

## PHY Proposal

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This contribution is BeamReach's PHY proposal presentation for the next round, as we have been requested.

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# Some Broadband Wireless Challenges

## ¥ Coverage

— Cellularized networks are needed

¥ Supercells are not adequate at desired/projected penetrations

¥ Data rates are increasing and internet applications expanding

— Most carriers desire a large cell radius -> macro cell

¥ Minimize number of basestations, improve velocity of deployment, reduce siting cost, and minimize backhaul ports

¥ Challenges link budgets, data rates, fade margins and coverage margins

¥ RF channel difficulty increases with increasing cell radius

## ¥ Capacity

— Most large carriers own a modest amount of bandwidth in licensed bands

¥ Non-line-of-sight communications -> Below 4 GHz suitable for NLOS

¥ License bands needed to meet capacity, quality, availability, QOS objectives

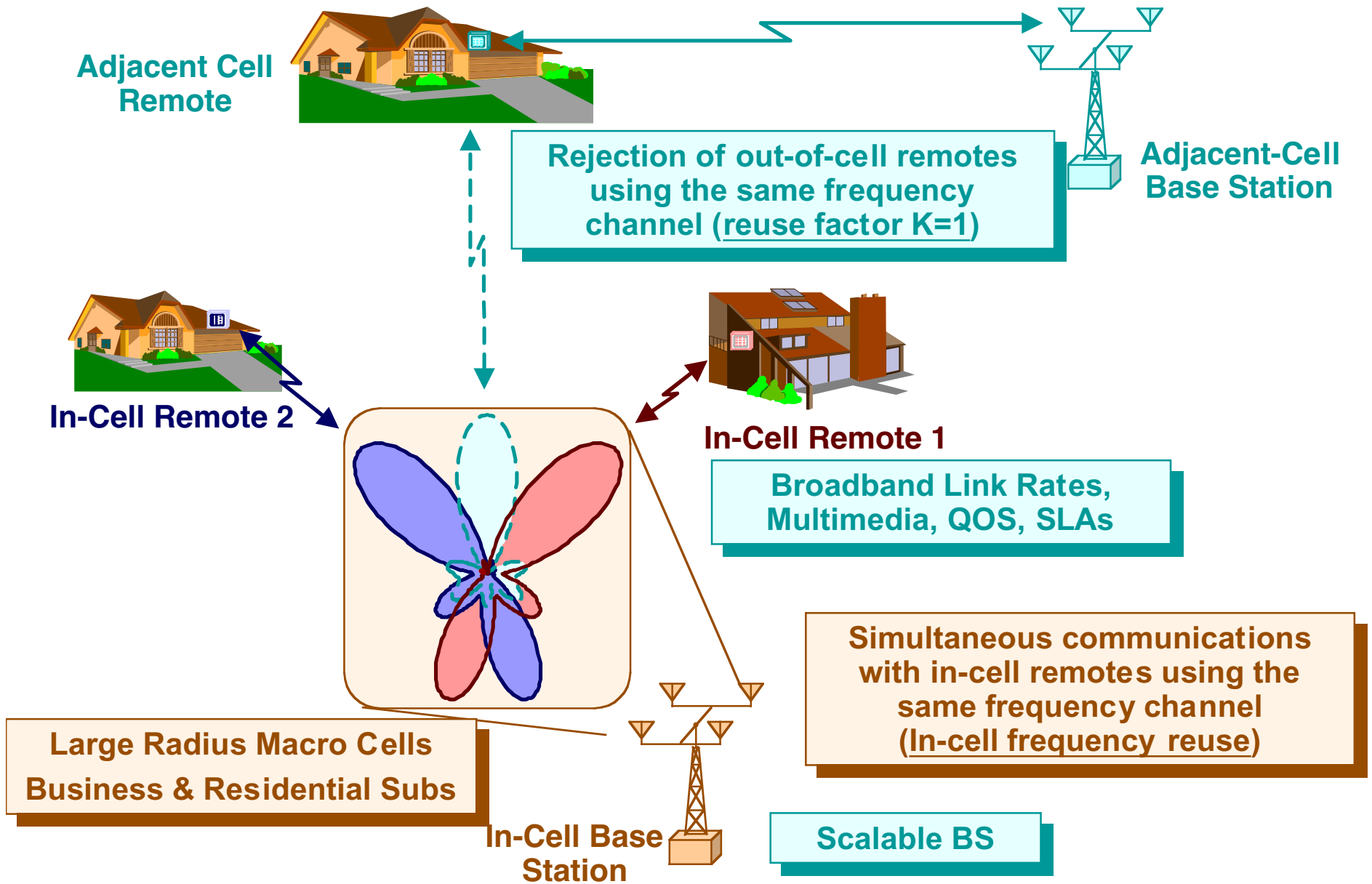
— Spectrum is expensive, demand exceeds supply

— High spectral efficiency is required for macro cells

¥ Required base station capacity increases by 4x as the cell radius doubles!

¥ Number of base stations decreases by 4x as the cell radius doubles!

# High Spectral Efficiency Packet Network



# Enabling Technology- Adaptive MultiBeam OFDM

## ∕ AM-OFDM Properties

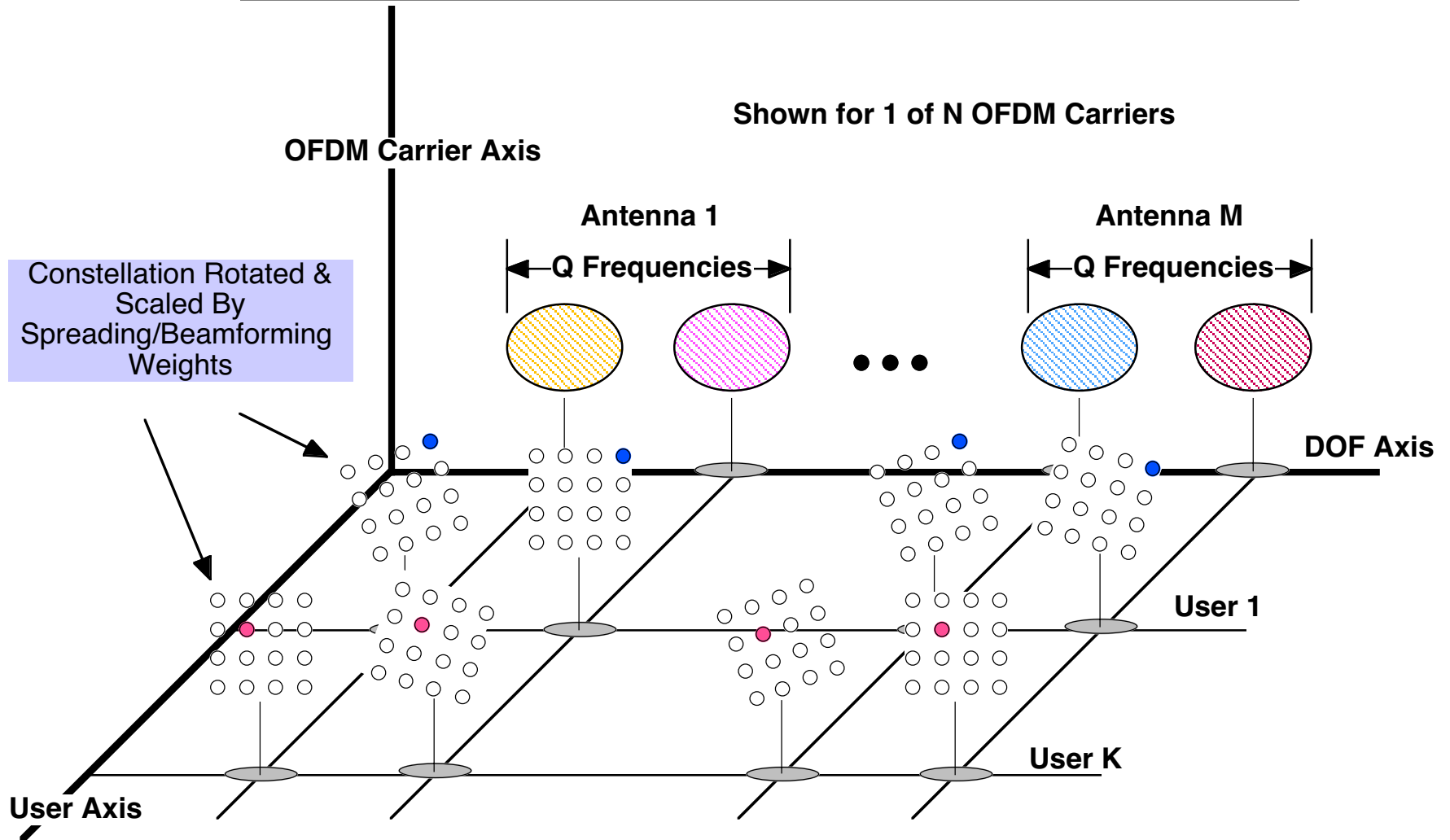
- Spread spectrum modulation using a multi-carrier baseband (e.g. OFDM)
- Can be seamlessly integrated with adaptive arrays -> generalized AM-OFDM
- A multiple access technology
- Supports a high level of network scalability

## ∕ AM-OFDM Benefits

- Benefits of spread spectrum without severe spectral efficiency penalty
- Adaptive code nulling
  - ∕ Provides near optimal signal separation for multiple access
  - ∕ No tight power control tolerance issues that would otherwise effect capacity.
- Adaptive antenna arrays
  - ∕ High spectral efficiency -> Linear increase in spectral efficiency by increasing the number of antennas
  - ∕ Adds an extra dimension of basestation scalability
  - ∕ Improved multipath mitigation and interference cancellation performance
  - ∕ Array combining gain increases cell radius
  - ∕ Distributed power amplification -> lower cost/complexity designs

# Multiuser Adaptive MultiBeam OFDM Spreading in 2 Dimensions

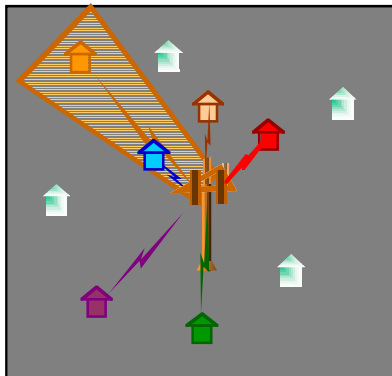
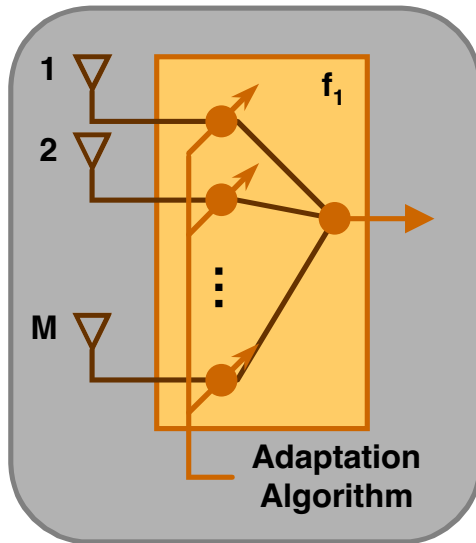
Data Spread in the Spectral and Spatial Domains



# In-cell Frequency Reuse via Spatial & Spectral Combining

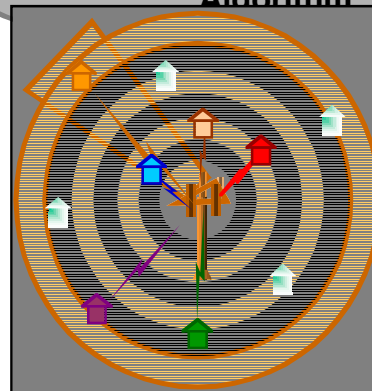
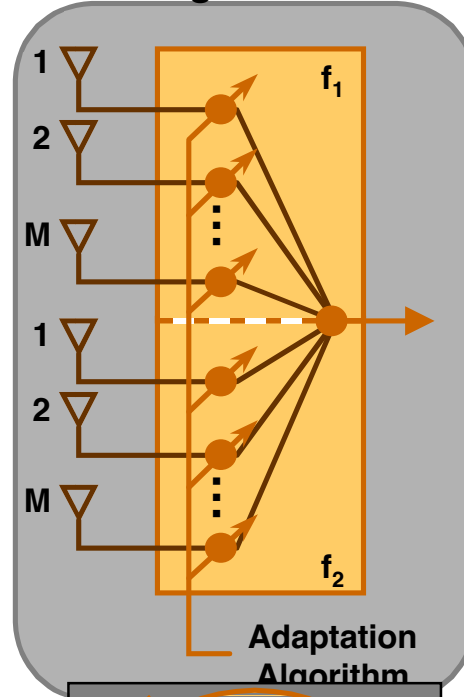
## Spatial Beamforming

M antennas  $\rightarrow$   
M degrees of freedom

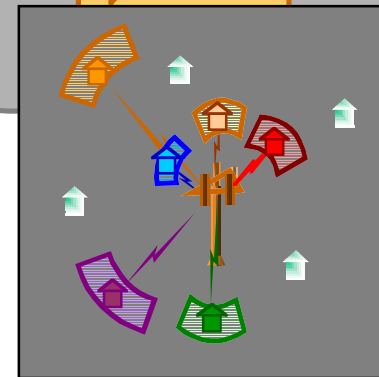
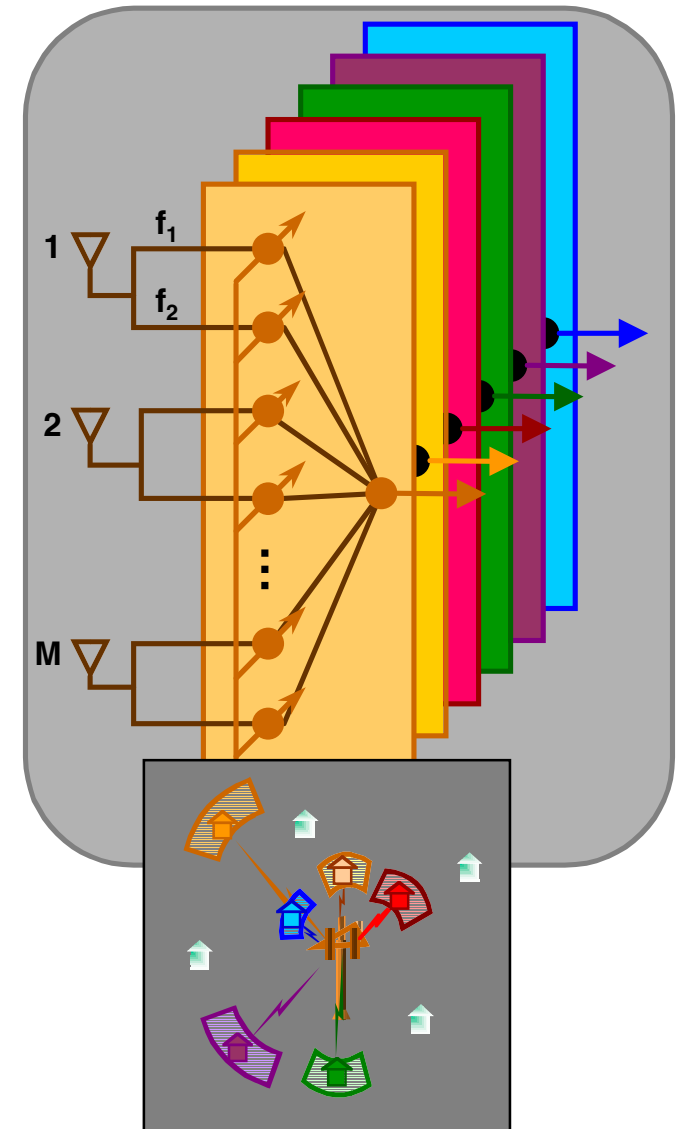


## Spatial + Spectral Beamforming

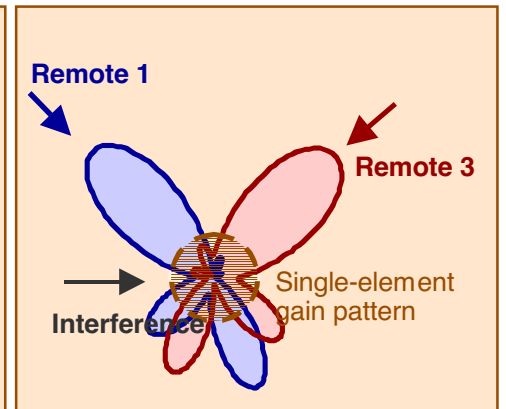
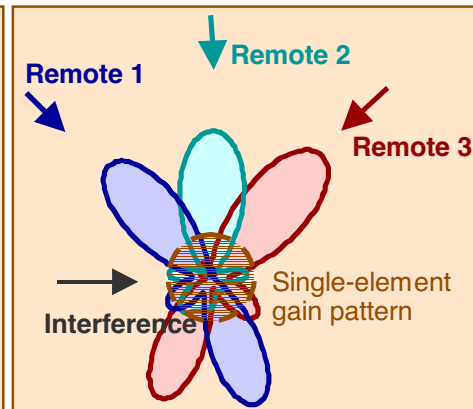
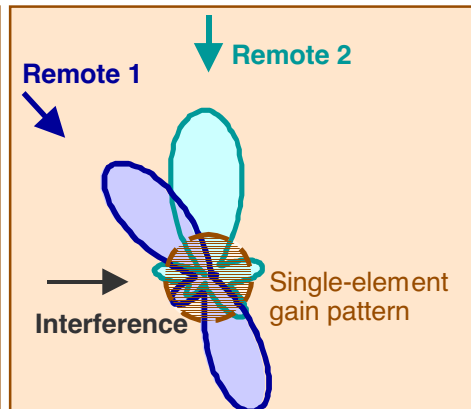
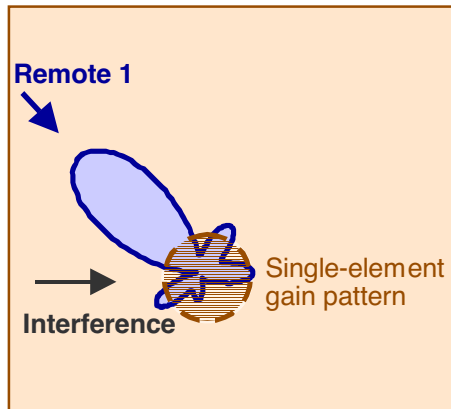
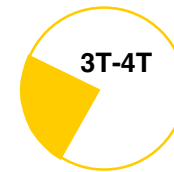
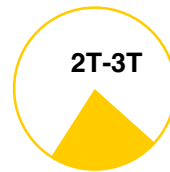
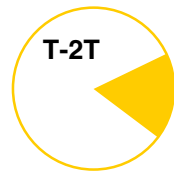
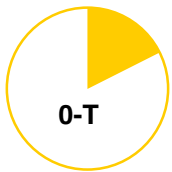
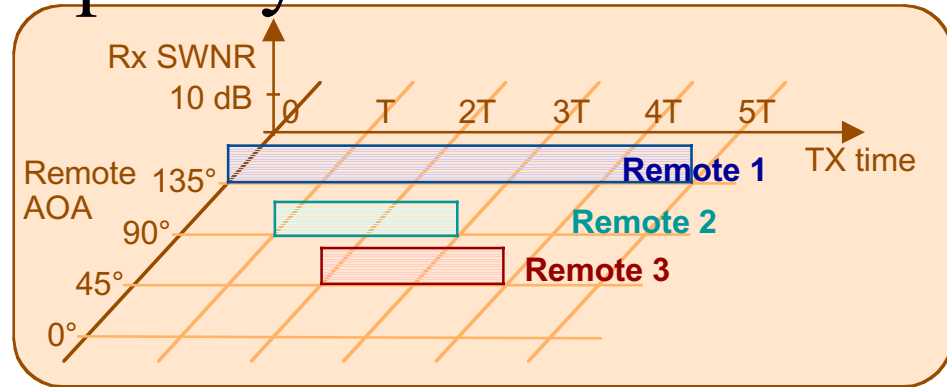
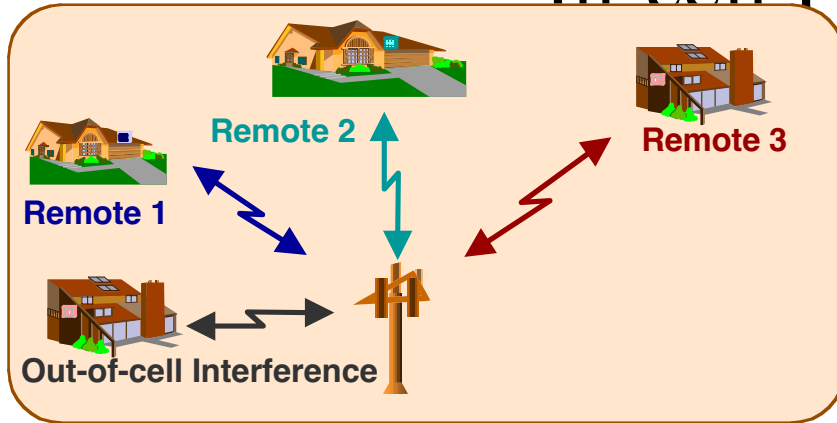
M antennas, Q frequencies  $\rightarrow$   
Q x M degrees of freedom



## Multuser Beamforming



# Fast Packet Adaptation & In-cell Frequency Reuse



**Beamforming provides gain compared to isotropic pattern**

**New links acquired without harm to existing links**

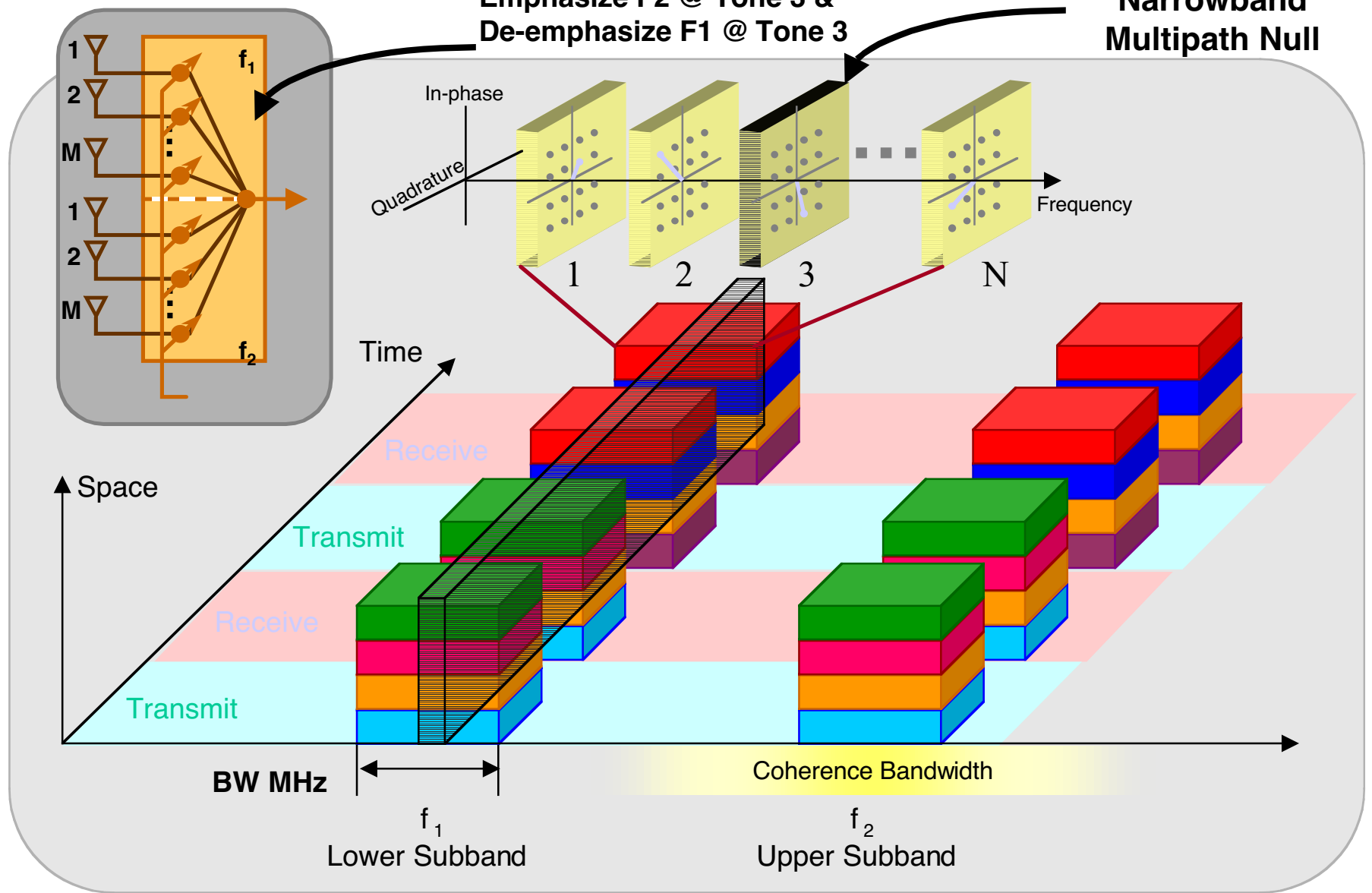
**Multiple users on the same frequency (each with high link quality)**

**Adaptation occurs on packet by packet basis**

# Adaptive Interference & Multipath Mitigation

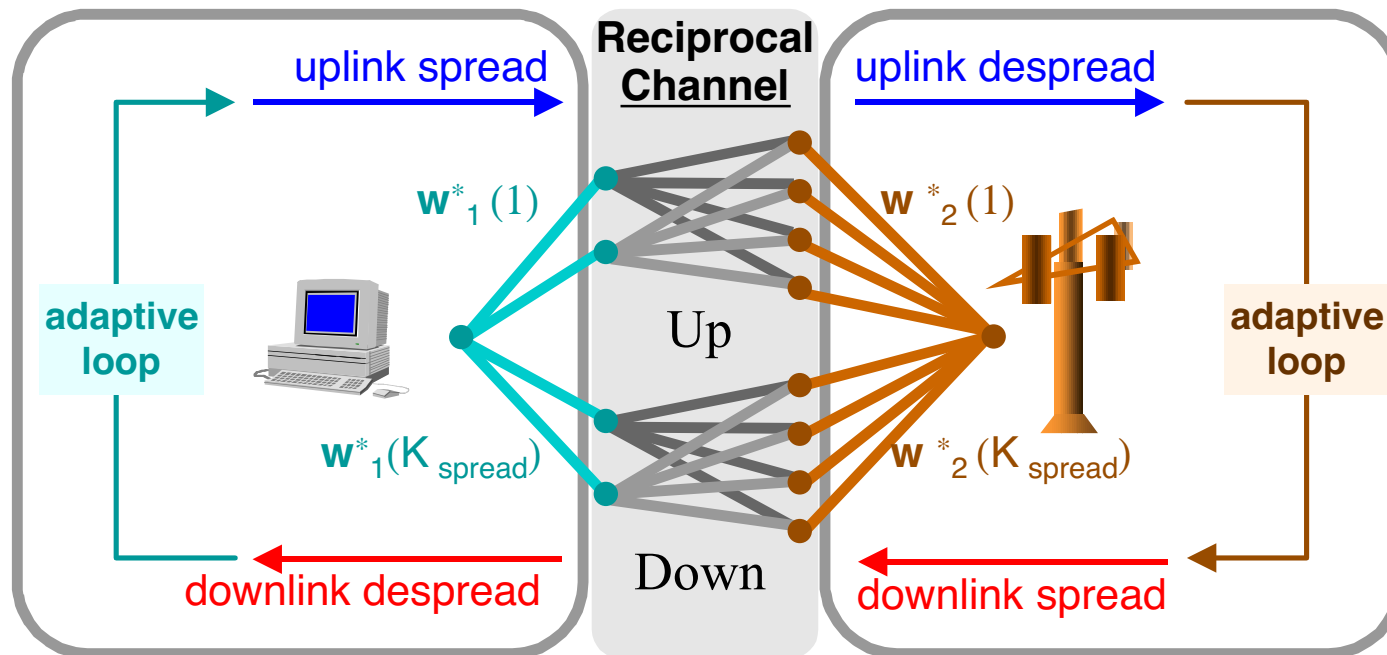
Emphasize F2 @ Tone 3 &  
De-emphasize F1 @ Tone 3

Narrowband  
Multipath Null





# The Reciprocal Multiple Input/ Multiple Output Channel



AM-OFDM systems using TDD exploit the reciprocal nature of the RF channel to increase spectral efficiency and improve range

# Summary: AM-OFDM Advantages

- ¥ Superior propagation characteristics
  - ¥ Adaptive P x Q diversity combining -> Less link margin needed
  - ¥ Spatial & spectral combining -> Added coherent gain, greater cell radius
  - ¥ High OFDM tone density -> Better equalization, lower dispersion
- ¥ Spectral efficiency up to 10 times greater in a fully cellularized network
  - Fewer base stations
    - ¥ Lower cost of coverage
    - ¥ Faster network build out
    - ¥ Reduced time and cost for acquiring and approving antenna sites
  - Supports growth in bandwidth intensive services
    - ¥ E.g., streaming audio/video, high bit rate voice, others
- ¥ Highly scalable solution -> 3-D Scalability
  - ¥ Scales with spectrum, number of antennas, adaptive modulation/partitioning
  - ¥ Low cost of coverage
  - ¥ Capacity (cost) grows with usage (revenue)
  - ¥ Avoid or minimize cell splitting
    - Avoid truck roll to realign customer antenna
- ¥ Full frequency reuse
  - ¥ No complex frequency planning, replanning and management
  - ¥ No inter-cell interference problems