Dynamic Software Updating for the Linux Kernel

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Why On-the-fly Kernel Updates?

- Software updates - necessary evil
  - Inconvenient, expensive
- OS update via stop/restart disruptive
  - Loss of OS/application state

- *Dynamic Software Updating* (DSU)
  - User-space programs: easy, safe
  - Challenge: kernel

DSU for User-space Applications

- Ginseng: update C programs while they run [PLDI'06]
  - Indirect type accesses, function calls
  - Dynamic patch: new/changed code&data, transformers
  - Update: load dynamic patch
  - Safety analyses (type safety)
- Results
  - Off-the-self apps: VsFTPd, OpenSSH, Zebra
  - 3 years of releases: 2002 - 2005
  - Easy to use: minor changes to apps/patches
  - Good performance: 0..30% overhead
  - Minimal disruption: < 5 *ms*

DSU for the Kernel

- Safety challenges
  - – Low-level, highly concurrent code

  → Transactions

- Layout & performance constraints

  → Selective indirection

Better Safety with Transactions

- Ginseng enforces *representation consistency*
  - Type safety: old code/new data or vice versa
- Transactions provide *version consistency*
  - Programmer-specified blocks: code/data from same version
  - Delineate logical events (e.g., ADT, top+bottom half)
  - No commit, rollback, log
  - Enforcement: static analyses + light dynamic checks
- When is it safe to update ?
  - Code outside transactions, or
  - Transaction doesn't conflict with update

Selective Indirection

- Performance/representation constraints
- Types
  - Fixed representation/no change expected
    - E.g., page table entry, IP address
  - Non-indirected types updated manually
- Functions
  - Indirection/patch size trade-off
- Static analysis-driven

Conclusions

- Updating the kernel dynamically…
  - Compile kernel specially (selective indirection)
  - Automatic patch generation
  - Safety analyses (version consistency)
- …leads to better OS maintenance
  - Wide range of updates applied on the fly
    - Security patches, bug fixes, new features
  - Updates easy to construct, safe to apply

http://www.cs.umd.edu/projects/dsu