

# Effect of SDMA in 802.11ac

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# Introduction

- **In PAR of TGac, more than 1 Gbps throughput must be achieved with multiple STAs.**
- **MIMO-SDMA can be a key technology to reach this very high throughput.**
- **The feasibility of MIMO-SDMA is evaluated in an actual indoor office environment, which can be a typical scenario in 802.11ac.**

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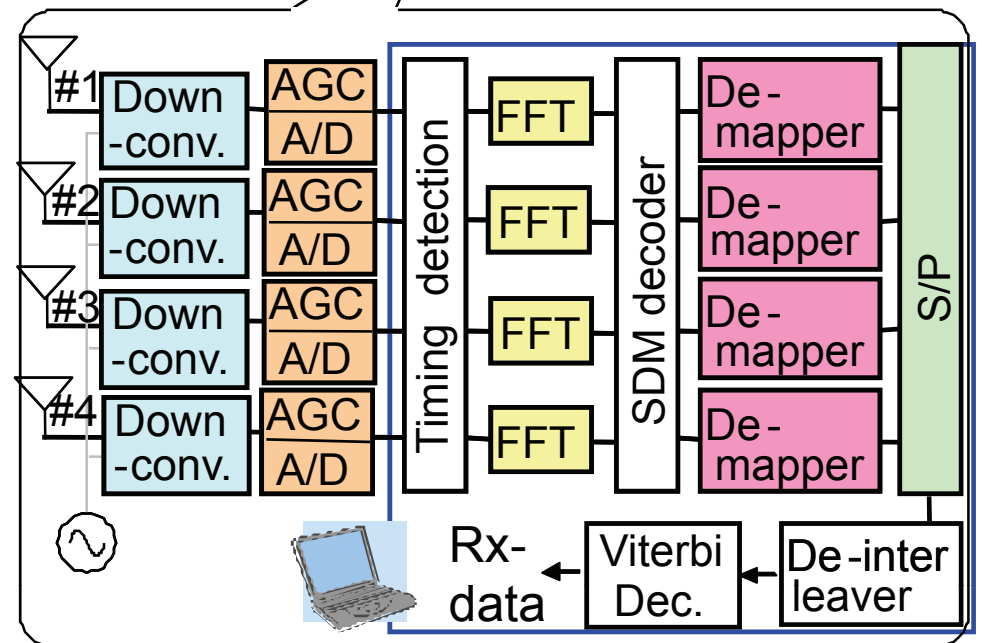
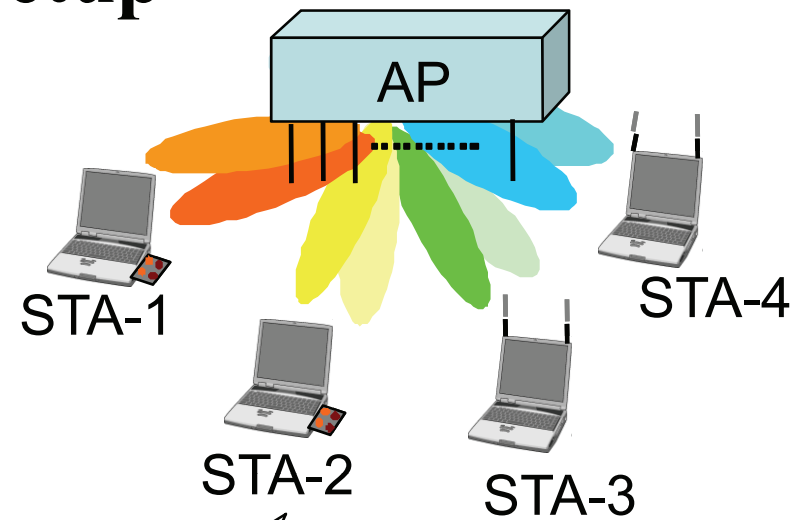
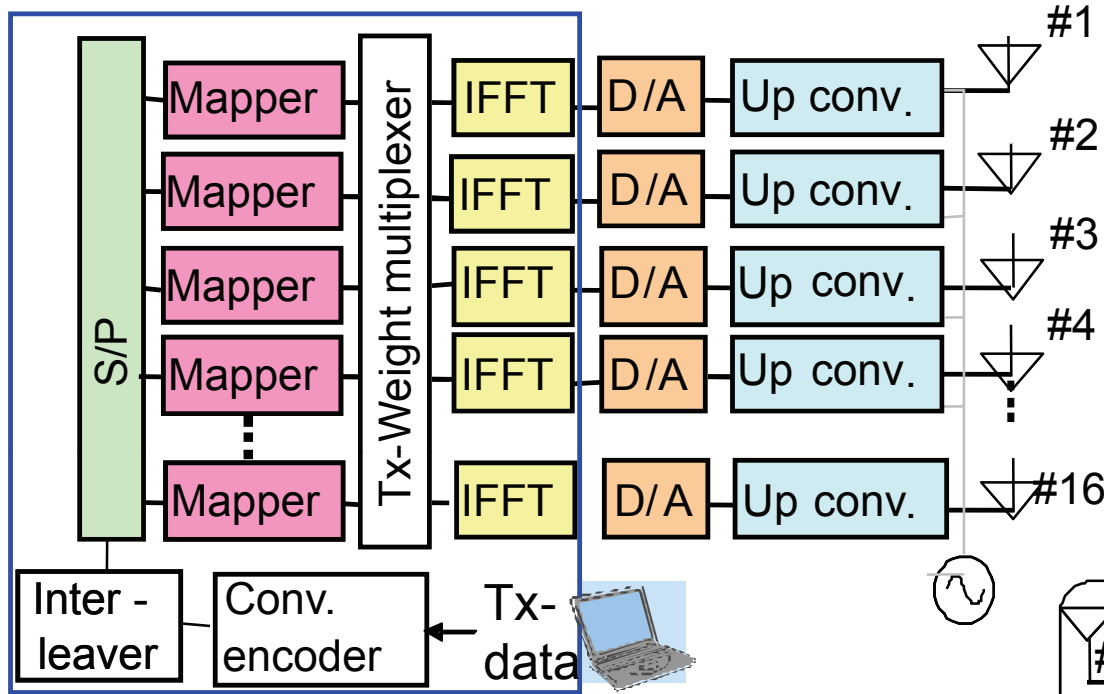
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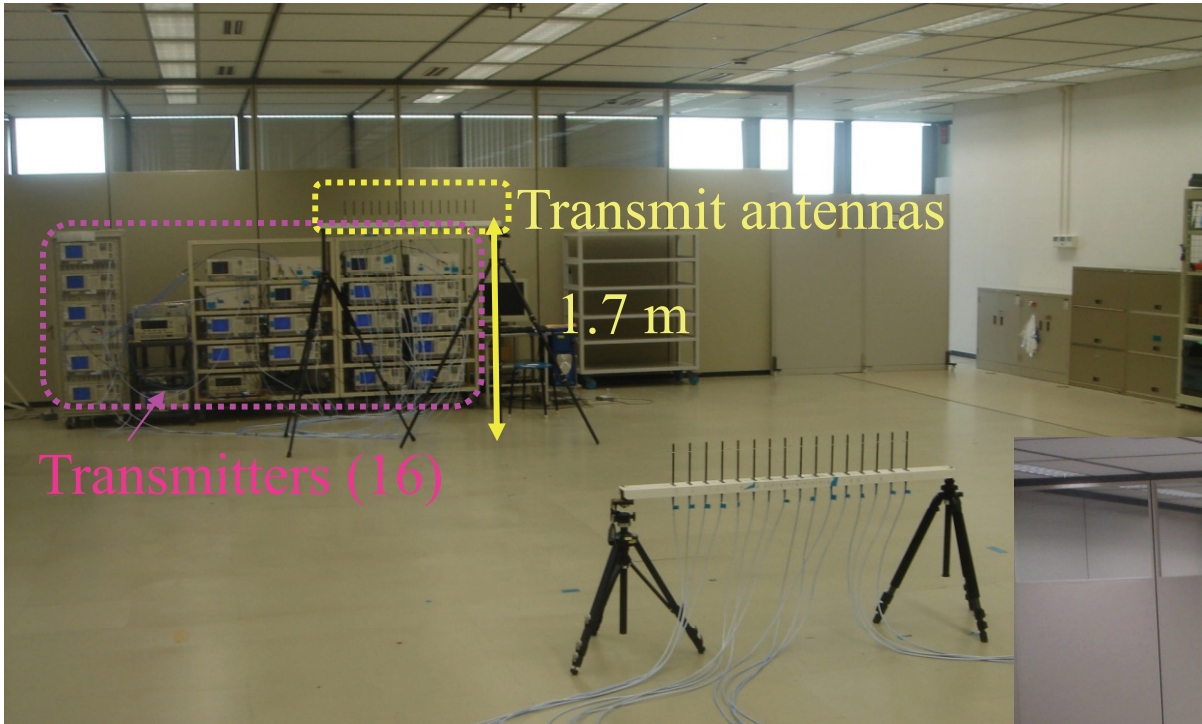
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# Measurement Setup



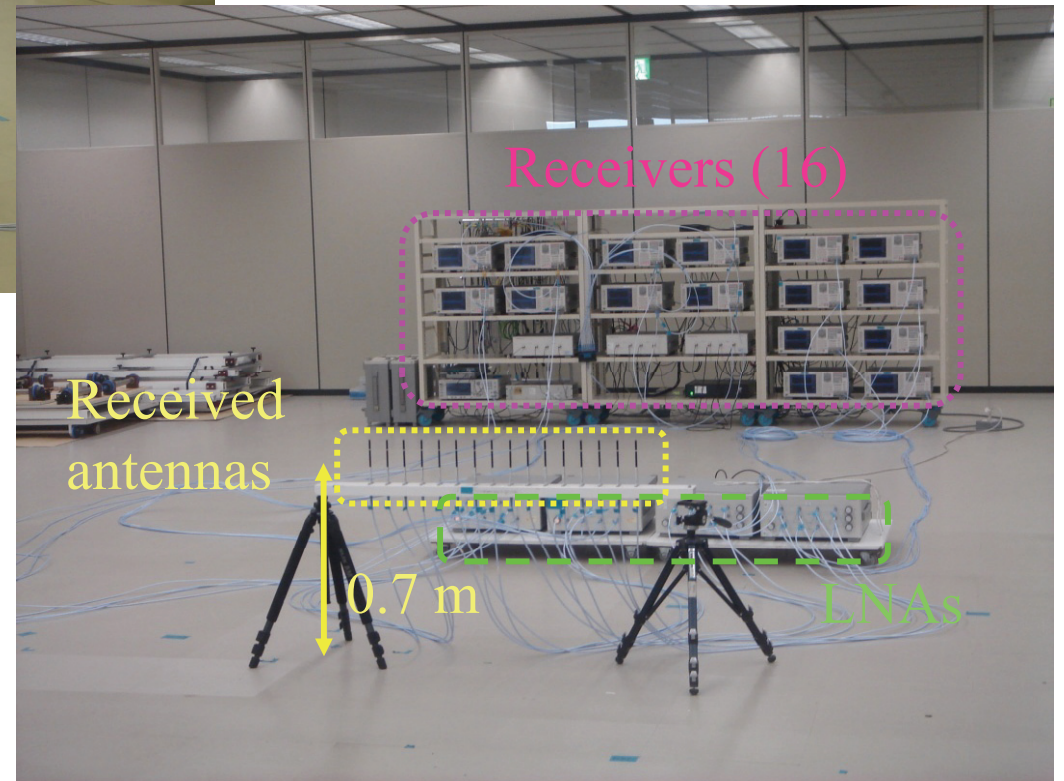
- 16x16 MIMO channel measurements and data transmission at 5GHz with 20MHz BW were conducted at a typical office room in NTT lab.
- Downlink performances were evaluated for up to 8 STAs in static and time variant channels.

# Developed Measurement System



Tx site

Rx site



# Transmission Parameters

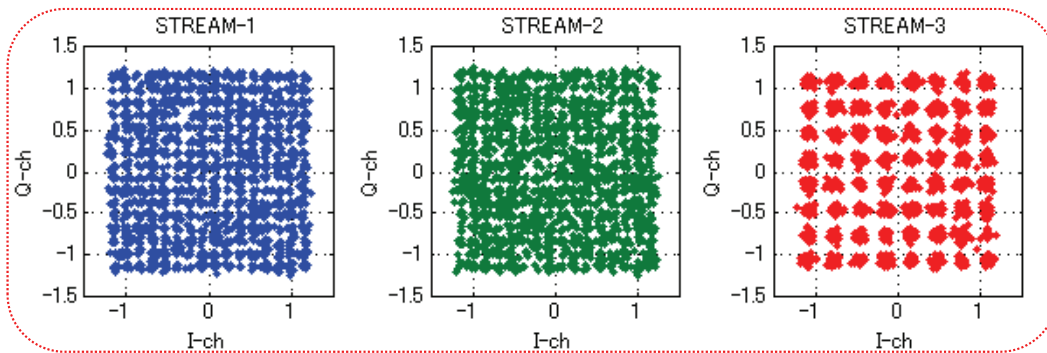
Signal format based on IEEE802.11n is used.

Number of antennas (Tx)	16 (Element spacing: $1\lambda$ )
Number of antennas (Rx)	2, 3, 4 (Element spacing: $0.5\lambda$ )
Transmit power	Max. 6 dBm (Total)
Packet length	100 coded OFDM signal
Number of subcarriers	48 ( Pilot 4)
Pilot signal	6, 20, 34, 48
Bit error	Less than $10^{-7}$
Bandwidth	20 MHz
Sampling rate	40 MHz
Modulation scheme	QPSK, 16QAM, 64QAM, 256QAM, and 1024QAM
Coding rate	1/2, 2/3, 3/4, 5/6, and 7/8

# Achieved over 42.8 bits/s/Hz (@SNR=30 dB)

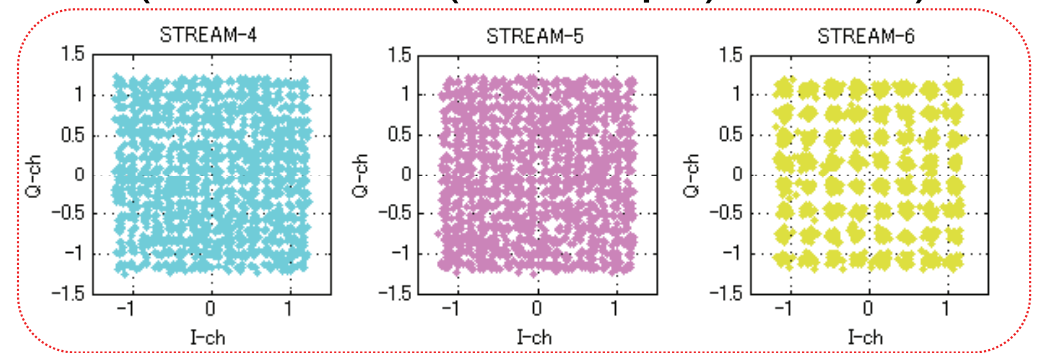
STA-1

(9.8 bit/s/Hz (196Mbps), R=5/6)



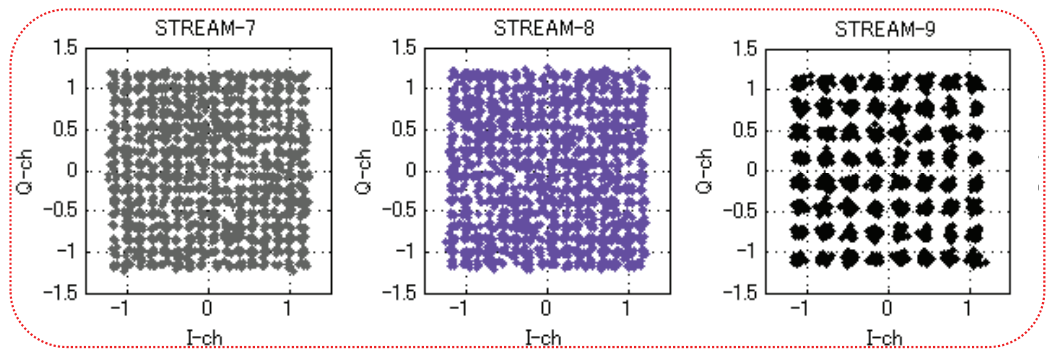
STA-2

(11 bit/s/Hz (220Mbps), R=7/8)



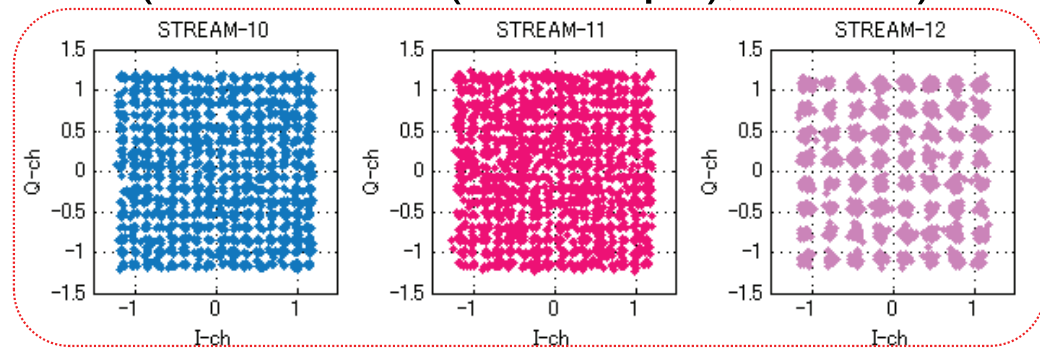
STA-3

(11 bit/s/Hz (220Mbps), R=7/8)



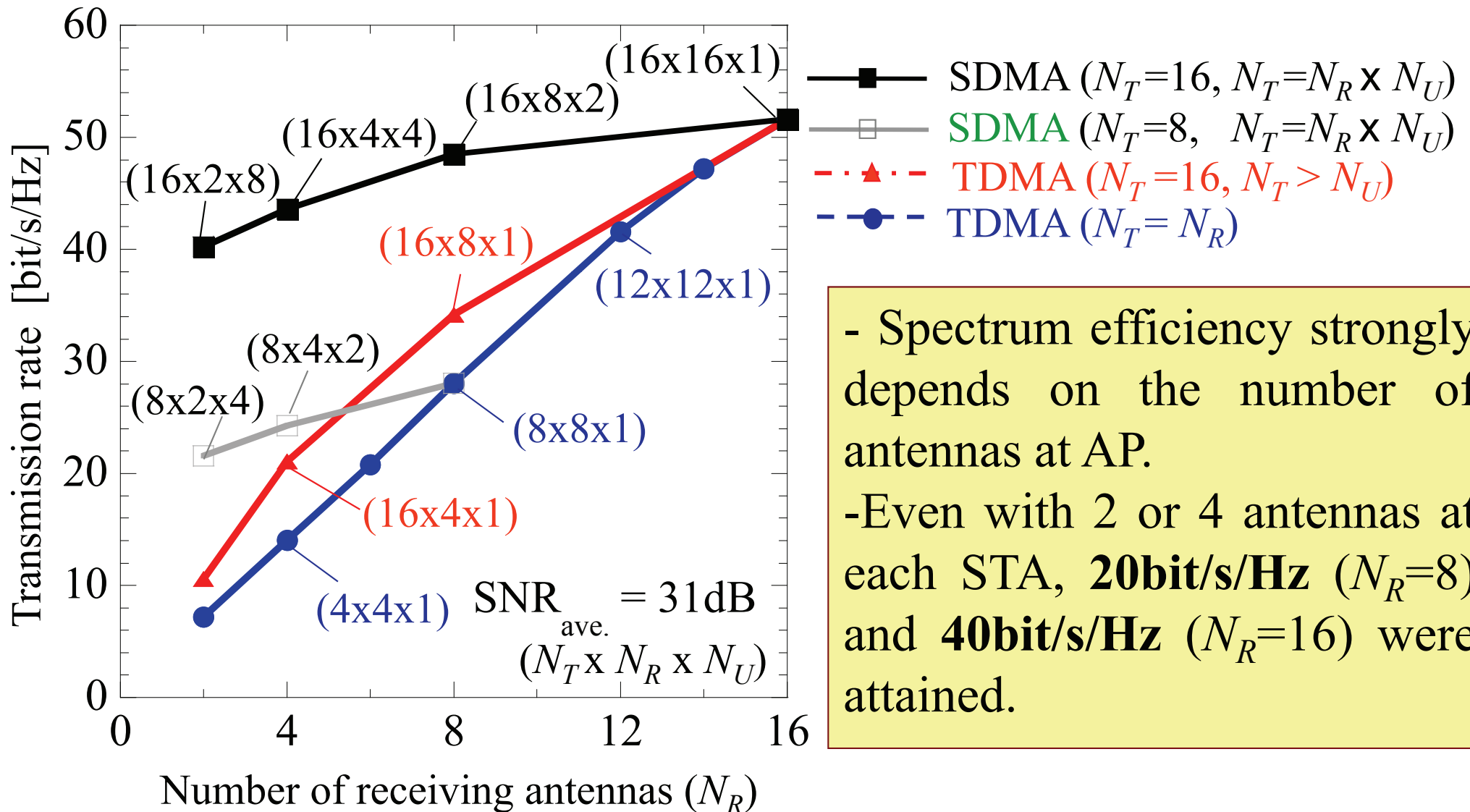
STA-4

(11 bit/s/Hz (220Mbps), R=7/8)

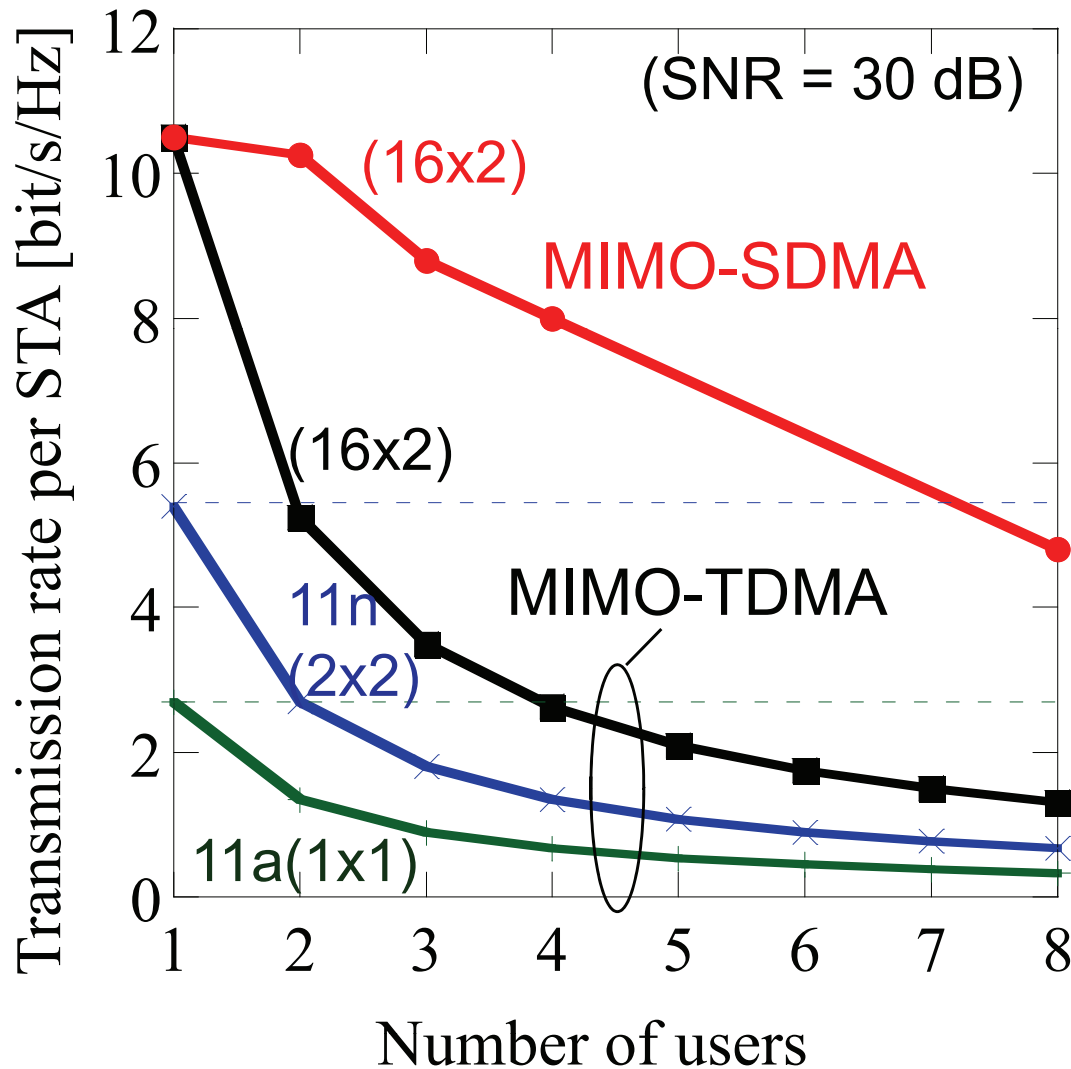




# Transmission Rate vs. Number of Receiving Antennas in a Static Office Environment



# Transmission Rate per STA vs. Number of STAs



## MIMO-TDMA

Transmission rate becomes  $R_s / U$ . U: Number of users

MIMO-SDMA yields a higher transmission rate than MIMO-TDMA, when the number of users is increased.

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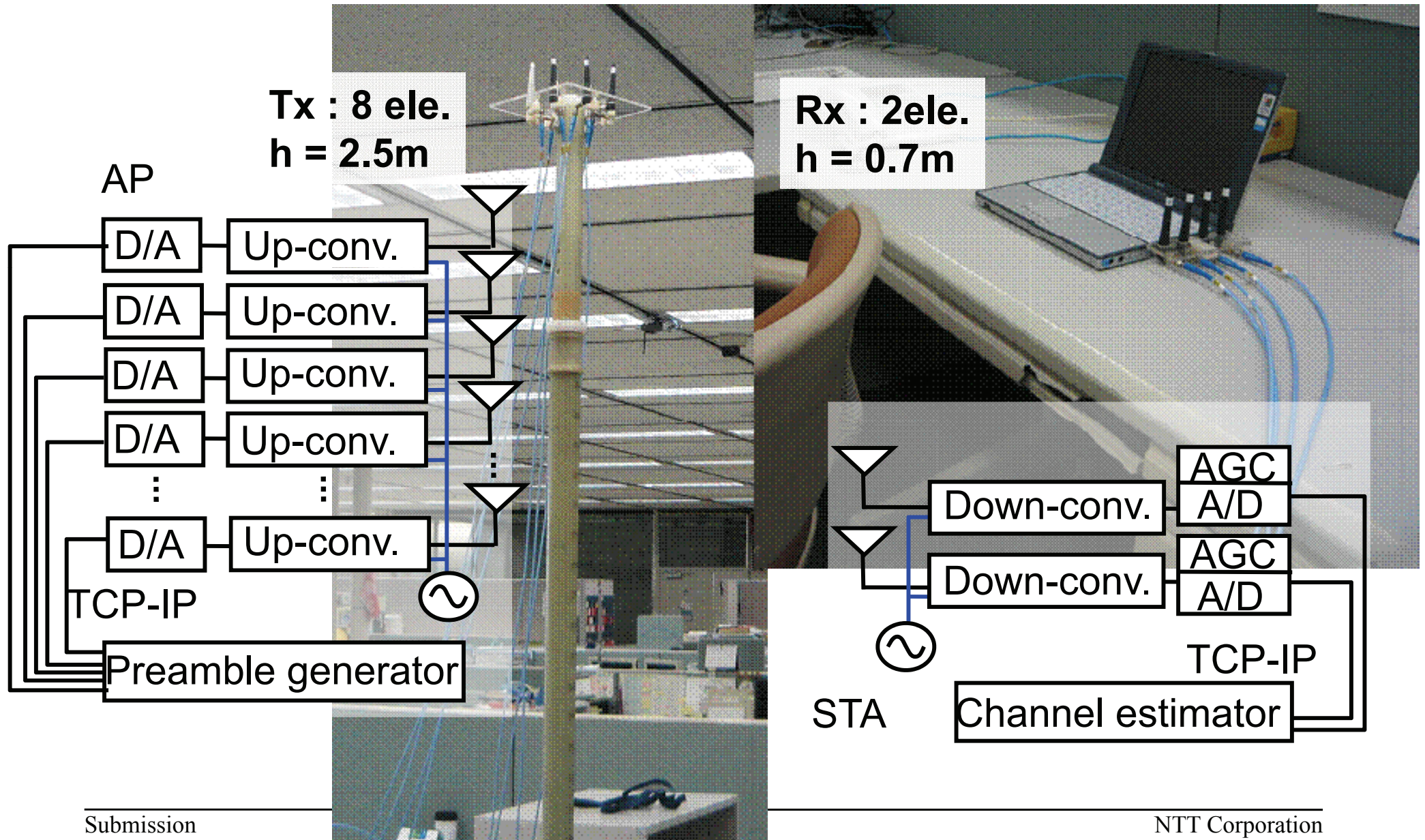
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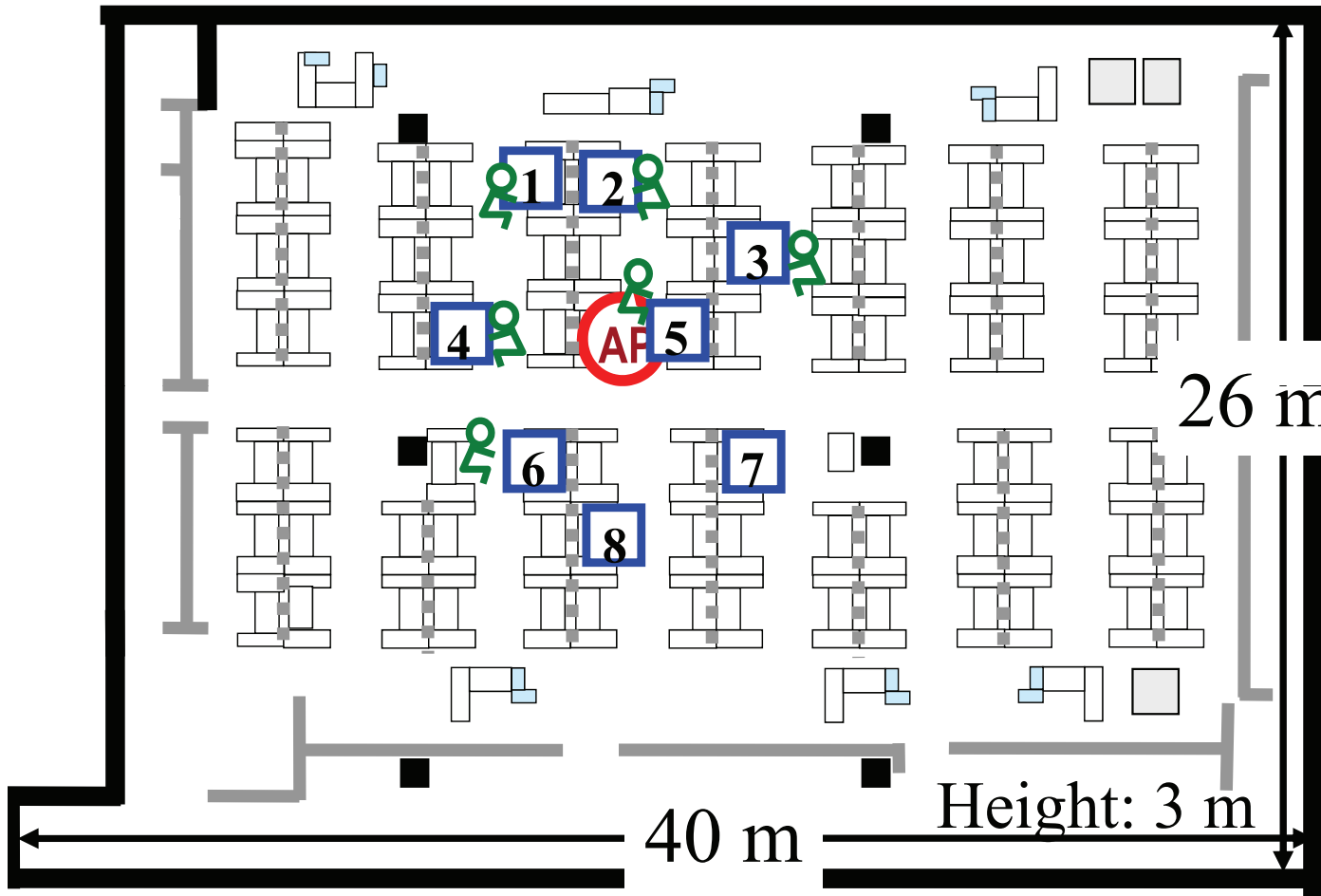
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# Evaluation in time variant channel



# Environment for the measurements



CSI is obtained from AP to P1~P8.  
 →  $H_1(t) \sim H_8(t)$   
 ( $0 \leq t \leq 100\text{msec}$ )

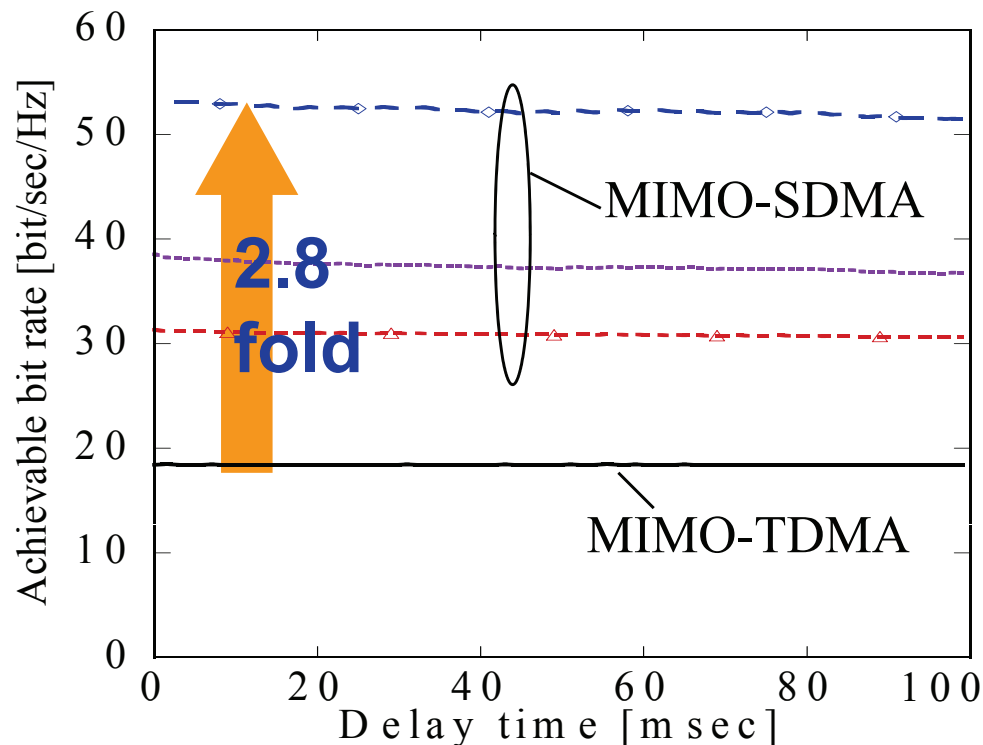
- 1) Without person in front of each STA
- 2) With person in front of each STA

■ Pillar    — Partition 1    ..... Partition 2    — Wall  
 ○ AP position    □ STA position    □ Desk

# Capacity in time variant channel (1)

## Without person in front of each STA.

- Eigen-mode transmission (MIMO-TDMA)
- ..... MIMO-SDMA (2-STAs, 2-streams)
- ..... (4-STAs, 2-streams)
- - - (8-STAs, 1-stream)

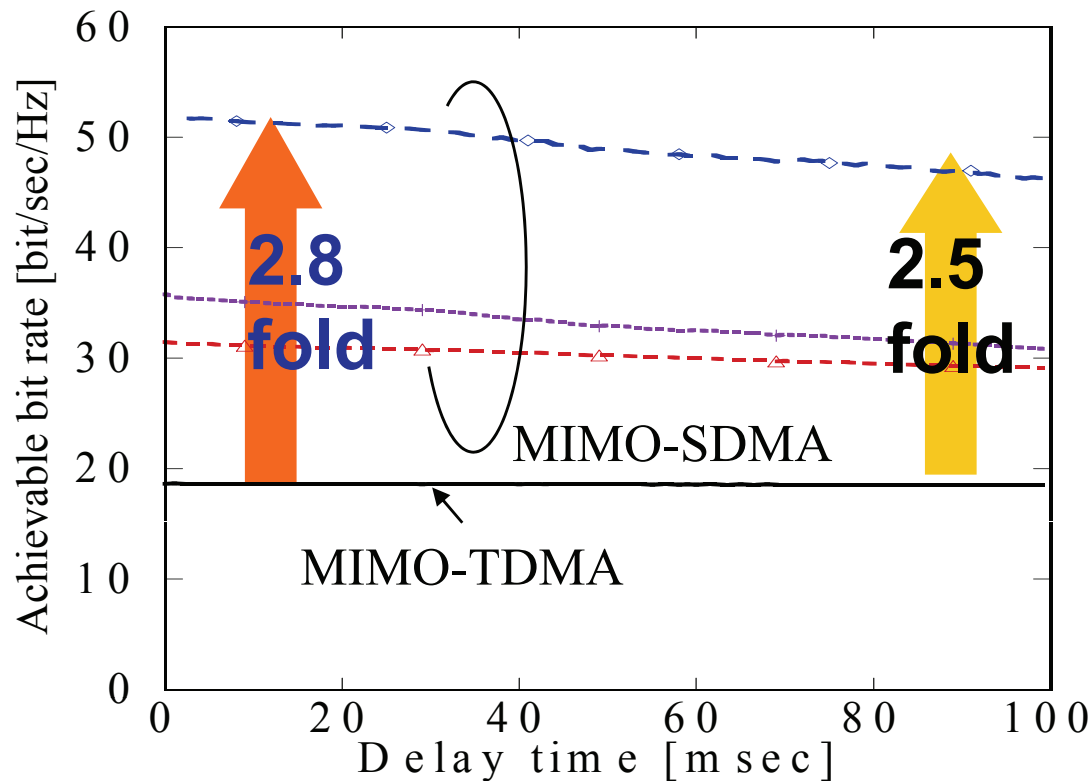


- MIMO-SDMA attains 2.8-fold improvement over MIMO-TDMA.
- Slight fall off in ABR is observed with MIMO-SDMA.

# Capacity for time variant channel (2)

**With person in front of each STA.**

- Eigen-mode transmission (MIMO-TDMA)
- ..... MIMO-SDMA (2-STAs, 2 streams)
- ..... (4 STAs, 2 streams)
- - - (8 STAs, 1 stream)



- MIMO-SDMA attains 2.5-2.8 fold improvement over MIMO-TDMA.
- Slight fall off in achievable bit rate is observed with MIMO-SDMA.

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# Conclusions

- **SDMA can be important technology in TGac**
  - 40 bits/s/Hz frequency utilization efficiency was achieved with 16 antennas @ AP and 2 or 4 antennas @ MT.
  - 20 bits/s/Hz frequency utilization efficiency was achieved with 8 antennas @ AP and 2 or 4 antennas @ MT.
- **Time-variant channel was measured: indoor environment**
  - Small effect of the human body on the bit-rate was observed.
  - The bit-rate deterioration can be alleviated by reducing the number of streams.
- **TGac channel models may consider time-variant characteristics with spatially multiplexed STAs.**