PAVE: Power-Fail Aware Byte-Addressable Virtual Non-Volatile Memory
Oliver Giersch, Dustin Nguyen, Jörg Nolte, Wolfgang Schröder-Preikschat

**Problem Statement**

NVRAM is significantly faster than other types of storage, capacity is pretty high, and no energy is needed to maintain its state. But:

- NVRAM speed is much slower than that of DRAM
- Other storage technologies offer significantly better price/capacity ratios
- Writing NVRAM consumes more power than writing DRAM
- NVRAM requires fail-safe guarantees from the system:
  - power failures on NVRAM-systems may turn a sequential process into a non-sequential one
  - a program has to deal with its own state from previous interrupted runs

**Solution Proposal**

Integrate these new types of storage-class memory (SCM) appropriately into the memory hierarchy via the virtual-memory subsystem:

- NVRAM-based data cache for conventional storage
- Size-limited DRAM-based page cache for mutable data in NVRAM
- Page-cache persistence with strict time guarantees
- Power failure tolerance: residual-energy-window–compliant page cache

\[ \Rightarrow \text{pave the way} \] – for application and system programs – for the use of NVRAM

**Milestones**

- NVRAM-based capacity scaling as a kind of OS-managed memory mode
- Extend capacity scaling with persistence guarantees
- Estimate worst-case period for the residual energy from the system power supply
- Limit volatile system state to allow for persistence in case of power failure
- Detection of critical sections with regard to persistence of stale or incomplete state
- Provision of a persistence-aware runtime system for data manipulation

**Project Contribution**

There are over 35,000 packages available on FreeBSD, which cannot utilize NVRAM:

- Make legacy software benefit from NVRAM
- Consistency without transactional programming
- Capacity scaling

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