LAG AND HARDWARE OFFLOAD TO SUPPORT RDMA AND IO VIRTUALIZED INTERFACES

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Agenda

Current Link Aggregation limitations
Link Aggregation for RDMA
Seamless Link Aggregation for Virtual Machines
Discussion
LAG using bonding driver

Link Aggregation (LAG) offers link-level redundancy and performance improvements by using multiple links

Implemented by bonding driver

- SW driver between LAN drivers and the rest of network stack
- Can use ports from one or more NICs
- LAN driver does not need to know about bonding
  - Notifications send by bonding driver allows to build LAG-aware drivers
Problems with a legacy solution

**HW RDMA does not work with LAG**
- RDMA queues are not aware of a bonded link
  - Different path for RDMA traffic and regular LAN traffic
- Consequences:
  - RDMA-based storage solutions do not tolerate single link errors
  - Cannot easily boost RDMA performance by SW-based active-active

**SR-IOV LAN virtual functions (VFs) do not work with LAG**
- VF maps via Physical Function to the selected port
- Infrastructure detail exposed to the VM
- Consequence: to obtain link redundancy or performance boost, VM must be aware of bonding interface

Legend:
- Port 0
- Port 1
- TCP/IP stack
- LAN driver
- RDMA driver
- Bonding driver
- VEB 0
- VEB 1
- PF 0
- PF 1
- OS & drivers
- HW
Proposed solution

Implement active-backup LAG in a NIC driver

- Combined SW/FW solution

Address HW RDMA and VFs

Generic concept but details are NIC-specific

- No changes in generic kernel code
- No changes in NIC hardware
- Small changes in the NIC firmware
RDMA LAG:
Before failover

Separate PCIe Physical Functions (PFs) handle separate NIC ports
- LAN PF driver is aware of RDMA driver
- Control queue allocations
RDMA queues allocated from “active” PF
- Application directly uses HW queues
- Backup PF not used to allocate RDMA queues
LAN traffic handled via bonding driver
- LAN PF drivers aware of other bonding members and bonding state from netdev notifications

Single Virtual Ethernet Bridge (VEB) configured on RX
- Detailed rules to direct the traffic
Management & statistics
- Management via NIC drivers
- Statistic read by bonding driver from NIC driver
  - NIC driver expose statistics of right HW queues
RDMA LAG:
TX path after failover

RDMA TX queues are moved to the new active port
- Not visible by the application
  - The application still uses the same queues
- Traffic destructed only for a short time
- Controlled by the LAN driver using existing firmware commands
  - Reprogram TX scheduler to send RDMA traffic over the new port

Legend:
- Active
- Backup
- Not active

TX RDMA traffic redirected to port 1
RDMA LAG:
RX path after failover

Virtual Ethernet Bridge (VEB) on RX reconfigured
- Traffic from a new active port redirected to old active queues
- Control traffic from the new backup port go to old backup queues
  - LLDP, LACP

LAN drivers reconfigured
- Packets received by the old active queues passed via the new active netdevice

RDMA drivers not changed
- Traffic received on the same queues as before failover
- [Configuration, statistics]
Sharing resources between PFs

Separate network ports are managed by separate PCIe Physical Functions (PFs)

Each queue belongs to a given PF

- To redirect TX traffic, queue must be scheduled on the port belongs to another PF

New mechanism to enable sharing resources between PFs on the same NIC

- For security, all PFs involved must agree

A mechanism to move TX queues between ports

- Existing operations of a scheduler modified to be used for move RDMA queues and VF queues between ports
VF LAG:
Before failover

SR-IOV pass-through mode
- A VM uses VFs and HW-specific VF driver

VFs allocated from “active” PF
- Application queues available via VFs
- Backup PF not used to allocate VFs

Single Virtual Ethernet Bridge (VEB) configured on RX as for RDMA
- Host LAN traffic handled as for RDMA case
VF LAG:

After a failover

Performed similar to RDMA

TX direction:
- VF TX queues moved to a scheduler tree on the new active port

RX direction:
- VF RX queues still used
- All traffic from new active port redirect to old queues
  - Except control traffic – LLDP, LACP
Host-switch synchronization during handover

Before fail-over

Host kernel

MAC:AA:BB:CC:DD:01

bond0

eth0


eth1

Switch

Port0

FIB: AA:BB:CC:DD:01 – port0

After fail-over

Host kernel

MAC:AA:BB:CC:DD:01

bond0

eth0


eth1

Switch

Port0

FIB: AA:BB:CC:DD:01 – port1

1. Link failure

2. Failover from Eth 0 to Eth 1

2.1. Move MAC address

2.2. Send LOOPBACK packet

LOOPBACK: Eth 0x9000
MAC: AA:BB:CC:DD:01

3. Reconfigure internal forwarding data base
LAG for VMs: problem with the switch synchronization

Bonding driver notifies the Ethernet switch about MAC address assignment to port
- Only for bare metal LAN
- Bonding driver is not aware of VMs
- It cannot communicate the changes to the switch
- Switch FIB is no updated – VMs are not available

VM MAC addresses still visible at failed port
LAG for VMs: Ethernet switch FIB update

LAN driver notifies the Ethernet switch about VF MAC address assignment to a new port

- LAN PF driver knows all VFs
- The same LOOPBACK packet
- Switch FIB is updated – VMs are now available on the new port
Solution extension: use backup PF resources

Resources from backup PF can be also used when needed
- RDMA queues and VFs configured using “after failover” path
- Go back to “before failover” after actual failover
Conclusions and questions

Addressed problems:
- Active-backup for RDMA
- Seamless active-backup for VM

Remaining open:
- Active-active for RDMA and VMs

Looking for Your feedback about:
- Overall architecture
- Sending unsolicited LOOPBACK by the PF driver on behalf of VMs
BACKUP
RDMA LAG: Details of RX failover

- Single VEB for both ports
- RX rules to control packet flows
  - Detailed control traffic rules
  - Generic rules for the rest of the traffic
  - SW control mapping RX queues to netdevs

Legend:  
- Active
- Backup

![Diagram showing RDMA LAG and RX failover rules](image)
RDMA LAG: Details of RX failover

Single VEB for both ports

RX rules to control packet flows

- Detailed control traffic rules
- Generic rules for the rest of the traffic
- SW control mapping RX queues to netdevs

Legend:  
Active  
Backup