

Three-User MIMO Broadcast Channel with Delayed CSIT: A Higher Achievable DoF

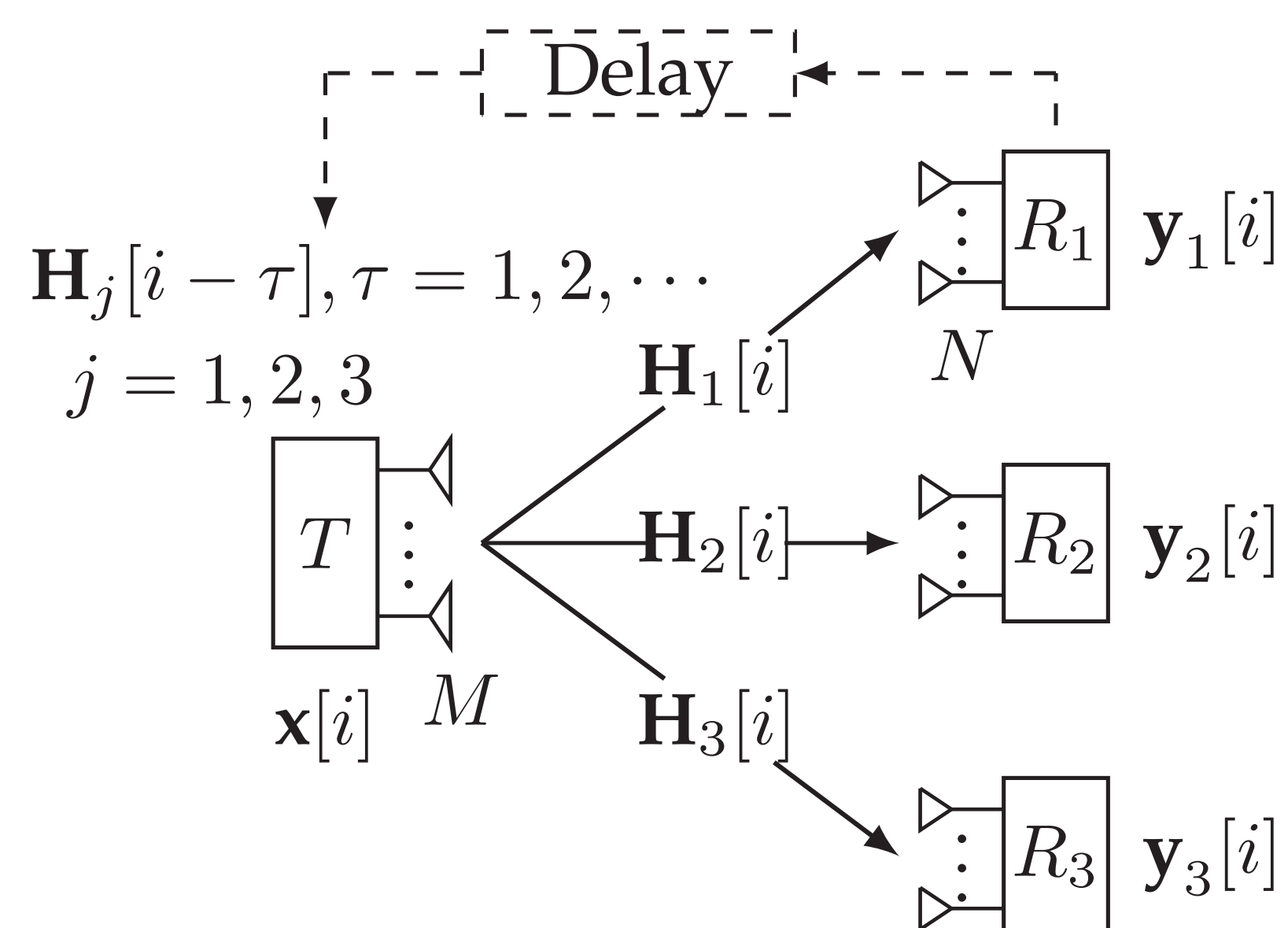
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Problem & Objective ①

- **Ultimate Goal:**
To find the best possible degrees of freedom (DoF) for K -user multiple-input multiple-output (MIMO) broadcast channel with delayed CSIT
- **Objective of Present Work:**
To improve the achievable DoF for $2N < M < 3N$ antenna configuration in a three-user MIMO broadcast channel

System Model ②

- **DoF Definition:**
DoF denotes the maximal multiplexing gain, i.e., maximal number of independent channels can be utilized for communication
 $C = \text{DoF} \log(\text{SNR}) + o(\log(\text{SNR}))$ bps/Hz
where
$$o(\log(\text{SNR})) = \lim_{\text{SNR} \rightarrow \infty} \frac{C}{\log(\text{SNR})} = 0$$



- **Three-User MIMO Broadcast Channel:**
Each receiver has N antennas, while the transmitter has M antennas
The channel matrix at time slot i from transmitter to receiver j is $\mathbf{H}_j[i]$
The transmitter wants to send private information $\mathbf{a}, \mathbf{b}, \mathbf{c}$ for receiver 1, 2, 3

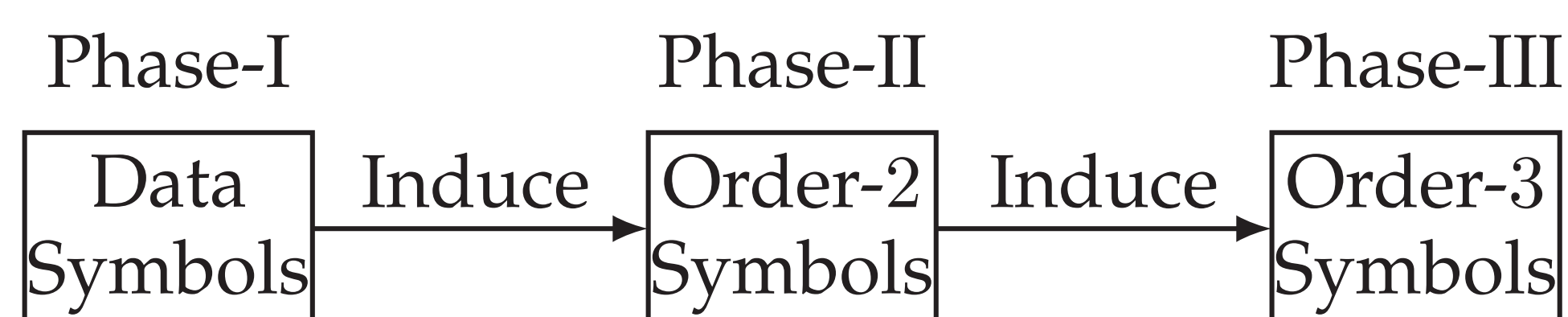
- **Delayed CSIT:**
When the channel is fast time-varying and the feedback is not instantaneous, the CSIT will be delayed and might have different values from the current one

Existing Scheme [1] ③

- **Coded Transmission:**
In each time slot, the transmitter sends sum of data symbols, e.g. $\mathbf{a} + \mathbf{b}$
Due to the interference and shortage of equations, each receiver cannot decode their desired data symbols immediately
- **Sequential Design of Auxiliary Symbols:**
Order-2 and -3 auxiliary symbols are constructed based on delayed CSIT to help decode the desired symbols
After transmission of data symbols, order-2 symbols are generated to decode data sym-

bols at 2 receivers
After transmission of order-2 symbols, order-3 symbols are designed to facilitate the decoding of order-2 symbols at 3 receivers

- **Drawback:**
The auxiliary symbols are not structured in an integrated way
- **Flowchart:**



Proposed Scheme ④

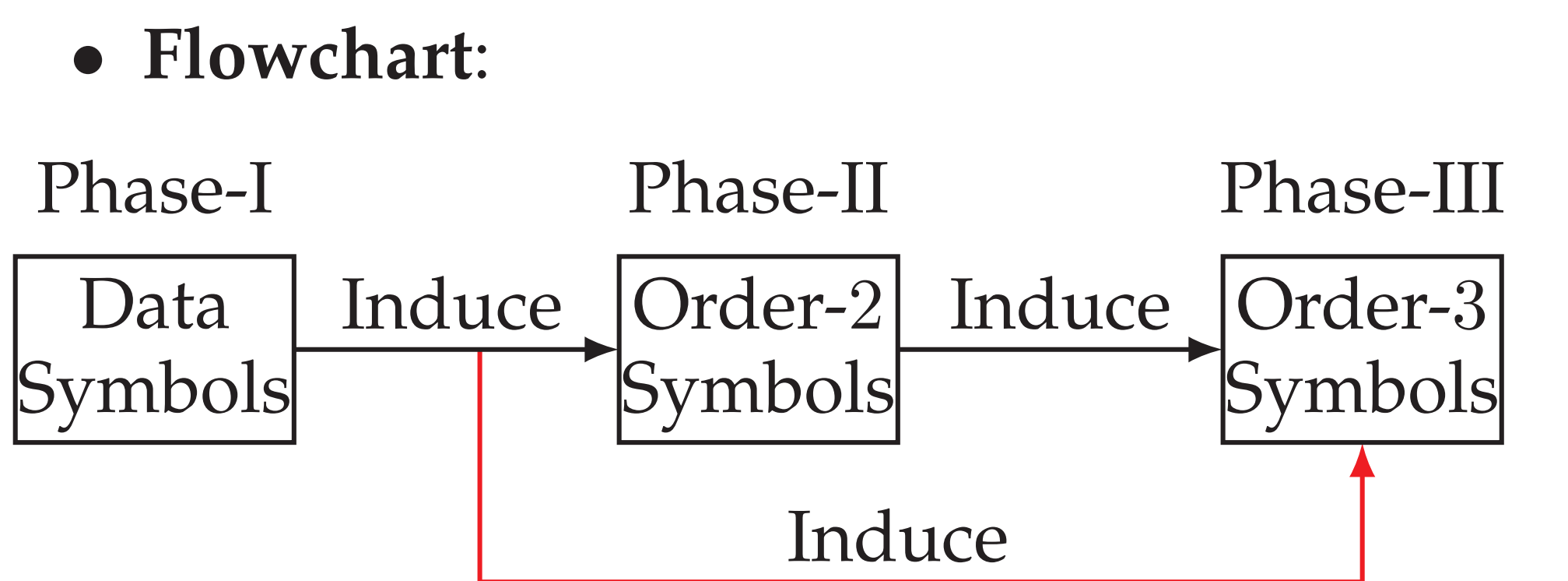
- **Coded Transmission:**
In each time slot, the transmitter sends sum of data symbols, e.g. $\mathbf{a} + \mathbf{b}$. After 3 time slots transmission, the received signals are given as follows:

$$\begin{aligned} \mathbf{y}_1[1] &= \mathbf{H}_1[1]\mathbf{a}_1 + \mathbf{H}_1[1]\mathbf{b}_1 & \mathbf{y}_1[2] &= \mathbf{H}_1[2]\mathbf{b}_2 + \mathbf{H}_1[2]\mathbf{c}_1 & \mathbf{y}_1[3] &= \mathbf{H}_1[3]\mathbf{c}_2 + \mathbf{H}_1[3]\mathbf{a}_2 \\ \mathbf{y}_2[1] &= \mathbf{H}_2[1]\mathbf{a}_1 + \mathbf{H}_2[1]\mathbf{b}_1 & \mathbf{y}_2[2] &= \mathbf{H}_2[2]\mathbf{b}_2 + \mathbf{H}_2[2]\mathbf{c}_1 & \mathbf{y}_2[3] &= \mathbf{H}_2[3]\mathbf{c}_2 + \mathbf{H}_2[3]\mathbf{a}_2 \\ \mathbf{y}_3[1] &= \mathbf{H}_3[1]\mathbf{a}_1 + \mathbf{H}_3[1]\mathbf{b}_1 & \mathbf{y}_3[2] &= \mathbf{H}_3[2]\mathbf{b}_2 + \mathbf{H}_3[2]\mathbf{c}_1 & \mathbf{y}_3[3] &= \mathbf{H}_3[3]\mathbf{c}_2 + \mathbf{H}_3[3]\mathbf{a}_2 \end{aligned}$$

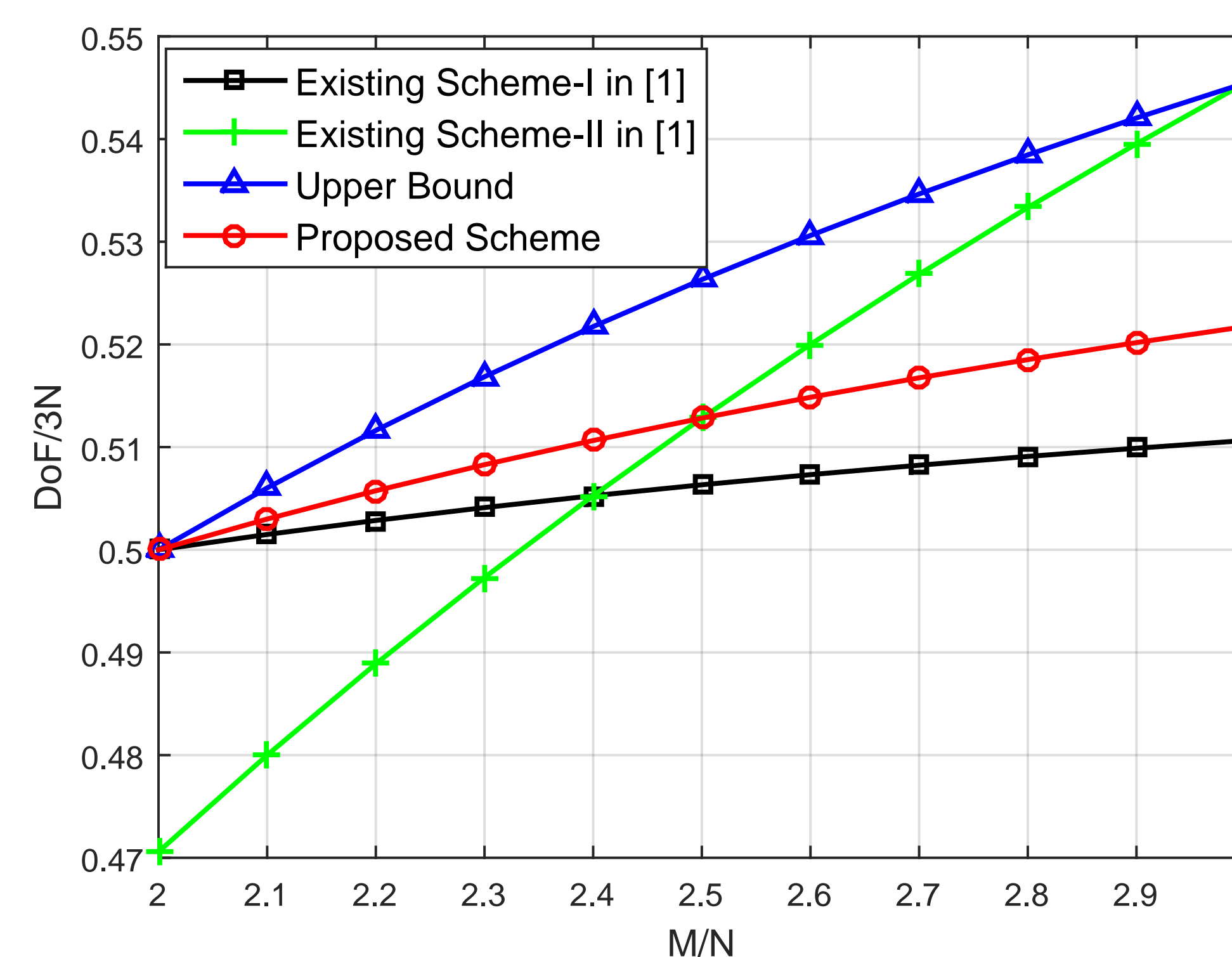
Due to the interference and shortage of equations, each receiver cannot decode their desired data symbols immediately
We generate auxiliary symbols in an integrated way, rather than the sequential approach in [1]

- **Integrated Design of Auxiliary Symbols:**
Order-2 symbols are the underlined parts and the sum of same colored parts
Specially, after transmission of data symbols, we generate order-3 symbols $\mathbf{y}_1[2] + \mathbf{y}_2[3] + \mathbf{y}_3[1]$, which are used to acquire the desired data symbols along with the generated order-2 symbols
- **Three Transmission Phases:**
In Phase-I, we transmit $12MN$ desired data symbols using $6N$ time slots. After Phase-I, we produce $6MN$ order-2 symbols

and $2(M - 2N)N$ order-3 symbols
In Phase-II, we transmit $6MN$ order-2 symbols using $3M$ time slots. After Phase-II, we generate $2MN$ order-3 symbols
In Phase-III, we transmit $4(M - N)N$ order-3 symbols using $4(M - N)$ time slots



Results & Contribution ⑤



- **Proposed Achievable DoF:**
We transmit $12MN$ data symbols using $7M + 2N$ time slots
$$\frac{12MN}{7M + 2N} > \max \left\{ \frac{24MN}{15M + 2N}, \frac{12MN}{5M + 7N} \right\}$$

proposed existing [1]
- **Contribution:**
We propose a higher sum achievable DoF, i.e., $\frac{12MN}{7M+2N}$ for the antenna configuration, $2N < M < 2.5N$, with a distinctive achievable scheme

References