A High-Performance Driver Ecosystem for NVM Express

Andy Rudoff

Datacenter Software

Intel

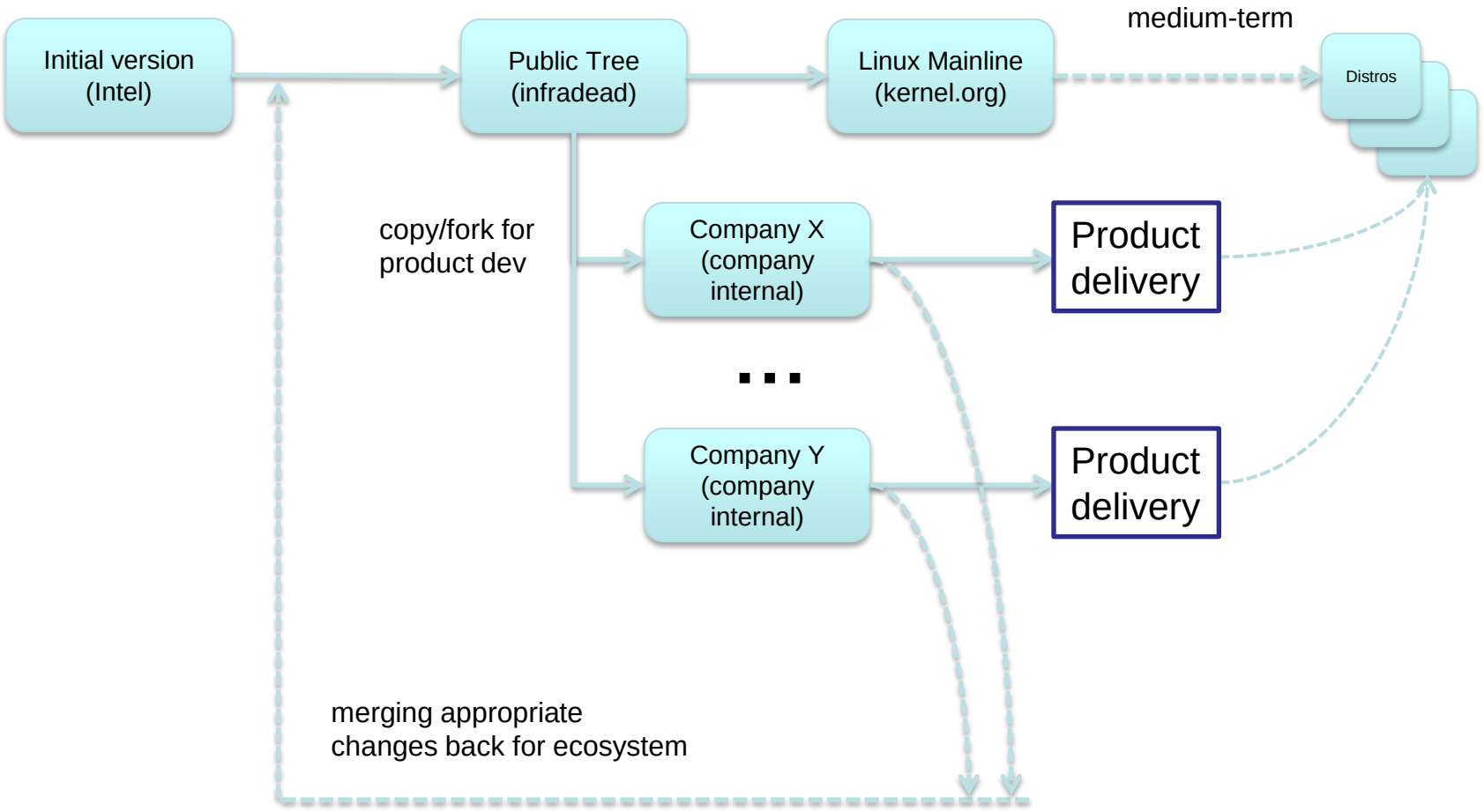
Ecosystem Goals

- Long-term
  - Each OS comes with standard NVMe driver
- Short-term
  - Allow NVMe vendors to provide the drivers they need with their products without major driver development

Ecosystem Goals

- Achievable
  - High-performance, validated, fully-compliant drivers available in the ecosystem with minimal license hassles (i.e. GPL, BSD, whatever license is appropriate)
- Not Achievable
  - Anticipate every product's unique needs
  - Get driver integrated into OS ahead of products
- Result: Strategy must take varied product goals into account

Linux Driver Flow



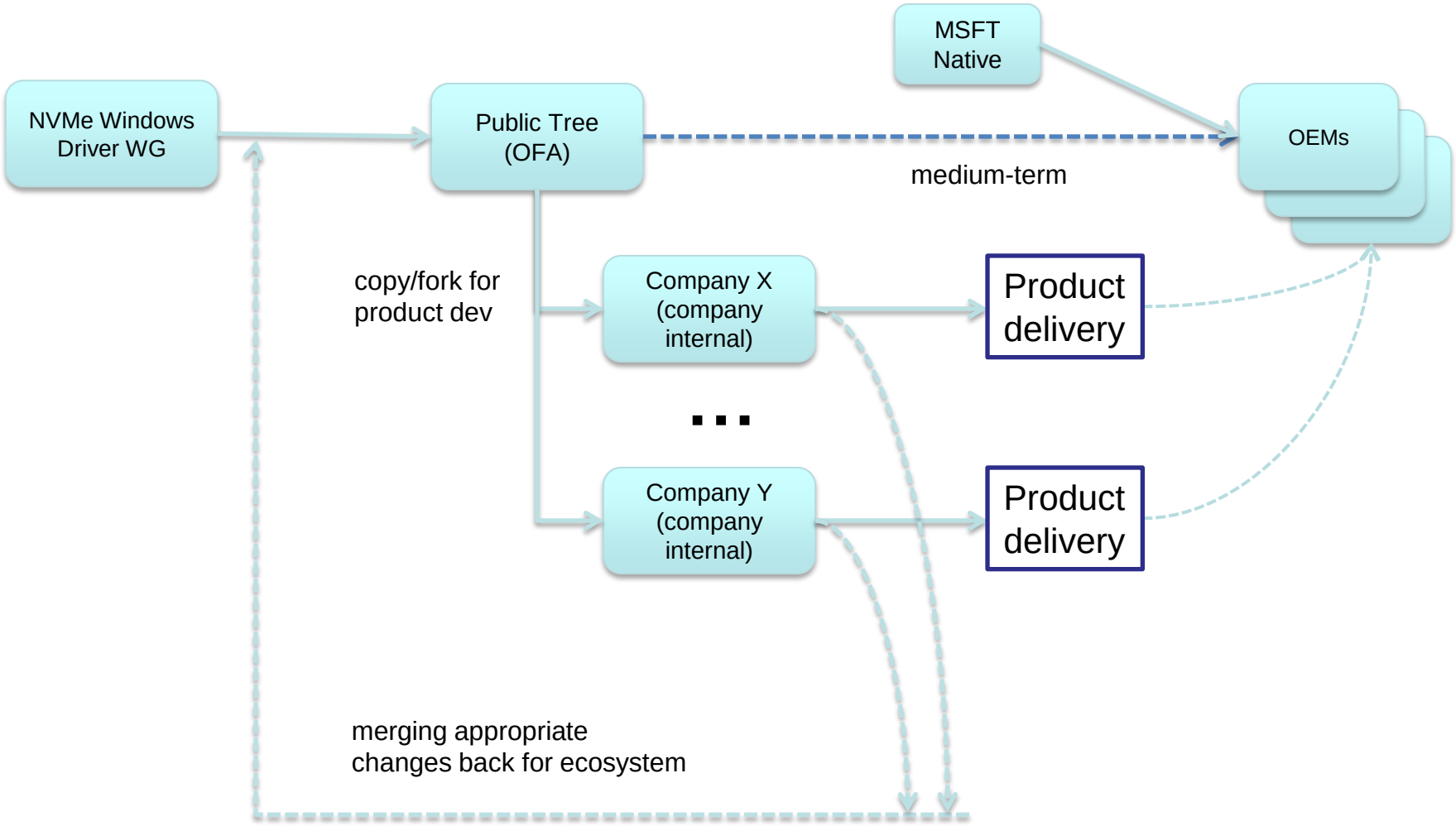
Linux Driver Current Status

- Supports most of the ‘M’ NVMe features
  - All by production driver
- Supports some of the ‘O’ NVMe features
- Conservative quality schedule:
  - Beta quality in Q4 ‘12
  - Production quality in Q2 ‘13
- Quite likely emerging products will cause validation to happen earlier

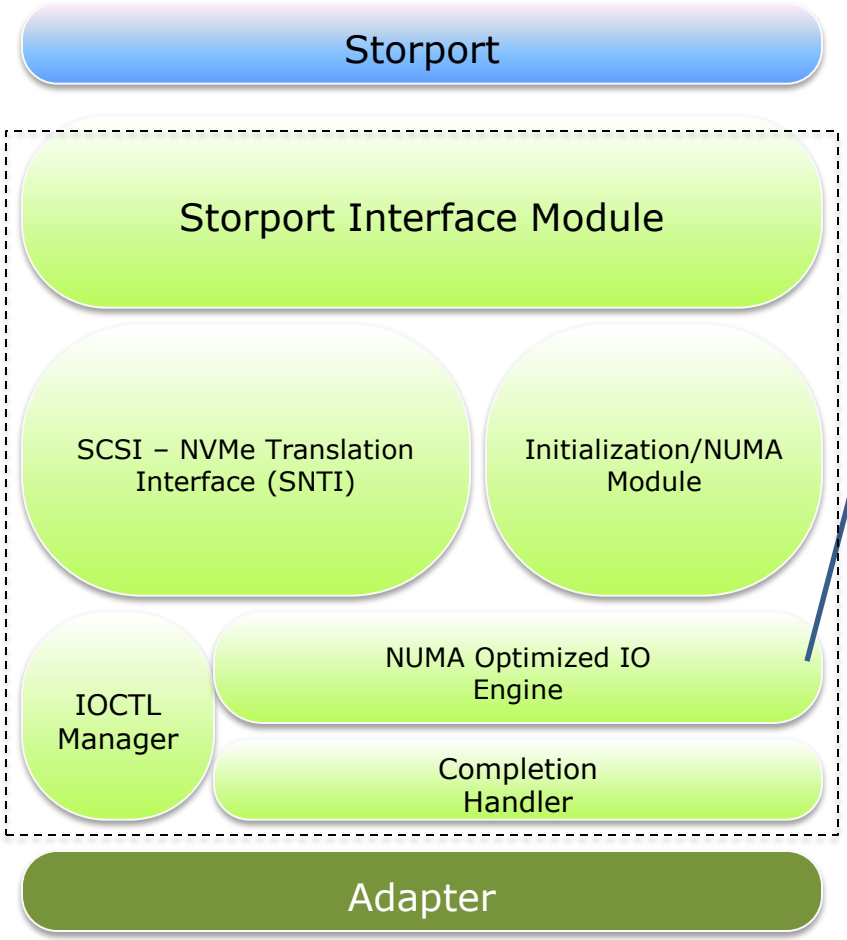
NVMe Linux Patch Submission

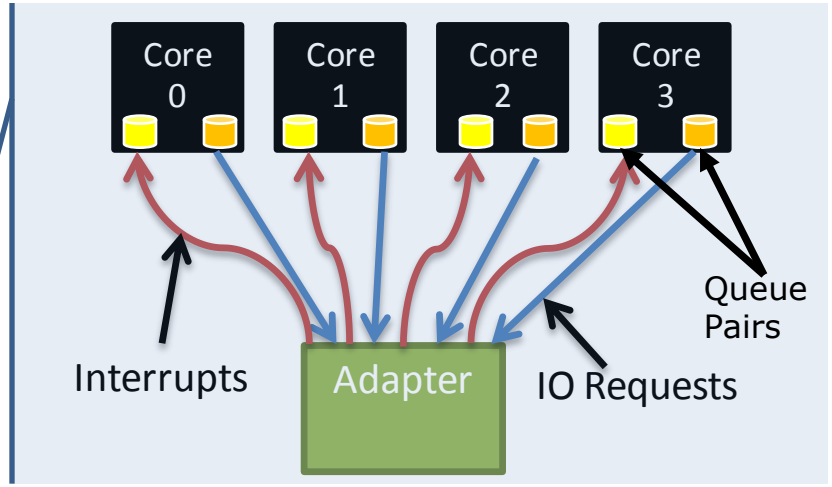
- **Understand the Linux kernel patch submission guide and coding style**
  - http://www.kernel.org/doc/Documentation/SubmittingPatches
  - http://www.kernel.org/doc/Documentation/CodingStyle
- **Clone nvme repo on infradead with ‘git clone’**
- **Create a branch and develop your patch**
- **Test your patch against the kernel version used from the cloned repo**
- **Once satisfied your patch is correct, format the patch with ‘git format-patch’**
- **Submit your patch to the linux-nvme mailing list using ‘git send-email’**
- **The maintainer on the mailing list will either accept your patch or provide feedback.**
  - If accepted, you’re done
  - If changes are required, repeat the patch creation/submission process
  - Feel free to post additional questions on the thread that the patch submission created

Windows Driver Flow



NVMe Miniport Architecture





Taking advantage of NVM Express

- Distribute I/O Submission & Completion Queues amongst cores
- Submission and Completion Queue memory allocation optimized for NUMA. Queue and MSIX mapping and allocation done during initialization.
- Specify MSI-X vector when creating Completion Queue to process completion optimal core.

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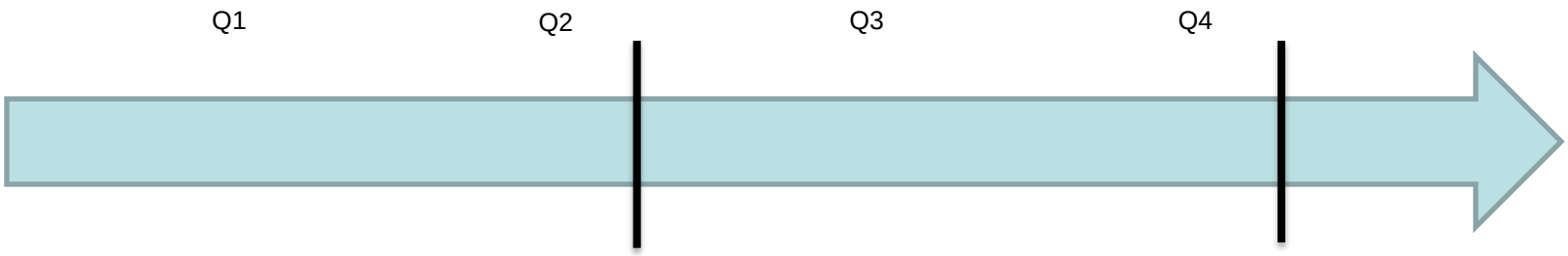
OFA NVMe Driver 2012 Release Plans



Release 1:

- Initial Release
- NVME 1.0b
- Win7,2008R2

Release 1.1:

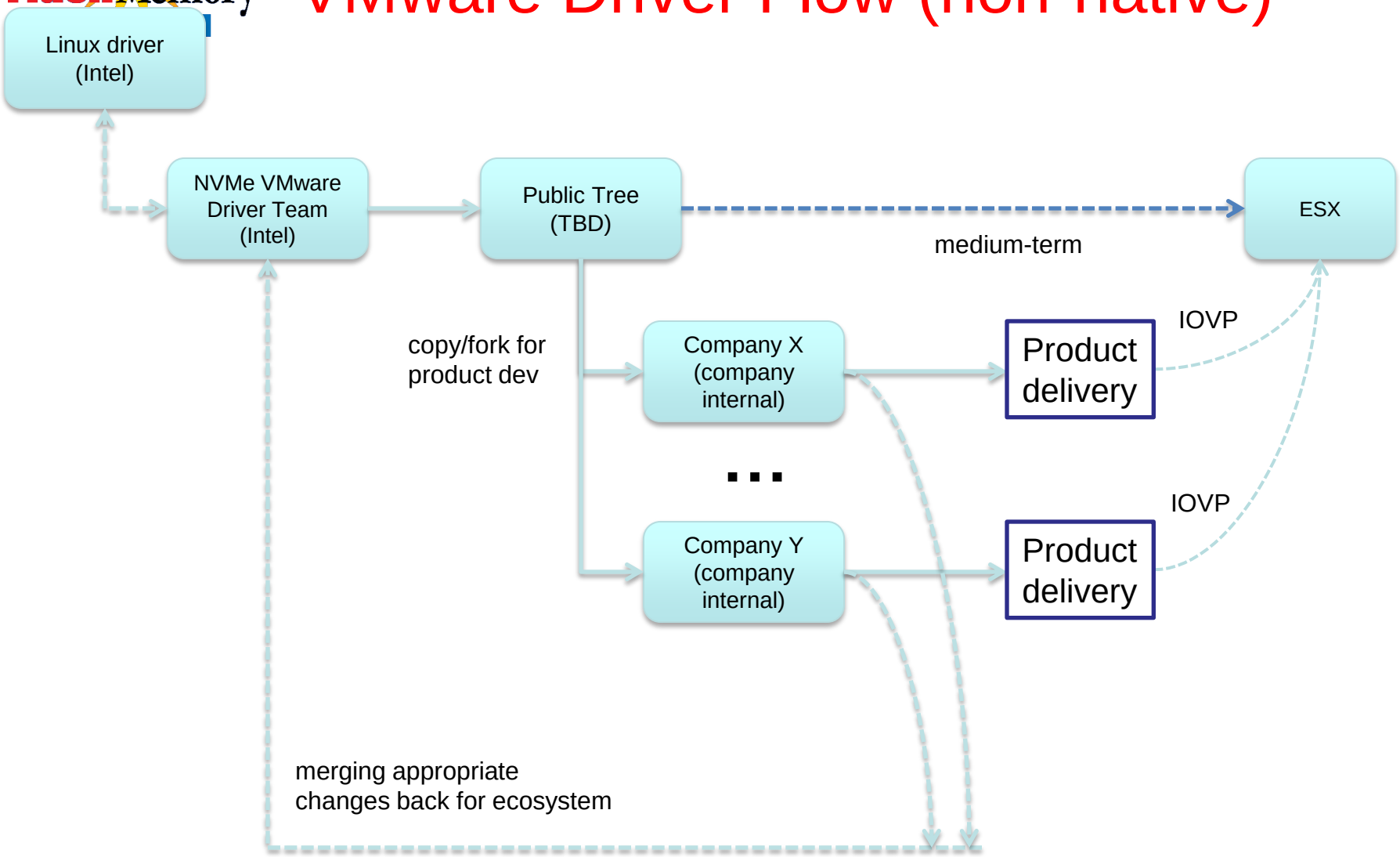
- NVME Spec Updates
- Public IOCTLs
- Win8 Storport Specific
- Bug Fixes
- Win7,2008R2,Win8

Releases are binaries for x86, x64, matching source available on OFS via SVN.

Windows Release/Patch Criteria

- **Reviews**
  - Patches submitted by anyone, email to distribution list
  - Patch submission should include time sensitivity/expectations
  - Patch submission should include justification for the patch (what value will it add, and are tradeoffs what are they and why would we want to take a hit). If multiple implementation options were considered, what data/reasoning was behind the implementation choice.
  - At a minimum reviews need to be competed by Intel, IDT and LSI representative
  - Reviews include compliance with coding guidelines (in SVN) as well as logic
- **Testing**
  - All patches and release candidates required, at a minimum, the following;
    - 1 hour of data integrity testing using sdstress (Microsoft Tool)
    - 1 hour of heavy stress testing using IOMETER covering, at least, 512B, 4KB and 128KB ranging from 1 OIO to 64 OIO both sequential and random
    - Quick and slow format of both MBR and GPT partitioning
    - Microsoft SCSI Compliance, no failures except (warnings OK):
      - READ_CAP due to the test support of a lower SBC than we do
      - WRITE(10) due to what appears to be a false positive (investigating)
    - Performance regression (scripts and procedures) are TBD; will be added shortly.
  - Additional testing with other tools is encouraged
  - Occurs in all supported OSs for the release
  - Minimum test platform is latest QEMU. Those with their HW should test on it as well. QEMU is available at https://github.com/nvmeqemu/nvmeqemu

VMware Driver Flow (non-native)



VMware Driver Current Status

- Initial “vmklinux” based driver tracking Linux driver day-to-day
- Native NVMe Driver with pluggable Vendor Extensions planned for future
- VMware’s IOVP program includes workflow for bugs/issues

NVMe Solaris Driver

- Feature Plan
  - Fully implement and conform to 1.0c spec
  - Efficient block interfaces bypassing complex SCSI code path
  - NUMA optimized queue/interrupt allocation
  - Reliable with error detect and recovery fitting into Solaris FMA.
  - Build ZFS with multiple sector size (512,1K, 2K, 4K) on namespaces.
  - Fit into all Solaris disk utilities and fwflash(1M) for firmware.
  - Boot & install on SPARC and X86.
  - Surprise removal support
  - New Spec: Multipath, SRIOV, SGL, SOP command set, etc.

NVMe Solaris Driver

- Status
  - Have working driver prototype
  - Plan to validate driver against Oracle SSD partners
  - Plan to integrate into S12 and a future S11 Update Release

NVMe UEFI Driver

- Under Development
- Will be Open Sourcing the Driver Around Q1 ‘13
  - Will include a bug/patch process
- Expect Beta Quality by Q1 ‘13
- Expect Production Quality by Q2 ‘13

Strategy Summary

- "Fork and Merge"
  - Maximize re-use, enable continuous improvement of ecosystem code base
  - Allow product groups to focus on their delivery goals
    - Drivers delivered with products should have unique binary names
    - Drivers delivered with products should bind to those products only
  - Support product groups
    - Maintainers available to review driver changes
    - Maintainers maximize ability for a change to be general, flexible for eventual inclusion in ecosystem driver
  - Ask product group to merge changes back when appropriate
    - Not time critical like product delivery
    - NVMe WG encourages this to make it happen