FW centric devices,
NIC customization

Firmware Centrict Device

Configurable Firmware

- Modern devices are complex
  - More functionality <> More HW units and engines
  - More Processing power <> More capabilities
  - More NVM capacity <> More Configuration options !

- Modern Device <> FW centric device
- Some Modern Devices have ARM cores and can run entire Linux OS.
- Even some early NICs had MIPs cores running Linux OS

Customization Nightmare

Configurable Firmware

Multitude of features

- Multi port
- Multi function
- E-switch
- Virtualization
- Traffic shaping and rate limiting
- Multi protocol/stack (ethernet, rdma, vdpa, virtio, nvme, etc ..)
- Standard offloads (Checksum, GRO, TSO, etc ..)
- Modes of operation: eBPF, XDP, XSK, HDS, RDMA.
- Crypto offloads engines (TLS, IPSec, MACsec)
- TC offloads, tunneling and full pipeline offloads.
- Vendor specific optimizations

- These features simply don’t work in harmony magically out of the box.
- User specific demands per feature

ConnecTX (4 and later)

Some Stats

- 500K Lines of “core” code.
- ~600 NV config parameters
- Forward compatible devices
  - FW/driver backward compatible

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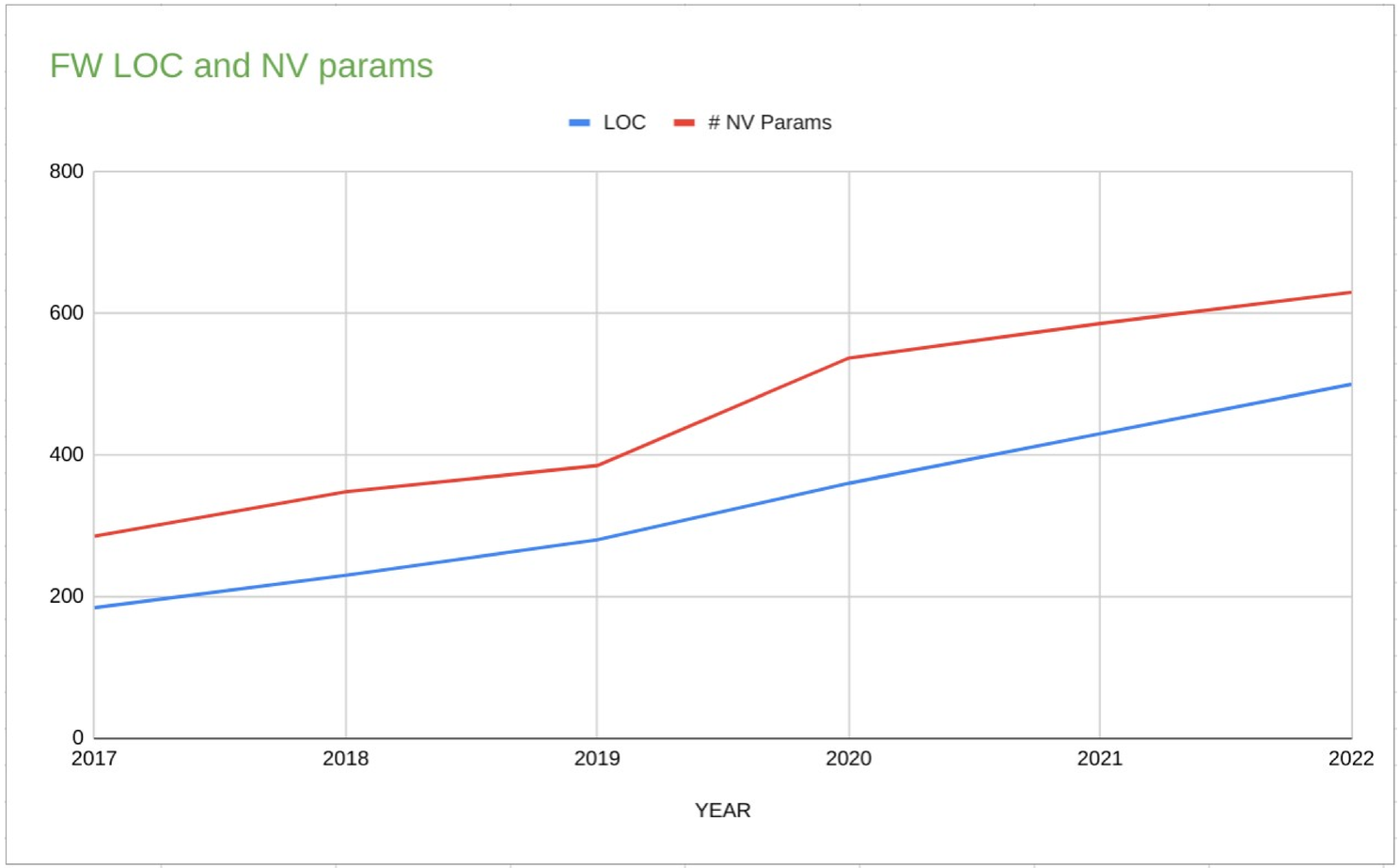


Highly configurable

Yet Not Flexible

- Sadly, although highly configurable, these devices aren’t as flexible.

- Human intervention is required, and recommended :).
- Exact combination of features to boot with
- Most efficient configuration
- Vendor specific optimizations and parameters.
  - ConnectX device has ~600 NV Firmware parameters
  - ~25% growth year over year.

- standardization can only go so far.

Vendor Specific Toolbox :’(

I don’t like them too!

- To address some of the issues vendors had to extend there basic Firmware and NVM tools

- Require direct user space access to PCI
- Require proprietary kernel modules and long list of toolchain

- Not welcome in production
- Long turnaround cycles
- Secure boot and secure kernel, no solution !

Real life stories :

- How do I increase your HW GRO timeout ?

- Booting to other OS to make configuration changes

- Personal Laptop i2c on production machines

- Forgetting a debug fw running in production

- down time due to bad custom fw, just to enable a simple flag !

Types of dials and knobs

- Functionality <> enable/disable/select.
- Performance <> parameters values, and rangers.
- Verbosity/Debugability (RAS feature) <> tirgger, monitor, capture, report

Categorization:

1) non-volatile device configuration and firmware update - static and preserved across reboots
2) Volatile device global firmware configuration – runtime.
3) Volatile per-function firmware configuration (PF/VF/SF) – runtime.
4) RAS features for FW - capture crash/fault data, read back logs, trigger device diagnostic modes, report device diagnostic data, device attestation

upstream APIs

Mainstream utilities (Devlink)

https://man7.org/linux/man-pages/man8/devlink-dev.8.html

- devlink goal was always to provide a healthy mix of standards based multi-vendor APIs side by side

- Devlink [vendor specific] params
- Devlink health
- Devlink resource
- Devlink port functions *

(1 & 2) Non-Volatile and Volatile NIC customization

Devlink parameters

https://www.kernel.org/doc/html/latest/networking/devlink/devlink-params.html

- SET:
  - devlink dev param set DEV name PARAMETER value VALUE cmode { runtime | driverinit | permanent }
- READ:
  - devlink dev param show
- Reload driver:
  - devlink dev reload pci/0000:01:00.0

- Vendor Specific params are marked
  - driver-specific

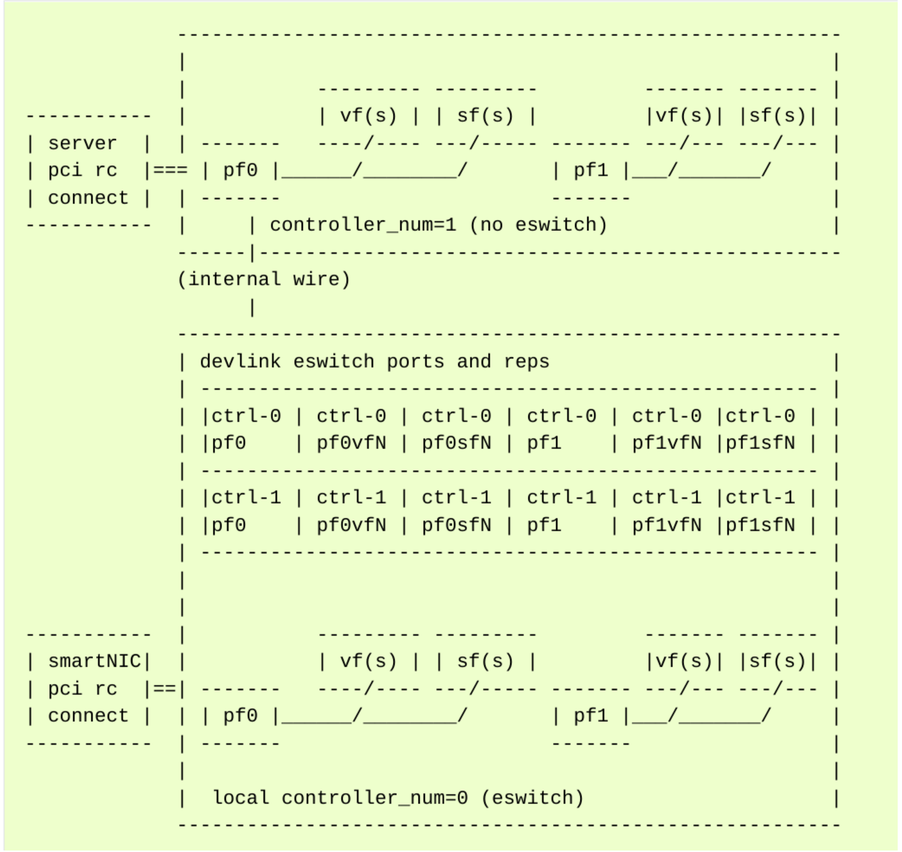
- Problems:
  - very hard to agree what's driver-specific what's generic
  - Almost everything starts as driver-specific
  - Only a small subset of NIC FW customization exist today in devlink !

```
bash-4.4# devlink dev param show
pci/0000:82:00.0:
  name internal_error_reset type generic
    values:
      cmode runtime value true
      cmode driverinit value true
  name max_macs type generic
    values:
      cmode driverinit value 128
  name region_snapshot_enable type generic
    values:
      cmode runtime value false
      cmode driverinit value false
  name enable_64b_cqe_eqe type driver-specific
    values:
      cmode driverinit value true
  name enable_4k_uar type driver-specific
    values:
      cmode driverinit value false
```

(3) Volatile Per function configuration (PF/VF/SF)

Devlink port functions
Virtualization mess

- Virtualization environments where physical, virtual and synthetic functions are spawned on demand
- VFs are created via sriov sub-system
- SFs are managed by eswitch
- These functions, are represented via function ports (port flavor) in devlink
- VF/SF customization required and life cycle managment
- High scale HW resource limitations
- Missing devlink params infrastructure per function port



RAS feature for FW

Trigger, monitor, capture, report

- Devlink provides many mechanisms but still the picture is incomplete !

- Devlink DPIPE – very specific to the offloading pipeline !
- Devlink health – very specific to driver faulty flows, although very rich in terms of RAS
- Devlink region – dump the whole configuration space or pre-defined registers
- Devlink resource – control limits of driver-registered HW resources

- Not really utilized or implemented by many drivers
- All of the above is READ only, the NIC debug state is immutable, without any external tools !
- Missing set-ability to enable disable hw dumps tracing and diagnostic mechanism

Vendor extensions

Dynamic approach

- High configurability issues isn’t specific to NICs and already had been addressed in many products
- Ethtool module eeprom and register dump* vendor specific parsing
- Nvme-cli : https://man.archlinux.org/man/nvme.1
  - Nvme-fw-log(1), nvme-smart-log(1) , nvme-fw-activate(1), nvme-fw-commit(1)
  - Plugins/Vendor extension commands:
    - nvme-intel-xyz
- Kubernetes: Container Network Interface (CNI) Specification plugins
  - plugin is a program that applies a specified network configuration.
  - https://github.com/containernetworking/cni/blob/spec-v1.0.0/SPEC.md#summary
- OpenStack
  - “OpenStack SDK is implemented as an extensible core, upon which vendor extensions can be plugged in”
- Libvirt ?

To summarize

- NIC attestation is still immature even with all
- Embargo on devlink parameters should be lifted ! it’s an unpopulated wonderland !
- Kernel Admins, developers, testers, and curious HW explorers will welcome such ability to easily customize the HW !

Questions ?