



BITS: Bits of Information, Transmitted and Stored

情報科学系・准教授・クルカスキー ブライアン



School of Information Science
Brian Kurkoski, Associate Professor

BITS: Bits of Information, Transmitted and Stored

情報の基礎

情報を送信

情報を記憶

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Keywords:

- Information Theory (I232)
- Coding Theory (I437), Error-correcting codes

Fundamentals of Reliable Communication

Transmission and Storage

通信システム

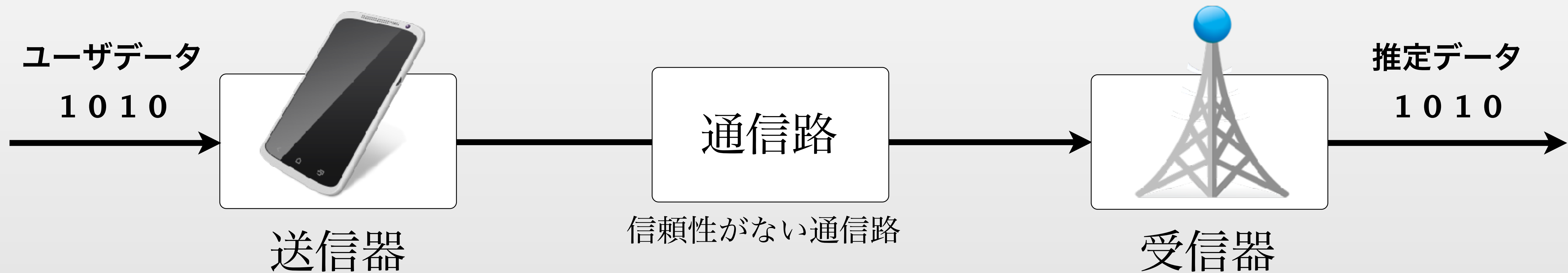
- 移動データ通信
- WiFi
- 光ファイバー

記憶装置

- フラッシュメモリ/SSD
- ハードディスク
- Distributed Storage

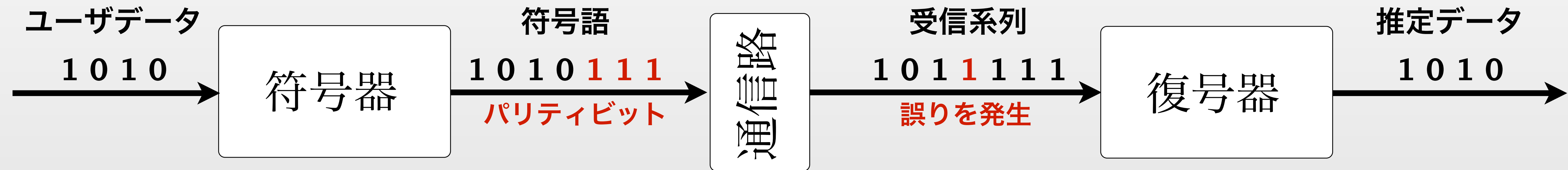


Reliable Communications System



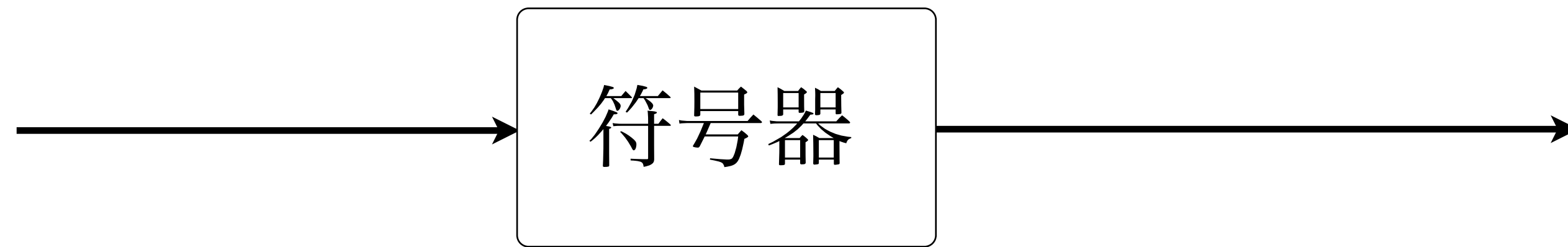
高信頼性：ユーザデータ = 推定データ

Reliable Communications System

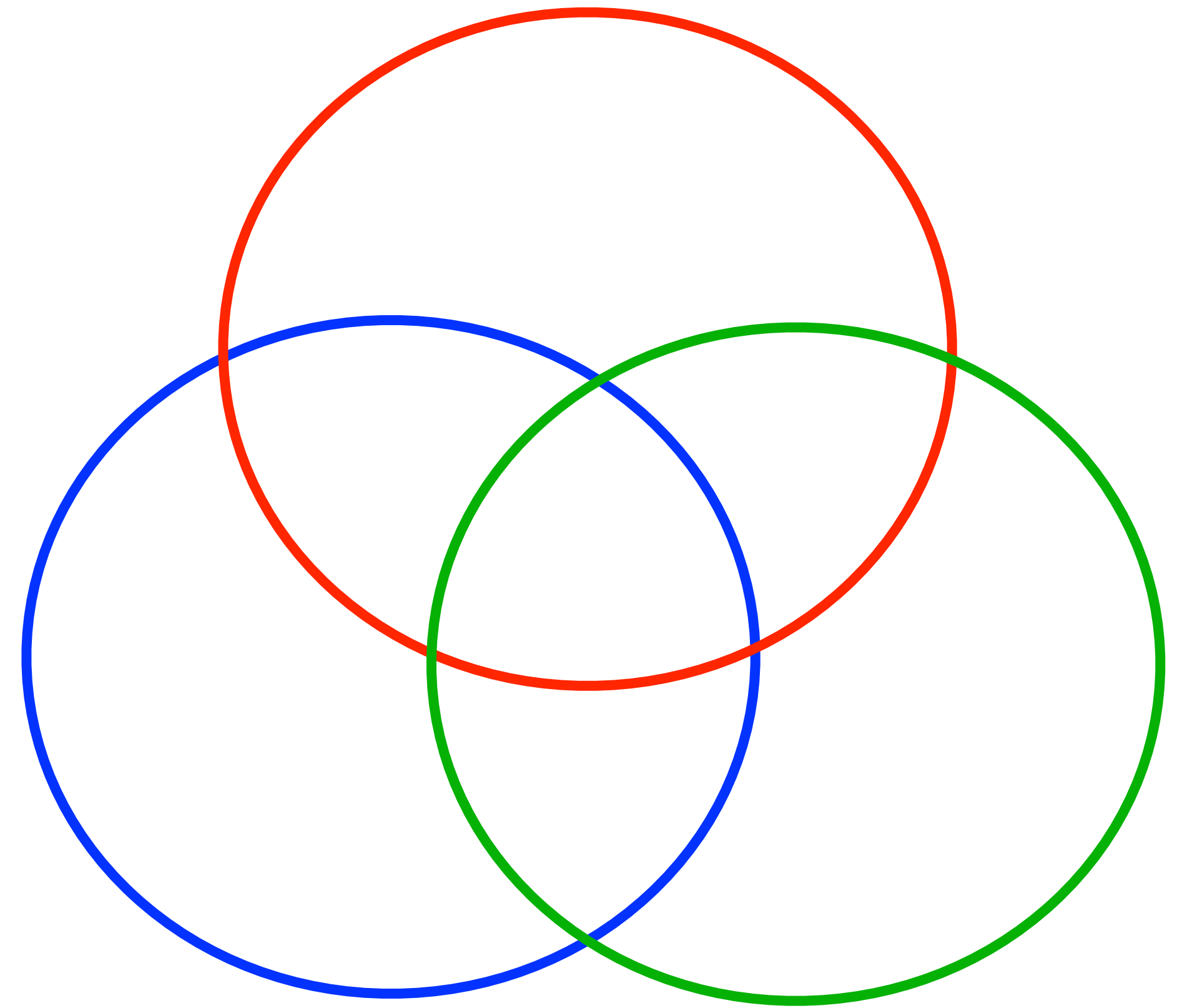


高信頼性：ユーザデータ = 推定データ

Error-Correcting Code



- 3 overlapping circles
- 7 code bits in the 7 intersections:
 - 4 user bits
 - 3 parity bits



Error-Correcting Code

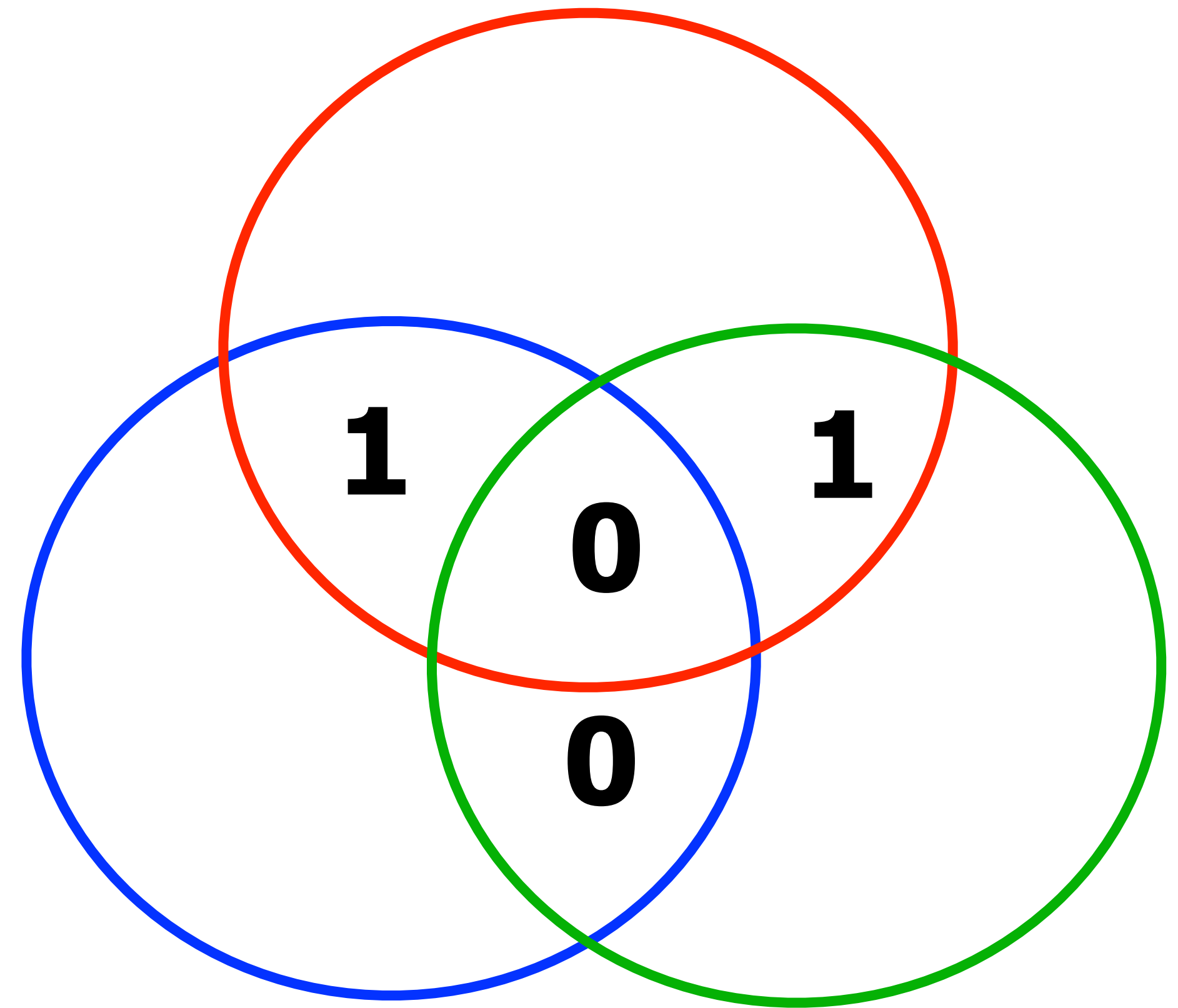
ユーザデータ

1 0 1 0

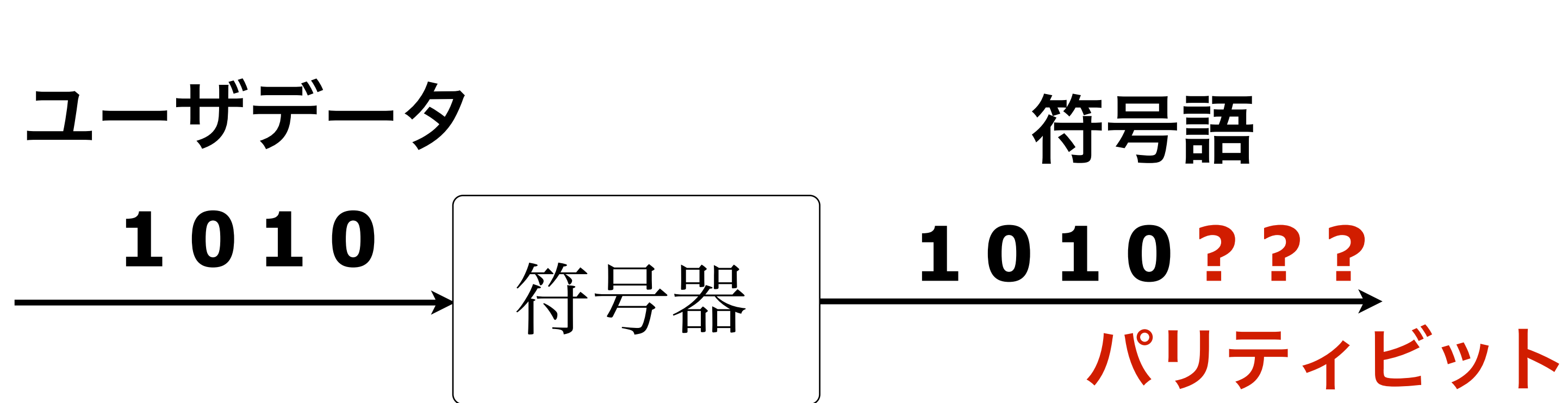
符号器

ユーザデータ

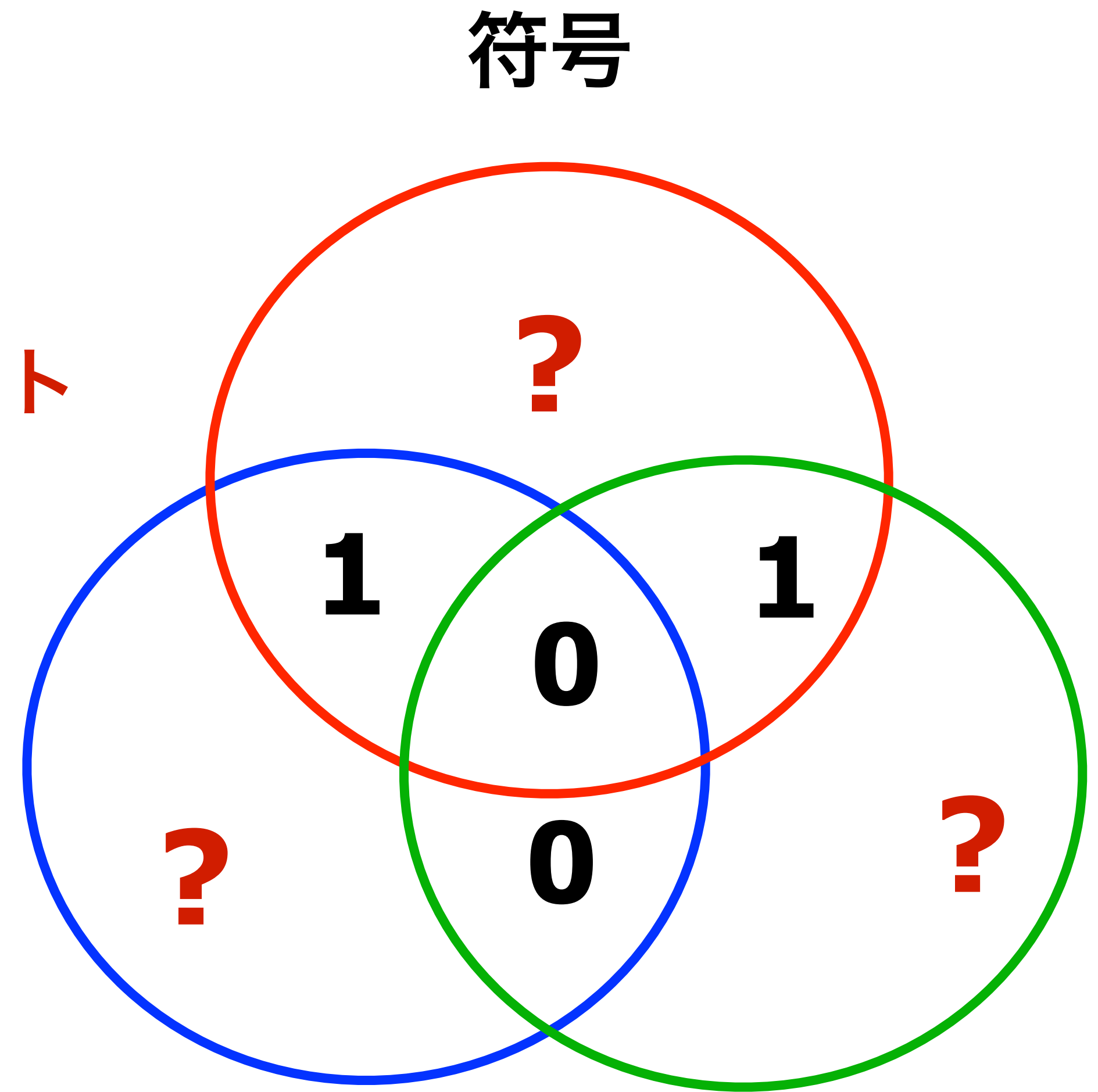
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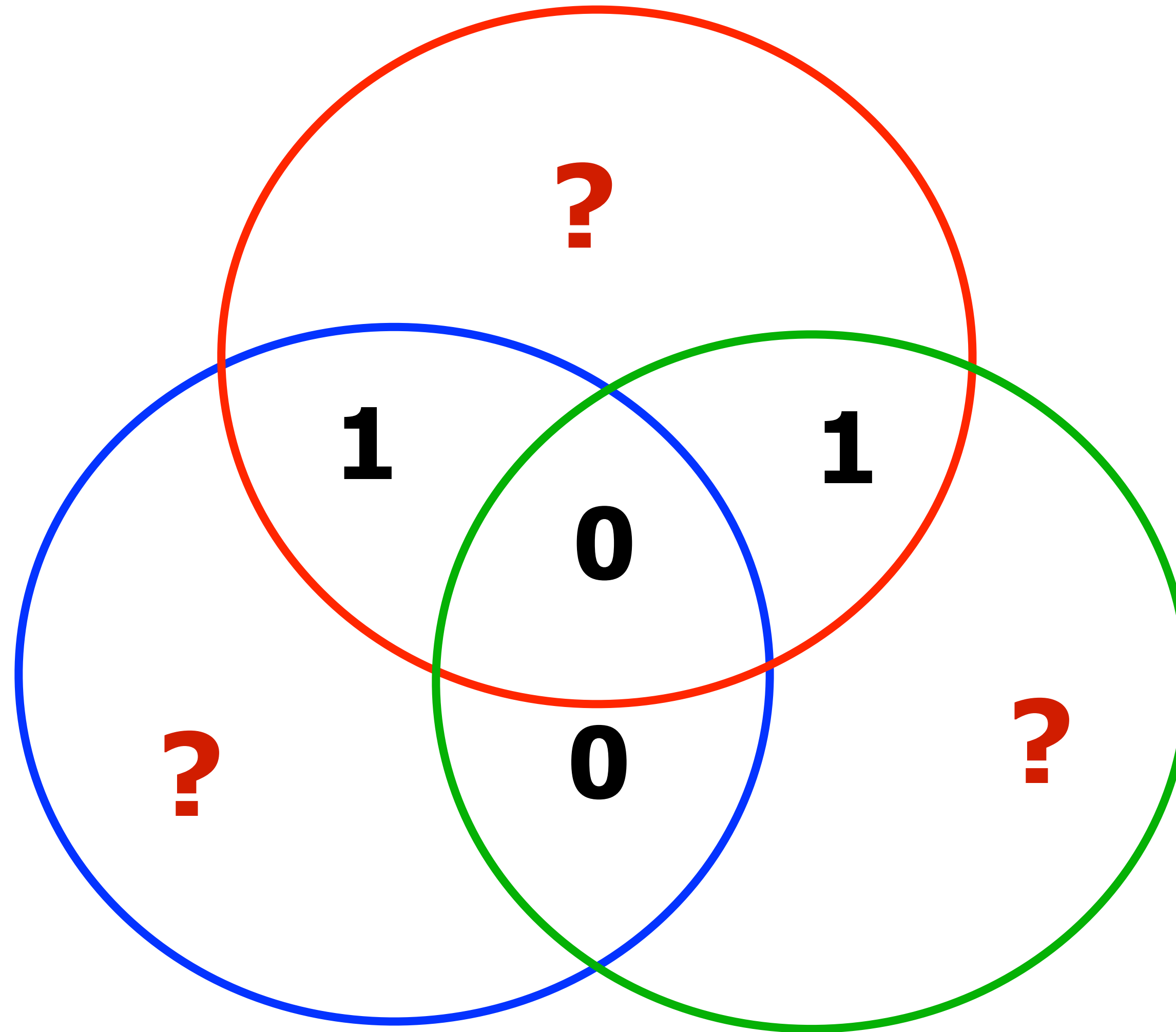
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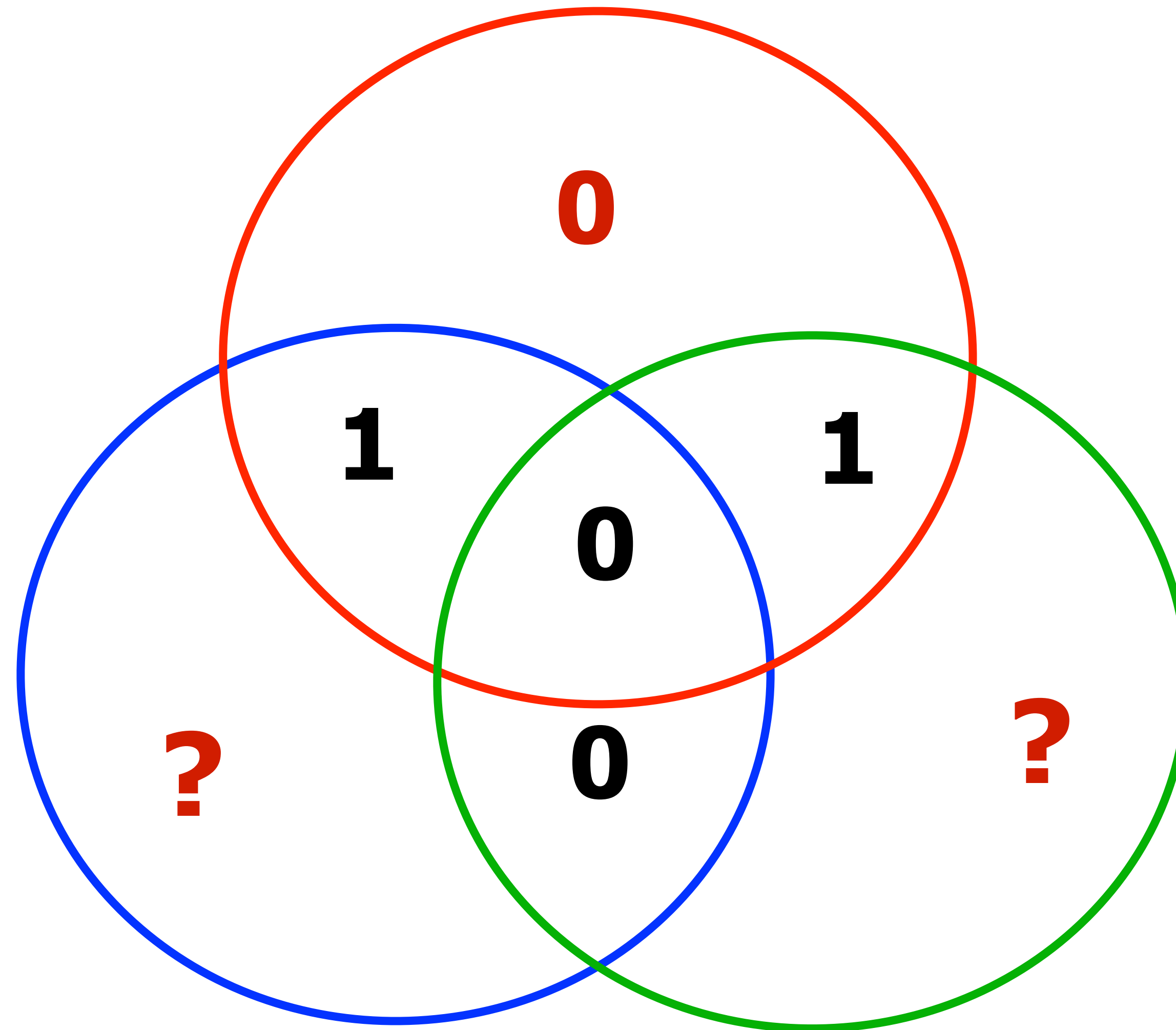


Encoding Rule: Even number of 1's



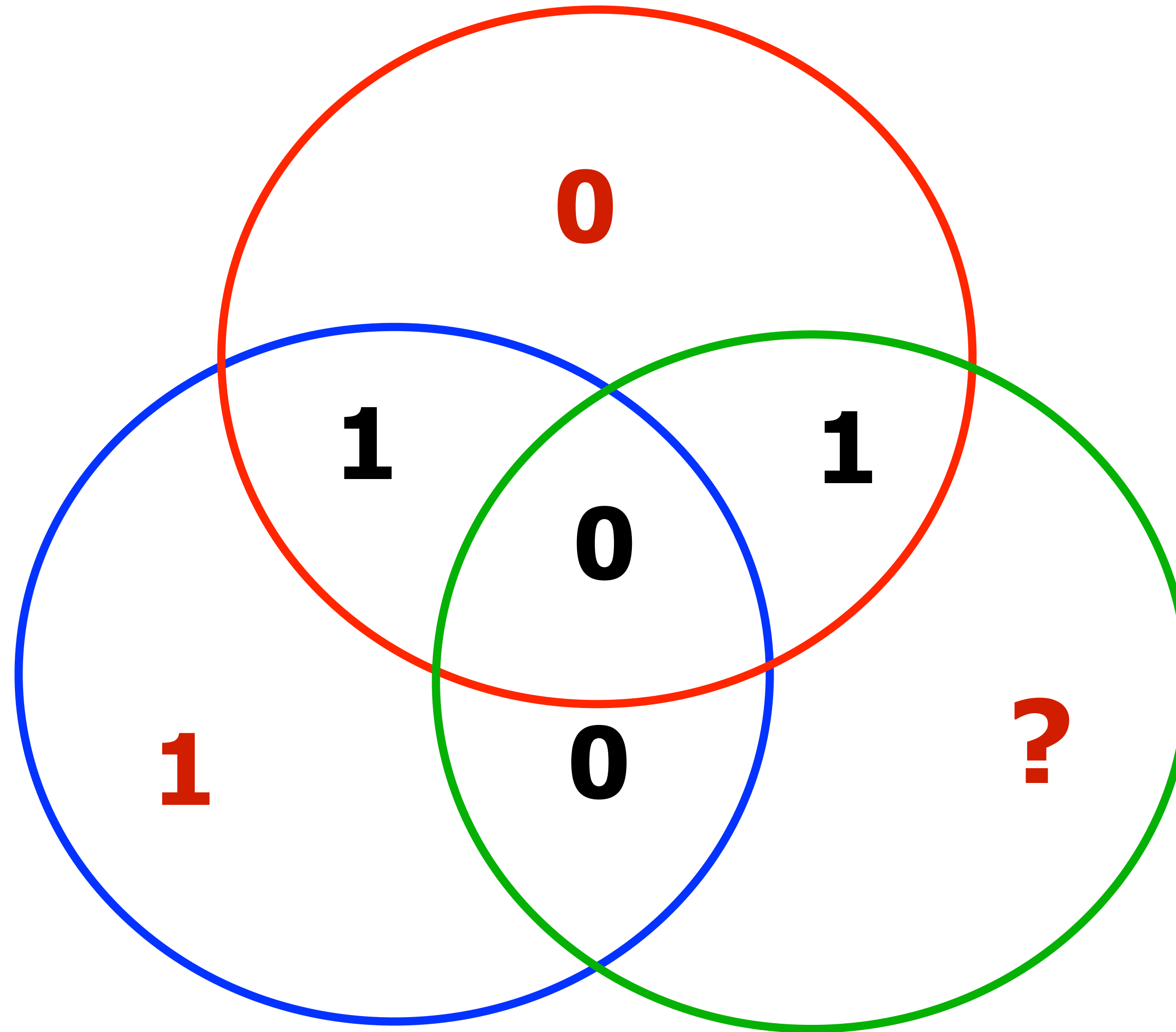
- Rule: Must be an **even number** (偶数) of 1's inside each circle

Encoding Rule: Even number of 1's



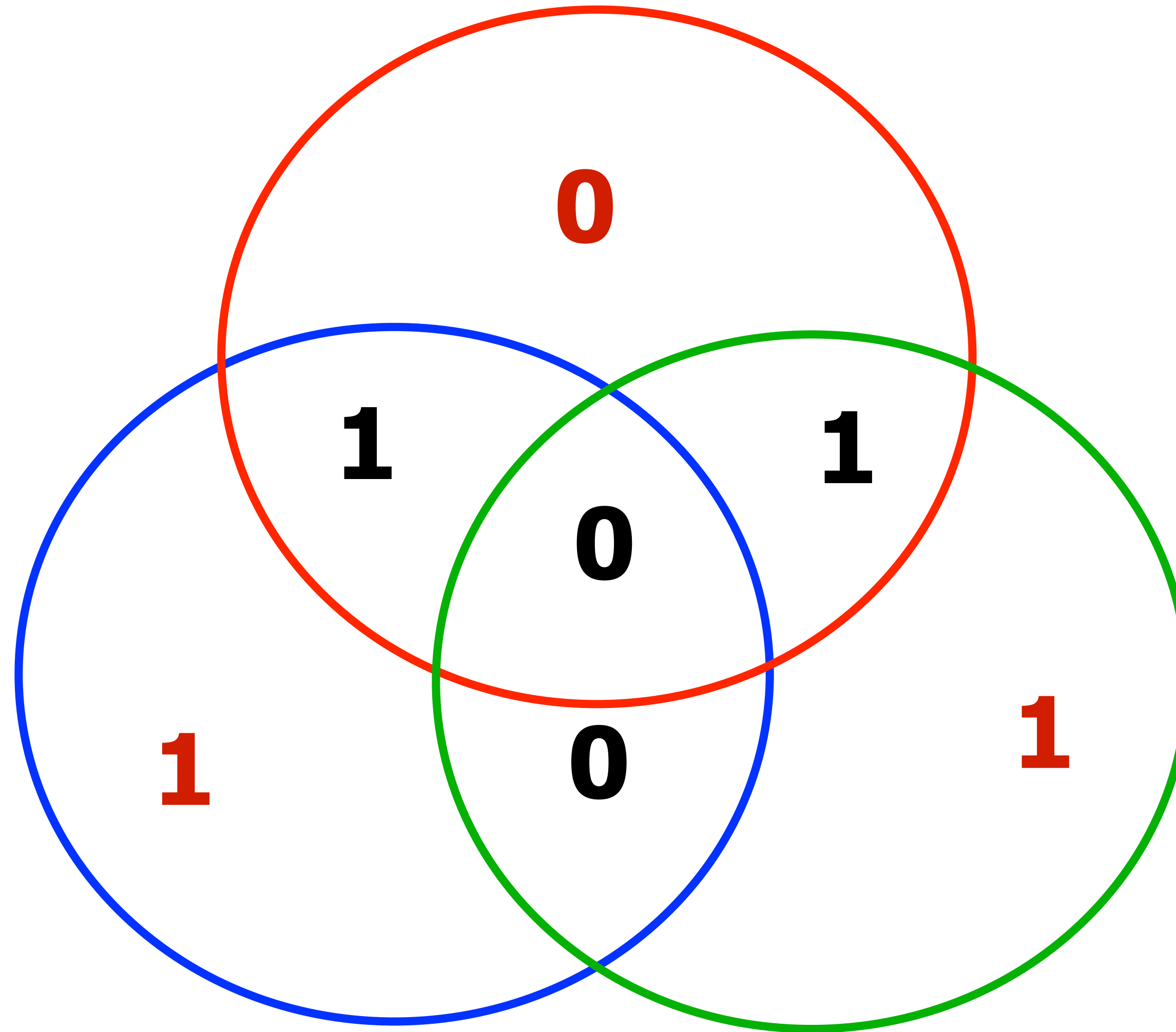
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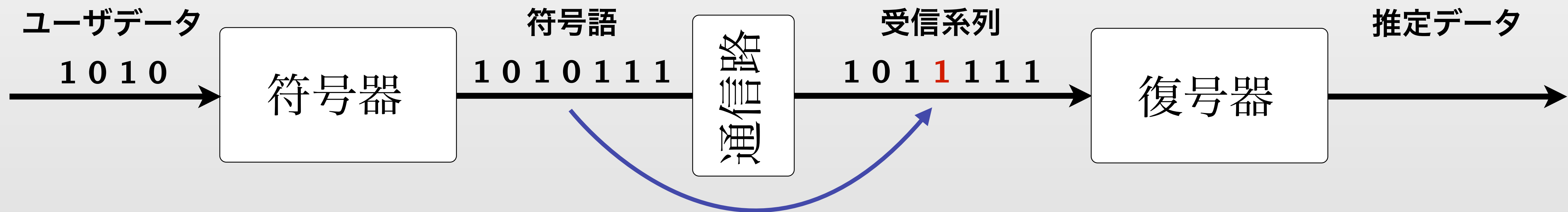
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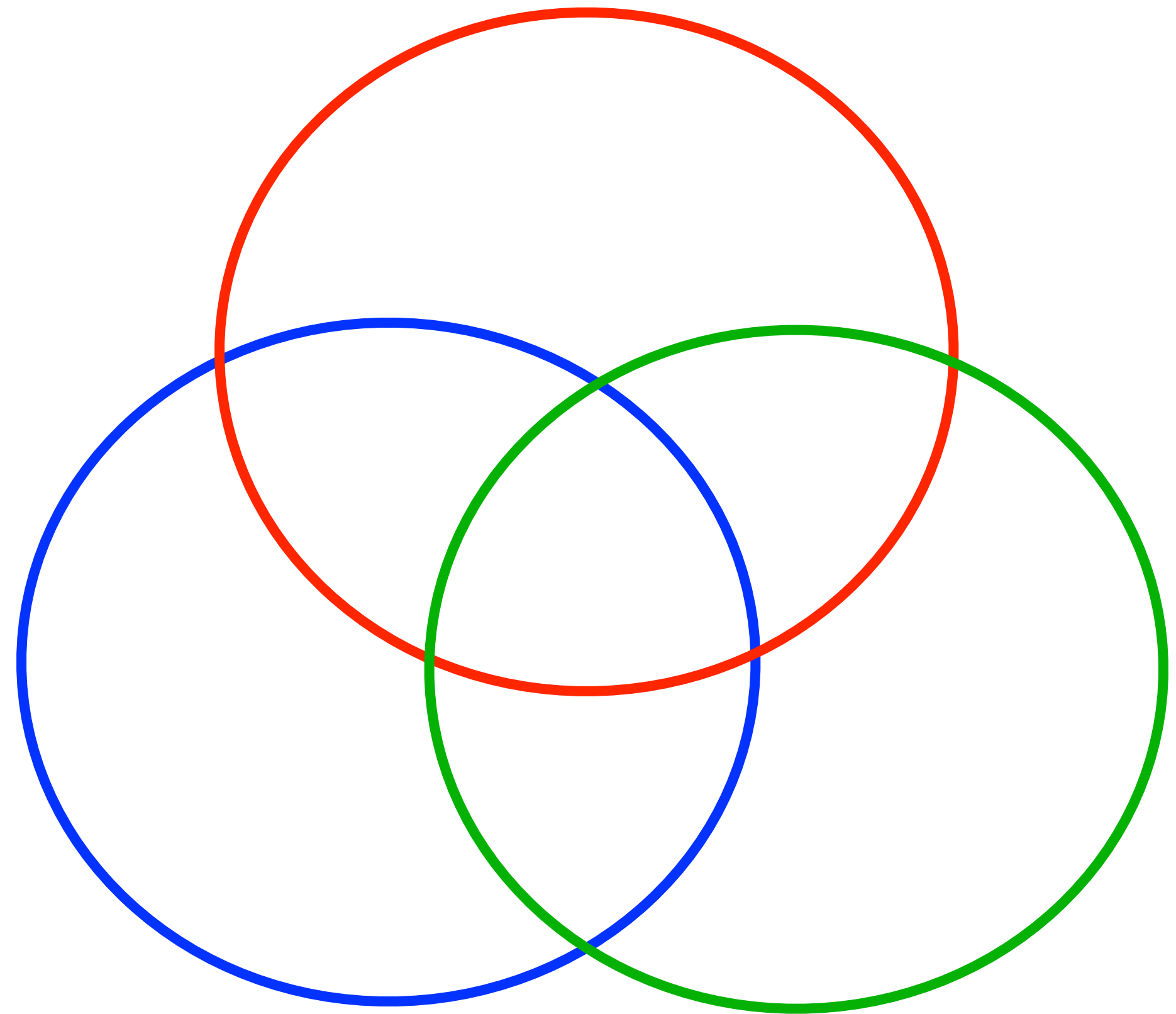
Transmission and Decoding at the Receiver



Can You Perform Error Correction?

- One error occurred! $0 \rightarrow 1$ or $1 \rightarrow 0$
- Which bit?

Remember: there must be an **even number** of 1's inside each circle



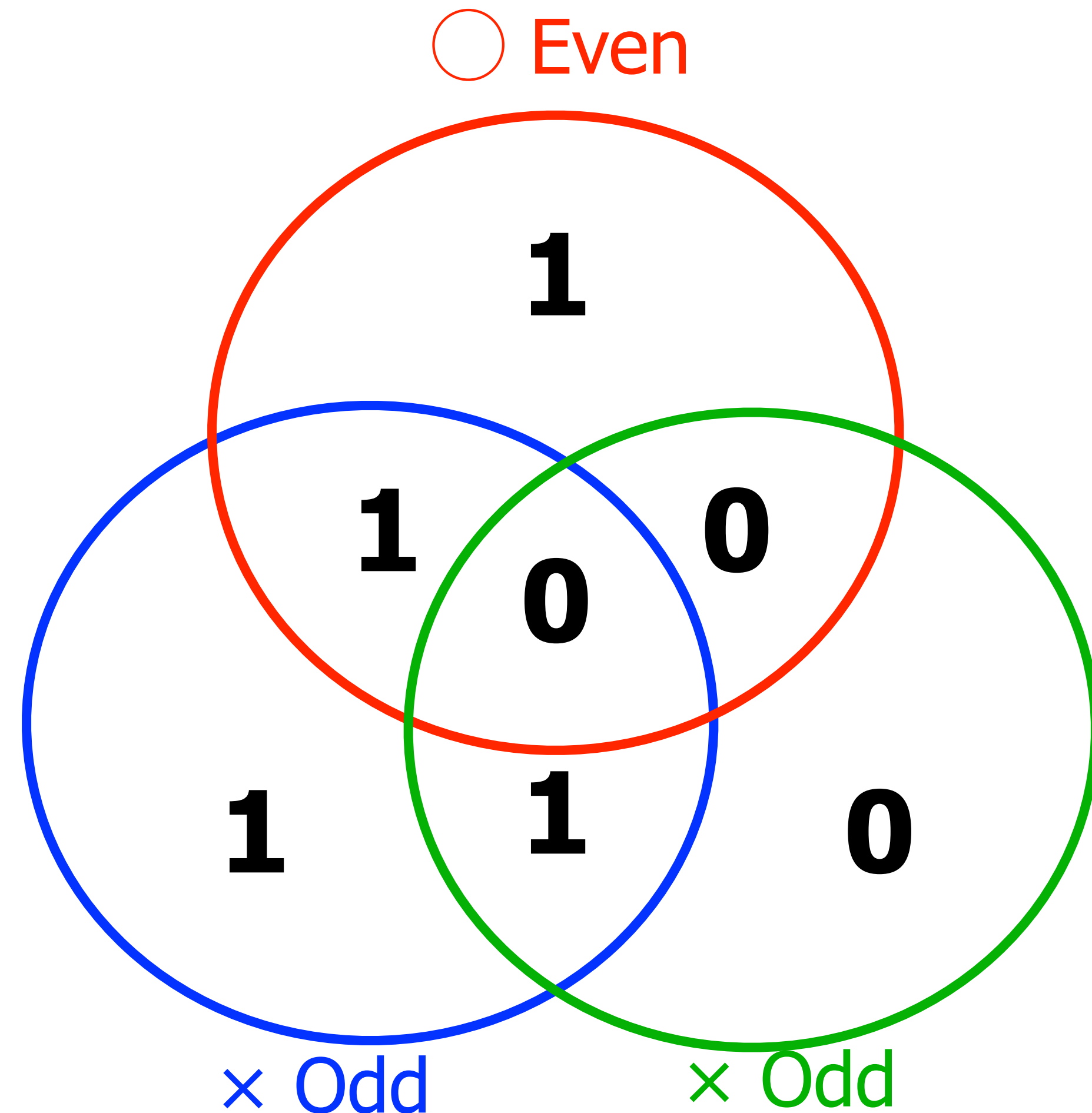
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受信系列

1 0 0 1 1 1 0



Can You Perform Error Correction?

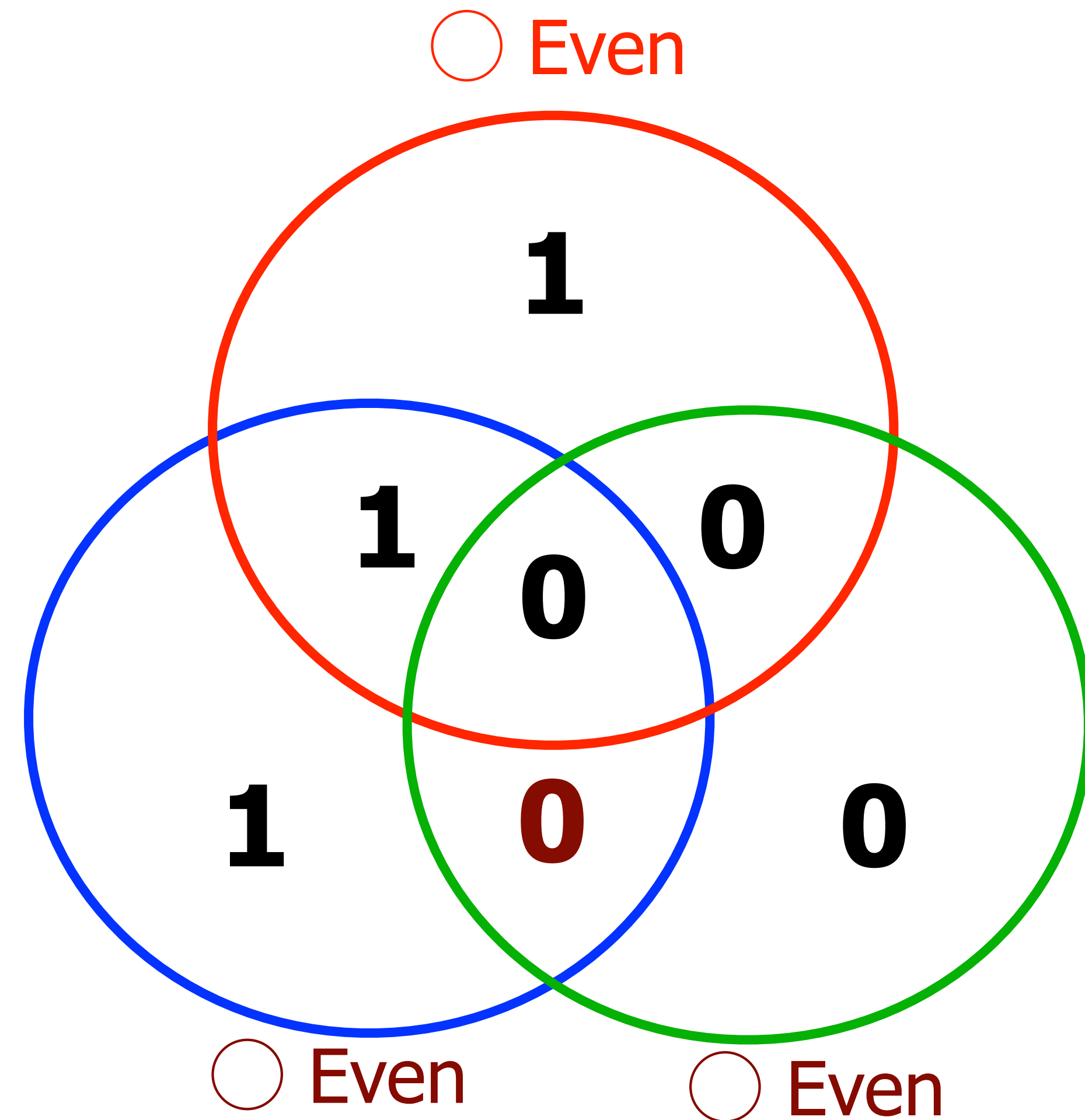
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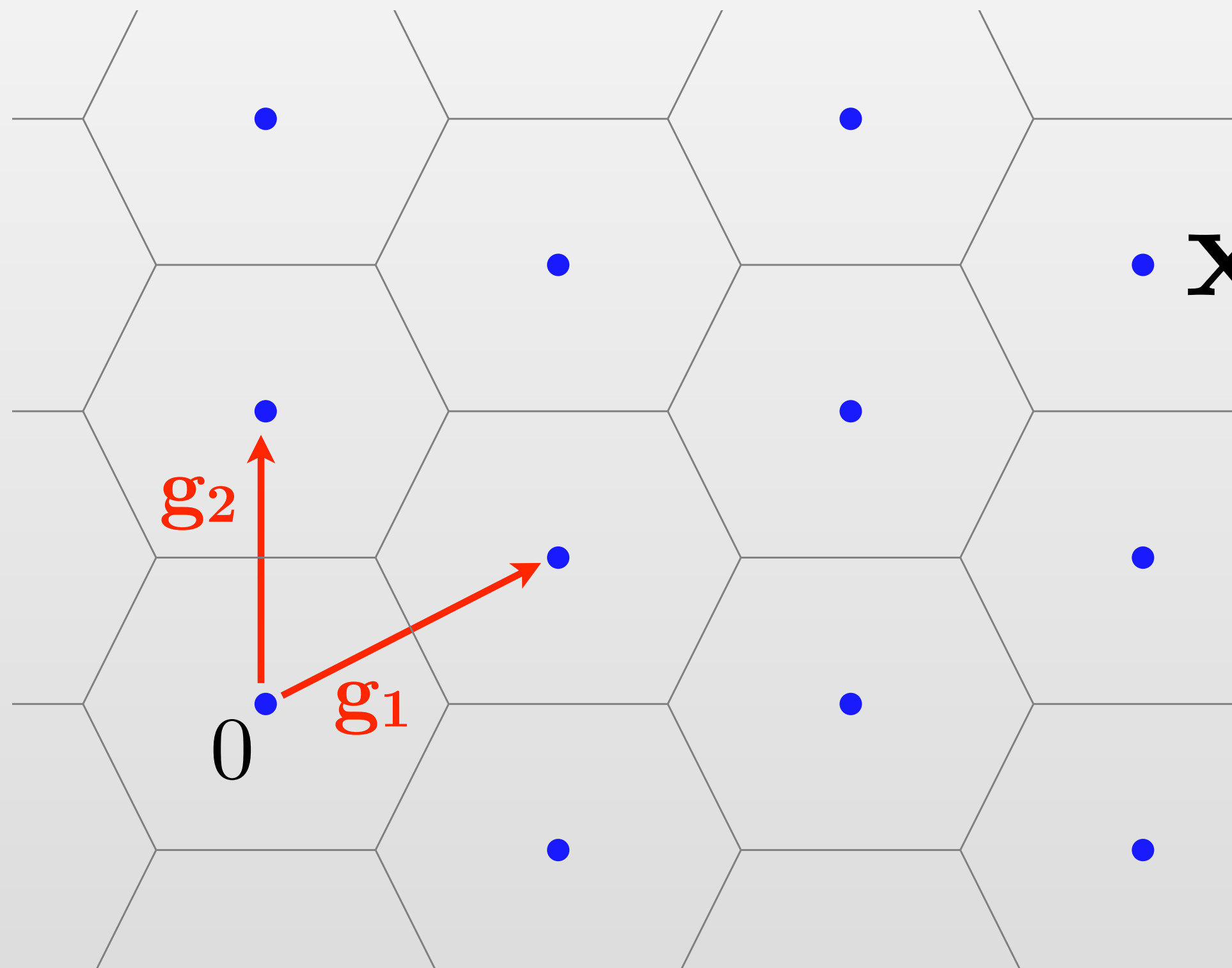
1 0 0 0 1 1 0

Error Corrected!



Research Topics

Lattice Codes — Codes over Real Numbers



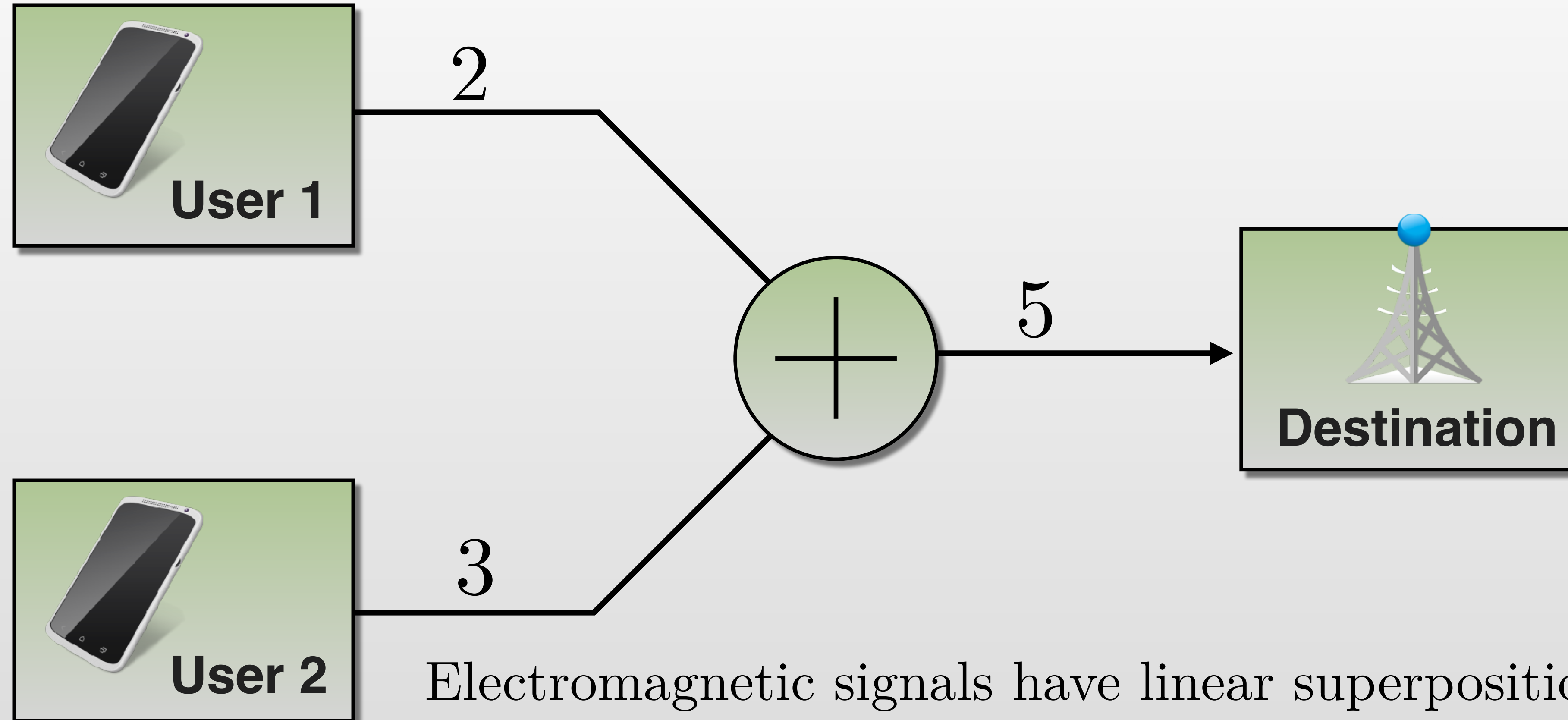
$$\mathbf{x} = G \cdot \mathbf{b}$$

$$G = \begin{bmatrix} 1 & 0 \\ 0.5 & 1 \end{bmatrix}$$

$\mathbf{g}_1$ $\mathbf{g}_2$

Research Topics

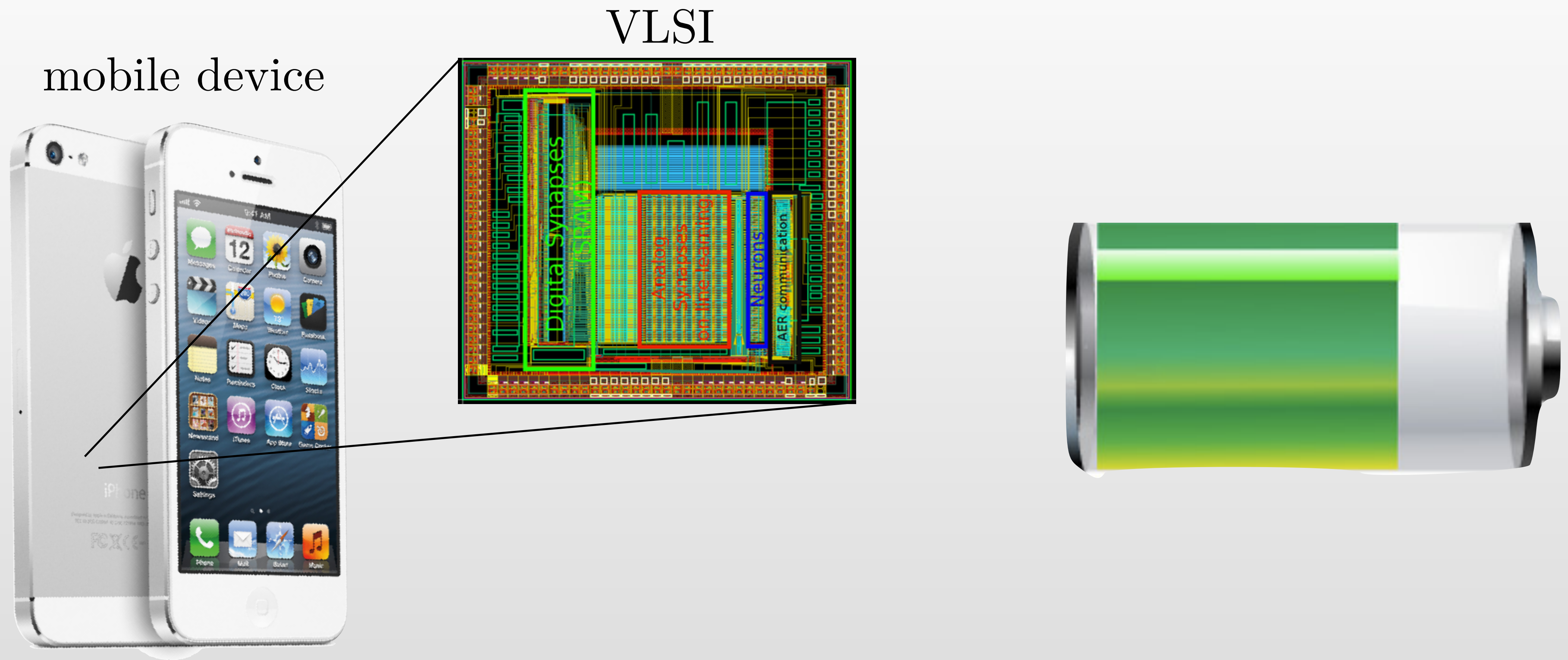
Lattices for Wireless Networks



Electromagnetic signals have linear superposition

- Codes over the real numbers are natural
- Physical layer network coding

Research Topics



Efficient Implementations for Long Battery Life

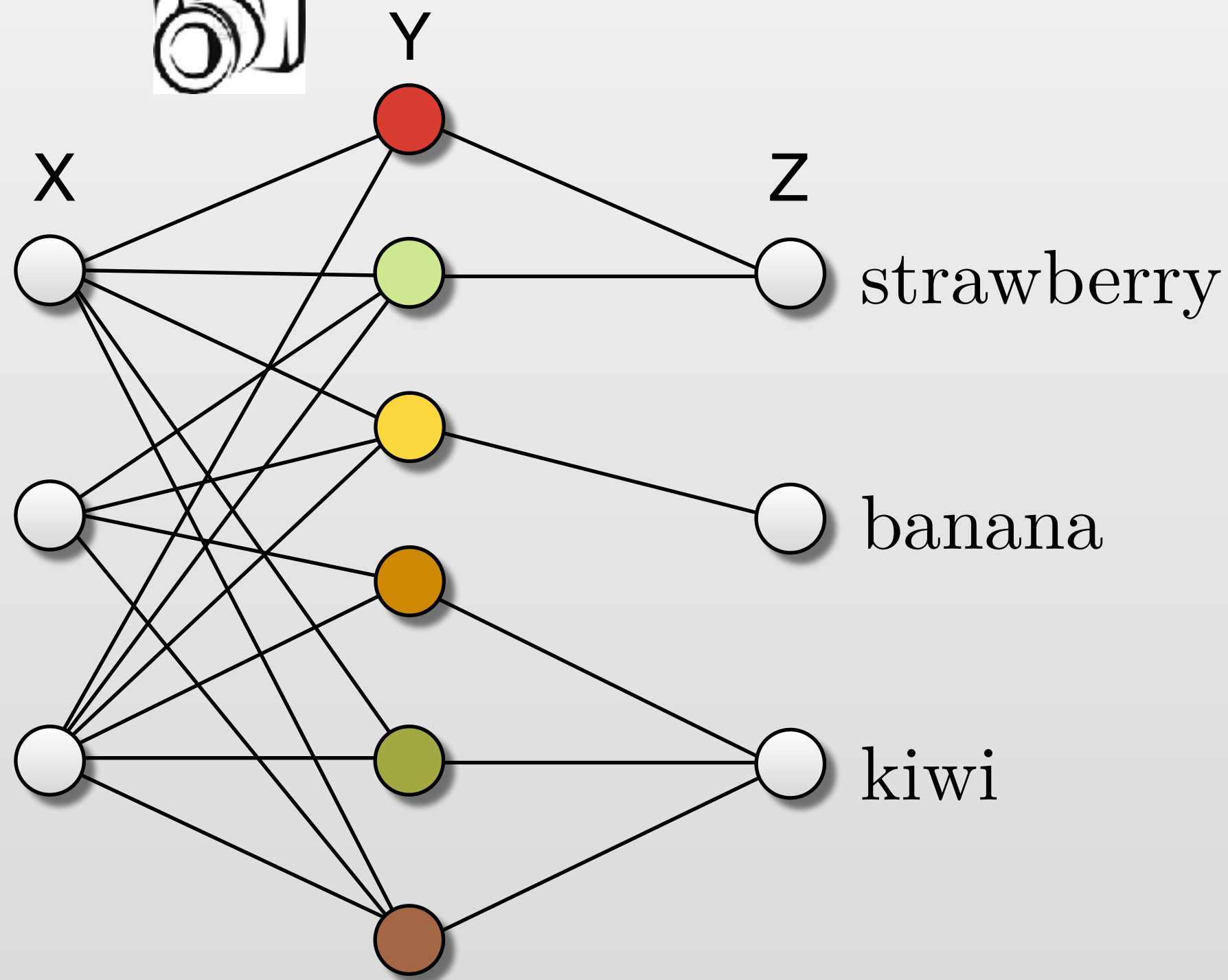
Do You Want to Join BITS Lab?

You need:

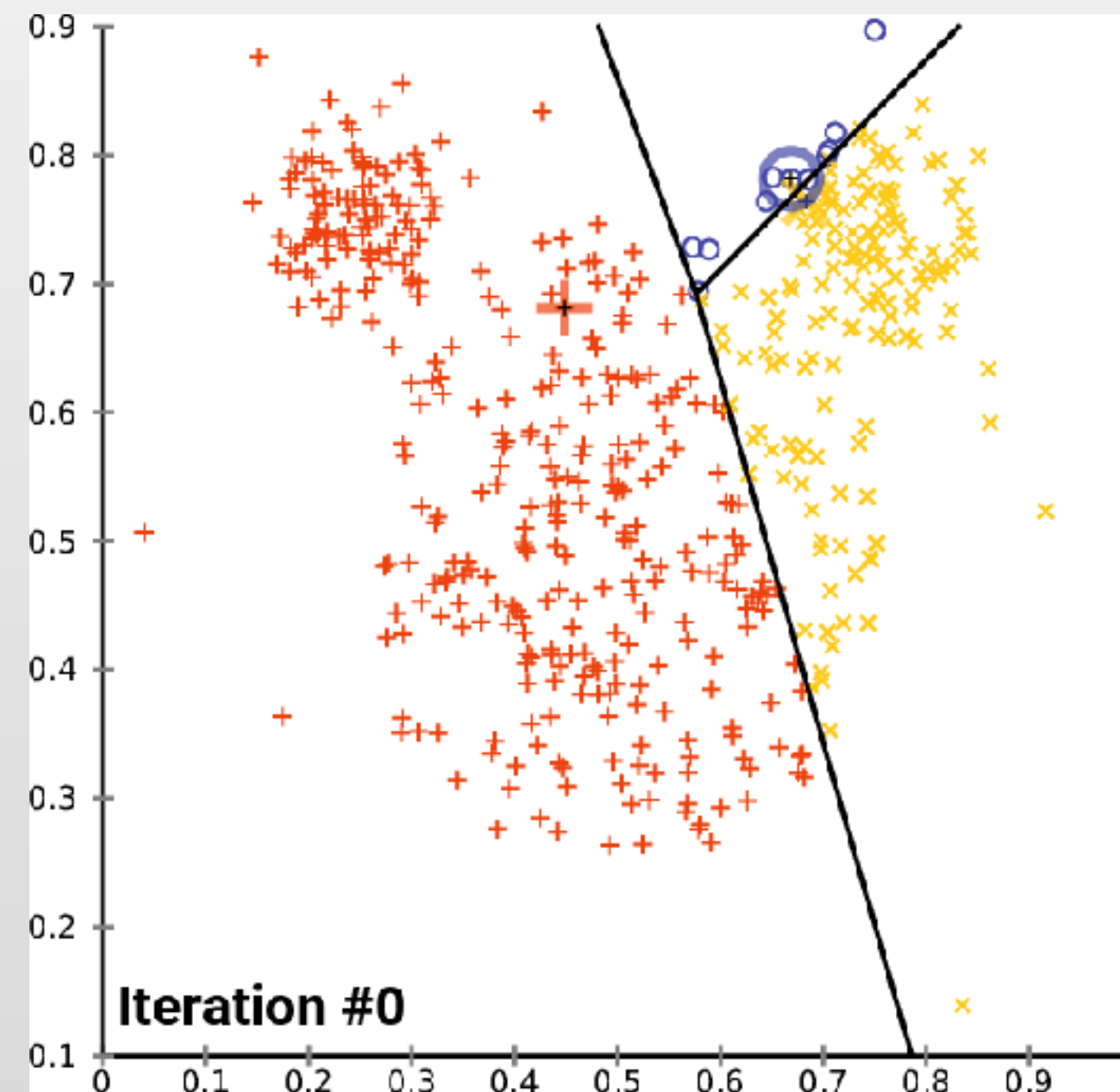
- **Basic mathematical skills**
 - Probability theory, linear algebra
- **Basic interest in programming**
 - C/C++, Java, Matlab, GitHub
- **Passion to use English as a technical language**

Masters Research Topic 1

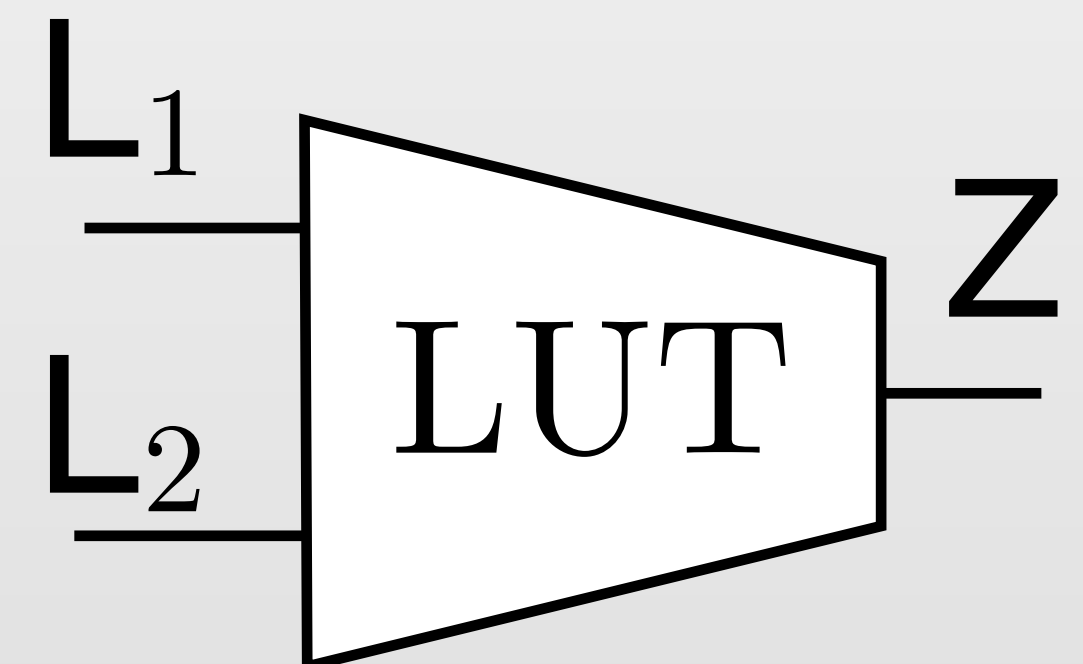
Machine Learning for Communications



Classification



K-Means Algorithm



Lookup-table
decoder

wikipedia

Masters Research Topic 1

Machine Learning for Communications

- Use classification to implement discrete-valued decoders



Y

X

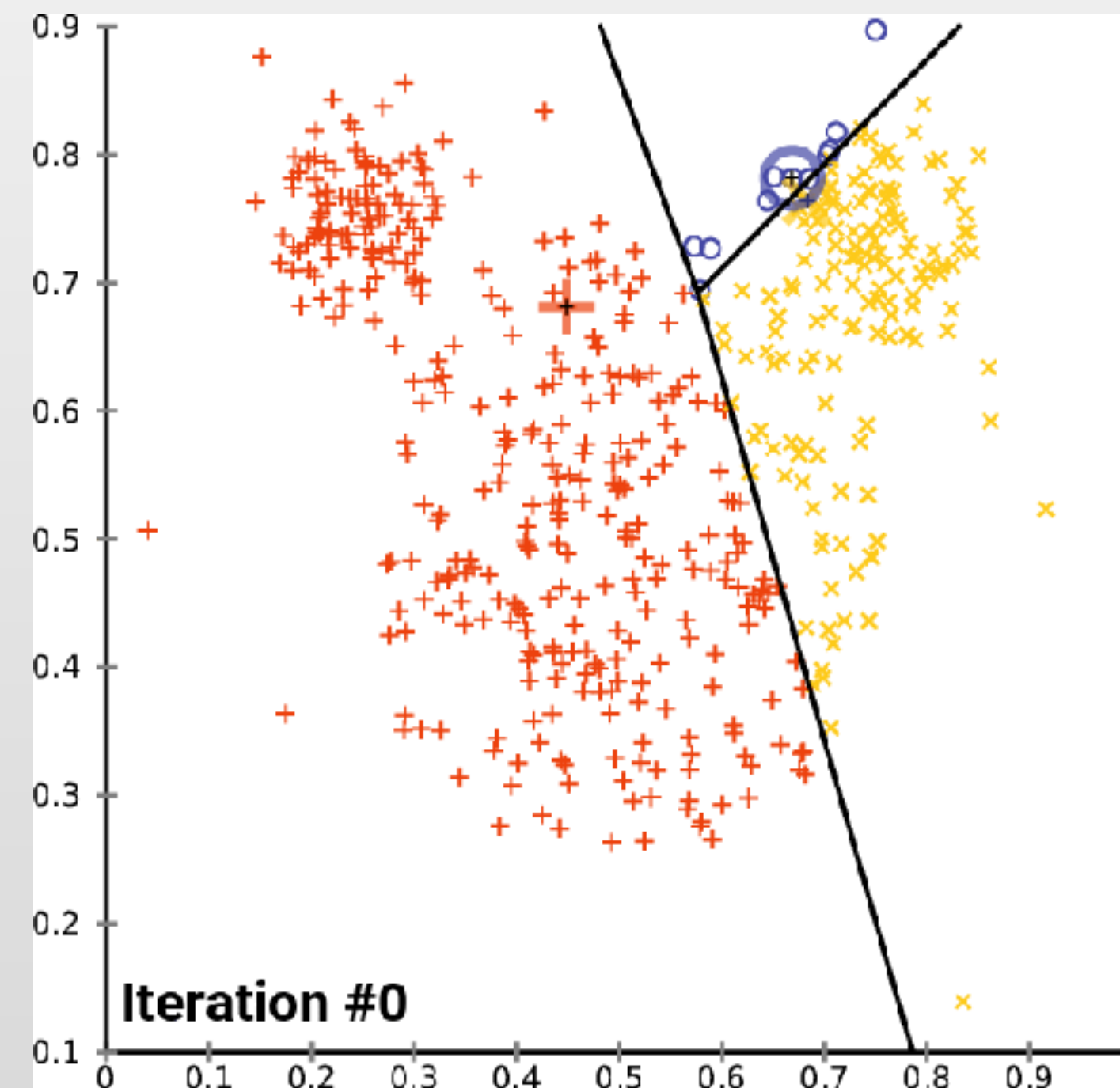
Z

strawberry

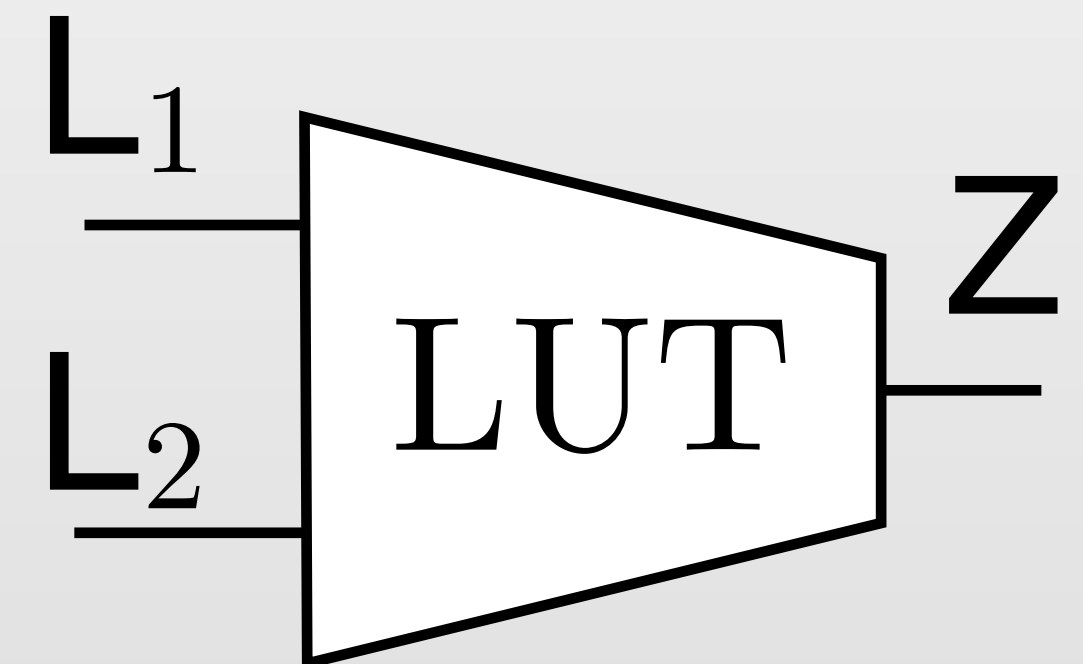
banana

kiwi

Classification



K-Means Algorithm

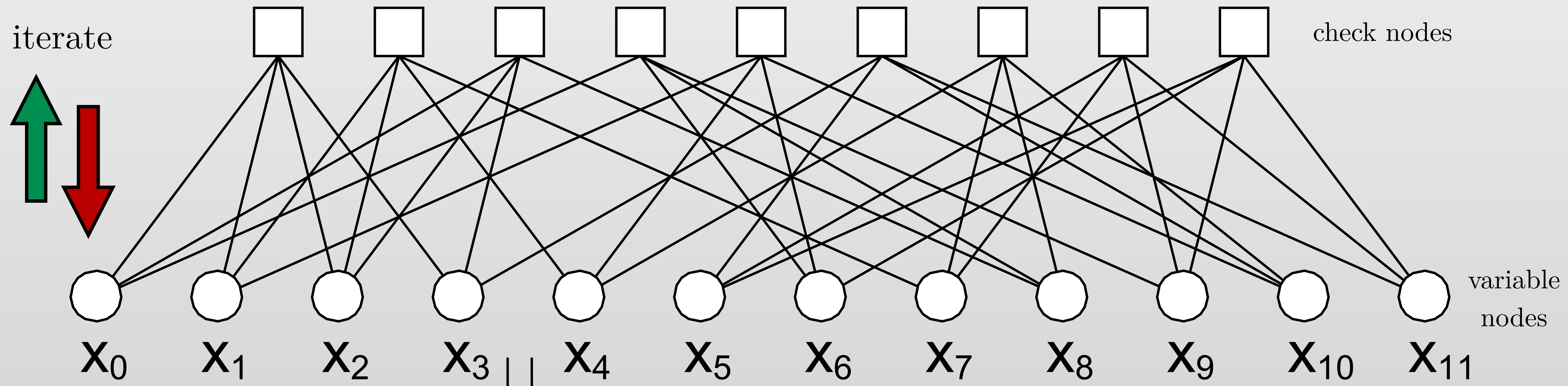


Lookup-table
decoder

Masters Research Topic 2

Machine Learning for Communications

Conventional decoder for low-density parity-check code

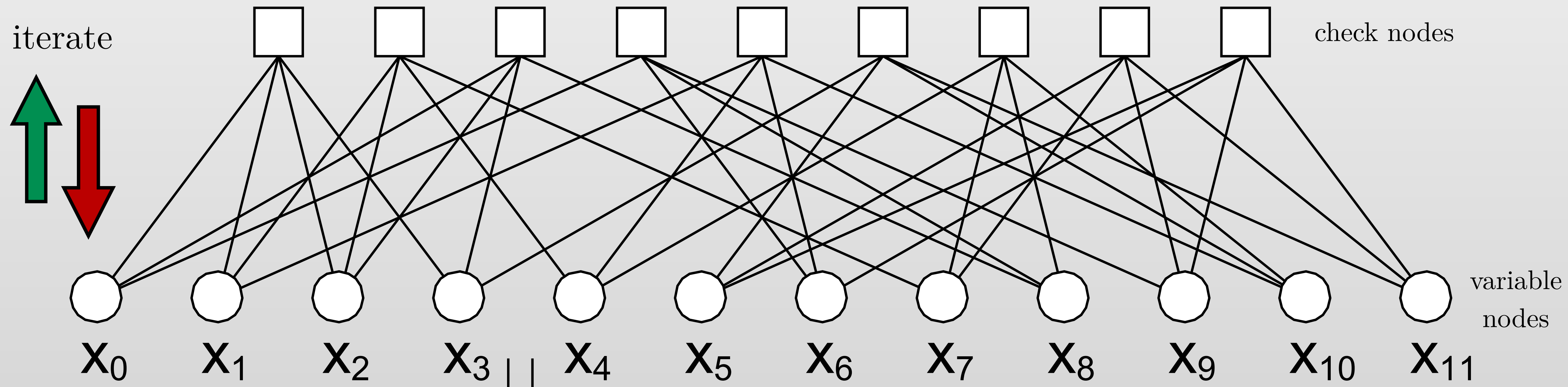


Masters Research Topic 2

Machine Learning for Communications

- Deep neural networks for decoding high-density codes

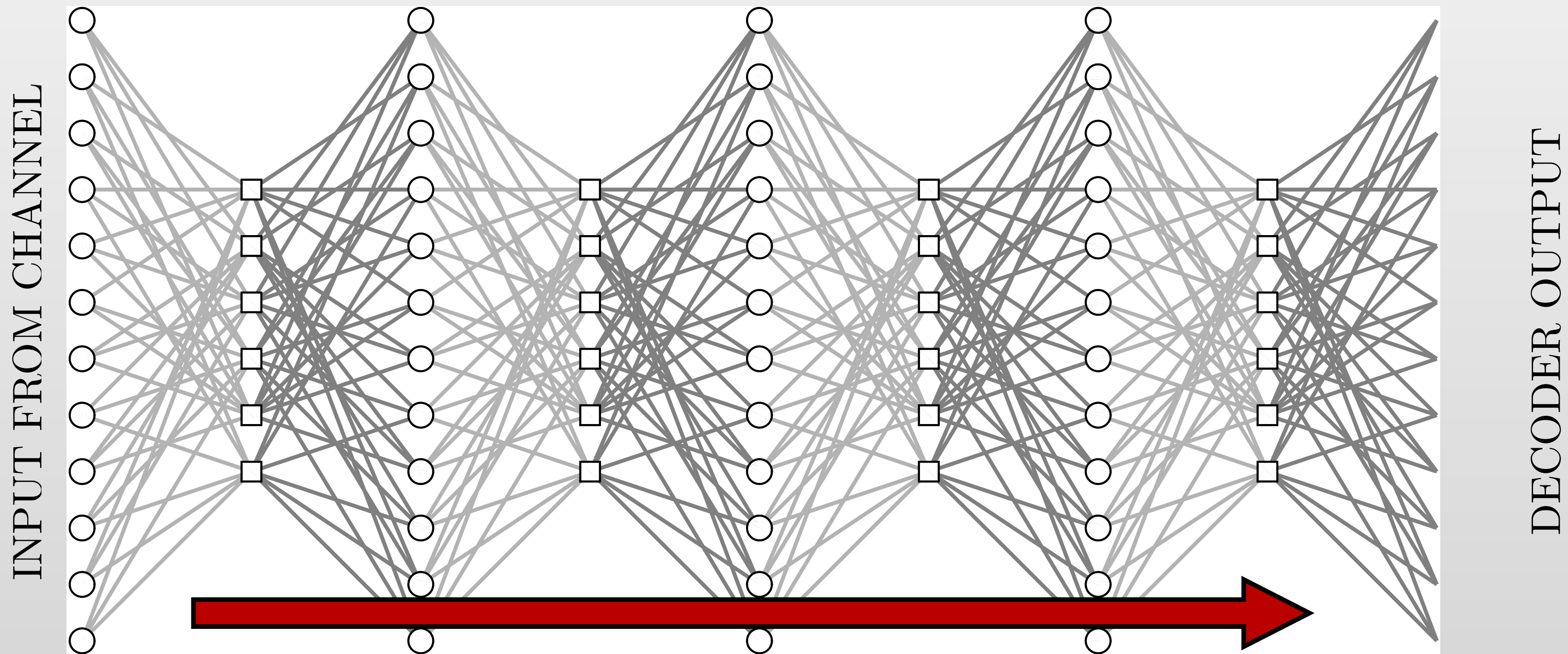
Conventional decoder for low-density parity-check code



Masters Research Topic 2

Machine Learning for Communications

Unwrap the decoder: use neural network to adjust decoder weights

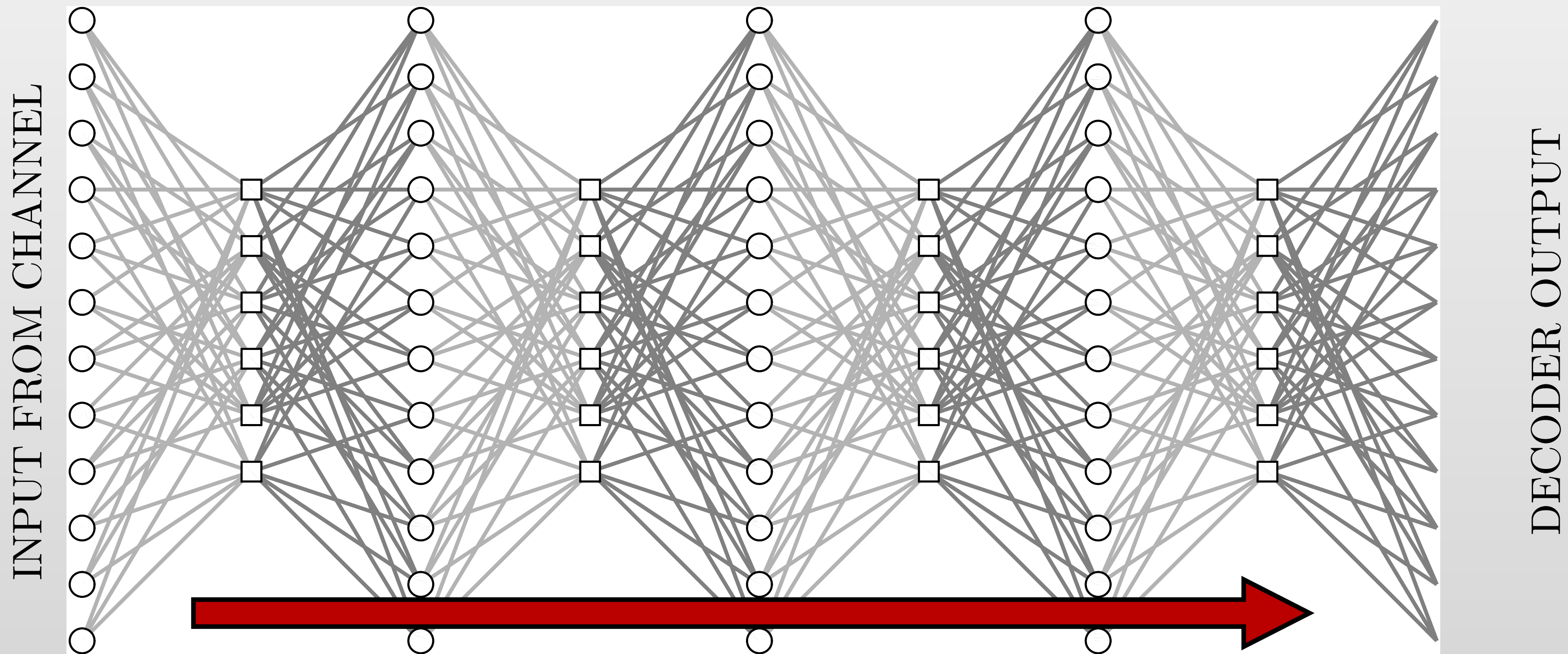


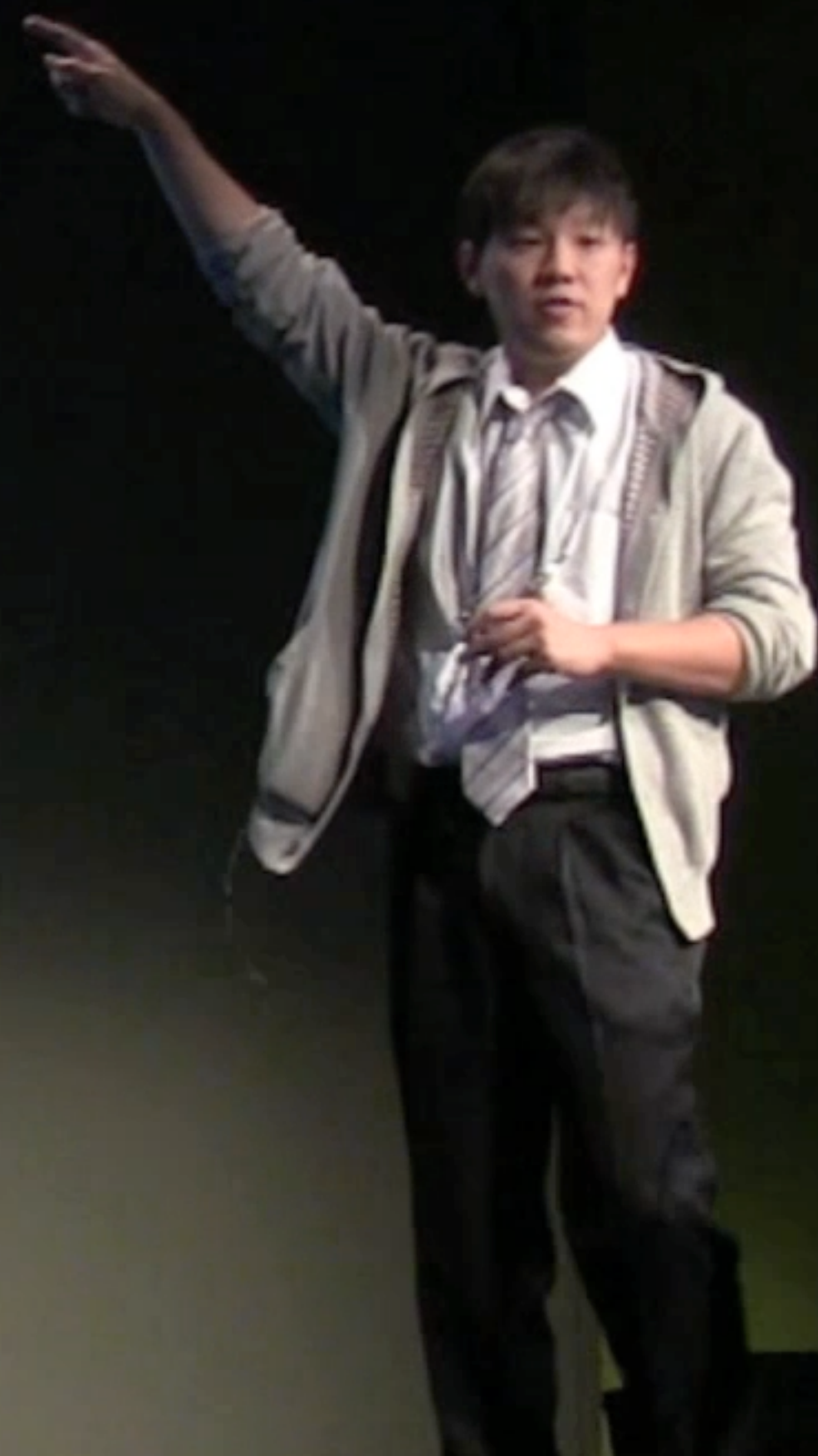
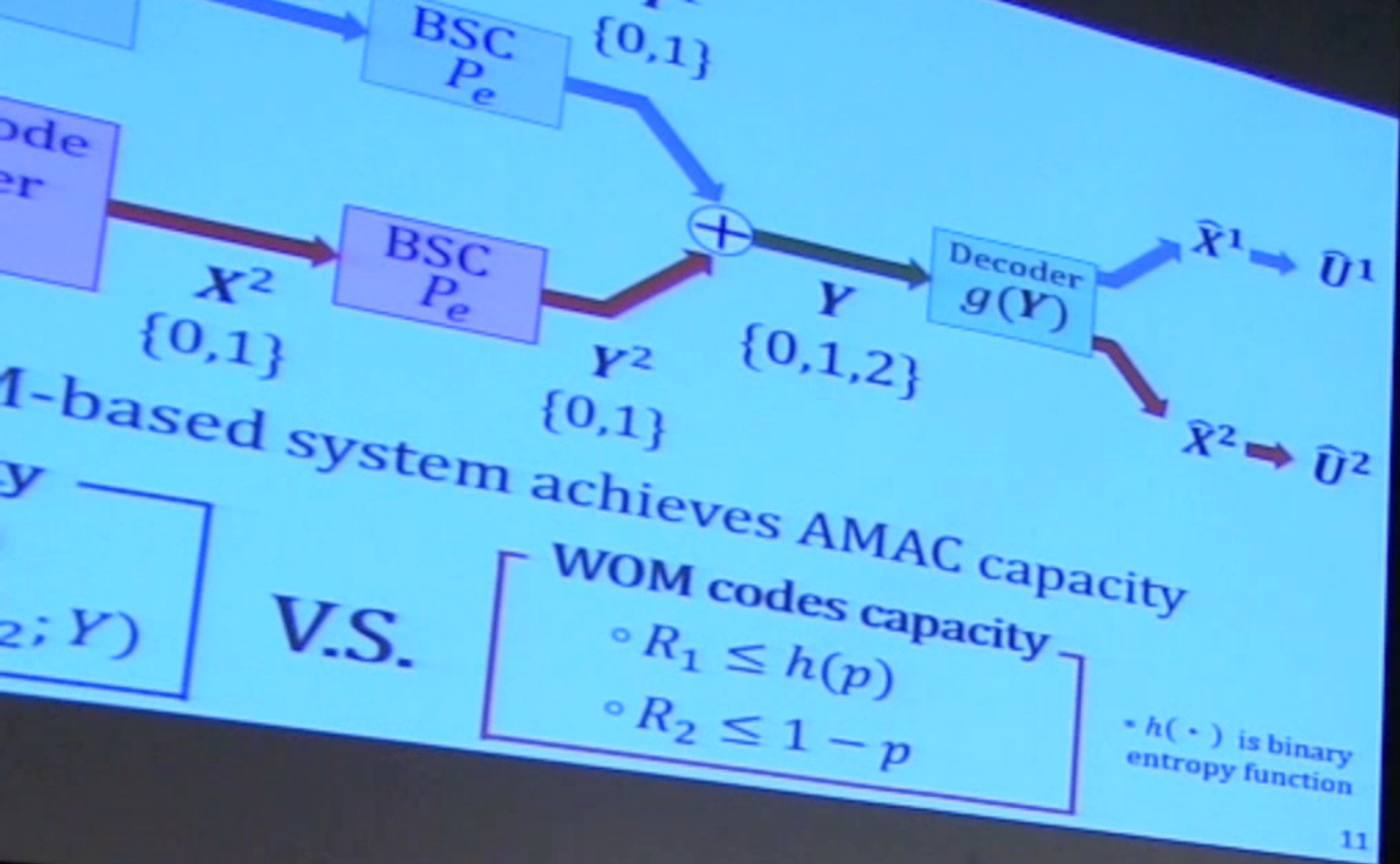
Masters Research Topic 2

Machine Learning for Communications

- Goal improve decoding for high-density codes

Unwrap the decoder: use neural network to adjust decoder weights





Ryota Sekiya at ISITA2014
Melbourne, Australia



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Bits of Information, Transmitted and Stored
Laboratory Introduction