PHY Proposal

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Randall Schwartz
BeamReach Networks, Inc.
329 N. Bernardo Ave
Mountain View, CA 94043

Voice: 650-988-4758
Fax: 650-988-4713
E-mail: rschwartz@beamreachnetworks.com

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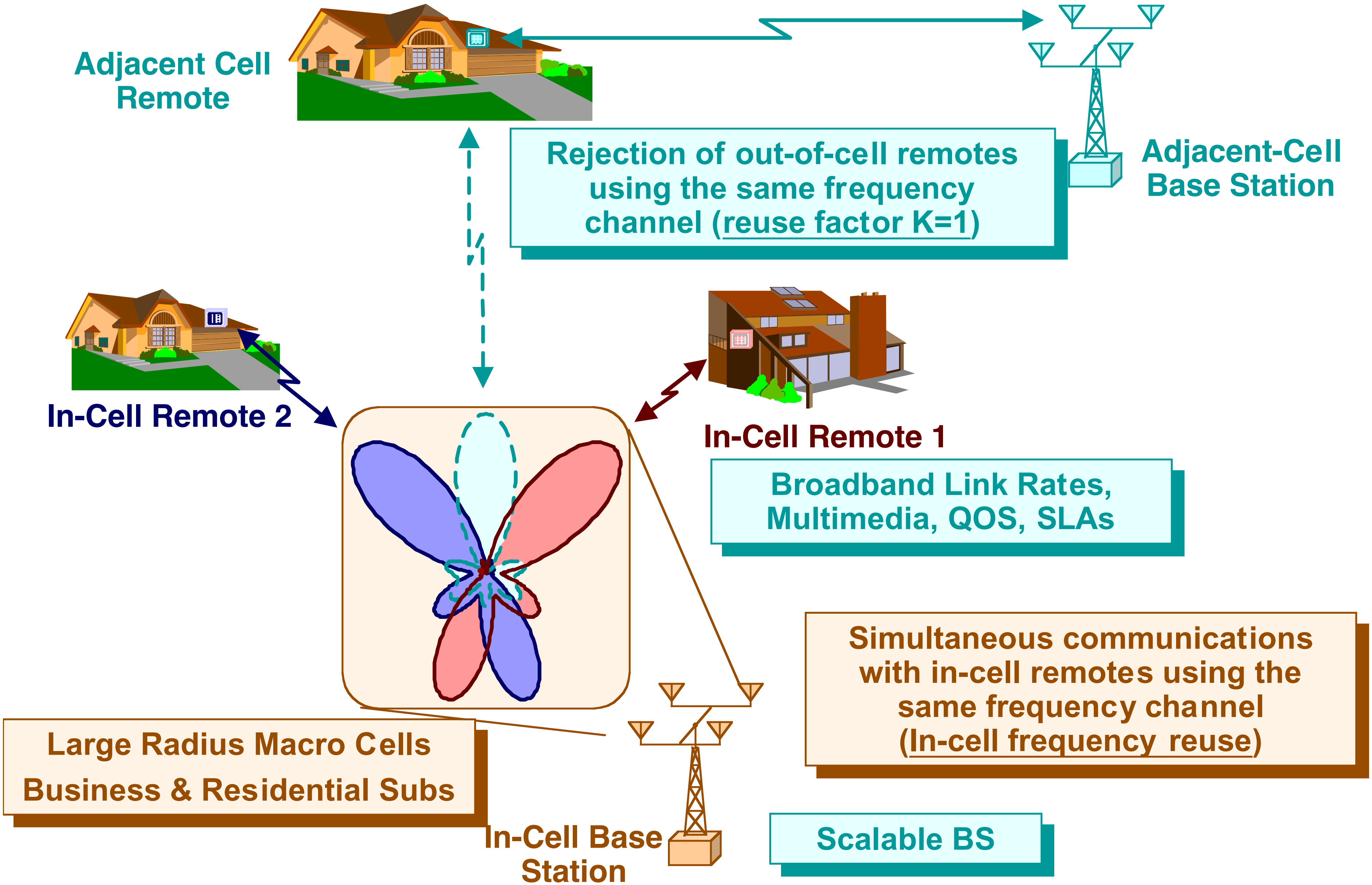
Purpose:

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

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

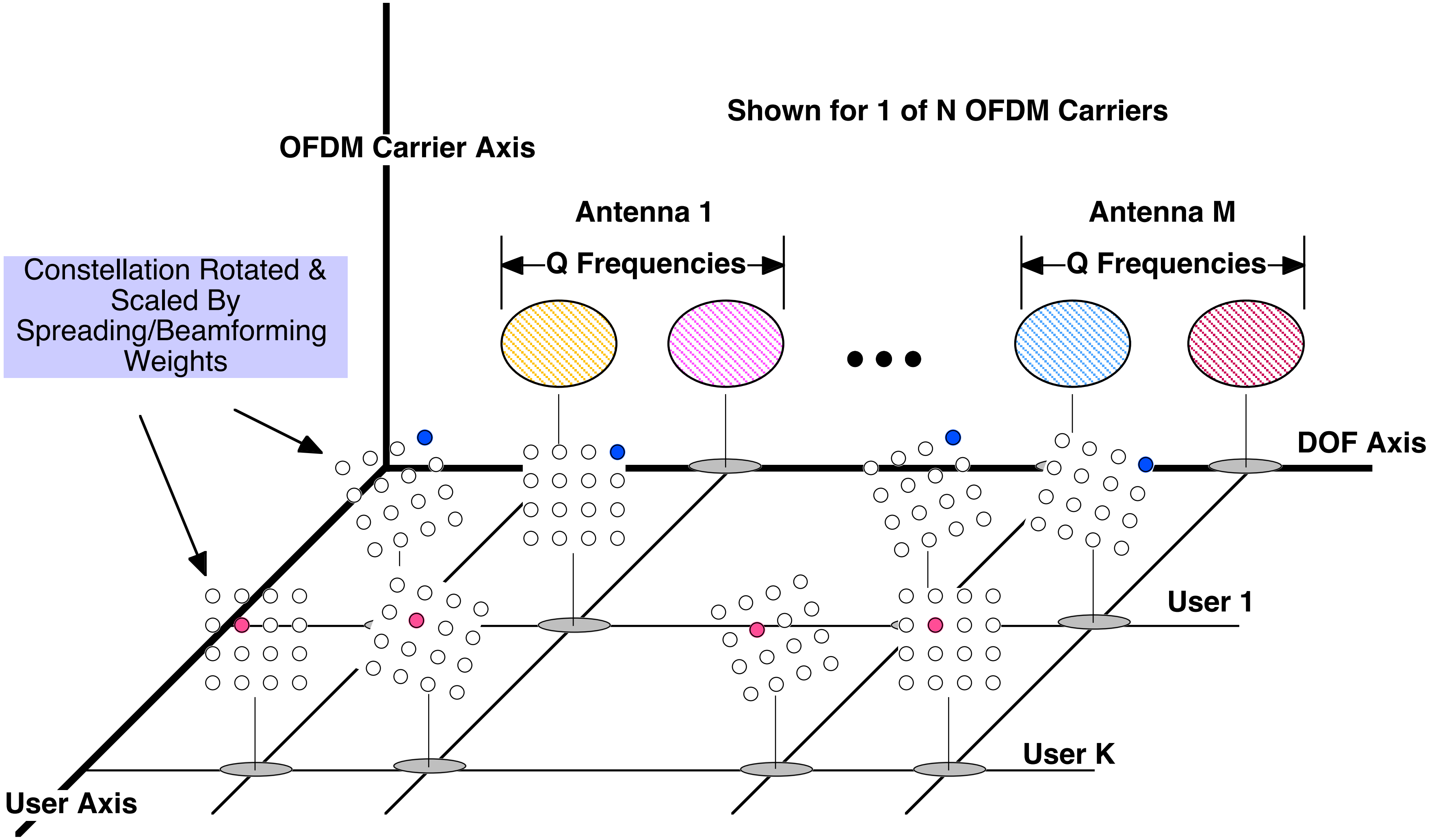


Enabling Technology- Adaptive MultiBeam OFDM

- ¥ 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

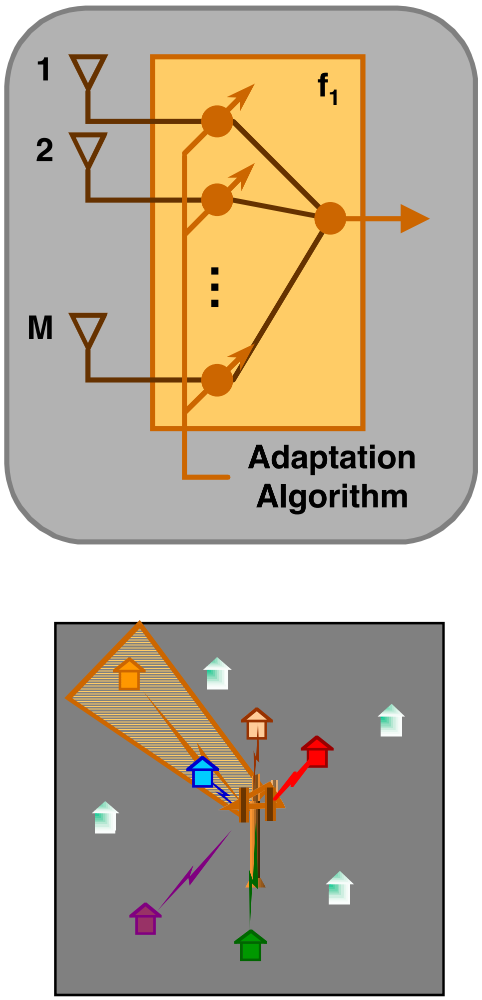
Data Spread in the Spectral and Spatial Domains



In-cell Frequency Reuse via Spatial & Spectral Combining

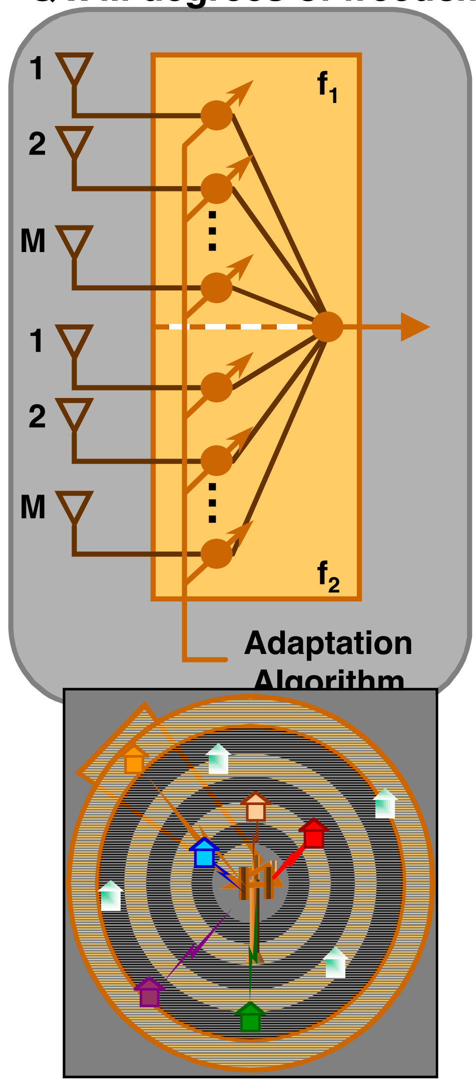
Spatial Beamforming

M antennas → M degrees of freedom

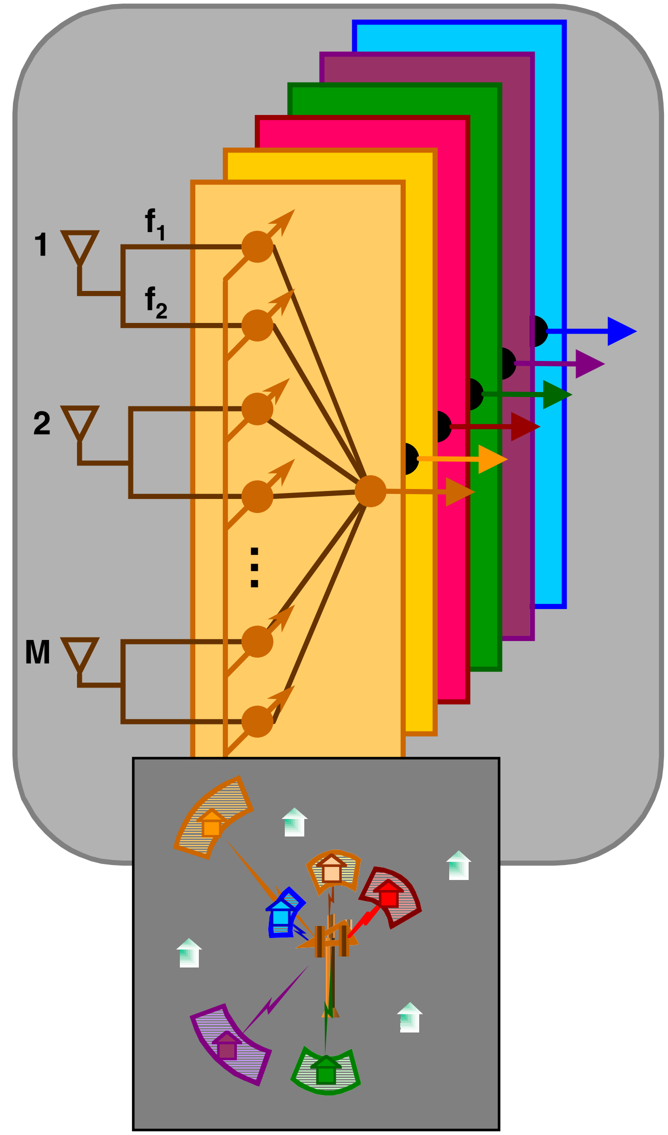


Spatial + Spectral Beamforming

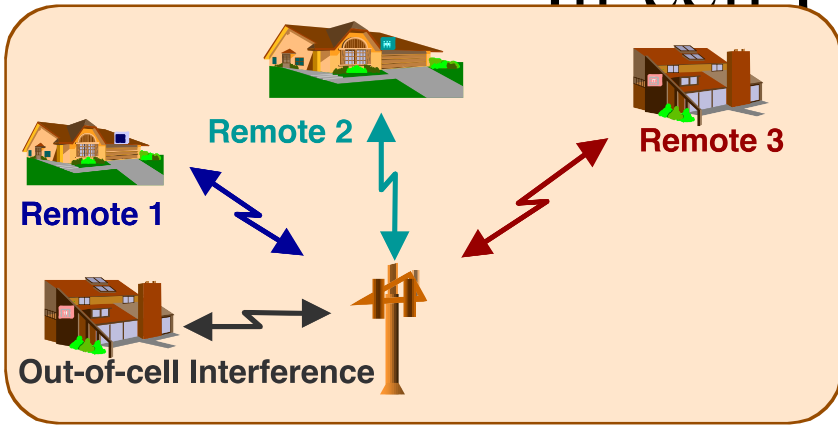
M antennas, Q frequencies → Q x M degrees of freedom

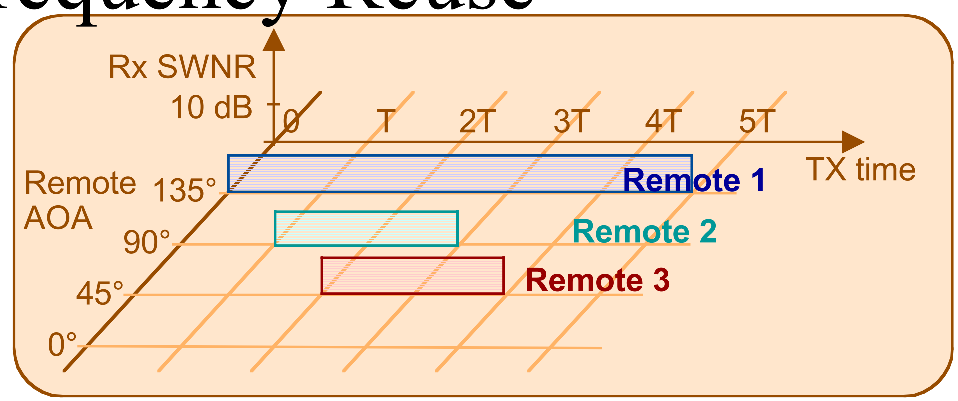


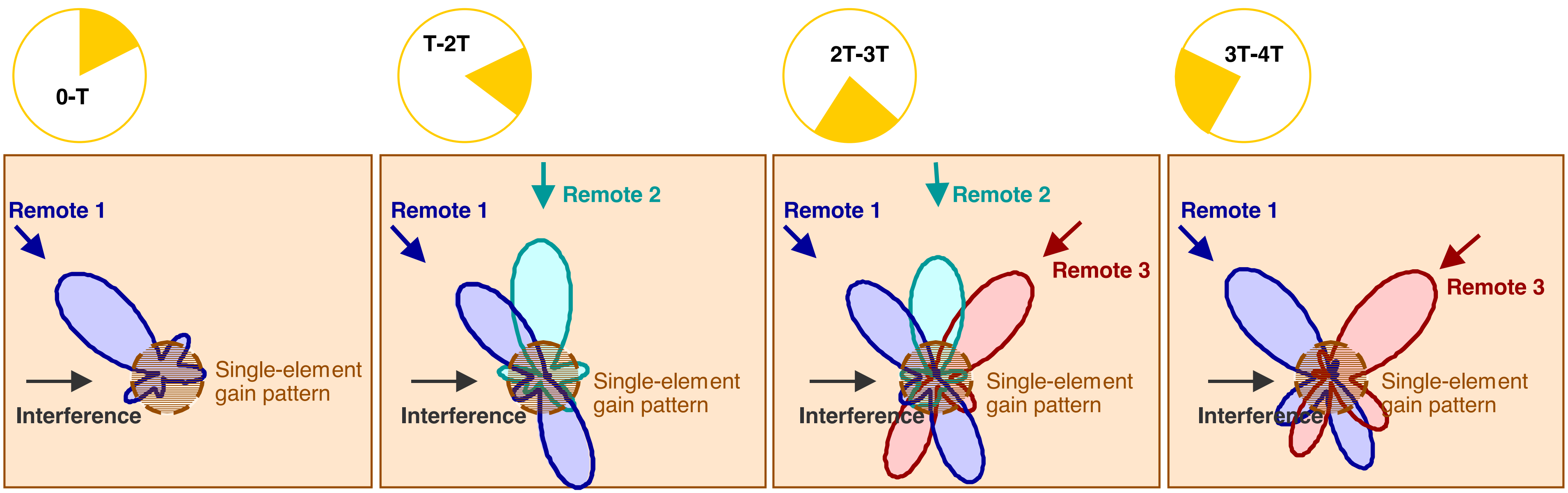
Multiuser Beamforming



Fast Packet Adaptation & In-cell Frequency Reuse

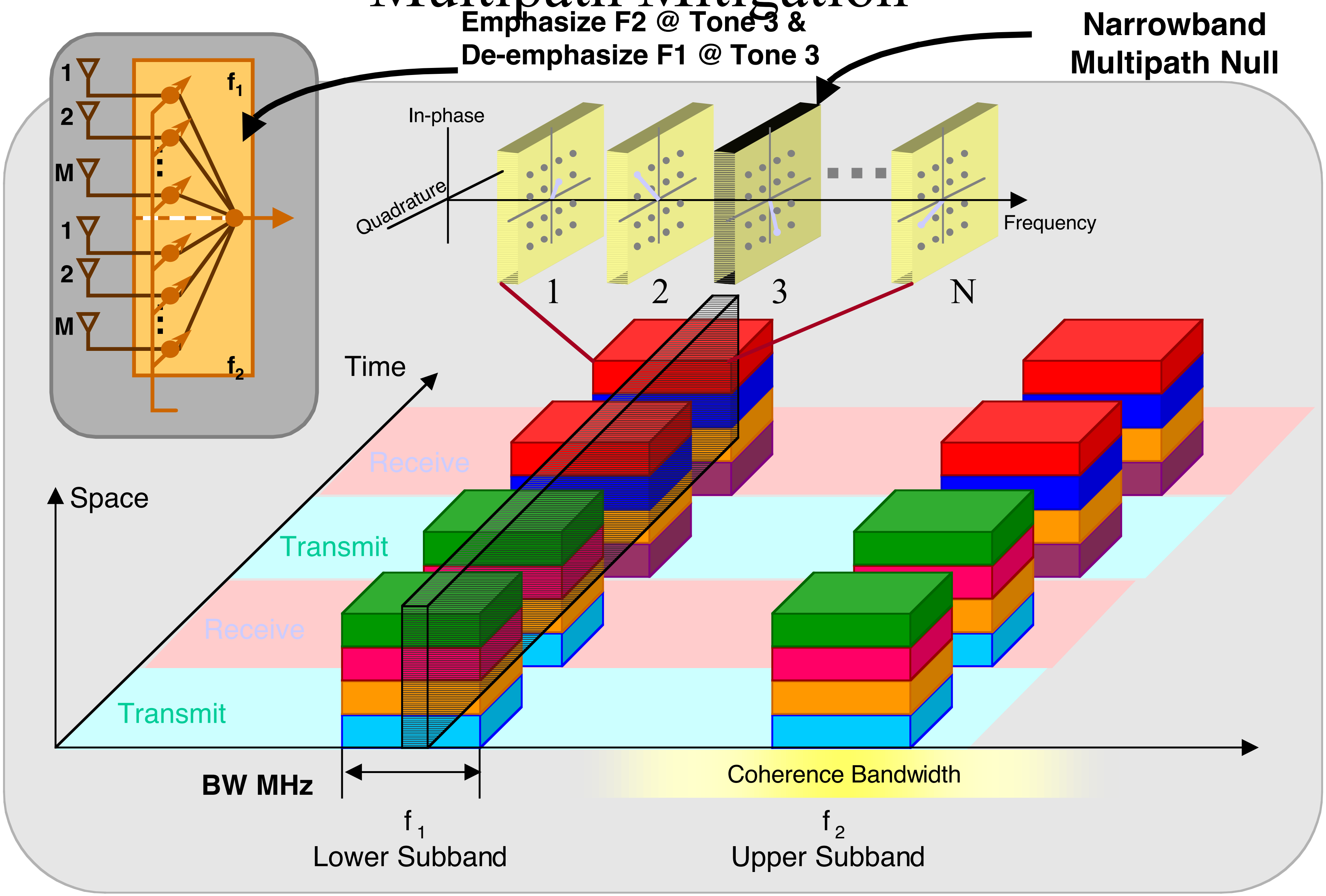




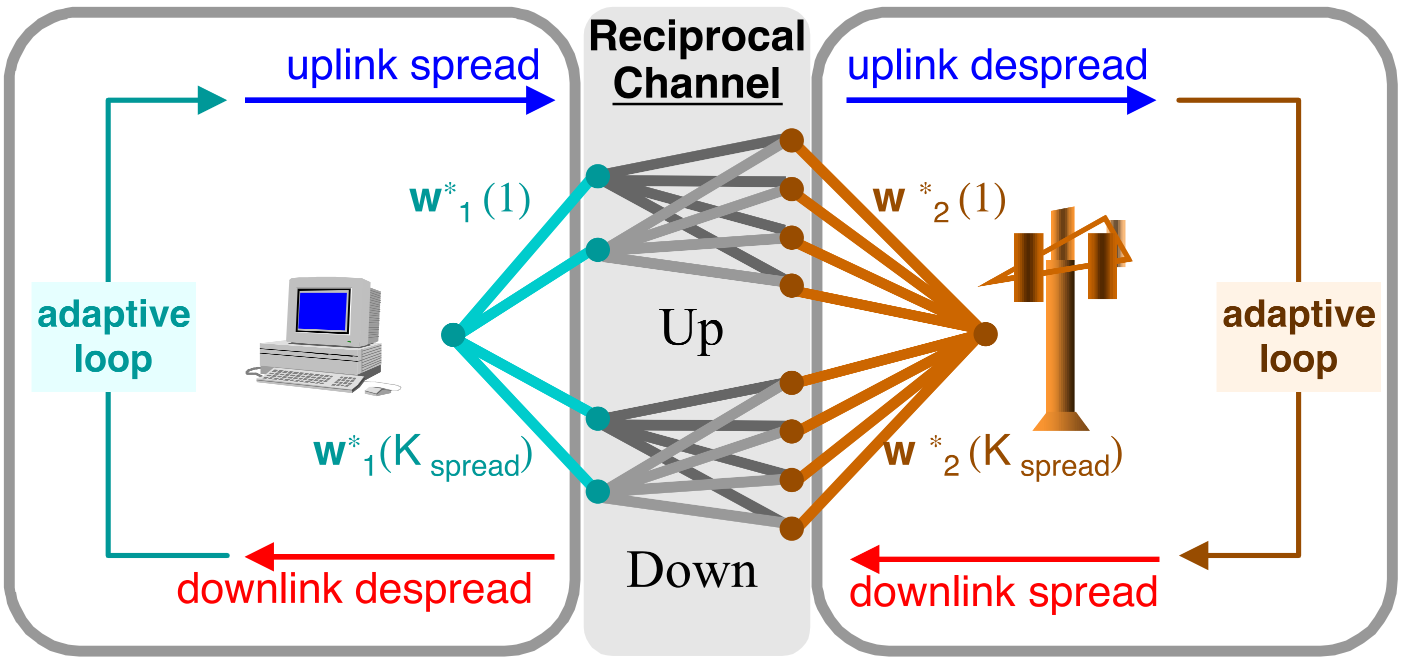


Beamforming provides gain compared to isotropic pattern	**New links acquired without harm to existing links**	**Multiple users on the same frequency (each with high link quality)**	**Adaptation occurs on packet by packet basis**

Adaptive Interference & Multipath Mitigation



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