FUTURE 5G CELLULAR NETWORKS

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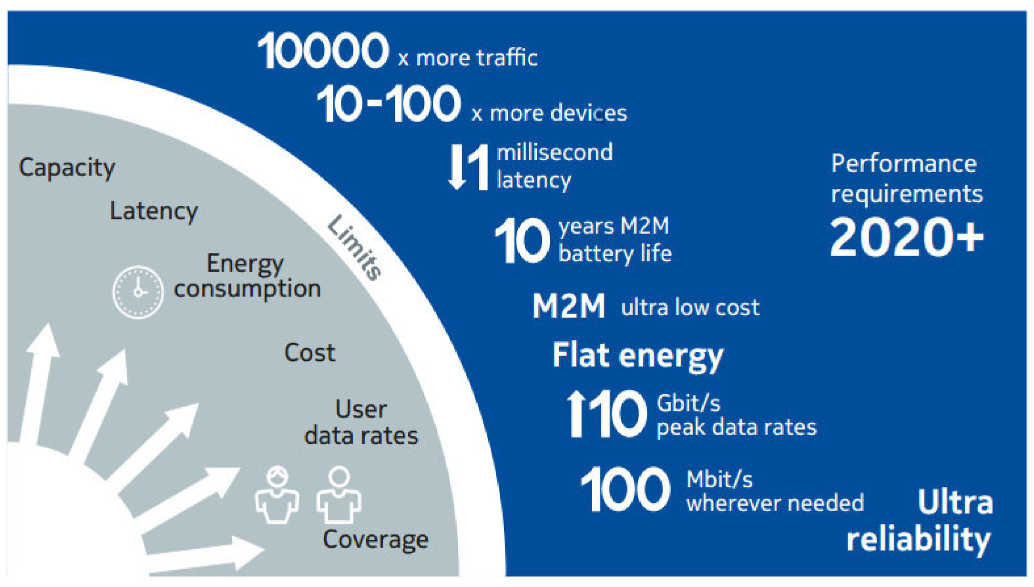
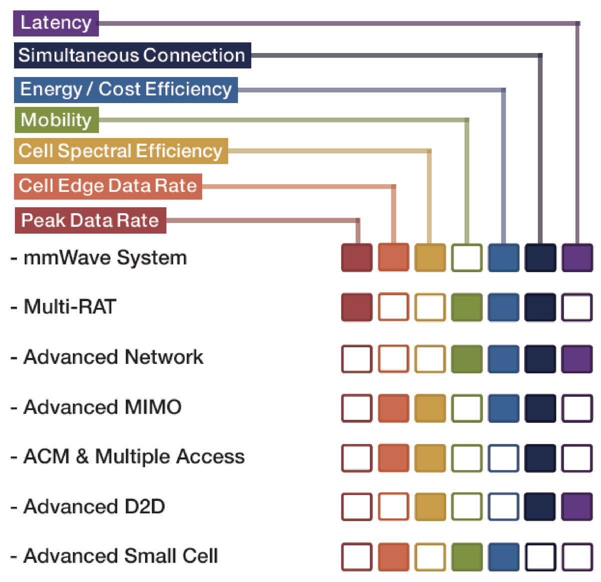
Motivation

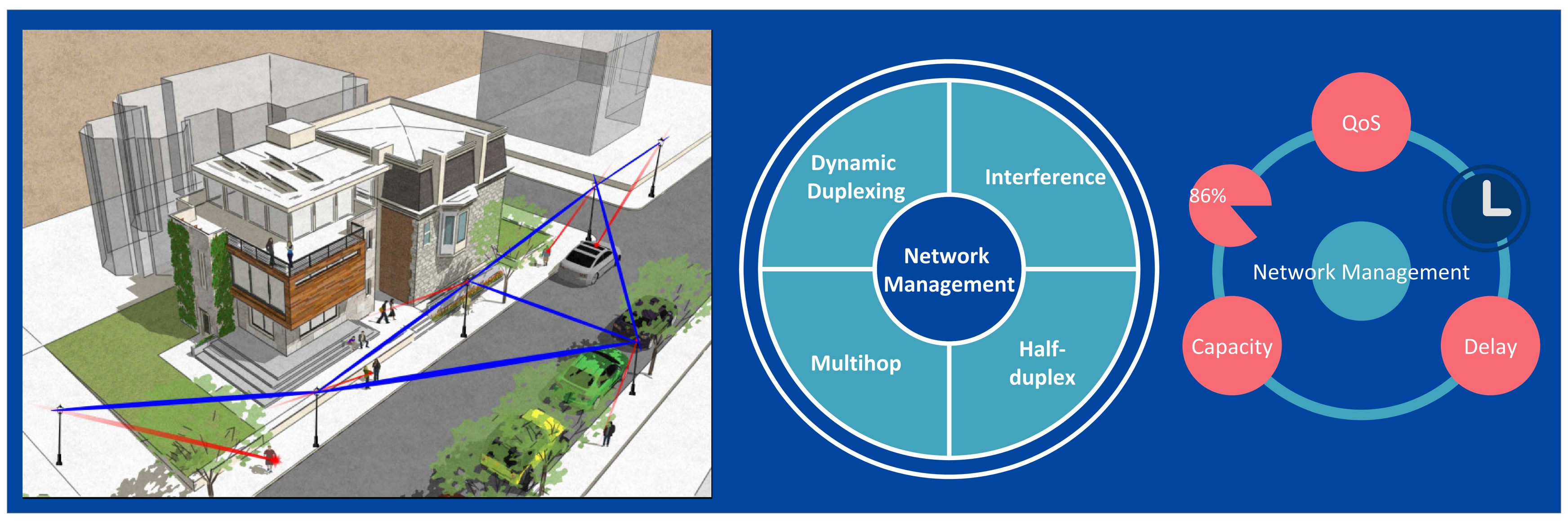
5G Expectations [1]



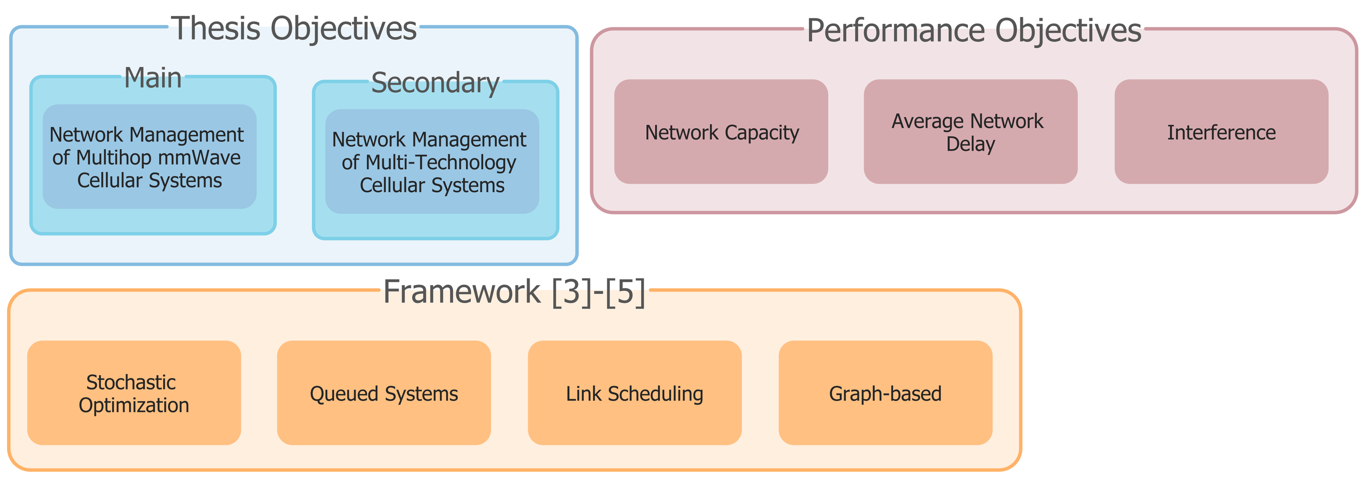
5G Technologies [2]



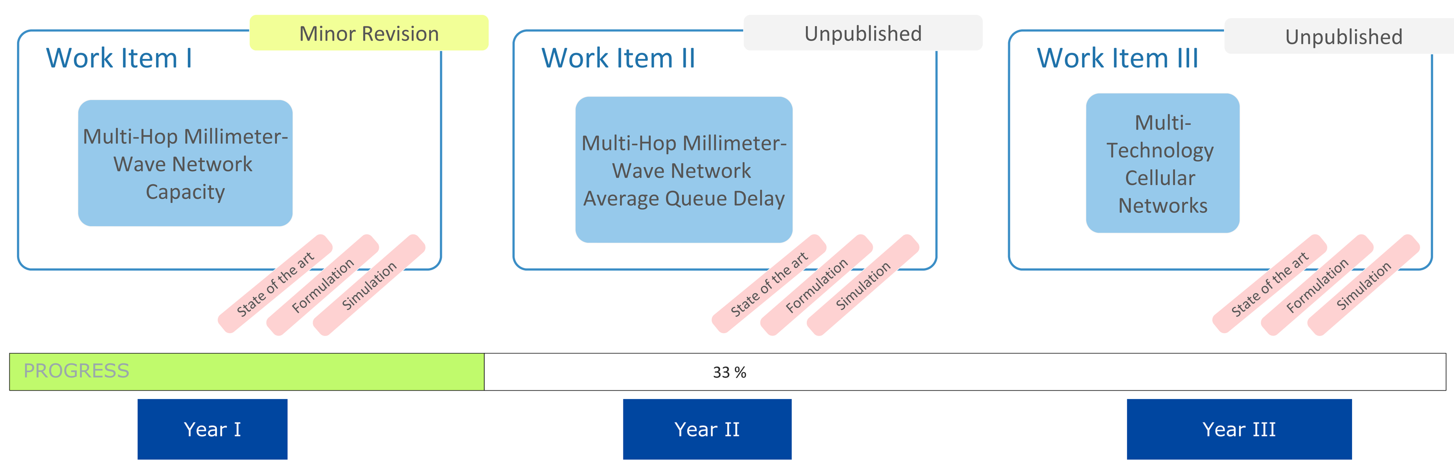
5G mmWave System



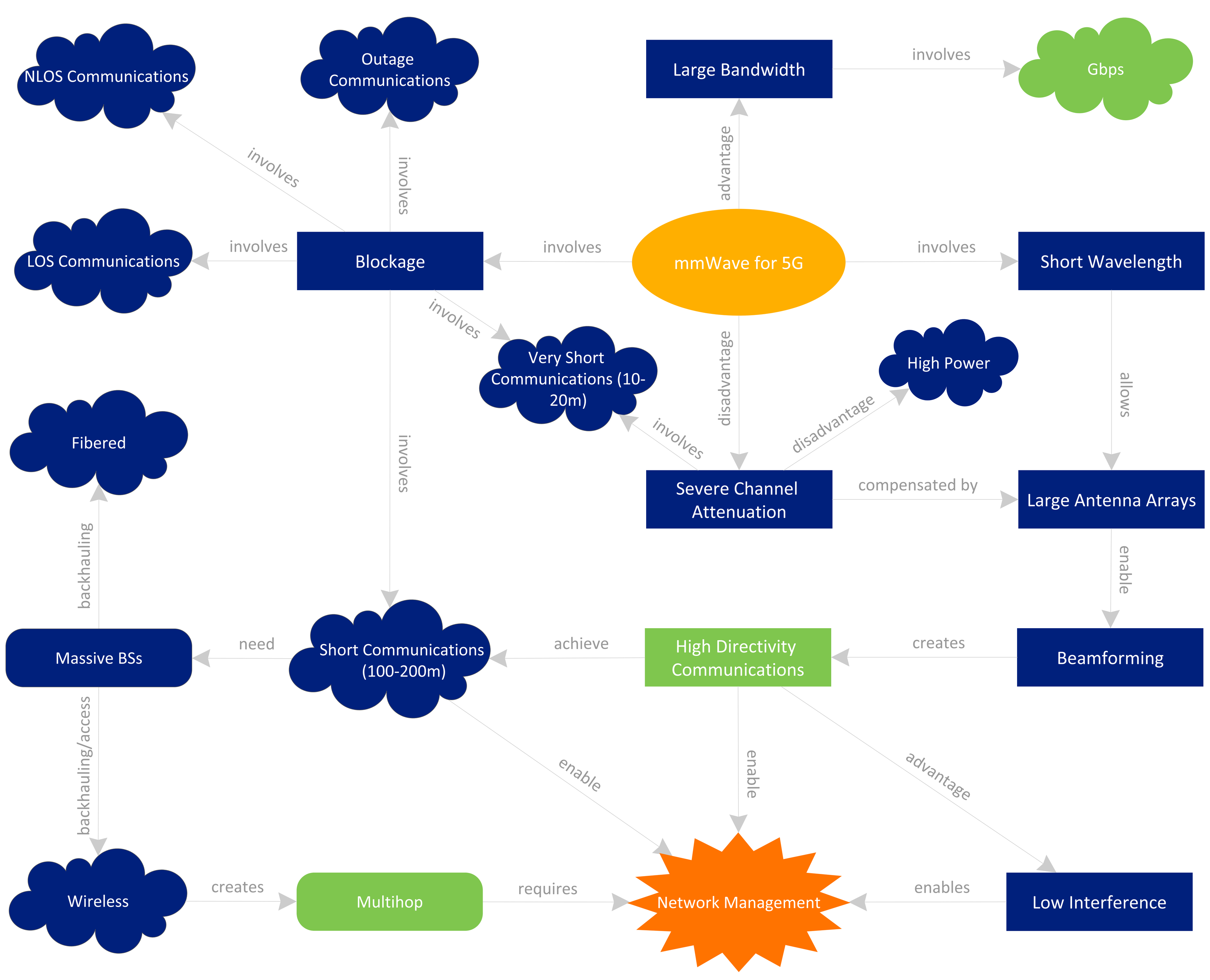
Thesis Objectives



Research Plan



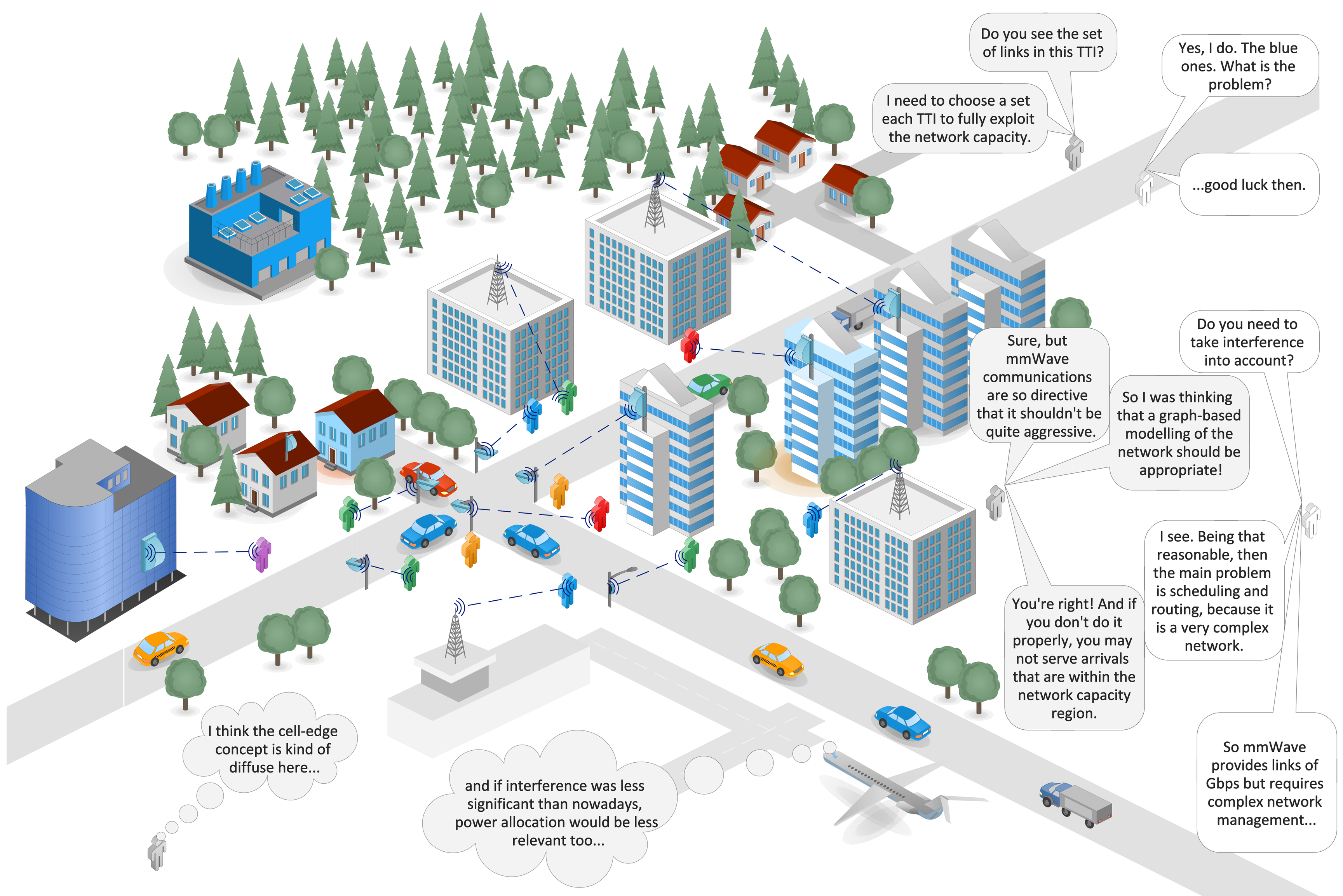
Context of mmWave in 5G



Work Item I (Year I)

Given a potentially multi-hop millimeter-wave cellular network architecture, is there any network-management policy that fully-exploits the network capacity region?

- Throughput-Utility *Optimal Dynamic Duplexing* Allocation with Congestion Control.
- *Theoretical results* extended from [5] for schedule dependent interference in mmWave.
- *Three graph-based interference models* (AI, IF and WI) to evaluate the network capacity region (See R1 Section). Based on the 3-state mmWave channel model in [6].
- Performance studies for *throughput improvement* (see R2 Section) and *coverage extension* using relays.
- Collaboration with **New York Wireless Center (NYU).**
- Submitted to be considered for publication in *IEEE Transactions on Wireless Communications*. Current State: ***Minor revision.*** (See [7]).



Urban multi-hop mmWave 5G network

Work Item I. Interference Models Comparison (R1)

- *Interference is clearly schedule-dependent* (Fig. 1).
- *Optimal Dynamic Duplexing* is capable of delivering *similar rates* with both SINR graph-based (*AI*) and SNR graph-based (*IF*) conditions. See Fig. 2.
  - *IF model* provides *realistic* capacity evaluations. Graph-based modeling is suitable for mmWave.
  - Long-term interference avoidance property of the network management policy.
- *Optimal power allocation is less relevant* in mmWave cellular networks.

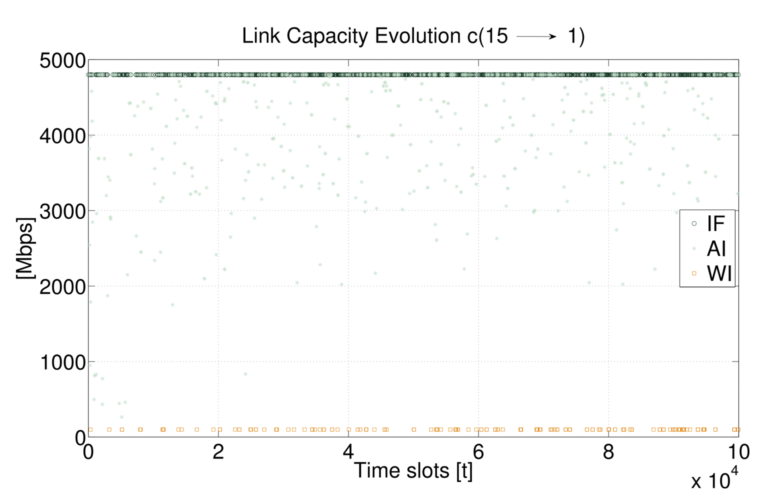


Fig. 1: Capacity evolution of a link with IF, AI and WI.

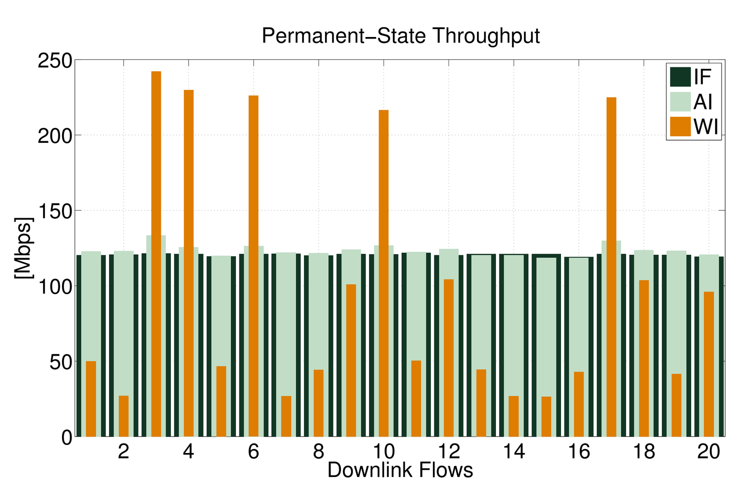


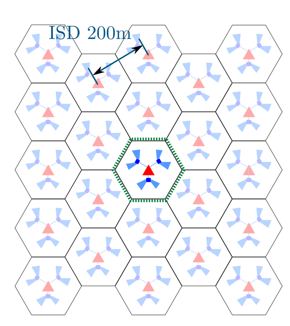
Fig. 2: Downlink Long-Term Rates with IF, AI and WI

Work Item I. Relaying at mmWave picocells (R2)

As opposed to the current LTE-Advanced standard where relaying is mainly used for coverage extension, *relaying in mmWave can be used for throughput improvement, mainly for* those users that observe channel instances with a poor SINR (we called them *"cell-edge users"*).

#RNs	Cell Cap		Cell Edge (5%)		% C_{max}
	DL	UL	DL	UL	
0	2094.41	1894.80	10.09	3.40	83.1%
2	2369.51	2279.48	28.29	5.99	96.8%
4	2444.86	2334.11	238.56	185.25	99.6%

Table 1: Performance results for an Urban mmWave Picocell



Reference(s)

[1] *Nokia 5G White Paper*, 2014.
[2] *Samsumg 5G Vision White Paper*, 2015.
[3] L. Tassiulas, "Linear complexity algorithms for maximum throughput in radio networks and input queued switches," in *IEEE INFOCOM*, vol. 2, March 1998, pp. 533–539.
[4] M. J. Neely, *Stochastic Network Optimization with Application to Communication and Queueing Systems.* Morgan & Claypool, 2010.
[5] A. Eryilmaz, A. Ozdaglar, and E. Modiano, "Polynomial complexity algorithms for full utilization of multi-hop wireless networks," in *IEEE INFOCOM*, May 2007, pp. 499–507.
[6] M. R. Akdeniz, Y. Liu, M. K. Samimi, S. Sun, S. Rangan, T. S. Rappaport, E. Erkip, and S. Member, "Millimeter Wave Channel Modeling and Cellular Capacity Evaluation," *IEEE Journal on Selected Areas in Communications*, vol. 32, no. Jun., pp. 1164–1179, Apr. 2014.
[7] J. García-Rois, F. Gómez-Cuba, M. R. Akdeniz F. J. González-Castaño, J. C. Burguillo-Rial, S. Rangan, B. Lorenzo, "On the Analysis of Scheduling in Dynamic Duplex Multihop mmWave Cellular Systems," *IEEE Trans. Wireless Communications*, in revision.