Motto: Wireless Mesh and Relay Networks

Self-Organized Scheduling over IEEE802.16 Multi-Hop Relay

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Outline

- Background
- Problem Statement
- Scheduling scheme considering QoS
- Scheduling algorithm with Interference Mitigation/Capacity enhancement
- Performance Evaluation

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Background

•We have started to study IEEE802.16-based multihop system since around 2004, and cooperated in chartering IEEE802.16's Mobile Multihop Relay (MMR) Study Group (currently 802.16j) realizing to:

- *expand the service area*
- *reduce the number of dead spots*
- *enhance throughput*

by introducing RS (Relay Station) between BS and MS.

The features of 802.16 are…

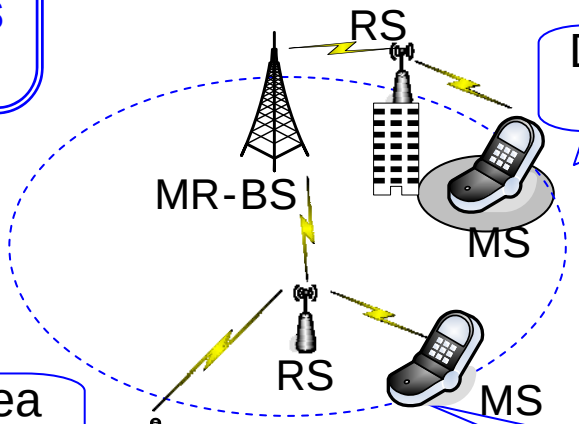
•16 has been designed to support QoS

•BS completely controls DL/UL transmissions

etc.…

IEEE 802.16MMR-SG: Jul. 2005 – Mar. 2006
IEEE 802.16 TGj (Relay Task Group): Mar. 2006 -
to RevCom: Feb. 2009 (According to a current plan)

IEEE802.16 P-MP based relay system



Dead spot reduction

Service area expansion

Throughput enhancement

BS: Base Station
RS: Relay Station
SS: Subscriber Station

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Problem Statement

- QoS can be guaranteed even for the MS attached to the RS??

- The radio resource can be used efficiently over 16j??
  -- if BS and RS simply take turns to use the resource, the utilization becomes low.

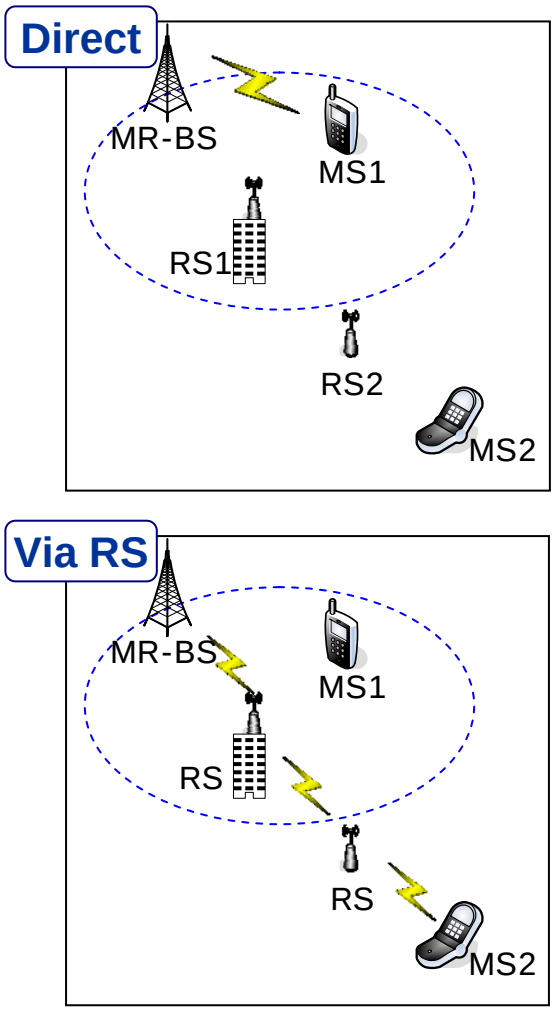
The proposal here is a scheduling mechanism that supports:
-- QoS (delay and bandwidth) guarantee for all MS (incl. under RS)
-- improvement of the radio resource utilization efficiency (i.e., Capacity enhancement)

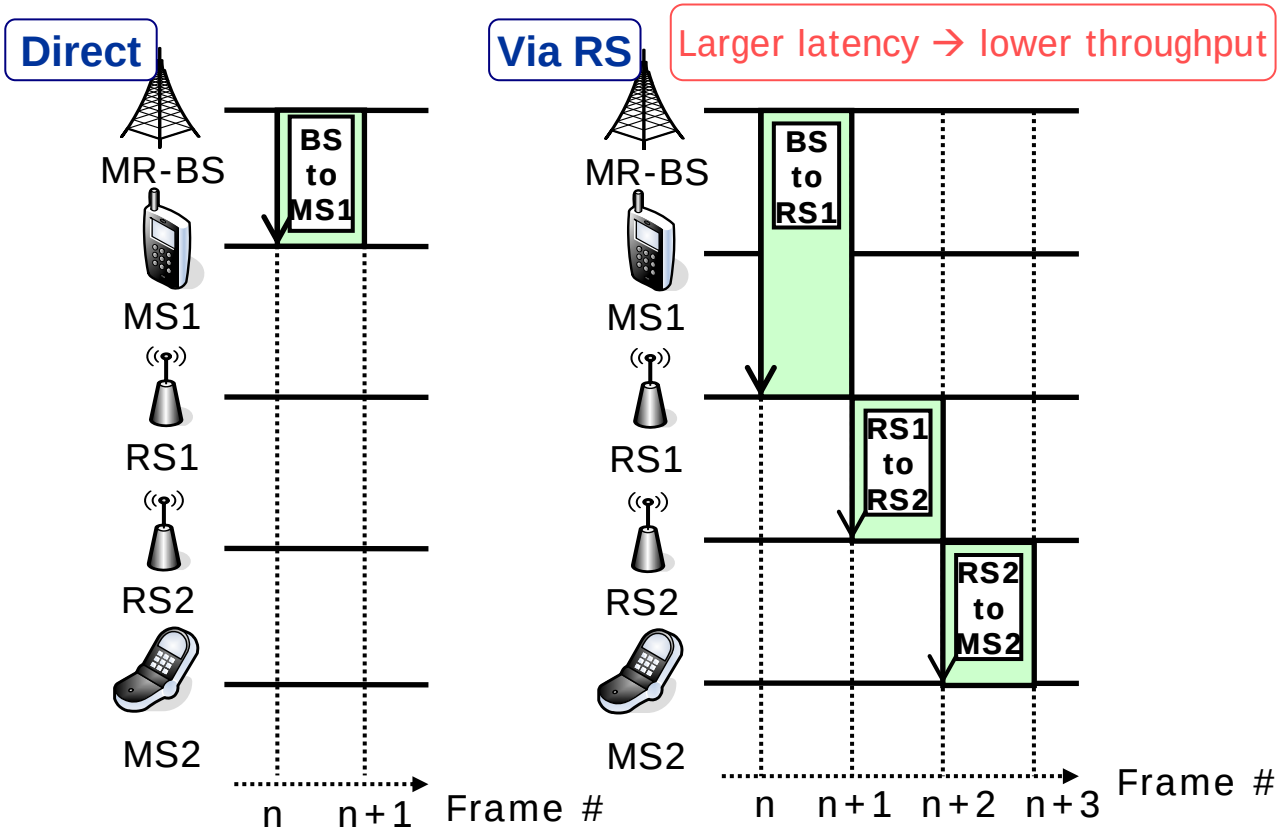
NOTE: In this proposal, Non-transparent RS system with Centralized scheduling in 16j is assumed.

* Scheduling is outside the scope of the standardization.

QoS Guarantee

•***QoS can be guaranteed even for the MS attached to the RS??***



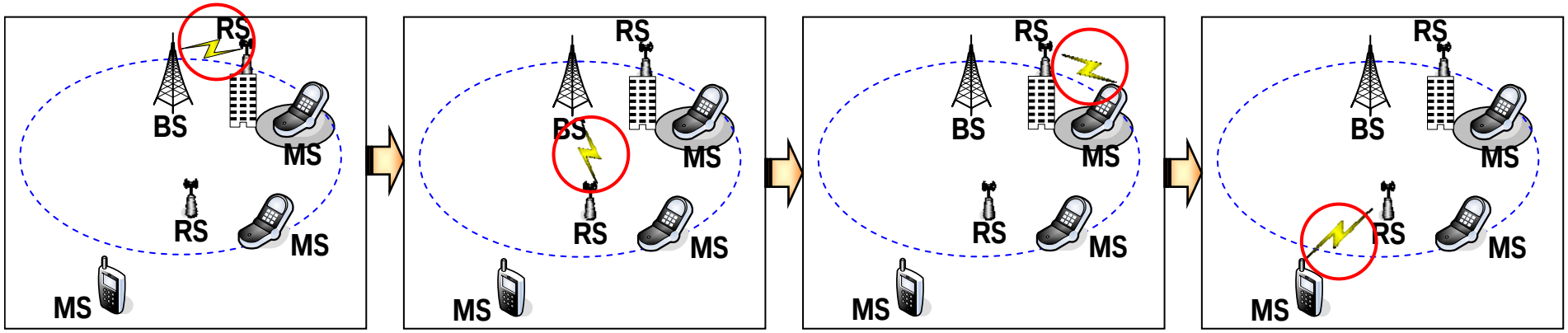


It is necessary to assure QoS for MSs under RS just as for direct-connected MSs.

Capacity Enhancement

- ***The radio resource can be used efficiency over 16j??***
  -- if BS and RS simply take turns to use the resource, the utilization becomes low.

BS and RS take turns to use radio,
which degrades radio resource utilization.



*BS and RS shares same freq band.

It is necessary to improve the utilization of radio resource over 16j system.

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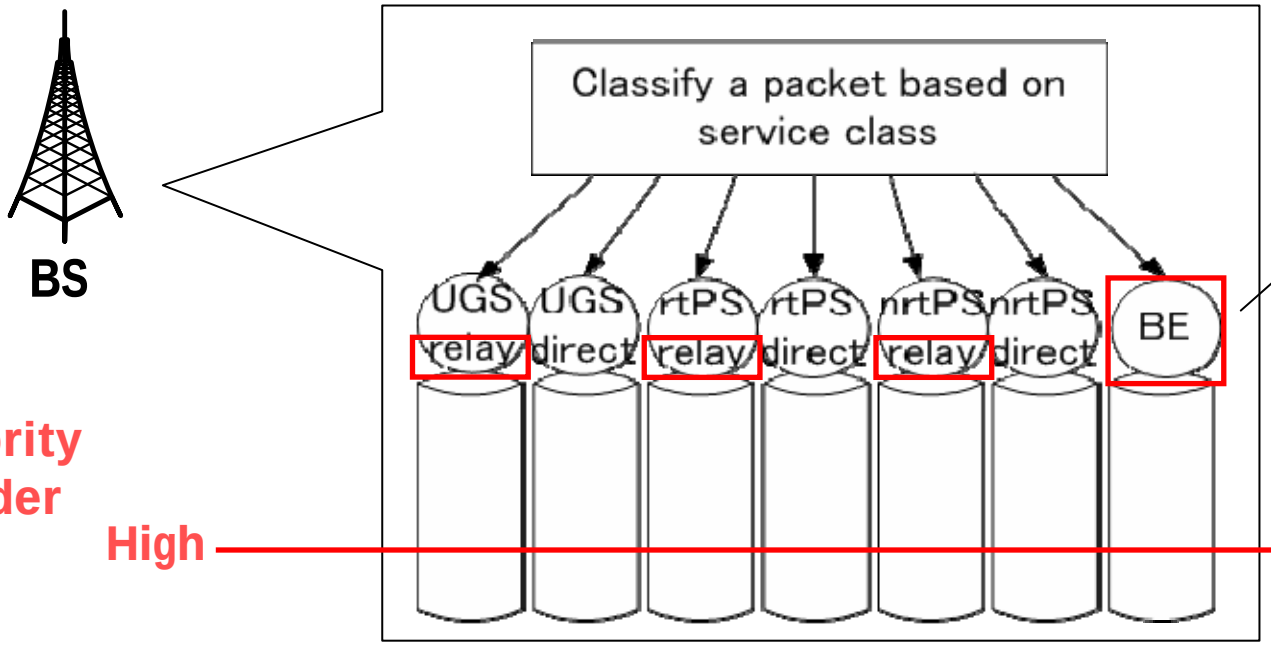
Scheduling considering QoS

BS creates queues based on hop(s) as well as service classes



*Two-hops case

UGS (Unsolicited Grant Service) : app. w/ strict delay req such as VoIP
rtPS (realtime Polling Service) : app. w/ less stringent delay req e.g., video
nrtPS (non-realtime Polling Service) : app. w/ minimum b/w guarantee, e.g., FTP
BE (Best Effort) : app. w/o guarantee, e.g., HTTP

The detailed explanation of the scheduling algorithm is skipped here in the interest of time.

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Scheduling for Capacity Enhancement

BS Allows simultaneous transmission to/from several stations if possible.

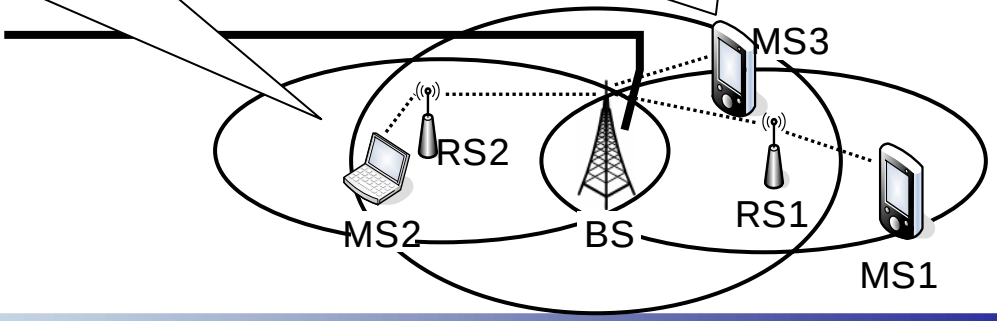
* BS collects the interference information using MOB_SCN_REQ/REP message from MSs (and RSs as well).
* BS maintains the information in a management table that includes the MS-ID, point of attachment of the MS and interferers.
* When BS schedules the transmission, BS checks the management table and schedules some packets at the same timing as already scheduled timing for another packet unless interference occurs.

BS can be the interferer to MS2 because MS2 attaches to RS2 and is in the service area of BS

RS1 can be the interferer to MS3 because MS3 attaches to BS and is in the service area of RS1

management table

MS	Point of attachment	interferer
MS1	RS1	–
MS2	RS2	BS
MS3	BS	RS1
...	...	...

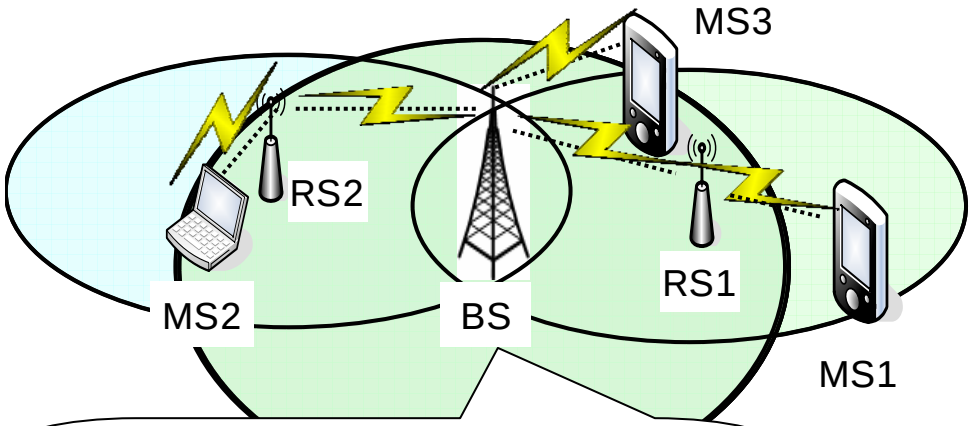


Scheduling for Capacity Enhancement

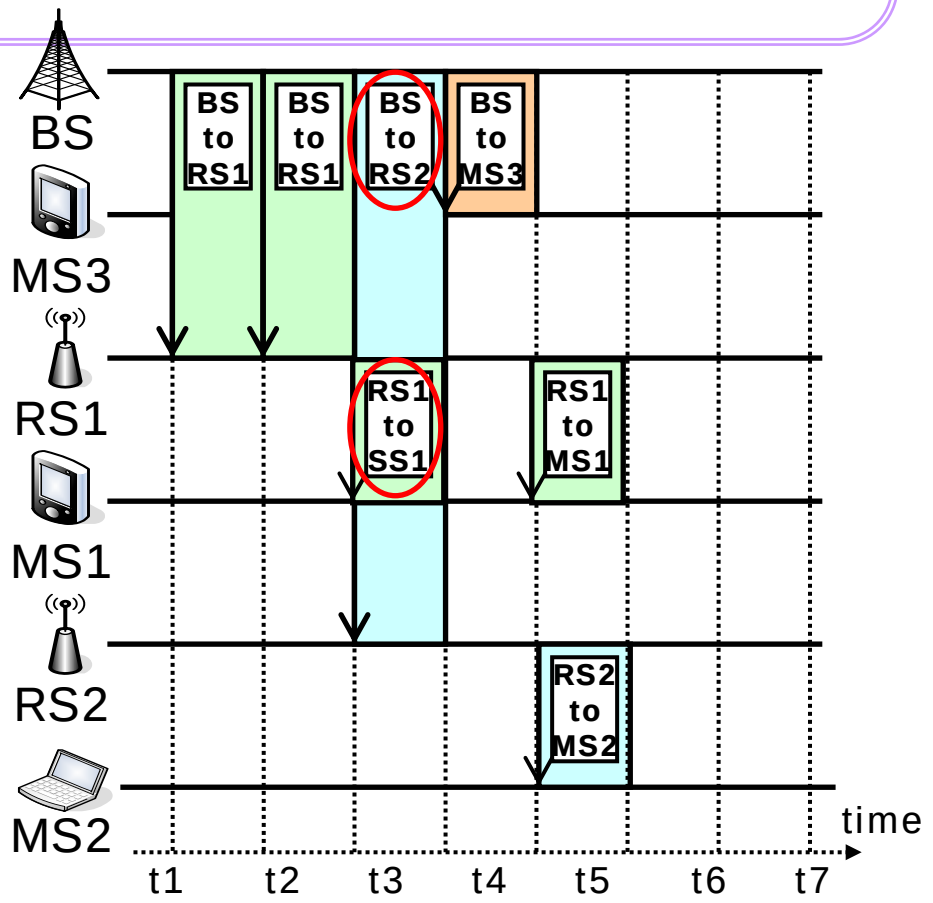
- ***The scheduling can be completely performed in a self-organized manner***
- ***The scheduling improves the radio resource utilization to schedule some TX/RX pair at the same timing not to occur interference to refer the management table.***

management table

MS	Point of attachment	interferer
MS1	RS1	–
MS2	RS2	BS
MS3	BS	RS1
...	...	...



A number of DL data destined to each MS
-to MS1: 2
-to MS2: 1
-to MS3: 1



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Evaluation for QoS

Simulation parameters

Simulator	ns-2 (Ver. 2.27)
System	IEEE 802.16-2004 base
PHY	OFDM
Frequency	2.5 GHz
Channel bandwidth	10 MHz
FFT size	256
Duplexing	TDD
Propagation model	BS-RS: Free space BS/RS- SS: Okumura-Hata
ANT height	30 m (BS, RS) 1.5m (SS)
Mod. and coding rate	16QAM (3/4)
Offered traffic type	CBR/UDP
Packet size	1000 Byte
Offered traffic rate (Downlink traffic)	UGS: 1.3 Mbps rtPS: 2.8 Mbps nrtPS: 2.8Mbps BE: 4.7 Mbps

QoS parameters

UGS

Guaranteed Rate	1.3 Mbps
Latency	< 50 msec

rtPS

Guaranteed Rate	1.0 Mbps
Latency	< 150 msec

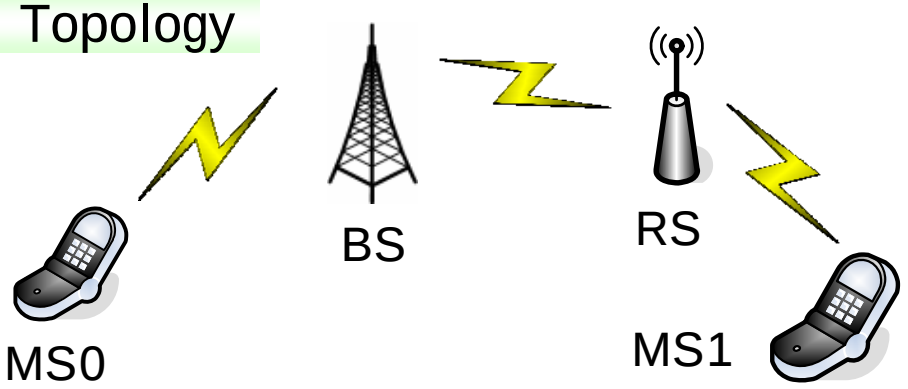
nrtPS

Guaranteed Rate	500 Kbps
Latency	N/A

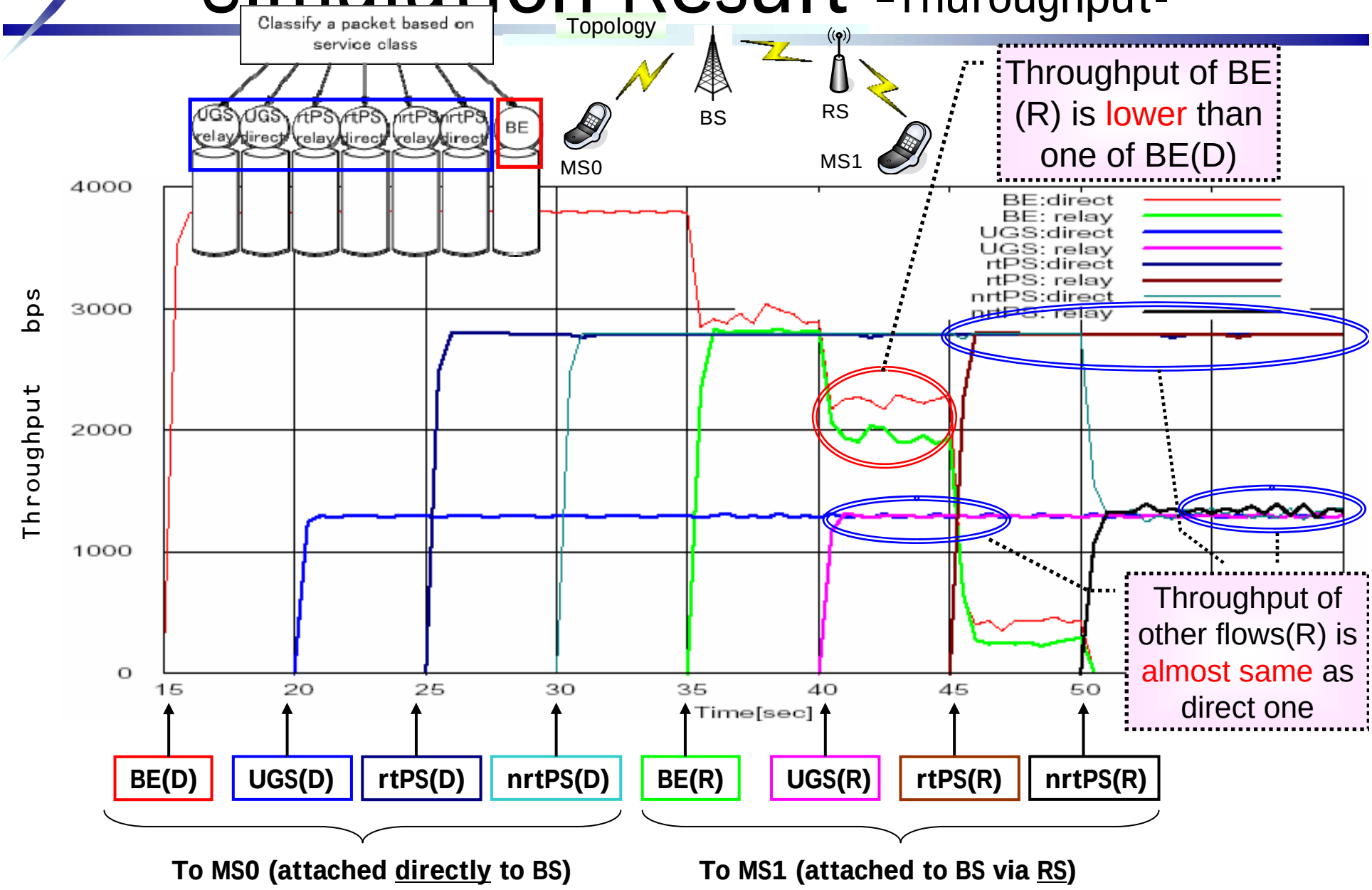
BE

Guaranteed Rate	N/A
Latency	N/A

Topology



Simulation Result –Thuroughput-



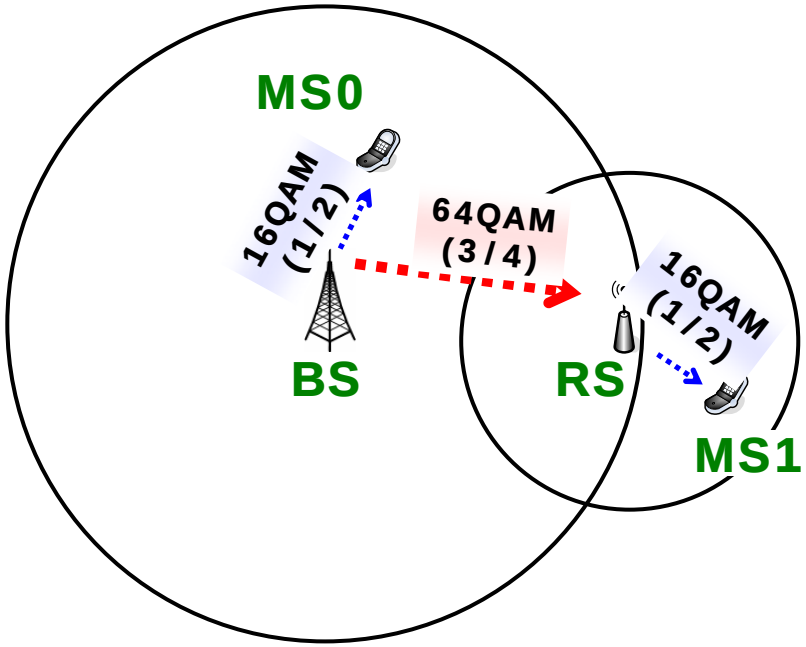
Evaluation for Capacity Enhancement 1

Simulation parameters

Simulator	ns-2 (Ver. 2.27)
System	IEEE 802.16-2004 base
PHY	OFDM
Frequency	2.5 GHz
Channel bandwidth	10 MHz
FFT size	256
Duplexing	TDD
Propagation model	BS-RS: Free space BS/RS- SS: Okumura-Hata
ANT height	30 m (BS, RS) 1.5m (SS)
Mod. and coding rate	Varied
Offered traffic type	CBR/UDP *1
Packet size	1000 Byte

*1: All flows belong to a same class simply to evaluate capacity.

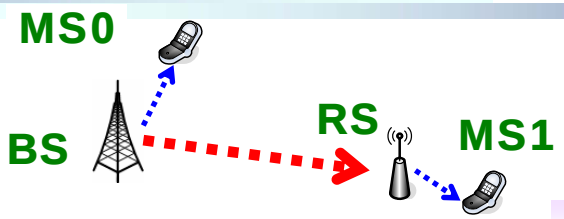
Simulation Topology



Offered traffic

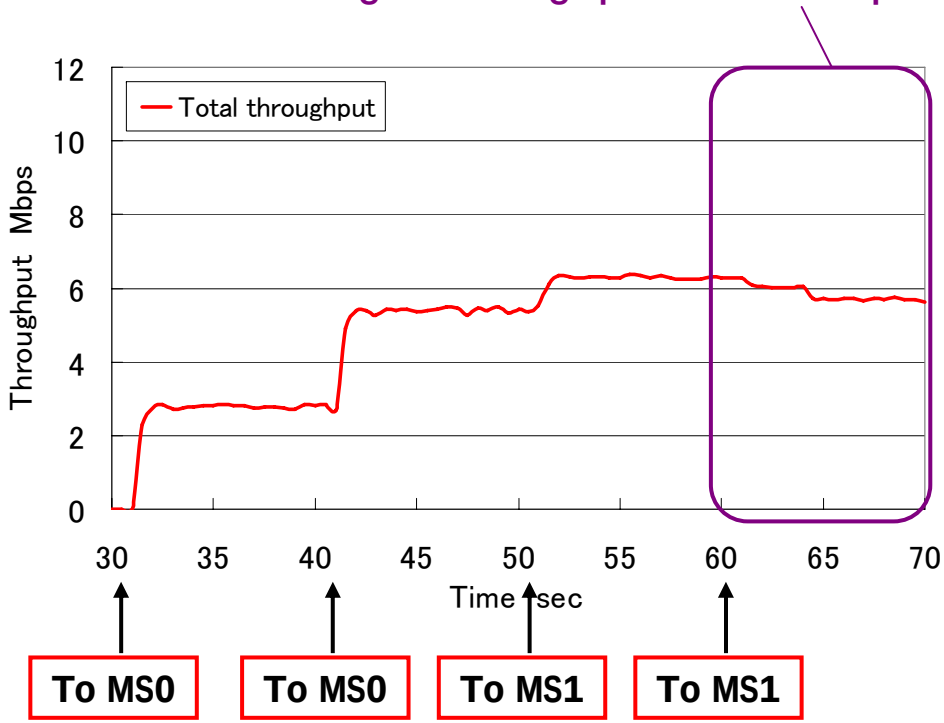
Time (sec)	Offered load	Dst
30 ~ 70	2.8 Mbps	MS0
40 ~ 70	2.8 Mbps	MS0
50 ~ 70	2.8 Mbps	MS1
60 ~ 70	2.8 Mbps	MS1

Simulation Result -thuroughput-



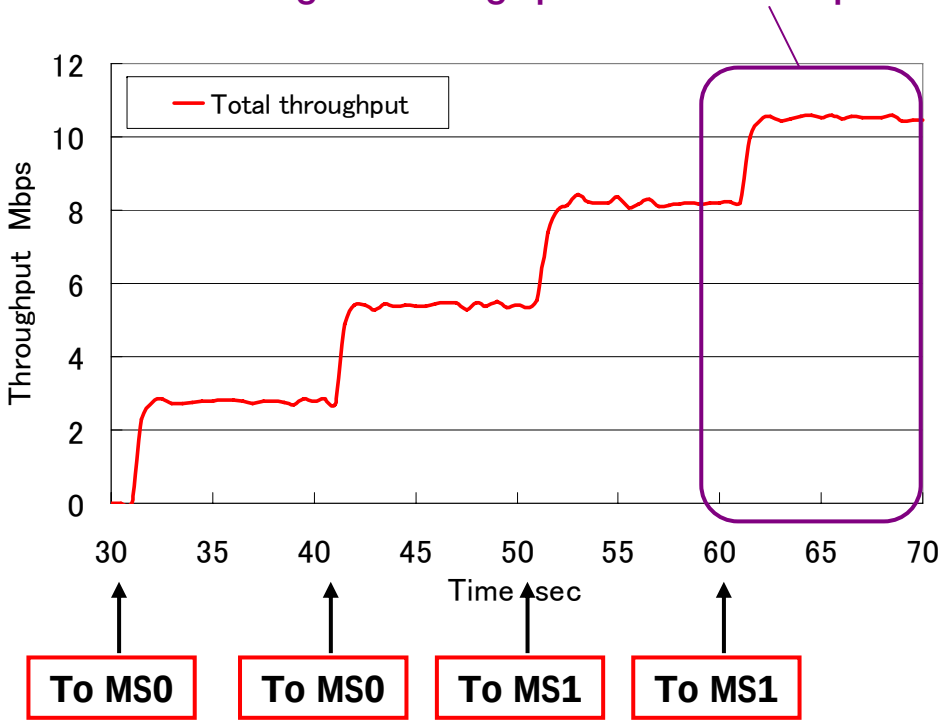
Existing scheme

Average Throughput: 5.88 Mbps



Proposed scheme

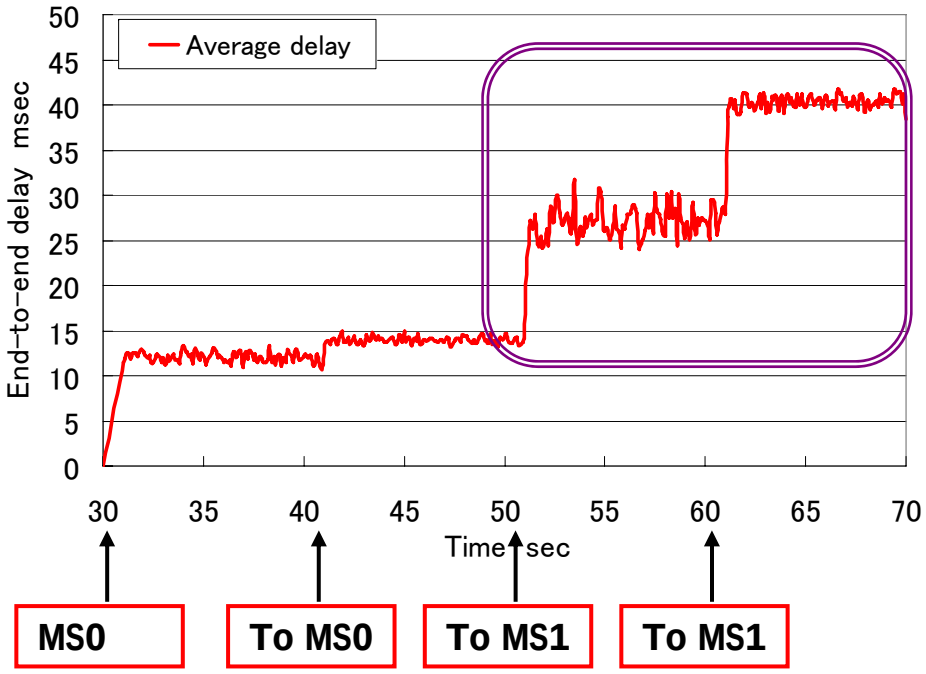
Average Throughput: 10.16 Mbps



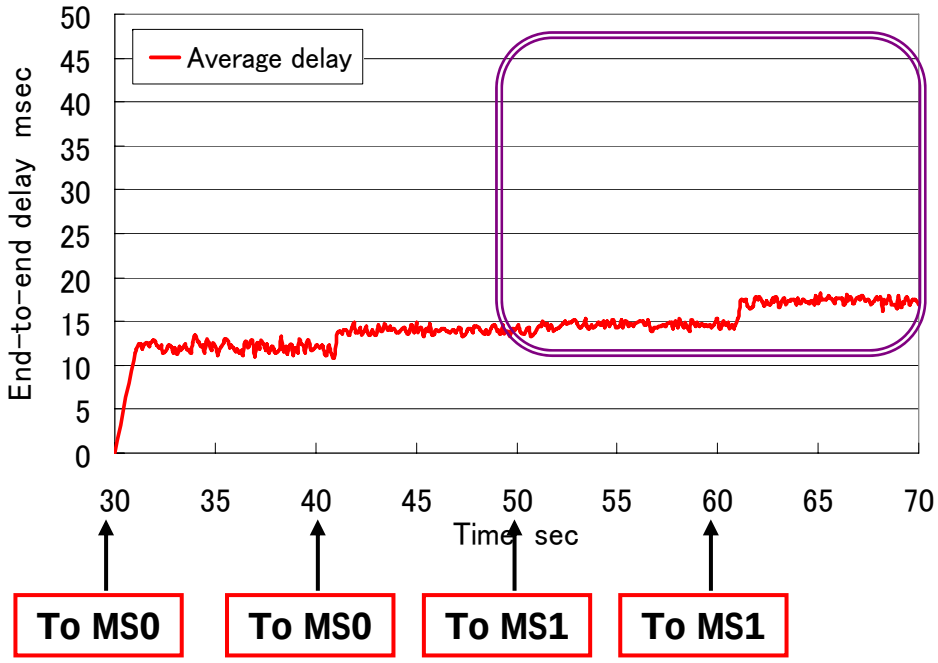
The proposed scheme enhances capacity.

Simulation Result –latency-

Existing scheme



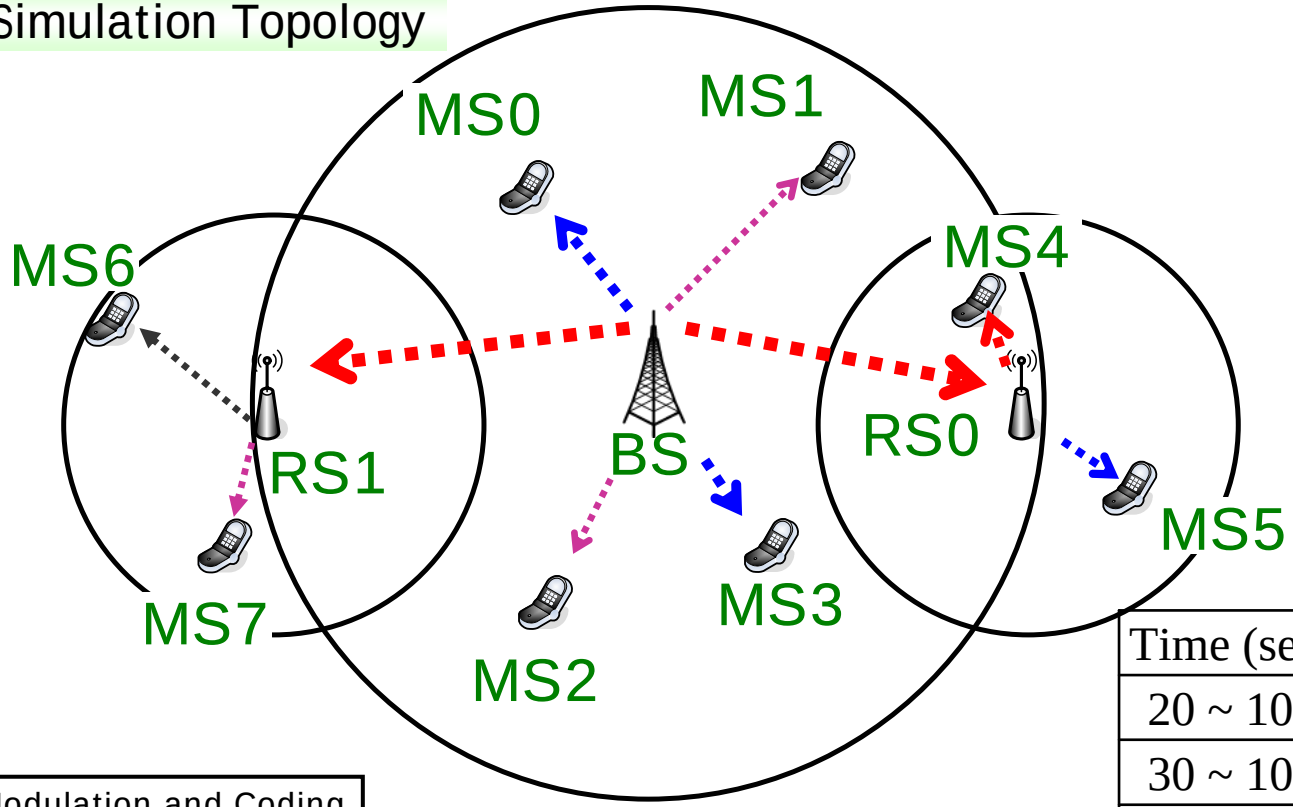
Proposed scheme



Latency is also reduced.

Evaluation for Capacity Enhancement 2

Simulation Topology



Modulation and Coding of each link

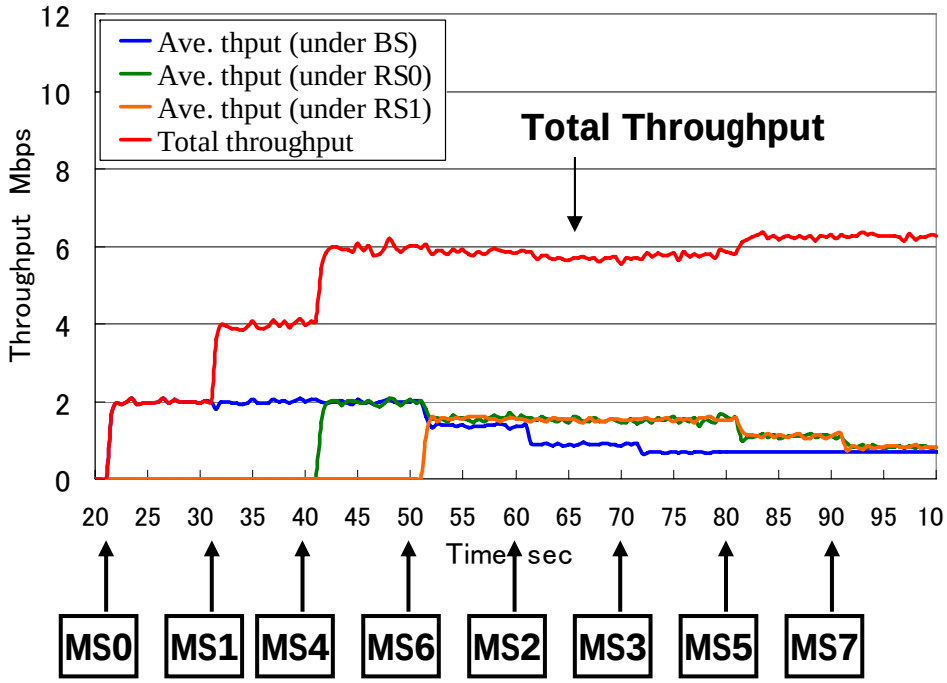
BS-RS0: 64QAM(3/4)
BS-RS1: 64QAM(3/4)
BS-MS0: 16QAM(3/4)
BS-MS1: 16QAM(1/2)
BS-MS2: 16QAM(1/2)
BS-MS3: 16QAM(3/4)
RS0-MS4: 64QAM(3/4)
RS0-MS5: 16QAM(3/4)
RS1-MS6: QPSK(1/2)
RS1-MS7: 16QAM(1/2)

Traffic Pattern

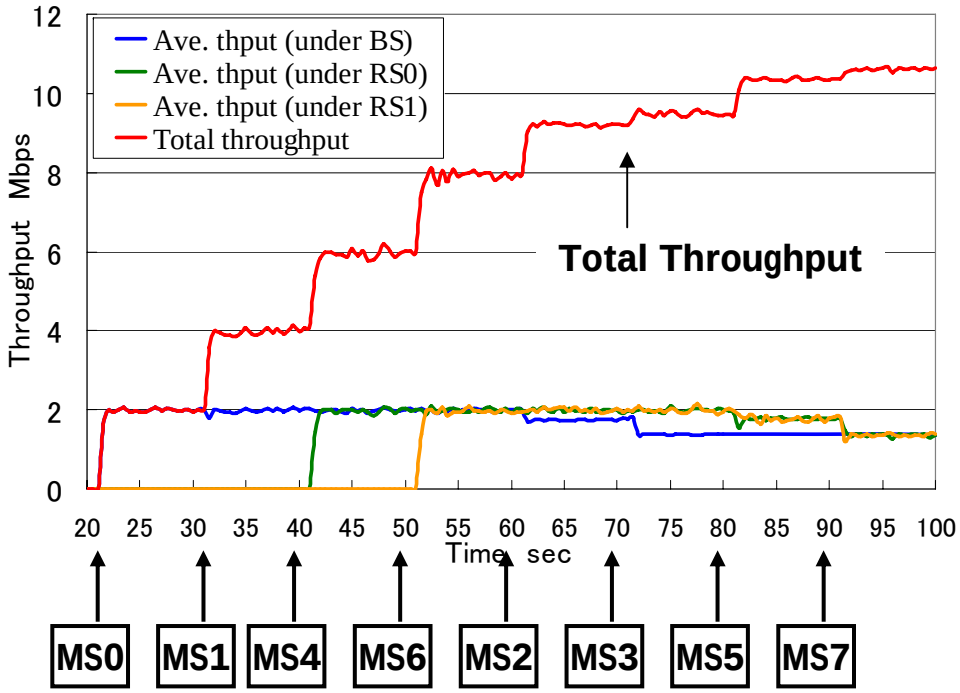
Time (sec)	Offered Traffic	Dst
20 ~ 100	2 Mbps	MS0
30 ~ 100	2 Mbps	MS1
40 ~ 100	2 Mbps	MS4
50 ~ 100	2 Mbps	MS6
60 ~ 100	2 Mbps	MS2
70 ~ 100	2 Mbps	MS3
80 ~ 100	2 Mbps	MS5
90 ~ 100	2 Mbps	MS7

Simulation Result

Existing scheme



Proposed scheme



The proposed scheme enhances capacity.

Conclusion

Proposed scheduling scheme is…

- *able to assure QoS for MSs under RS just as for direct-connected MSs*
- *able to improve the system capacity*
- *able to reduce the latency*
- *self organized*

in IEEE802.16 based Relay system.

Vielen Dank
für Ihre
Aufmerksamkeit.