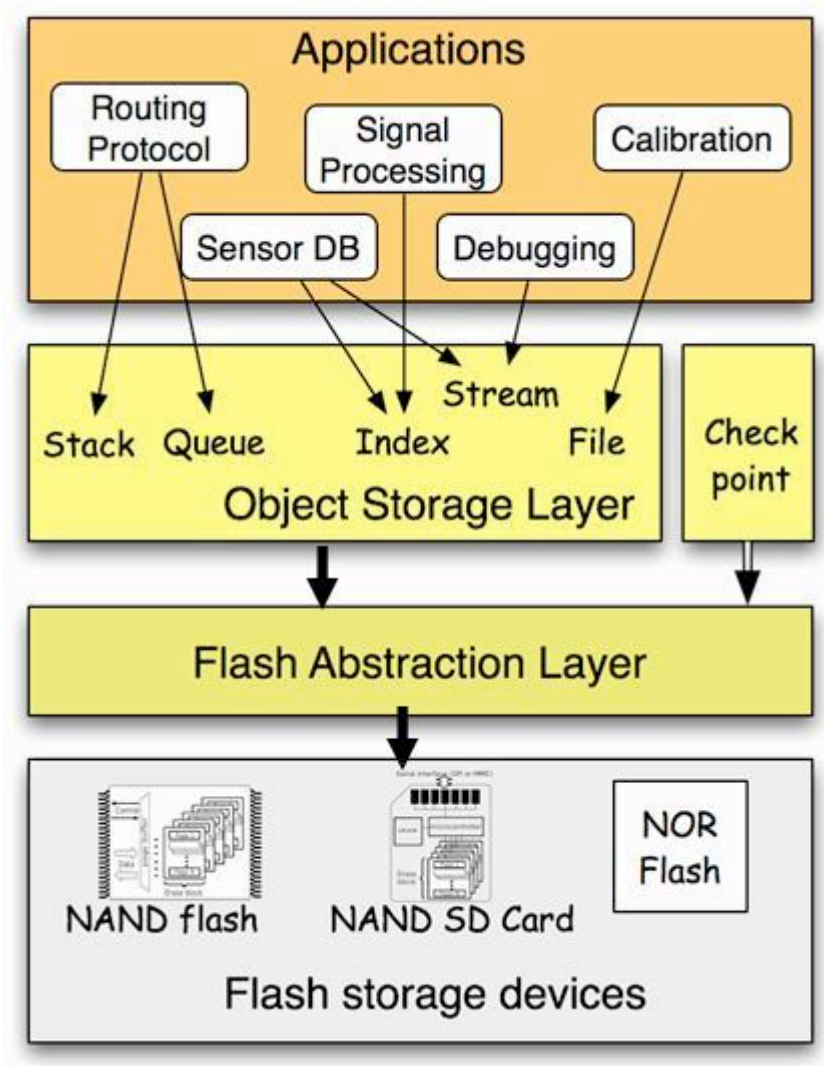
Outline

- Mathur, G., Desnoyers, P., Ganesan, D., and Shenoy, P. **Capsule: an energy-optimized object storage system for memory-constrained sensor devices**. SenSys '06
  - Sensor storage technologies such as NAND and NOR are energy efficient. Develop a energy efficient storage abstraction
  - Use object interface to help applications
    - Can even support checkpointing
  - NAND and NOR have special operation semantics (no modification, data is erased and rewritten. Erasure on a large chunk rather than byte level)

Architecture



Flash storage

- Write once, erase is slow and expensive. Erase on a erase block boundary
  - Number of non-overlapping writes limited between 1 & 4
  - Writes within erase block should be sequential
- Energy consumption:
  - Write has higher fixed cost (24.54) vs read (4.07)
  - Per byte energy is almost same

Problems addressed

- Mismatch between storage abstraction and application needs:
  - Traditional storage uses a file based abstraction
  - Applications use data stream, data stream with index, stack, queue, static sized index and array, file system
- Supporting use of flash as a backing store
  - Requires treating flash different from files
- Optimized for energy and memory constraints of Sensor platforms

Contributions

- Object based abstraction
  - Types can be composed
- Energy efficient and memory efficient design
  - Log structured design. Write caching with flush on full semantics
  - Optimizing storage organization to access type
  - Efficient memory compaction
- Support for compaction: Storage notifies when full, each object implements a compaction mechanism
- Handling failures using checkpointing - Capsule provides checkpointing facilities

Important features

- Error handling - probability of errors is higher in NAND. FAL uses simple error detection and correction
- FAL allows bypassing FAL (for reprogramming motes etc.)
- Implementation details:
  - Challenging in motes because of event driven model of the Operating System
- Applicability of this storage for non-sensor scenarios: Laptops of the (near) future, iPods?