

# FCoE Target Functional Specification

Version 1.02

Jun 23 2008

## 1 Project Description

Fibre Channel over Ethernet (FCoE) is a mapping of Fibre Channel over selected full duplex IEEE 802.3 networks. "Selected" means:

- The network must be lossless by supporting 802.3x PAUSE;
- The network must support Jumbo frame to encapsulate the 2KB FC frames;
- The NICs must support multiple unicast MAC addresses, required by FPMA (Fabric Provided MAC Address) defined in FCoE Specification.

The purpose of this project is to provide FCoE target functionality to Solaris.

### 1.1 Definition

Although FCoE transports FC frames over Ethernet, it still has the same FC-2 and above layers as standard FC. This means we could make use of all common FC features in Solaris and only implement FCoE specific functions.

FC target capability has already been integrated into Solaris with COMSTAR project. In order to provide FCoE target capability, we need to define two new entities :

- An FCA driver which exports FC target port to COMSTAR FCT module (Fibre Channel Port Provider), but talks to FCoE transport instead of a physical FC HBA.
- An FCoE transport which talks to MAC layer to access Ethernet frames directly (VLAN is supported).

In Solaris, most Ethernet controller drivers are implemented under GLDv3 framework where they all register to a common MAC service module. So we are designing the FCoE transport as a GLDv3 MAC client, hence the FCoE transport could run on top of any GLDv3 NIC drivers theoretically.

The management of FCoE target is through fcadm utility. Two new sub-commands will be added to fcadm to create and delete FCoE target ports.

HBAAPI will be able to handle FCoE target ports just like normal FC target ports.

### 1.2 Motivation, Goals, and Requirements

FCoE is a newly proposed T11 standard and is advocated by all leading IT vendors. With FCoE, customers can achieve I/O consolidation by leveraging their existing FC investment and knowledge with the 10 Gigabit Ethernet infrastructure. I/O consolidation results in less adapters, less power consumption, less cooling requirement and less cabling. Adding support of FCoE will enrich Solaris open storage stacks, make Solaris competitive to other Operating Systems in terms of storage

connection capability.

The purpose of this project is to provide FCoE target capability for Solairs. This is a software FCoE solution which means it will run with normal Ethernet NICs. It's supposed to run on both x86/x64 and SPARC.

### **1.3 Changes From the Previous Release**

This is a new product.

### **1.4 Program Plan Overview**

#### **1.4.1 Development**

Development is ongoing in Beijing. The fcoe driver, fcoet driver and fcadm changes have been prototyped.

#### **1.4.2 Quality Assurance/Testing**

Functional tests.

Performance tests: Basic I/O performance over Neptune PCI-E 10G NIC.

Interoperability tests: Will be tested with Cisco Nexus 5000 FCoE switch, normal FC initiators and FCoE initiators (including Open-FCoE software initiator, QLogic CNA and Emulex CNA).

#### **1.4.3 Documentation**

Two new manpages fcoet(7d) and fcoe(7d) will be created.

fcadm(1M) will be updated.

Solaris SAN Configuration and Multipathing Guide (820-1931) will be updated.

#### **1.4.4 Release Cycle**

An alpha release of the project will be put on OpenSolaris by July 2008. Integration to Solaris Nevada is targeting build 112 (Q3 FY09).

#### **1.4.5 Technical Support**

TBD

#### **1.4.6 Training**

TBD

## **1.5 Related Projects**

### **1.5.1 Dependencies on Other Sun Projects**

PSARC/2007/523 COMSTAR: Common Multiprotocol SCSI Target

PSARC/2004/291 Fibre Channel HBA Port Utility

PSARC/2004/571 Nemo - a.k.a. GLD v3

PSARC/2006/357 Crossbow - Network Virtualization and Resource Management

### **1.5.2 Dependencies on Non-Sun Projects**

Part of fcoet driver source is ported from Open-FCoE (a Linux based software FCoE implementation) under BSD license. Homepage is at <http://www.open-fcoe.org>

### **1.5.3 Sun Projects Depending on this Project**

None

### **1.5.4 Projects Rendered Obsolete by this Project**

None

### **1.5.5 Related Active Projects [Describe the relationship.]**

None

### **1.5.6 Suggested Projects to Enhance this Program**

Software Fabric Services running on Solaris systems.

This project will eliminate the requirement of FCoE switches in case that all nodes in the Data Center Ethernet are FCoE nodes.

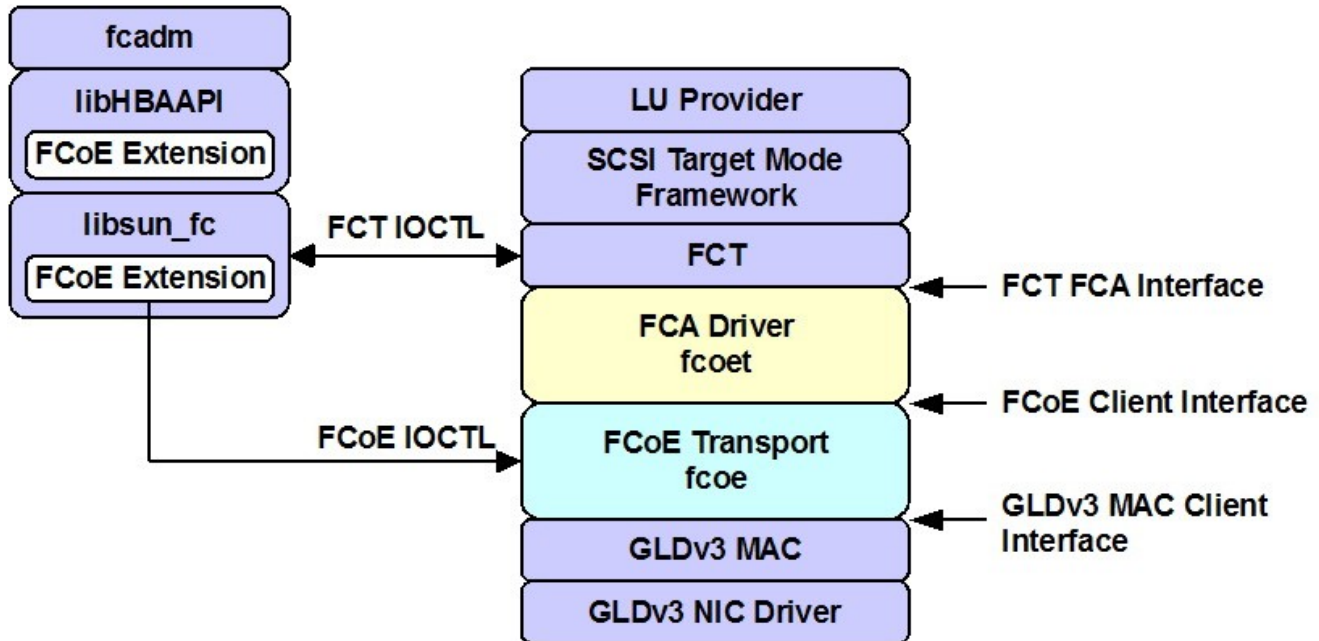
## **1.6 Competitive Analysis**

Intel is maintaining an open-source FCoE target stack on Linux which has both initiator and target capability. Both QLogic and Emulex have announced CNAs (Converged Network Adapter) which are hardware FCoE HBAs. So far no FCoE target devices have been announced by storage vendors.

This project is a software solution, instead of inventing a new FC target mode stack, the existing COMSTAR FCT framework is used. This project may enable Solaris based storage devices (especially SunFire X4500) to be among the earliest FCoE target devices/disk arrays in the market.

## 2 Technical Description

### 2.1 Architecture



Two new kernel drivers are introduced in this product.

- The FCA driver is designed as a new pseudo kernel driver "fcoet". It's also an implementation of FCoE VN\_Port entity as defined in FCoE Specification.
- The FCoE transport is designed as another pseudo kernel driver "fcoe". It's an implementation of FCoE LEP entity as defined in FCoE Specification.

fcoe and fcoet work together in a service provider/client manner. There is only one instance of fcoe driver across the system which provides FCoE transport services (MAC interface management, FCoE frame encapsulation/de-encapsulation, FCoE frame TX/RX). Multiple fcoet driver instances could co-exist within the same system and consume FCoE transport services provided by fcoe through FCoE Client Interface.

Part of fcoet code is ported from [www.open-fcoe.org](http://www.open-fcoe.org) under BSD license. The inbound OSR and outbound OSR have been approved.

The management of FCoE target is through fcadm utility. Two new sub-commands will be added to fcadm to create and delete FCoE target ports. fcadm will use libHBAAPI to issue ioctls to fcoe driver to accomplish this.

A new SMF service will create FCoE ports upon boot according to the information in `/etc/fcoe/fcoe_ports`.

## 2.2 Interfaces

### 2.2.1 Exported Interfaces

Interface Name	Proposed Stability Classification	Specified in What Document?	Former Stability Classification or Other Comments
FCoE client interface	Project Private	See R.3.1	
IOCTLs for libHBAAPI	Project Private	See R.3.2	
fcadm command line	Committed	fcadm.man	
fcadm output	Committed Not an interface	fcadm.man	

### 2.2.2 Imported Interfaces

Interface Name	Proposed Stability Classification	Specified in What Document?	Former Stability Classification or Other Comments
T11 FCoE Specification	Standard	T11 web site	See Appendix A for exact titles
FCT FCA Interface	Project Private	writing_fca.txt	FCA programming guide for COMSTAR FCT
GLDv3 MAC Client Interface	Consolidation Private	PSARC/2004/571 PSARC/2006/357	Crossbow project will change GLDv3 MAC Client Interface, but is not integrated yet
libstmf	Committed		Used for storing FCoE port configurations

## 2.3 User Interface

There will be extensions to existing CLI user interfaces.

fcadm will allow creating and deleting FCoE ports.

```
fcadm create-fcoet-port <mac i/f> [-o] [-n <FCoE_Node_WWN>] [-p <FCoE_Port_WWN>]
```

```
fcadm delete-fcoet-port <mac i/f>
```

See fcdm.man for more details.

## **2.4 Compatibility and Interoperability**

### **2.4.1 Standards Conformance**

FCoE is a technology being developed with TC T11 as part of the FC-BB-5 project. The current documents are at <http://www.t11.org/fcoe>

### **2.4.2 Operating System and Platform Compatibility**

Solaris Nevada on both X86 and SPARC platforms will be supported.

Ethernet controllers meets the following requirements are supported:

- Has a GLDv3 driver in Solaris;
- Supports 802.3X PAUSE;
- Supports Jumbo frame;
- Supports Multiple Unicast MAC Address (However if this feature is not supported by the hardware, FCoE can still function by setting Promiscuous mode. In this case, an explicit option must be given at the fcdm command line when creating FCoE target ports).

### **2.4.3 Interoperability with Sun Projects/Products**

FCoE Target will support Leadville FC initiators (across an FCoE switch) and Solaris FCoE Initiator (PSARC/2008/311).

### **2.4.4 Interoperability with External Products**

FCoE Target will interoperate with any FC initiators with the existence of an FCoE switch in the SAN.

FCoE Target will interoperate with any FCoE initiators, either in back-to-back mode, or with connections to an FCoE switch.

### **2.4.5 Coexistence with Similar Functionality**

No known overlap in functionality.

Both Emulex and QLogic CNAs provide FCoE connectivity, but so far without target capability.

### **2.4.6 Support for Multiple Concurrent Instances**

There will be only one instance of fcoe driver. There could be multiple instances of fcoet driver.

Version mismatch between fcoe and fcoet driver will stop FCoE target ports from being created.

### **2.4.7 Compatibility with Earlier and Future Releases**

This will be the first release of the product. All exported interfaces will maintain backward

compatibility in the future.

## **2.5 Performance and Scalability**

### **2.5.1 Performance Goals**

When running on systems that have enough CPU power, the FCoE Target is supposed to saturate a 10G Ethernet link provided that the Ethernet controller is able to fan out to multiple tx/rx rings and load balance FCoE frames so that it can reach full line speed throughput. SCSI I/O throughput will be lower than line rate due to overheads.

### **2.5.2 Performance Measurement**

The performance will be measured by dd, vdbench and other SCSI benchmarking tools.

### **2.5.3 Scalability Limits and Potential Bottlenecks**

Any MAC interface in the host could be configured as an FCoE target port as long as system resources are available. Hardware limitation like CPU power, PCI-E resources, NIC RX/TX channel configuration, LUN backing stores are potential bottlenecks.

### **2.5.4 Static System Behavior**

fcoe and fcoet driver footprints are small (no more than 500 kbytes).

FCoE port configuration file will be small, approximately 100 bytes per FCoE port.

### **2.5.5 Dynamic System Behavior**

This is a software FCoE solution, there are code paths which are CPU intensive (e.g. FC-CRC calculation). Depending on the CPU power, when I/O traffic to FCoE target ports is heavy, CPU utilization could go very high.

## **2.6 Failure and Recovery**

### **2.6.1 Resource Exhaustion**

FCoE target port creation will fail when system resource is exhausted.

### **2.6.2 Software Failures**

No planned software failures.

### **2.6.3 Network Failures**

FCoE network failures are managed in the same way as FC SAN. Link failures between NIC port and switch are reported by MAC layer, link failures between switch and remote devices are reported through RSCN ELS to the local FCoE port. All failures will be handled accordingly by determining the

nature of the change.

#### **2.6.4 Data Integrity**

FCoE data integrity is protected via 32-bit FC-CRC which is calculated and checked in fcoe driver.

#### **2.6.5 State and Checkpointing**

N/A

#### **2.6.6 Fault Detection**

TBD

#### **2.6.7 Fault Recovery (or Cleanup after Failure)**

N/A

### **2.7 Security**

A physically secured and controlled network is mandatory for FCoE to run on. However FC-SP (Fibre Channel Security Protocol standard by T11) can be used with FCoE to enforce more security. FC-SP is intended as a secure protocol which includes authentication and encryption, but it is not widely implemented in the industry and is not implemented in Solaris yet

### **2.8 Software Engineering and Usability**

#### **2.8.1 Namespace Management**

Common prefix for fcoe driver source is fcoe\_.

Common prefix for fcoet driver source is fcoet\_.

New package for fcoe driver is named "SUNWfcoe".

New package for fcoet driver is named "SUNWfcoet".

#### **2.8.2 Dependencies on non-Standard System Interfaces**

N/A

#### **2.8.3 Year 2000 Compliance**

N/A

#### **2.8.4 Internationalization (I18N)**

No change in existing I18L level. fcdm will follow current convention.

### **2.8.5 64-bit Issues**

This product will be 64-bit clean.

### **2.8.6 Porting to other Platforms**

No.

### **2.8.7 Accessibility**

No new CLI or GUI, only additions to existing CLI.

## **3 Release Information**

Note: Some of the packaging and installation details may not be available at design time. Describe expected solutions, and augment the description as the details are decided.

### **3.1 Product Packaging**

This product is bundled with Solaris.

#### **3.1.1 Package Overview**

New package "SUNWfcoe"

- package for fcoe driver
- default installation root is /kernel/
- required

New package "SUNWfcoet"

- package for fcoet driver
- default installation root is /kernel/
- required

The reason to deliver this product in two new packages is that another project FCoE Initiator will also need fcoe driver (but not together with fcoet driver).

#### **3.1.2 (Default) Installation Locations**

fcoe and fcoet drivers will be installed at /kernel/ directory structure.

#### **3.1.3 Effect on External Environment**

SUNWfcoe will be shared with a future project "FCoE Initiator" PSARC/2008/310

## **3.2 Installation**

### **3.2.1 Installation procedure**

Standard Solaris installation, no change.

### **3.2.2 Effects on System Files**

None.

### **3.2.3 Boot-Time Requirements**

fcadm will be called at boot time (from SMF) to create FCoE ports.

### **3.2.4 Licensing**

N/A

### **3.2.5 Upgrade**

FCoE client interface is versioned. In case of version mismatch between fcoe and fcoet, creating FCoE target port will abort and an error message will be printed.

### **3.2.6 Software Removal**

Standard package tools.

## **3.3 System Administration**

Only CLI administration tools are supported:

- fcdm is used to create and delete FCoE target ports.
- fcinfo is used to report status of FCoE target ports.

## **4 FCoE Target Driver Architecture**

### **4.1 Description**

fcoet is a pseudo driver that:

- registers to fcoe driver as client of FCoE transport;
- registers to FCT as local port;
- implements FCT local port functions through FCT FCA interfaces;
- dispatches incoming FC frames to FCT routines for processing;
- implements FC exchange/sequence management.

fcoe is a pseudo driver that:

- loads on demand (when creating FCoE ports via fcdm);
- has only one instance across the system;
- registers to GLDv3 MAC layer as a MAC client;
- maintains the FCoE-enabled MAC interface table;
- provides IOCTLs for fcdm to create or delete FCoE ports and attaches/detaches fcoet drivers accordingly;
- manages WWNs for each FCoE ports;
- encapsulates FC frames to FCoE frames, de-encapsulates FC frames from FCoE frames;
- transmits/receives FCoE frames via the MAC interface;
- maintains global data structure to track registered fcoet instances.

libHBAAPI and libsun\_fc will be extended to handle FCoE ports.

There are some functions to be implemented in fcoet driver to support HBAAPI. HBA attributes and port attributes are populated from fcoet driver to FCT when libsun\_fc issuing FCTIO\_GET\_###\_ATTRIBUTES commands. Port statistics are tracked by fcoet driver and sent upon FCTIO\_GET\_ADAPTER\_PORT\_STATS command issued to FCT.

## 4.2 Interfaces

### 4.2.1 User-visible

None.

### 4.2.2 Internal (optional for ARC review)

fcoe driver is exporting FCoE client interface for fcoet driver.

## 4.3 Operation

The first time fcoe driver gets loaded is when "fcdm create-fcoet-port" is issued. Upon rebooting with FCoE ports configured, service /lib/svc/method/fcoeconfig will call fcdm to create the ports at boot time, and fcoe driver will be loaded then.

fcdm will issue ioctl to fcoe driver, and fcoe driver will open the designated MAC interface, then load fcoet driver. fcoet driver registers itself to FCT and creates an FCT local port. When the initialization is done, FCT takes control of login process and a FCoE target port is accessible to initiators.

When FCoE target port is online, FCoE frames received at the MAC interface are de-encapsulated in fcoe driver, the FC frames are then passed to fcoet driver to be dispatched to different FCT functions according to their R\_CTL fields. FC data sent from FCT are passed to fcoet to build valid FC frames, then encapsulated into FCoE frames and transmitted to MAC layer with minimum overhead.

After successful "stmfadm offline-target", an FCoE target port could be deleted by issuing "fcdm delete-fcoet-port". fcoe driver will offline fcoet and close the associated MAC interface. Both fcoet and fcoe driver could be unloaded then.

## **5 fcdm and fcinfo CLI**

### **5.1 Description**

Two new subcommands will be added to fcdm to create and delete FCoE target ports. fcinfo will be able to list FCoE target port attributes and link statistics.

### **5.2 Interfaces**

#### **5.2.1 User-visible**

See proposed fcdm man page and additions for fcinfo.

#### **5.2.2 Internal (optional for ARC review)**

fcdm will open fcoe driver and send IOCTLs to fcoe driver to create and delete FCoE target ports.

### **5.3 Operation**

fcdm will be used to create and delete FCoE target ports.

fcinfo will be used to return status of FCoE target ports.

FCoE target port data will be stored and retrieved with libstmf functions. The configuration is read upon boot by fcdm to create FCoE target ports automatically.

## **Appendix A: Standards Supported**

dpANS - Fibre Channel - Backbone - 5, T11/08-352v0

<http://www.t11.org/ftp/t11/pub/fc/bb-5/08-352v0.pdf>

Latest FCoE Specification and all documents are available at <http://www.t11.org/fcoe>.

## **References**

### **R.1 Related Projects**

PSARC/2007/523 COMSTAR: Common Multiprotocol SCSI Target

PSARC/2004/291 Fibre Channel HBA Port Utility

PSARC/2004/571 Nemo - a.k.a. GLD v3

PSARC/2006/357 Crossbow - Network Virtualization and Resource Management

### **R.2 Background Information for this Project or its Product**

OpenSolaris project page

<http://opensolaris.org/os/project/fcoe/>

## R.3 Interface Specifications

### R.3.1 FCoE Client Interface

fcoe\_client\_t

Structure used to manage FCoE Client (fcoet or fcoei).

Format

```
typedef struct fcoe_client {
    uint32_t    ect_eport_flags;
    uint32_t    ect_max_fc_frame_size;
    uint32_t    ect_private_frame_struct_size;
    char        ect_channel_name[32];
    void        *ect_client_port_struct;
    void        (*ect_rx_frame)(fcoe_frame_t *frame);
    void        (*ect_port_event)(fcoe_port_t *eport, uint32_t event);
    void        (*ect_release_sol_frame)(fcoe_frame_t *frame);
} fcoe_client_t;
```

Fields

ect\_eport\_flags

Flags for FCoE port. This is a bitfield with the following values

```
#define    EPORT_FLAG_N2N            0x01
#define    EPORT_FLAG_TGT_MODE      0x02
#define    EPORT_FLAG_INI_MODE      0x04
```

ect\_max\_fc\_frame\_size

Maximum FC frame size in bytes.

Default is 2136.

ect\_private\_frame\_struct\_size

Size of fcoet\_frame\_t or fcoei\_frame\_t. Depending on the client type (fcoet or fcoei).

ect\_channel\_name

Null ended MAC interface name string.

ect\_client\_port\_struct

Pointer to fcoet\_soft\_state\_t or fcoei\_soft\_state\_t. Depending on the client type (fcoet or fcoei).

ect\_rx\_frame

Function pointer to fcoet or fcoei. Called by fcoe when FCoE frames are received from MAC layer.

ect\_port\_event

Function pointer to fcoet or fcoei. Called by fcoe when port event occurs.

ect\_release\_sol\_frame

Function pointer to fcoet or fcoei. Called by fcoe in its watchdog routine to release all solicited frames.

### **R.3.2 fcoe driver IOCTL**

2 IOCTLs are defined in fcoe driver.

#### **FCOEIO\_CREATE\_FCOET\_PORT**

This IOCTL is used to create an FCoE target port on the given MAC interface.

Input arguments: MAC interface name, FCoE target port NWWN, FCoE target port PWWN.

If the NWWN and PWWN arguments are not specified, fcoe driver will generate one pair based on the MAC address of that interface.

If MAC interface is successfully opened, fcoe driver will load fcoet driver.

#### **FCOEIO\_DELETE\_FCOET\_PORT**

This IOCTL is used to delete an FCoE target port from the given MAC interface.

Input argument: MAC interface name.

The precondition is that the FCoE target port be offlined by stmfadm first, otherwise an error will be returned to the userland.

If the FCoE target port has been successfully offlined, fcoe driver will offline fcoet devnode. Upon success the both fcoe and fcoet driver instance could be unloaded from memory.

### **R.3.3 FCoE SMF Service**

Content of /lib/svc/method/fcoeconfig

```
/usr/sbin/fcadm create-fcoet-ports
```

Content of fcoe\_config.xml

Dependencies TBD

### **R.3.4 Suggested manpage change for fcadm**

See fcadm.man.

### **R.3.5 COMSTAR FCT FCA Programming Guide**

See writing\_fca.txt.

## **R.4 Project Details**