# Network Coding Teaching Module

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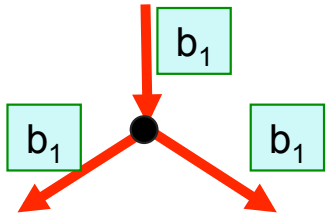
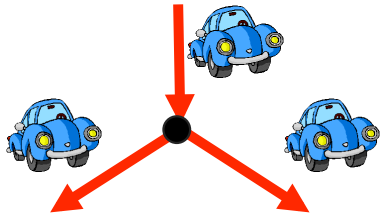
Faculty Teaching Workshop

# Network Coding Paradigm

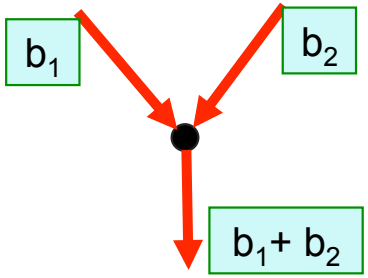
- Information flow vs. commodity flow



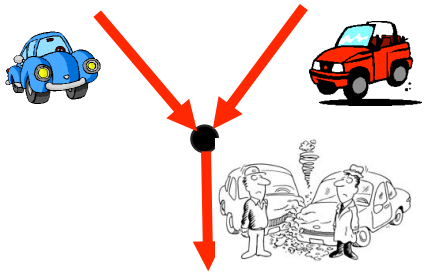

Replication



Replication



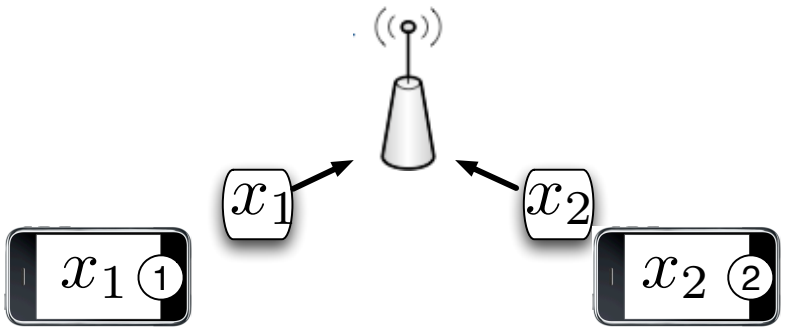

Encoding



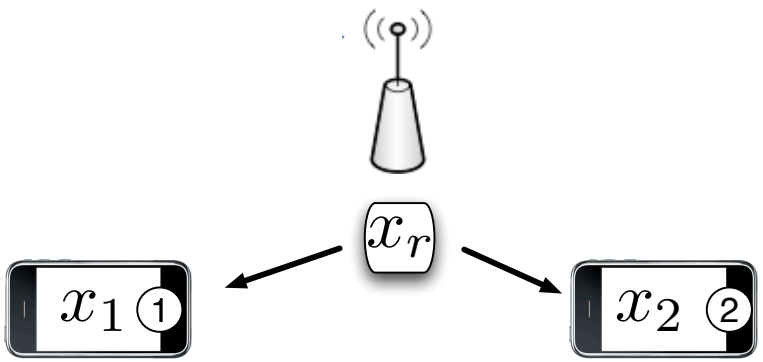
Encoding

# Physical layer network coding

$$y_r = x_1 + x_2 + z$$




MAC phase

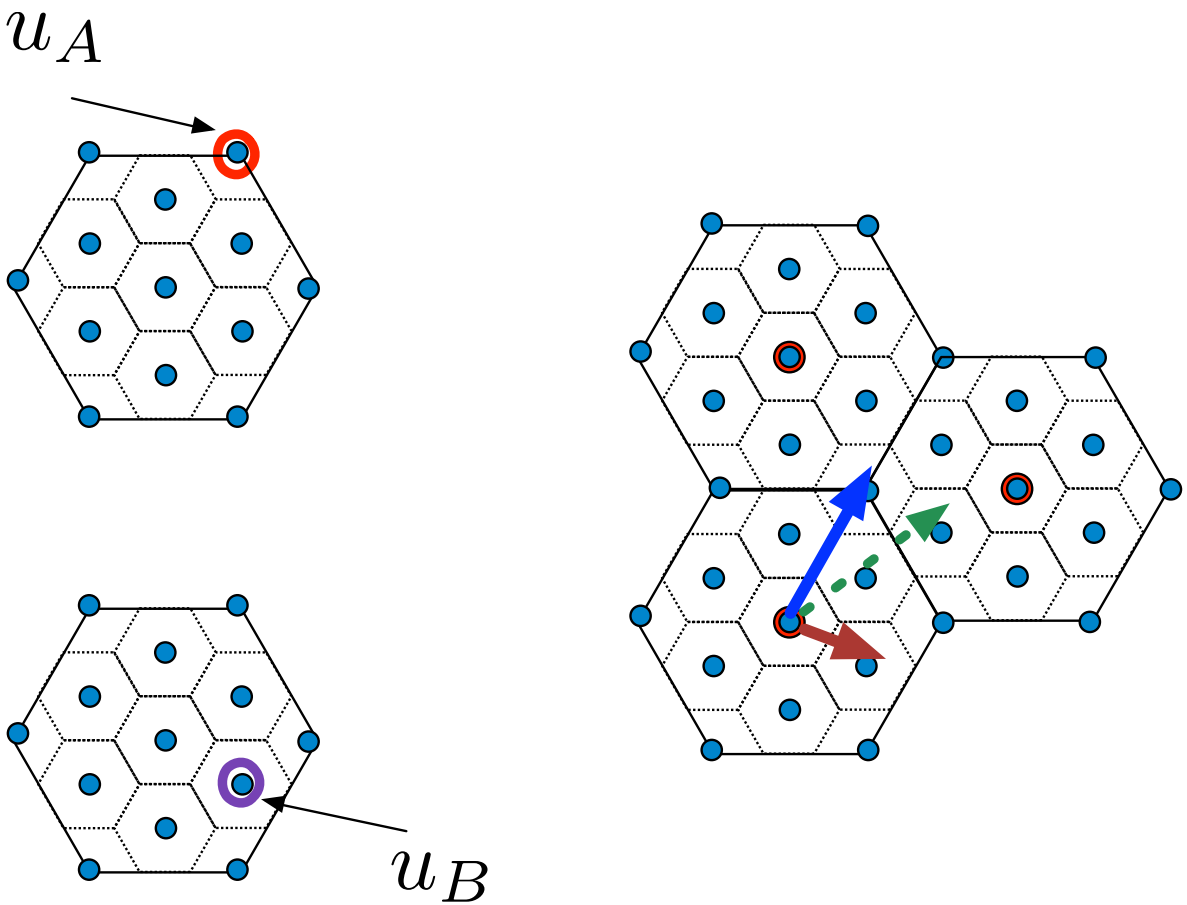



$y_1 = x_r + z_1$ $\qquad$ $y_2 = x_r + z_2$

Broadcast phase

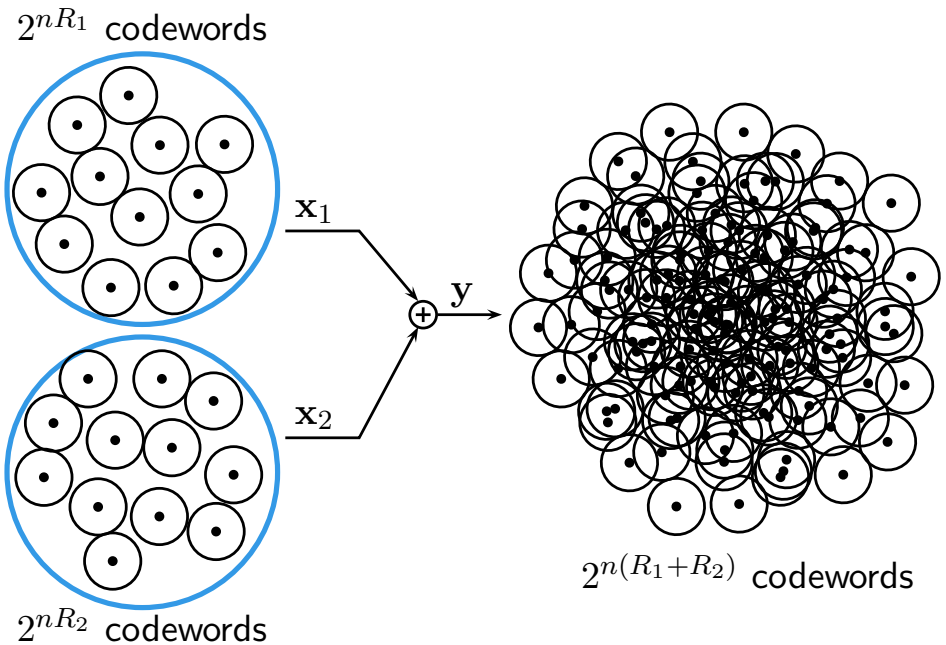
# Lattice Codes

- Lattice codewords are scaled
- Channel adds a noise



# Lattice Codes (cont)

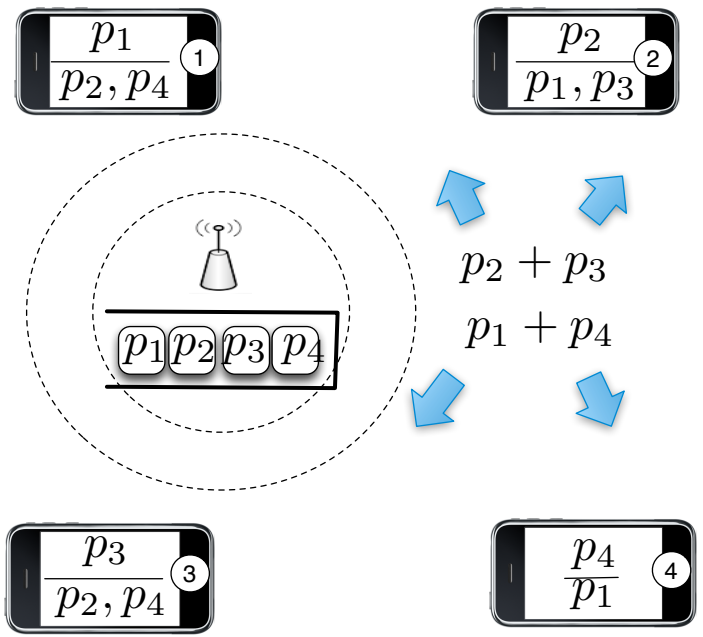
- Random i.i.d. codes are not good for computation
- Structured codes outperform random codes.



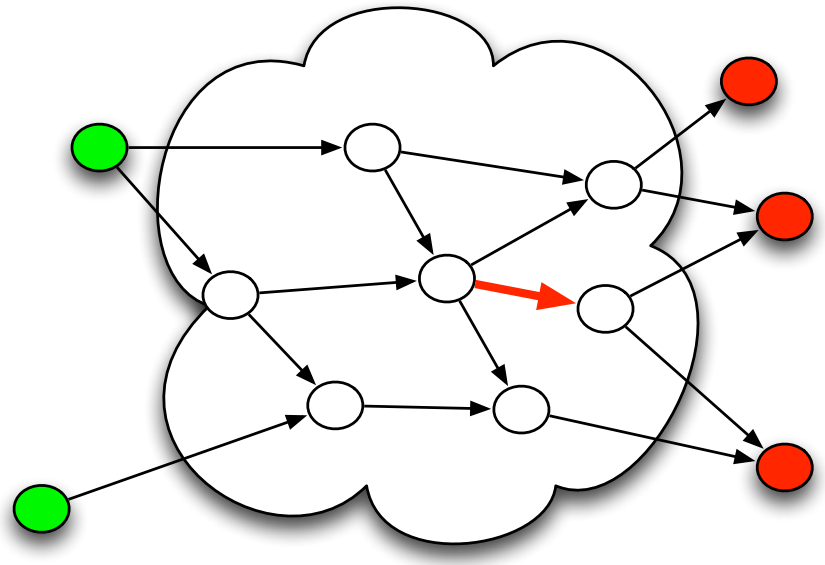

Picture courtesy to B. Nazer

# Index Coding Problem

- Option 1: transmit four uncoded packets
- Option 2: mix packets to take advantage of available side information



# Relation between Index and Network Coding

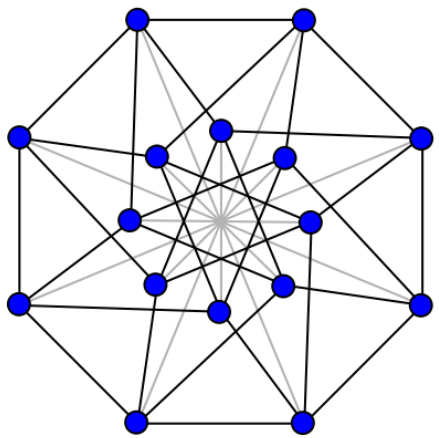


- All links have an infinite capacity except for the bottleneck link

H. Maleki, V. Cadambe, S. Jafar “Index Coding- An Interference Alignment Perspective.”

# Impact of field size

- There exists a family of graphs such that
  - $\mathrm{minrk}_2(G) \geq n^{1-\epsilon}$
  - $\mathrm{minrk}_p(G) \leq n^{\epsilon}$
- Using Ramsey graphs for the construction.



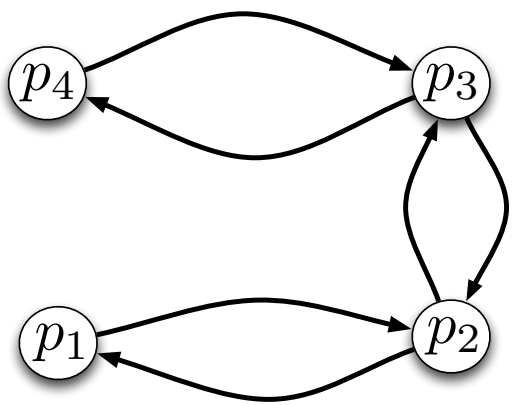
Lubetzky, E. and Stav, U. 2007. Non-Linear Index Coding Outperforming the Linear Optimum.

N. Alon, The Shannon capacity of a union

# Minimum Rank Problem

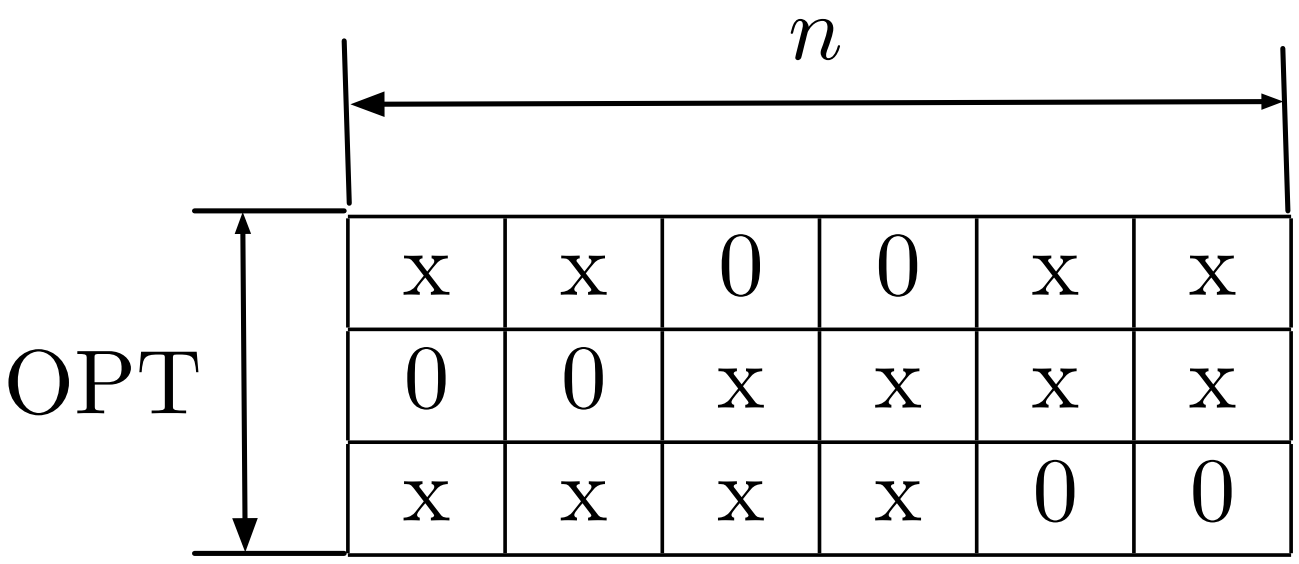
- Given a matrix
  - Non-zero diagonal
  - Do-not cares
  - All other entries are zeros
- Minimize the rank of the matrix

$$A_G = \begin{bmatrix} 1 & X & 0 & 0 \\ X & 1 & X & 0 \\ 0 & X & 1 & X \\ 0 & 0 & X & 1 \end{bmatrix}$$



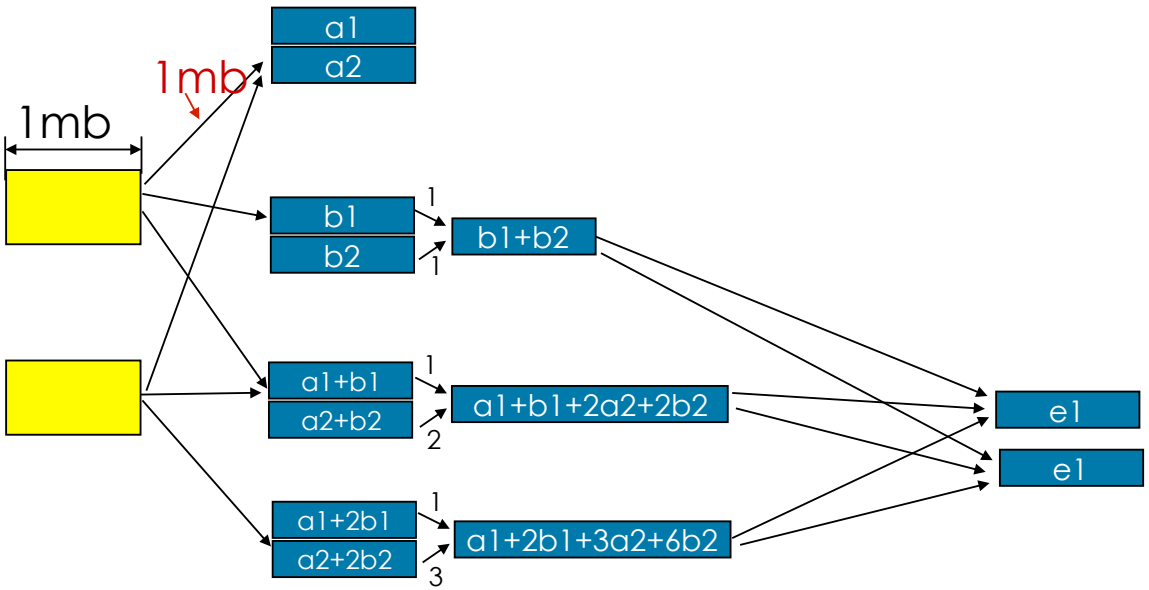
# Error-correcting codes

- Our case: constraints on the code construction
  - Due to the side information available at the clients
- Random code works with high probability
  - Hard to check since finding a minimum distance is an NP-hard problem

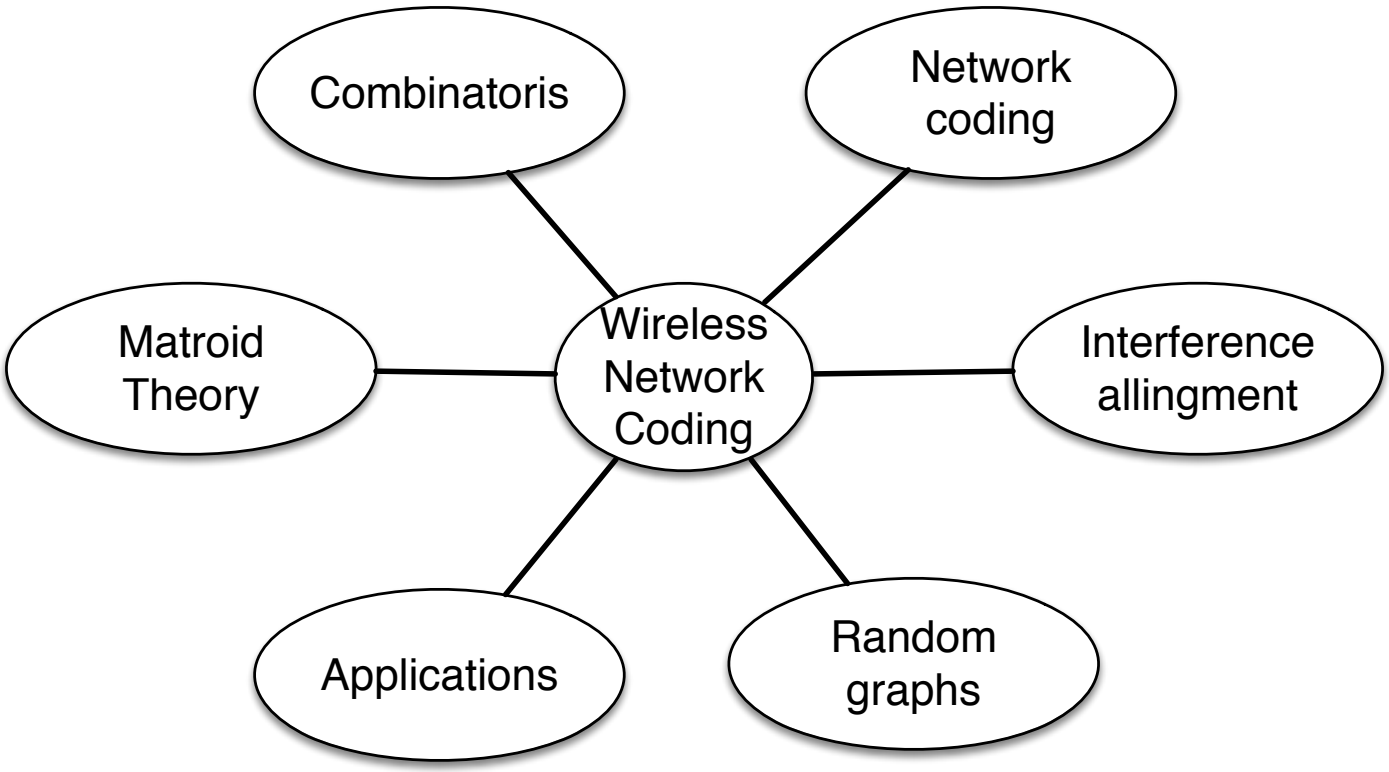


# Codes for Distributed Storage

- Special class of distributed Storage codes
- Optimally trade-off storage space for repair bandwidth



# Network Coding and Related Areas



# Developed module

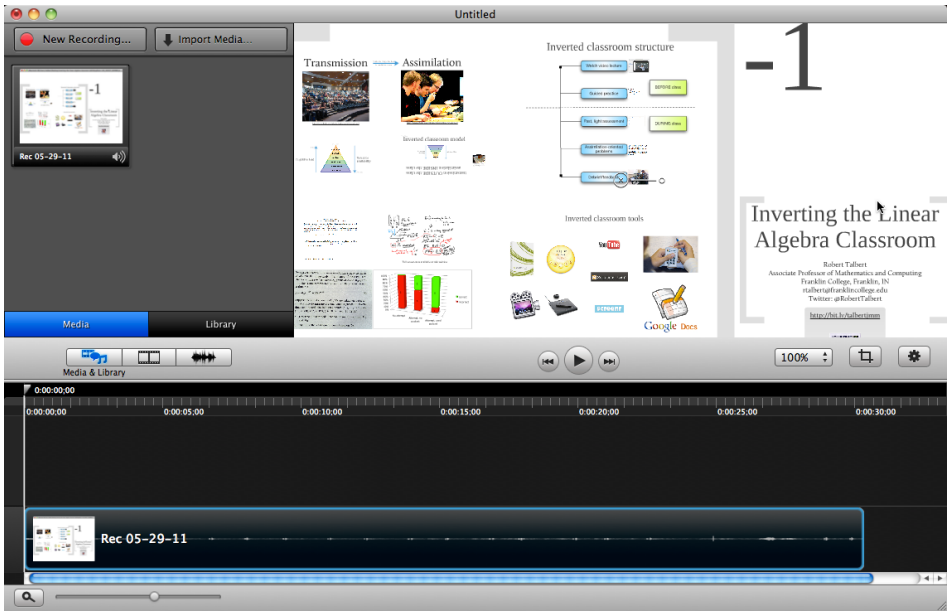
1. Provide a comprehensive survey of discoveries and insights gained from years of intensive research
2. Discuss open problems and present new exciting opportunities in coding research and applications.
3. Target: advanced undergraduate and graduate level courses
4. Can be used for independent study and massive online courses

# Topics covered

1. Introduction (two lectures);
2. Mathematical foundations, coding advantage, diversity coding (four lectures);
3. Polynomial and randomized algorithms for network code construction (four lectures);
4. Coding complexity (two lectures);
5. Network coding applications in network security and reliability (two lectures);
6. Wireless network coding (including the index coding problem) (four lectures);
7. Applications for network storage (two lectures);
8. Conclusions and future directions (two lectures).

# Delivery

1. Series of short videos - around 20 minutes each
2. Screencast, using Wacom tablet (similar to Khan academy)
3. Accompanied lecture notes in pdf format
4. Will be used in the graduate level class taught in Spring 2015



# TAMU Math Circle

1. Bring students into direct contact with mathematical professionals in an informal setting
2. More than 60 students grades 5-8 attended the circle in Spring 2014
3. Foster a passion for mathematics.
4. 90-minute meetings most Saturday afternoons featuring presentations/activities by faculty.
5. Each circle starts with an unstructured activity, such as mathematical games (e.g. Set or Gardner's Eluesis), puzzles, or building toys (e.g. zometools or polydrons).