

## Analysis and calculations of re-use factors and ranges for OFDMA in comparison to TDMA systems

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Purpose: Provide Information for comparison of various PHY features

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# Analysis and Calculations of Re-use Factors and Coverage for OFDMA Systems

Avi Freedman

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# Purpose

- Estimate the spectral and system efficiency of the OFDMA option
- Extension of work previously done in DVB-RCT for
  - Frequency band (<1GHz → <11 GHz)
  - Channel properties
  - Bandwidth, data capacity etc.

# Content

- Scenarios
- System parameters
- Results
  - Single cell
  - Multi-cell
- Future analysis
- Conclusions

# Scenarios

- Single cell
  - Coverage with no interference
  - Effects of interference
- Mutli-cell
  - 2km cells
  - 6km cells
  - Re-use 1, 3, 6

# Propagation Models

- As per IEEE 802.16.3c-01\_29r1
  - Terrain type : A
  - Base station antenna height: 20m
  - Terminal station antenna height: 5m
  - $\gamma = 5.08$

# System Parameters

- Frequency band – 2.5 GHz - MMDS
- Channel bandwidth: 6 MHz
- Transmission power: 20 dBm
- Antenna gains
  - Base station: 15 db
  - CPE : 18 db

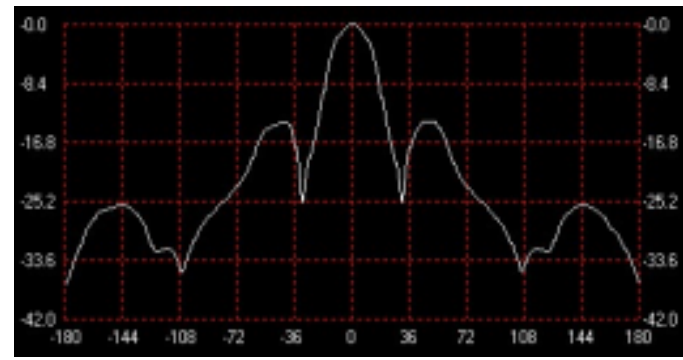
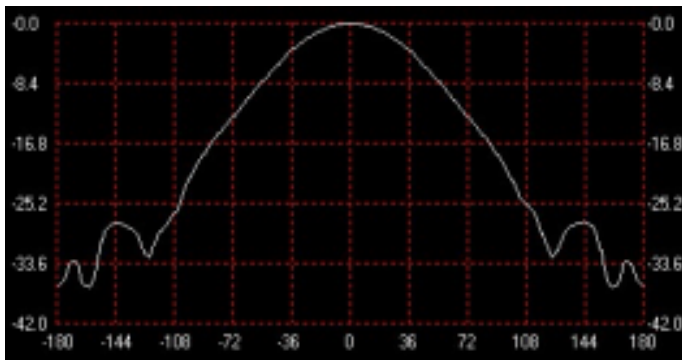
Net data rate (Mbps)	5	10	15
Required S/N (dB)	13	22	29
Sensitivity (dBm)	-88	-79	-72

# Antenna Patterns

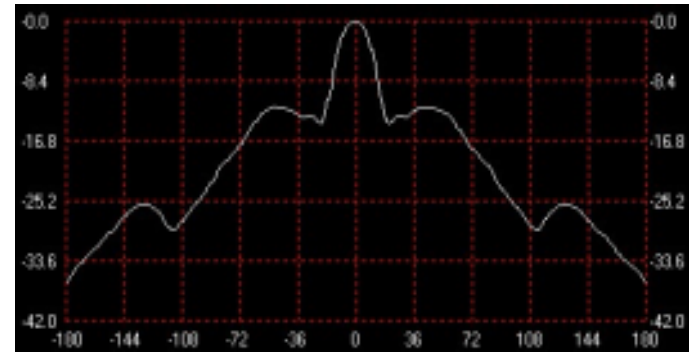
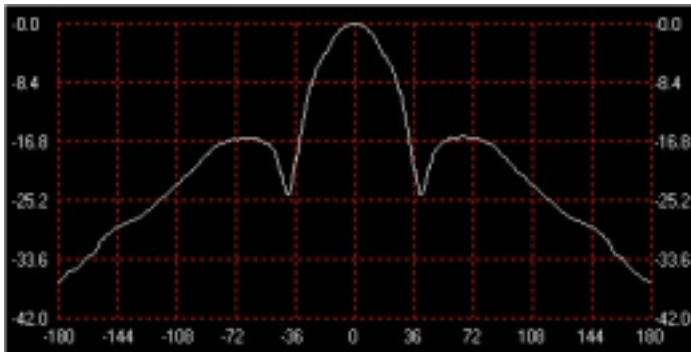
Azimuth

Elevation

BS



CPE

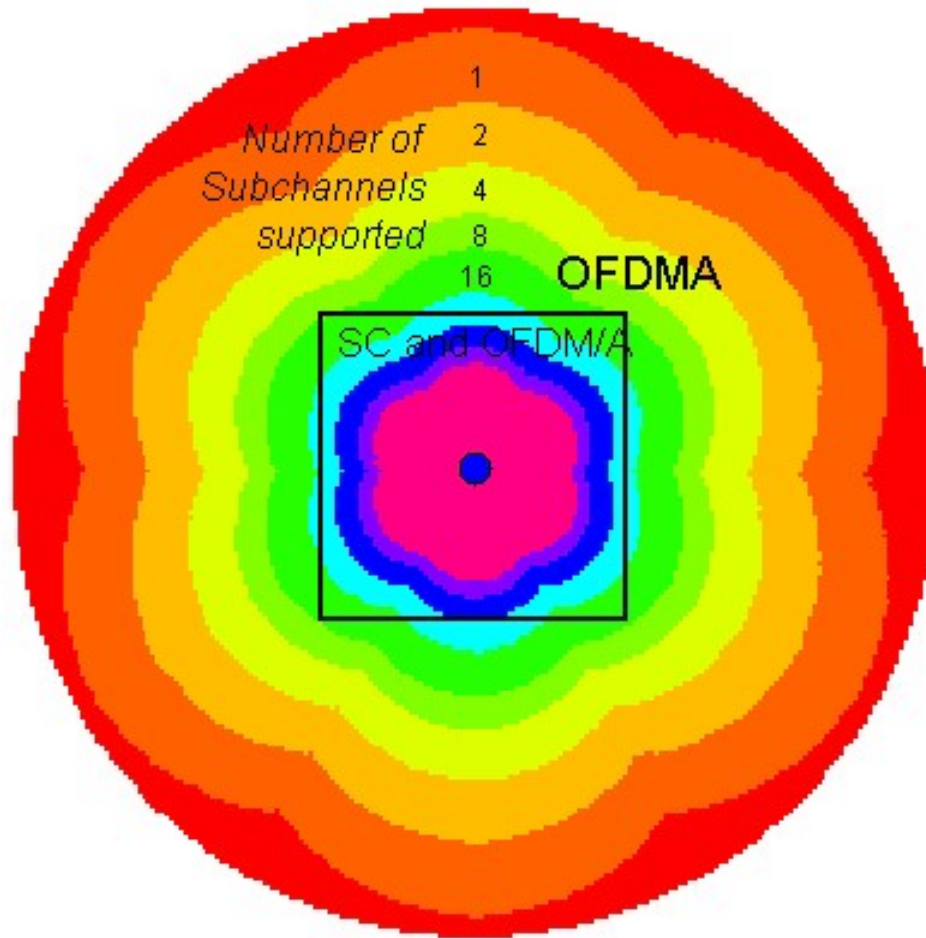




# Adjacent Channel Rejection

	Basic	"Improved"	"Best"
Adjacent	22 dB	27 dB	40 dB
2 <sup>nd</sup> adjacent	40 dB	50 dB	60 dB
3 <sup>rd</sup> adjacent	50 dB	60 dB	80 dB

# Single Cell Coverage



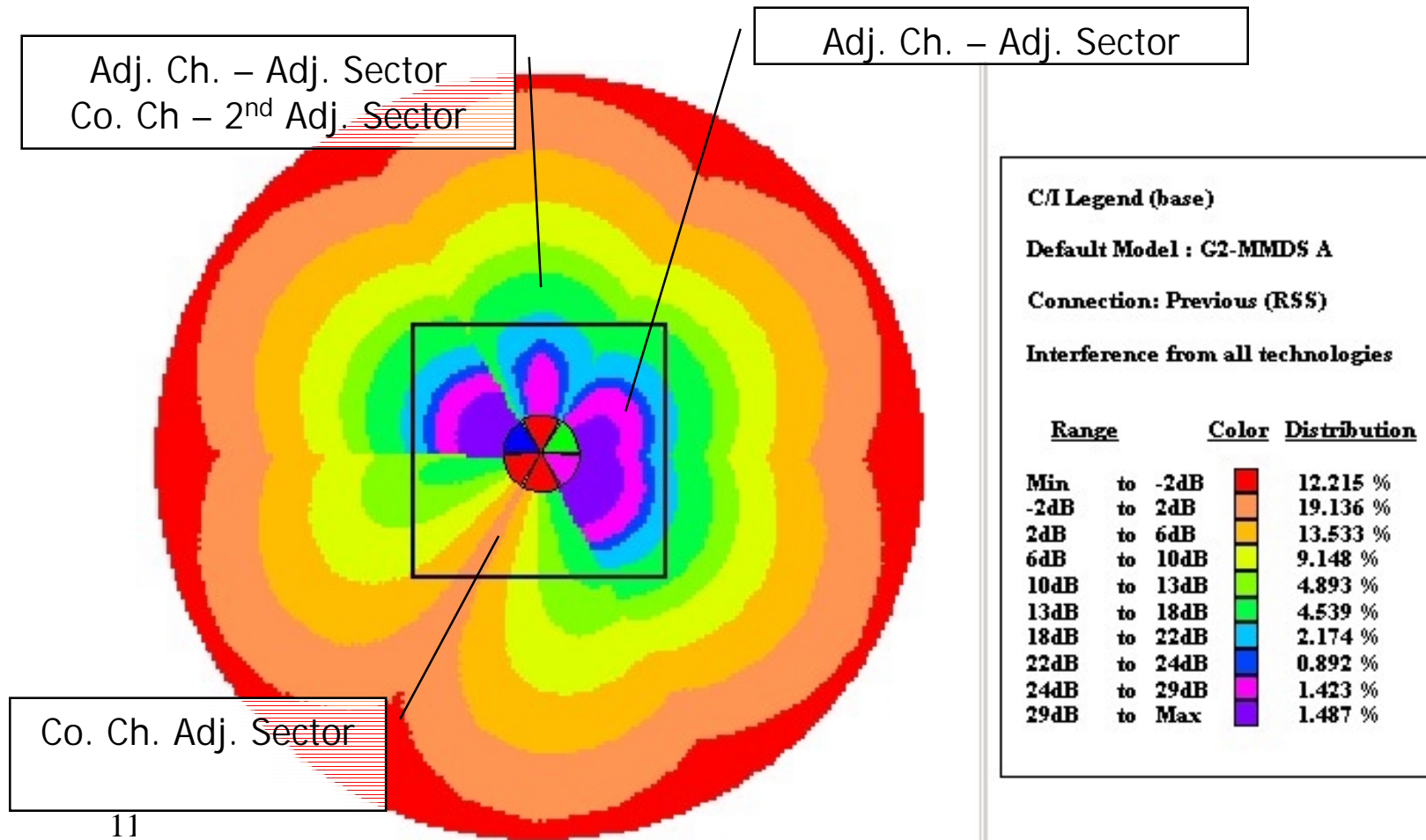
## RSS Legend (base)

Default Model : G2-MMDS A

Connection: Previous (RSS)

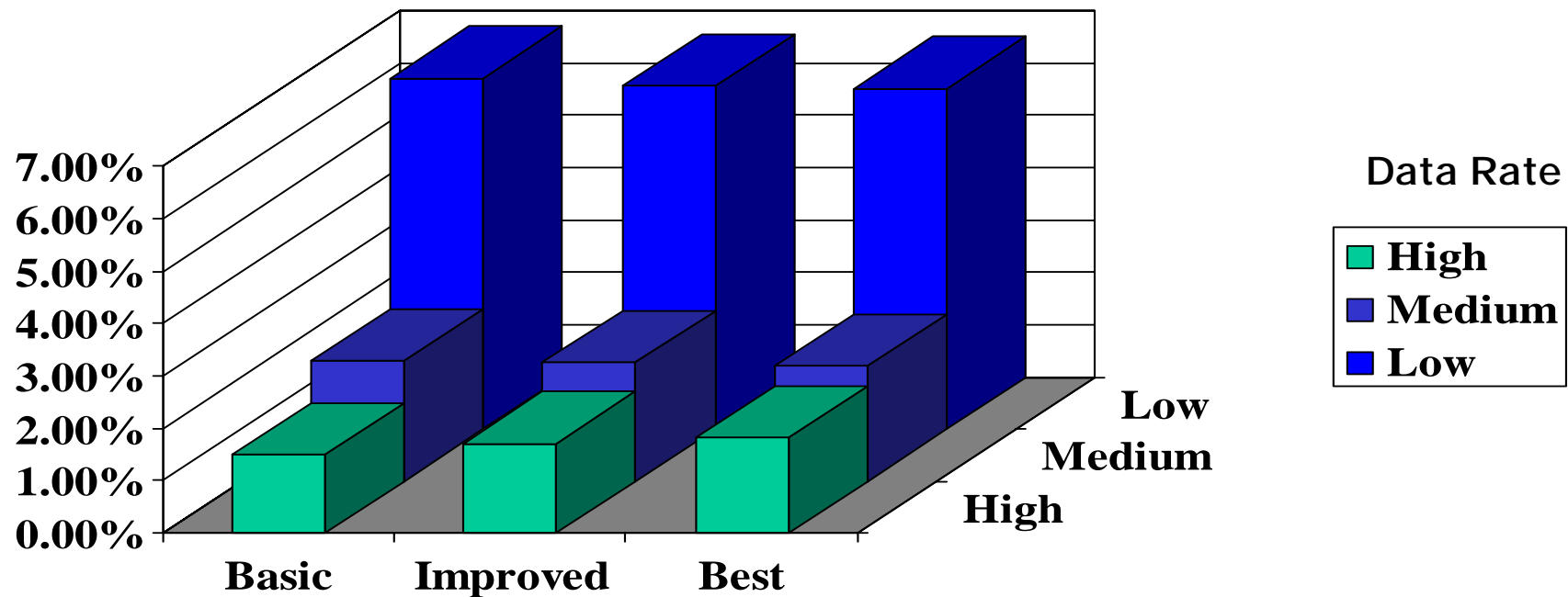
<u>Range</u>	<u>Color</u>	<u>Distribution</u>
Min to -103dB	Red	11.172 %
-103dB to -99dB	Orange	17.717 %
-99dB to -95dB	Yellow	12.341 %
-95dB to -91dB	Light Green	8.573 %
-91dB to -88dB	Green	4.701 %
-88dB to -83dB	Cyan	5.428 %
-83dB to -79dB	Blue	2.886 %
-79dB to -75dB	Purple	1.998 %
-75dB to -72dB	Dark Purple	1.107 %
-72dB to Max	Pink	3.518 %

# Single Cell Coverage Effects of Interference



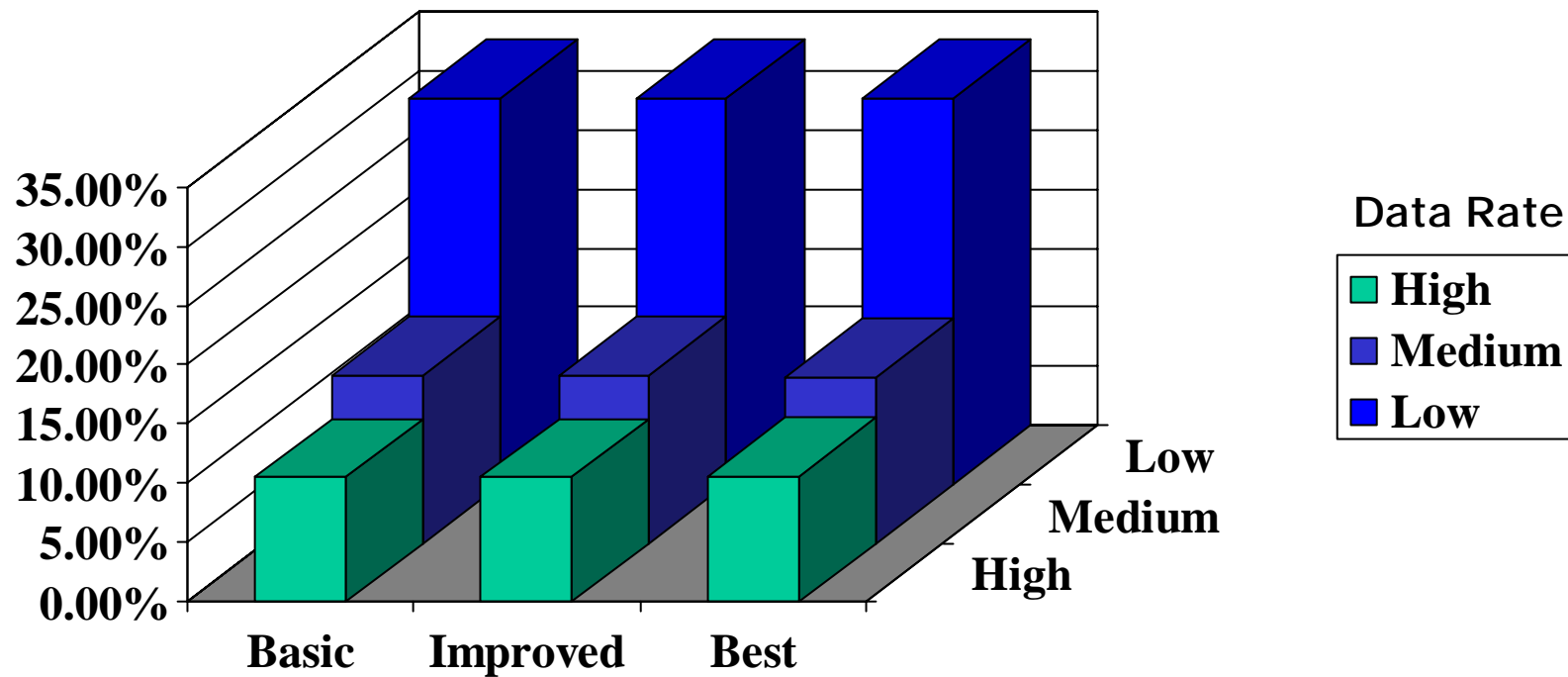
# Single Cell Coverage

## Effects of Adjacent Channel Rejection

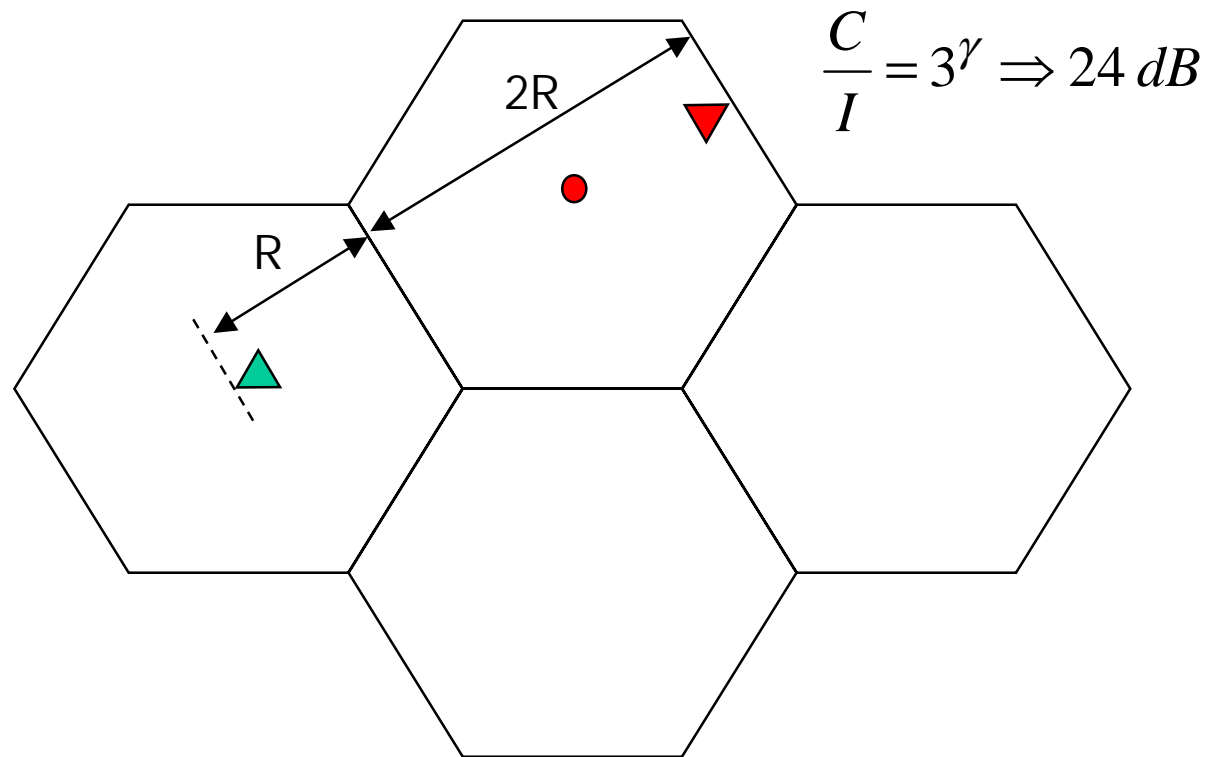


# OFDMA Single Cell – Single Sub Channel

## Effects of Adjacent Channel Rejection

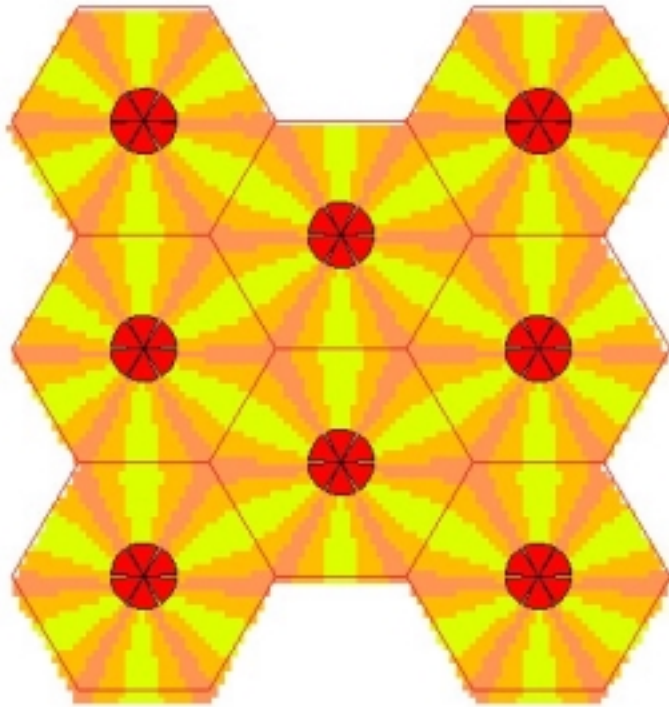


# Multi-Site Coverage

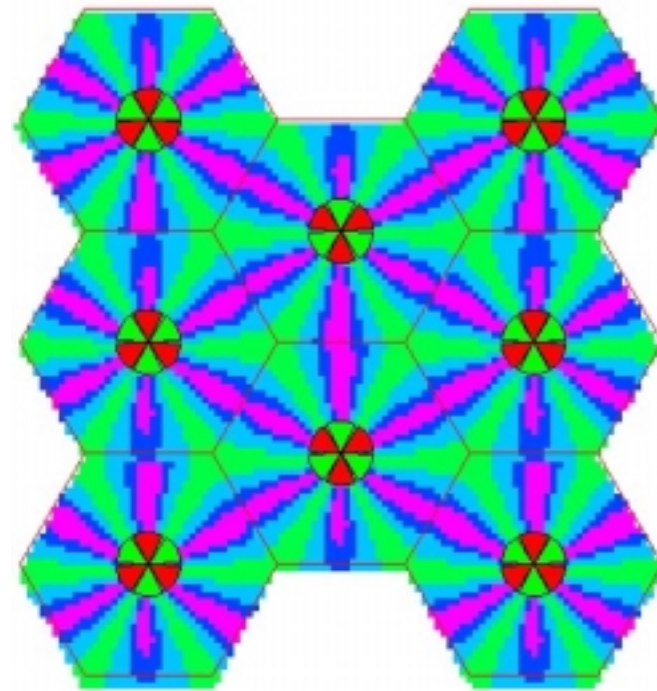


# Coverage Patterns

## 1 frequency, 2 frequencies



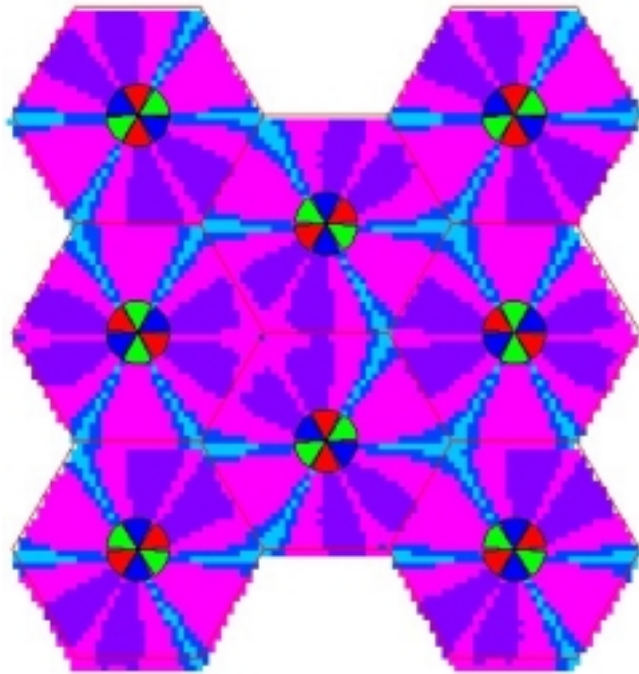
1 Frequency  
 $C/I = 2 - 10$  dB



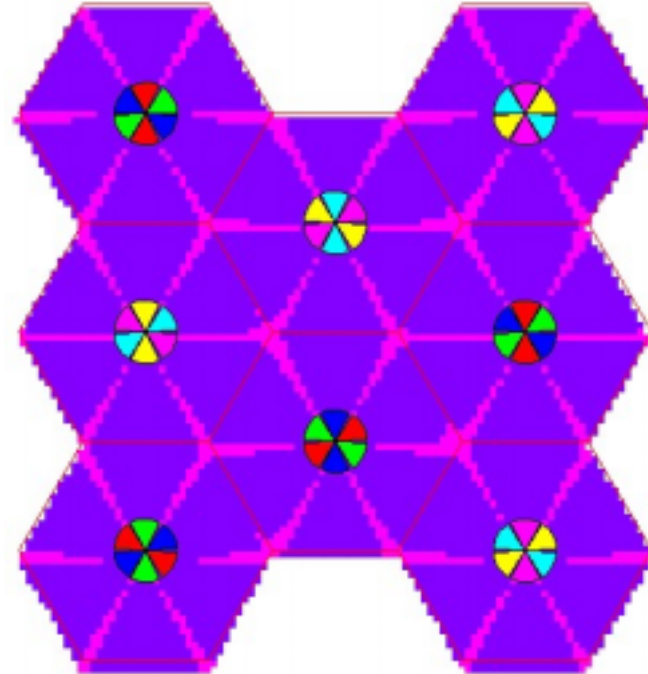
2 Frequencies  
 $C/I = 10 - 29$  dB

# Coverage Patterns

3 frequencies, 6 frequencies



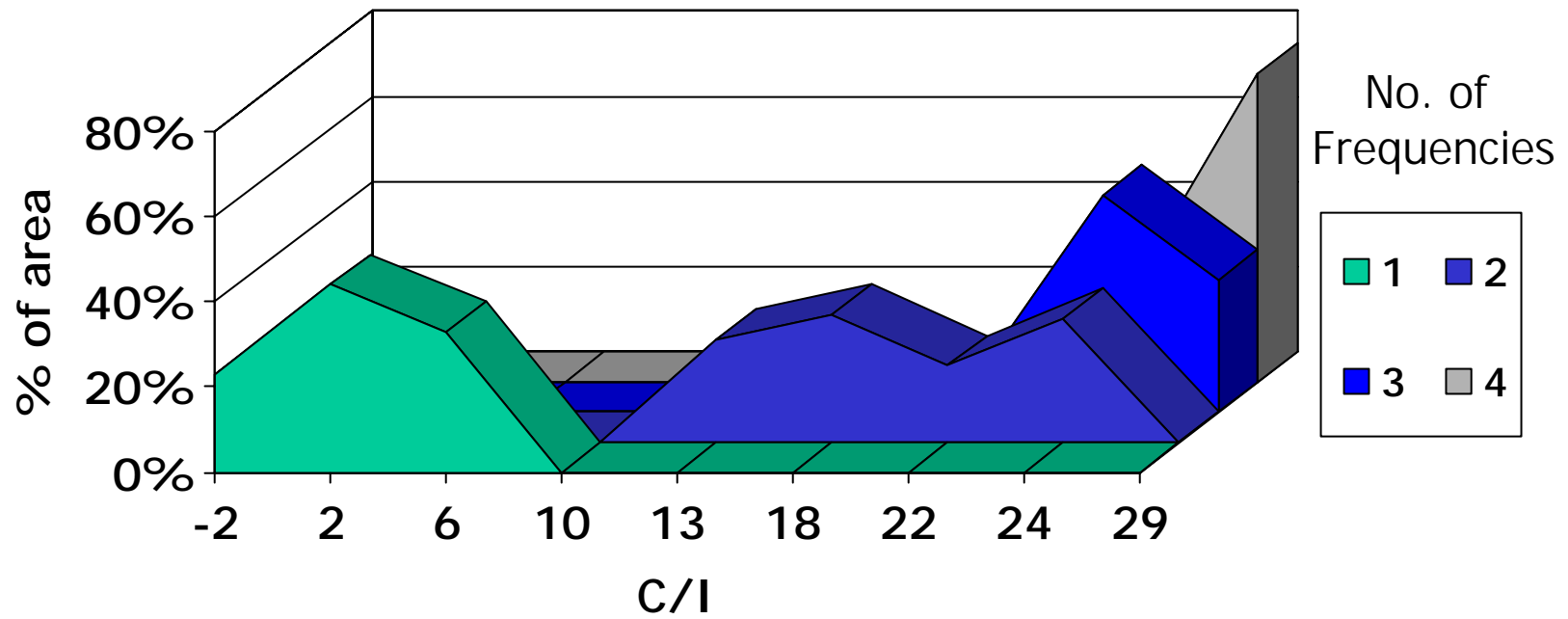
3 Frequencies  
C/I = 18-30 dB



6 Frequencies  
C/I = 22-30+ dB



# C/I Distribution

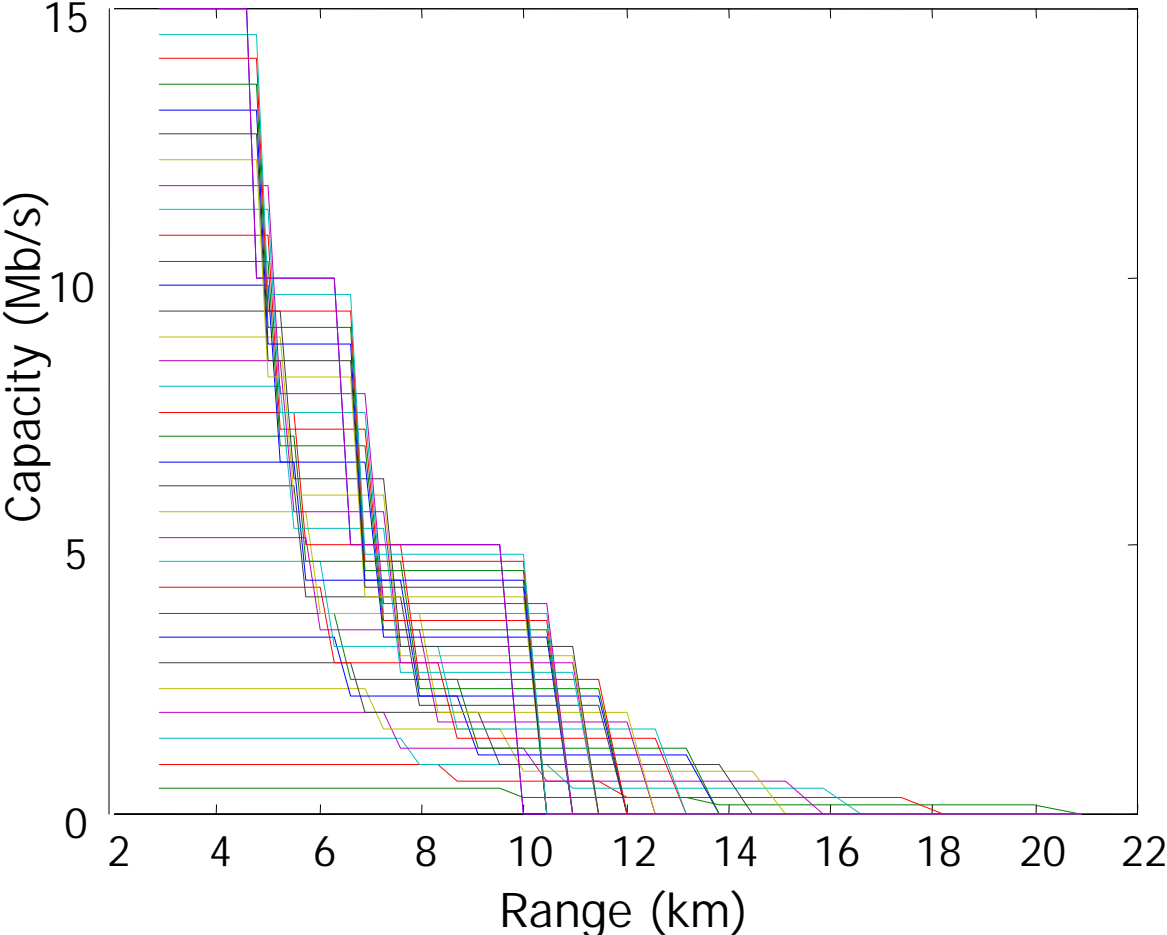


2km Cells – Improved Case

# Resource Management with OFDMA

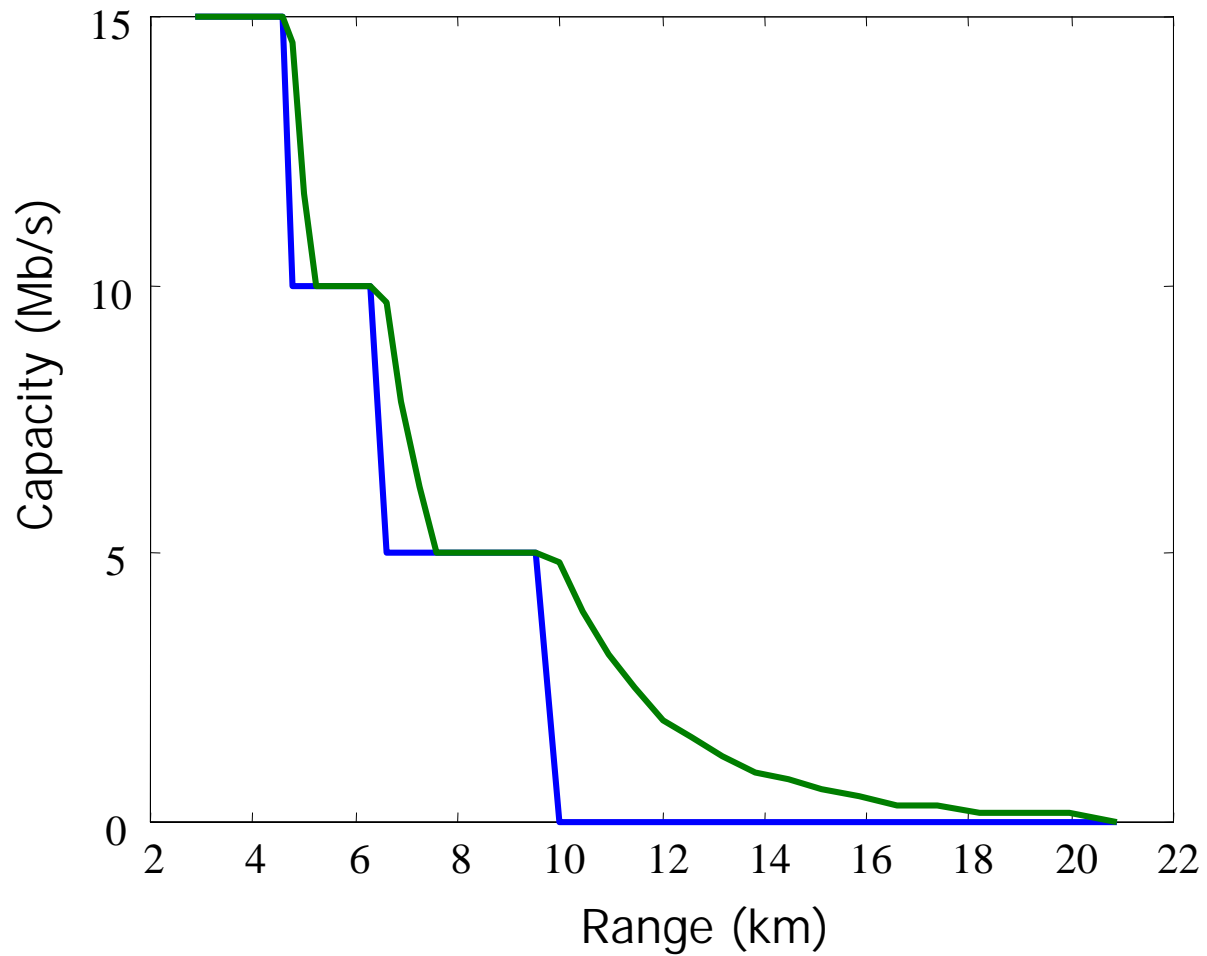
- Low C/I – single frequency case
  - Split the band
    - 2 distinct sets – 16 sub-channels
    - 3 distinct sets – 10 sub-channels
  - Managing channels in adjacent sectors – statistical multiplexing gain
- Downlink
  - Allocate power to low-C/I links on expense of others
- Uplink
  - Use higher bit rate on a limited number of sub-channels.

# OFDMA Range



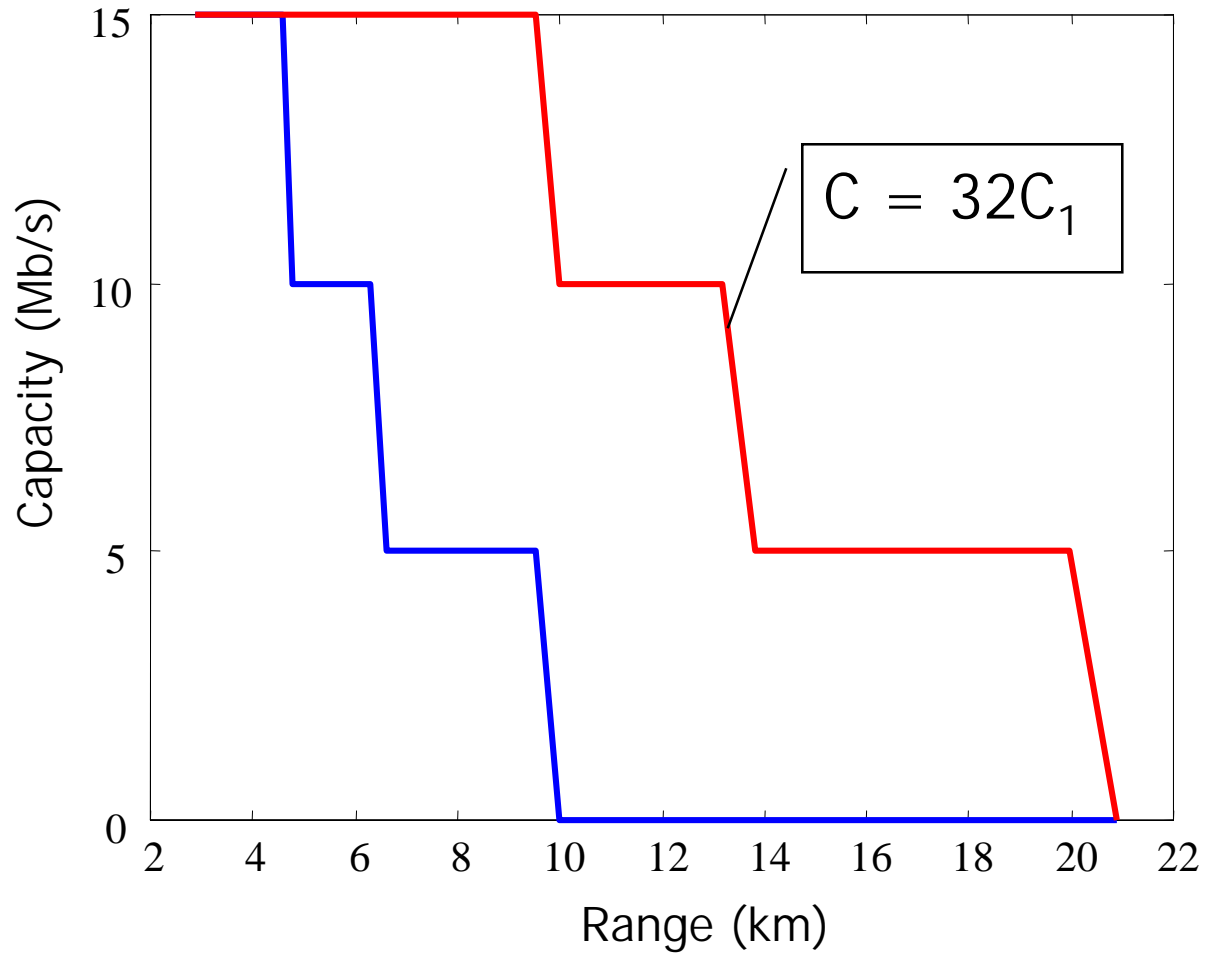
# OFDMA vs. TDMA Range

For one subscriber

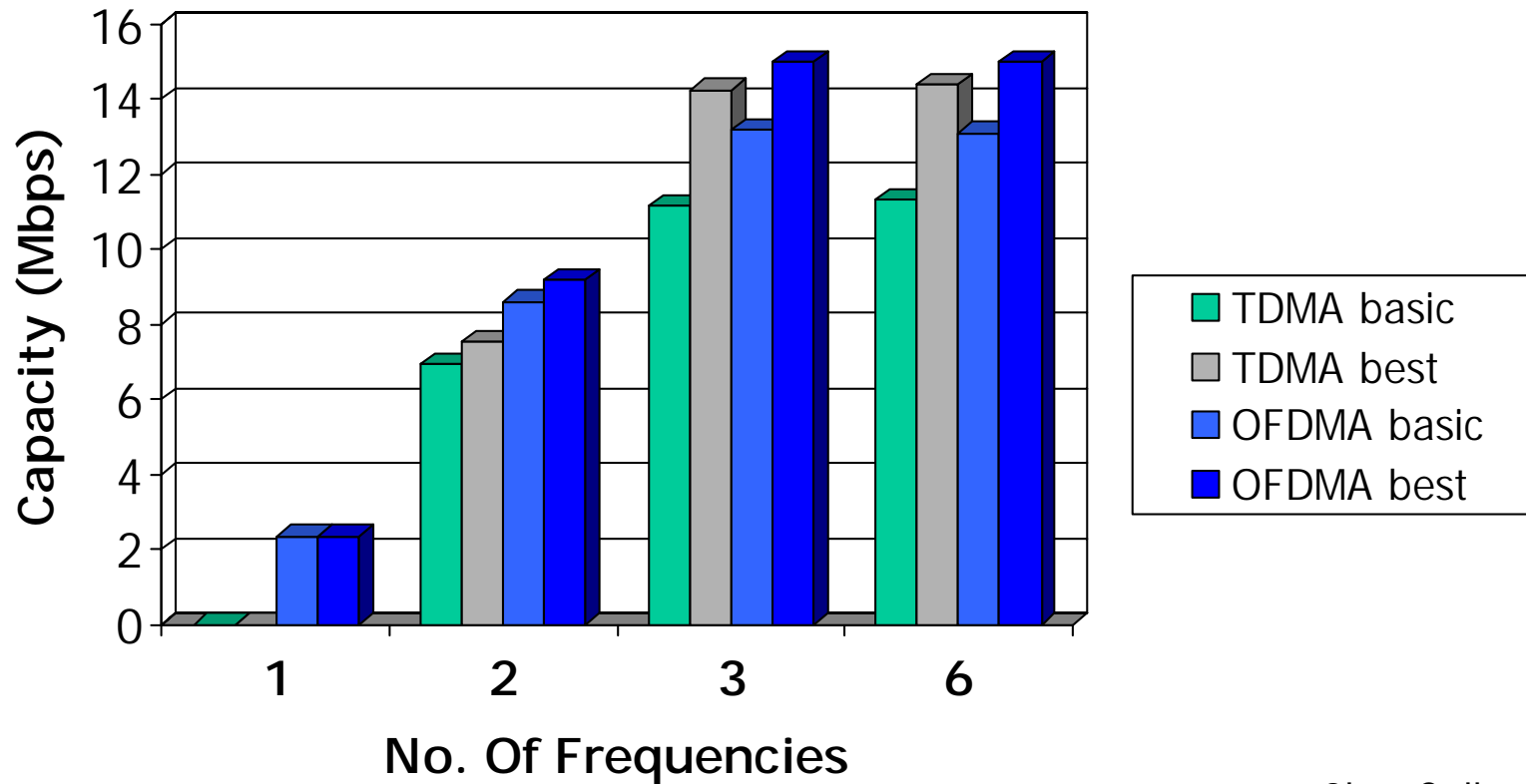


# OFDMA vs. TDMA Range

## Uplink Aggregated Capacity Envelope



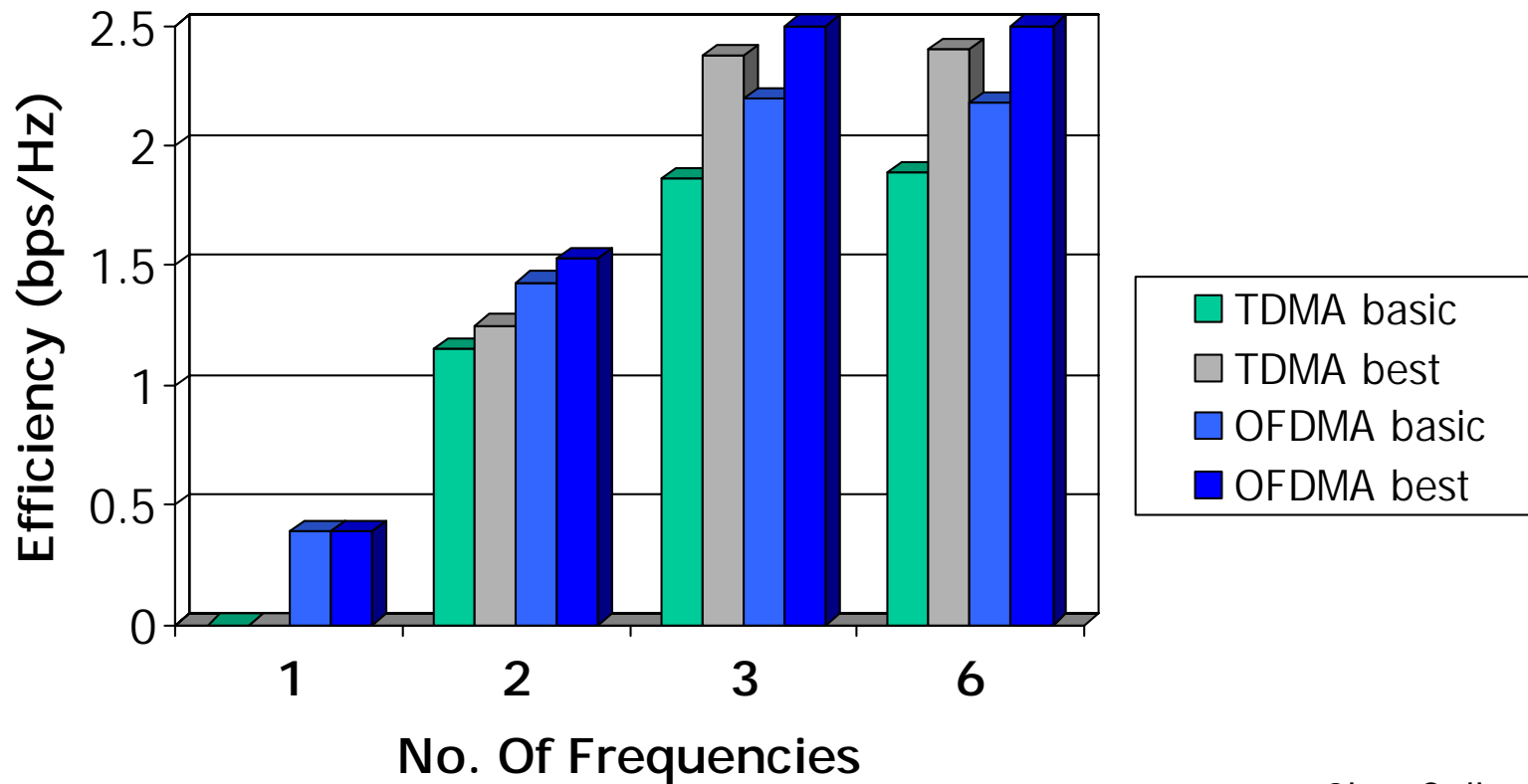
# Average Capacity Downlink



2km Cells

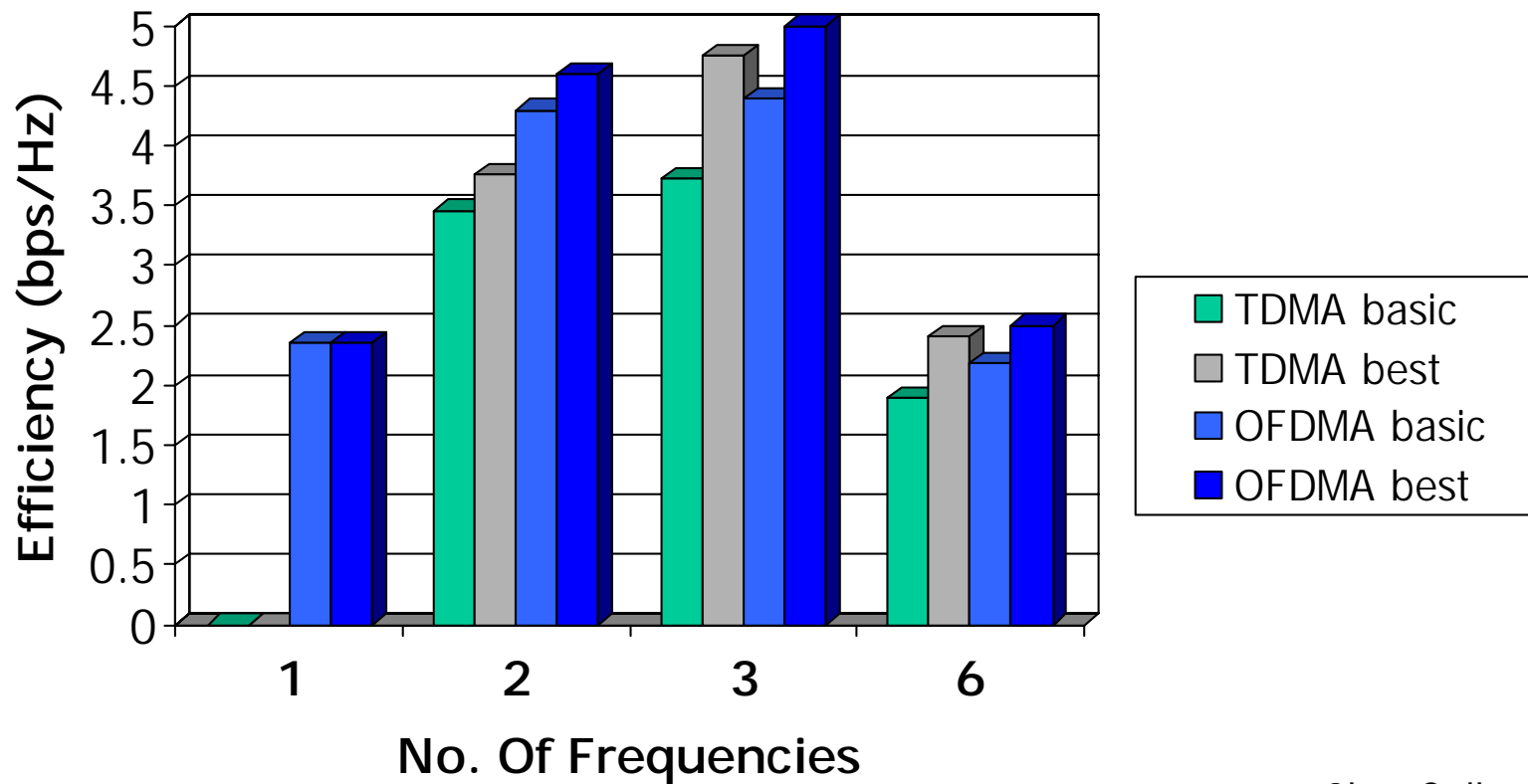
# Spectral Efficiency (bps/Hz)

## Downlink



2km Cells

# System Spectral Efficiency (bps/Hz/cell) Downlink



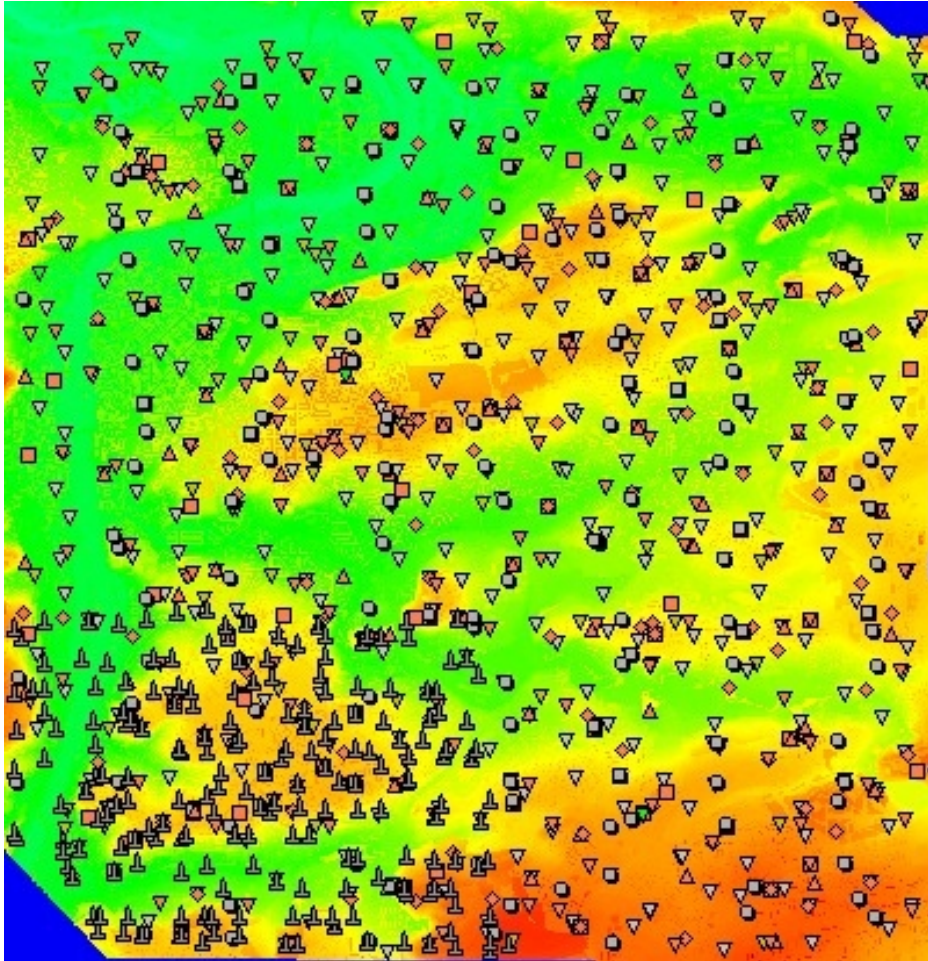
2km Cells



## Further work

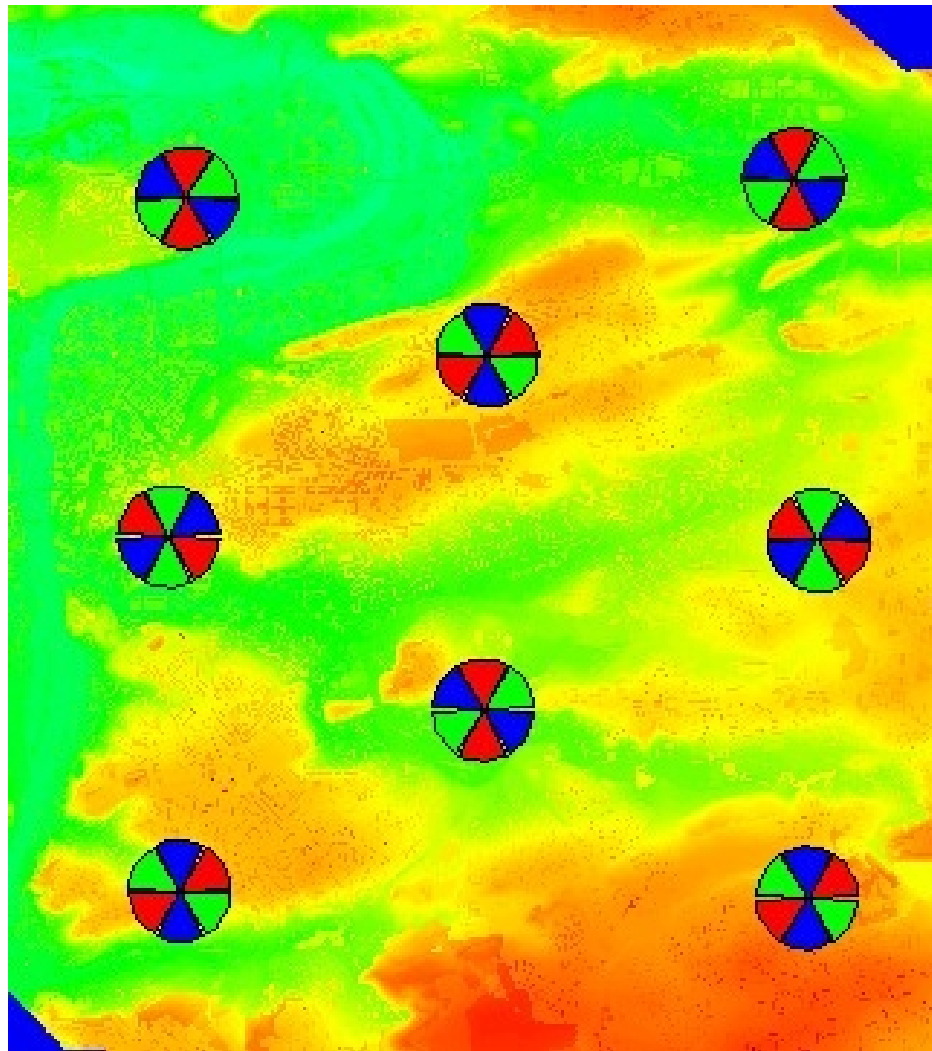
- Use realistic scenarios
- Estimate favorable vs. non-favorable scenarios for OFDMA
- Estimate the contribution of wide sector statistical multiplexing
- Advanced antenna techniques
- Additional data for further analysis

# Real Scenarios

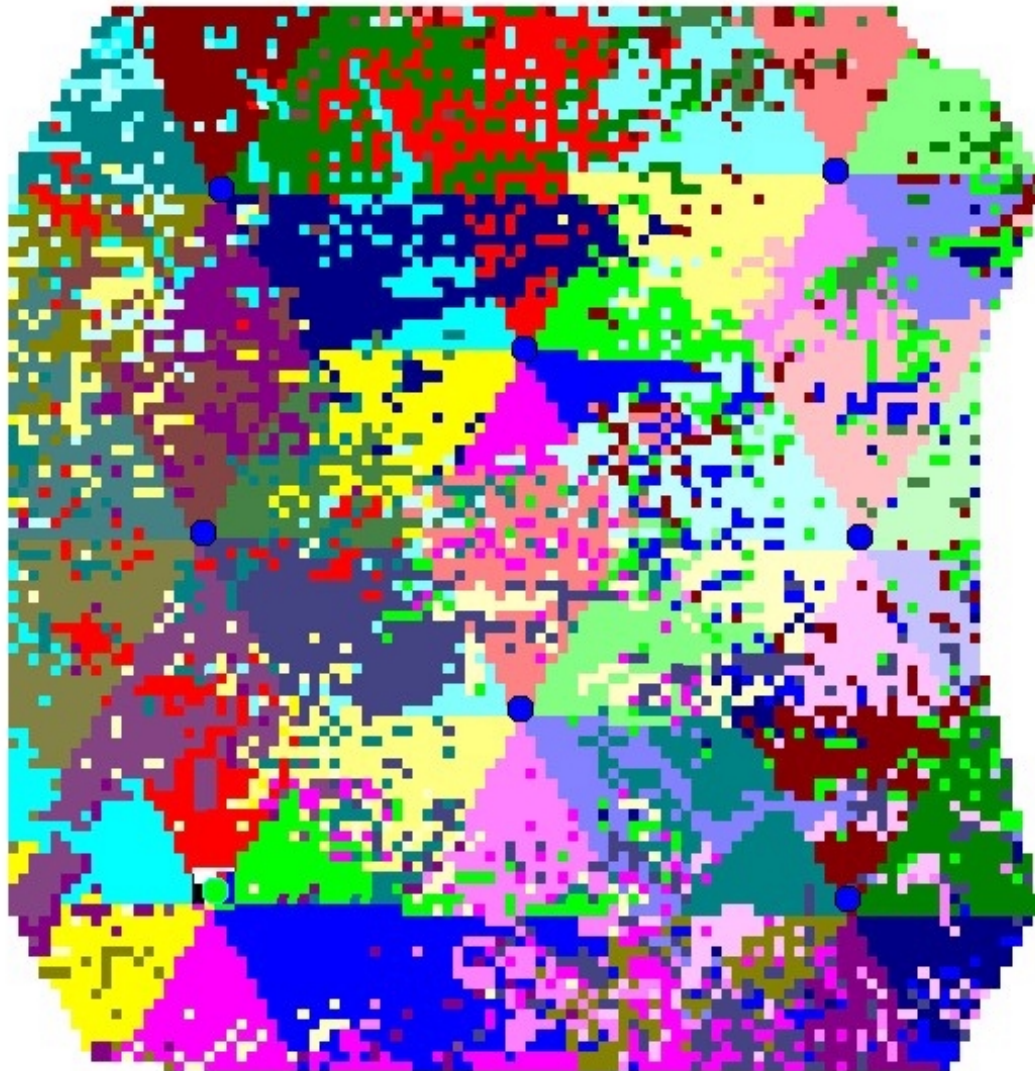


- Terrain data
- Customer types
- Customer distribution

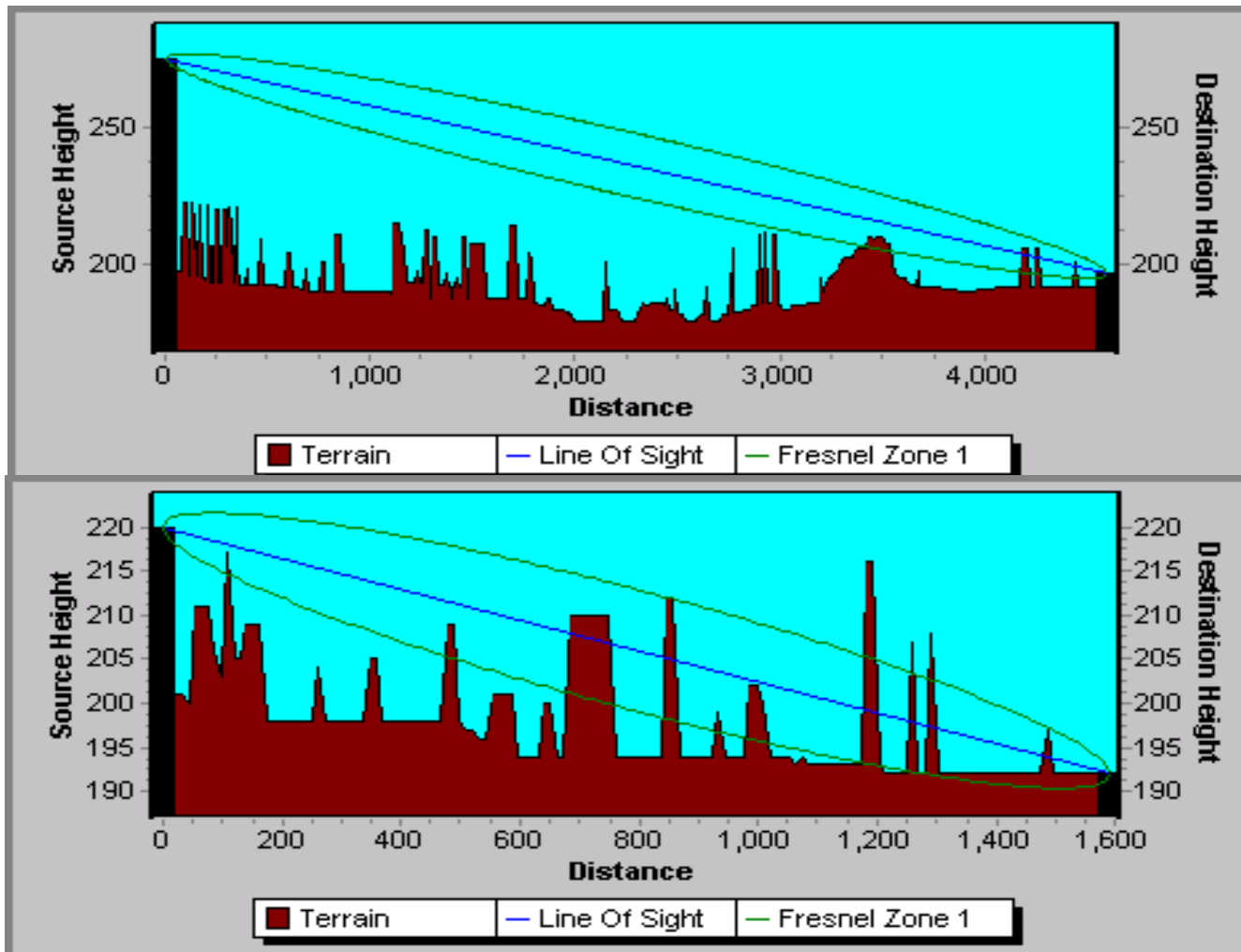
# Base Stations



# Customers Connections



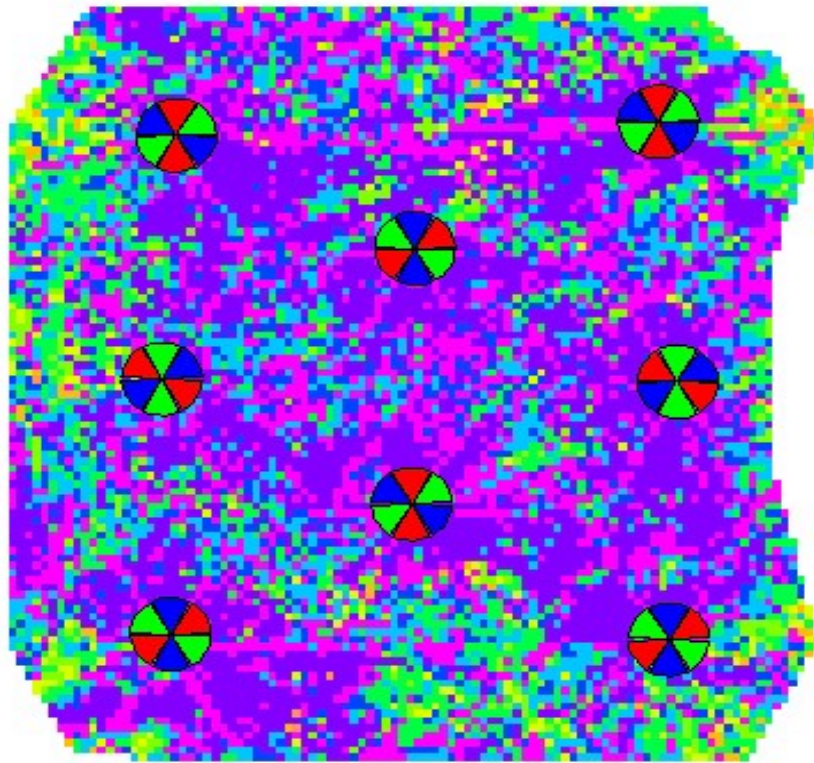
# Path Profiles













Far  
base station

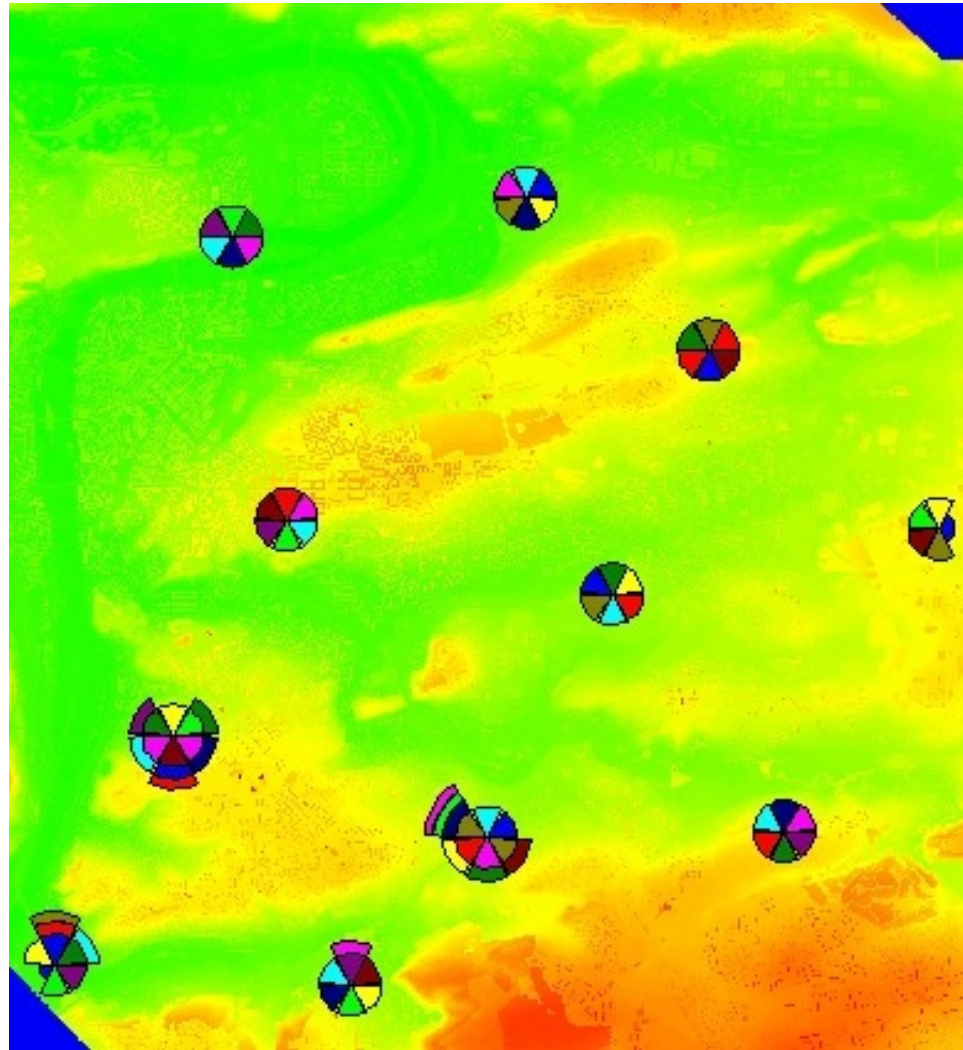
Near  
base station

# C/(I+N) Map

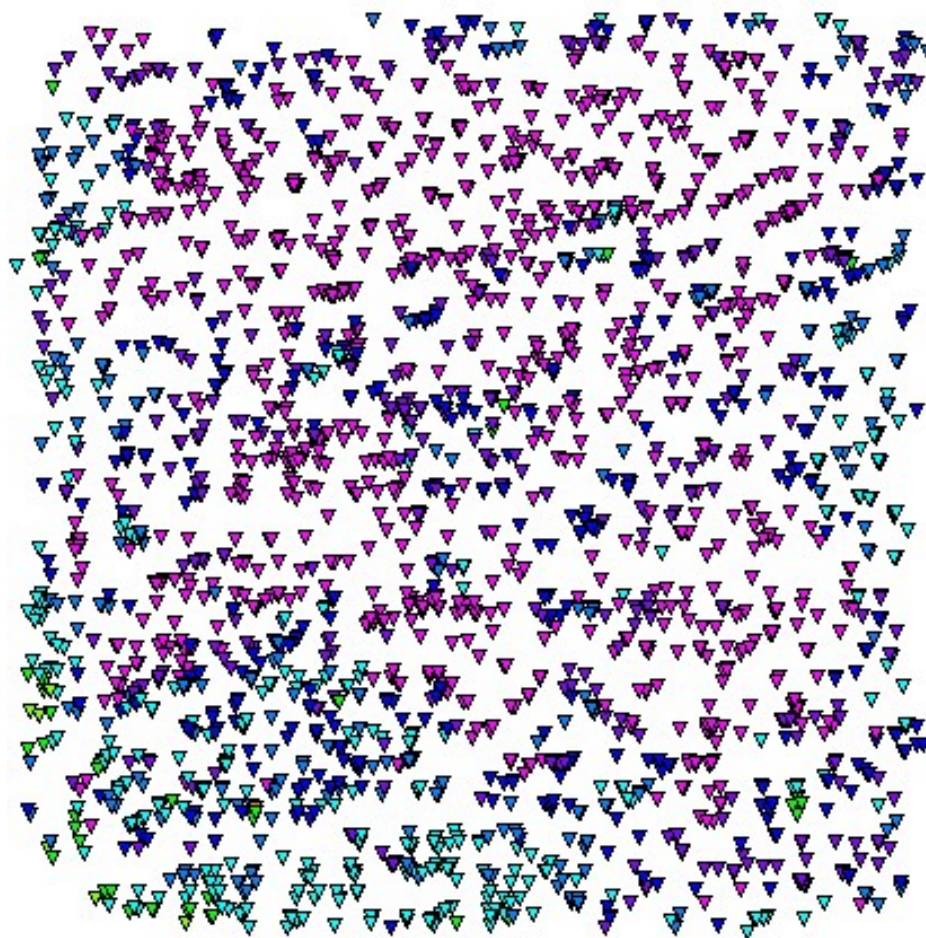


<u>Range</u>	<u>Color</u>	<u>Distribution</u>
Min to -2dB		0 %
-2dB to 2dB		0.052 %
2dB to 6dB		0.773 %
6dB to 10dB		2.267 %
10dB to 13dB		4.107 %
13dB to 18dB		12.812 %
18dB to 22dB		13.47 %
22dB to 24dB		8.715 %
24dB to 29dB		24.192 %
29dB to Max		33.608 %

# Base station and frequency allocation



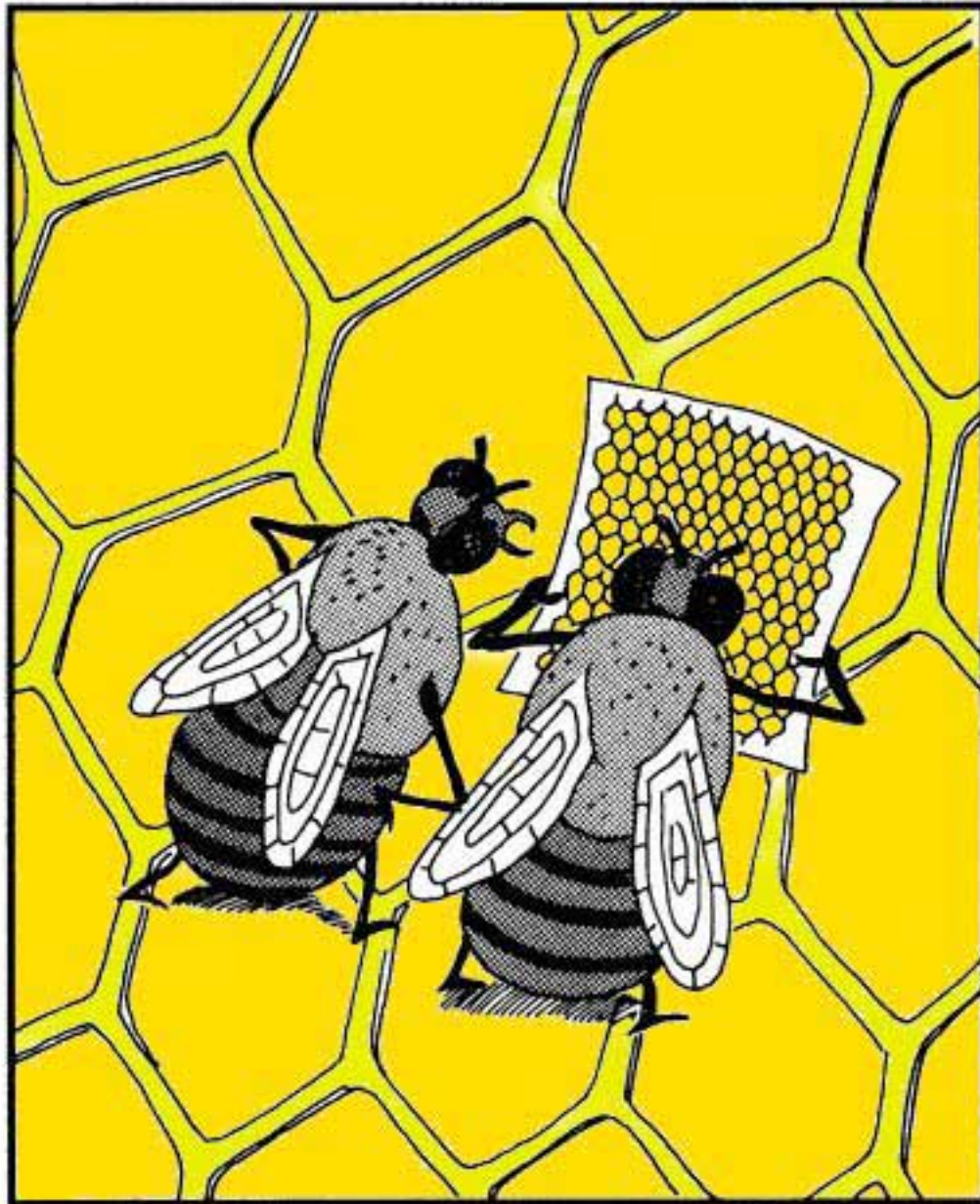
# C/I



**Customers C/I**  
**Default Model : JRC**

▼ Min To -2	(0)
▼ -2 To 2	(1)
▼ 2 To 6	(0)
▼ 6 To 10	(8)
▼ 10 To 14	(73)
▼ 14 To 20	(532)
▼ 20 To 24	(402)
▼ 24 To 28	(606)
▼ 28 To 32	(650)
▼ 32 To Max	(1328)





So, Where are we exactly?

# Conclusions

- OFDMA can provide extended range and capacity over TDMA
- OFDMA is capable to work in conditions where TDMA cannot
- Adjacent channel rejection is important and provides extra capacity in some scenarios
- System spectrum efficiency is an important tool for system evaluation