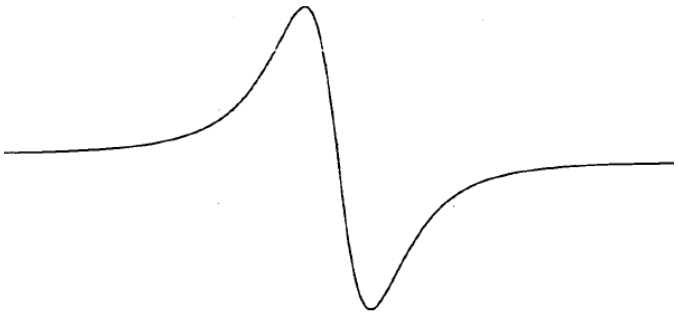
algolma
laboratoire d'algorithmique
laboratoire de mathematiques algorithmique

Study of Partial-Response Channel in HDD



Luoming Zhang
ALGO

algolma
laboratoire d'algorithmique
laboratoire de mathematiques algorithmique

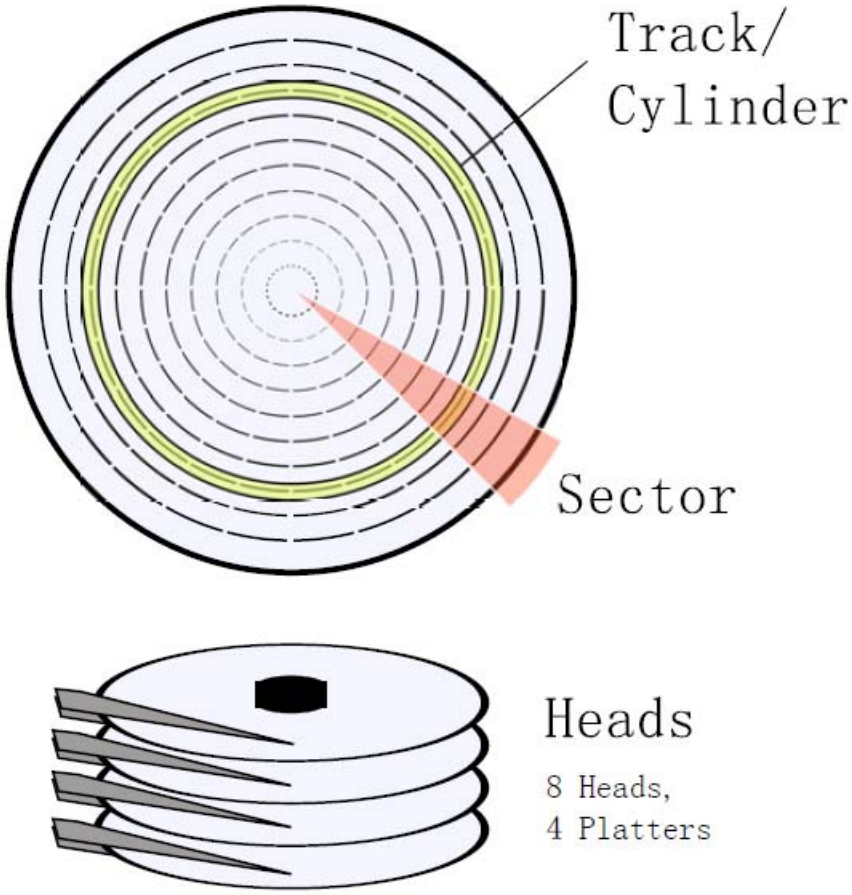
Outlines

- Background
  - Long Data Sector Program
  - HDD working Mechanism
- Channel Model
  - Microtrack Channel Model
- Partial Response Signaling
  - PR4 Signaling
- Future Work

Long Data Sector Program

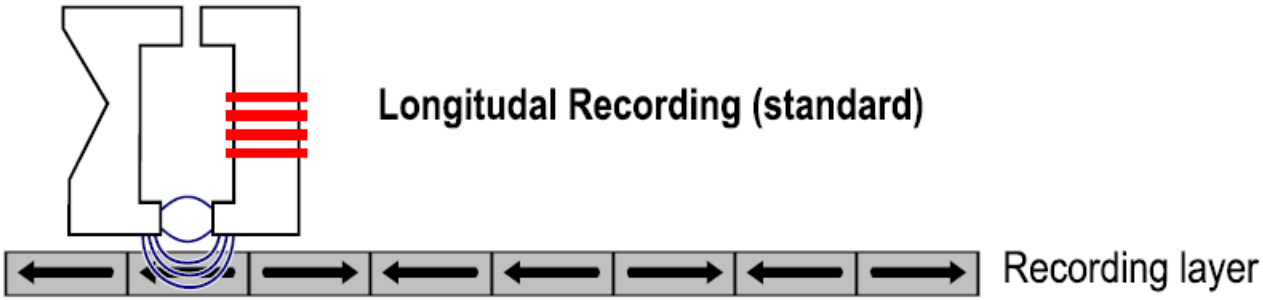
- Motivation
  - 512-byte Sector format could not satisfy the data integrity requirement in the growing areal density of HDD
- Scope
  - Operating System
  - Hardware Manufacture
- 4k-byte sector
  - Tradeoff between the ECC codes and data efficiency of sector

Physical Structure of HDD

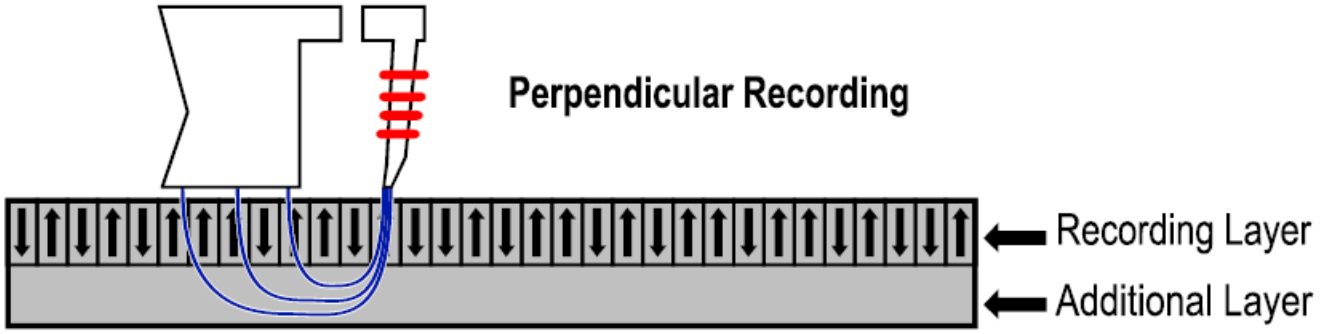


Working Mechanesm of HDD

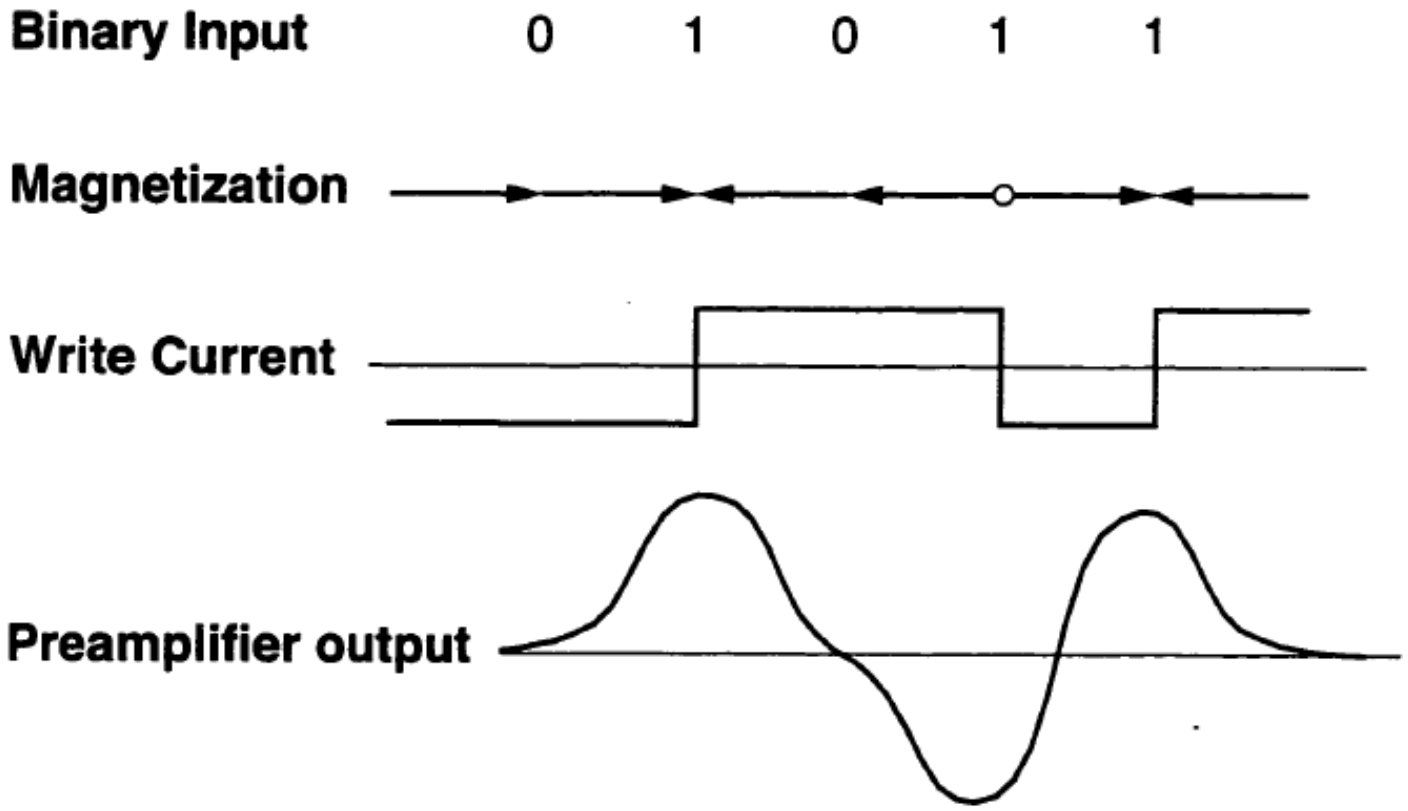
"Ring" writing element



"Monopole" writing element



Signaling Mechanism of HDD



$$h(t) = \sqrt{\frac{4E_t}{\pi PW50}} \cdot \frac{1}{1 + (2t/PW50)^2}$$

algolma
laboratoire d'algorithmique
laboratoire de mathematiques algorithmique

Transition Pulse Response

- Longitude Recording System

$$h(t) = \sqrt{\frac{4E_t}{\pi PW50}} \cdot \frac{1}{1 + (2t/PW50)^2}$$

- Perpendicular Recording System

$$h(t) = A \bullet \tanh\left(\frac{Log(3)t}{T_{50}}\right)$$

algolma
laboratoire d'algorithmique
laboratoire de mathematiques algorithmique

Effective elements

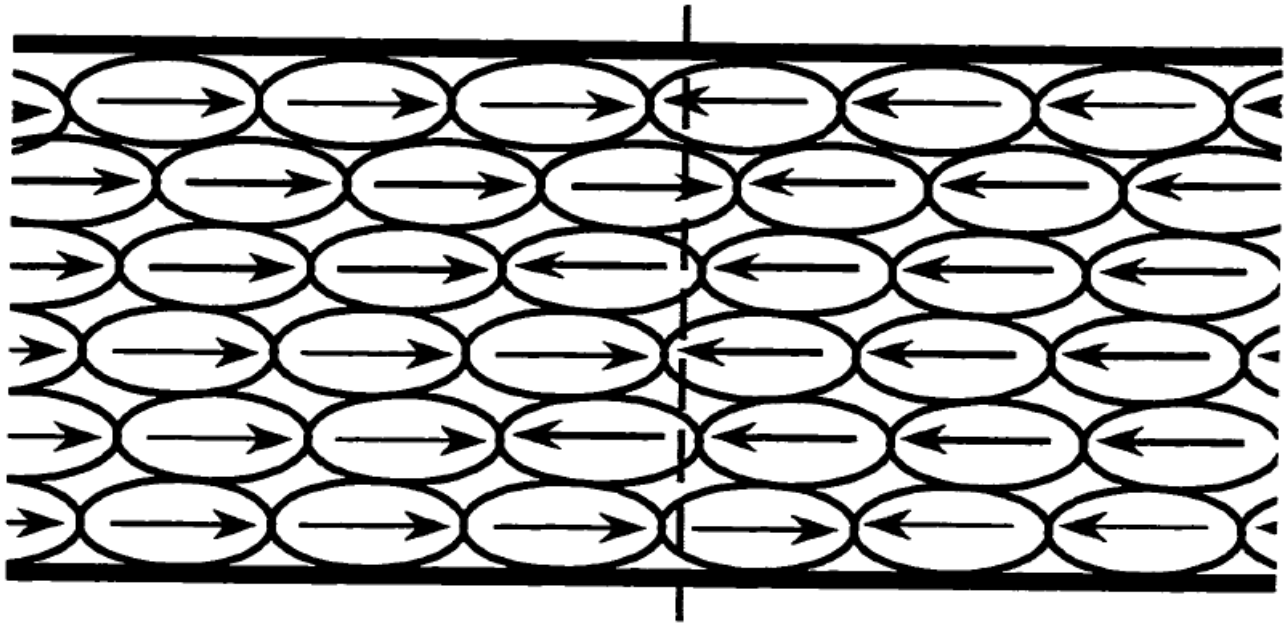
- Magnetic materials
  - Thin film material
- Writing and Reading Head
  - Magnetism Resistive Head (MR)
  - Giant Magnetism Resistive Head (GMR)
- Digital signal Processing Technique
  - Reed-Solomn Codes
  - Partial Response Signaling

algolma
laboratoire d'algorithmique
laboratoire de mathematiques algorithmique

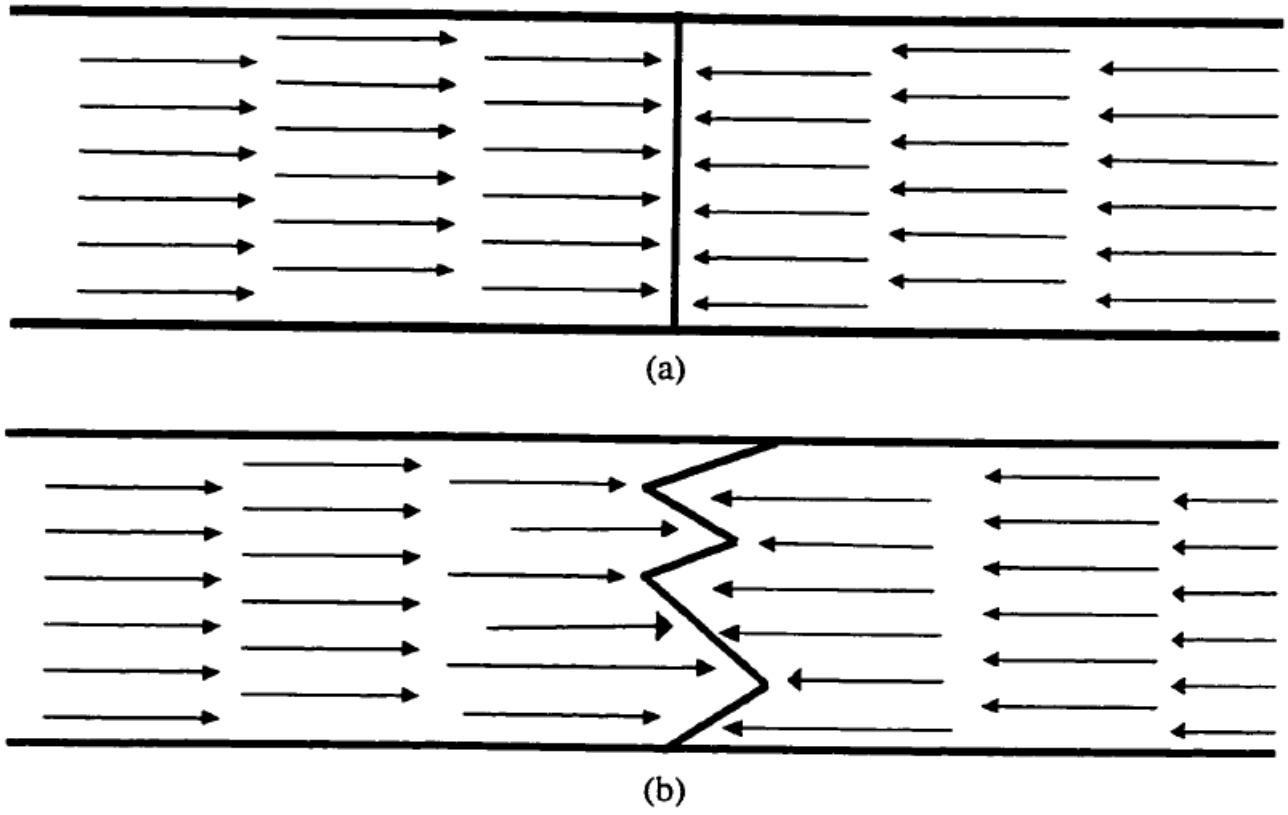
Signal Processing Issue (1)

- InterSymbol Interference
- Media Effect
- Cross Track Interference

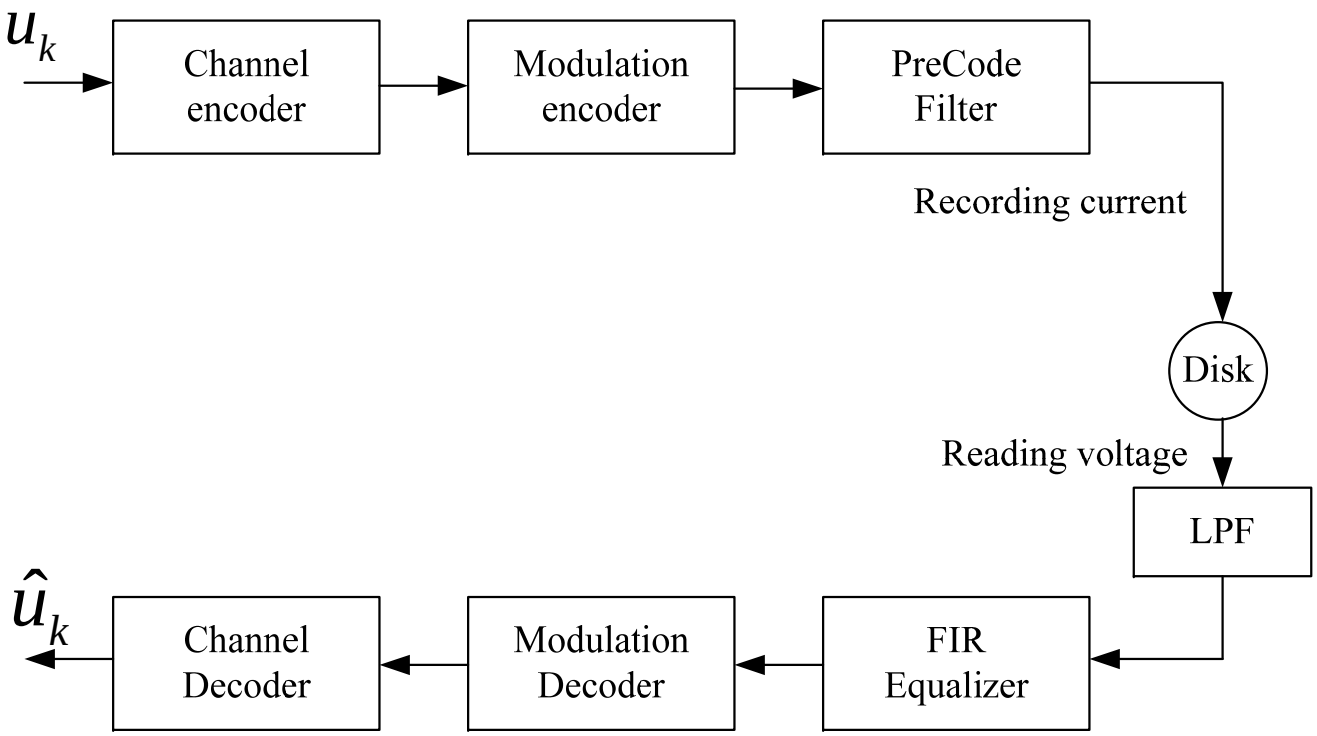
Signal Processing Issue (2)



Signal Processing Issue (3)



Generalized Diagram for HDD



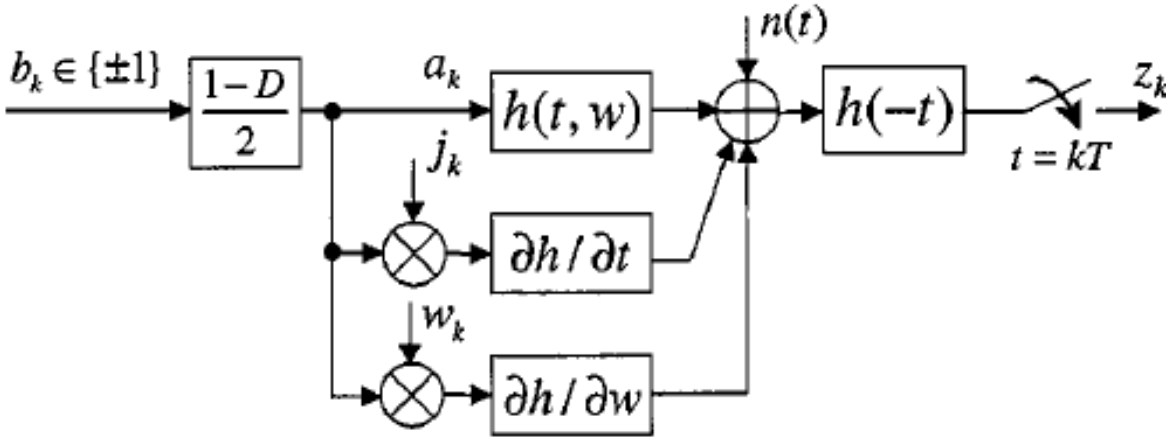
MacroTrack Model (1)

$$r(t) = \sum_i a_k h(t + j_k - iT,\ w + w_k) + n(t)$$

$$\cong h(t,\ w) + j_k \partial h(t,\ w)/\partial t + w_k \partial h(t,\ w)/\partial w$$

j_k Position Jitter

w_k Width Variation



MacroTrack Model (2)

$$\mathrm{SNR} = \frac{E_t}{N_0 + M_0} = \frac{E_t}{N_\alpha}$$

$$M = \left(\frac{\alpha}{100}\right) N_\alpha \qquad M_j = \lambda M \qquad M_w = (1-\lambda)M$$

$$\sigma_n = \sqrt{\frac{N_0}{2}} \quad \sigma_j = \sqrt{\frac{M_j}{4E_t}}\, PW50 \text{ and } \sigma_w = \sqrt{\frac{M_w}{4E_t}}\, PW50$$

$N_0/2$ Spectral hight of electronic noise

$M_0/2$ Average energy hight of transition noise

α Fraction of the transition noise proportion to the whole noise

λ Fraction of the transition noise due to the position jitter

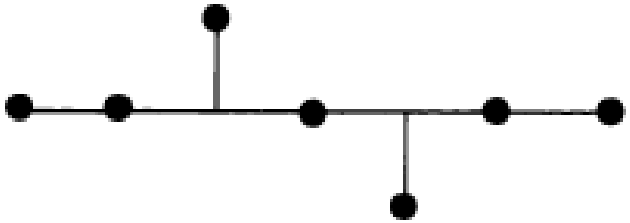
Partial Response Signaling

- Using MMSE criterion to find the best match of the transition response output by interference cancellation

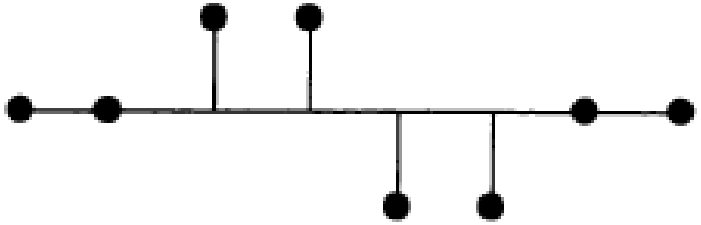
$$g(D) = (1 - D^2)(1 + c_1 D + c_2 D^2 + \cdots)$$

Partial Response Signaling

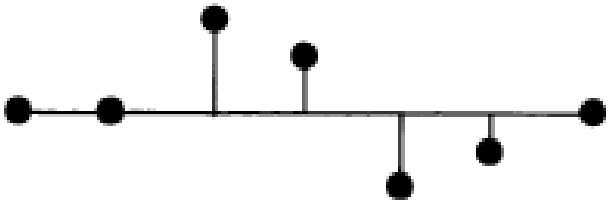
$1-D^2$ (PR4)



$1+D-D^2-D^3$ (EPR4)



Generalized Partial Response (typical)



algolma
laboratoire d'algorithmique
laboratoire de mathematiques algorithmique

Future Work

- Simulating the Partial Response Channel
- Algebraic Codes
- Iterative Codes based on Graph
- Modulation Codes

algolma
laboratoire d'algorithmique
laboratoire de mathematiques algorithmique

Thanks!