Karlsruhe Institute of Technology

Operating Systems Group
https://os.itec.kit.edu

Towards Fast and Power-Efficient System Suspend

Yussuf Khalil, Felix Zimmer, Fabian Meyer, Frank Bellosa

State-of-the-Practice

Suspend-to-Memory (e.g., ACPI S3, suspend-to-idle)

Keep system memory alive

- ✓ Fast wakeup
  - DRAM is kept alive
- × Some energy consumption
  - DRAM is kept alive
- × Limited suspend duration
  - Battery dead = DRAM dead

Suspend-to-Disk (e.g., ACPI S4)

Store system memory on disk

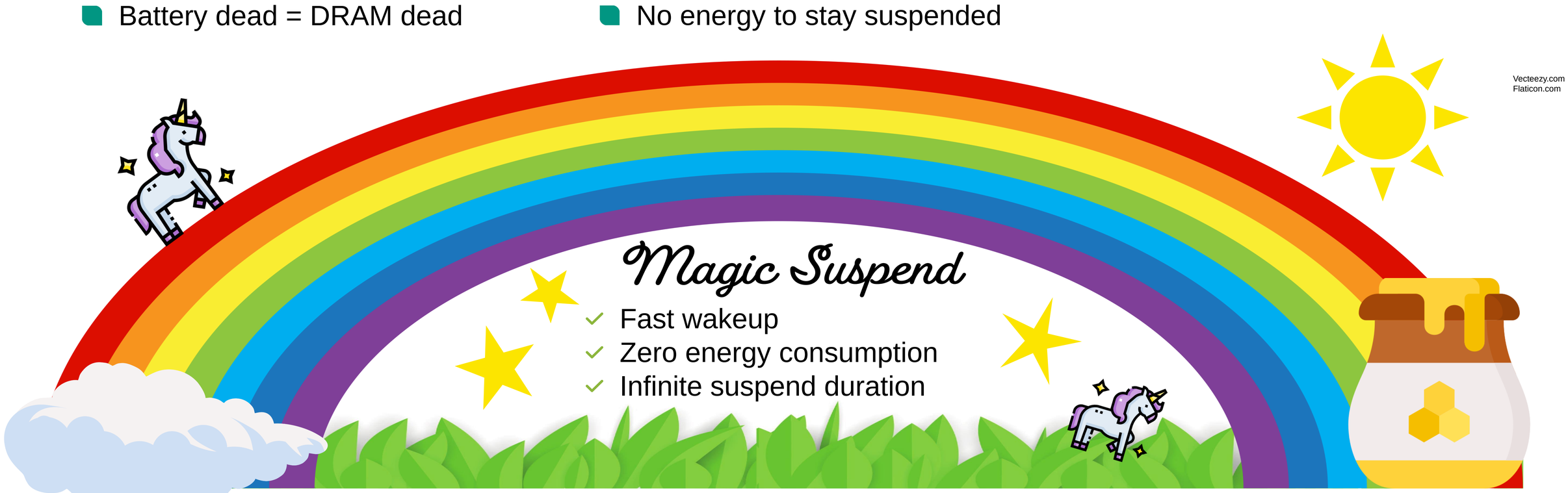
- × Slow wakeup
  - Copy image from disk
- ✓ Zero energy consumption
  - System is turned off
- ✓ Infinite suspend duration
  - No energy to stay suspended

Related Work

Whole System Persistence (e.g., Miemietz et al. 2023)

Make entire memory persistent

- × Degraded runtime performance
  - NVM slower than DRAM
- × Infeasible with SSDs
  - Too slow



coreboot + Linux + CXL Compute Express Link + CXL SSD

Firmware + OS Co-Design Approach with Hybrid CXL SSDs.

Suspend

1. Perform suspend preparations as usual
2. Migrate user space pages to hybrid SSD
3. Trigger System Management Interrupt (SMI)
4. Copy kernel memory to hybrid SSD (coreboot)
5. Power off system (coreboot)

Resume

1. Initialize as far as necessary (coreboot)
2. Copy kernel memory from hybrid SSD to DRAM (coreboot)
3. Jump to S3 wake vector (coreboot)
4. Perform kernel resume as usual
5. User space mapped to SSD – system is usable!
6. Asynchronously migrate user space pages to DRAM