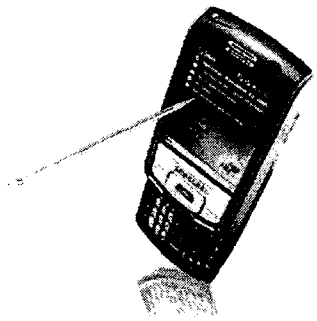
IEEE 802.16 TGj
Multihop Relay



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2006년 7월 5일

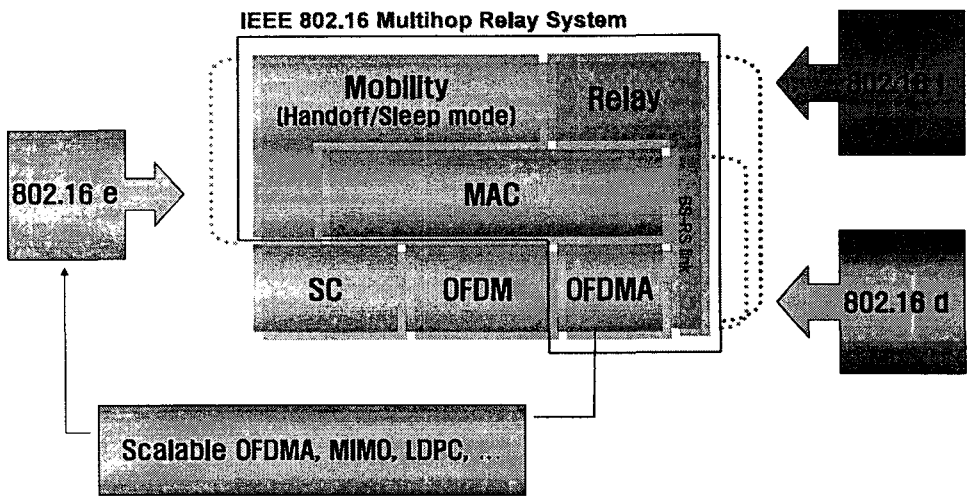
Outline

- IEEE 802.16 TG j
  - IEEE 802.16 Task Groups
  - 802.16 TGj 3월/5월회의 요약
  - Abstract of PAR Draft
  - Mesh mode vs. Multihop Relay mode
  - Mobility/Capability of Relay Stations
  - Backward Compatibility
  - Expected TG Schedule
- Appendix: Performance Evaluation
- References

IEEE 802.16 Task Groups

- TGd Standard Draft
  - **IEEE Std 802.16-2004**: Standard specification published (종료)
  - **P802.16-2004/Cor1/D5**: Maintenance Task Group (종료)
- TGe Standard Draft
  - **P802.16e/D12**: Amendment to IEEE Std 802.16 on enhancements to support mobility (PHY/MAC) (종료)
  - **IEEE Std 802.16e-2005** 출판: P802.16-2004/Cor1/D5 + P802.16e/D12
- TG f/g Standard Draft
  - P802.16f: Amendment to IEEE Std 802.16 on MIB (종료)
  - P802.16g: Amendment to IEEE Std 802.16 on Management Plane Procedures & Services (진행중)
- TG h (진행중): License Exempt Coexistence
- **TG j (Multihop Relay)** : IEEE 802 3월 EC Meeting에서 승인

Amendment to IEEE Std 802.16



MMR SG 3월회의 요약

- IEEE 802.16 WG the 42nd Session
  - 2006년 3월 6일 ~ 9일 @ Denver, USA
- 802.16 MMR (mobile multihop relay) tutorial [1]: 2006년 3월 6일
  1. General Overview: Mitsuo Nohara (KDDI)
  2. Economical Feasibility and Serviceability: Jose Puthenkulam (Intel)
  3. Technical Study and Feasibility: Mike Hart (Fujitsu UK)
  - Other contributors: Samsung, Motorola, ITRI, ...
- Multihop Relay TG 승인 @ 802 EC meeting
  - PAR & 5 Criteria Document: IEEE 802.16mmr-06/002r1 [2]
  - Project number: **802.16 TG j**
- Main features in PAR draft
  - Infrastructure Relay, No modification to 16e MS, OFDMA, Licensed band
  - Schedule: Sponsor Ballot - 2007년 3월, REV.COM Submission – 2007년 9월

TGj 5월회의 요약

- IEEE 802.16 the 43nd Session
  - 2006년 5월 8~11일 @ Tel Aviv, Israel
- TGj Officers
  - Chair: Mituso Nohara (KDDI)
  - Vice Chair: Peiying Zhu (Nortel)
  - Editor: 손중제 (삼성전자), Mike Hart (Fujitsu UK)
- Main issue
  - TGj Process 관련된 논의 (기술적 논의는 main scope이 아니었음)

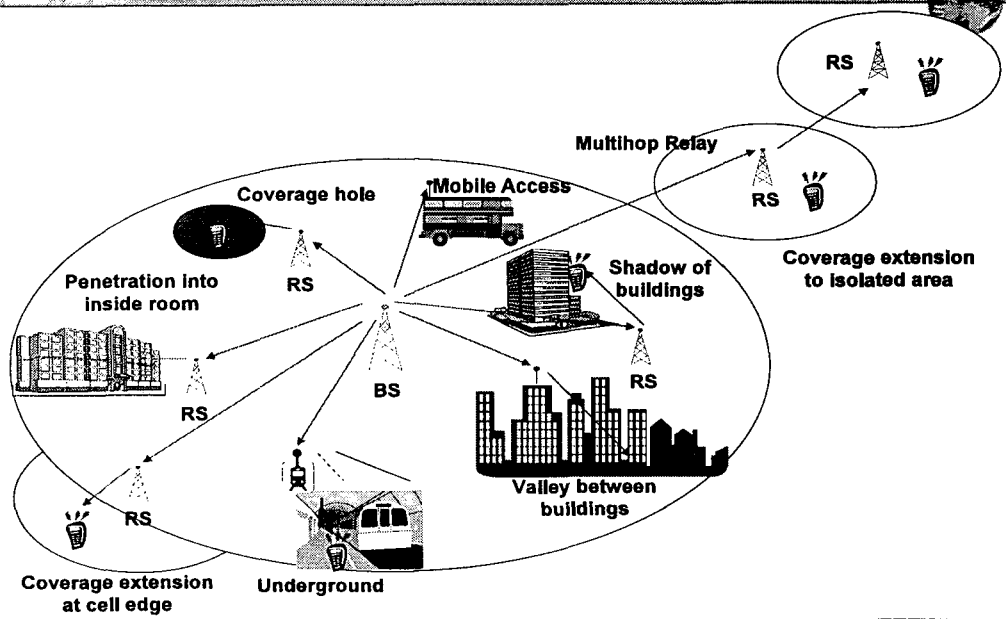
(1) Plan and Selection Procedure: baseline 확정
(2) Usage model: ad-hoc group을 구성하여 계속 논의 (chair: Jerry, Intel)
(3) Terminology: baseline 확정, 차기 회의에서 계속 논의
(4) System requirement: 논의가 차기 회의로 연기
(5) Evaluation document: baseline 확정

Abstract of PAR Draft (IEEE 802.16mmr-06/002r1)

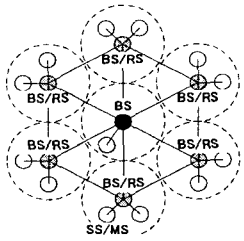
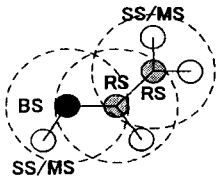
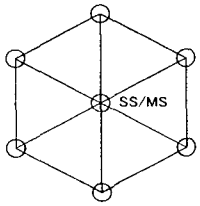
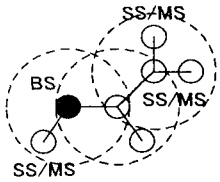
1. Project Number: *802.16j*
2. Title:
   Amendment to IEEE Standard for Local and Metropolitan Area Networks
   – Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems
   – Multihop Relay Specification
3. Expected Date of Submission for Initial Sponsor Ballot: *2007 March*
4. Projected Completion Data for Submittal to REVCOM: *2007 Sept.*
5. Scope of Proposed Project:
   This document specifies OFDMA physical layer and medium access control layer enhancements to IEEE Std 802.16 for licensed bands to enable the operation of relay stations. Subscriber station specifications are not changed.

   ** Additional Explanatory Notes: Control functions may be centralized at the base station or distributed among the relay stations with central coordination from the base station.*
6. Purpose of Proposed Project:
   To enhance coverage, throughput and system capacity of 802.16 networks by specifying 802.16 multihop relay capabilities ad functionalities of interoperable relay stations and base stations.

Use Scenario of 802.16 Multihop Relay



Relay mode vs. Mesh mode

	Mesh	Relay
Infra-structure		 **16 Multihop Relay mode**
Client	 **Mesh mode in 802.16-2004**	

- Mesh mode in 802.16-2004: **OFDM only, not compatible to PMP mode**, allow SS-to-SS ad-hoc mode

Infrastructure Relay

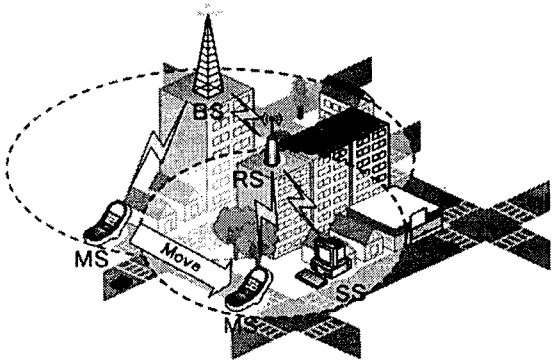
- Infrastructure Relay only in 16 Multihop relay

Type		Infrastructure	Client (Subscriber)
Mesh		Not Considered	Not Considered
Relay	Fixed	16 Multihop Relay	Not Considered
	Nomadic		
	Mobile		

- Infrastructure RS is ...
  - Neither traffic data sink nor source
  - Deployed and controlled by Operator
  - No limitation of energy
  - Less security issue

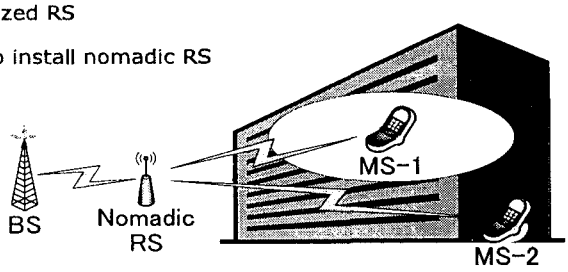
Infrastructure Fixed RS

- Application
  - Coverage expansion: Metropolitan, Dead spot, Indoor
    - I.e., Wireless Backhaul
    - In particularly, at the initial deployment phase
- Appearance
  - Permanently deployed
  - High-capable RS
- Benefits
  - Less OPEX
  - Rapid deployment



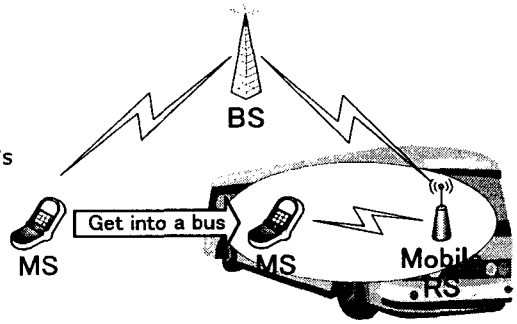
Infrastructure Nomadic RS

- Application
  - BWA service for an event, exhibition etc.
  - Coverage expansion and/or throughput improvement
    - User throughput improvement in low SINR area
    - Cooperative relay can be also considered
- Appearance
  - Temporally deployed, Small-sized RS
  - A subscriber can be allowed to install nomadic RS
- Benefits
  - Easy deployment/removal



Infrastructure Mobile RS

- Application
  - Coverage expansion: Inside vehicle
  - Public Transportation - Bus, Subway
- Appearance
  - Temporally deployed
  - Small-sized RS
- Benefits
  - Efficiently handle a bunch of MS's which are moving together

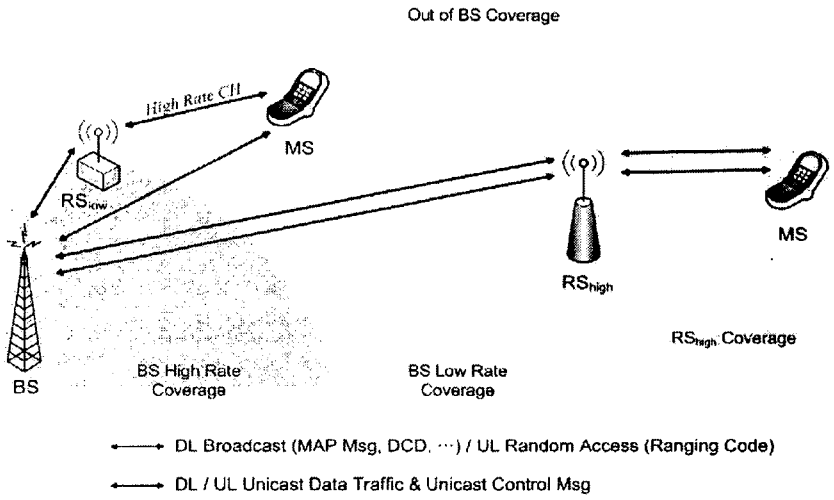


Potential RS types & Capabilities

Objective	Higher user throughput at low SINR region	Cell coverage extension
Relaying Channels	Only Unicast Traffic CH	Both Broadcast Control CH and Unicast Traffic CH
RS Capabilities	**Low Capability** • Relay data traffic only • Control messages are provided through a direct link from BS • RS-MS link control by BS	**High Capability** • Transmit its own control messages • Provide MS with Network Entry procedure on behalf of BS • RS-MS link control by RS

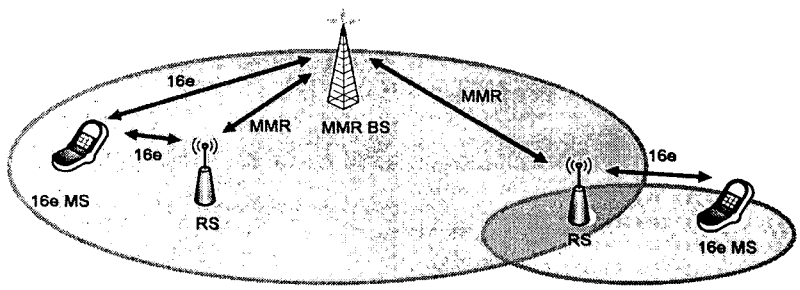
Centralised vs. Distributed control

Example: Scenario vs. RS Capability



Backward Compatibility

- No modification to legacy MS
  - A 16e MS shall communicate with RS as well as MMR BS
  - A relay-path shall be provided transparently to 16e MS

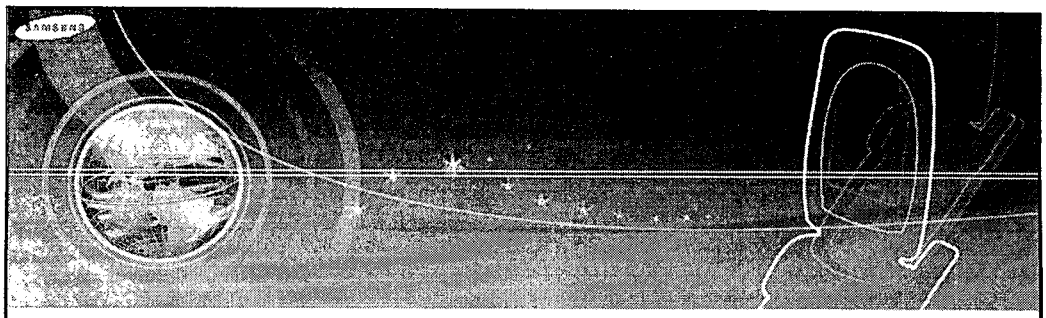


TG j Schedule

Year	Month	802.16	Expected Schedule in C802.16mmr-06/021r1
2006	Mar.	#42 Plenary	802 EC endorses PAR approval
	May	#43 Interim	Begin Requirement and Usage Scenario. Complete TGj schedule
	July	#44 Plenary	Complete Requirement, Usage Scenario and ToC
	Aug		Call for Proposal based on the ToC
	Sept.	#45 Interim	Presentation, Selection, Merging
	Oct.		Drafting baseline document; Call for Comments on the document
	Nov.	#46 Plenary	Continue Presentation, Selection, Merging through Comment Resolution
	Dec.		Drafting TGj Draft v.1.0. Begin 1st WG letter Ballot on TGj D1
2007	Jan.	#47 Interim	Comment Resolution
	Feb.		Drafting TGj Draft v.2.0; Begin 2nd WG letter Ballot on TGj D2
	Mar.	#48 Plenary	Confirmation: Begin the 1st Sponsor ballot
	May.	#49 Interim	Comment Resolution
	June		Begin Sponsor Recirculation
	July.	#50 Plenary	Confirmation
	Aug		Submission to Rev. Com
	Sep.	#51 Interim	SA Approval

Summary

- Relay 기반의 IEEE 802.16 시스템
  - TG j (multihop relay) : 1st meeting in May 2006
- Working scope
  - PHY: Enhance normal frame structure
  - MAC: Add new protocols for the Relay networking
- Main features
  - Terminals that can talk with RS: Legacy MS (16e MS)
  - Spectrum/Modulation: Licensed/OFDMA only
  - RS Type: Fixed, nomadic and mobile
  - Tree structure: one of the end of relayed data path should be at BS
  - Efficiently provide relay connection to MS (with small number of hops)
  - Backward compatible to PMP mode



Appendix - Performance Evaluation

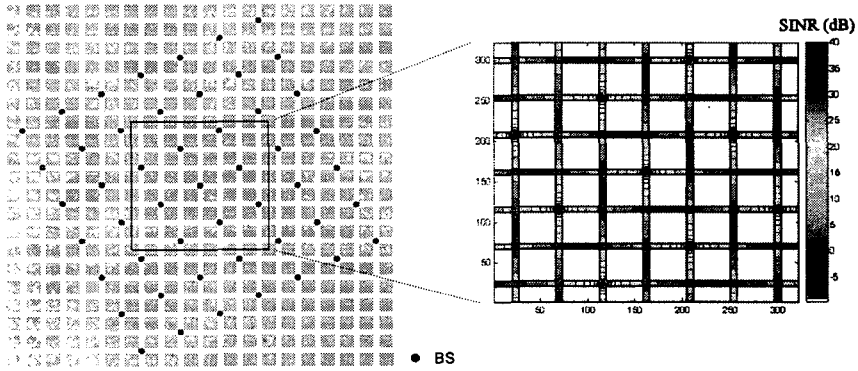
IEEE C802.16mmr-06/003 [3]

Introduction

- This contribution shows an achievable throughput gain from 2-hop fixed relay
  - Coverage advantage is obvious and previously studied
  - Analysis results confirm that the fixed relay can provide capacity gain as well
- System model
  - Manhattan-like urban environment
  - TDD OFDMA based on IEEE Std 802.16e-2005
  - Infrastructure RS type
  - Rate adaptation control scheme for both down- and up-links
  - Full buffer model

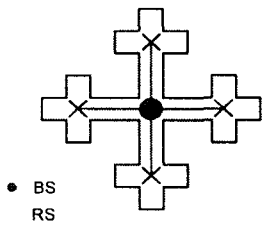
Manhattan Urban Environment

- Deployment model
  - Total 49 BS's, Block size: 200 m, Road width: 30 m
  - Frequency reuse = 1

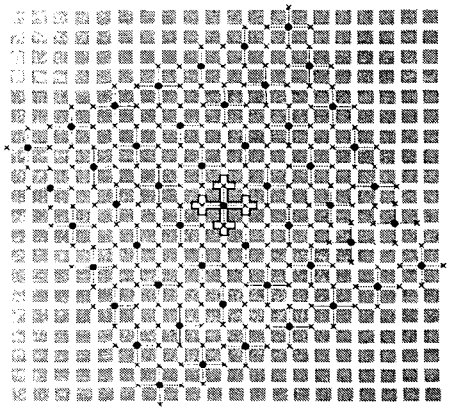


RS Deployment Model

- Number of RS's per BS = 4
- Frequency reuse among relays = 1 or 4



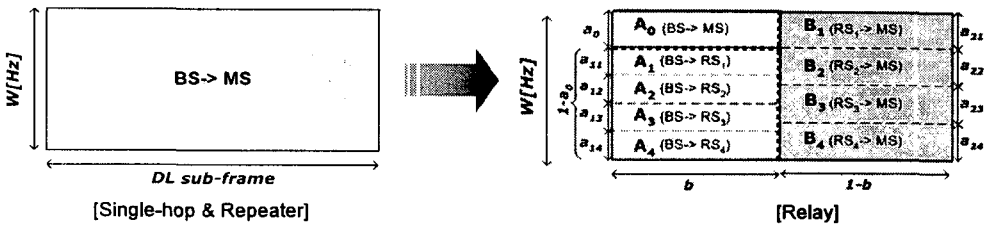
BS deployment with RS's



Statistical data from the center cell are collected.

Frame Structure Model

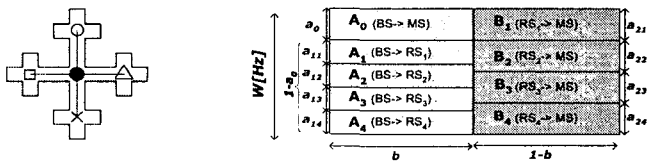
- 16e: TDD OFDMA
- Dedicated RS: no data source/sink (infrastructure type), 2-hop relay
- Assumed a homogeneous network with uniform traffic density



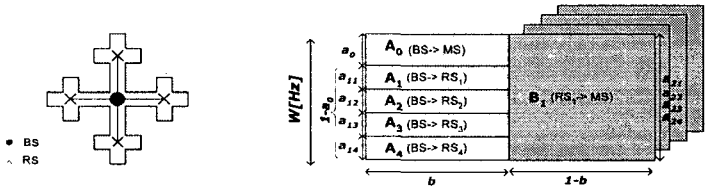
where,
W : Total bandwidth
a_0 : Ratio of freq. bandwidth allocated to BS sub-cell
a_{1i} : Ratio of freq. bandwidth allocated to relaying transmission (BS-RS links)
a_{2i} : Ratio of freq. bandwidth allocated to RSi sub-cell
b : Ratio of frame time assigned to BS transmission
γ_{mbr}^{bs} : Received SINR from BS sub-cell
γ_{mbr}^{rs} : Received SINR from RS sub-cell

Frequency Reuse among Relays

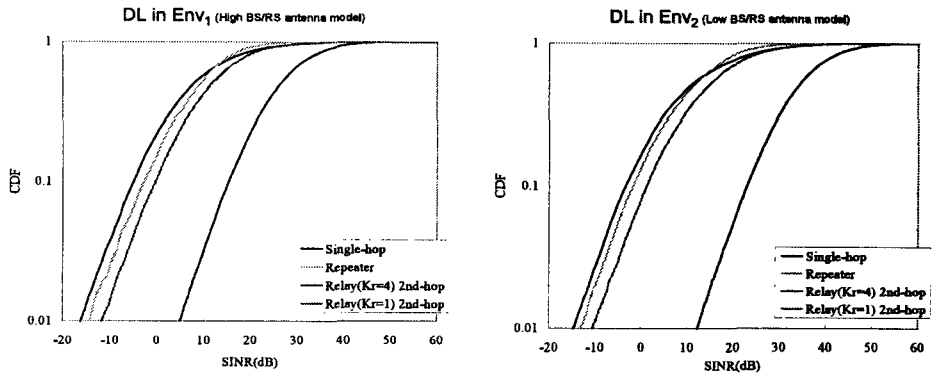
- Frequency reuse factor among RS-MS links (K_r)
  - K_r = 4: Different channel for each RS



  - K_r = 1: Same channel for all RS's

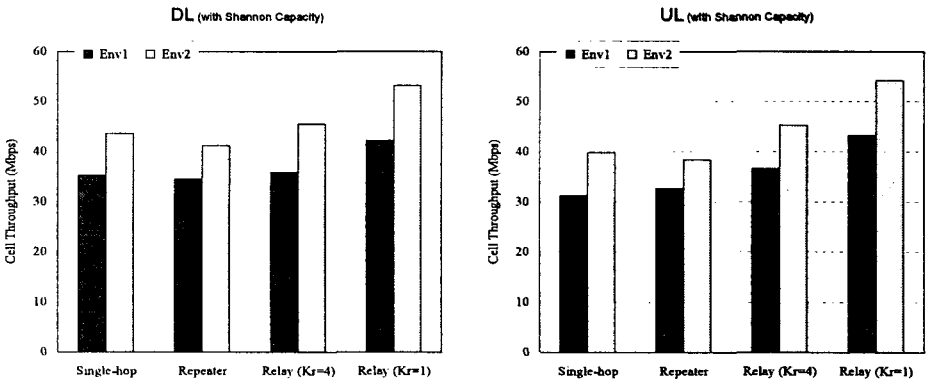


SINR Distributions



- SINR performance: Single hop system < Repeater system < Relay system
- As more frequency is reused ($K_r \downarrow$), SINR decreases but a gain from SDMA can be expected
- Higher SINR in Env_2, due to more link attenuation for interference

Cell Throughput



- Throughput enhancement (Relay with Kr = 1 over Single-hop)
  - In Env_1 (High BS/RS antenna model): 20% Downlink, 38% Uplink
  - In Env_2 (Low BS/RS antenna model): 22% Downlink, 36% Uplink

References

- References

1. M. Nohara, "Draft P802.16j PAR and Five Criteria: Mobile Multihop Reply", IEEE 802.16mmr-06/002r1, Mar. 2006.
2. R. Marks *et al.*, "IEEE 802 Tutorial: 802.16 Mobile Multihop Relay", IEEE 802.16mmr-06/006, Mar. 2006.
3. J. Cho *et al.*, "On the Throughput Enhancement of Fixed Relay Concept in Manhattan-like Urban Environments", IEEE C802.16mmr-06/003, Jan. 2006.
4. J. Cho *et al.*, "Classification of RS Type in Mobile Multi-hop Relay System", IEEE C802.16mmr-05/002, Sept. 2005.

- Official site:
  - IEEE 802.16 WG: www.ieee802.org/16
  - IEEE 802.16 MMR SG: www.ieee802.org/16/sg/mmr
  - IEEE 802.16 TG j: www.ieee802.org/16/tgj (expected)