Abstract
Dell EMC delivers dynamic interface groups to simplify the use of multiple network interfaces between backup-application clients and the Dell EMC Data Domain System. Dynamic interface groups offer superior performance, load balancing and failover operations without involving the backup-application. This solution contains a policy engine that automatically routes clients to/from networks and encompasses multi-speed interfaces and VLAN tagged interfaces for smooth integration into any customer’s network.

August, 2017
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Executive Summary
One of the biggest challenges for ingesting hundreds of streams into the Data Domain system is to distribute those streams across multiple network interfaces for optimum performance. However, backup application clients access the Data Domain system through one host-name or IP address, creating a bottleneck due to the single IP connectivity. Data Domain Boost in conjunction with dynamic interface groups provides dynamic load balancing and redundancy for failover recovery while delivering full network bandwidth capacity and maintaining data-path (VLAN) isolation.

Audience
This white paper is intended for customer administrators, Dell EMC systems engineers, Dell EMC partners and members of the Dell EMC and partner professional services community responsible for deploying and configuring connectivity between backup-application client devices and a Data Domain system.

Background
The dynamic interface groups (formerly known as ifgroups) mechanism distributes backup-application client connections across available links on the Data Domain system while maintaining data-path (VLAN) isolation. When an error is encountered on a link, the dynamic interface groups’ configuration initiates a fail-over to another link within the isolated VLAN. The dynamic interface groups’ solution has no additional overhead on the stream of data to the Data Domain system; therefore, dynamic interface groups provide better performance and easier configuration compared to LACP. This white paper will describe the dynamic interface groups best practice configuration and its advantages over LACP.

Link Aggregation
There are two types of link aggregation that are commonly used for load balancing and failover. They are LACP and dynamic interface groups.

LACP (see figure 1) is one method of bundling several physical interfaces into one logical interface. LACP is defined in IEEE 802.3ad and is an open standard and should be used in a mixed vendor environment. However it is a point to point protocol, not an end to end protocol. LACP works in layer 2/3 of the Network stack.

Figure 1: LACP (Point to Point)
Dynamic interface groups (see figure 2) is a Dell EMC proprietary technology with 3 United States patents and is implemented in the application layer so it is an end to end protocol. It also has better performance due to less overhead in doing health check operations etc. Dynamic interface groups is part of the DD Boost API and recommended for efficient load balancing and failover plus many advanced features not available with LACP.

Since backup-application clients continue to access the Data Domain system through a single host-name or IP address, the dynamic interface groups mechanism utilizes the DD Boost client software in conjunction with Data Domain to manage the network connections. Backup-applications connect to the Data Domain system prior to initiating the “backup image” or “restore image” operations. These images vary from multiple megabytes to terabytes. Load balancing is established at the start of the operation with network disconnect/reconnect to select the best network interface for the particular client. Once backup-application operations are in progress, there is no additional overhead. Unlike LACP, there are no additional health check messages to consume usable interface bandwidth. This means that dynamic interface groups can be up to 60% more efficient.

Network errors are a combination of physical errors, such as a failed network switch, and transient errors, such as congestion errors. LACP is equipped to handle physical errors, but not transient errors at the TCP layer of the network. Dynamic interface groups is designed to handle both errors, and is especially effective for transient errors, where a network can reconnect on the same interface to clear transient congestion. The DD Boost protocol takes advantage of the dynamic interface groups failover ability; the client side protocol detects an unresponsive connection and initiates failover to reconnect to an IP provided by the Data Domain system.

All dynamic interface groups configurations are localized to the Data Domain system, unlike LACP where additional configuration is required on the network switch to associate network interfaces into Ether Channels. The Data Domain
The dynamic interface groups feature set handles a wide variation of customer’s networks with:

- **WAN** – Single physical interface that is used by backup-application to connect to Data Domain system.
- **LAN** – Multiple physical interfaces that can be used to distribute send or receive data including failover between these interfaces.
- **Multi-speed network** – Mixed physical interfaces with different network speed (i.e. 1G and 10G) where each backup-application client may be able to connect to a single speed or multiple speeds.
- **VLAN** – Data-path isolation through virtual interfaces where backup-application client is limited to accessing specific virtual interfaces.
- **NAT** – Client connection across NAT support load balancing over multiple Data Domain private IP addresses.

From a network connectivity perspective, VLAN tagged interfaces and different interfaces such as 1G and 10G, are similar in that they both result in client not being able to connect to a given IP address. Therefore, the dynamic interface group mechanism for these two unrelated problems is solved with the backup-application client “Group” association.

The configuration of dynamic interface groups associates a list of IP addresses with a list of backup-application clients in a group. There are two underlying rules for a dynamic interface group,

1. All the clients MUST be able to connect to every IP address within the group.
2. Every IP address within the group is on a unique physical interface, to ensure failover recovery.

These two rules ensure that a backup-application client can load balance against all interfaces within the group and can fail-over recover to any interface within its associated group. It is important to note that 10G interface and 1G interface are treated equally in the load balancing decision. Operations that start on the 10G interface will complete sooner, allowing the next operation to re-use the interface, therefore there is no advantage in assigning weights to the interface bandwidth capacity for load balancing assignment. However, the decision to combine 10G interface and 1G interface within the same dynamic interface group requires that each of the clients be able to communicate with both 10G and 1G.

Each physical interface may exist as a virtual interface within a dynamic interface group. This allows multiple VLANs to utilize the same physical ports while maintaining data-path isolation. A typical network environment can also be gradually updated from 1G to 10G and move backup-application clients from dynamic interface groups containing 1G interfaces to dynamic interface group containing 10G interfaces.

A dynamic interface group for NAT is established by configuring the pre-translated IP address of the Data Domain system against the physical port of the translated IP, creating a new group. Clients that need to access via NAT are configured to use the dynamic interface group with the pre-translated IP addresses.

Unlike LACP which requires taking interfaces offline for configuration, dynamic interface groups configuration can be done at any time without impacting network traffic and availability. Adding dynamic interface groups with additional VLAN interfaces, or adding backup-application clients to dynamic interface groups does not impact any in progress operations. Newly made configuration changes are effective at the start of the next backup-application operation. For example, if an additional interface is added to a dynamic interface group, it will be available for load balancing at the start of next backup-application “backup image” or “restore image”.

The dynamic interface groups mechanism is tailored to optimize performance between backup applications and the Data Domain system over multiple network paths where the physical network interfaces are dedicated to the backup-application connections. For Data Domain systems prior to DD OS 5.7, the best practice recommendation was to separate physical interfaces involved in replication and they were not to be included in the list of dynamic interface groups interfaces. Prior to DD OS 5.7 Data Domain Managed File Replication (MFR) had been optimized to work best if it did not share a physical interface with “backup image” or “restore image”. This was especially true when the MFR source connection was a 10G interface and the target network had a much lower bandwidth. Sharing a physical link...
between dynamic interface groups and MFR caused TCP congestion, which was transparently recoverable for backup or restore operations, but not for MFR operations.

Beginning with DD OS 5.7, Dell EMC has expanded the use cases for dynamic interface groups to include replication. Dynamic interface groups provides customers with a tool to increase replication performance (2 links) and reliability (failover) which is particularly attractive in situations where networks are unreliable. Dynamic interface groups are supported for Managed File Replication.

Both the source and destination Data Domain systems are involved in load balancing and failover selection of the local interface. The dynamic interface group for MFR is selected based on the remote Data Domain system name and local Data Domain system MTree path involved in the replication.

This mechanism allows separate dynamic interface groups to be created between two Data Domain systems for a different MTree path. This is ideal for service provider environments where they want to isolate replication traffic for each tenant to a different network.

**Client Routing and IP Management**

Client routing is a tool that allows administrators to control client connections using a dynamic interface group policy. This dynamic interface group use case started when customers asked Dell EMC to come up a solution to access clients on different subnets without using static routes. Subnets were growing fast because they were running out of IP address. Our solution was to implement a policy engine which could be used for automatic distribution of backup LAN IP addresses.

Another customer challenge is that most backup networks are not linked to DNS server, so the backup IP addresses have to be managed separately. Dynamic interface groups provides a way to automate the distribution of IP addresses.

There are multiple customer use cases for client routing with dynamic interface groups. Cost management for charge back purposes is one reason why many enterprise customers have metered-LANs to monitor traffic and control costs. Corporate LANs are metered-LANs, while backup networks are not. Dynamic client routing make sure the backup traffic says on the backup network, even when the backup client sits on the corporate LAN. In addition, if there is a problem with a client connecting to the Data Domain system, dynamic interface groups can prevent the clients from failing back to the public IP.

Another use case is for IPv4 to IPv6 Transitions. If a client connects with an IPv6 or IPv4 address, it will be routed to the dynamic interface group of its type.

A third use case is for managing a large pool of clients. In large customer environments it is difficult to maintain a client IP range on the same subnet as the Data Domain system. If the client and the Data Domain system are on separate subnets, often the solution is to implement static routes. Static routes are manual overrides which have to be tracked offline, which network administrators like to avoid because it creates extra work and risk because all changes are manual and it is easy to overlook one or more static routes over time. A better solution is to create additional IP alias/VLANs to match the client subnet, no longer requiring the use of static routes.

And finally, another use case is to overcome rules set by network administrators. Often large enterprises don't allow any deviation/changes to ETC/Host files on Unix clients. With this rule, you cannot make the changes necessary to put these clients onto the backup network. Administrators can overcome this obstacle using dynamic interface groups.

**How Client Routing Works**

Here is a brief explanation of how client routing works using dynamic interface groups. (see figure 3),

1. The client sends a session request that contains host name, client IP and the Data Domain system IP (IPv4 or IPv6)
2. The client information is matched to a group policy (lookup table) stored on the Data Domain system
3. The Data Domain system issues client a new IP address per group policy
4. The backup client is connected to the Data Domain system over the backup network & begins backup job.

![Client Routing: How it works](image)

**Best Practices**

Customers use dynamic interface groups to avoid having to configure VLAN IPs on clients for the data-path interface they want to use. Without dynamic interface groups customers would need to edit the /etc/hosts file on each client and add an entry for the Data Domain system data-path for the particular VLAN,

- For the DD Boost protocol use the dynamic interface group feature set for backup-application clients to get best performance. LACP does not deliver full bandwidth of all the interfaces that compose the link. For two interfaces, only 40% of the second interface is available for user data with LACP.
- In High Availability is required, use LACP on the WAN interface for the backup-application administered connection. The “backup image” and “restore image” will utilize the dynamic interface groups interfaces without LACP.
- For MFR use a separate physical interface than the dynamic interface groups interfaces to avoid network congestion.
- In a mixed protocol environment it’s better to keep CIFS/NFS traffic and DD Boost traffic on different interfaces. If the customer cannot afford to create multiple interfaces it is ok to use dynamic interface groups for CIFS/NFS traffic.

**Comparing with LACP**

Some customers hesitate to use dynamic interface groups because they are not as familiar with it as LACP and don’t understand some of the important differences of these two networking approaches. The chart in figure 4 highlights some of the important differences between Dynamic Interfaces Groups and LACP.
Customer Benefits
Data Domain customers using DD Boost can benefit in many ways by leveraging the dynamic interface groups feature set. Data Domain dynamic interface groups,

- Are easier to install and maintain than LACP
- Provide up to 60% greater bandwidth than LACP
- Changes are applied more quickly without the need to take interfaces down providing higher availability
- Provide greater resiliency to network failures
- Provide load balancing between 1G and 10G interfaces
- Gives customers more flexible client routing options
- Enables more scalable IP management
- Improve replication performance & reliability

Conclusion
Dynamic interface groups is a market proven Dell EMC patented technology that provides efficient load balancing and client failover, as well as dynamic client routing. With the greater performance and bandwidth that dynamic interface groups provides, customers can reduce costs and maximize private network utilization by redirecting clients. In addition, with dynamic interface groups, Hybrid Cloud application capabilities allow new DD Boost enabled clients to connect to a Data Domain system over the backup network lowering costs and requiring less configuration management.