MODERNIZING DIGITAL VIDEO SYSTEMS AT THE NATIONAL IGNITION FACILITY (NIF): SUCCESS STORIES, OPEN CHALLENGES AND FUTURE DIRECTIONS

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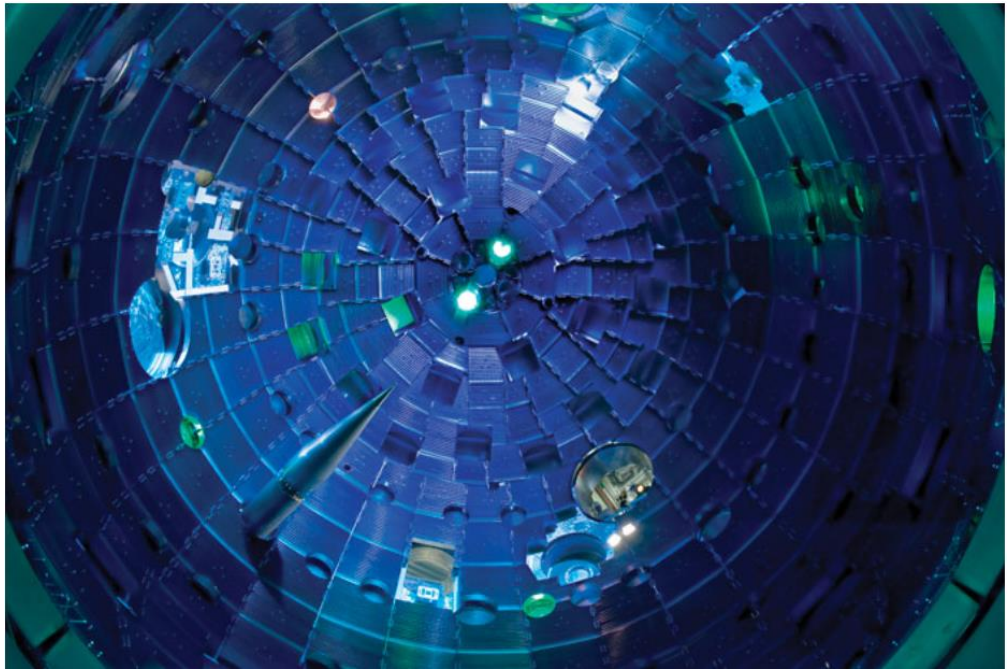
MODERNIZING DIGITAL VIDEO SYSTEMS (DVIDs)

- Introduction to DVIDs
- The Maintenance Challenge
- Potential Mitigation Strategies
- Modernized DVID Architecture
- Verification and Deployment
- Future Directions



How do we solve the long-term maintenance risk of DVIDs?

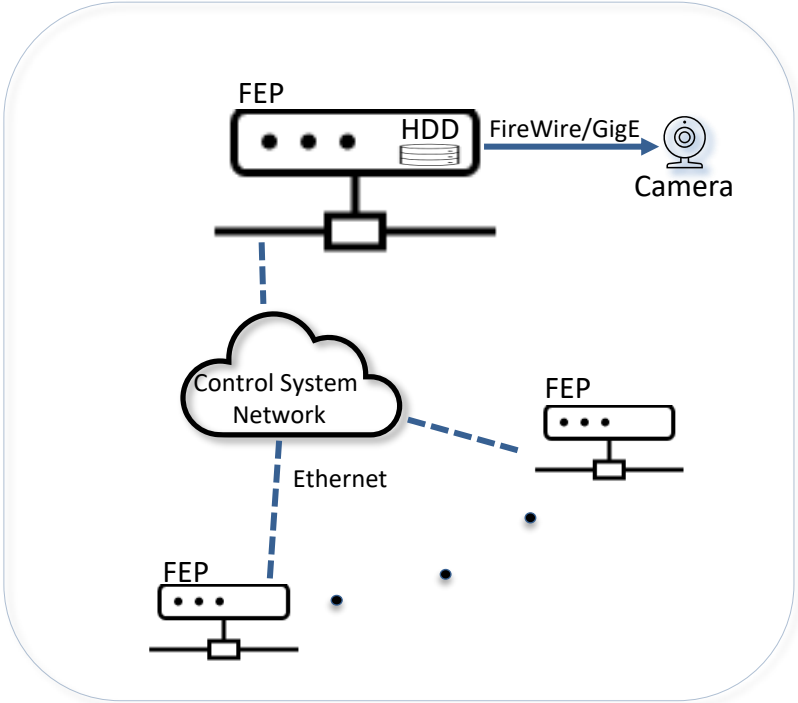
Introduction to DVIDs – DVID's Role in NIF Control Systems

- Participate in automatic loops
  - e.g., automatic alignment
- Provide critical diagnostics to study the laser
- Allows operators to observe the state of the system in real time
- Spatial measurements of optical wavefront
- Optics inspection
- And many more ..

DVIDs are an integral part of the NIF control system.

Maintenance Challenge – Large number of legacy systems

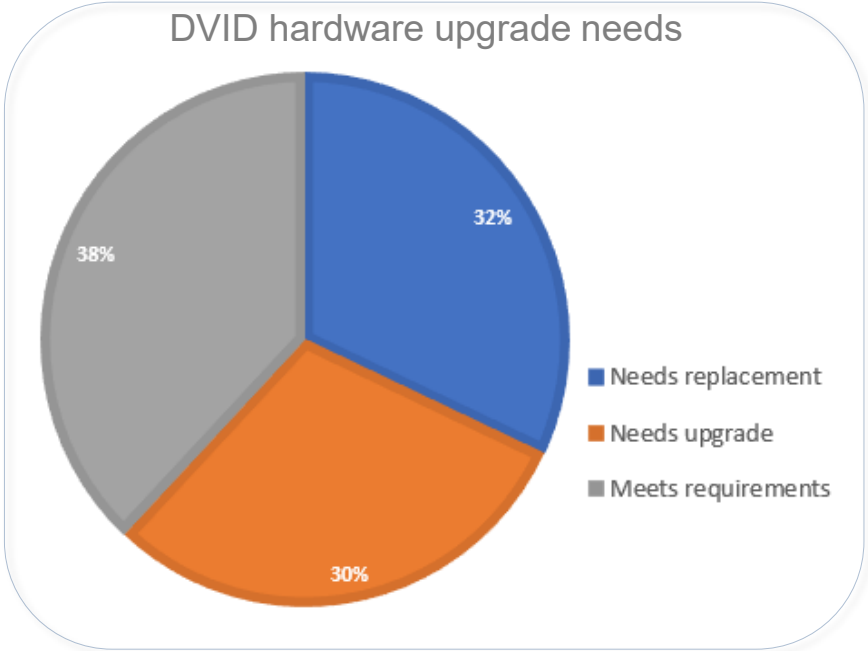
- **DVID FEPs (Front End Processor) run an obsolete Windows XP OS**
  - **Unsupported, no security patches**
  - **Cannot be installed in newer computer hardware**
- **500+ FEPs**
  - **500+ Windows OS Images**
    - **Need to be individually upgraded and patched.**
  - **Each FEP boots from hard disk drive**
    - **500+ Hard Disks**
    - **A significant point of failure (high MTBF)**



DVIDs' operating system is obsolete and needs replacement.

Maintenance Challenge – Aging Computer Hardware

- **Different generations of machines**
  - **Need to ensure that modern OS can be installed**
- **Replace/Upgrade**
  - **Upgrade RAM**
  - **Replace with newer machine**



Many DVID computers need replacement or upgrade to support modern operating systems.

Maintenance Challenge - Many camera types

- **Different control applications require different camera types**
  - **Image resolution, streaming frame rates**
  - **Radiation / vibration tolerance**
- **Each camera type comes with its associated drivers/software**
  - **Multiple drivers / libraries**
- **Proprietary software licensing schemes**
  - **Node locked, hardware dongles, built into camera**

Interface	No. of FEPs	Camera Manufacturers	Camera Models
FireWire	487	4	7
GigE	318	4	15
Analog-FireWire	110	1	1
Analog-PCIe	2	1	1

It is difficult to maintain multiple drivers, libraries and licenses for each camera type – need a way to consolidate.

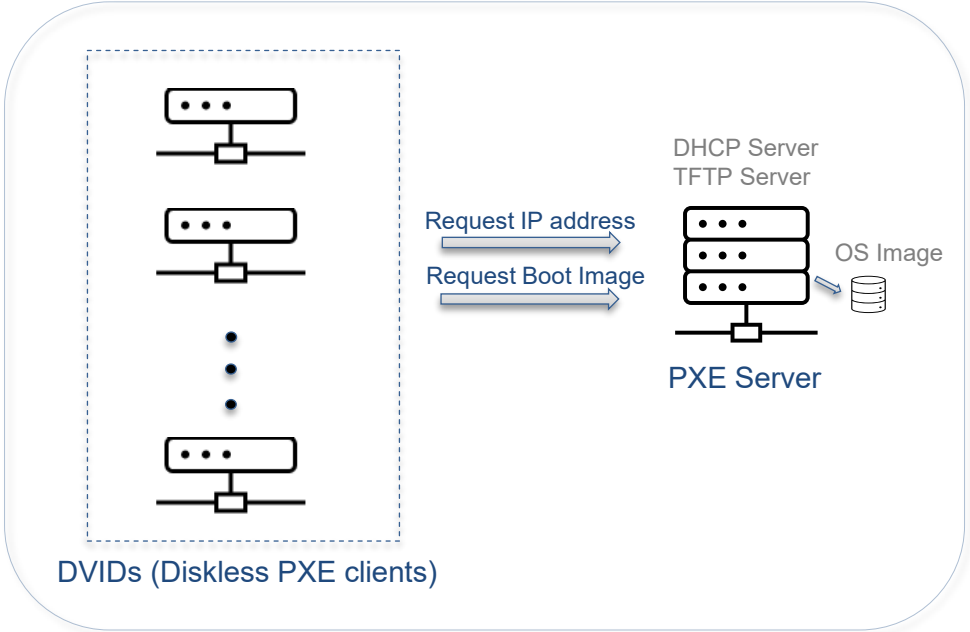
Potential Mitigation Strategies

- **Overall upgrade strategy**
  - In-Place incremental upgrade
  - Proven method with prior success
- **OS Upgrade / Replacement**
  - Windows options
    - Windows 7/ Windows 10
    - Multiple image problem remains
  - Linux options
    - Diskless Gentoo OS
      - A proven baseline implementation exists
    - RHEL, Debian or other distros
      - Significant effort to build a custom image
- **Camera Drivers / Software**
  - Proprietary
    - Manufacturer / 3rd party software vendor
    - Consolidated option not available / license costs
  - Opensource
    - Optimal approach: One driver per interface standard
- **Camera Maintenance Tools**
  - Test tools were available with proprietary camera software
  - Moving to opensource will require integrating alternative opensource tools

There are multiple upgrade strategies with associated pros and cons.

Modernized Architecture – Network booting Linux OS

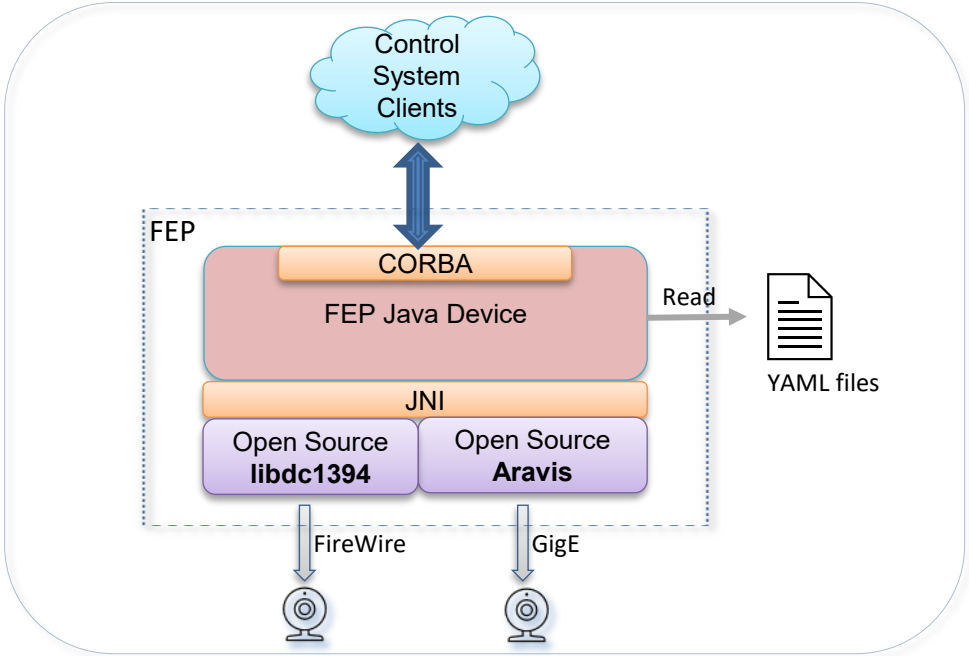
- **Gentoo based FEP OS**
  - Built on top of existing Diskless VME FEP OS
  - v4.14 LTS Kernel
- **Network booting**
  - Implemented using PXE, DHCP and TFTP.
- **Single image hosted by the TFTP server**
  - All DVIDs boot from the same image
  - DVIDs do not need an HDD (diskless)
- **Deploying a new OS image is simplified**
  - Deploy new OS image to the PXE server
  - Reboot DVIDs



The diskless DVIDs network boot from a single Linux OS image solving the multiple image and HDD maintenance problem.

Modernized Architecture – FEP software

- **Camera driver / library**
  - **FireWire: libdc1394**
  - **GigE: Aravis**
- **FEP Java implementation**
  - **Text based camera description file (YAML)**
  - **Generic architecture**
  - **Easy to add new cameras**
- **Performance considerations**
  - **CPU**
    - **Intel's Integrated Performance Primitives (IPP)**
  - **Network**
    - **Performance network driver availability**



Generic FEP implementation based on open-source camera drivers provides a clean and performant solution

Verification and Deployment - Streaming Performance

- **Extensive measurement of streaming performance**
  - **Multiple camera types**
  - **Multiple FEP machine types**
- **Optimizations to fix performance**
  - **Buffer size, packet size**
  - **Compression**

host	configuration			fps	measured* fps	diff from windows
	ROI	compression	bit depth			
PixeLINK 959G on Linux FEP, Dell R200)	1600 x 1200	ON	16	4	4	0.14
				5	5	0.35
				6	6	1.04
				7	6.93	1.07
				8	6.92	0.61
				9	6.833	0.433
	1600 x 1200	ON	8	10	8.8	-0.77
				11	8.75	-1.49
				12	8.58	-1.54
				13	8.6	-1.68
				14	8.55	-2.28
	1600 x 1200	OFF	16	4	3.95	0.92
				5	4.77	1.89
				6	5.22	2.32
				7	5.4	2.47
				8	7.54	4.68
				9	7.61	4.78
	1600 x 1200	OFF	8	10	9.46	3.63
				11	10.24	4.49
				12	10.78	4.99
				13	11.55	5.82
				14	13.16	7.33

Performance measurements assured that the converted system meets of exceeds the original performance.

Verification and Deployment

- **Test environments**
  - Dev, Int, QA
    - Replica of production DVIDs
    - Testing, dry-run of conversions.
  - Manual and automated tests
- **Deployment procedures**
  - Multiple teams involved
  - Short time window
  - Detailed procedure documentation
- **Revert strategy**
  - Windows Disk/Image retained as fallback
  - Removing DHCP config for a DVID automatically reverts to Windows disk boot

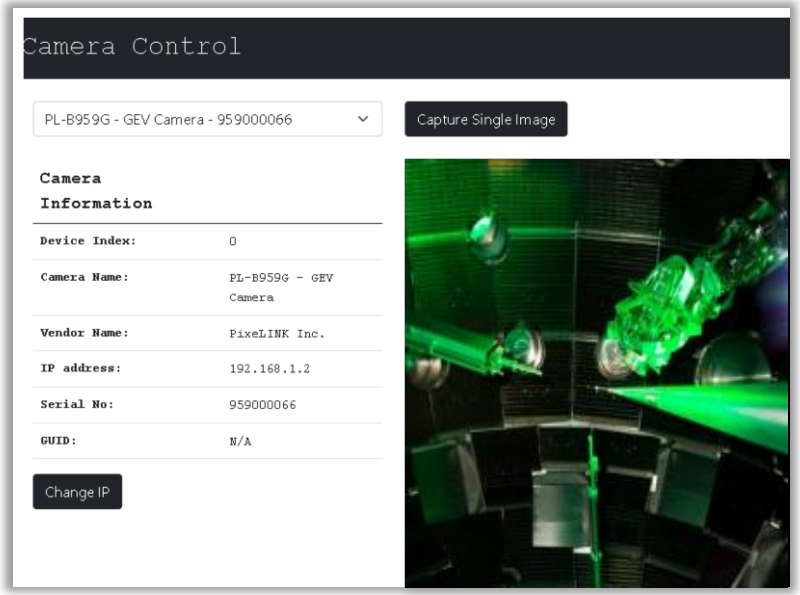
Status of deployments to NIF

- Diskless Linux solution successfully deployed to DVIDs in NIF
- Proven reliable operation in the NIF's 24x7 control system
- Successfully accomplished technology refresh of DVIDs, effectively solving the long-term maintenance challenge.

Verification in offline environments assured success at production deployments

Future Directions

- **Diskless Gentoo OS roadmap**
  - **Continuous integration**
    - **Faster rate of release and quicker fault isolation.**
  - **Semiannual releases**
- **Diskless Video FEP enhancements**
  - **More cameras per FEP**
  - **Support for other interface types**
    - **Analog-PCIe, Analog-Firewire**
- **Camera Maintenance GUI Tools**
  - **DVIDs provide a RESTful API**
  - **Secure access to camera controls**
  - **Web application uses the API service**



Long term maintenance risk is solved, but opportunities for further improvements exist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