SATA

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Introduction

- **What is SATA?**
  - Stands for Serial Advanced Technology Attachment
  - A Serial Interface Standard
  - Connects Storage to a computer’s motherboard
  - Replaces the older parallel ATA (PATA)

Introduction

- **Key Features**
  - Serial Communication: Better than PATA
  - Hot-Plugging
  - No Timing Skew
  - Point-to-Point Technology

Evolution & Overview of SATA

- **Pre-SATA Era**
  - Parallel ATA (PATA) dominate storage interfaces until the early 2000s
  - Limitations of PATA (More wires, Slower Speed max 133 MB/s)
- **SATA Introduction**
  - Developed by the SATA-IO consortium (Serial ATA International Organization) in 2000
  - Replace PATA with a faster, simpler and more scalable interface
  - First released in 2003 as SATA 1.0

Evolution & Overview of SATA

SATA 1.0 2003	1.5 Gb/s	First-generation serial Interface	Add Optional NCQ (Native Command Queuing)
SATA 2.0 2004	3 Gb/s	Mandatory NCQ	Hot-plugging support
SATA 3.0 2009	6 Gb/s	Improved NCQ for deeper queues	Enhanced power management

SATA Architecture Overview

01 Physical Layer

- Electrical and physical connection between the SATA controller and the drive
- Differential signaling with TX and RX
- Point-to-Point topology
- Utilize OOB (Out-of-Band) signaling

02 Link Layer

- Uses 8b/10b encoding
- Controls flow control
- Error Detection using CRC
- Handles Link Power Management (LPM) to reduce power consumption

03 Transport Layer

- Organizes data into frames called FIS (Frame Information Structure)
- Implements commands such as DMA
- Features like NCQ

04 Application Layer

- Implements ATA command sets (read, write, flush, ...)
- Supports features like TRIM (for SSDs)
- SMART (self-Monitoring, Analysis and Reporting Technology)

Physical Layer Details

Differential Signaling

Utilizes TX/RX pairs for data transmission

Low Voltage Differential Signaling (LVDS) for reduced electromagnetic interference

Out-of-Band (OOB) Signaling

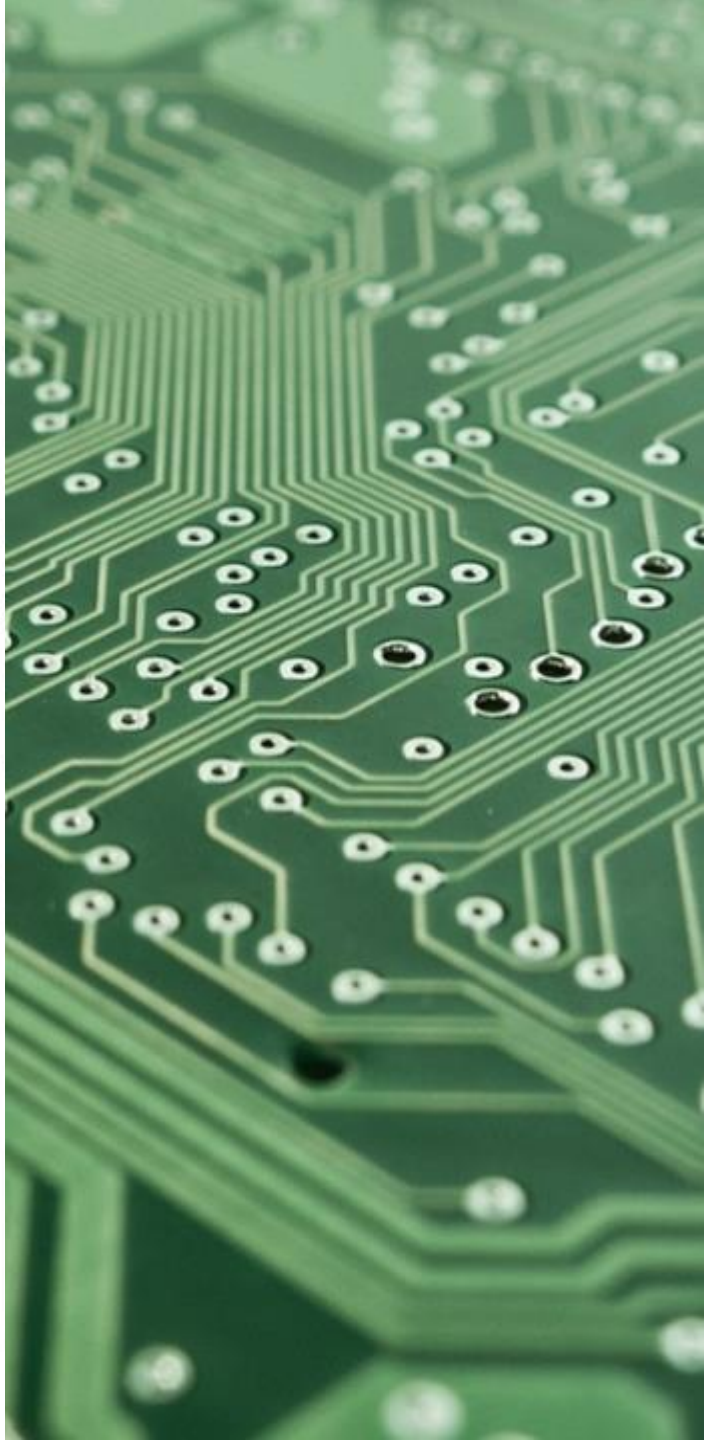
COMRESET: Resets the device and initiates communication

COMWAKE: Wakes the device from a low-power state

Point-to-Point Connectors

Direct connection between the host and storage device

Simplifies the architecture and enhances performance



Link Layer: Encoding, Flow Control, and Error Detection

8b/10b Encoding

Ensures DC balance to maintain signal integrity.

Facilitates clock recovery for synchronized data transmission.

Utilizes control characters for effective communication.

Flow Control Mechanisms

Manages data transmission rates to prevent overflow.

Implements techniques like stop-and-wait and sliding window protocols.

Error Detection Techniques

Employs CRC (Cyclic Redundancy Check) for data integrity verification.

Detects and corrects errors during data transmission.

Link Power Management (LPM)

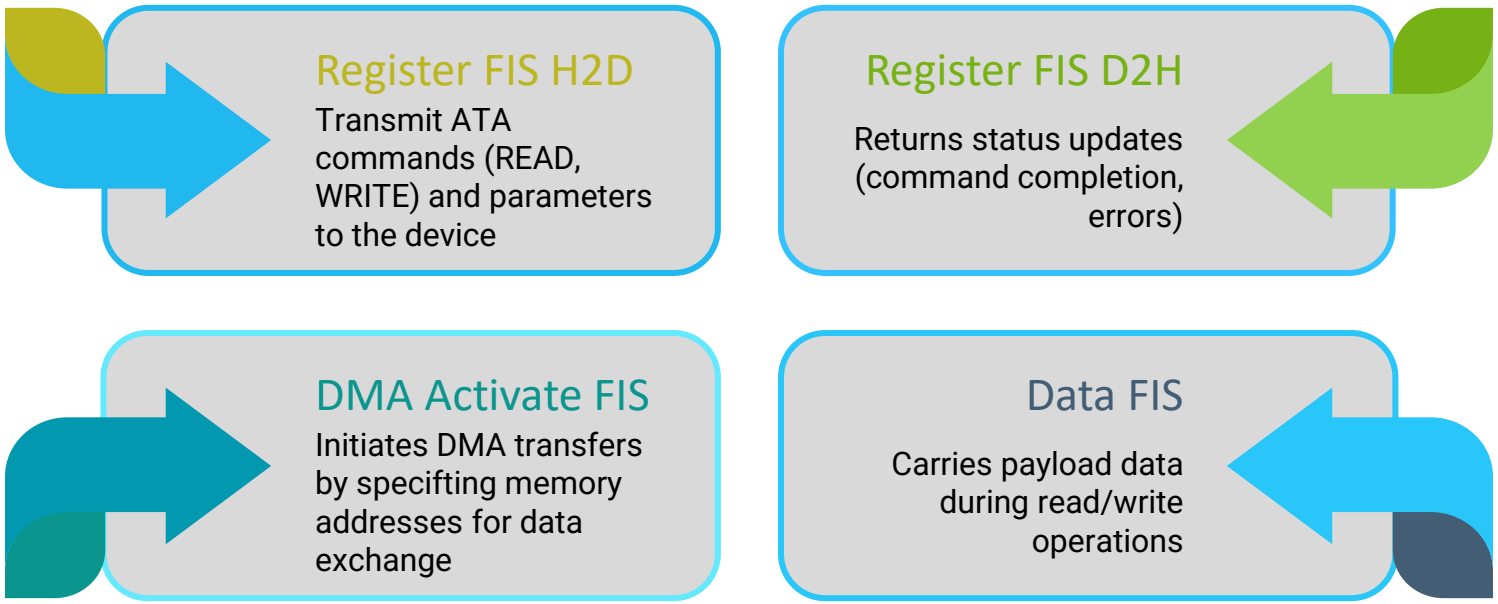
LPM allows the SATA link to enter low-power states when idle.

Has Two state of power consuming. Partial (Lower) and Slumber (Higher)

Transport Layer – Frame Information Structures (FIS)

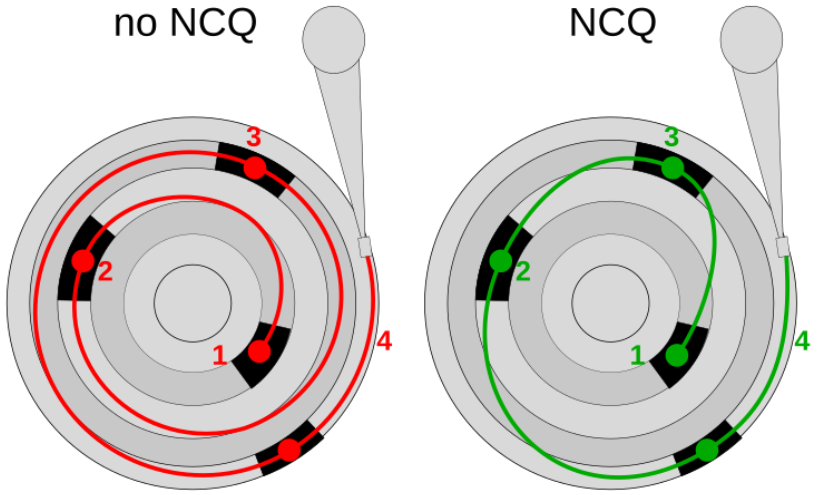
- **FIS (Frame Information Structure)**
  - **FIS** is the fundamental data packet used by SATA to communicate between the host and storage device
  - Structure:
    - **Header:** Specifies FIS type, direction, and control flags. (1 Byte)
    - **Payload:** Contains command parameters, sector addresses or actual data. (4 to 32 bytes)
    - **CRC:** 32-bit checksum for error detection

Transport Layer – Frame Information Structures (FIS)



Transport Layer – Frame Information Structures (FIS)

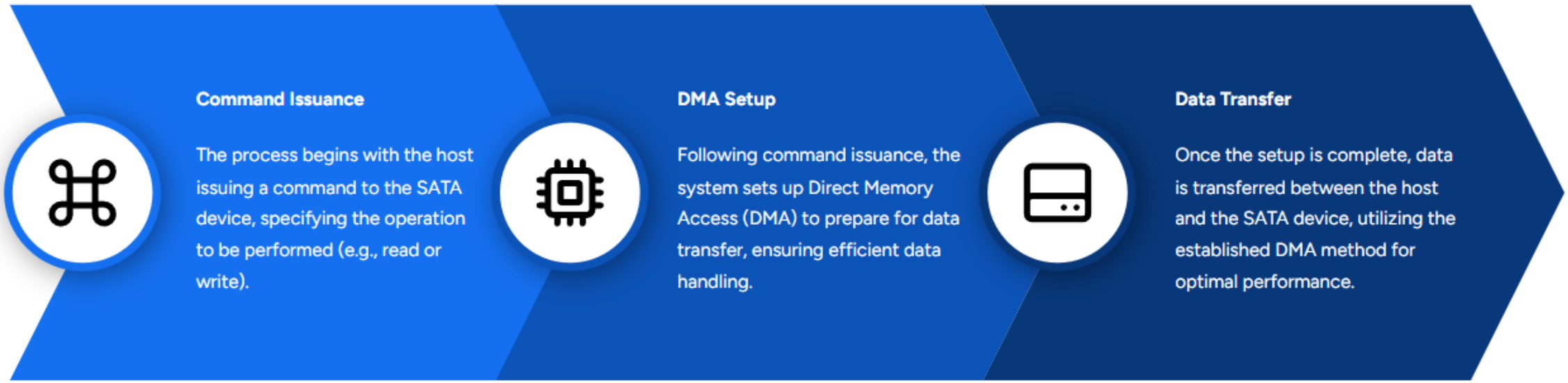
- **NCQ (Native Command Queuing)**
  - Optimize commands to minimize delays (Mechanical delays HDDs, Latency SSDs)
  - Supported in SATA II and later (in SATA I was optional)



Transport Layer – Frame Information Structures (FIS)

- **How it Works**
  - Command Queue that saves multiple commands
  - The device’s controller rearranges commands based on:
    - Physical data location
    - Priority
  - Commands are executed in the most efficient sequence

Message Flow & Command Sequencing



Summary & Q&A

Layered Architecture

The SATA protocol is structured in a layered model, including Physical, Link, Transport, and Application layers, facilitating modular communication.

FIS Message Formats

Frame Information Structures (FIS) are crucial for command and data exchanges, encompassing various types such as Register, Data, and DMA Setup FIS.

NCQ

In computing, Native Command Queuing (NCQ) is an extension of the Serial ATA protocol allowing hard disk drives to internally optimize the order in which received read and write commands are executed.