Pseudonoise Sequences in DSSS Technique

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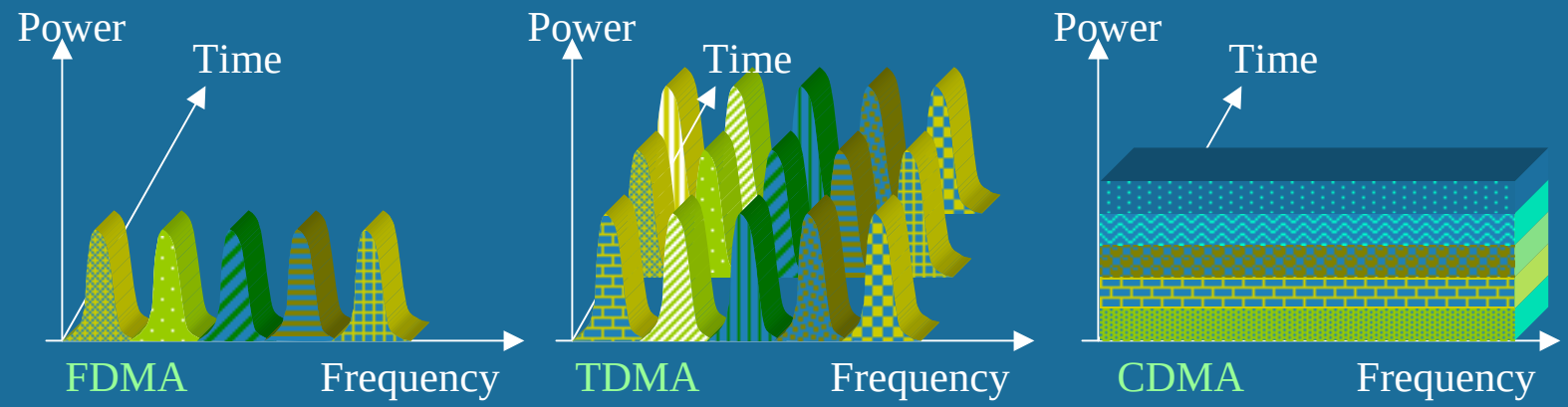
OUTLINE

- Introduction
- Theory of PN Sequences
- Application of PN Sequences in IS-95
- Simulation of PN Sequences
- Summary
- Future Work
- Reference

Introduction

- Multiple Access Techniques
  - FDMA: AMPS
  - TDMA: IS-54
  - CDMA: IS-95



Introduction

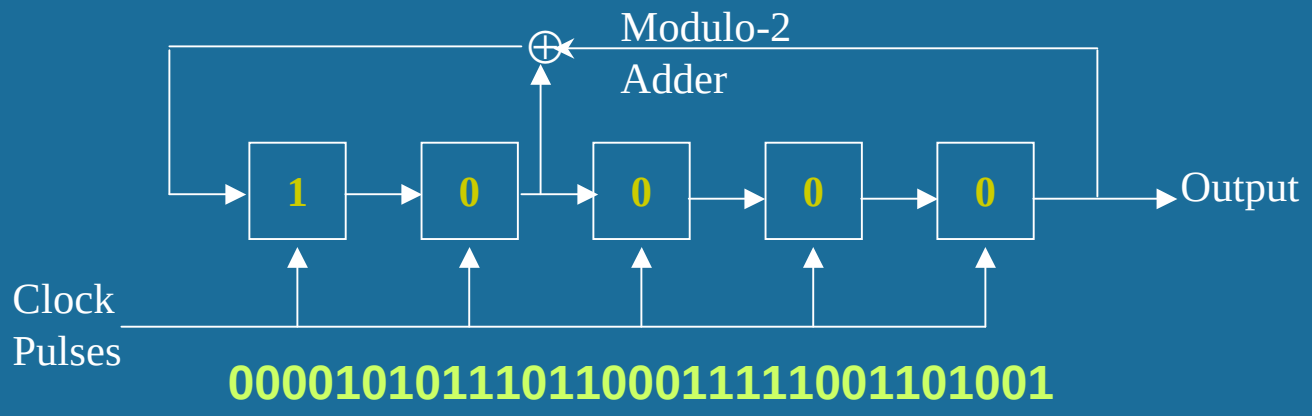
- Spread Spectrum Techniques
  - Frequency Hopping S.S.
  - Direct Sequence S.S.
    - Advantages using PN Sequences
      - Antijamming: $J/S=(BW/R_b)/(E_b/N_0)$
      - Multipath Protection: throughout BW
      - Multiple Access: Orthogonality
      - Message Privacy: Pseudorandom
      - Selective Calling
      - Identification
      - Navigation
      - Low Radiated Flux Density

Theory of PN Sequences

- Applications in IS-95 system
  - Data Scrambling
  - Spread-spectrum Modulation
- Necessities
  - Sufficient Randomness
  - Changing Back

Theory of PN Sequences

- Generation of PN Sequences
  - Linear Feedback Shift Register (LFSR)
    - N stages
    - Period: 2^n-1
    - Maximal length sequence:



Theory of PN Sequences

- Pseudonoise Sequences
  - Balance Property
    - Number of 1s differs from the number of 0s by at most 1
  - Run Property
    - 2^{n-1} runs of consecutive 1s or 0s
  - Correlation Property
    - Scaled Autocorrelation: 1
    - Scaled Cross-correlation: 0

Theory of PN Sequences

000010101110110001111110011001

- Balance: 15 0s ; 16 1s
- Run: 2 runs of length 3; 4 runs of length 2; etc.
- Correlation:
  - Auto ~ 1=31/31
  - Cross ~ 0≈-1/31

Theory of PN Sequences

- Mathematical Background
  - Finite Fields
    - A finite set of elements with two operations: *addition* and *multiplication*
    - Galois Field of q: *a finite field of element q*
  - Example: GF(2)={0,1}

Addition

$\oplus$	0	1
0	0	1
1	1	0

Multiplication

$\bullet$	0	1
0	0	0
1	0	1

Theory of PN Sequences

- Extension Galois Fields
  - GF(q)=GF(p^m): P ~ prime; m ~ any integer
  - GF(p): prime field
- Primitive Polynomials

$$f(x)=x^n+a_{n-1}x^{n-1}+a_{n-2}x^{n-2}+\cdots+a_2x^2+a_1x+x^0 \qquad a_i\in GF(2)$$

$$f(\alpha)=\alpha^n+a_{n-1}\alpha^{n-1}+a_{n-2}\alpha^{n-2}+\cdots+a_2\alpha^2+a_1\alpha+1=0$$

$$\alpha^n=a_{n-1}\alpha^{n-1}+a_{n-2}\alpha^{n-2}+\cdots+a_2\alpha^2+a_1\alpha+1$$

Theory of PN Sequences

- Multiplication

$$\alpha^k \cdot \alpha^t = \alpha^{k+t}$$

- Addition

$$\alpha^k + \alpha^t = \sum_{i=0}^{n-1} c_{k,i}\alpha^i + \sum_{i=0}^{n-1} c_{t,i}\alpha^i$$

$$= \sum_{i=0}^{n-1} (c_{k,i} \oplus c_{t,i})\alpha^i \qquad k,t \geq n$$

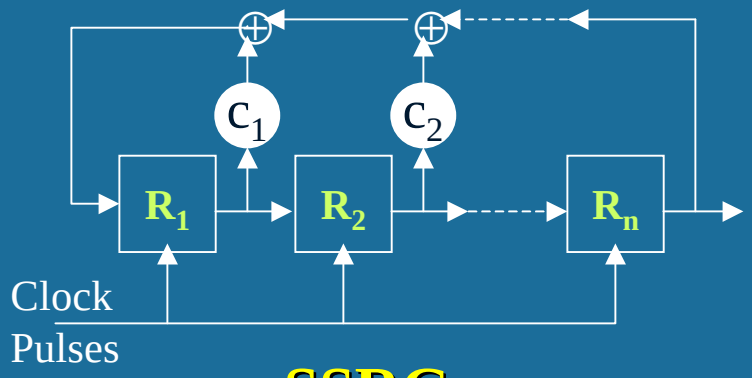
Theory of PN Sequences

- An example of GF(2^3)=GF(8) generated from $f(x)=1+x^2+x^3 \qquad \alpha^3=\alpha^2+1$

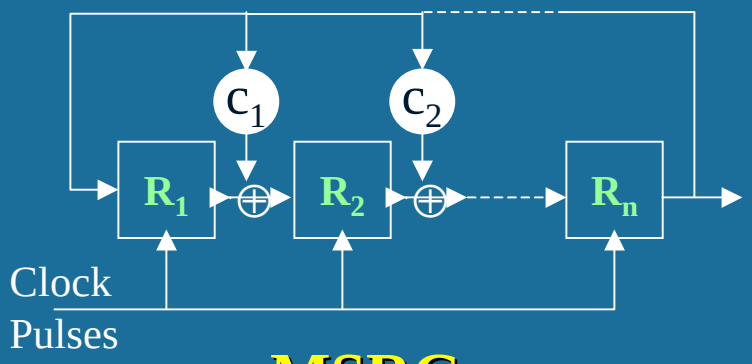
0 and Powers of α	Polynomials over GF(2)	Sequence over GF(2)
0=	0	0 0 0
α^1=	1	0 0 1
α^2=	α	0 1 0
α^3=	α^2 +1	1 0 1
α^4=	α^2 +α +1	1 1 1
α^5=	α +1	0 1 1
α^6=	α^2 +α	1 1 0

Theory of PN Sequences

- Mechanization of LFSR for Binary Primitive Polynomials
  - Simple Shift Register Generator
  - Modular Shift Register Generator



SSRG



MSRG

Application of PN Sequence in IS-95

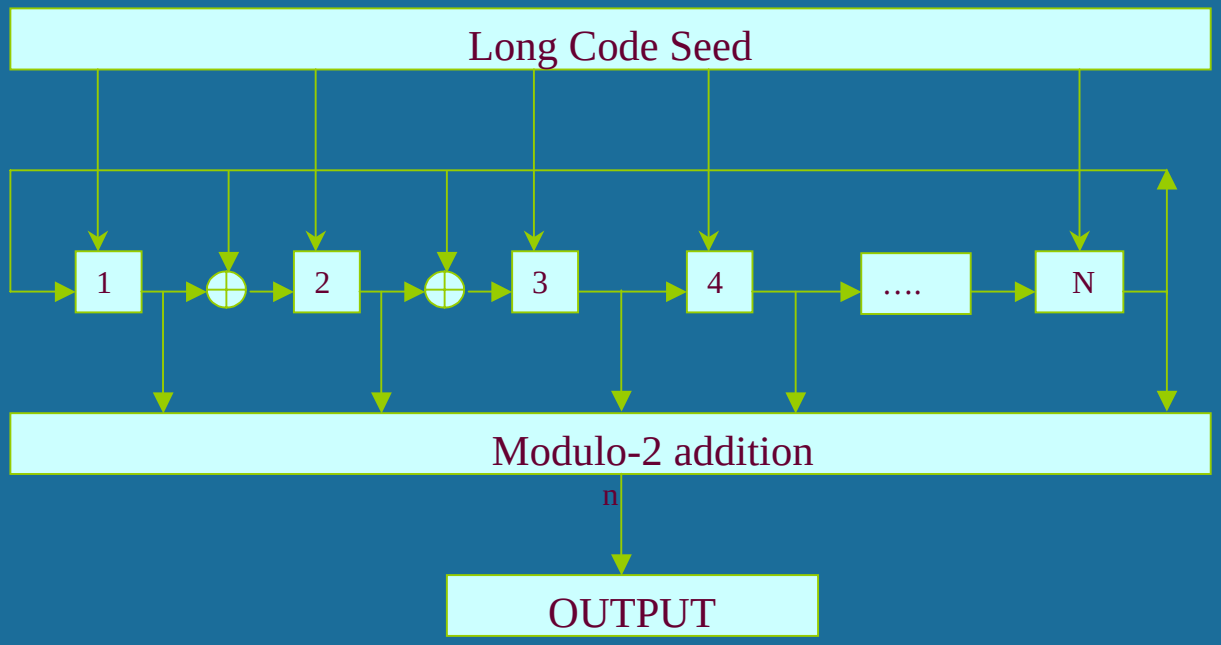
- Overview of IS-95 System
  - Forward Link
    - Pilot Channel
    - Synchronization Channel
    - Paging Channels
    - Traffic Channels
  - Reverse Link
    - Access Channel
    - Traffic Channel

Application of PN Sequence in IS-95

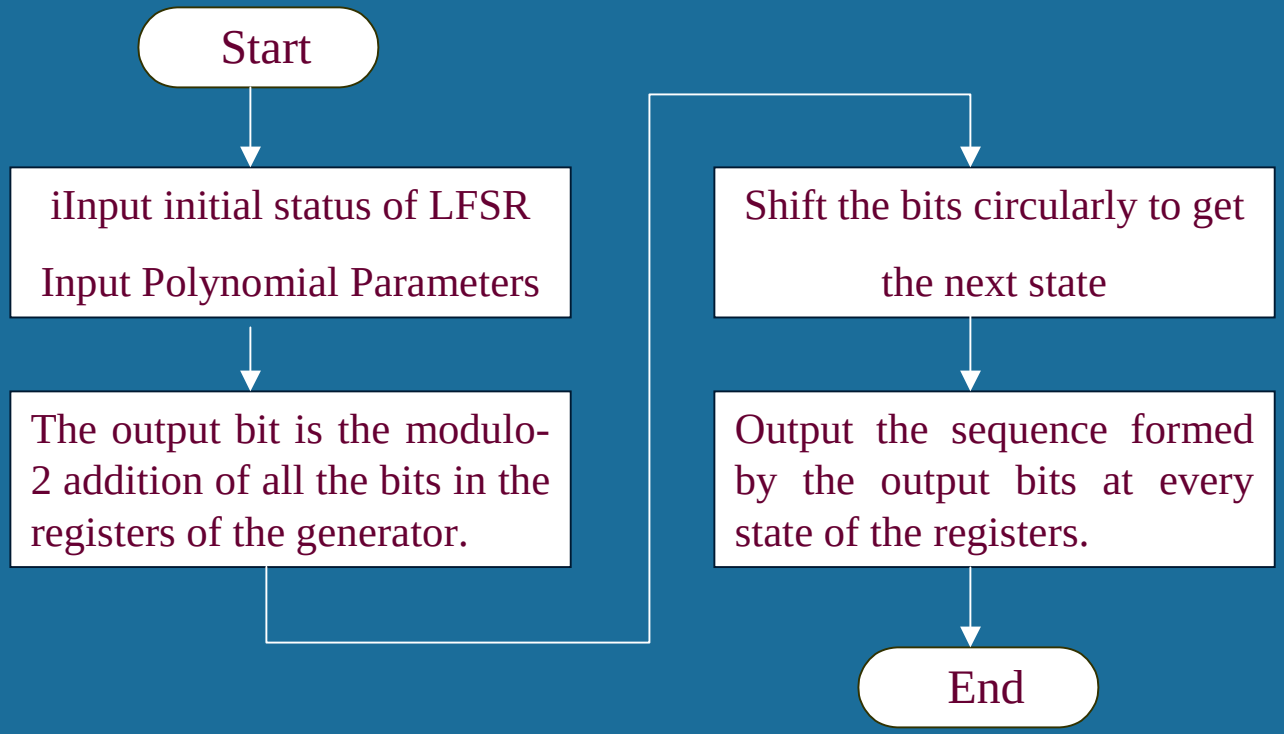
- Role of PN Sequences in IS-95

	Forward Link	Reverse Link
Long PN n=42	Scrambles user data	N/A
Short PN n=15	Multiple access	Multiple access

Simulation of PN Sequences



Simulation of PN Sequences



Summary

- DSSS is the core of CDMA techniques
- PN sequence is crucial to DSSS
- PN sequence realizes
  - Multiple Access
  - Message Privacy
  - Suitable to real-world communication channels

Future Work

- Simulation of Spreading with Walsh codes
- Simulation of Transmitter
- Simulation of Receiver

Reference

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»[5] V. Garg and J. Wilkes, *Wireless and Personal Communications Systems*, Prentice Hall, Upper Saddle River, NJ, 1996.

Got A Question???