"Using Boundaries in the SSP to Understand and Design Data Storage Systems."

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Overview

System of System's processes enables an abstract point of view of systems that serves to increase the level of understanding of specific systems and how they work. This in turn allows new insights on how to improve system functioning and why specific system solutions emerge.

This poster demonstrates this by exploring just one specific isomorph from the 80+ isomorphs of SSP in data storage systems. It describes the system processes features and functions and then gives examples of them in data storage systems. A specific improvement in data storage system design is then highlighted for this process.

The system processes (isomorph) explored in this poster is Boundaries and Boundary Conditions.
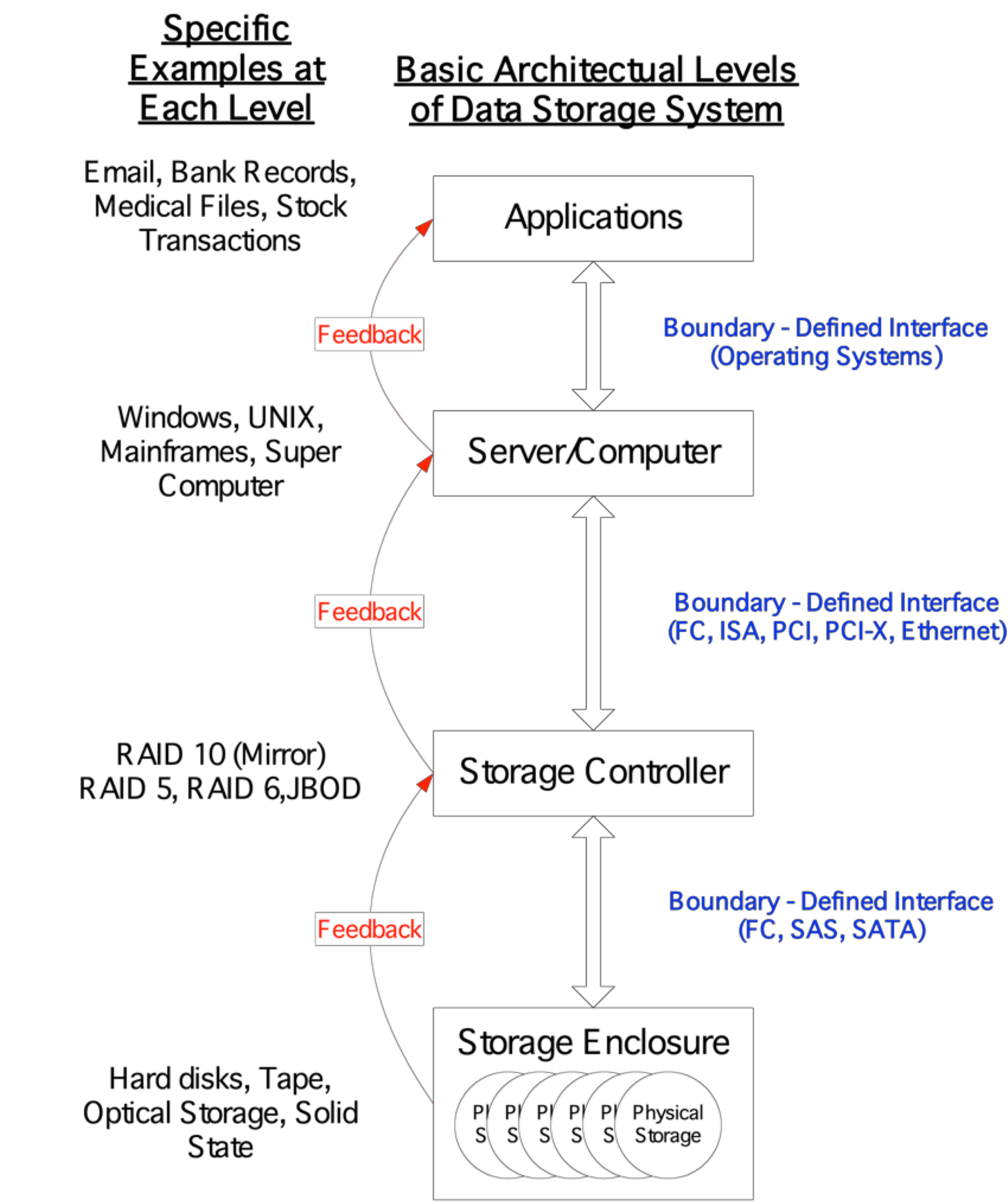
System Process - Boundaries

- **General Description and Features of Boundaries**
  - Rates of processes stronger on the inside, weaker on the outside,
  - Connections are stronger within and connections to the outside are weaker
  - More work is required to move through a boundary than through the system it surrounds and through the surrounding system
  - Contains channels/holes for exchanges of information/matter/energy

- **Data Storage Examples of Feedback Features:**
  - Boundaries between levels of the storage system are defined by standardized interfaces. Each level has a different set of standard interfaces that can be used.
  - These interfaces limit the interaction between levels and allow several different possible solutions within the level to successfully interface with the other levels within the storage system.
  - In storage systems, these interface boundaries exchange information. (matter and energy are exchanged indirectly)
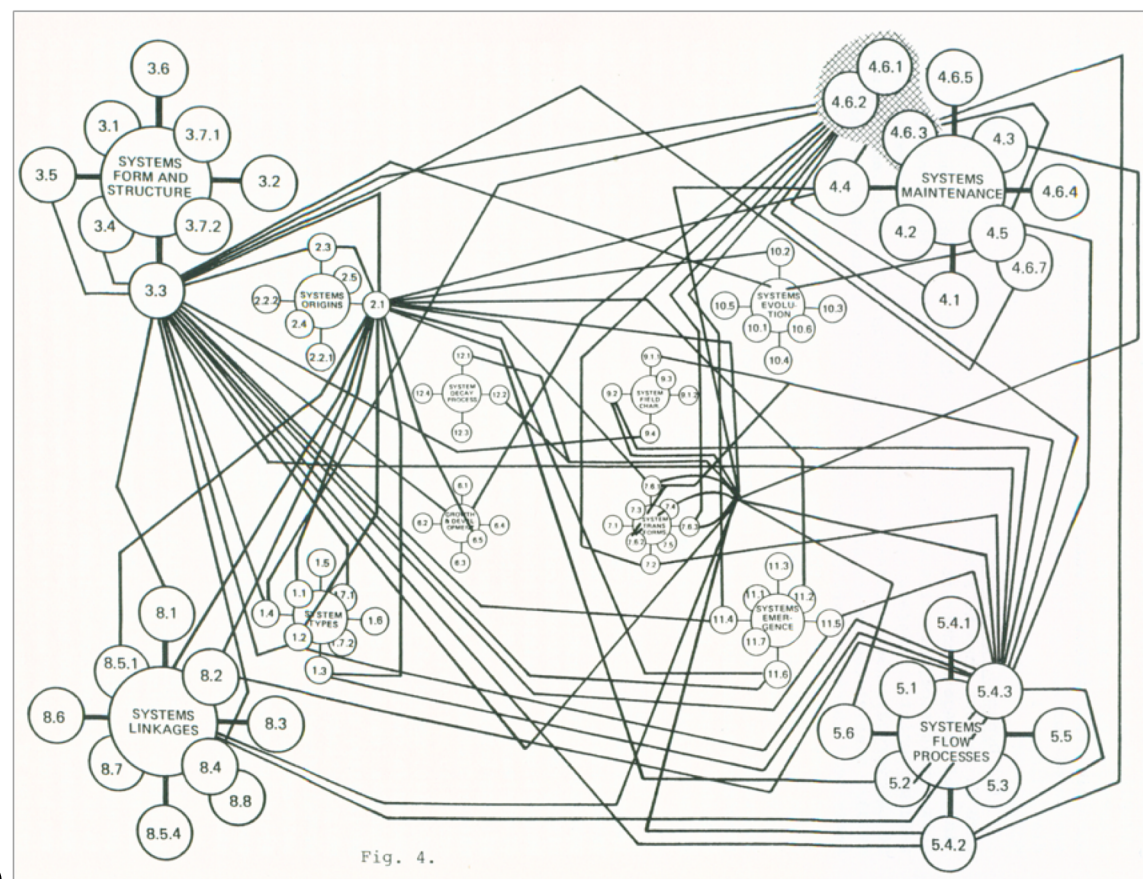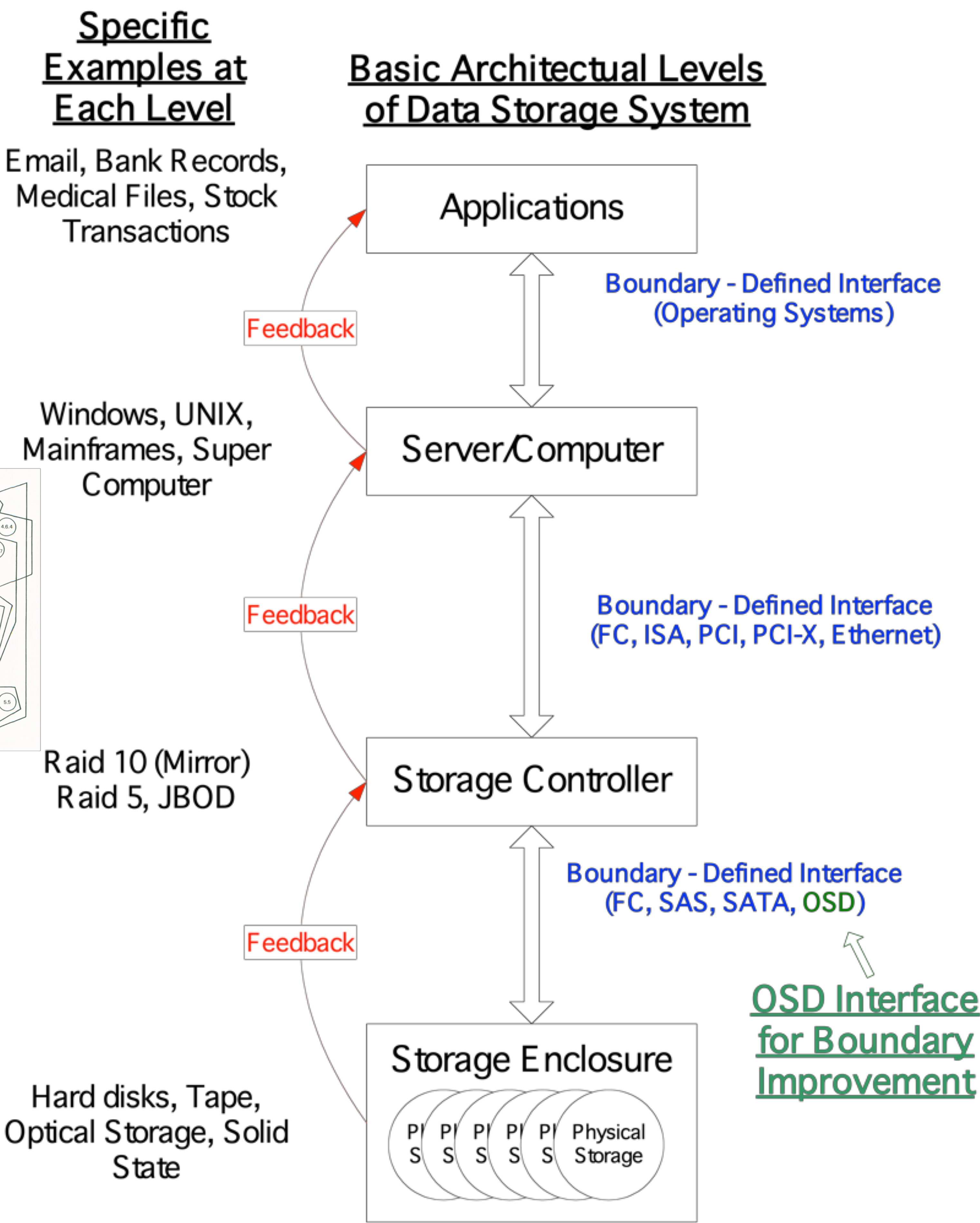
- **Functions of Boundaries**
  - Prevents matter/energy stresses in systems
  - Separates systems, subsystems, components
  - Regulates flows of energy, matter, information
  - Filters information/matter/energy into the system
  - Allows more complexity in group of systems

- **Data Storage Examples of Boundary Functions:**
  - The interfaces that serve as boundaries between levels separate the subsystems and components of the storage system.
  - They regulate the flow of information across the levels of the system.
  - They allow the internal parts of the system to be as complex as the developer needs to make them without increasing the complexity of the interactions with the other levels.

- **Data Storage Improvement Example:**
  - A new storage interface is emerging called OSD. (Object Storage Device). Rather than access the data by it's logical block address (LBA) as is currently done, it references data by an object. This adds a layer of abstraction and further isolates the internal details of the storage system. That way the controller doesn't need to know where or how the data is stored on the device.

Data Storage Diagram

Specific Examples at Each Level — Basic Architectual Levels of Data Storage System

- Email, Bank Records, Medical Files, Stock Transactions → Applications
- Feedback — Boundary - Defined Interface (Operating Systems)
- Windows, UNIX, Mainframes, Super Computer → Server/Computer
- Feedback — Boundary - Defined Interface (FC, ISA, PCI, PCI-X, Ethernet)
- RAID 10 (Mirror) RAID 5, RAID 6, JBOD → Storage Controller
- Feedback — Boundary - Defined Interface (FC, SAS, SATA)
- Hard disks, Tape, Optical Storage, Solid State → Storage Enclosure (PI/S PI/S PI/S PI/S PI/S Physical Storage)

Data Storage Diagram with Improvement

Specific Examples at Each Level — Basic Architectual Levels of Data Storage System

- Email, Bank Records, Medical Files, Stock Transactions → Applications
- Feedback — Boundary - Defined Interface (Operating Systems)
- Windows, UNIX, Mainframes, Super Computer → Server/Computer
- Feedback — Boundary - Defined Interface (FC, ISA, PCI, PCI-X, Ethernet)
- Raid 10 (Mirror) Raid 5, JBOD → Storage Controller
- Feedback — Boundary - Defined Interface (FC, SAS, SATA, OSD)
- OSD Interface for Boundary Improvement
- Hard disks, Tape, Optical Storage, Solid State → Storage Enclosure (PI/S PI/S PI/S PI/S PI/S Physical Storage)

Technical Definitions

- **RAID** – Redundant Arrays of Inexpensive Drives. These are different ways of distributing the data across the storage devices. Depending on the levels, it can improve performance and allow data to be recovered if a number of devices fail.
- **JBOD** – Just a Bunch of Disks – no data layout techniques are used.
- **FC, SAS, SATA** – Different types of communication interfaces used for communicating to storage devices. Each of them have standards that are developed so that any controller using a certain protocal can communicate with any device using the same protocal.
- **ISA, PCI, PCI-X, Ethernet** – Some examples of communication protocals used to communicate to internal or external storage controllers.
- **SAN, NAS** – Storage Area Network, Network Attached Storage. Different ways of creating another level of abstraction for organizing storage devices for servers.