

CHARACTERIZING THE EFFECTS OF RAPID LTE DEPLOYMENT: A DATA-DRIVEN ANALYSIS

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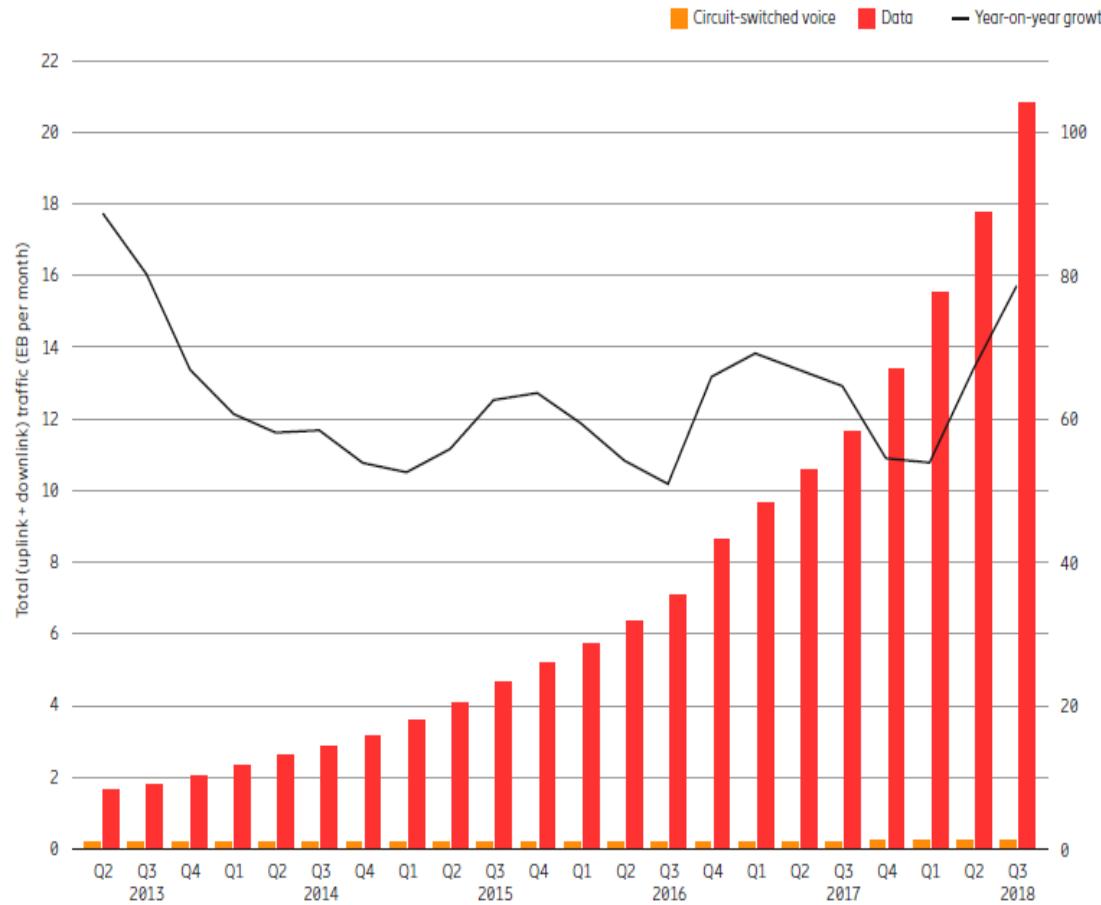
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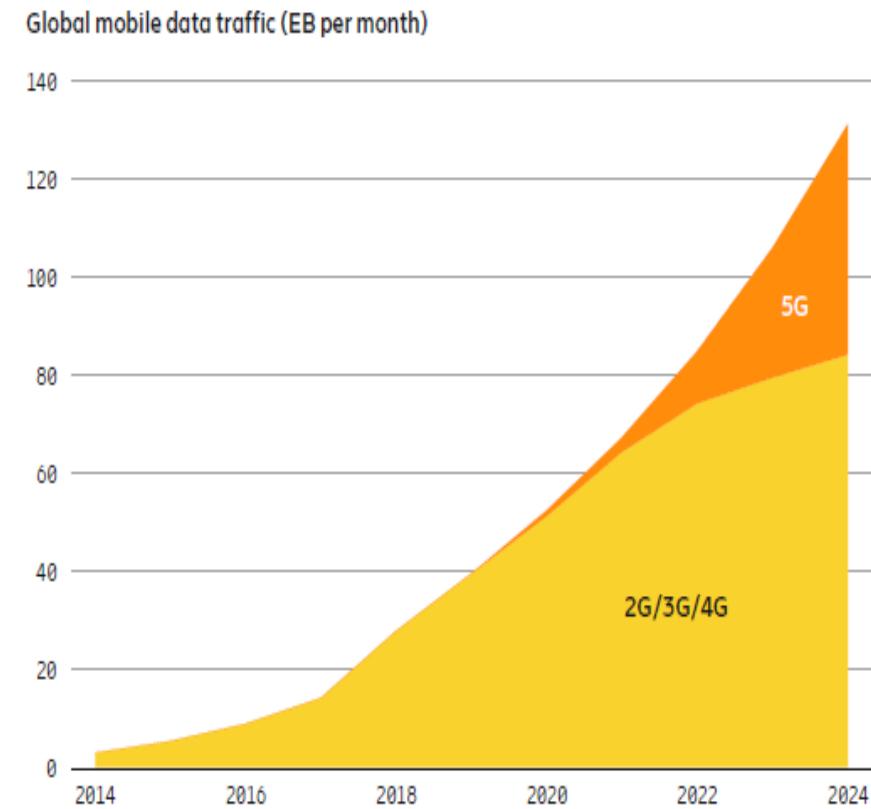


Data Continue to Grow with around 50% YoY Driven by Smartphone Penetration and Higher usage per sub*



4G NOT 5G!

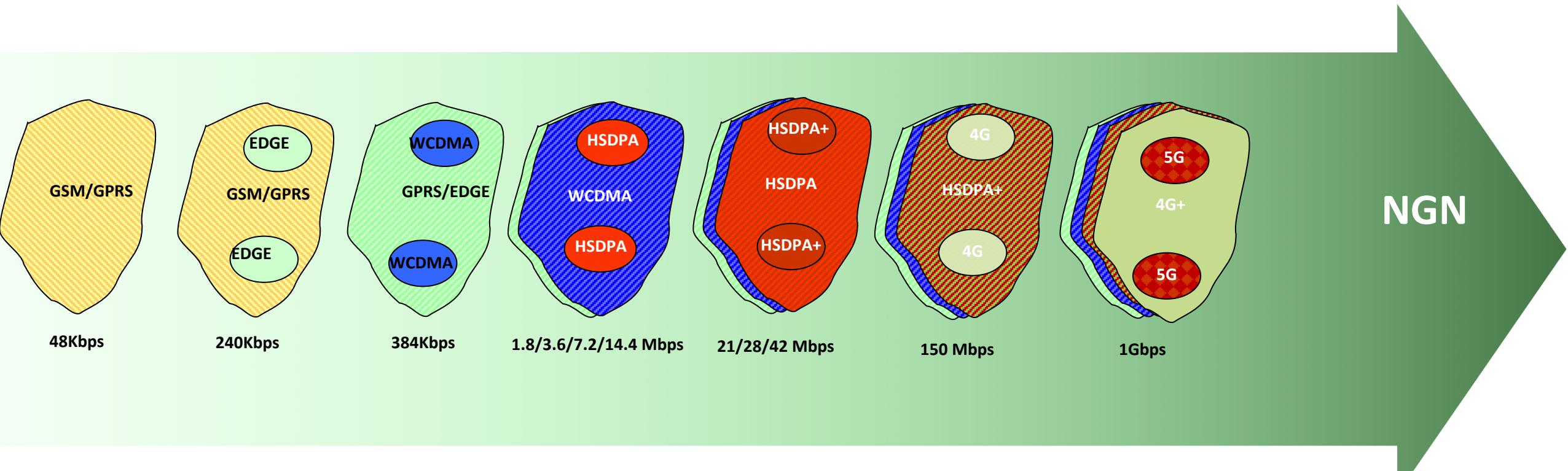
- **3G Shutdown is on its way, re-farming the allocated spectrum from 3G to 4G**
 - Global mobile data traffic will increase seven-fold between 2017 and 2022, with 4G traffic share of 71 % and 5G with 11.8 %.*
 - Global 4G (LTE) devices market value to Increase from US\$ 344.8 Bn in 2016 to US\$ 926.1 Bn by 2024*
- **New 4G deployment in developing countries**
- **Deployments in community-operated cellular networks that service underdeveloped regions**



Ericsson mobility report, Q2-2019

Spectrum, Most Valuable Asset for Mobile Operators

- Operators always focus on increasing spectrum efficiency (bps/cell/Hz), adopting new technology generations



Hence, operators replace 3G with 4G for better spectrum utilization

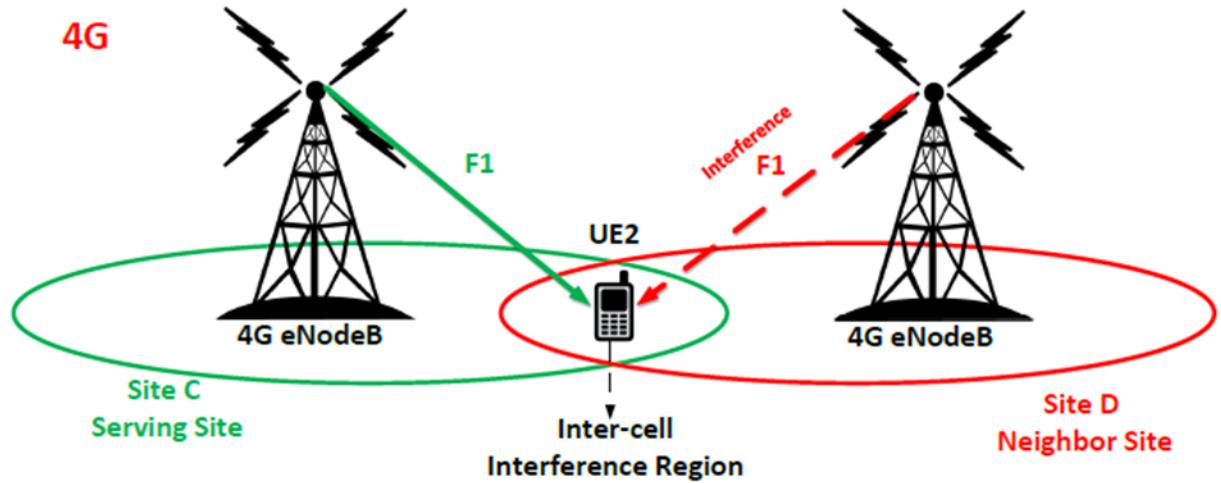
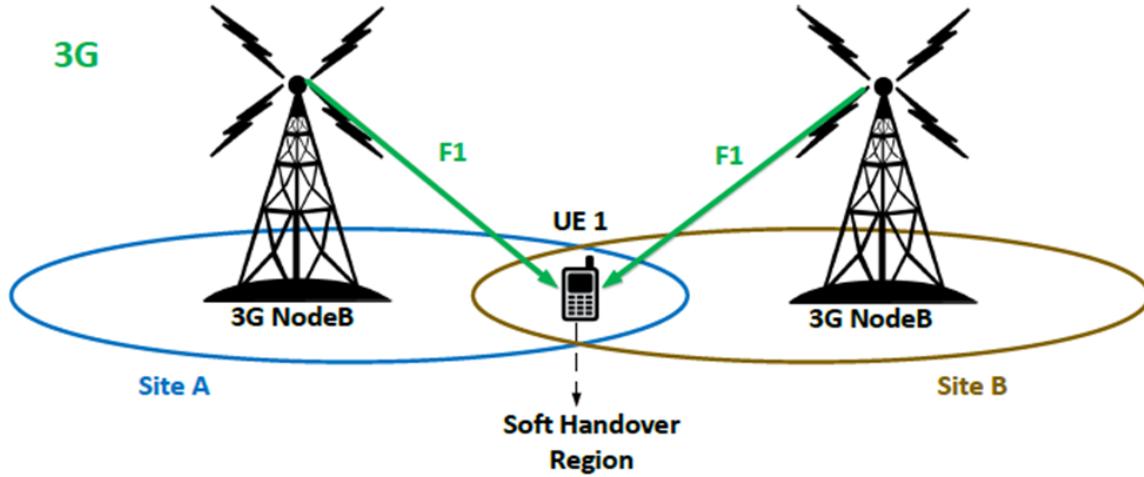
4G DEPLOYMENT

- **Standard 4G deployment involves many steps**
 - Network dimensioning of user demand and density
 - Desired Quality of Service (QoS)
 - Plan optimal radio parameters through rigorous **pre and post activation optimization procedures**

This is an expensive operation!

- **Rapid deployment reuses 3G sites as is, only changing software (Single RAN).**
- **Why Rapid Deployment?**
 - Reducing time to market
 - Cost efficiency

3G AND 4G ARE SIGNIFICANTLY DIFFERENT



4G is robust for intra-cell interference but inter cell interference could dramatically affect 4G performance

OBJECTIVE

- Characterizing the side effects of the rapid deployment approach

- Developing a data-driven approach to mitigate the negative side effects

OUTLINES

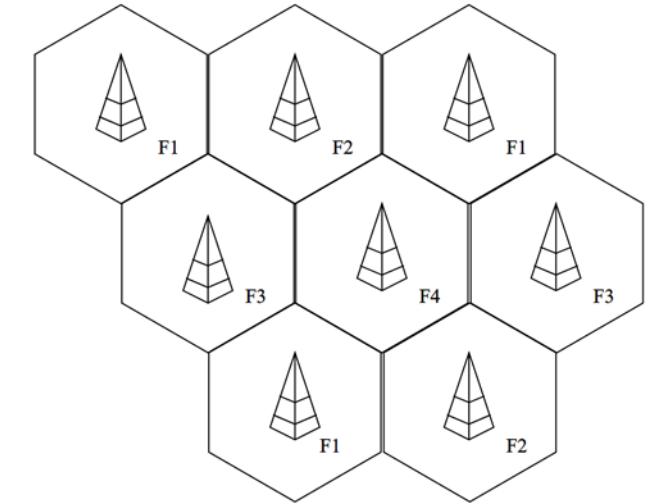
- **Measurement Methodology**
- **Key Observations**
- **Handling the pitfalls of rapid deployment**
- **Conclusion**

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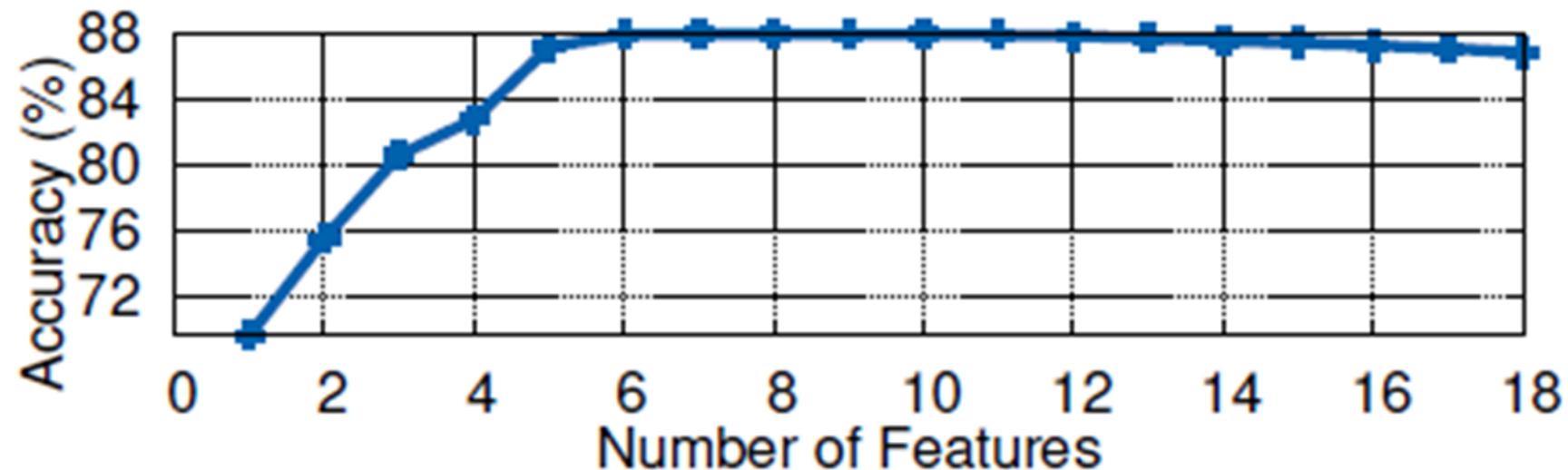
MEASUREMENT METHODOLOGY

- Key Performance Indicators (KPIs) collected from a cluster of cells spanning two major cities, over two consecutive months
- Data Collected before the post activation optimization taking place.
- KPIs measured at the eNodeBs, capturing both network KPIs and per-cell aggregate end-user KPIs.



MEASUREMENT METHODOLOGY (CONT.)

- A model was devised to classify the cells into degraded or not based on the avg user throughput.
- Feature selection algorithms were used to select the most relevant KPIs for our analysis.



Estimation accuracy improvement using sequential forward selection, the first six features are enough to provide best estimation accuracy

SELECTED FEATURES

a) Radio Conditions Indicators

- **High-order modulation penetration Ratio (HOMPR)**

It's the percentage of traffic having users enjoying 64-QAM modulation



b) Capacity Indicators

- **Resource Block Utilization (PRB)%**

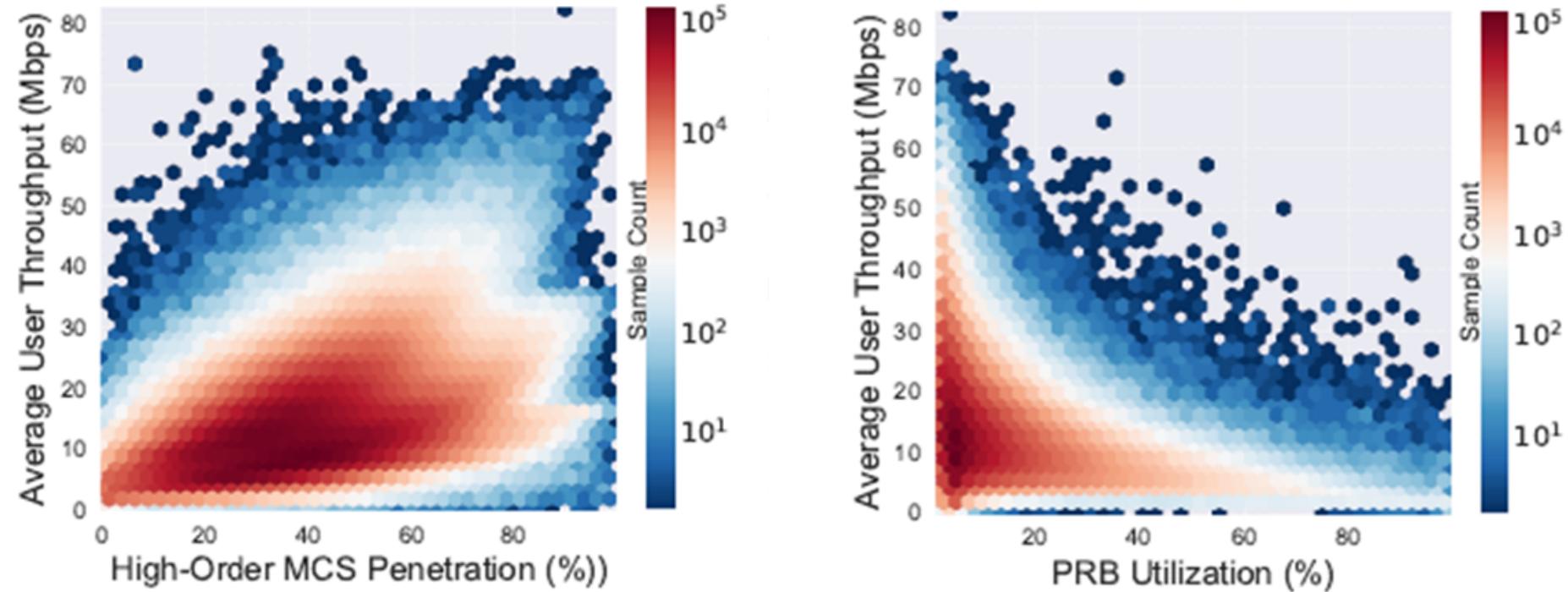
It's the Radio spectrum resources utilization



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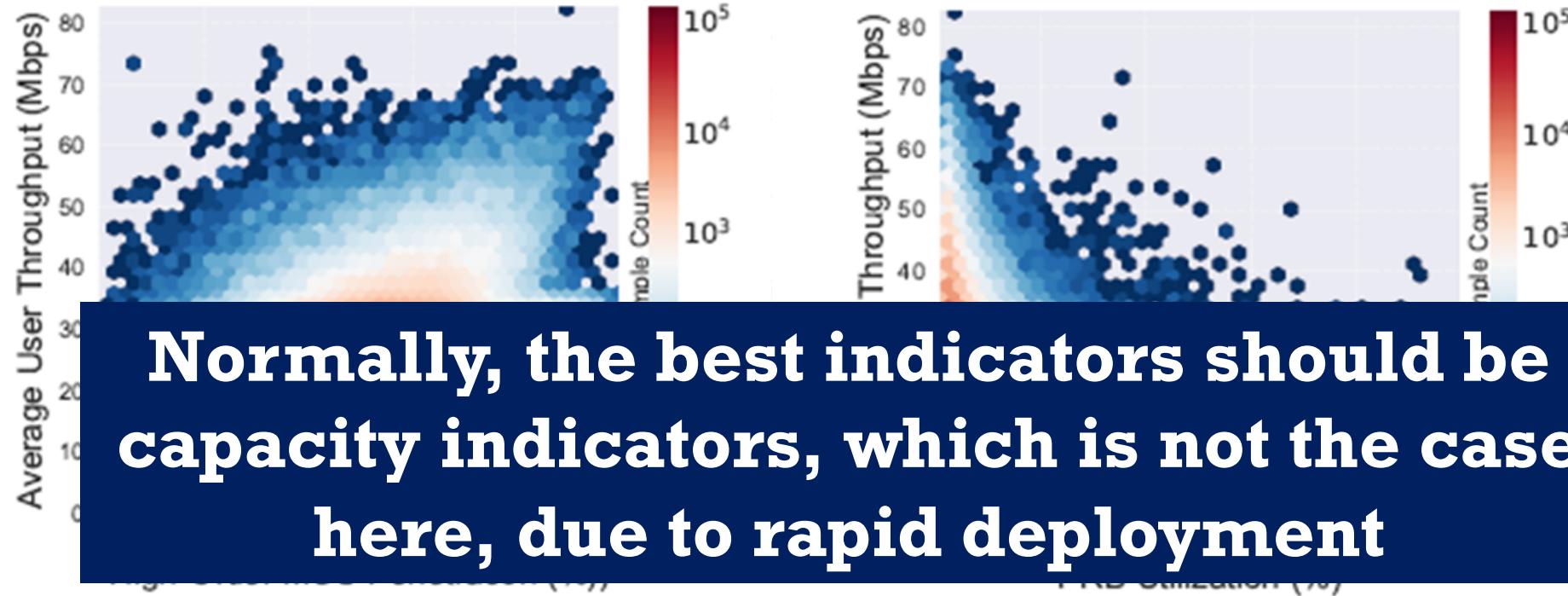
RADIO CONDITIONS, THE BEST INDICATORS



KPI (Whole Cluster)	Correlation with Average User Throughput
HOMPR	0.454163
BLER	-0.316519
PRB Utilization	-0.311759
# of Active Users	-0.18782

High-Order MCS Penetration % is the best indicator for the problem

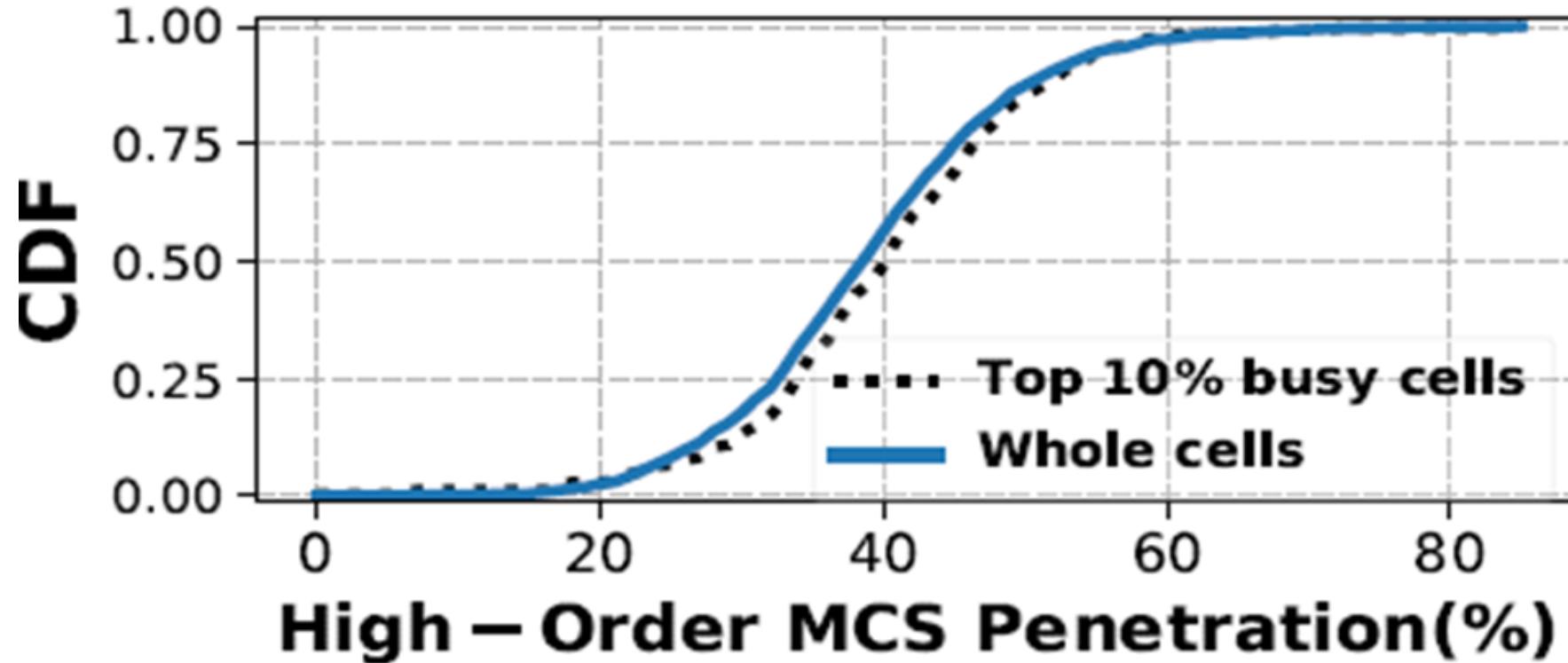
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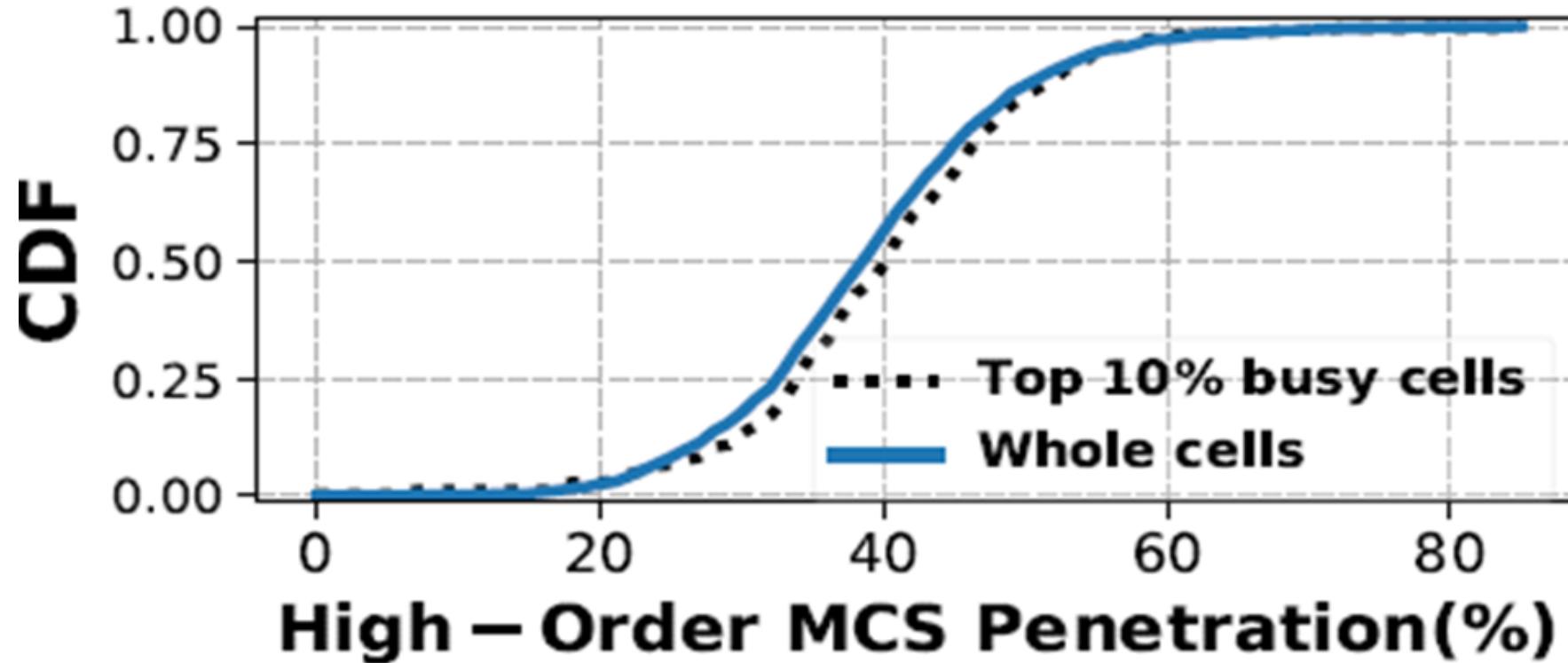
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BAD RADIO CONDITIONS ARE PREVALENT

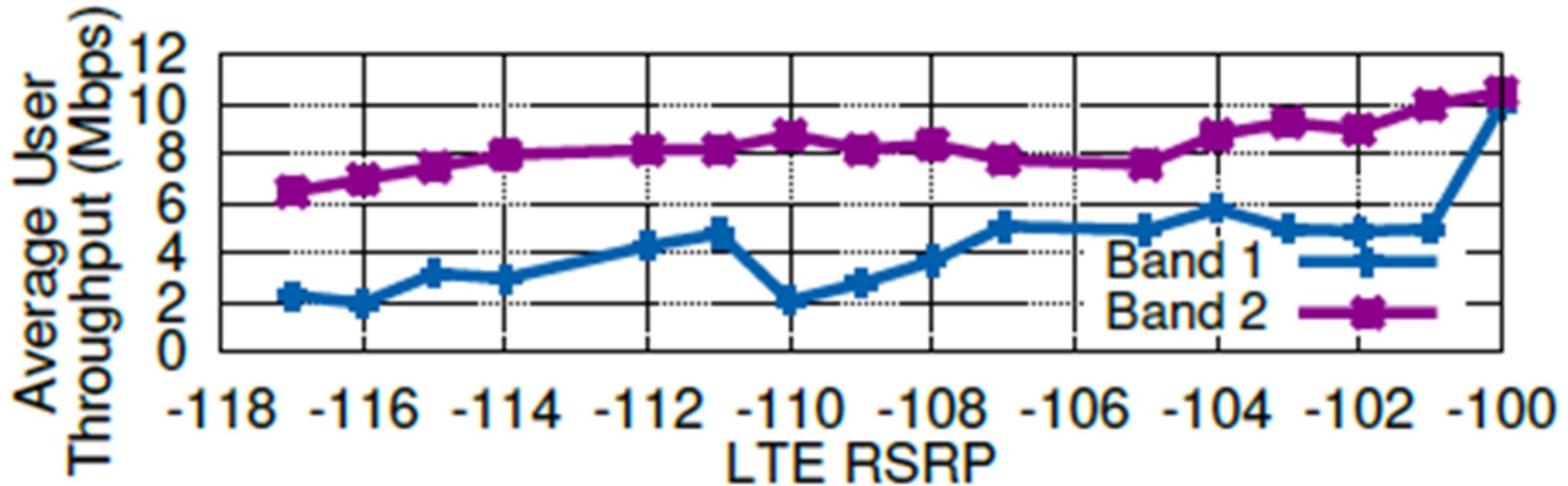


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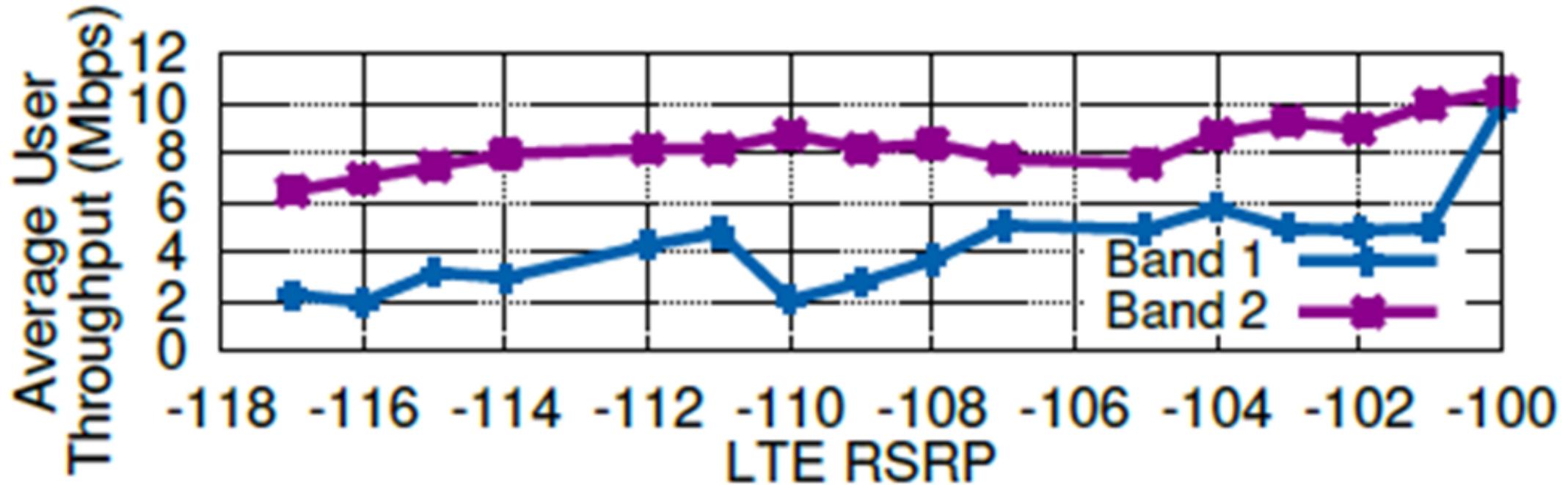


Rapid deployment without post-activation optimization causes bad radio conditions in more than 50% of studied cells

SIDE EFFECTS LIMITED TO OVERLAPPING AREAS



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Reducing cell overlap can significantly improve the performance of the affected cells

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HANDLING PITFALLS OF RAPID DEPLOYMENT

- Managing cells affected by rapid deployment has two steps:
 - Detection
 - Tuning
- Detection relies on low HOMPR as a proxy
- Physical optimization is used to tune the affected cells

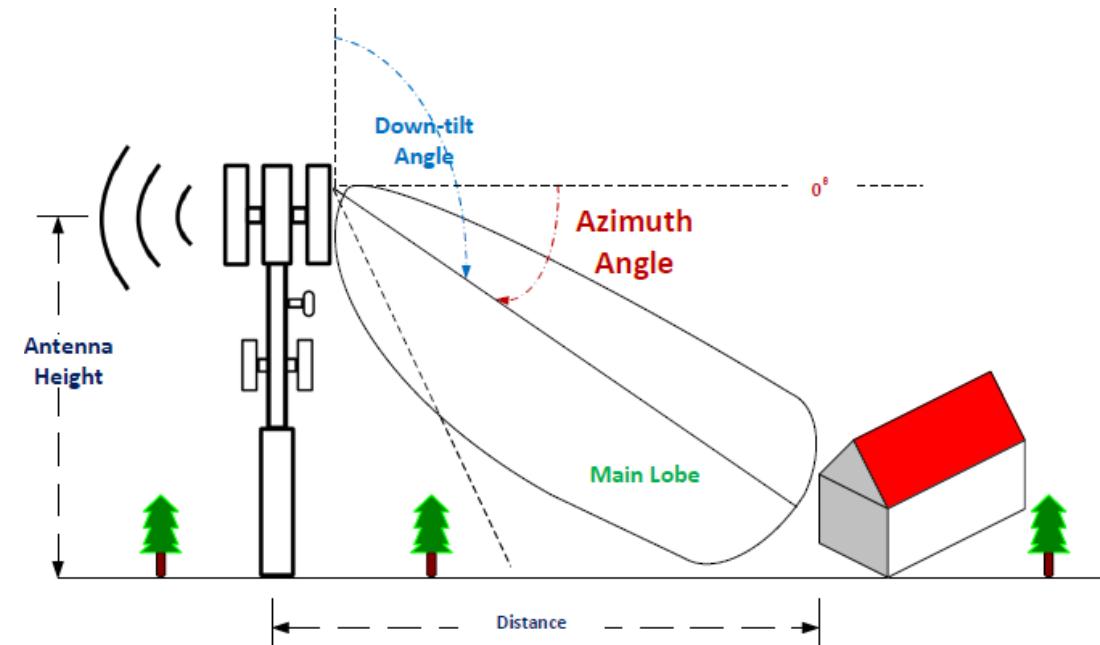
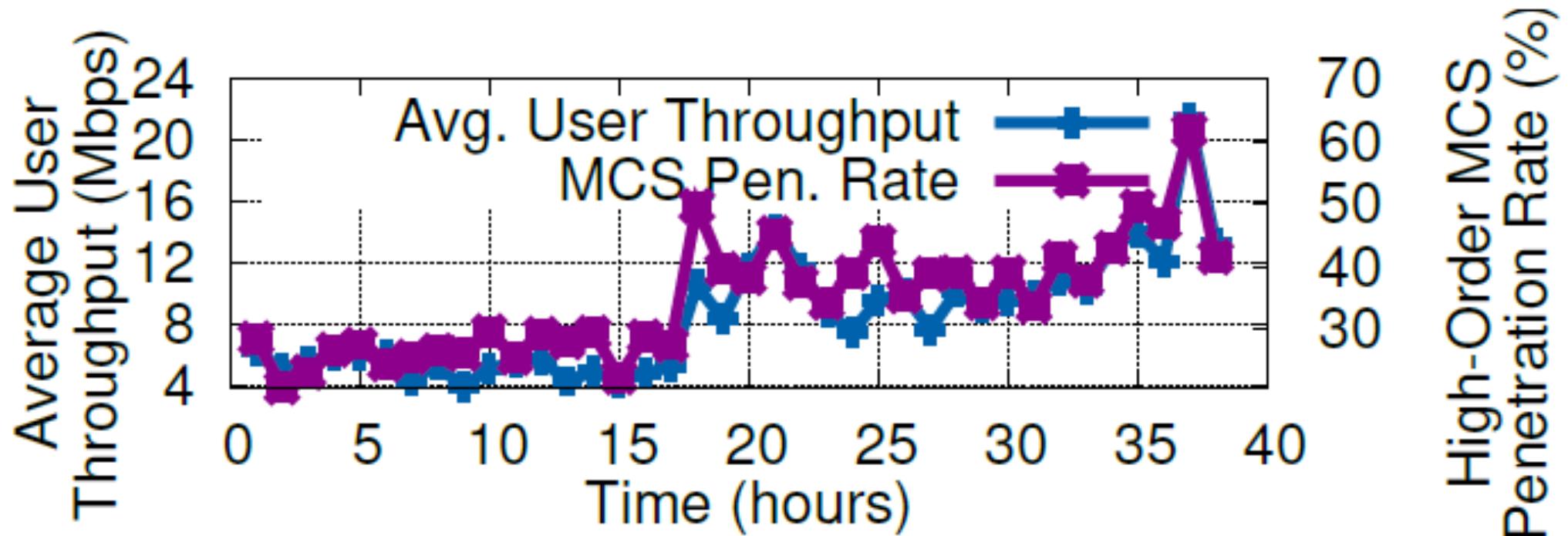
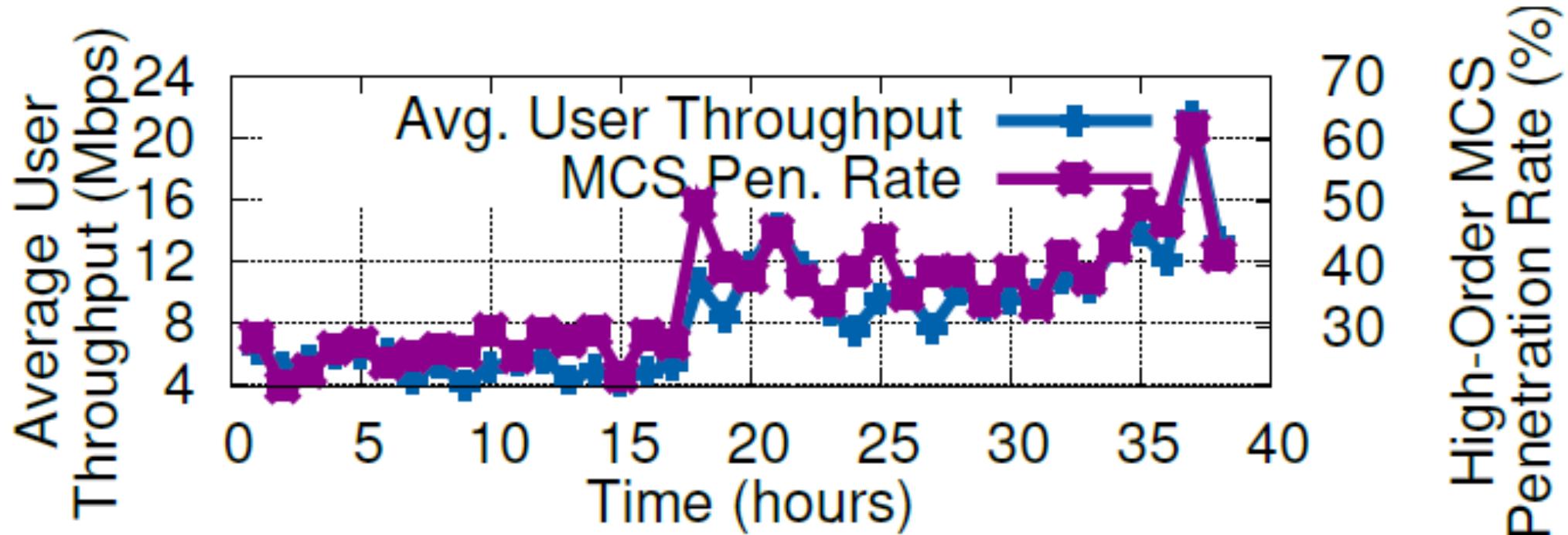


Illustration of cell physical parameters.

HANDLING PITFALLS OF RAPID DEPLOYMENT



HANDLING PITFALLS OF RAPID DEPLOYMENT



Improving radio conditions by physical optimization led to average user throughput enhancement up to 114%.

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CONCLUSION

- **Rapid deployment provides lower cost and faster LTE rollout at the expense of users performance**
- **Underperforming cells can be detected through data-driven analysis and remedied through physical optimization**

Thank you!

Questions?