

# Cooperative relaying system

## IEEE 802.16 Presentation Submission Template (Rev. 8.3)

Document Number:

IEEE C802.16mmr-05/042r2

Date Submitted:

2005-11-15

Source:

Amir Rubin

Intel Corporation

92 Em-Hamoshavot, Bldg 4

Park Azorim, Petach-Tikva ISR

Sumeet Sandhu

Intel Corporation

2200 Mission College Blvd

Santa Clara, CA 95052 USA

Voice: +03-9205750

E-mail: [amir.rubin@intel.com](mailto:amir.rubin@intel.com)

Venue:

IEEE 802.16 Session #40 Vancouver, CANADA

Mobile Multihop Relay (MMR) Study Group Meeting

Base Document:

None

Purpose:

Information

Notice:

This document has been prepared to assist IEEE 802.16. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.

Release:

The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE's name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE's sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.16.

IEEE 802.16 Patent Policy:

The contributor is familiar with the IEEE 802.16 Patent Policy and Procedures <<http://iee802.org/16/ipr/patents/policy.html>>, including the statement "IEEE standards may include the known use of patent(s), including patent applications, provided the IEEE receives assurance from the patent holder or applicant with respect to patents essential for compliance with both mandatory and optional portions of the standard." Early disclosure to the Working Group of patent information that might be relevant to the standard is essential to reduce the possibility for delays in the development process and increase the likelihood that the draft publication will be approved for publication. Please notify the Chair <<mailto:chair@wirelessman.org>> as early as possible, in written or electronic form, if patented technology (or technology under patent application) might be incorporated into a draft standard being developed within the IEEE 802.16 Working Group. The Chair will disclose this notification via the IEEE 802.16 web site <<http://iee802.org/16/ipr/patents/notices>>.

# **Cooperative relaying system**

Amir Rubin

Intel Corporation

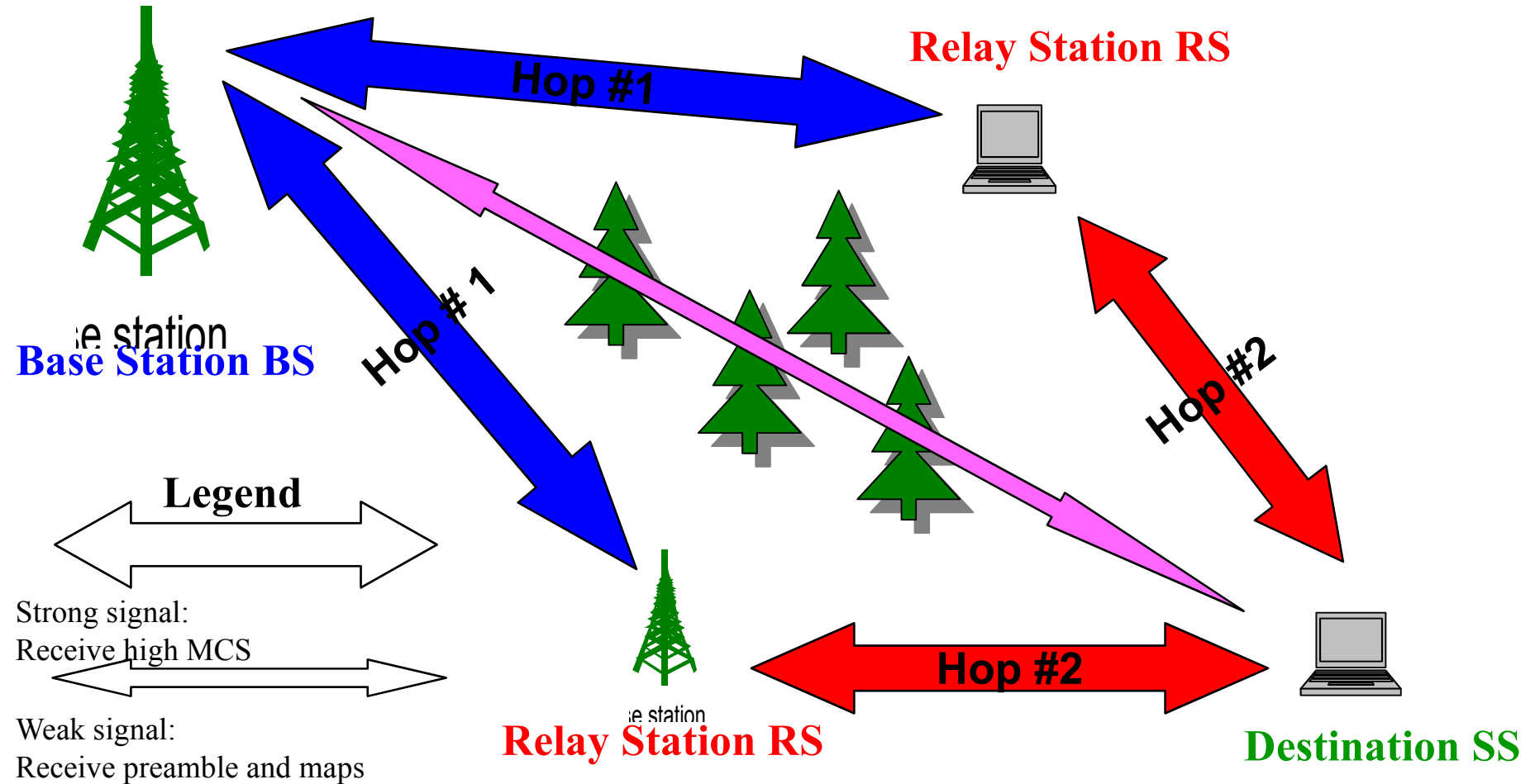
# Cooperative relaying accelerates 802.16 networks

- Communication performance breakthrough
- Longer battery lifetime
- Quick implementation
- Low cost solution

# Cooperative relaying characteristics

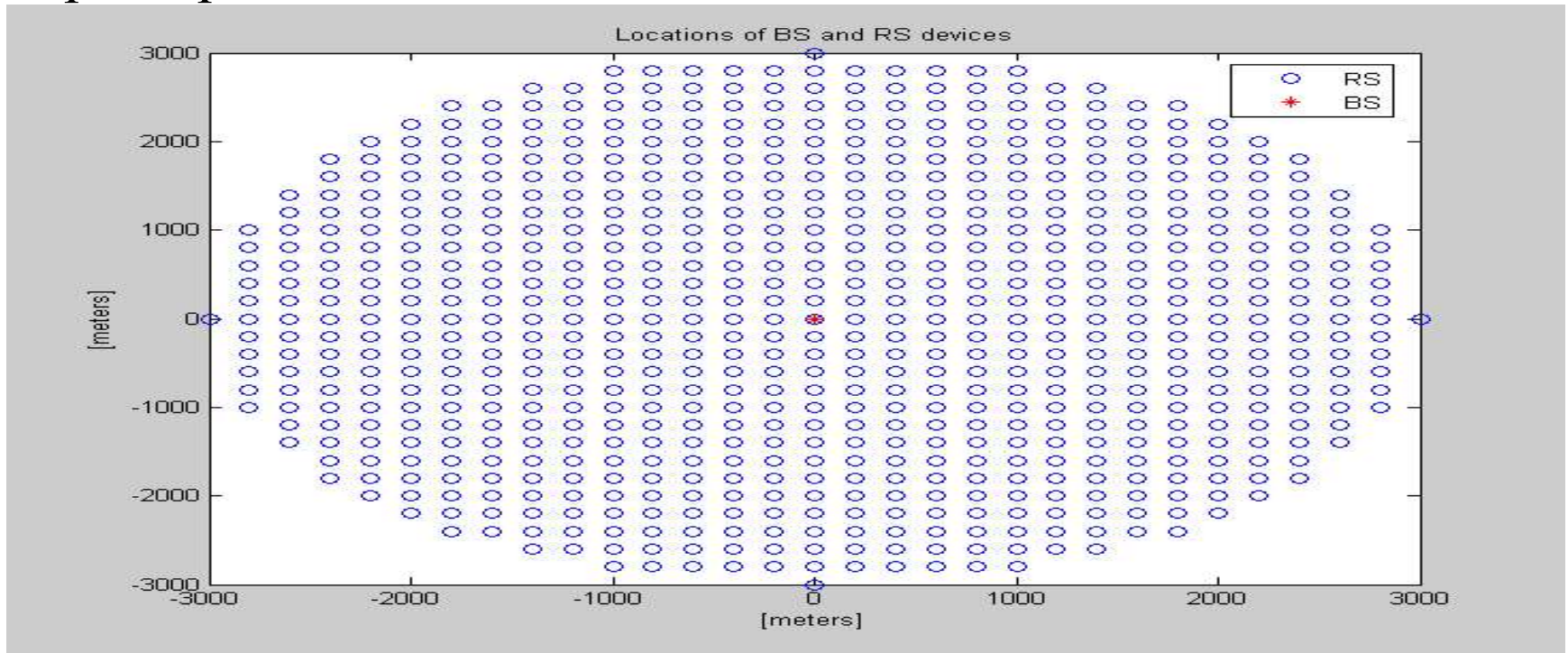
- Relaying stations forward received physical layer information towards the destination
- Multiple synchronized transmissions from spatially distributed relaying stations on the uplink or downlink
- Known to combat effectively wireless channel conditions

# Example: two RS serving a SS with 2-hop relaying



# Performance breakthrough illustration

- Infrastructure relay stations in a 3km radius cell
- Deployment of relays is 200m grid at 3 meter above roof tops
- Pedestrian speed indoor: 2.5Ghz model from ITU-R
- Uplink performance is examined



# Channel model

## •Pedestrian speed indoor model for 2.5 GHz

Transmit power	<b>20dBm</b>
Noise power	$-174\text{dBm/Hz} + 10\log_{10}(240\text{e}3) + \text{NF} =$ $-174+54+6 = \mathbf{-114\text{dBm}}$
Shadowing [dB]	$\sim\text{N}(0,8)$
Building Penetration [dB]	$\sim\text{N}(10,8)$ for BS and 0 for RS
Fast fading taps [dB]	ChanA:[0, -9.7, -19.2, -22.8 -100 -100] ChanB:[0 -0.9 -4.9 -8.0, -7.8 -23.9]
Path loss [dB]	$40*(1-4\text{e-}3*h)*\log_{10}(R) - 18*\log_{10}(h) + 80 +$ $21*\log_{10}(f)$

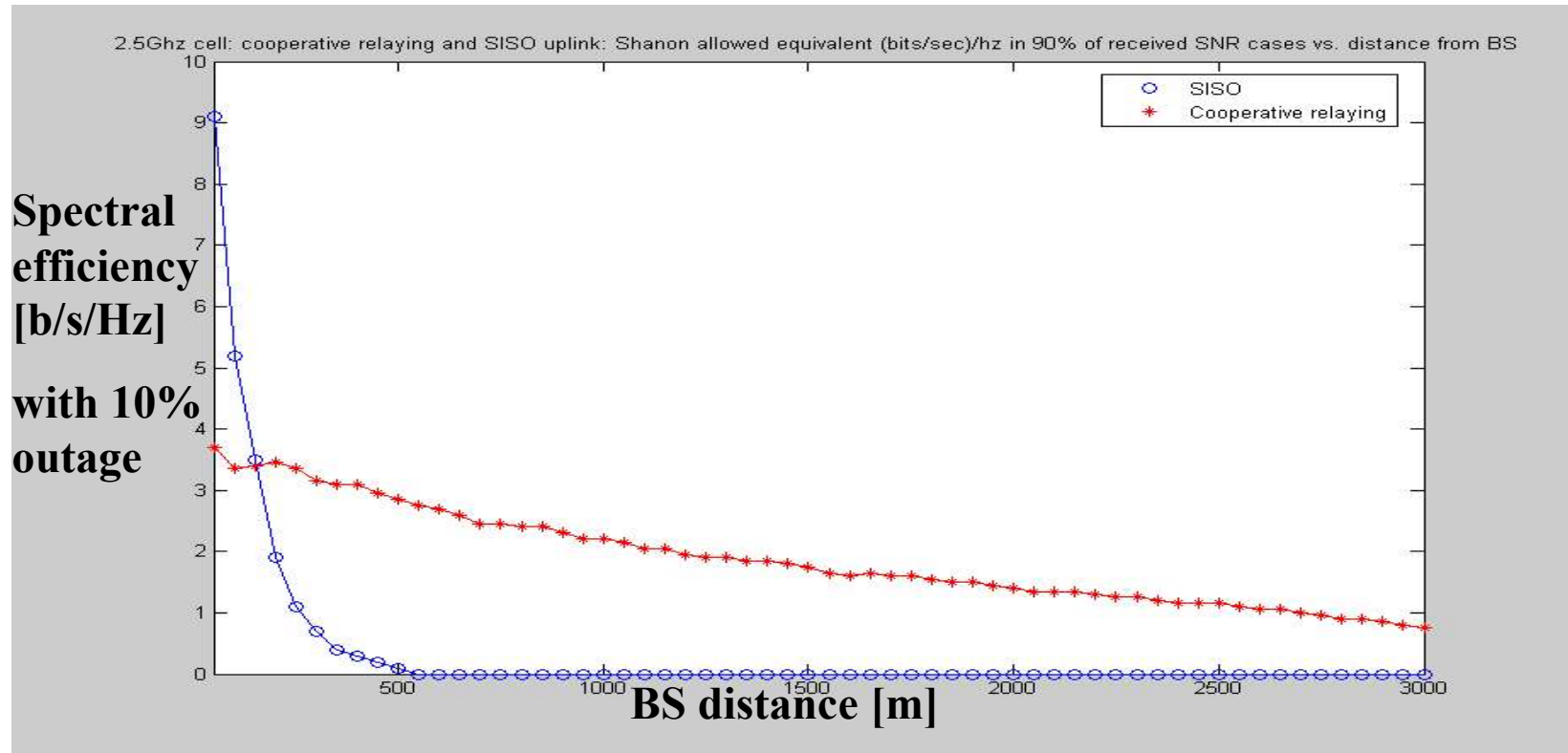
h = Height above roof top of BS and of RS in meters, BS=15 and RS=3

f = carrier frequency (MHz), 2500 used

R = distance between BS and mobile (km)

# Performance : increase in spectral efficiency

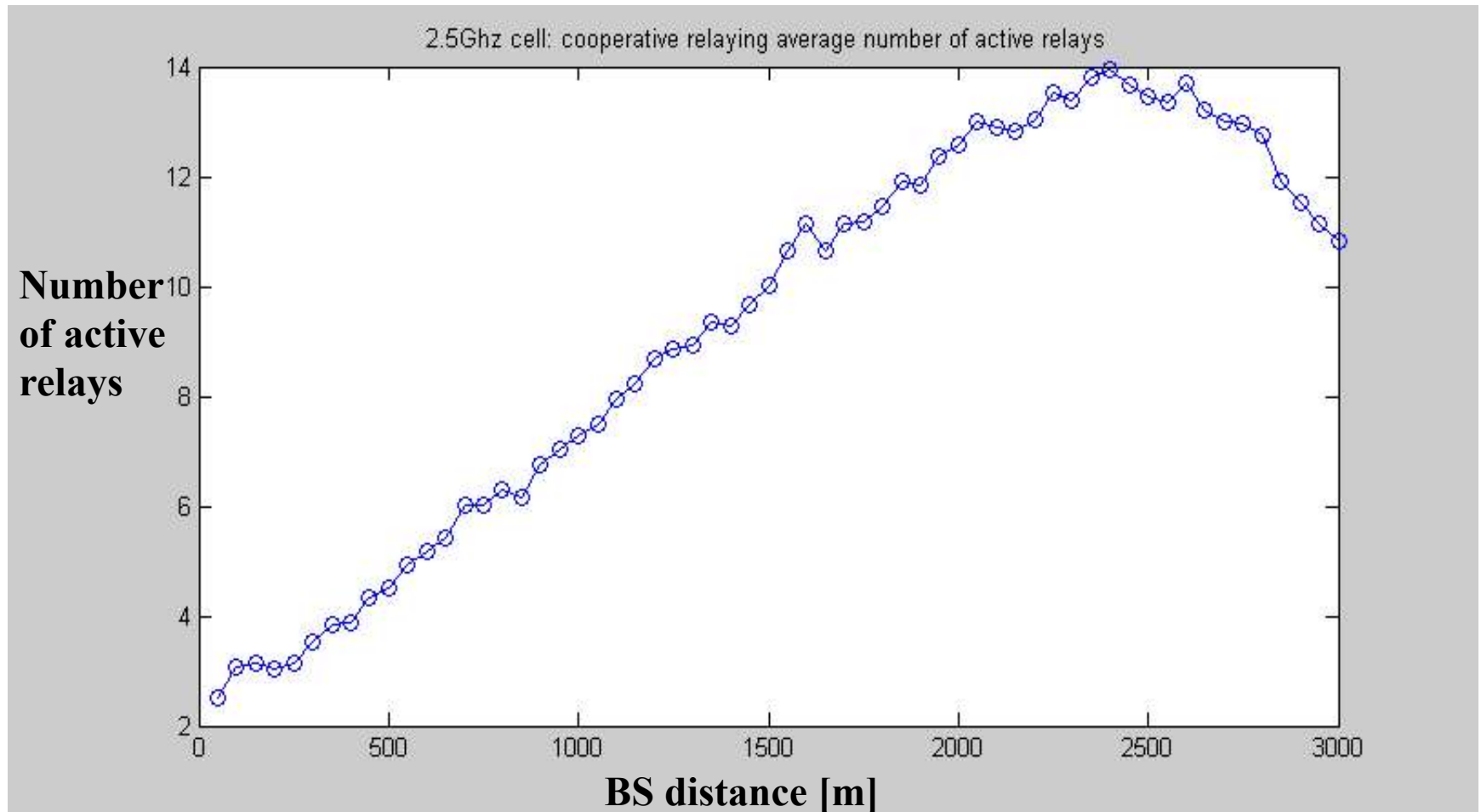
- Performance metric: Shannon capacity at 10% outage
- Two-hop relaying with same rate supported on both hops
- Compare direct rate and relayed rate [b/s/Hz] vs. BS distance [m]





# Performance : average number of active relays

- Average amount of active relays vs. BS distance



# Cooperative relaying – cost effectiveness

- Relay stations are low cost
  - No MAC functions are required
  - Transmitted power as of regular subscribers
- Subscriber cost unchanged
- Increased cell size
  - Quantities of relay stations can be used
- Allows low cost 5-6Ghz frequency networks
  - More relays should be deployed

# Suggested cooperative relaying mechanism

- Decode-and-forward at the relaying stations according to reception reliability (e.g. CRC)
- The BS schedules relaying transmissions
- Dedicated uplink and downlink zones
- The relaying stations may be SS with relaying capability or dedicated relay stations

# Suggested cooperative relaying implementation

- Backwards compatible
- Several new information elements
- Data bursts relaying
  - Extended throughput with higher modulation-coding schemes
  - Sufficient for SS that can communicate maps and initial ranging directly with the BS
- Preamble, maps and initial ranging relaying
  - Required for extended range and coverage

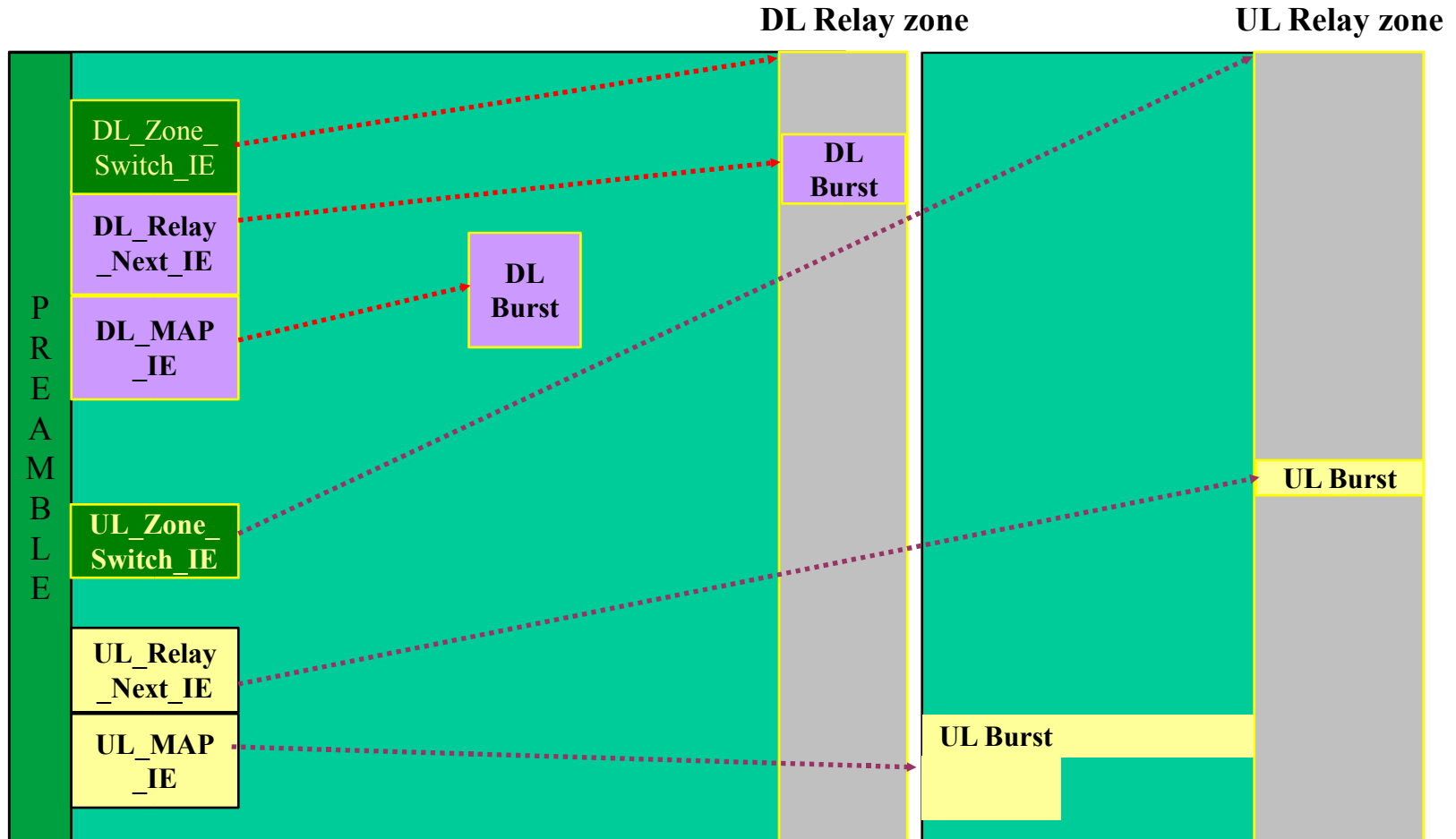
# Information elements for cooperative relaying

- Indicating bursts to be relayed
- Relaying allocations and conditions
- Source and destination of the burst
- Relaying transmission characteristics
- Provisioning for diverse algorithms of multi-hop relaying scheduling
- Provisioning for virtual MIMO

# Example of only data bursts relaying

Downlink sub frame

Uplink sub frame



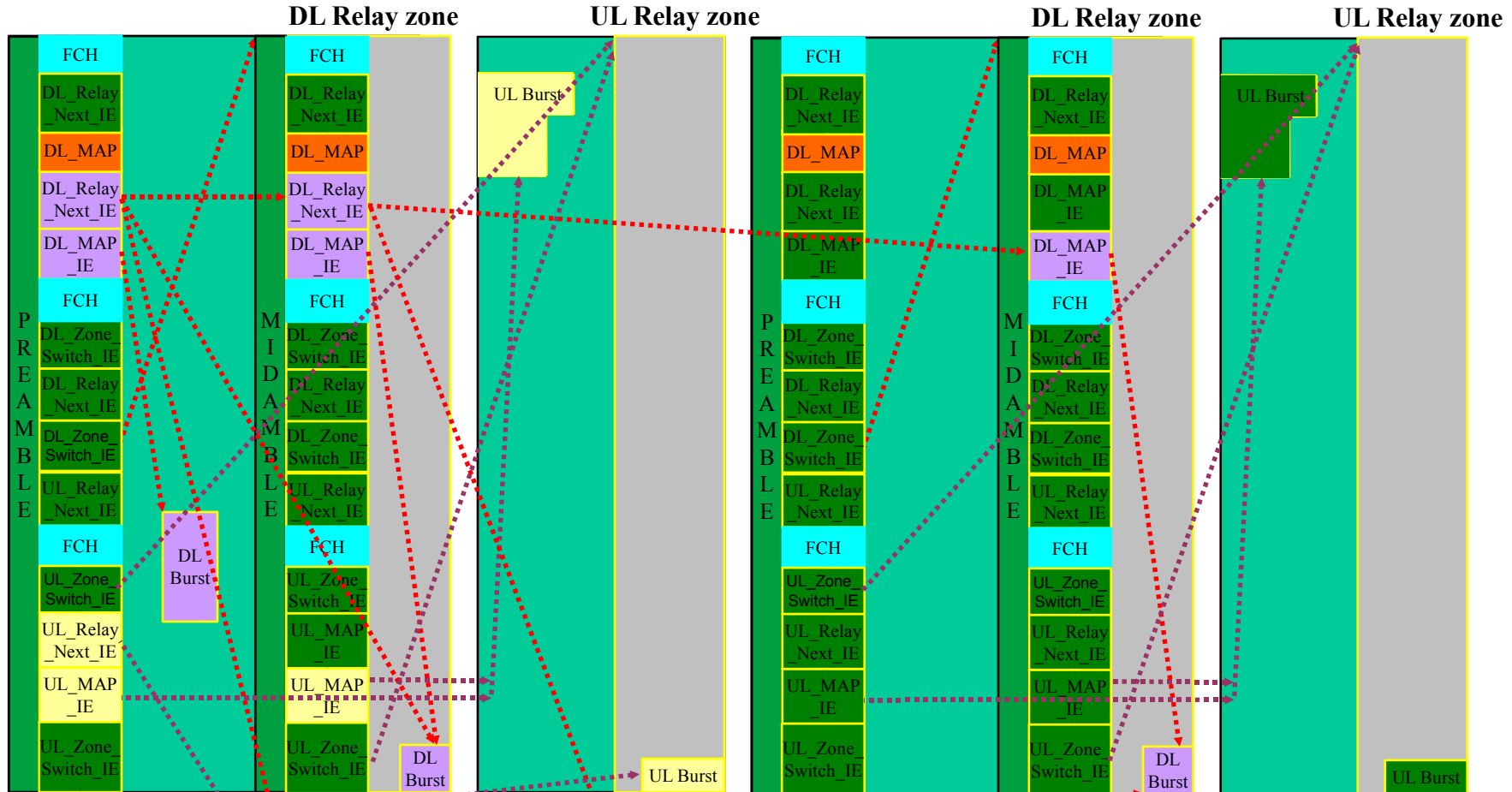
# Example of preamble, maps and data relaying

Downlink sub frame

Uplink sub frame

Downlink sub frame

Uplink sub frame



# Considerations

- Inter-cell Interference
  - Conditioning downlink relaying by proximity to destination strongly decreases Inter-cell Interference
- Inter Symbol Interference from the spatially diverse relaying stations
  - Cooperating relays are close and relaying transmissions power is low and controlled.
- Limitations on deployment of relay stations
  - Relays transmission power may be similar to SS's.



# **The bottom line:**

## **“Cooperative relaying ASAP, improvements later”**

- Quick and low cost usage of cooperative relaying is crucial and achievable
- Allows breakthrough in 802.16 networks
- Accelerated market penetration
- Provisioning diverse future algorithms without waiting for them

# BACKUP

# Reference: channel model

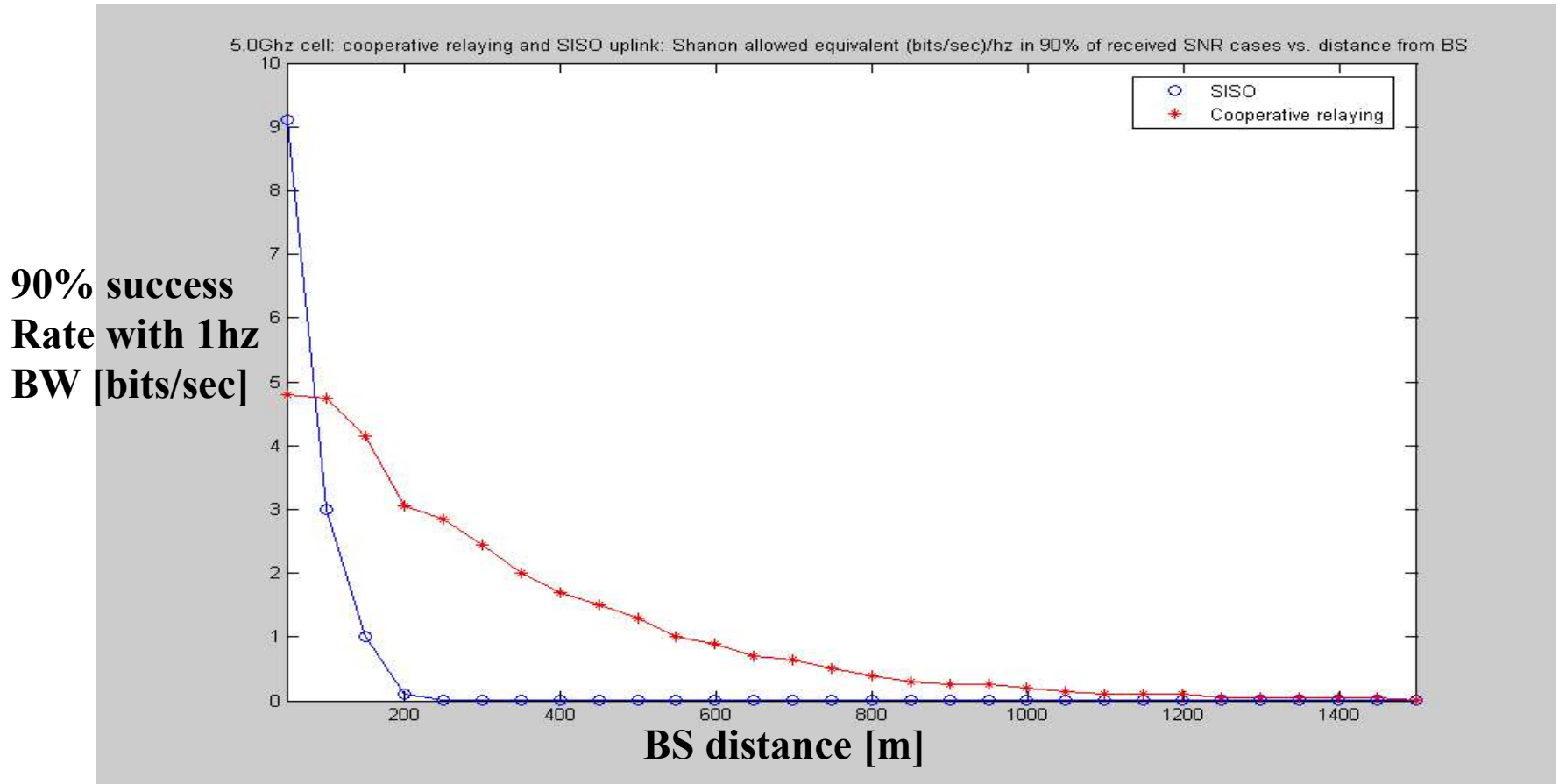
- Pedestrian speed indoor model at 5GHz

• From: "IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, VOL. 20, NO. 3, APRIL 2002 507, Propagation Characteristics for Wideband Outdoor Mobile Communications at 5.3 GHz, Xiongwen Zhao, Jarmo Kivinen, Pertti Vainikainen, Member, IEEE, and Kari Skog"

Transmitted power	<b>20dBm</b>
Noise power Bandwidth = 240kHz	$-174\text{dBm/Hz} + 10\log_{10}(240\text{e}3) + \text{NF} =$ $-174 + 54 + 6 = \mathbf{-114\text{dBm}}$
Shadowing [dB]	$\sim N(0,4)$
Building Penetration [dB]	$\sim N(16,8)$
Fast fading taps [dB]	ChanA: [0, -9.7, -19.2, -22.8 -100 -100] ChanB: [0 -0.9 -4.9 -8.0, -7.8 -23.9]
Path loss [dB]	$58 * \log_{10}(R) - 16.9$

# Performance : 5 GHz

- Direct and relayed rate [bits/sec] with 1hz BW vs. BS distance [m]
  - Relayed value is half of original and relayed rate
- Rates in graph allow 90% success ratio with Shanon limited receiver



# Performance : 5 GHz

- Average amount of active relays vs. BS distance

