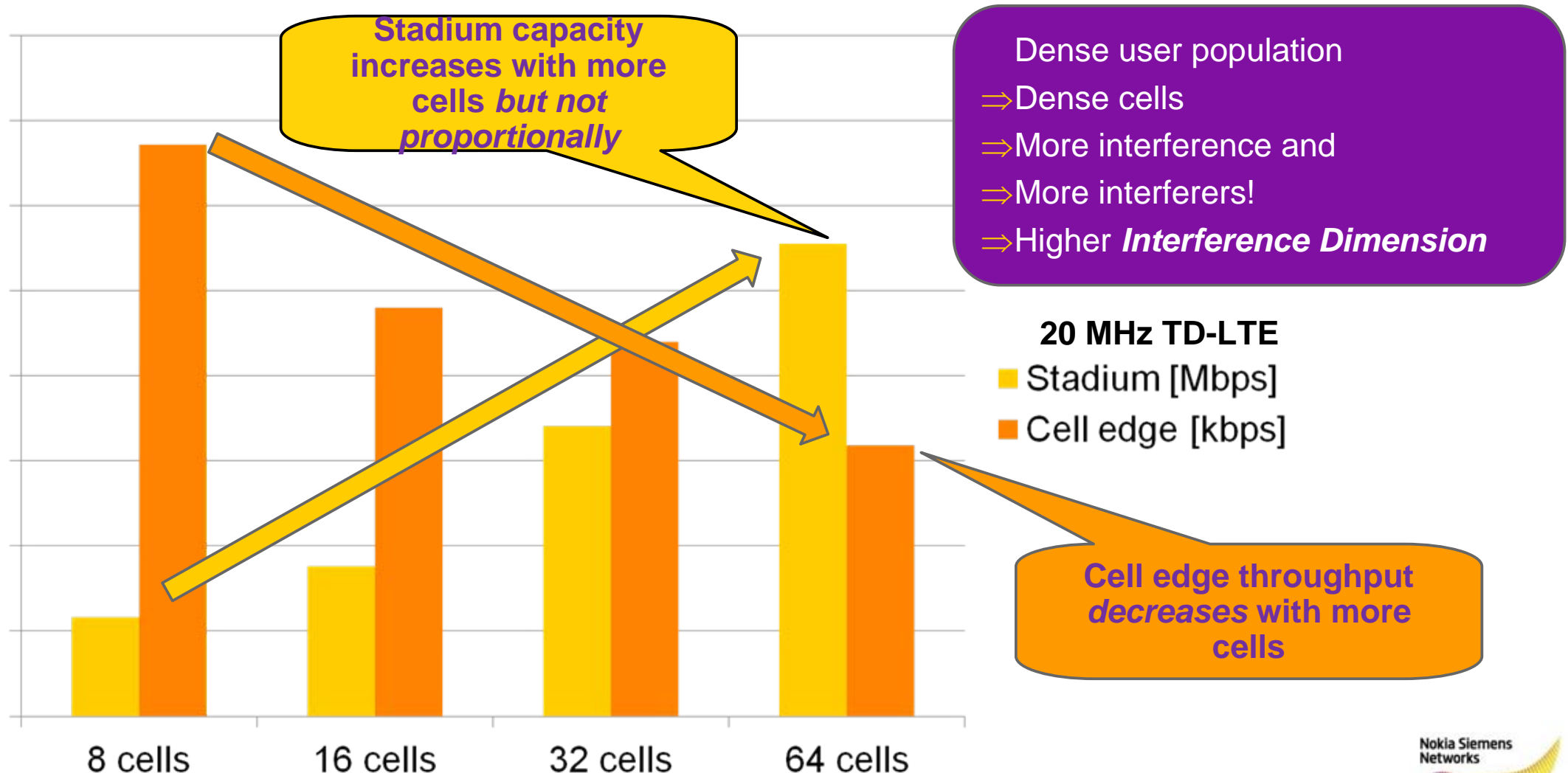
Comparison of Stadium Dense RAN Uplink Methods

Chart: Cell-edge Throughput (kbps) vs Stadium Throughput (Mbps)

Legend:
- Independent Cells
- CoMP (Static)
- CoMP (Dynamic)
- CoMP (Dynamic, Advanced Joint Rx.)

Annotations: "Cell-edge eliminated!" and "Capacity scales with Dense RAN methods"

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Elimination of the cell edge on the uplink

Independent cells

CoMP (Static)
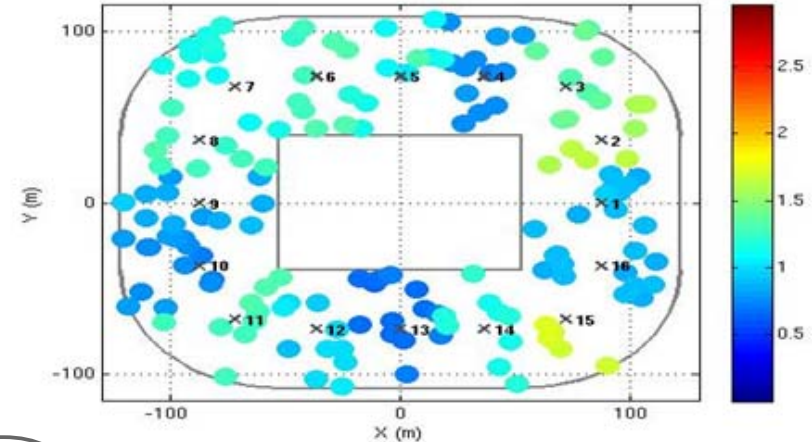
Throughput in Mbps
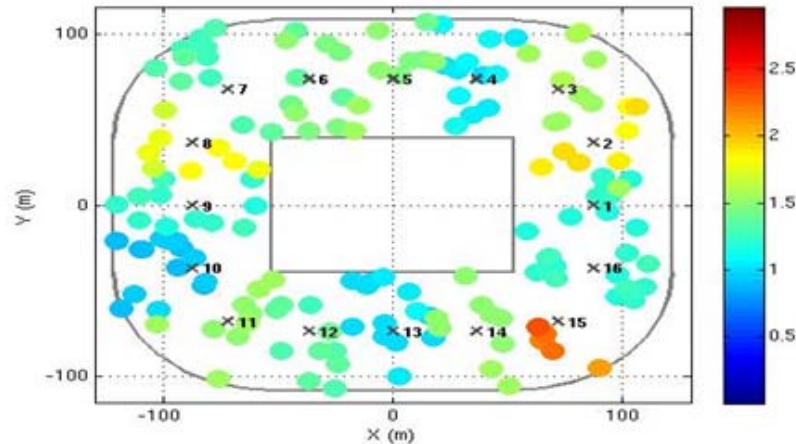
CoMP (Dynamic)

CoMP (Dynamic, Advanced Joint Rx.)
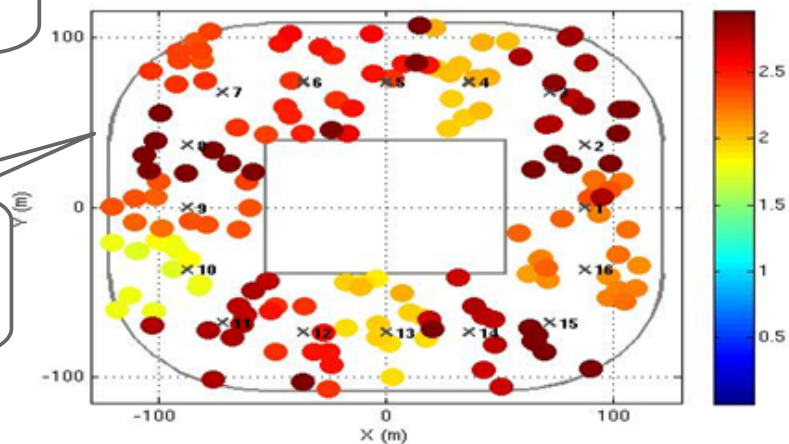
Many users have Tput < 0.5 Mbps
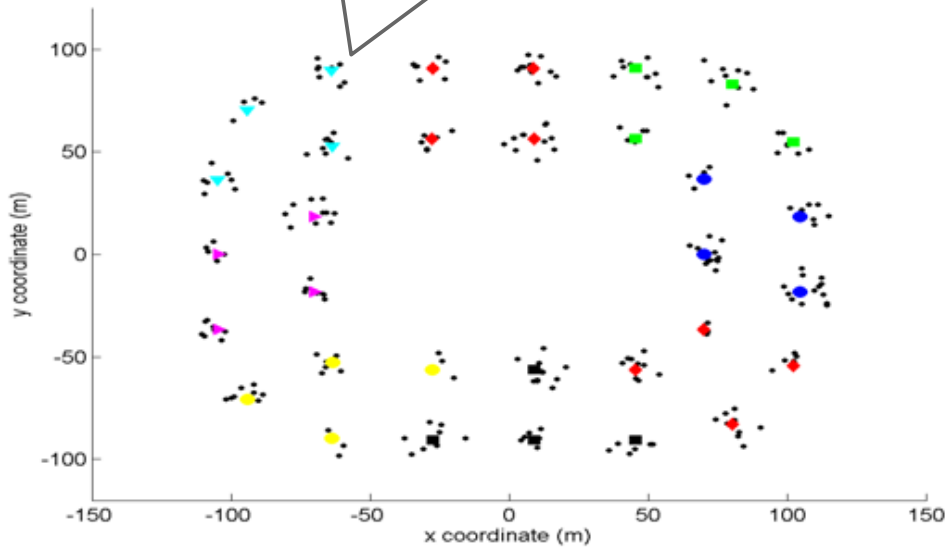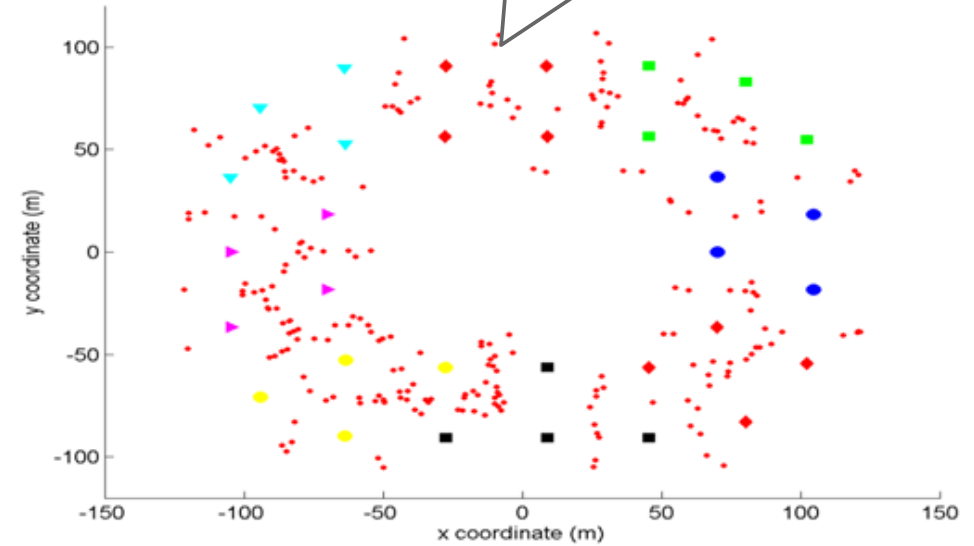
All users have Tput > 1.5 Mbps

Downlink without Dense RAN

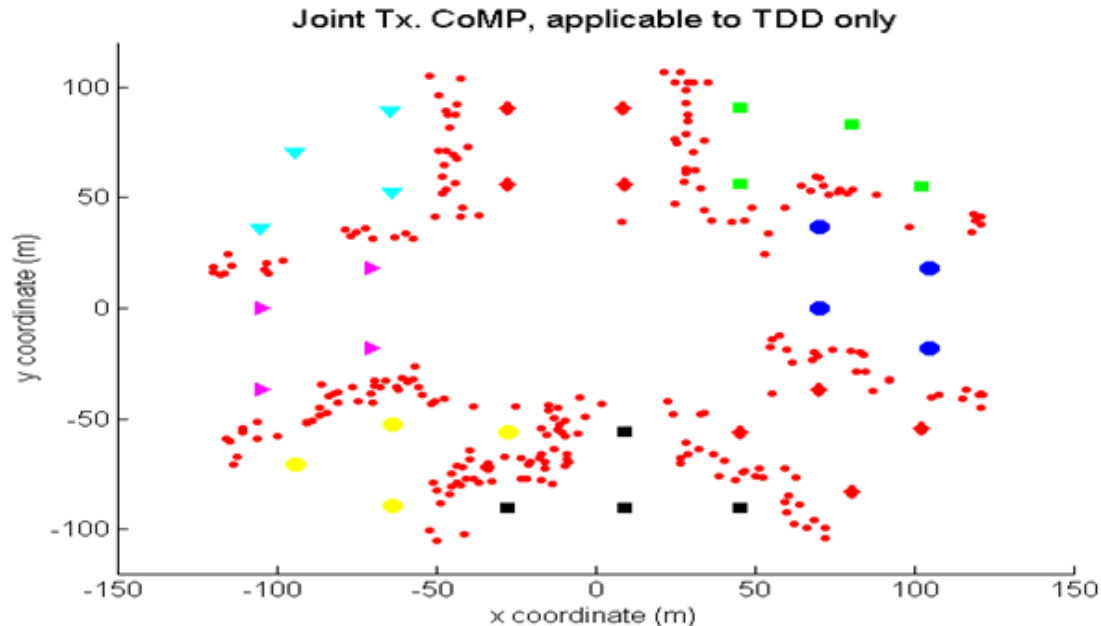High throughput users

Low throughput users

In 32-sector stadium system, the low throughput users cluster on the cell edge
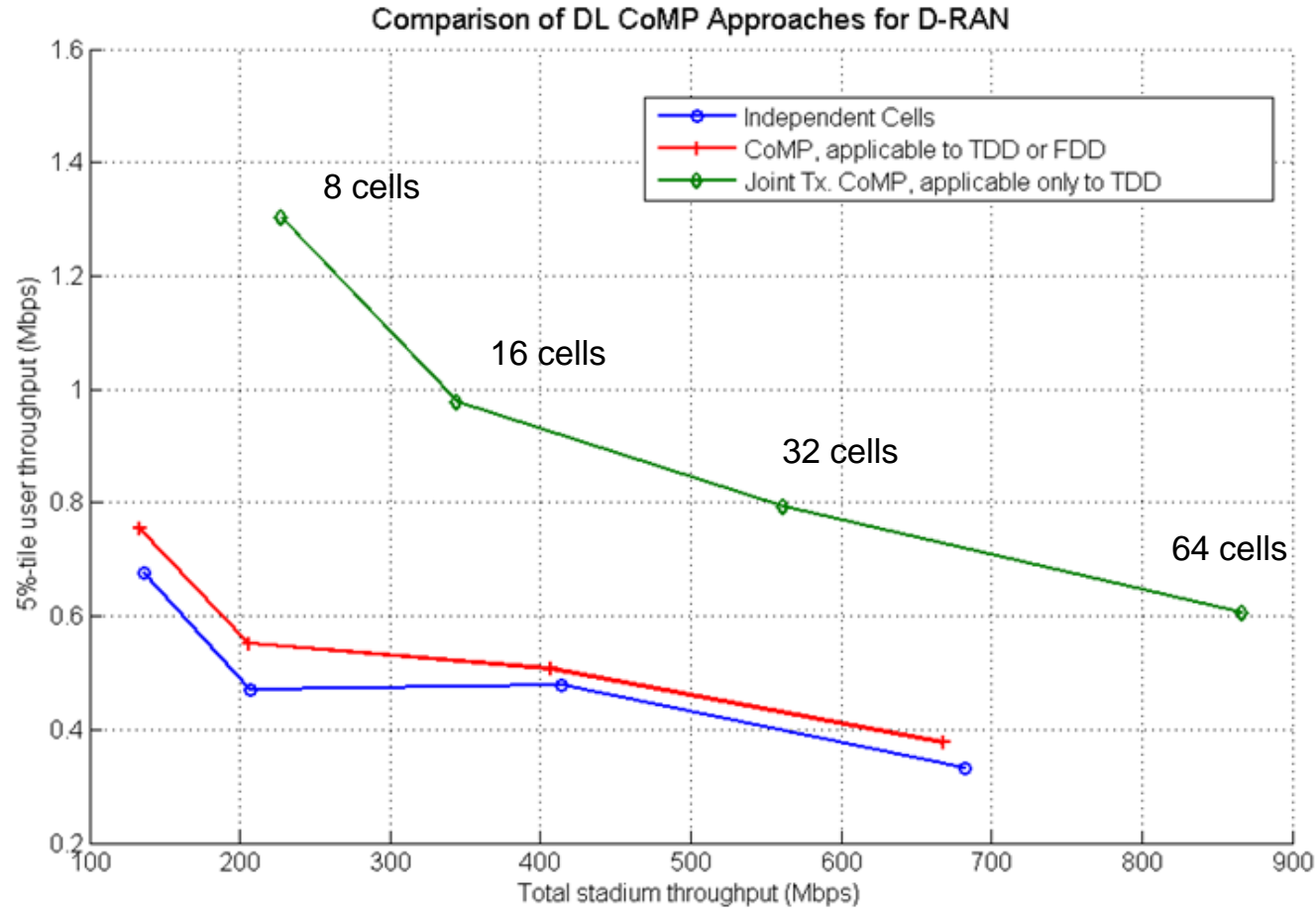
Downlink with Dense RAN

Dense RAN transmission algorithms leverage the reciprocity of TD-LTE

Fewer low throughput users that are clustered in the outer rim of the CoMP set

Dense RAN will use overlapping CoMP sets to <u>eliminate the cell-edge</u>

Bottom 10% throughput users' location distribution

Joint Tx. CoMP, applicable to TDD only

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Downlink Dense RAN Throughput comparison

Comparison of DL CoMP Approaches for D-RAN

Legend:
- Independent Cells
- CoMP, applicable to TDD or FDD
- Joint Tx. CoMP, applicable only to TDD

8 cells, 16 cells, 32 cells, 64 cells

X-axis: Total stadium throughput (Mbps)
Y-axis: 5%-tile user throughput (Mbps)

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Summary

NSN has Dense RAN solutions for both UL and DL
- Pico clusters using advanced joint reception and transmission algorithms
- Advanced architectures enabling overlapping CoMP groups of cells

Dense RAN Solutions designed for and evaluated in the most challenging ultra-dense venues in the world: **Stadiums**

Dense RAN efficiently handles high interference venues by eliminating the cell edge using overlapping clusters

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