System Capacity with Channelization

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Access-Point-Location Geometries

Two Frequency Channels
Many Data-Code Channels

Three Frequency Channels
One Code

Same nearest-neighbor separation gives \( \approx \) same areas per AP
Basic BSA Geometry

$R_p$ is “BSA Packing” Radius

Alternate-frequency APs fall on radius $2R_p$

STAs scattered around AP
Basic BSA Geometry

- $R_p$ is “BSA Packing” Radius
- Alternate-frequency APs fall on radius $2R_p$
- $R_0 = 1.2R_p$ is Radius of nominal coverage
- STAs scattered around AP

- 20 STAs per BSA
- Randomized placement $< R_0$
- Probe performance $> R_0$
Generation of Sample Connectivities

- Generate Random Link Connectivities within BSA\textsubscript{0}

- If AP Signal < Threshold+3 dB at STA
  - Re-generate that link connectivity (3 tries max.)
  - Emulates fine-scale repositioning STA if poor contact

- Also Compute Links Between other BSAs and BSA\textsubscript{0}

- Same Local Random STA Positions Re-Used in All BSAs
  - Allows use of BSA\textsubscript{0} STA & AP parameters for All BSAs
Propagation Models

- Large Scale Variation
  - Free-Space to 1m
  - $R^n$ beyond 1m
  - $n=1.5$ to 4

- Local Signal Fading
  - None
  - Rayleigh
  - Three-Ray

- Used: $n=2.5$ & Rayleigh
Interaction for Different Frequencies

- Interference at Short Range
- Suppressed by ACI Rejection Ratio (~35 dB)
- Consider Only Nearest Off-Frequency BSAs
Interaction for Same Frequencies

- Multiplicity of Effects
  - Interference (Near/Far)
  - Signal Correlations (Leakage)

- Must Consider Near and Some Far BSAs
Typical 3-Frequency Deployment
Typical 2-Frequency Deployment
Typical Link Statistics

20 STAs/BSA  100-dB Path Loss Tol.  35-dB ACI Rej.  2450 MHz

Links within BSA_0

Links between Off-Frequency BSAs and BSA_0

Links between Off-Frequency BSAs and BSA_0

2 frequency channels
BSA Traffic Model

- STA-to-AP and AP-to-STA Only (no peer-to-peer)
- 20 STAs Each Offer Poisson Traffic $\lambda$ Frames/s
- AP Offers 20 $\lambda$ Frames/s
- 1024-Bytes Frames
- AP Contends with STAs (no CFI)
- All BSAs Carry Same Traffic Load (by symmetry)
Generalized Throughput Equations

- Detailed Balance
  \[(1 - p_m)\lambda_m \left( \overline{T} + \overline{T} \right) = p_m \frac{P_{Collision} P_{Xm}}{\{k,1\}_{\text{max}}} \]

- Aggregate Queued Traffic

- Average Contention Parameters

- Compute Throughput
  \[k = \sum_m p_m \quad \rightarrow \quad \overline{P}_{Collision}, \overline{T}_{BO}, \overline{CW} \]

- What is \( \frac{P_{Xm}}{\{k,1\}_{\text{max}}} \)?

\[S = \sum_m (1 - p_m)\lambda_m\]
\( P_{X_m} \) for Uncorrelated Codes

For successful Exchange, Data Frame and ACK Must Get Through

STA \rightarrow AP

“external” frames at STA of greater power than AP signal

Requires neither of these happen

“external” frame at AP of greater power than STA signal
$P_{X_m}$ for Single Code

Hidden external STAs cause interference (handle as in many-code case)
Effect of Leakage for Single Code

"external" frames at STA above Rx threshold

STA

"Internal" frames at STA

\[
P_{X_m} \frac{\{k,1\}_{\text{max}} + k_{X_m}}
\]

Include effect of queued traffic as seen by each STA individually
Random Deployment made
Worse

Cluster in bad corner
(4 by symmetry)

All Units

BSA₀ Units Only
Ext. STAs above Rx Threshold at AP

They can be from quite a distance!
STAs 10-dB above Rx Threshold at AP
Isolated BSA: Case 1

3 Frequencies
1 Code
$\text{SNR}_{in} = 8\text{dB}$
Isolated BSA: Case 2

2 Frequencies
Many Codes
$\text{SNR}_{in} = 2\text{dB}$
Full Network

3F/1C

2F/MC Worst Case

Worst Case
Random Placements

3F/1C

2F/MC
Summary

• Case 1
  – 3 Frequency Channels, Single Code, $\text{SNR}_{\text{in}} = 8$ dB

• Case 2
  – 2 Frequency Channels, Many Code Channels, $\text{SNR}_{\text{in}} = 2$ dB

• 19 BSAs, 20 STAs + AP per BSA

• Use of Code Channels Offers Greatly Improved System Throughput by Isolating Leakage