

Analysis of Simple Infrastructure Multihop Relay Wireless System

IEEE 802.16 Presentation Submission Template (Rev. 8.3)

Document Number:

IEEE C802.16mmr-05/034r2

Date Submitted:

2005-11-16

Source:

Byoung-Jo "J" Kim

N. K. Shankar

AT&T Labs-Research

Amit Saha, Rice University

Voice:

732-420-9028

E-mail:

macsbug at research dot att dot com

E-mail:

shankar at research dot att dot com

E-mail:

amit.saha at cs dot rice dot edu

Venue:

IEEE 802.16 Session #40 Vancouver, CANADA

Mobile Multihop Relay (MMR) Study Group Meeting

Base Document:

Purpose:

Information for discussions on the future work areas for multi-hop relay support for 802.16

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>>.

Analysis of Simple Infrastructure Multihop Relay Wireless System

Byoung-Jo “J” Kim, AT&T Research

Amit Saha, Rice University

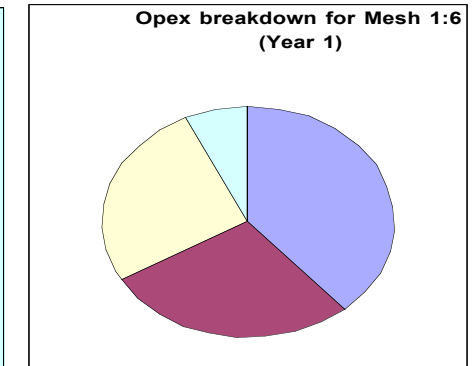
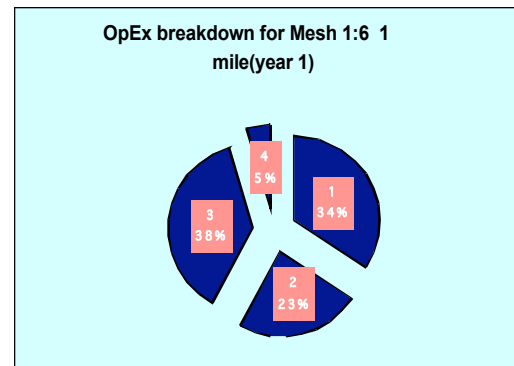
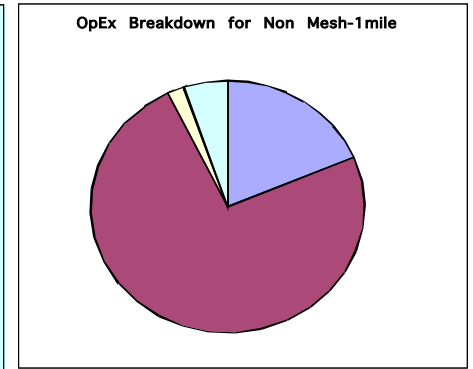
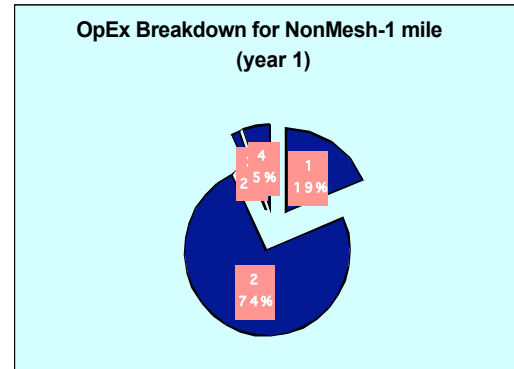
N.K. Shankar, AT&T Research

Variations of Infrastructure Multihop

- forwarding links in different dedicated spectrum/Radio
 - Becomes Economic and deployment engineering problems.
 - Enhancements on Conventional wireless backhaul
 - Dedicated spectrum cannot be used flexibly
 - Thus, cheaper spectrum at high frequencies are often used for backhaul.
- Same spectrum for backhaul and user links
 - Same type of radio technology (e.g., all WiFi meshes)
 - Most flexible: Dynamically used in time/frequency/code/tone, etc..
 - Concerns on Capacity Hit compared to conventional systems with same amount of spectrum
 - Must control resource consumption for backhaul
 - Number of hops, modulation efficiency, etc..
- Analyze a simple system to identify basic features needed in standards

Backhaul vs. Tower leasing

- The cost of electronics goes down but the cost of civil engineering, site acquisition & laying fiber remains very high.
- Non MMR:
 - High Backhaul cost & High or Low Tower Cost (depends on cell Radius)
- MMR(6 to 1 cell aggregation):
 - Backhaul (Aggregation) & Low Tower cost (cell radius small)
- Tower related cost become more important as backhaul cost go down
 - 1 → Tower Leasing
 - 2 → Backhaul facility
 - 3 → Customer Acquisition and CPE Subsidy
 - 4 → Maintenance



Assumptions

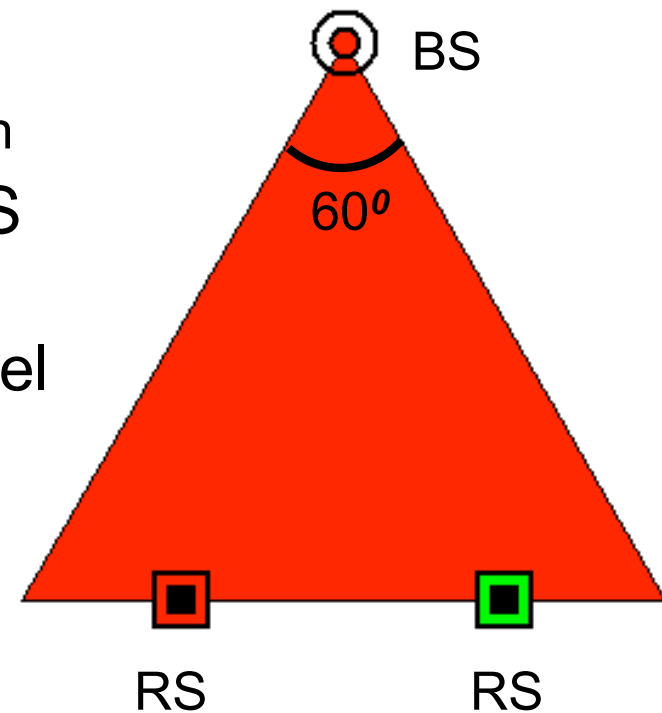
- Time-shared “centralized MAC” packet radio system
 - 802.16/WiMAX OFDM(A)
 - CDMA EV-DO, UMTS HSDPA
- Equal time per SS under uniform infinite offered traffic
 - Scheduling considerations later, perhaps outside of 16
 - Except measurements to assist scheduling decisions
- Two-hop infrastructure system
 - For now.. Lower complexity and cost
 - Most gain achieved by the first additional hop
 - due to exponential nature of propagation
 - Also in “On the throughput enhancement of multihop relaying” Jaeweon Cho; Haas, Z.J., JSAC, V 22, I 7, Sept. 2004, P 1206 – 1219

Assumptions

- “Low complexity” RS
 - Smaller and lower height than BS, but higher than SS
 - Infrastructure RS
 - Single radio communicating with both SS and BS
 - Omni directional antenna to serve SS
 - Similar complexity as SS except
 - May use Directional antenna for RS-BS link
 - Alternate between antennas using simple switch
- Capacity Limited system
 - Coverage advantage is obvious and previously studied
 - Examine the hit on user traffic capacity due to multihop relaying

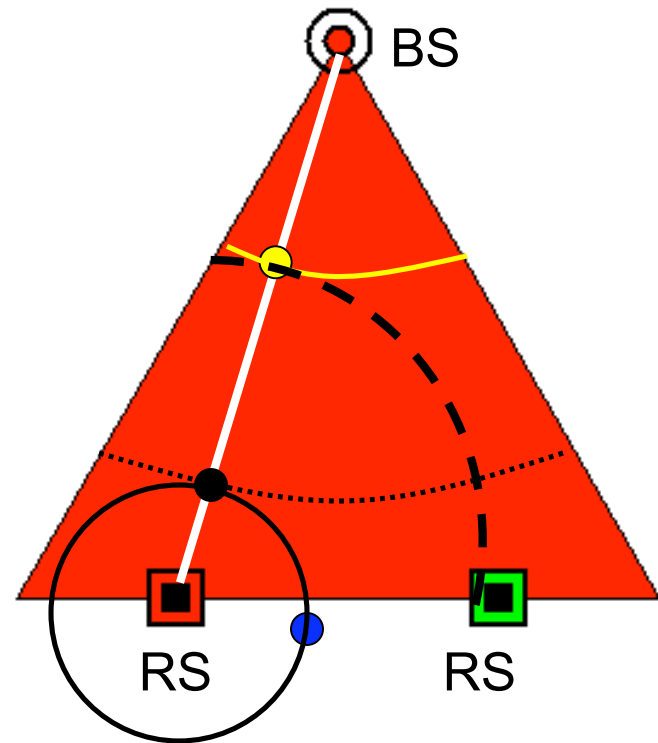
Mesh Sector

- Place RS near Sector boundary
 - Omni for RS
 - Symmetric, Simple, Shorter range.
 - Maximum benefit in terms of path gain
 - With smallest number of RS with Omni antenna
- Red RS using the same RF channel as the supporting red BS
 - Same reuse pattern as conventional systems
- Green RS belongs to the facing sector
 - Can switch sectors depending on load



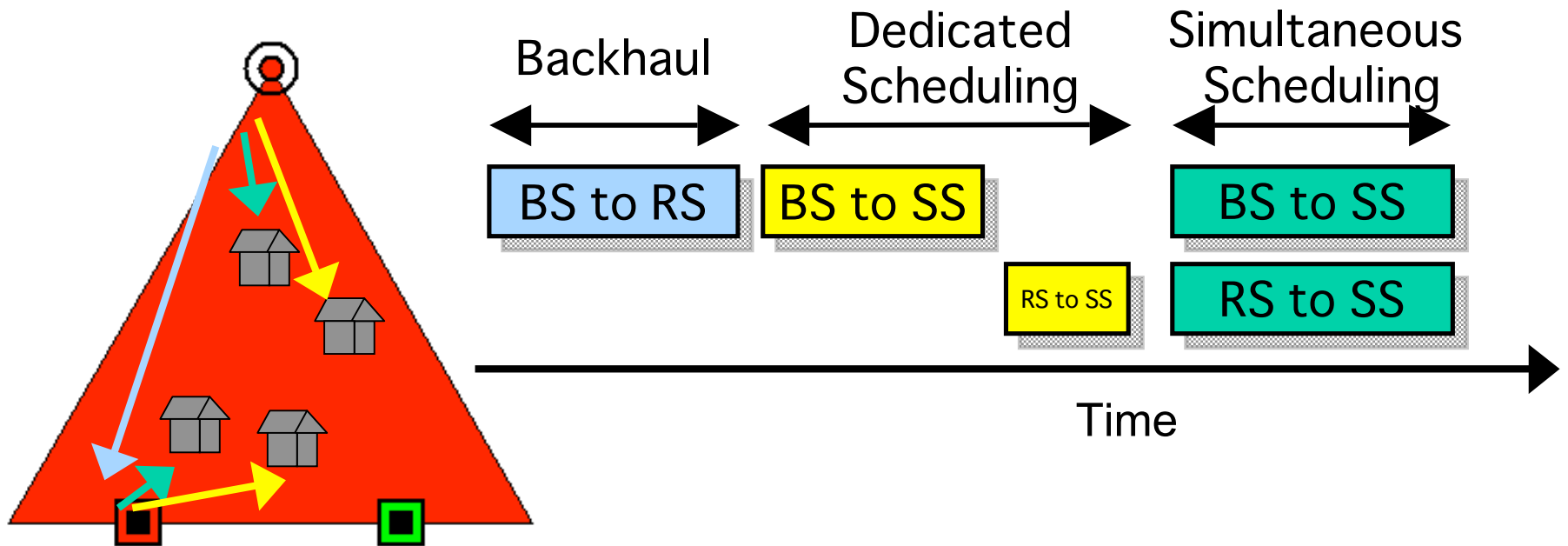
Simple Analysis

- Resource reuse feasible?
- If so, Sector throughput gain?
- Analytical formulation for worst case multi-cell arrangement indicates “Yes” to both questions.

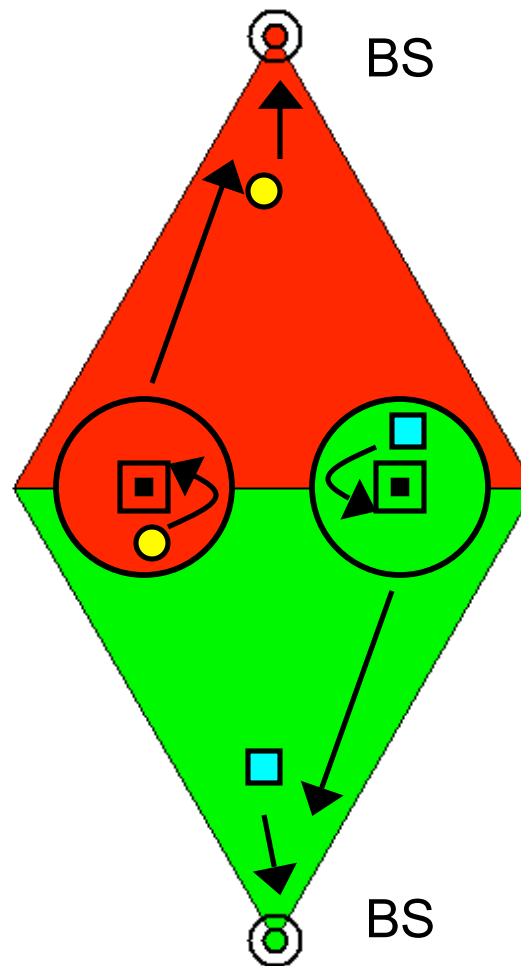


Intra-Sector Scheduling Approach


- Compatible with 802.16 PMP frame structure
 - One possible frame structure



Mesh Sector Analyzed



Simulation Parameters

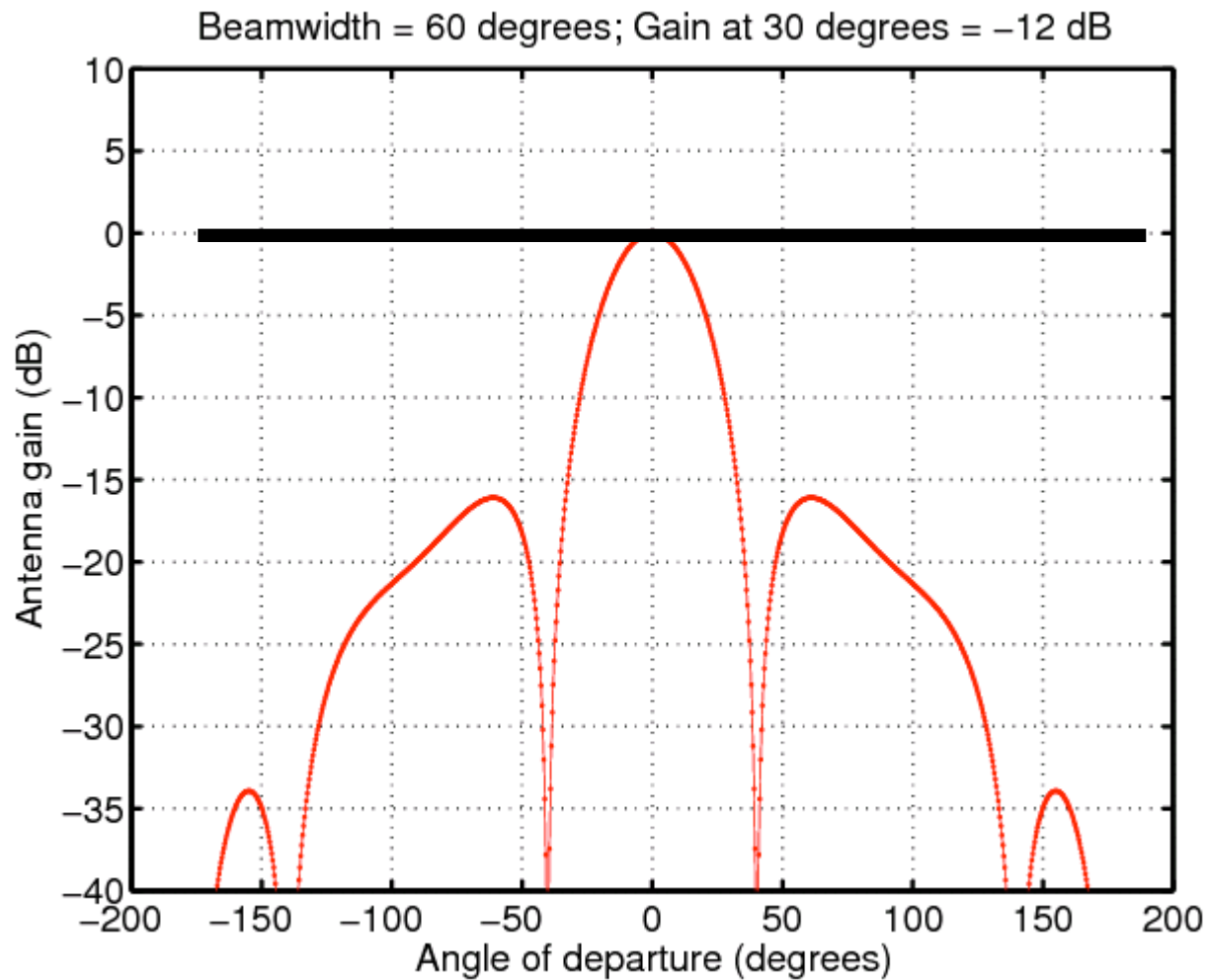
Frequency reuse	(1,6,6)  & (1,3,6)
Cell radius	1000 m
BS gain	20 dB
RS gain	0 dB
BS height	30 m
RS height	15 m
SS height	2 m
Transmit power	30 dBm
Power control	No, for now
Path loss model	Erceg-Greenstein (aka. 802.16 model)

Simulation Parameters - Rates

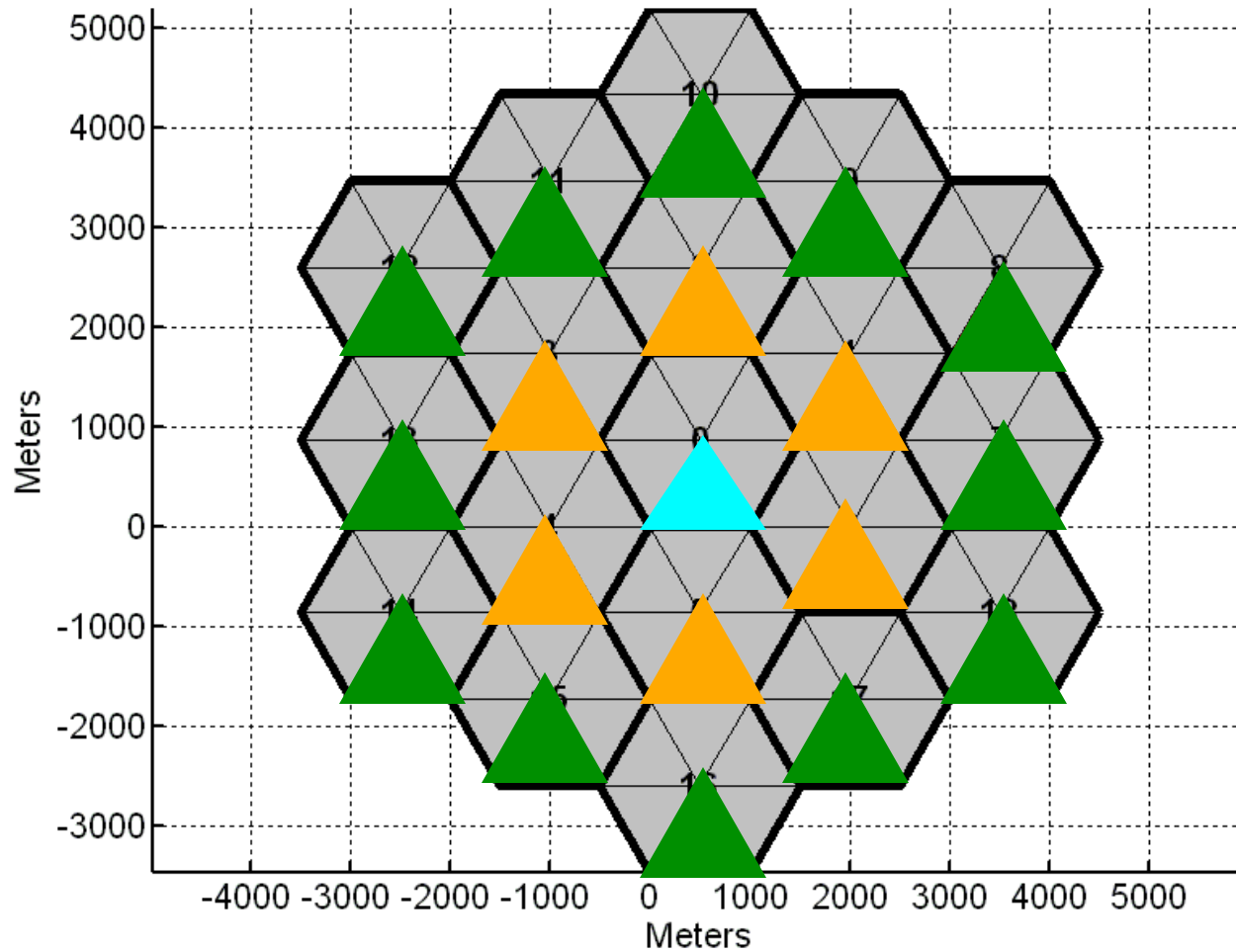
- 6 MHz channel
- Representative values for 802.16/WiMAX
 - Continuous capacity analysis tends to be optimistic
 - Lower yet more robust rates are available but not simulated.

Modulation	Code Rate	Required SINR (dB)	Data Rate (Mbps)
QPSK	1/2	6.6	6.0
16-QAM	1/2	10.5	12.0
64-QAM	2/3	15.3	24.0
64-QAM	3/4	20.8	27.0

Directional Antenna Pattern

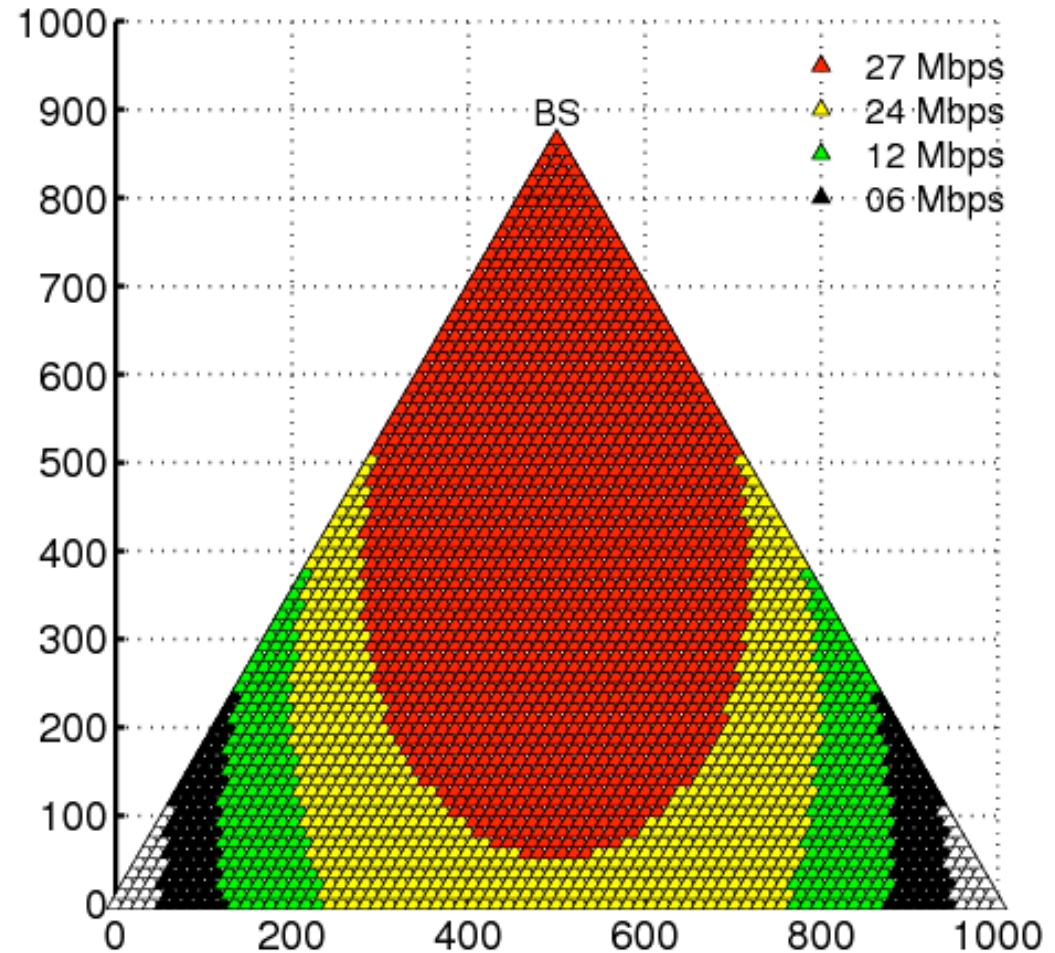


Multi-Cell Scenario without RS Reuse pattern (1,6,6)



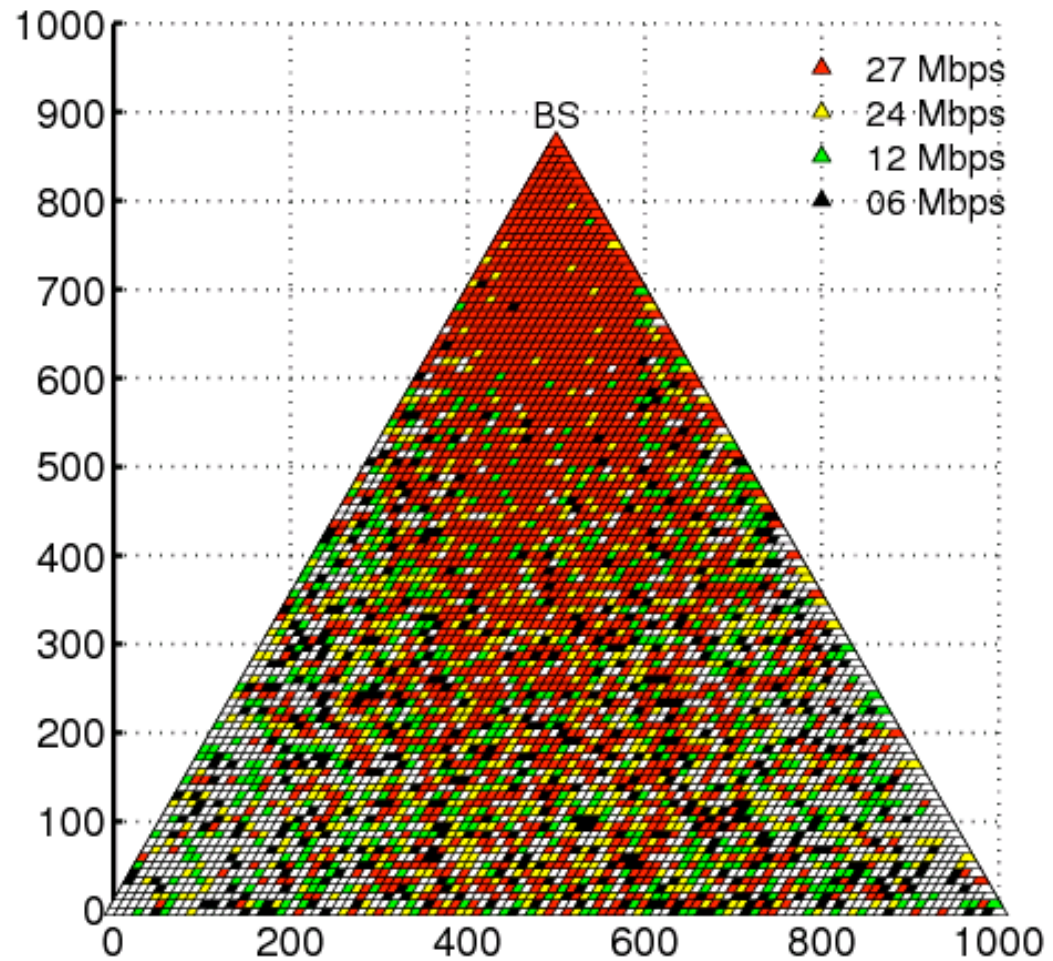
Multi-Cell Scenario without RS

- No log normal fading

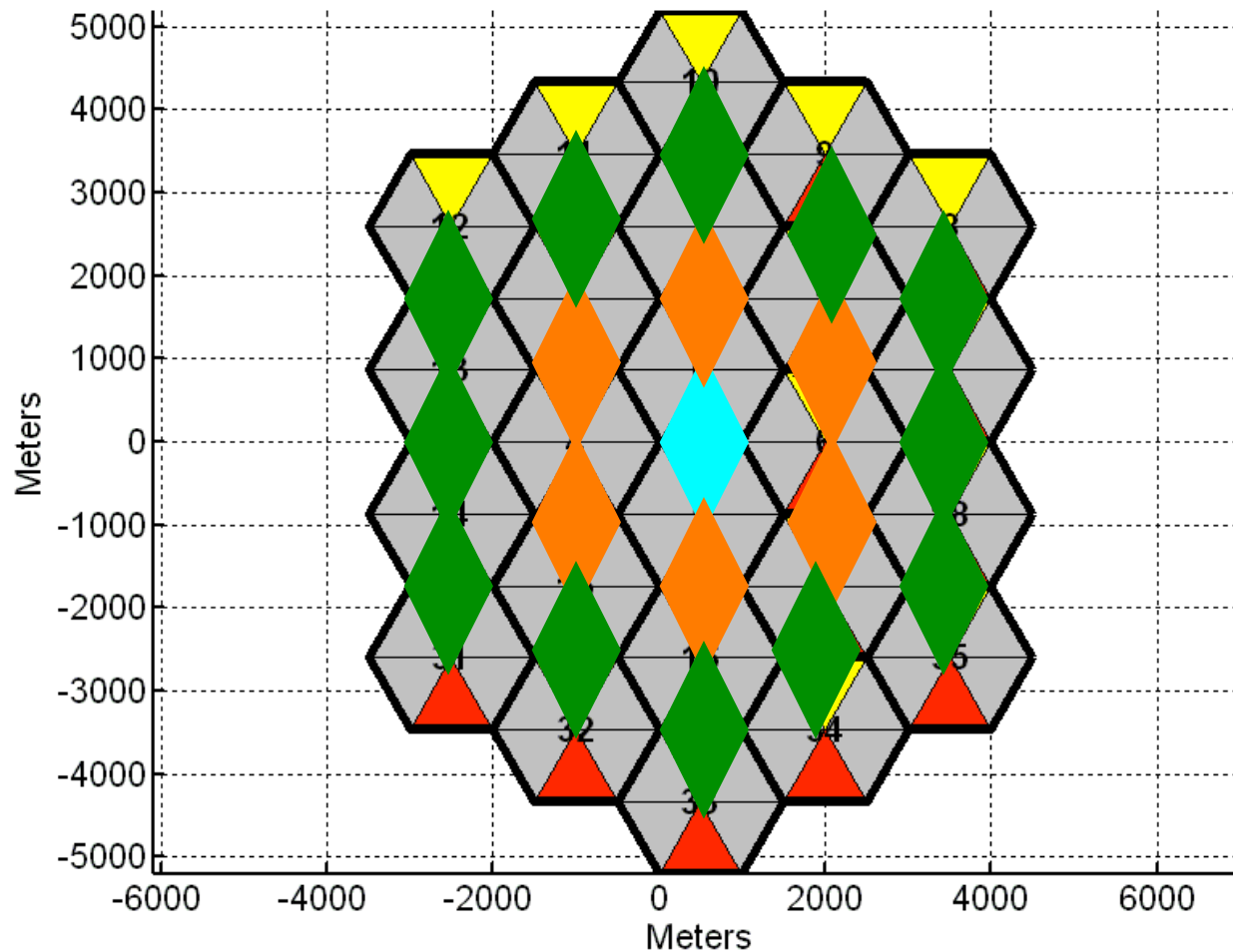


Multi-Cell Scenario without RS

- With log normal fading

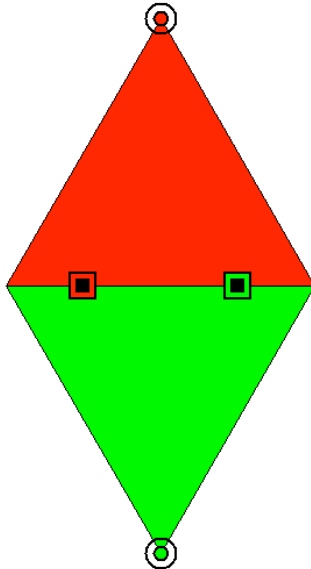


Multi-Cell Scenario with RS Reuse pattern (1,6,6)

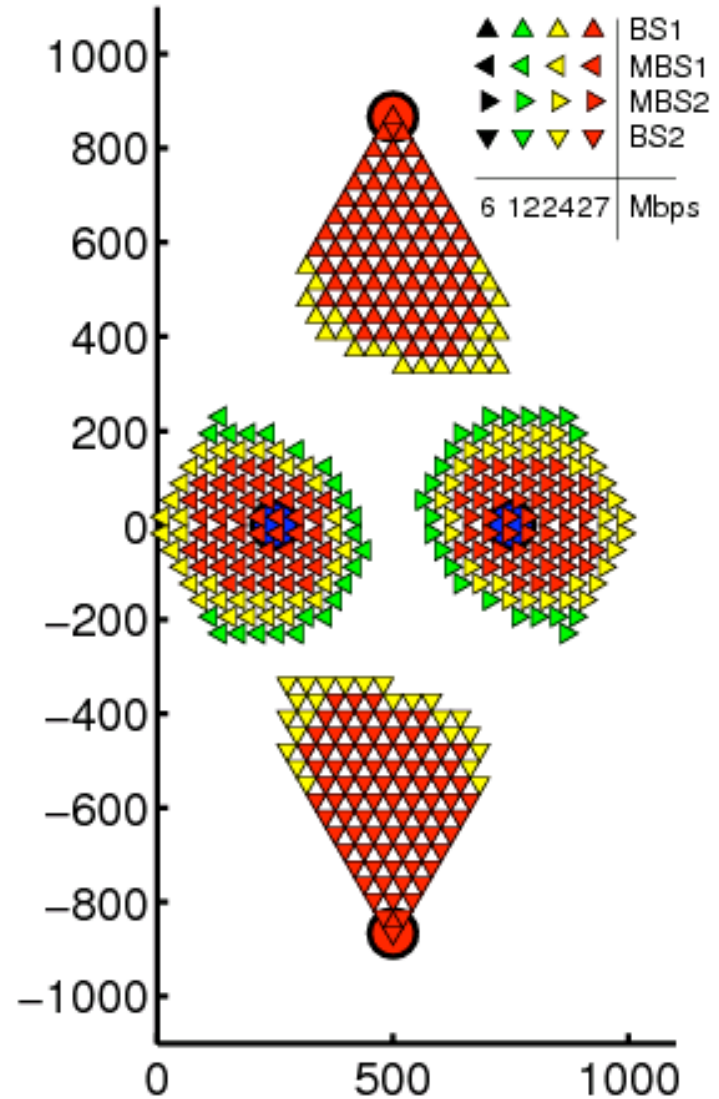


Multi-Cell Scenario with RS

- No log-normal fading
 - For illustration
- Simultaneous scheduling regions



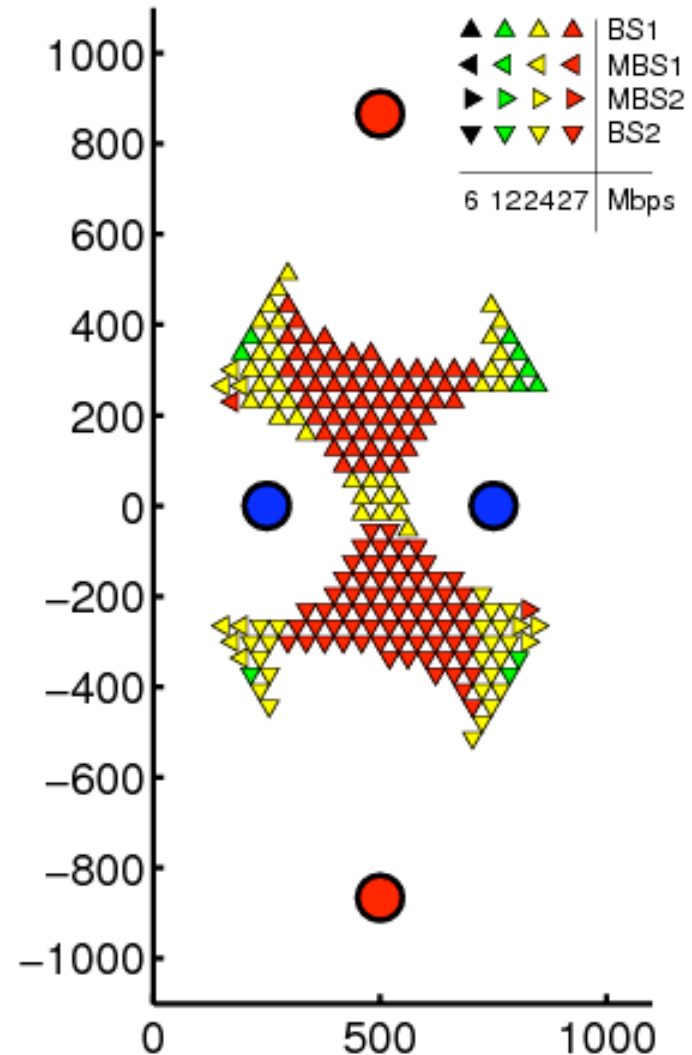
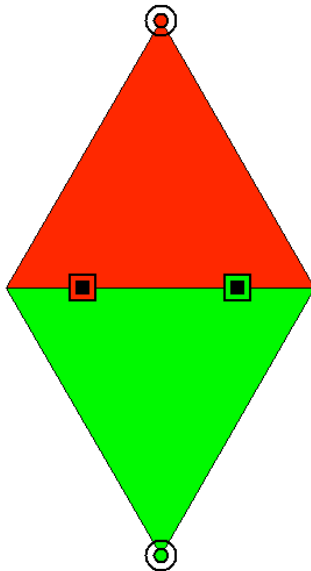
“J” Kim, Amit Saha, N.K. Shankar



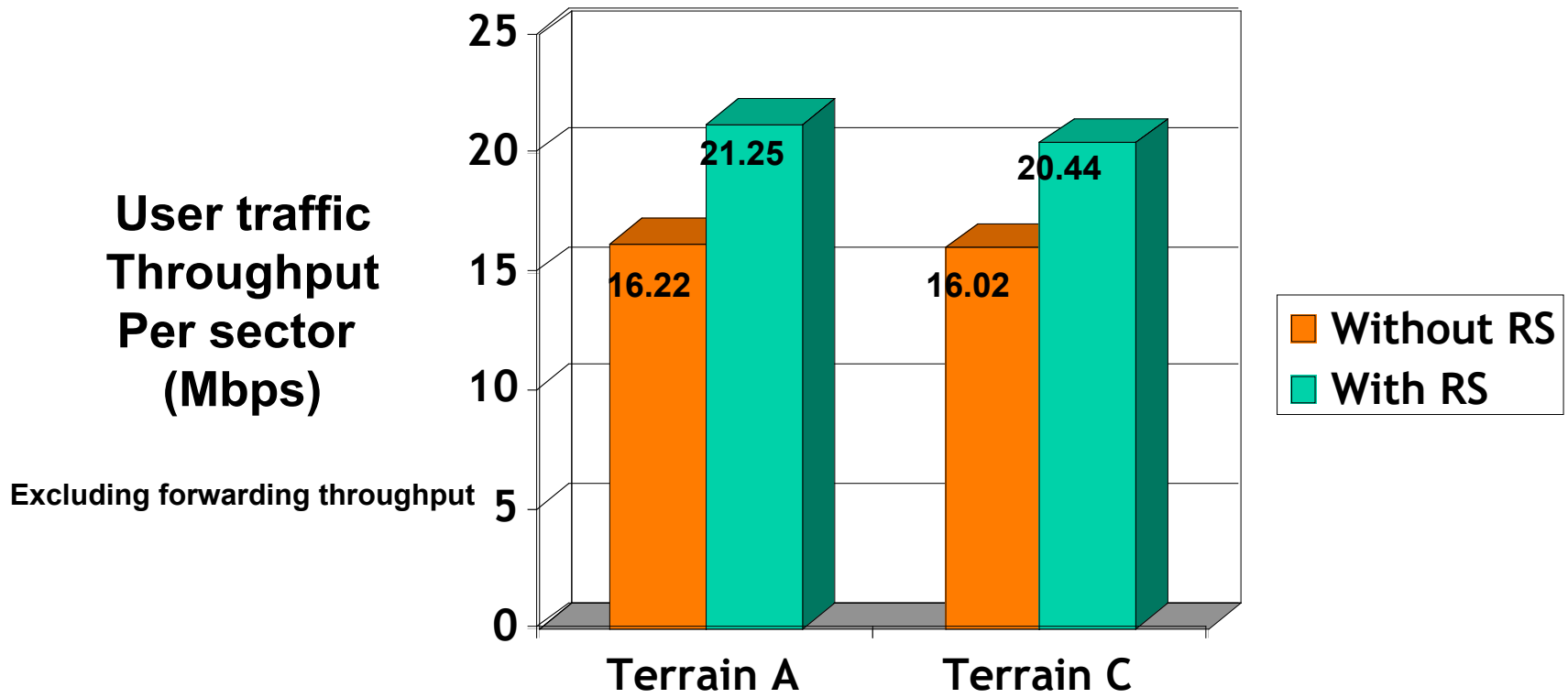
IEEE C802.16mmr-05/034r2

Multi-Cell Scenario with RS

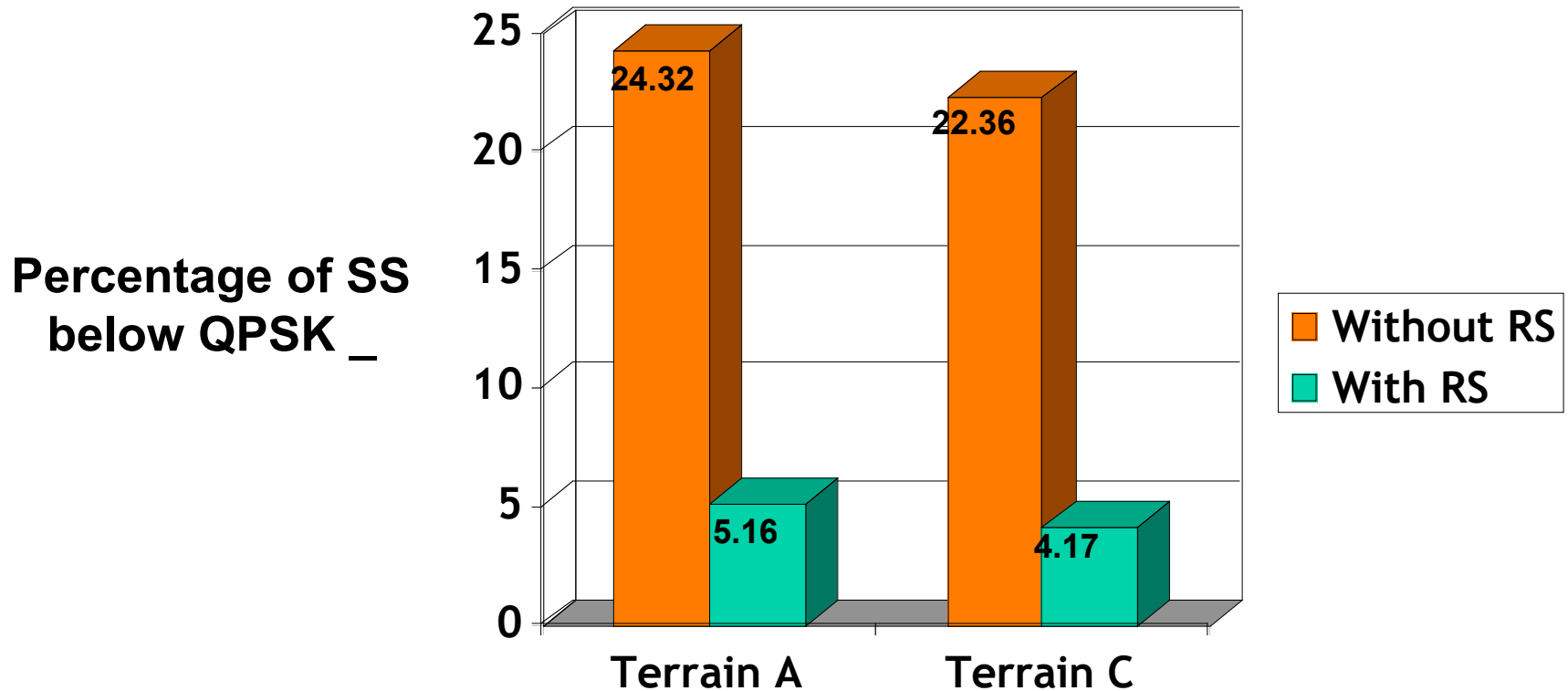
- No log-normal fading
 - For illustration
- Dedicated scheduling regions



Throughput Comparison: (1,6,6)

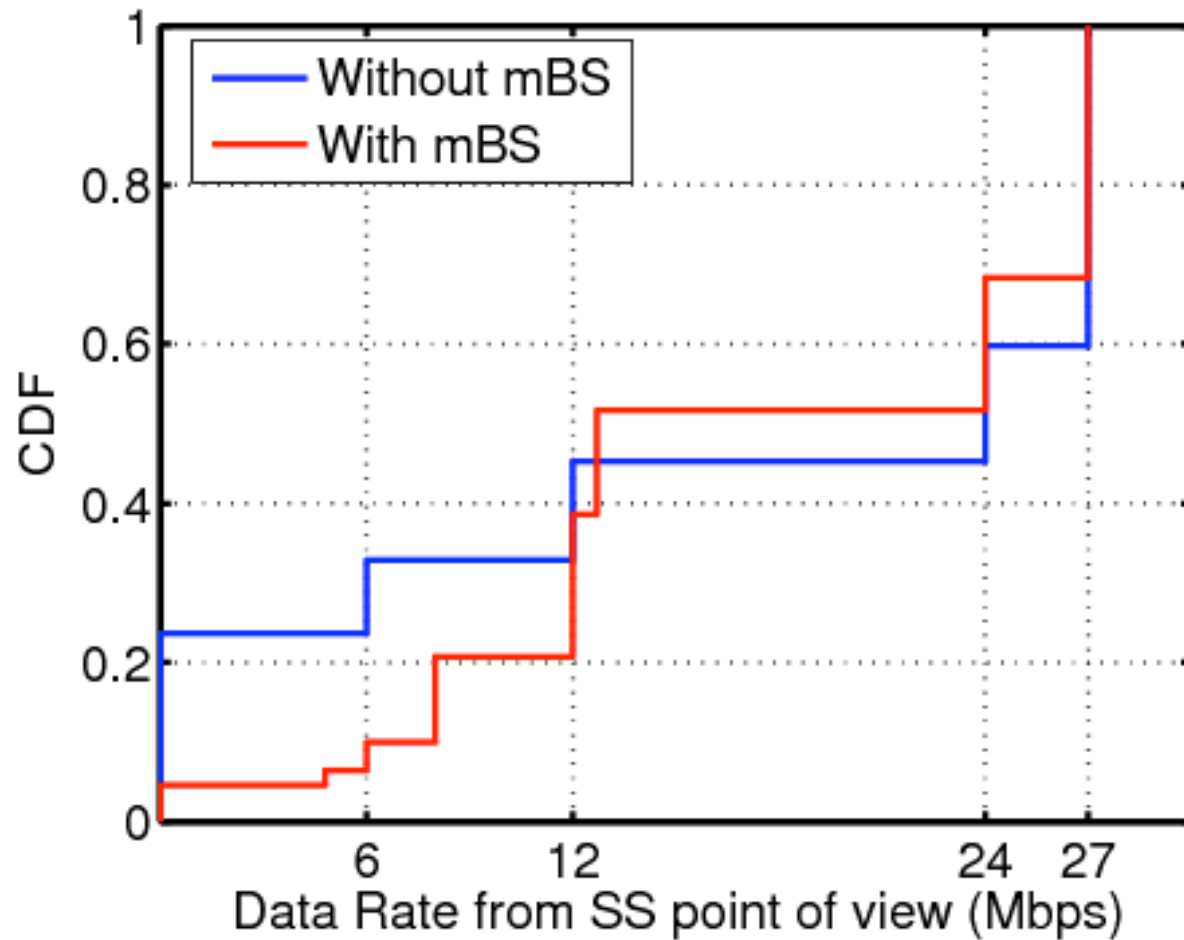


QPSK _ Outage Comparison (1,6,6)

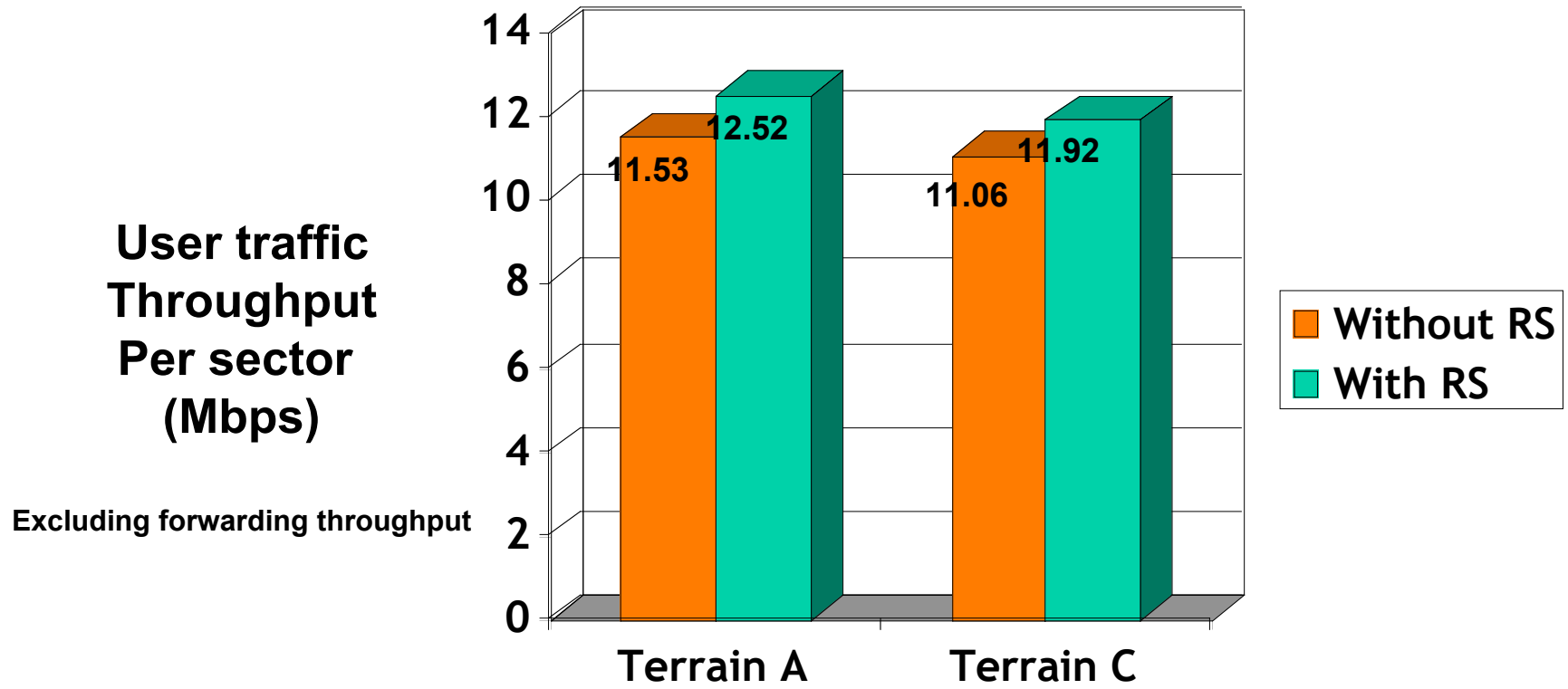


Obviously, Capacity and Coverage interplay, but the conventional system needs larger reuse distances to match the RS system. Thus. the capacity gain in the previous slide is in fact higher.

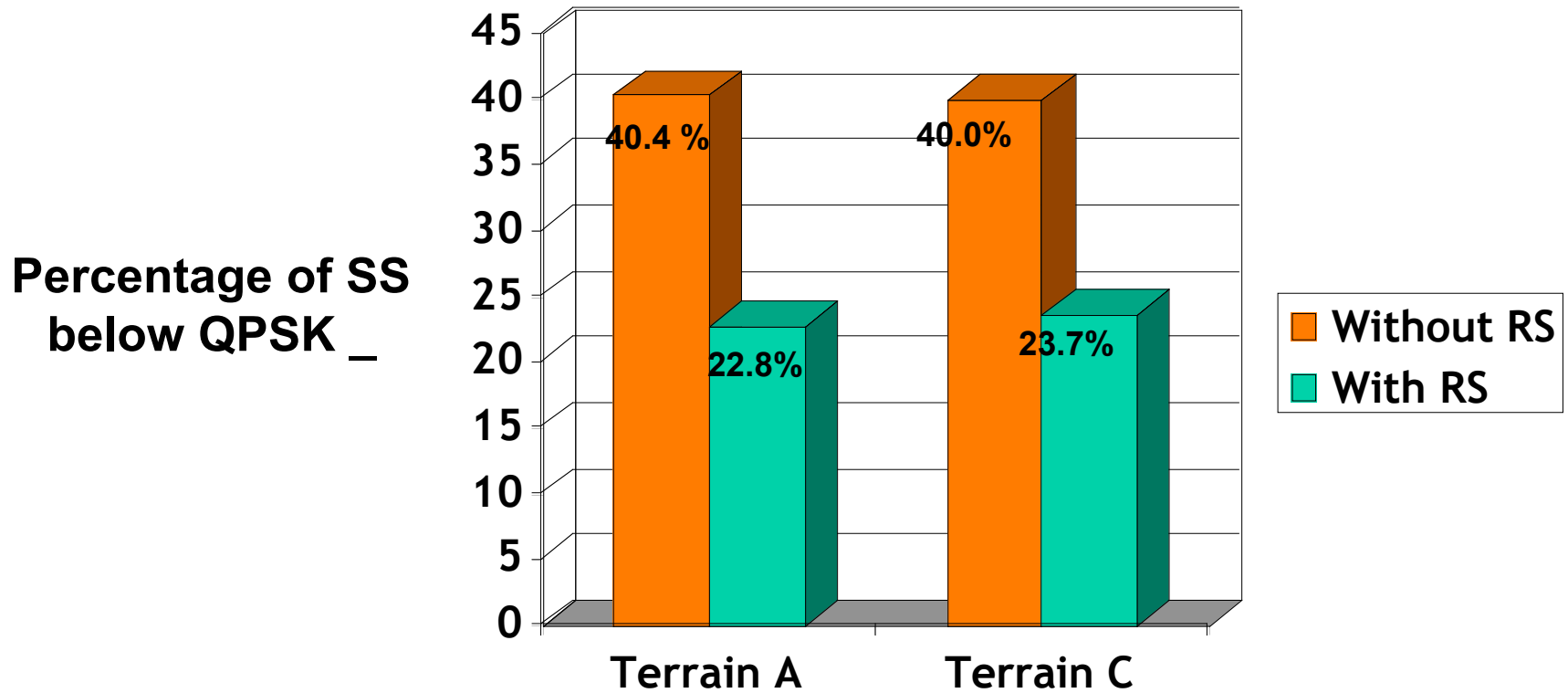
SS Data Rate Comparison



Throughput Comparison: (1,3,6)



QPSK _ Outage Comparison (1,3,6)



Conclusions

- (1,6,6) system with 6 mBS per cell shows:
 - QPSK _ Outage improvement around 80 %
 - Overall sector throughput improves from 16 Mbps to 21 Mbps
- Less Gains under more severe interference situations:
e.g., (1,3,6)
- Capacity improvement in multihop forwarding system more than compensates for radio resources diverted towards RS - BS Link
 - If simultaneous scheduling is supported.
 - Without sophisticated interference management

Implications on PAR/5C & Future Work

- Smaller Scope is more realistic for quick standardization
 - Basic well-understood toolkit for multiple scenarios and solutions
 - Limit to infrastructure fixed/nomadic RS?
 - Less impact on SS, but don't impose "don't touch SS" requirement
 - Provides large and immediate benefits in coverage and economics
 - General solution for arbitrary number of hops is harder than 1 or 2 additional hops? Too restrictive?
 - Additional PARs for further scenarios as current draft solidifies
 - Perhaps 2 or 3 PARs needed in staggered time schedule
- Mechanisms to support intra-sector spatial reuse
 - Channel/Interference measurement mechanisms: Examine existing methods and extend
 - Scheduling/Identification mechanisms

Implications on PAR/5C & Future Work

- Layer 2 routing remains transparent to SS Host OS.
 - Consider (M)RSTP from 802.1, though may not be optimal
 - Request extensions to 802.1?
 - Channel condition assisted routing decisions
 - e.g., “is RS-BS link fast enough to bother?”
- Multihop CID management
 - More compatible to 802.16, but scope, uniqueness, conflict, aggregation, assignment
- or MAC address inside BS-RS links?
 - Simpler routing and identity management, but overhead.
- Scheduling coordination among RS and BS?
 - Fragmentation and buffering btw two hops
- BS and RS may appear as BS to SS
 - If BS MAP controls all, coverage extension limited, but simpler?
 - ARQ independence for RS: Quicker turnaround
 - Better backward compatibility
 - Implications on the complexity of RS

Spellings suggested by PowerPoint

- Multihop → Ultimo
- Saha → Saga
- Erceg → Erect (Erect-Greenstein model)
- dBm → dam
- Shankar → Shaker
- WiFi → Wife