Attainable User Throughput in Dense Wi-Fi Deployments at 2.4 GHz in Residential Zones

Authors

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Delimitations

- Analytical / Non-experimental
- Simulation
- Simplified reality

Background

- Non-overlapping channels
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  - 60 MHz Bandwidth, 3 non-overlapping channels, 20 MHz and 40 MHz
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Previous Work

- D. H. Kang, K. W. Sung, and J. Zander "Attainable User Throughput by Dense Wi-Fi Deployment at 5 GHz"[2].

Methodology

How

- Adopt an analytical approach.
- Use snapshot-based Monte-Carlo simulation to estimate average throughput per user.

Propagation loss model

- Use the WINNER-2 indoor path loss model to compute the signal loss in different environments (line of sight, mall, and home).

Active AP contention model

- Identify all co-channel AP that are operating in the same frequency channel.
- Compute the contention order of the active APs (AP that are not within the carrier sensing range of each other) using the Simple Sequential Inhibition (SSI) process.

Data rate model

- Model SINR for each active AP.
- Compute the maximum achievable data rate for the given user.
- Estimate Average throughput per user based on the placement of the users and APs.

Methodology - Continued

Modeling Parameters

- We model this simulation based on the 802.11n standard
- The APs and users are dropped at randomly into an environment of dimensions 100m x 100m.
- Use both 20MHz and 40MHz channels for simulating different scenarios.
- Transmit power of 20dBm is used for a 20MHz channel and 23dBm for a 40MHz channel.
- Use Bandwidth efficiency $= 1$
- Noise power spectral density -174 dBm/Hz
- Use spectral efficient of 3.61 bps/Hz for 20MHz and 3.75 bps/Hz for 40MHz channel

Results AP range

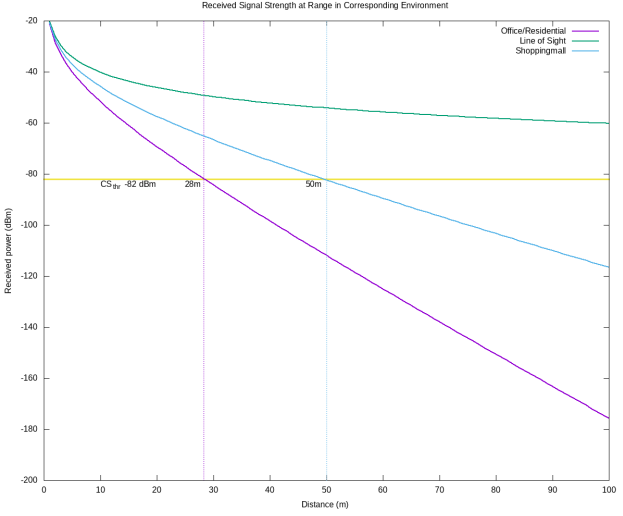

Figure: Signal Strength Dependant on Distance

Results AP range

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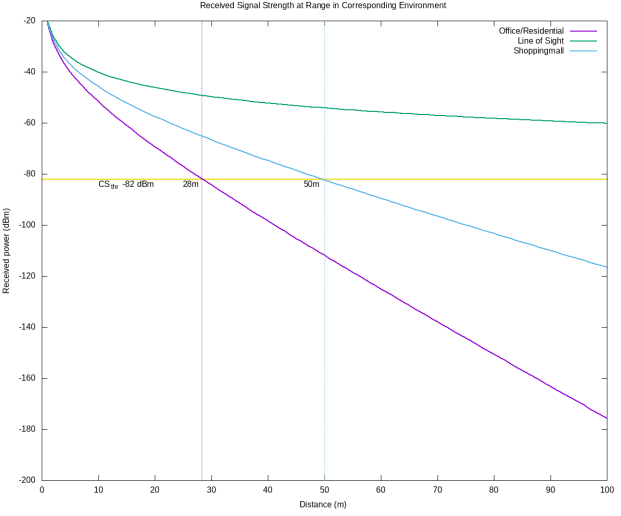

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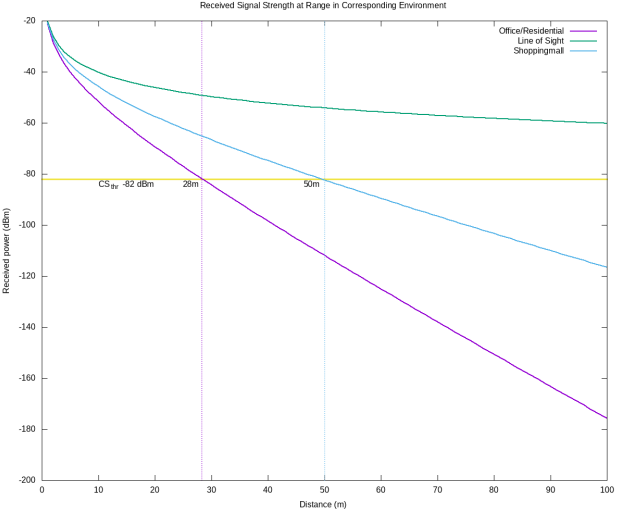

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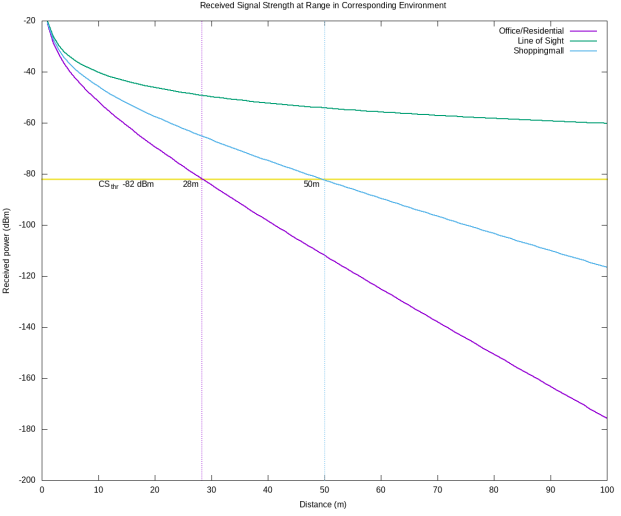
- Signal strength depending on distance from source
- Signal strength also depends on environment



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AP Deployment and Concurrent Transmitters

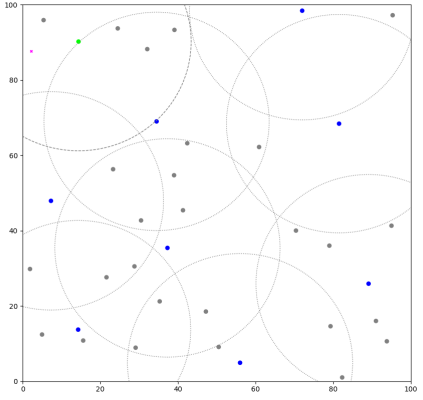

Figure: Example plot of positioning of users and APs

AP Deployment and Concurrent Transmitters

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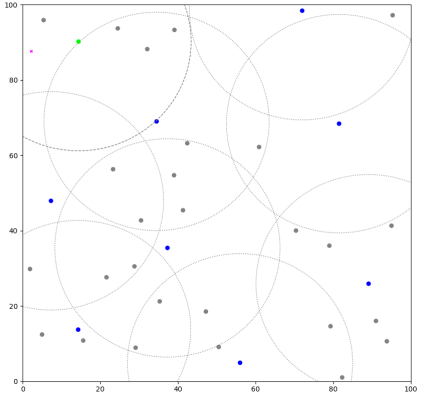

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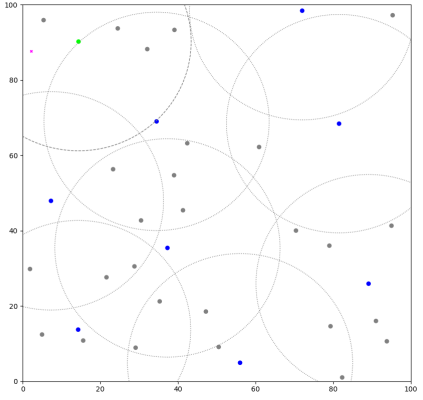

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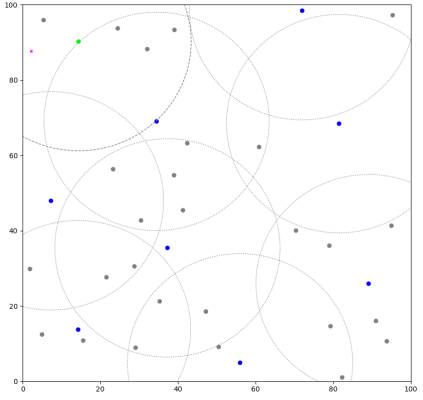

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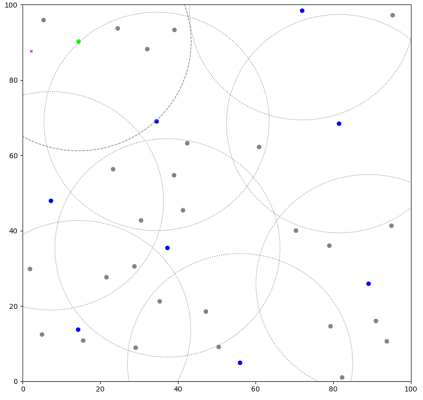

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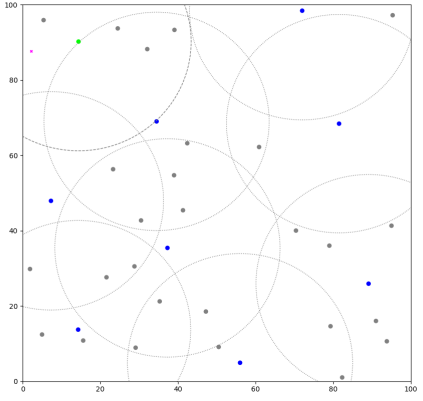

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Throughput Depending on Channels Available

- Near linear scaling with added channels

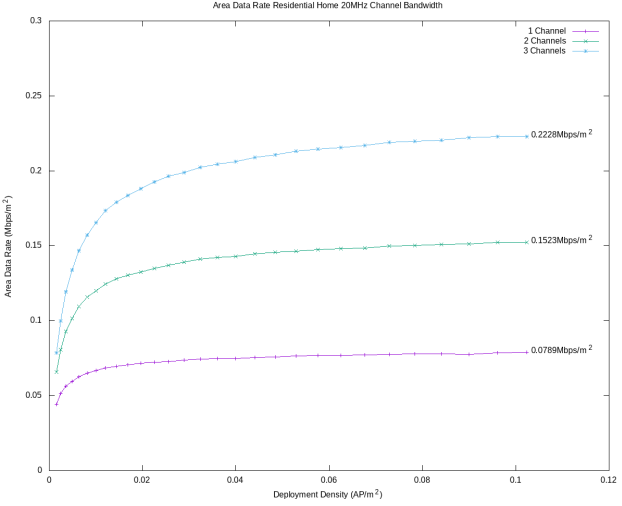
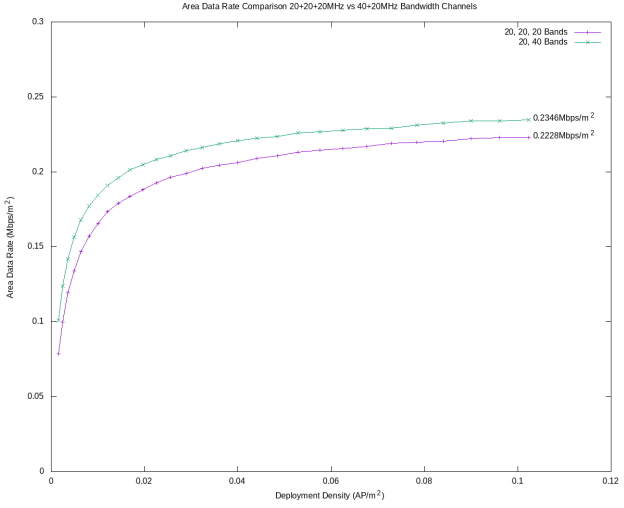


Figure: Throughput in Mbps/m^2 in a home environment

Throughput 3×20 MHz vs 20 & 40 MHz Bandwidth Channels



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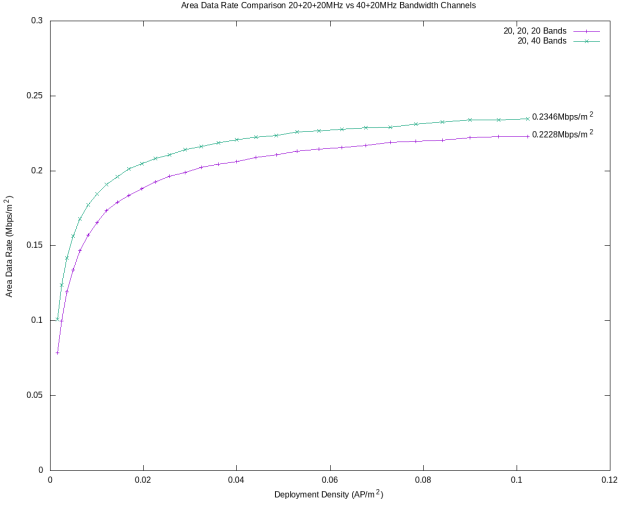

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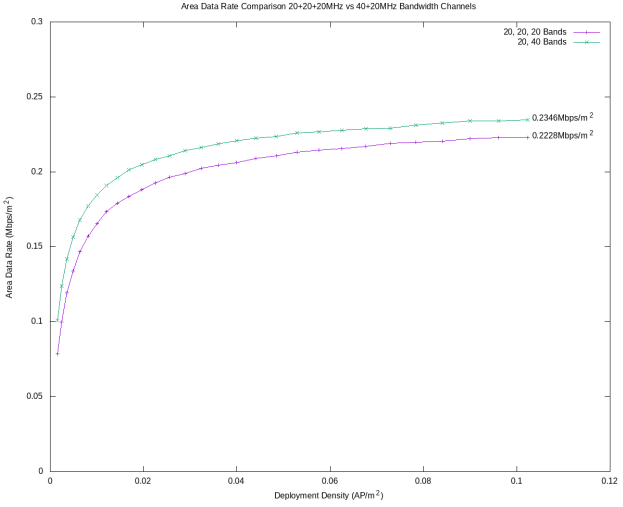
- Full utilization of available bandwidth
- Higher bandwidth channel allows for more throughput than multiple channels using the same bandwidth



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Maximum throughput for each user

- Using the highest throughput attained
- Logarithmic decrease in data rate

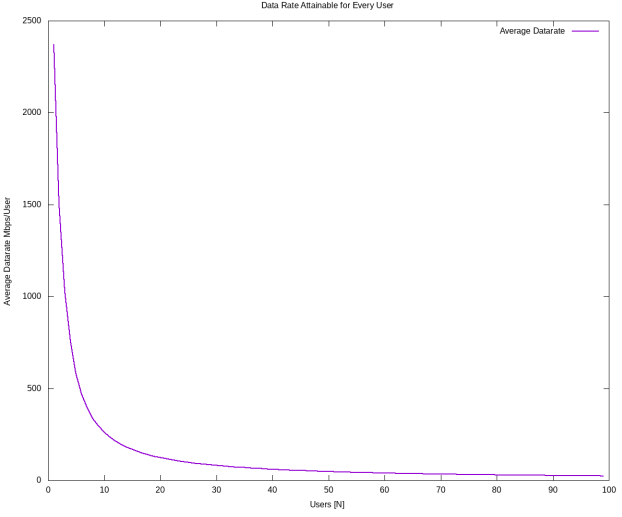

Figure: Data rate available for each user in the area

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- When in a line of sight environment only one AP was able to transmit at a specific time
- LoS deployment scenarios need more research
- Random deployment plots can be used for visualisation of how to place APs to get efficient coverage without too much interference

Reference

- P. Miklavčič, "On the number of non-overlapping channels in the ieee 802.11 wlans operating in the 2.4 ghz band," *Elektrotehniski Vestnik/Electrotechnical Review*, vol. 81, pp. 148–152, 01 2014.
- D. H. Kang, K. W. Sung, and J. Zander, "Attainable user throughput by dense wi-fi deployment at 5 ghz," in *2013 IEEE 24th Annual International Symposium on Personal, Indoor, and Mobile Radio Communications (PIMRC)*, pp. 3418–3422, IEEE, 2013.