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

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

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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

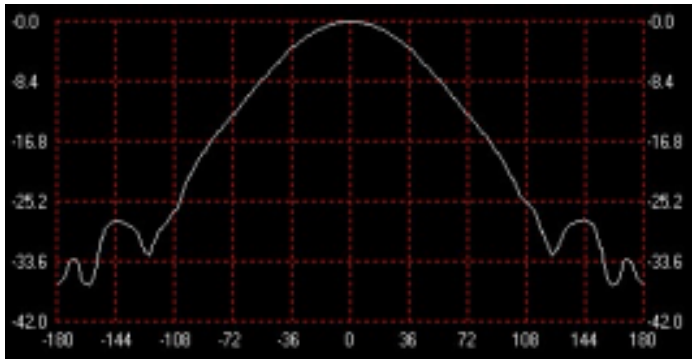
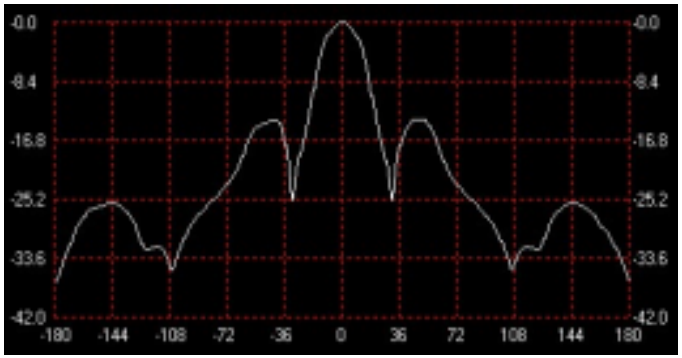
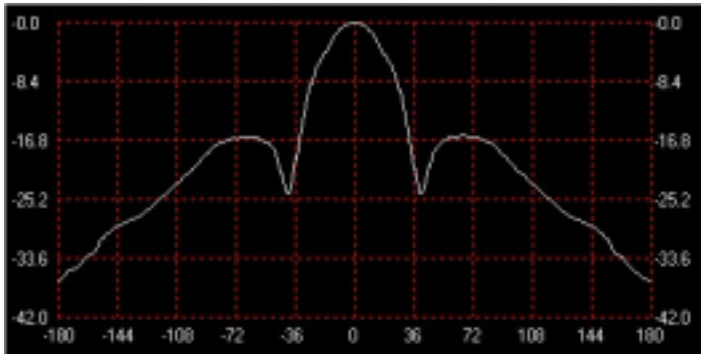
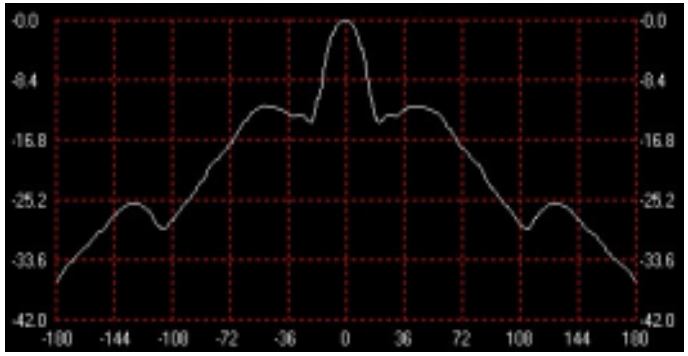
- As per IEEE 802.16.3c-01_29r1
  - Terrain type : A
  - Base station antenna height: 20m
  - Terminal station antenna height: 5m
  - $\gamma = 5.08$

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

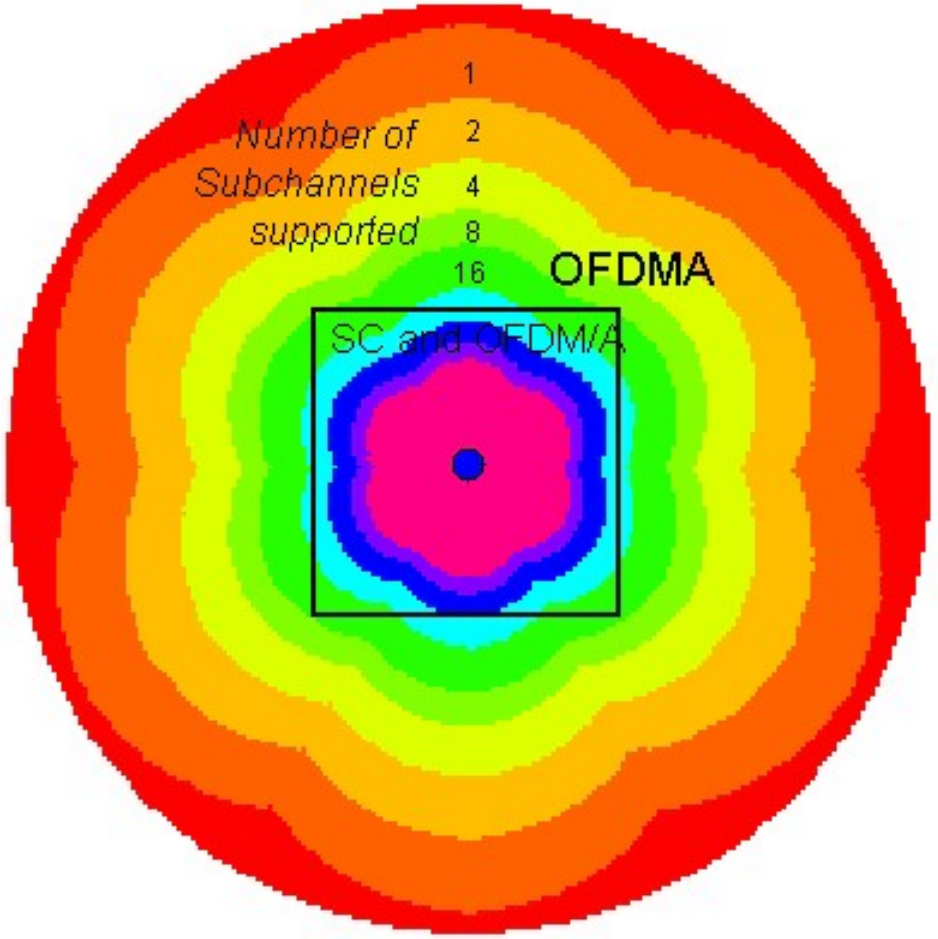
Antenna Patterns

	Azimuth	Elevation
BS		
CPE		

Adjacent Channel Rejection

	Basic	“Improved”	“Best”
Adjacent	22 dB	27 dB	40 dB
2nd adjacent	40 dB	50 dB	60 dB
3rd adjacent	50 dB	60 dB	80 dB

Single Cell Coverage



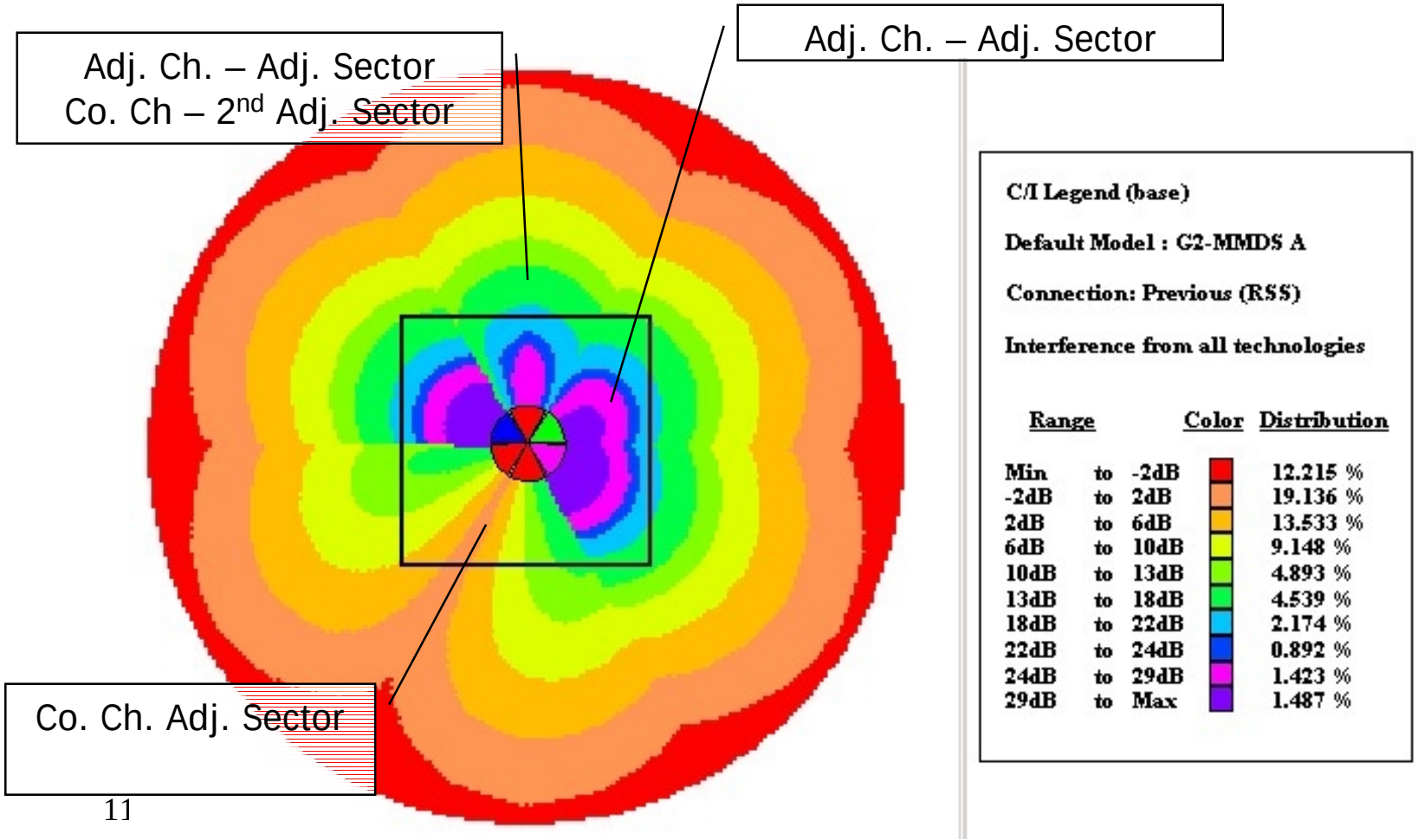
RSS Legend (base)

Default Model : G2-MMDS A

Connection: Previous (RSS)

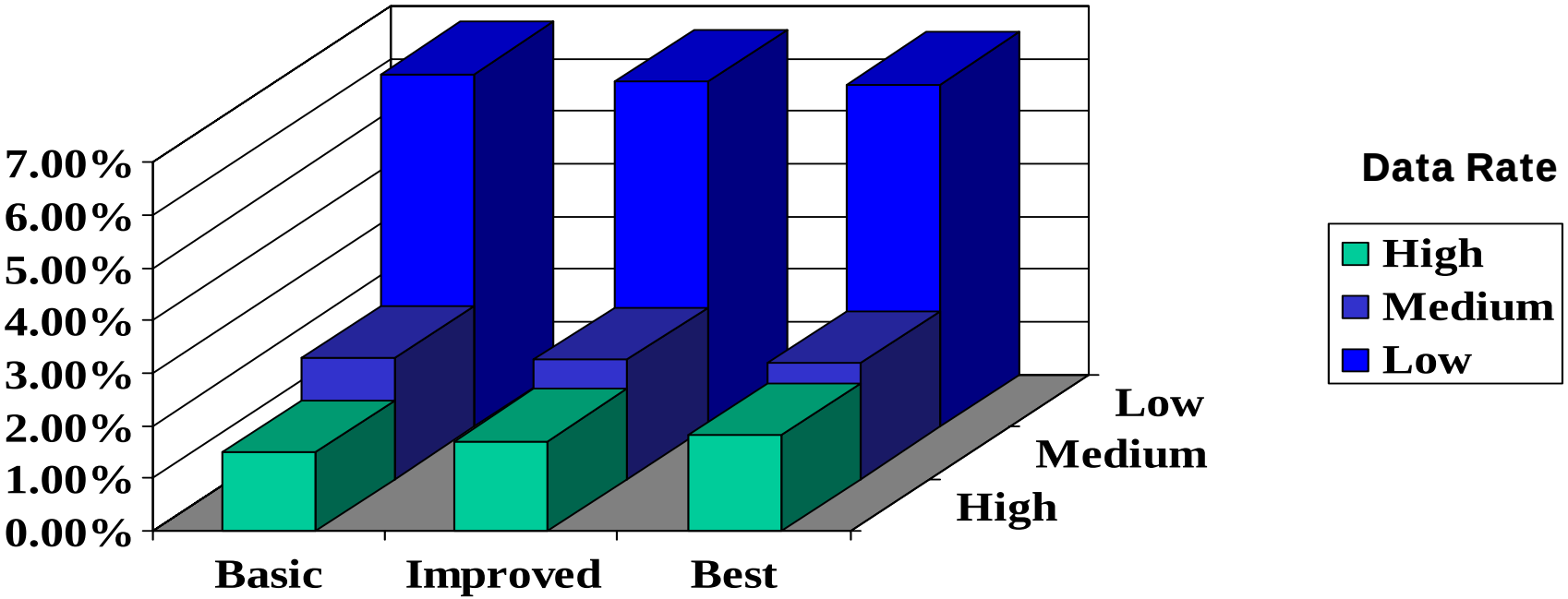
Range			Color	Distribution
Min	to	-103dB		11.172 %
-103dB	to	-99dB		17.717 %
-99dB	to	-95dB		12.341 %
-95dB	to	-91dB		8.573 %
-91dB	to	-88dB		4.701 %
-88dB	to	-83dB		5.428 %
-83dB	to	-79dB		2.886 %
-79dB	to	-75dB		1.998 %
-75dB	to	-72dB		1.107 %
-72dB	to	Max		3.518 %

Single Cell Coverage
Effects of Interference

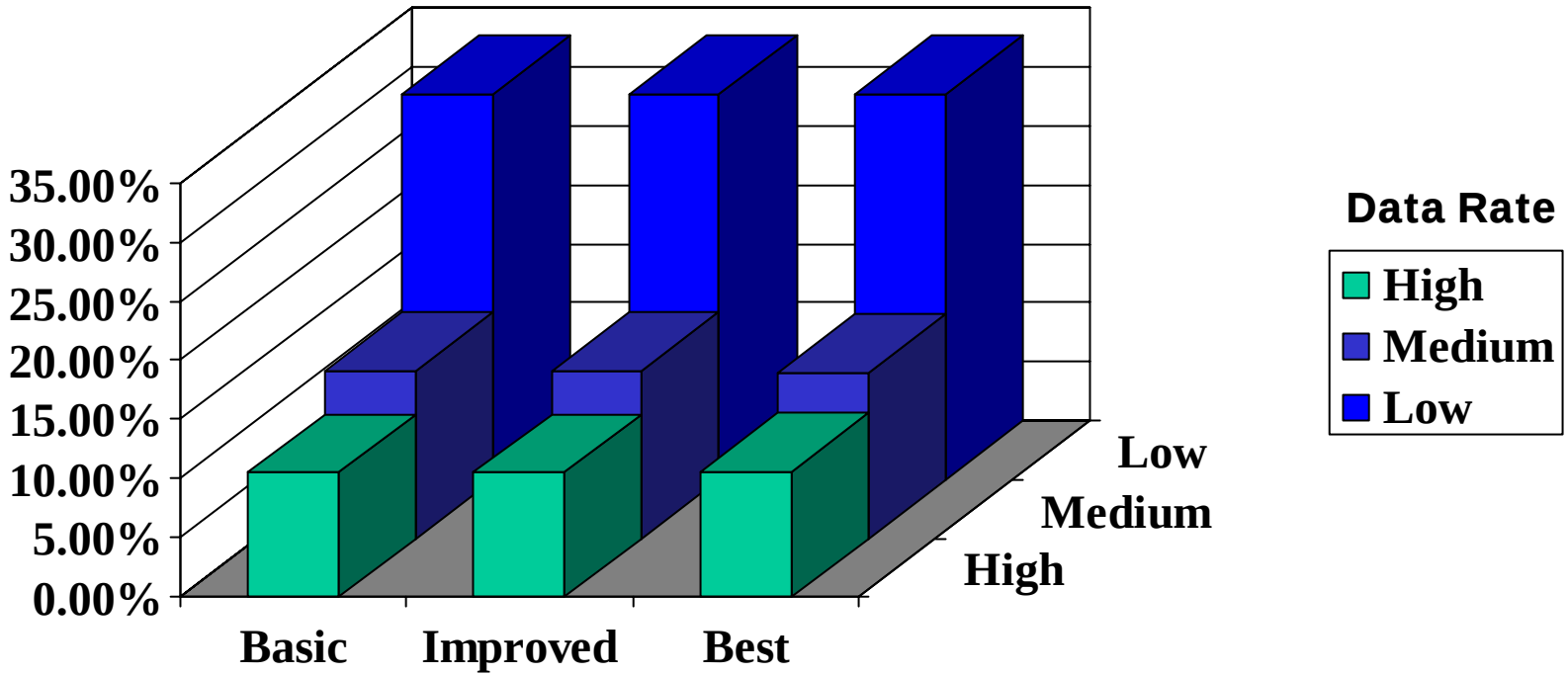


Single Cell Coverage

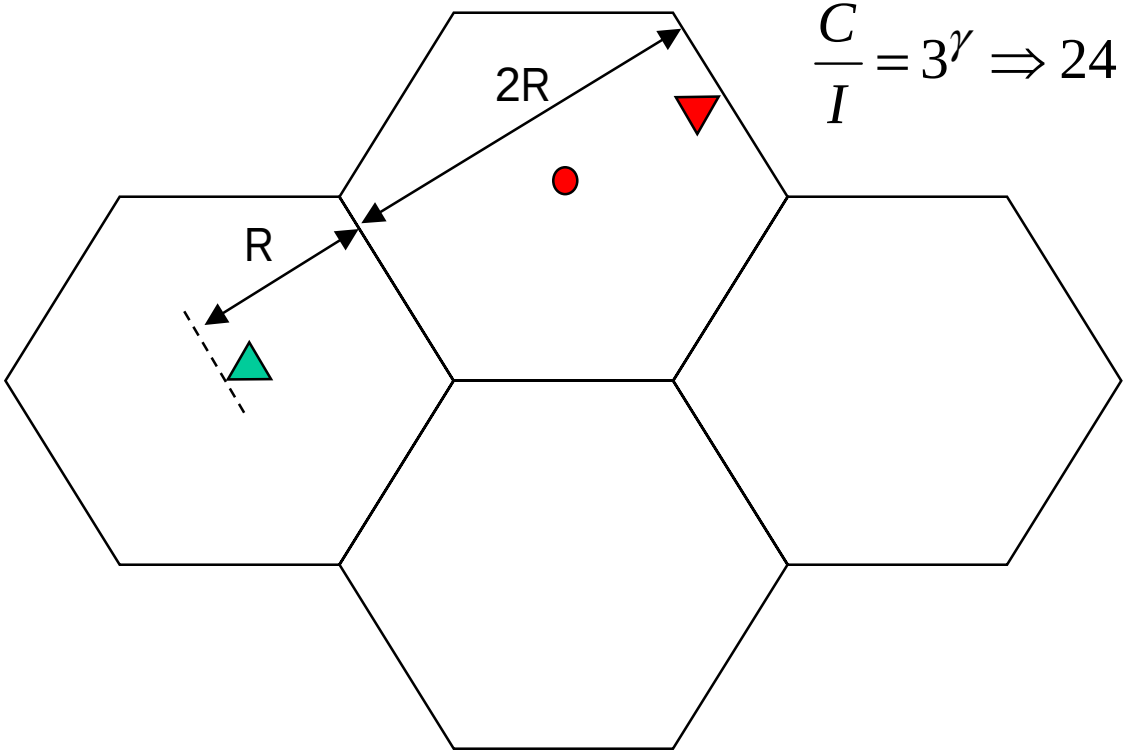
Effects of Adjacent Channel Rejection



OFDMA Single Cell – Single Sub Channel
Effects of Adjacent Channel Rejection

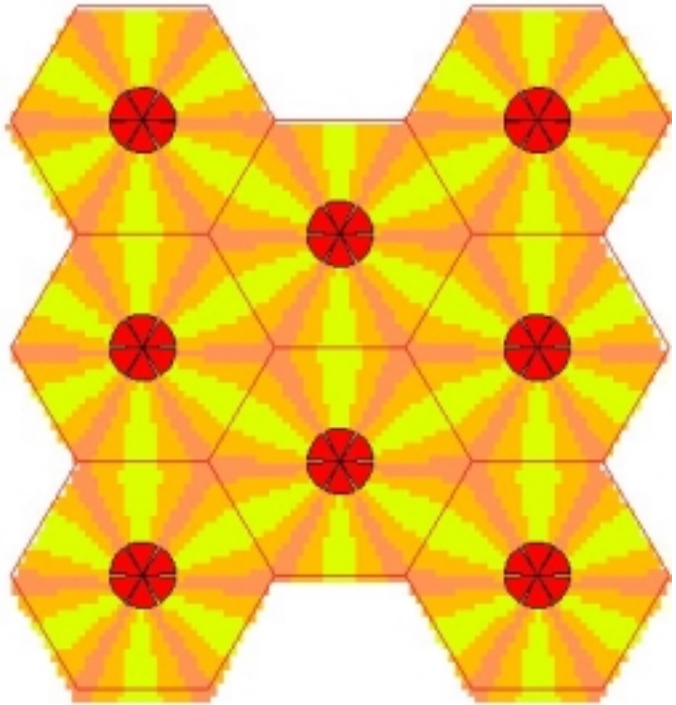


Multi-Site Coverage

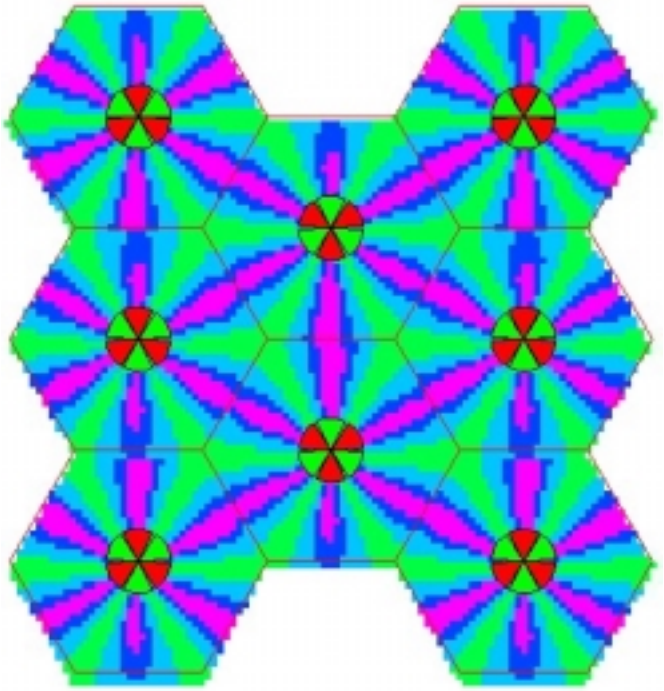


$$\frac{C}{I} = 3^{\gamma} \Rightarrow 24\,dB$$

Coverage Patterns
1 frequency, 2 frequencies

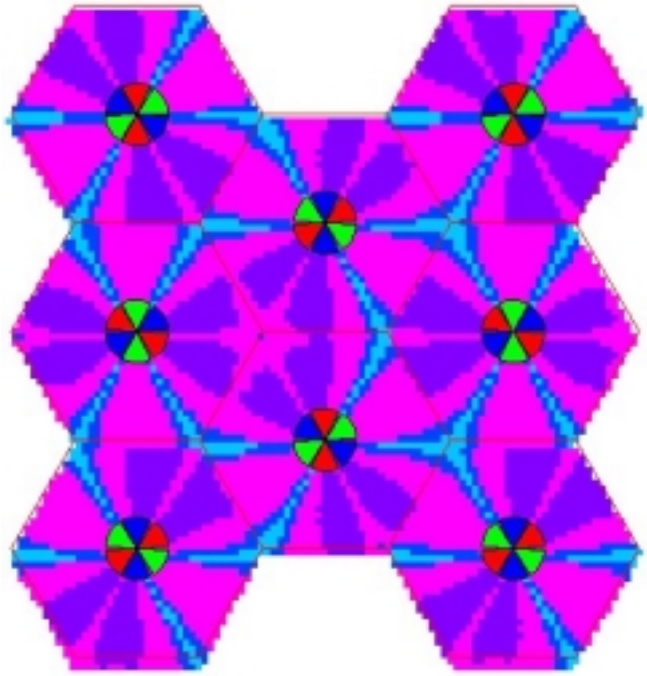


1 Frequency
C/I = 2 - 10 dB

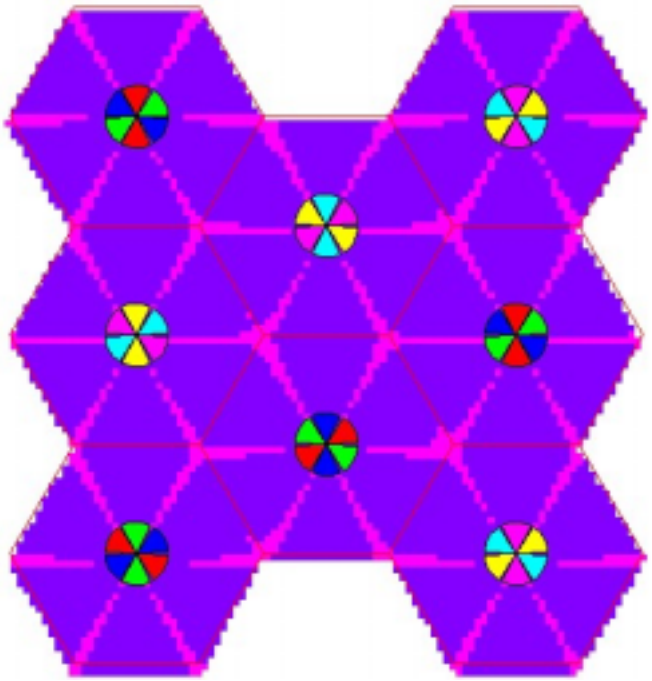


2 Frequencies
C/I = 10 -29 dB

Coverage Patterns
3 frequencies, 6 frequencies

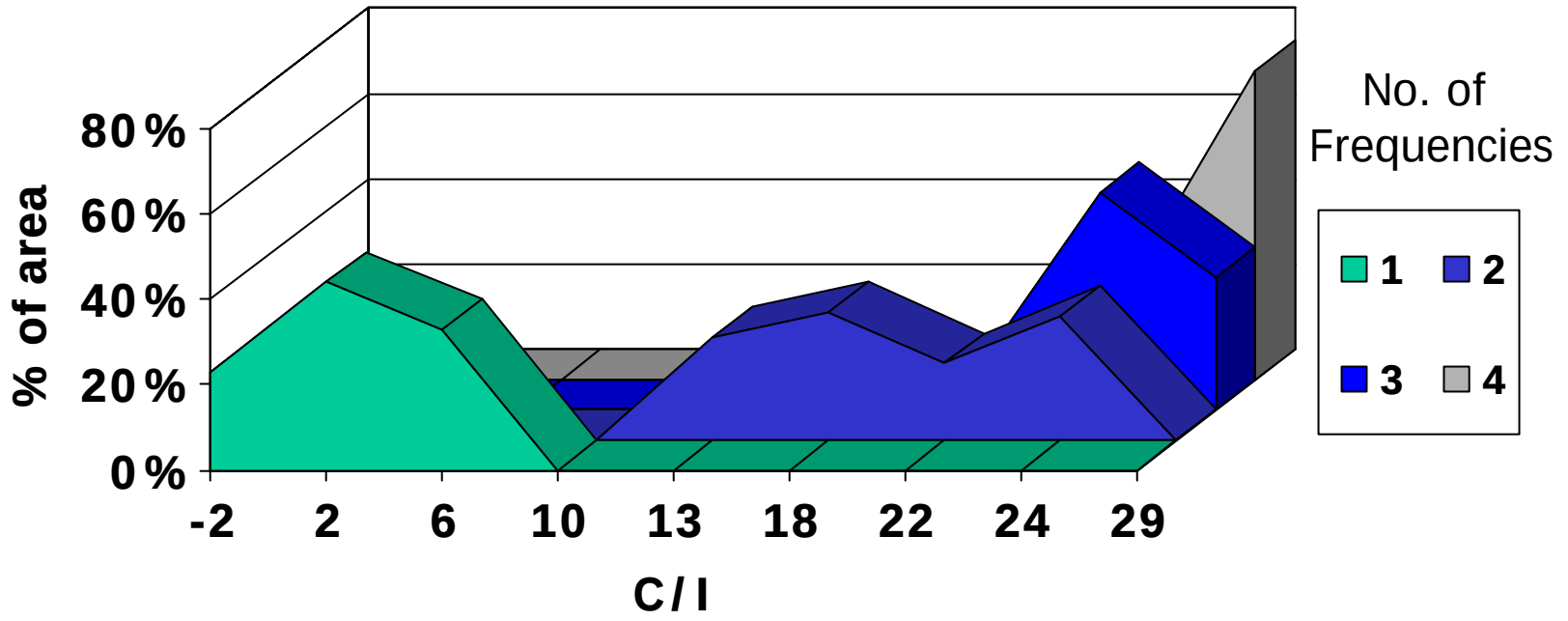


3 Frequencies
C/I = 18-30 dB



6 Frequencies
C/I = 22-30+ dB

C/I Distribution

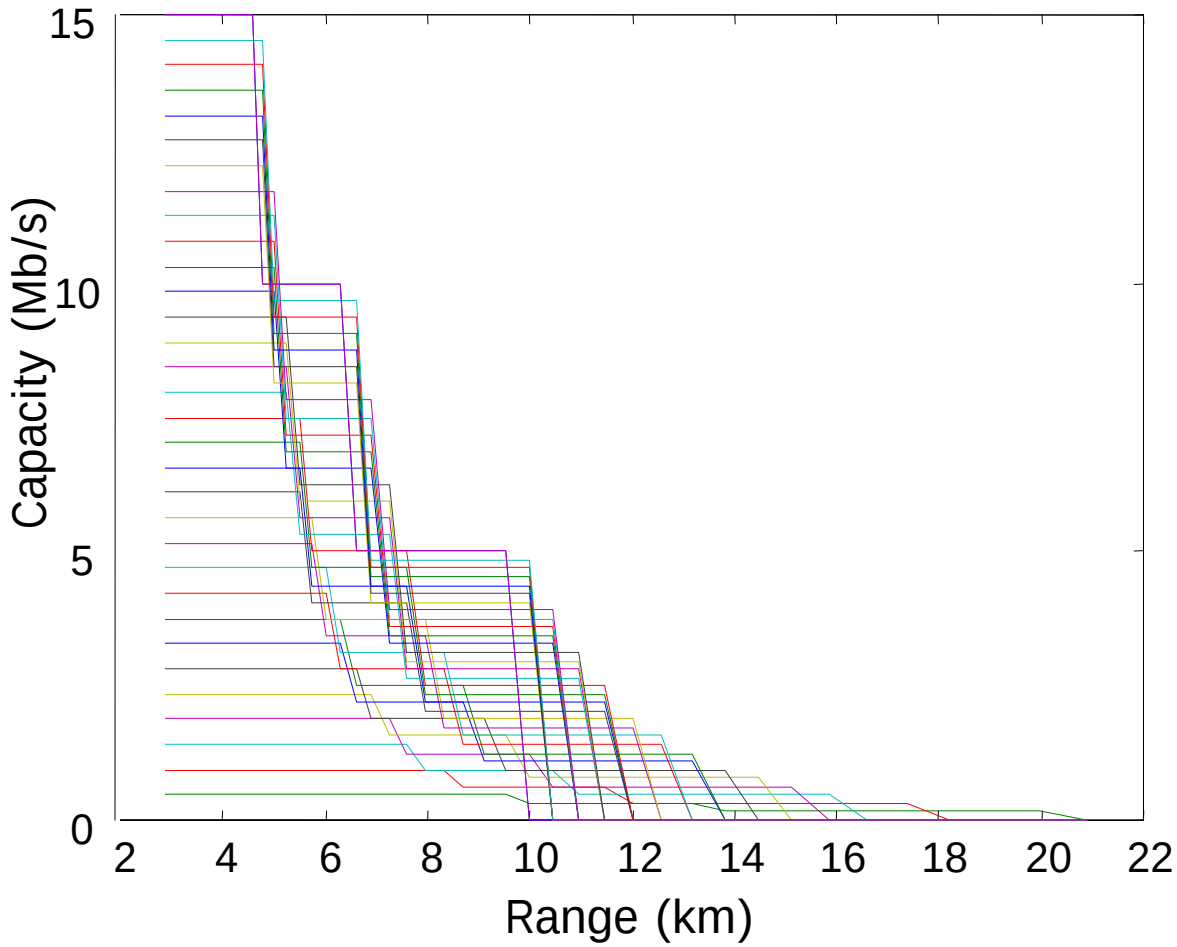


2km Cells – Improved Case

Resource Management with OFDMA

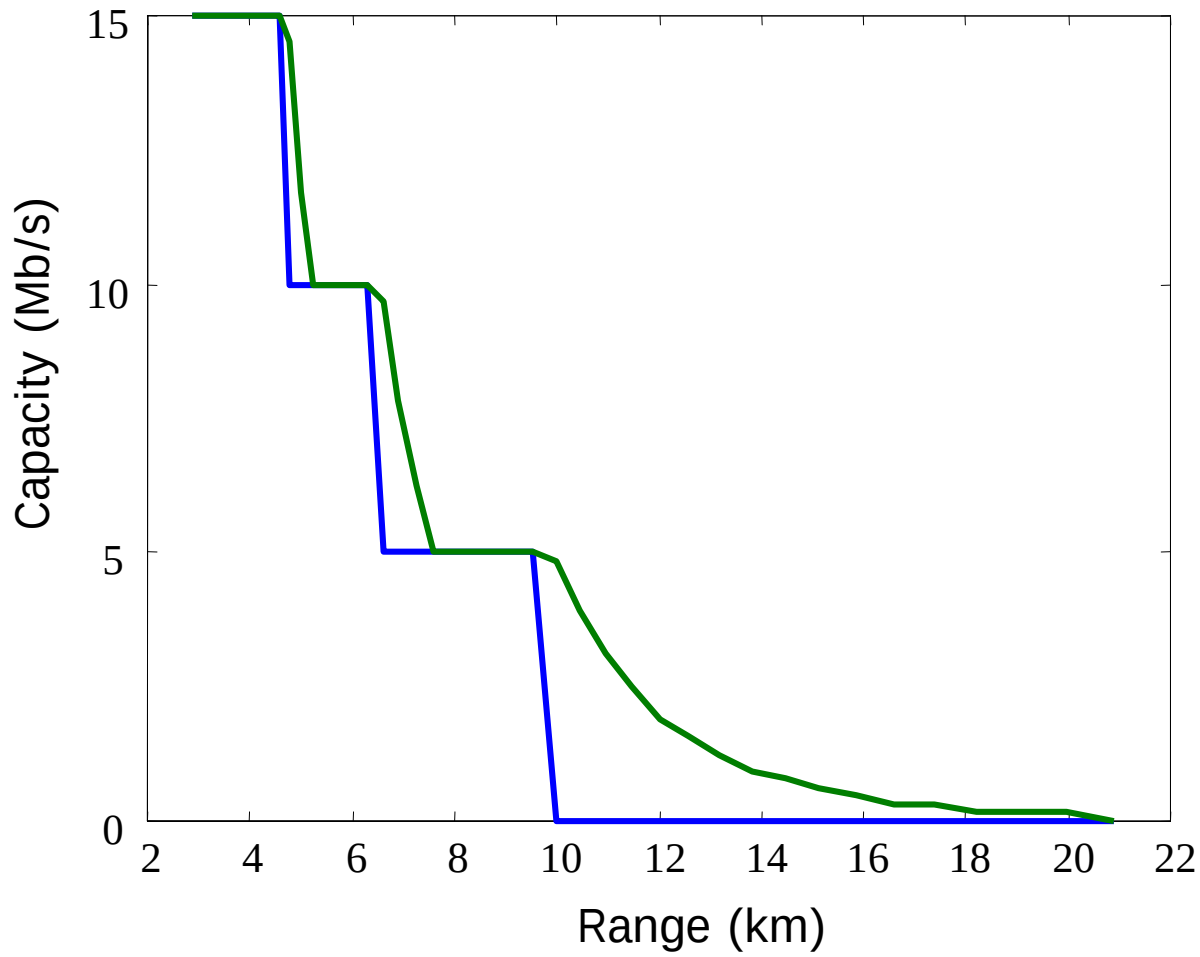
- Low C/I – single frequency case
  - Split the band
    - 2 distinct sets – 16 sub-channels
    - 3 distinct sets – 10 sub-channels
  - Managing channels in adjacent sectors – statistical multiplexing gain
- Downlink
  - Allocate power to low-C/I links on expense of others
- Uplink
  - Use higher bit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

OFDMA Range



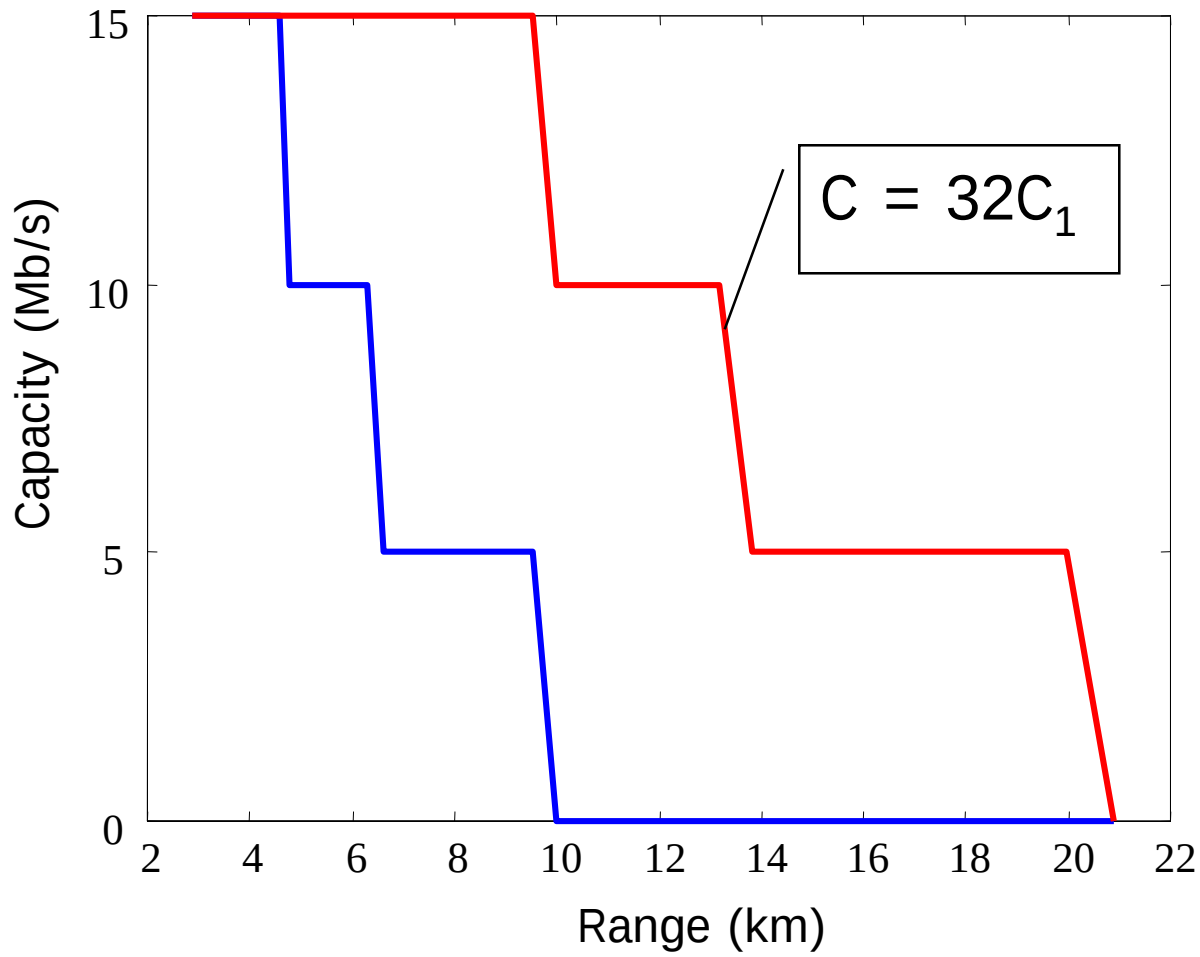
OFDMA vs. TDMA Range

For one subscriber



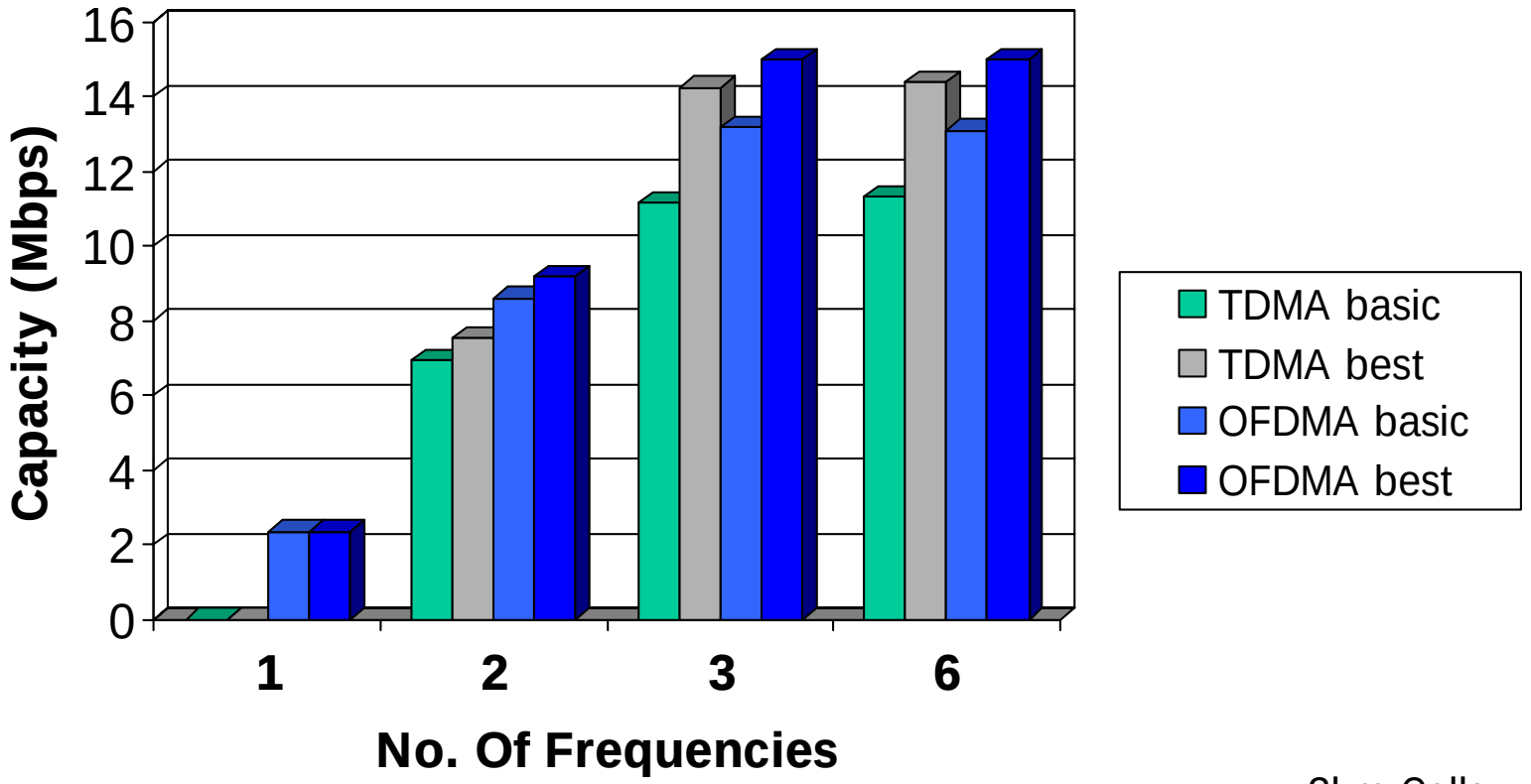
OFDMA vs. TDMA Range

Uplink Aggregated Capacity Envelope



Average Capacity

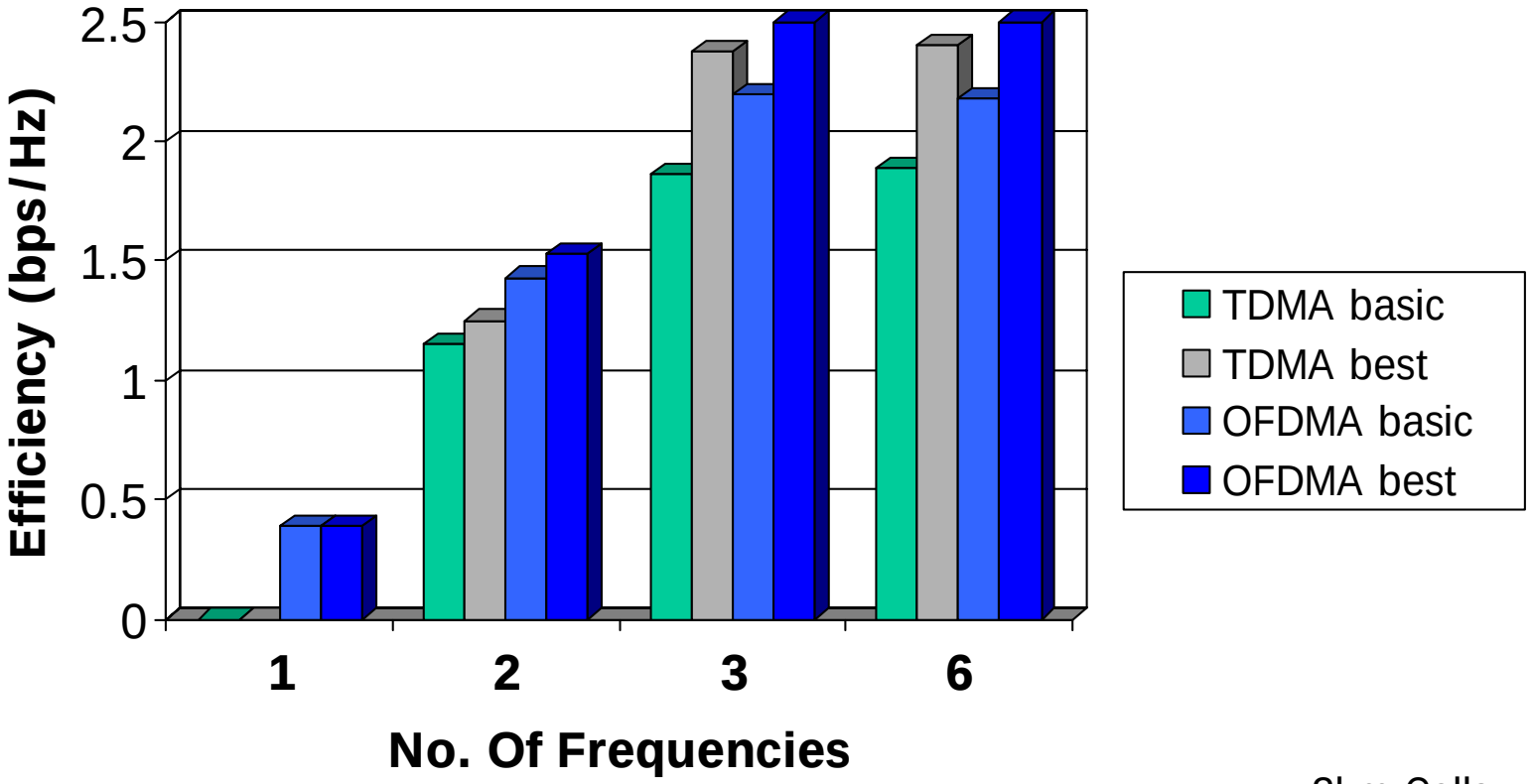
Downlink



2km Cells

Spectral Efficiency (bps/Hz)

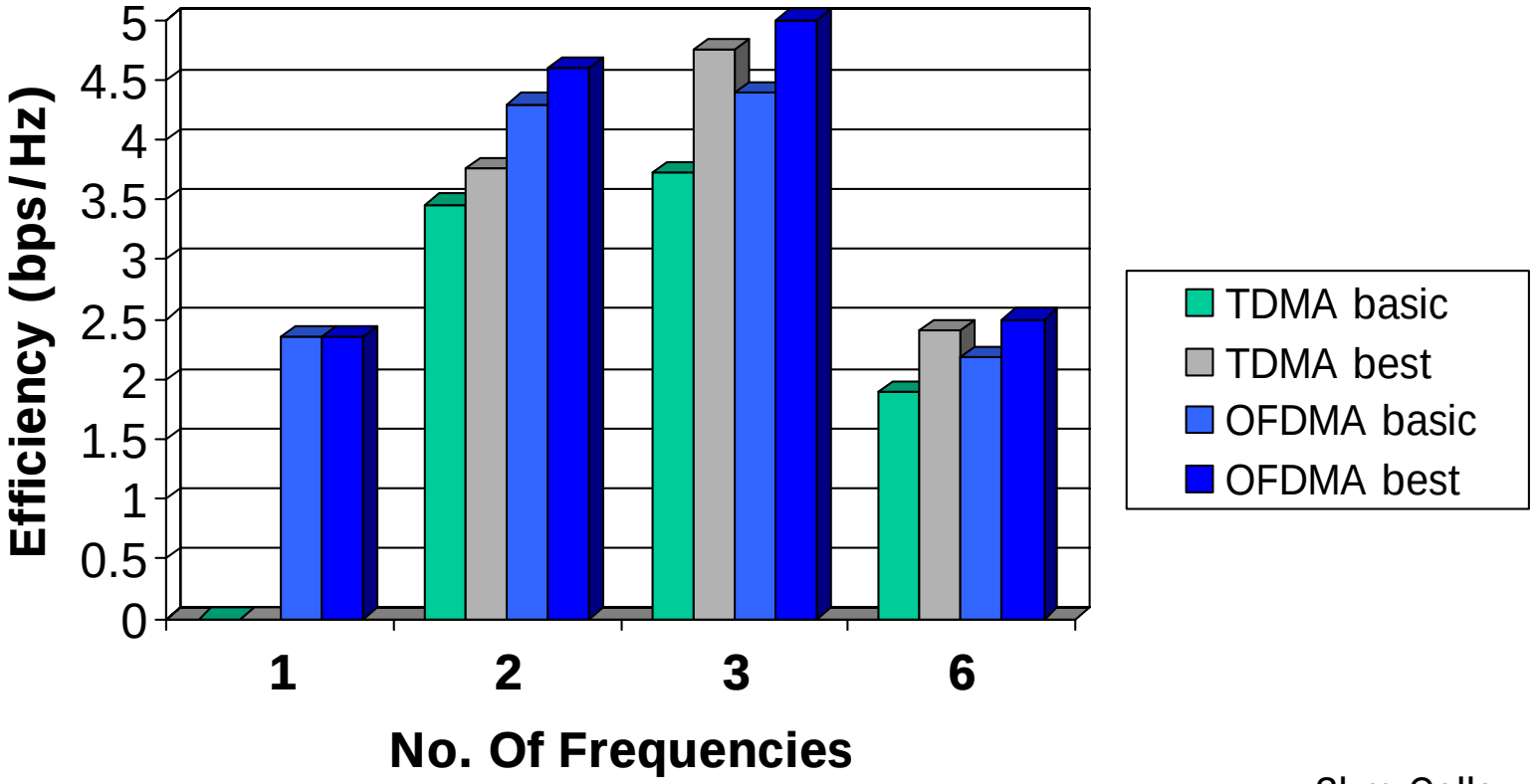
Downlink



2km Cells

System Spectral Efficiency (bps/Hz/cell)

Downlink

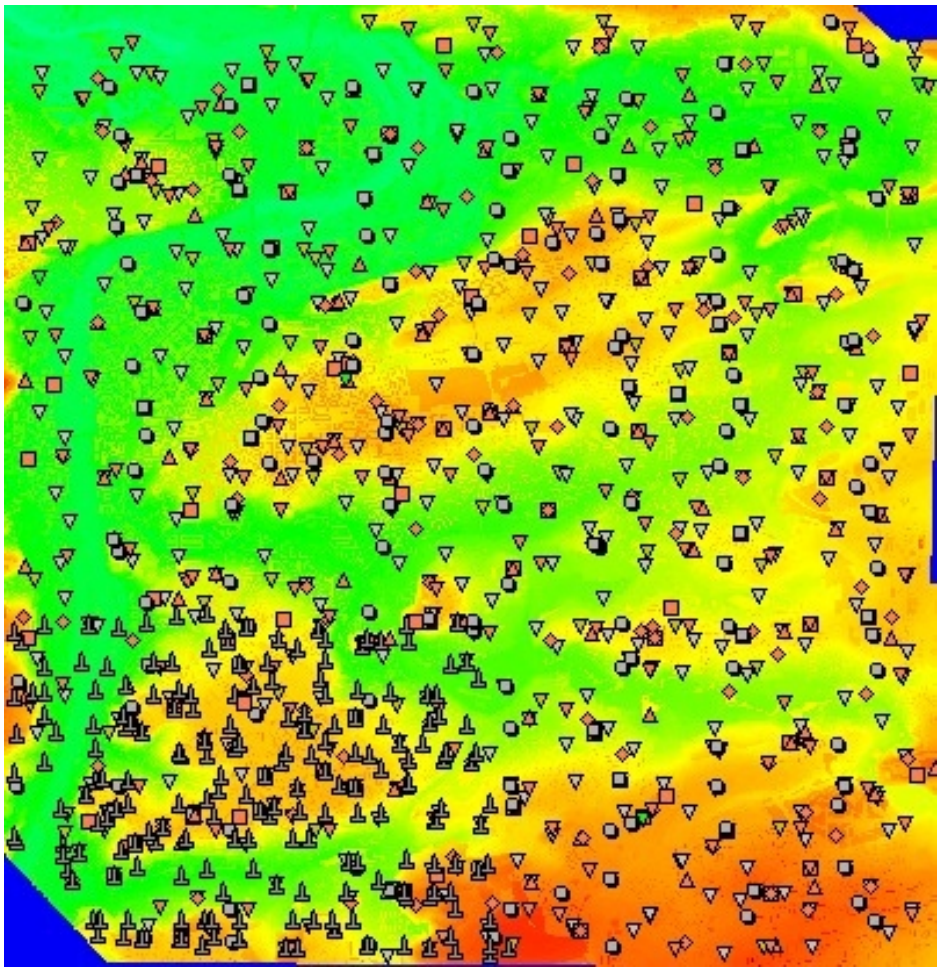


2km Cells

Further work

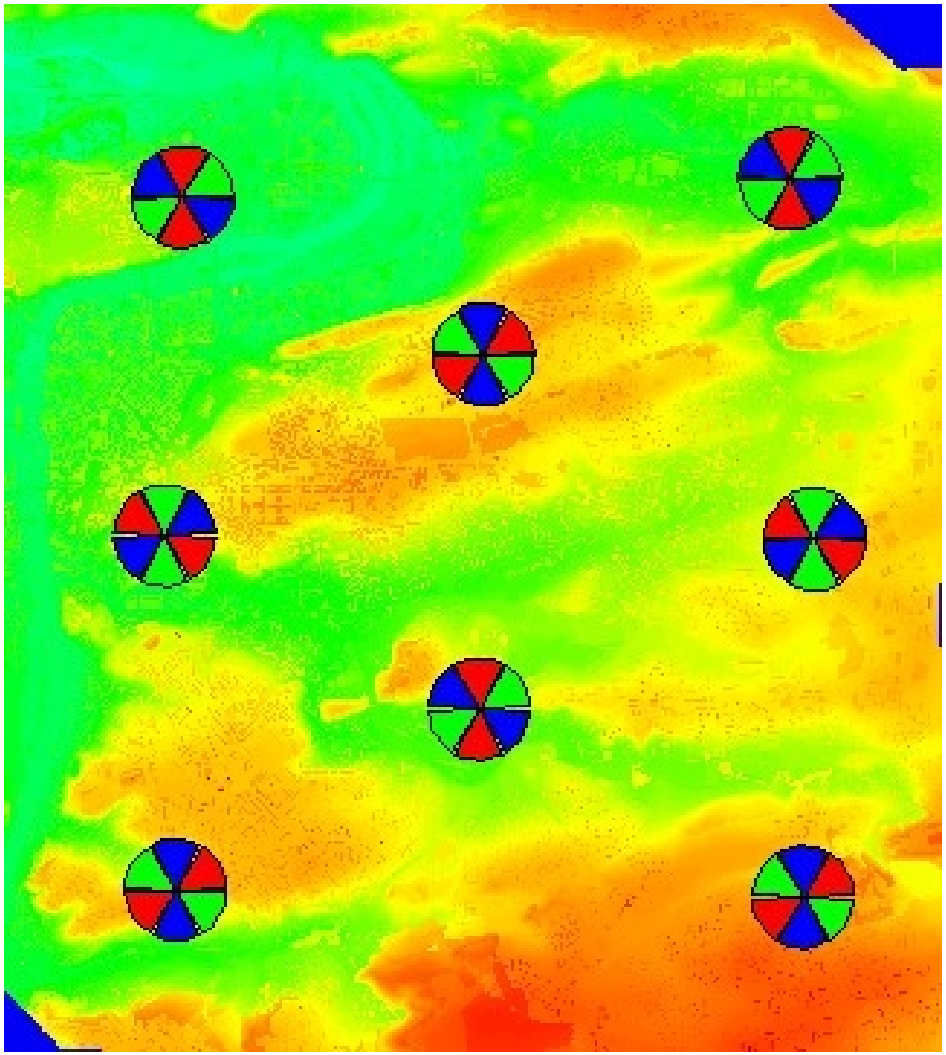
- Use realistic scenarios
- Estimate favorable vs. non-favorable scenarios for OFDMA
- Estimate the contribution of wide sector statistical multiplexing
- Advanced antenna techniques
- Additional data for further analysis

Real Scenarios

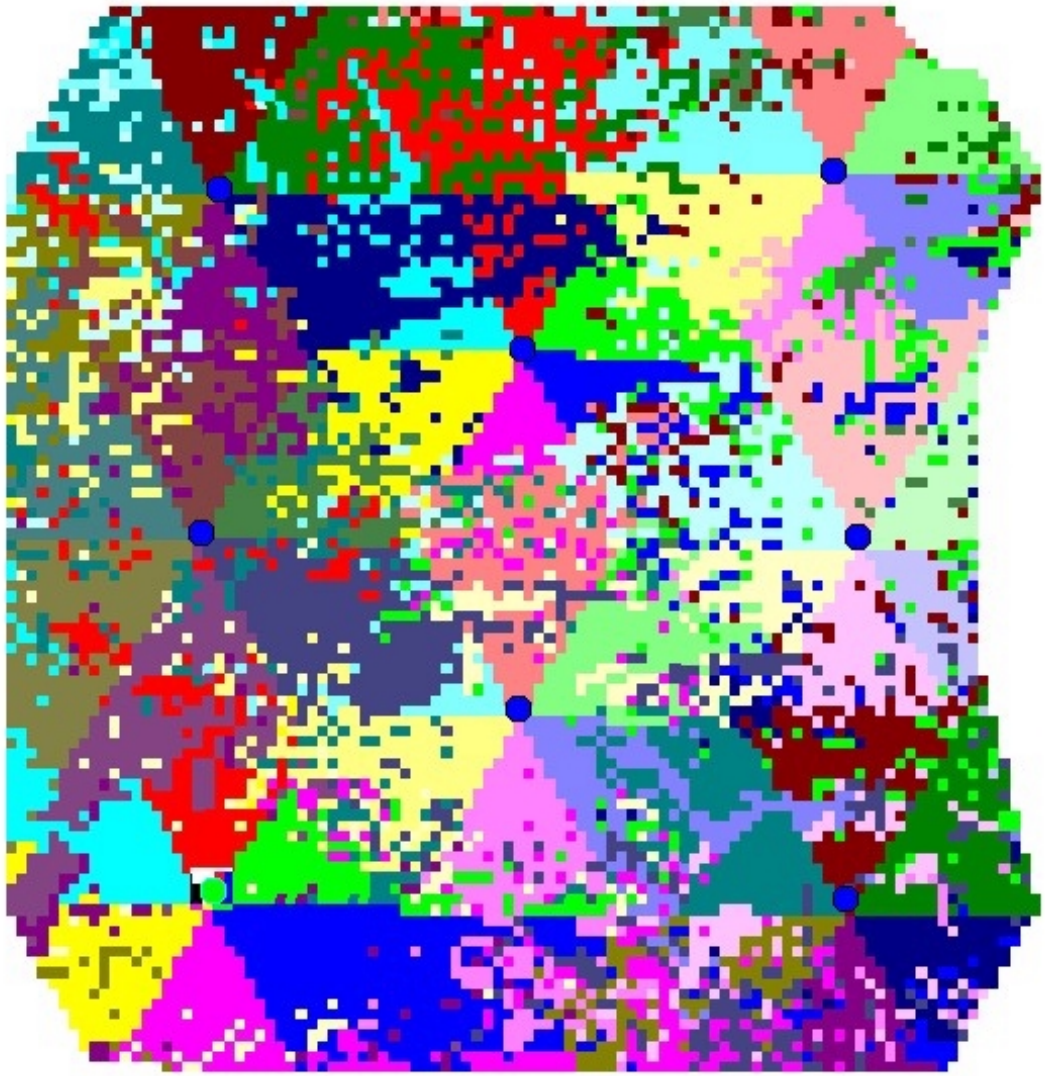


- Terrain data
- Customer types
- Customer distribution

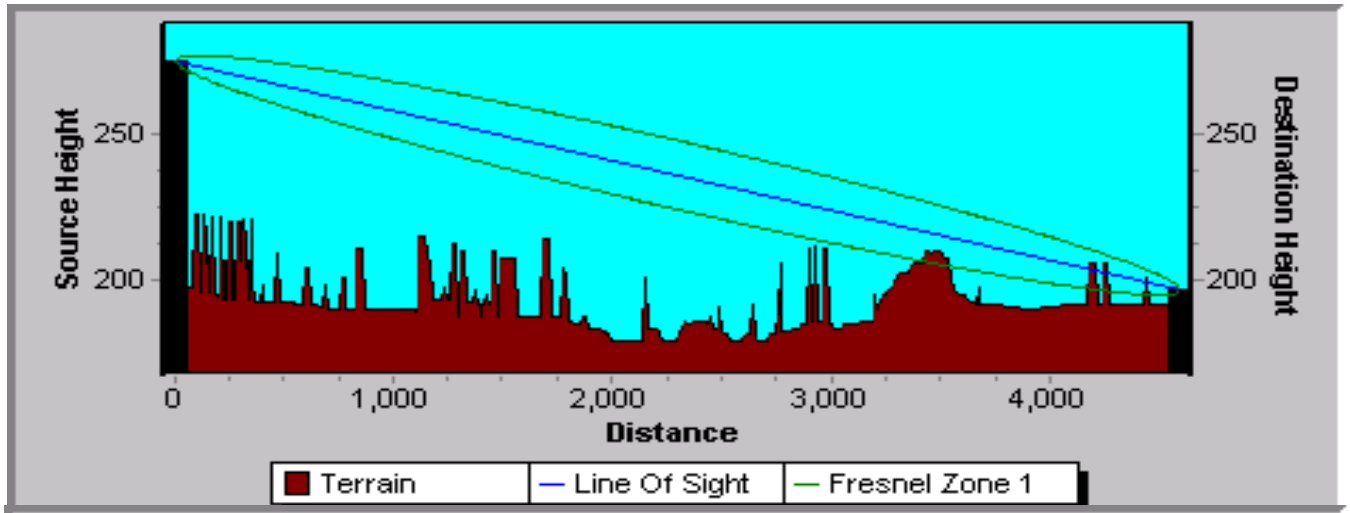
Base Stations



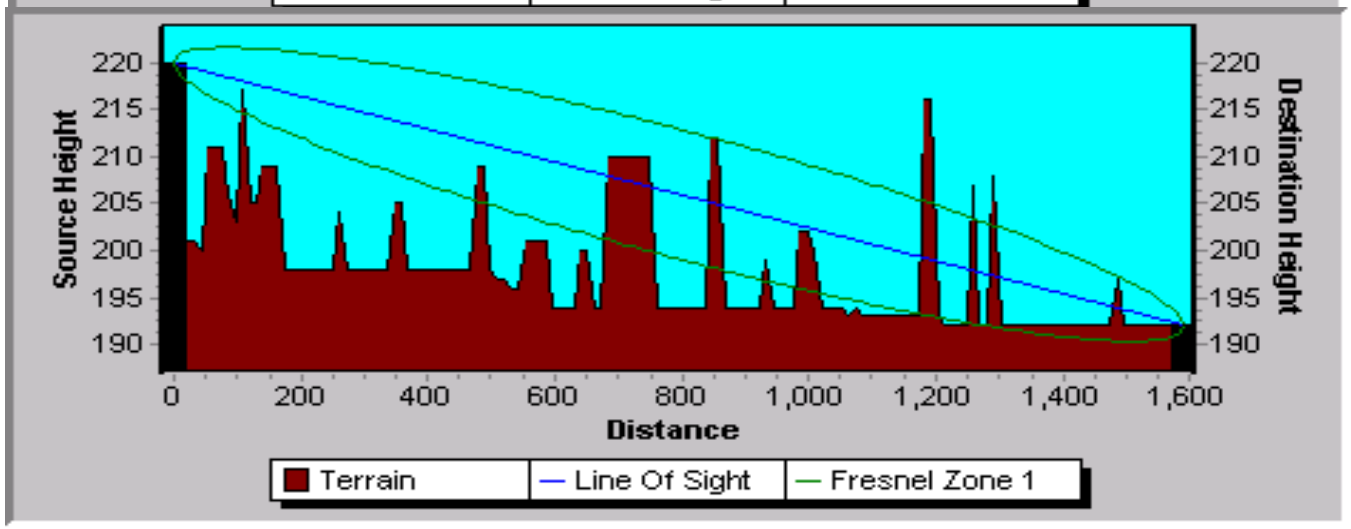
Customers Connections



Path Profiles

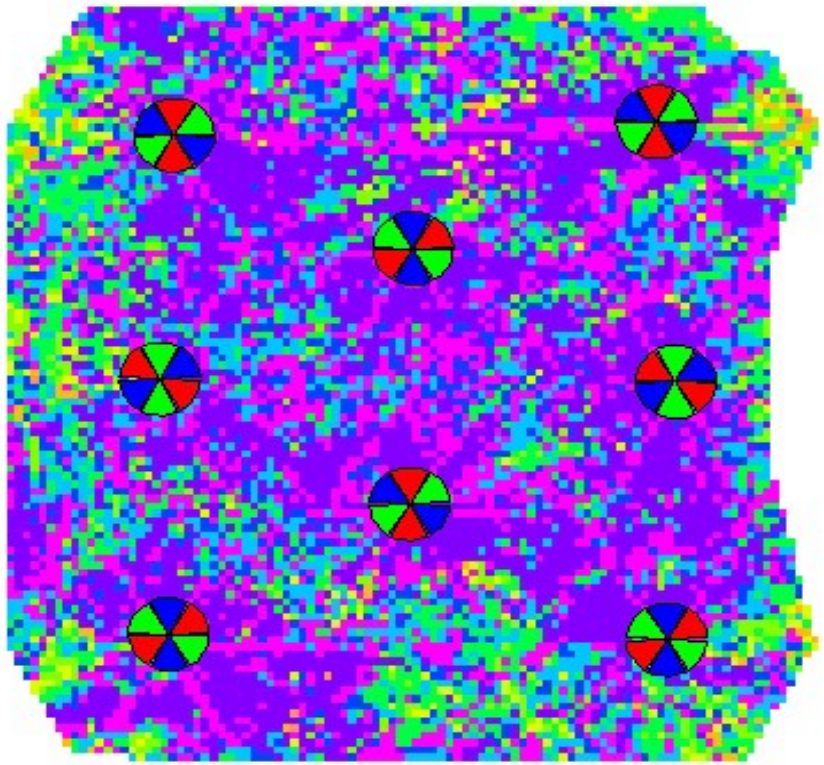


Far
base station



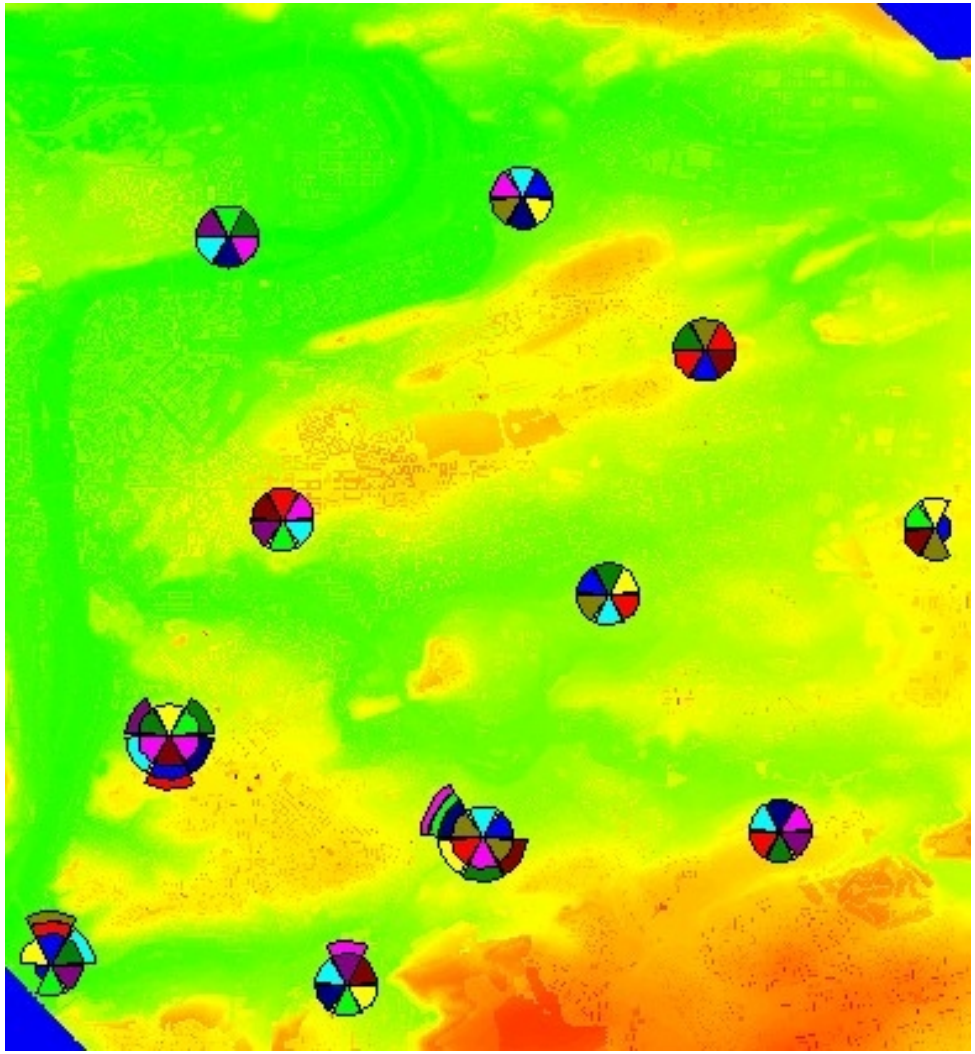
Near
base station

C/(I+N) Map

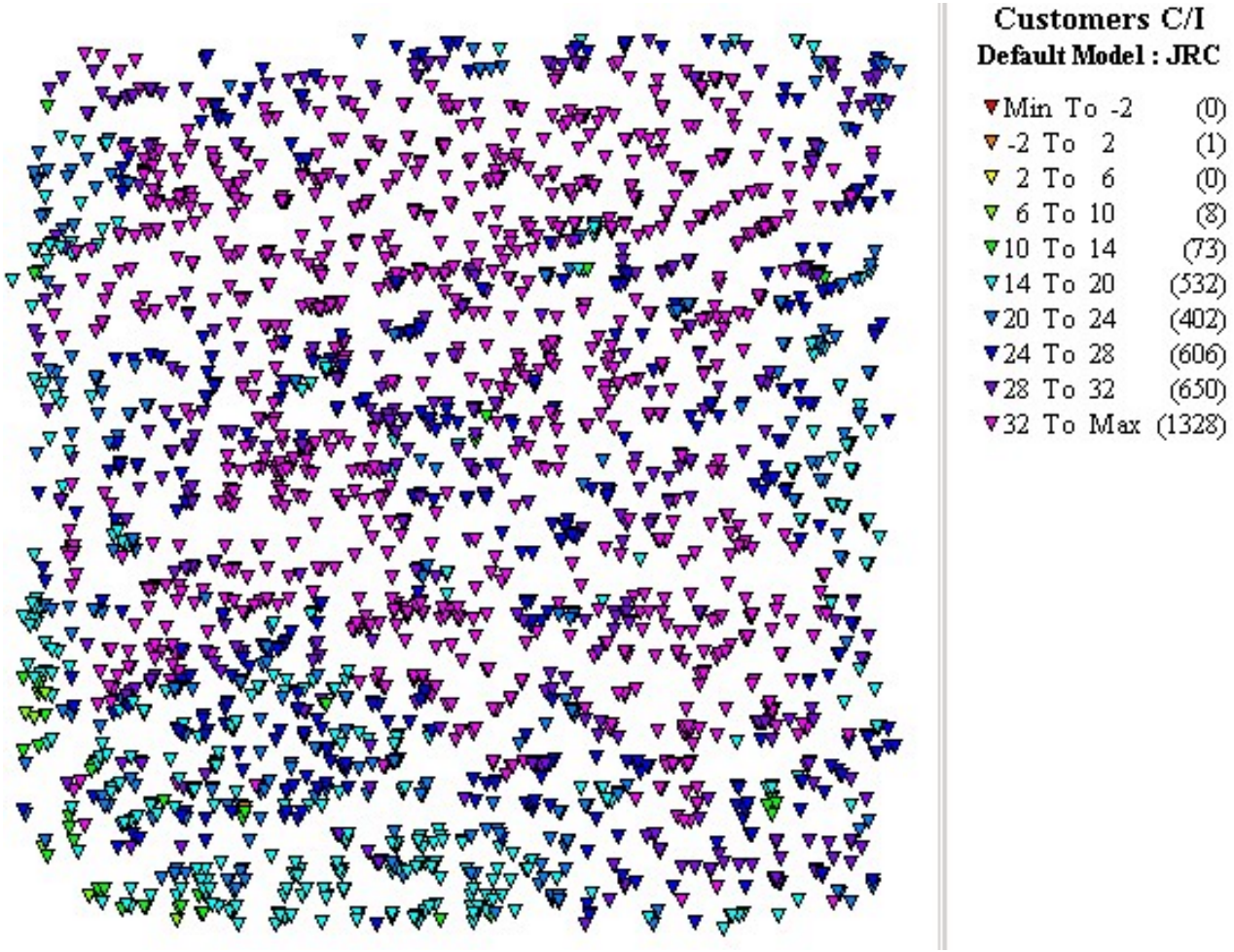


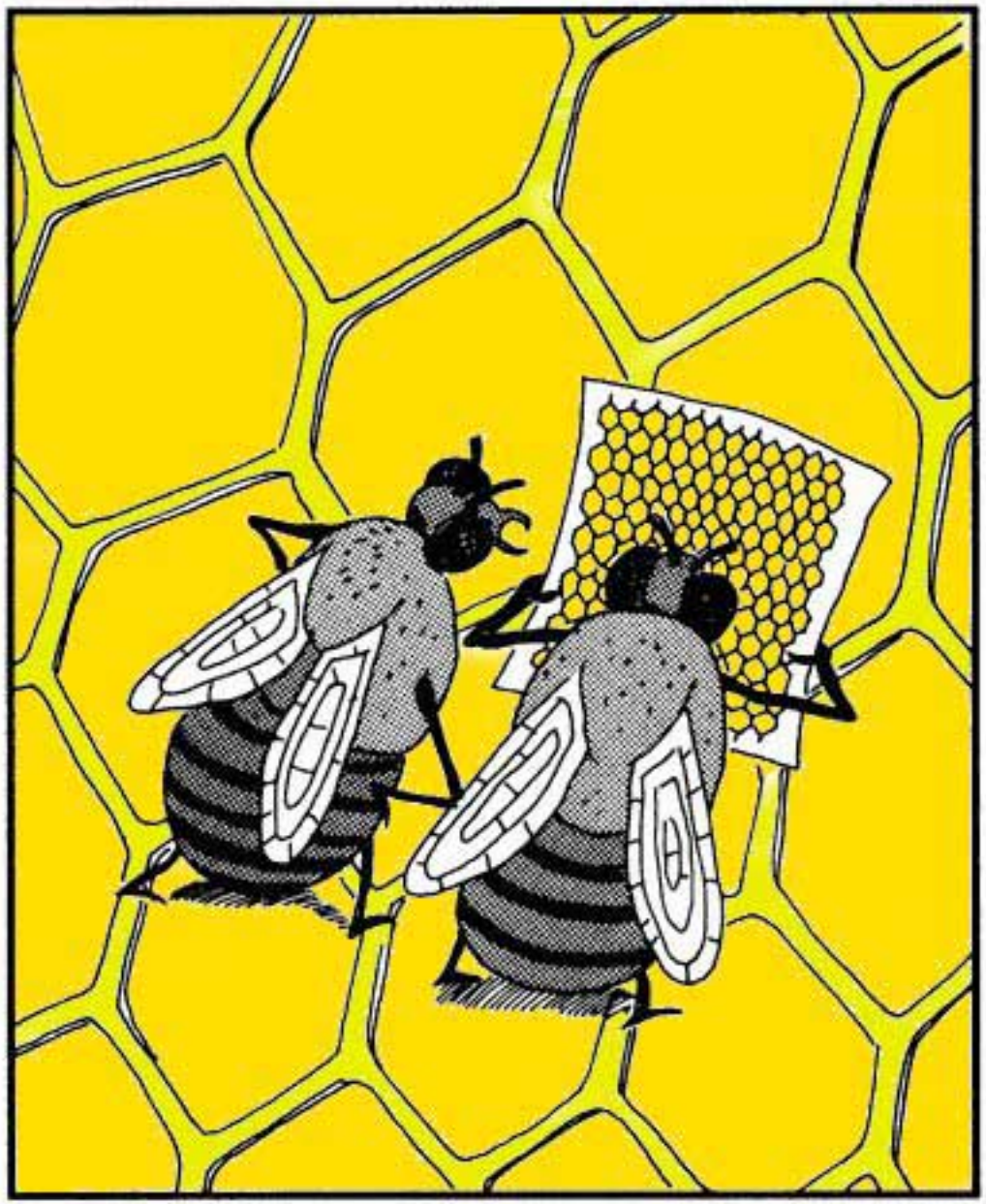
Range			Color	Distribution
Min	to	-2dB		0 %
-2dB	to	2dB		0.052 %
2dB	to	6dB		0.773 %
6dB	to	10dB		2.267 %
10dB	to	13dB		4.107 %
13dB	to	18dB		12.812 %
18dB	to	22dB		13.47 %
22dB	to	24dB		8.715 %
24dB	to	29dB		24.192 %
29dB	to	Max		33.608 %

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