



LAWRENCE
LIVERMORE
NATIONAL
LABORATORY

LLNL-TR-747669

Fibre Channel Development Final Report CRADA No. TC-0340-92-C

T. J. Voss, T. Flanagan

March 12, 2018

Disclaimer

This document was prepared as an account of work sponsored by an agency of the United States government. Neither the United States government nor Lawrence Livermore National Security, LLC, nor any of their employees makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or Lawrence Livermore National Security, LLC. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or Lawrence Livermore National Security, LLC, and shall not be used for advertising or product endorsement purposes.

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Fibre Channel Development

Final Report CRADA No. TC-0340-92-*c*

Date: June 1997

TACT:

Revision: 1

A. Parties

The project is a relationship between the Lawrence Livermore National Laboratory (LLNL) and Jaycor.

University of California
Lawrence Livermore National Laboratory
7000 East Avenue, L-XXX
Livermore, CA 94550

Jaycor
P.O. Box 85154
San Diego, CA. 92138-5154
Attn: Terry Flanagan

B. Project Scope

The Fibre Channel (FC) Development project was designed to enhance U.S. industrial competitiveness by accelerating the standardization and subsequent industrial acceptance of the American National Standards Institute's (ANSI) Fibre Channel Standard (now X3T11). It was also intended to give the principal U.S. participants a one- to two-year lead in developing heterogeneous high-speed computer networks, distributed computing through clustering, scientific visualization techniques, and high speed channels. The project was proposed to benefit U.S. industry as these high performance computing methods became generally available. In 1992-93, during the initial project phases, Fibre Channel (FC) was emerging as a new ANSI standard. It was envisioned as becoming the mechanism for data transfer between the next generation of computers, and between these computers and their peripherals. Using this channel standard, U.S. computer vendors were expecting to be able to provide high-speed interoperability between heterogeneous computers and their storage devices, with data transfer rates greater than a GBit/sec.

Our project was composed of key principal players in the FC standardization effort from both U.S. industry and the Department of Energy's (DOE's) Lawrence Livermore National Laboratory (LLNL). The industrial participants were developing individual FC interfaces to operate with their platform products. LLNL's role was to be a neutral testing site and a facilitator for helping to resolve conflicting interpretations of the embryonic Fibre Channel specification. LLNL anticipated that conflicts in the interpretation of such a standard would arise and require neutral resolution and that such resolutions would best be achieved in cooperation with the ANSI FC Working Group. Project plans included transferring to U.S. industry any resilient FC testing capabilities at the project conclusion.

This project was extended from its original planned termination of May 30, 1996, until December 31, 1996 under an agreement to shift a portion of the DOE-provided funding from FY95 into FY96.

Project deliverables were defined and modified on a case by case basis to suit the specific industrial partners needs for testing their equipment and their product availability. Since the fundamental activity performed by LLNL was product testing, the LLNL milestones & deliverables were

subject to industrial partners product availability and were adjusted to accommodate each partners readiness for testing. Most scheduling delays were either anticipated or announced by industrial partners in advance such that both parties could adjust resources to accommodate the scheduling changes.

C. Technical

LLNL has made several valuable contributions to the success of Fibre Channel as an acknowledged ANSI Standard:

1. LLNL's (and hence DOE's) presence and participation in the ANSI committees helped to provide industry with the reassurance that this Standard is a worthy pursuit.
2. LLNL authored the Fibre Channel Link Encapsulation (ANSI FC-LE) specification which is now an accepted ANSI Standard for coupling Fibre Channel with higher level protocols.
3. LLNL tested products and discovered conflicts in the interpretation of the early draft FC Standard and sought resolution in cooperation with the ANSI FC Working Group to revise the Standard and assisted the involved industrial partners to achieve interoperable products.
4. During the final project phases several other groups attempted to establish test beds for Fibre Channel and/or test beds for high speed switching & networking product testing. Time will tell if these efforts prove successful. LLNL did have a limited informal collaboration with two of these project groups in an advisory role.

D. Partner Contribution

Jaycor contributed the following product for testing at LLNL:

- a. FibreStar Fibre Channel S-bus Adapter, (266 Mbps, S-bus) (Qty 1)

LLNL was unable to test this FC product due to product status and insufficient resources. The card was provided as a prototype on a "best effort" basis without a suitable device driver for a supported platform, and as such could not be tested with the existing LLNL FC test bed resources.

E. Documents/Reference List

No CRADA Protected information was generated during this project.

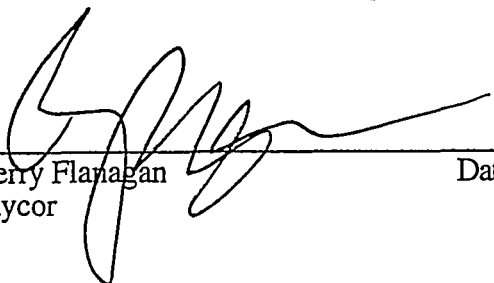
No patent or copyrights were generated, nor are any pending as a result of this project.

No subject inventions were disclosed by any industrial partners to LLNL, nor did LLNL disclose any inventions to any industrial partners during this project.

F. Acknowledgment

Participant's signature of the final report indicates the following:

- 1) The Participant has reviewed the final report and concurs with the statements made therein.
- 2) The Participant agrees that any modifications or changes from the initial proposal were discussed and agreed to during the term of the project.
- 3) The Participant certifies that all reports either completed or in process are listed and all subject inventions and the associated intellectual property protection measures attributable to the project have been disclosed or are included on a list attached to this report.
- 4) The Participant certifies that if real property was exchanged during the agreement, all has either been returned to the initial custodian or transferred permanently.
- 5) The Participant certifies that proprietary information has been returned or destroyed by LLNL.


Terry Flanagan
Jaycor

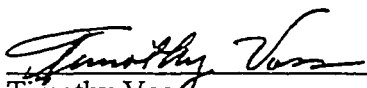
9/22/87
Date

Attachment I – Final Abstract
Attachment II – Project Accomplishments Summary
Attachment III – Final Quarterly Report

F. Acknowledgment

Participant's signature of the final report indicates the following:

- 1) The Participant has reviewed the final report and concurs with the statements made therein.
- 2) The Participant agrees that any modifications or changes from the initial proposal were discussed and agreed to during the term of the project.
- 3) The Participant certifies that all reports either completed or in process are listed and all subject inventions and the associated intellectual property protection measures attributable to the project have been disclosed or are included on a list attached to this report.
- 4) The Participant certifies that if real property was exchanged during the agreement, all has either been returned to the initial custodian or transferred permanently.
- 5) The Participant certifies that proprietary information has been returned or destroyed by LLNL.

 7-29-97
Timothy Voss Date

Attachment I – Final Abstract
Attachment II – Project Accomplishments Summary
Attachment III – Final Quarterly Report

Fibre Channel Development

Final Abstract Attachment I CRADA No. TC-0340-92

Lawrence Livermore National Laboratory has entered into a research agreement with Hewlett-Packard Corporation, International Business Machines Corporation, and Sun Microsystems, Inc. for a Fibre Channel Development project. LLNL will assess interoperability of heterogeneous Fibre Channel products and facilitate the resolution of conflicting interpretations of the draft Fibre Channel Standard. The CRADA's goal is to accelerate the standardization and acceptance of the American National Standards Institute's Fibre Channel, for the benefit of customers and vendors of Fibre Channel products. The Fibre Channel will be a future mechanism to facilitate communications at data rates greater than one gigabit per second, between heterogeneous computer systems and between systems and peripheral devices.

Fibre Channel Development

Project Accomplishments Summary (Attachment II) CRADA No. TC-0340-92

Date: July 1997

Revision: 1

A. Parties

The project is a relationship between the Lawrence Livermore National Laboratory (LLNL) and industrial partners: Hewlett-Packard Company, (HP), International Business Machines, (IBM), Jaycor Corp (Jaycor). and Sun Microsystems, (Sun).

University of California
Lawrence Livermore National Laboratory
P.O. Box 808, L-795
Livermore, CA 94550

Hewlett-Packard Company, (HP)
19420 Holmstead Road,
Cupertino, CA. 95014-9810
Attn: Suhas Badve, M/S 43LN

International Business Machines, (IBM);
Advanced Workstation Development (AWD)
11400 Burnett Rd.
Austin, TX 78758
Attn: Carl Zeitler, M/S 9570

Jaycor
P.O. Box 85154
San Diego, CA. 92138-5154
Attn: Terry Flanagan

Sun Microsystems, (Sun)
2550 Garcia Ave.
Mountain View, CA. 94043
Attn: Bob Williamsen, M/S MPK12-203

B. Background

In 1992, Fibre Channel (FC) was an emerging American National Standards Institute (ANSI) standard for next generation computer networking and peripheral I/O. Industry had only a few prototype implementations of Fibre Channel products. FC testing centers had yet to exist. Competing standards existed for high speed networking (e.g. ATM) and alternative standards for peripheral channels and/or clustering interconnects (e.g. SCSI, IPI, IEEE 1394 Serial Bus and IEEE 1596 SCI) had many computer systems manufacturers and end-users in search of better methods for connecting larger and faster storage systems to computers and networks.

This project was intended to give the principal US. participants a one- to two-year lead in developing heterogeneous high-speed computer networks and high-speed peripheral channels using this new FC standard.

LLNL had key principal members who helped originate the concept of Fibre Channel and who were then members of the ANSI committee for Fibre Channel, (then X3T9). LLNL also had needs for this emerging technology as it was envisioned that it would enhance LLNL's ability to build larger and faster computer systems to then contribute to the scientific programs' abilities to achieve their goals, such as stockpile stewardship. LLNL could also serve industry in this effort by being a neutral site for testing and ANSI standards committee negotiations, should that be necessary to resolve conflicts in standards interpretation.

C. Description

The Fibre Channel (FC) Development project was designed to enhance US. industrial competitiveness by accelerating the standardization and subsequent industrial acceptance of the ANSI Fibre Channel Standard (now X3T11). The project was proposed to benefit US. industry as these high performance computing methods became generally available. In 1992-93, during the initial project phases, Fibre Channel (FC) was emerging as a new ANSI standard. It was envisioned as becoming the mechanism for data transfer between the next generation of computers, and between these computers and their peripherals. Using this channel standard, US. computer vendors were expecting to be able to provide high-speed interoperability between heterogeneous computers and their storage devices, with data transfer rates greater than a GBit/sec.

The industrial participants were developing individual FC interfaces to operate with their platform products. LLNL's role was to be a neutral testing site and a facilitator for helping to resolve conflicting interpretations of the embryonic Fibre Channel specification. LLNL anticipated that conflicts in the interpretation of such a standard would arise and require neutral resolution and that such resolutions would best be achieved in cooperation with the ANSI FC Working Group.

The LLNL FC test bed was established in May 93 and operated until December 1996. During this project time frame, LLNL constructed the test bed and developed testing methodologies and test suites as proposed. LLNL assisted participants in testing their FC implementations and resolving interoperability issues. LLNL also collaborated with participants to demonstrate their new technologies to the open market at conferences and industry trade shows. These events (e.g., InterOP, SuperComputing, HPCN) were key to achieving interoperability and accelerating time-to-market and in gaining market acceptance and visibility.

D. Expected Economic Impact

Results of this effort are being witnessed today with the establishment of Fibre Channel as the method of choice for future high-speed channels and as the successor to SCSI as the peripheral attachment method of choice. Leading US. companies are now producing FC computer host adapters and/or FC storage systems and the market for FC products is projected to grow. US companies are now enjoying a lead in time-to-market for FC products over foreign competitors.

E. Benefits to DOE

Computer simulation and modeling form the cornerstone of the DOE ASCI program's efforts to shift from nuclear test-based methods to compute-based methods for maintaining the safety, reliability and performance of the nuclear stockpile. This modeling and simulation requires advanced data communications and storage capabilities with high transfer rates for rapidly accessing modeling data and running the necessary simulation codes. Fibre Channel is becoming a method of choice for providing this high-speed access.

LLNL core competence has been enhanced through our participation with industry and the ANSI committees including the insights we have gained into the technical aspects of FC and FC product utilization. This knowledge will benefit internal LLNL networks and computing and storage facilities.

F. Industry Area

Areas of industry which are benefiting from Fibre Channel include electronics components manufacturers, computer system manufacturers and integrators, data communications and networking companies, mass storage manufacturers, test equipment manufacturers, cabling and connector providers.

G. Project Status

This project is complete.

H. LLNL Point of Contact for Project Information

Tim J. Voss,
(510) 422-0452
(510) 423-2492 (FAX)
Internet: timvoss@llnl.gov

I. Company Size and Point(s) of Contact

This CRADA has multiple industrial participant companies. Current contacts are:

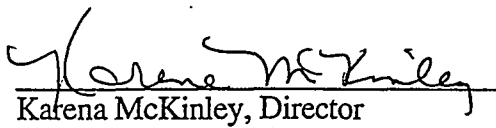
HP:	Gary Wermuth (916) 785-4520
IBM:	Jerry Chapman (512) 838-7530
Jaycor:	Terry Flanagan (619) 392-6580
Sun Microsystems:	Bob Williamsen (415) 786-6490

J. Project Examples

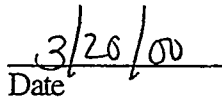
This project constructed a test bed for testing industrial partners' products. Results were reports of technical operation relevant to the product(s) being tested. After project conclusion, the test bed was dismantled and member's equipment was returned to them. Project notes, test software and results have been archived to off-line storage.

K Release of Information

I certify that all information contained in this report is accurate and releasable to the best of my knowledge.



Karena McKinley, Director
Industrial Partnerships
and Commercialization


Date

RELEASE OF INFORMATION

I have reviewed the attached Project Accomplishment Summary prepared by Lawrence Livermore National Laboratory and agree that the information about our CRADA may be released for external distribution.

Gary Wermuth
Hewlett-Packard Company

Date

July 13, 1997

RELEASE OF INFORMATION

I have reviewed the attached Project Accomplishment Summary prepared by Lawrence Livermore National Laboratory and agree that the information about our CRADA may be released for external distribution.

Jerry Chapman
IBM

Date

July 13, 1997

RELEASE OF INFORMATION

I have reviewed the attached Project Accomplishment Summary prepared by Lawrence Livermore National Laboratory and agree that the information about our CRADA may be released for external distribution.

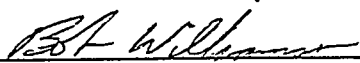
Terry Flanagan
Jaycor

Date

July 13, 1997

RELEASE OF INFORMATION

I have reviewed the attached Project Accomplishment Summary prepared by Lawrence Livermore National Laboratory and agree that the information about our CRADA may be released for external distribution.



Bob Williamsen
Sun Microsystems

10/2/97
Date

Lawrence Livermore National Laboratory

Title: Fiber Channel Development Consortium

Participant: See Attached

DOE TTI No.: 93-LLNL-047-C1

CRADA No.: TC-0340-92

TACT: CA&A

Account Numbers: 4725-02, 7606-01

Accounts Closed:

Approved Funding Profile (\$K)

Reporting Period: 07/01/95 - 12/31/96

Date CRADA Executed: 5/8/93

DOE Approval Date: 5/3/93

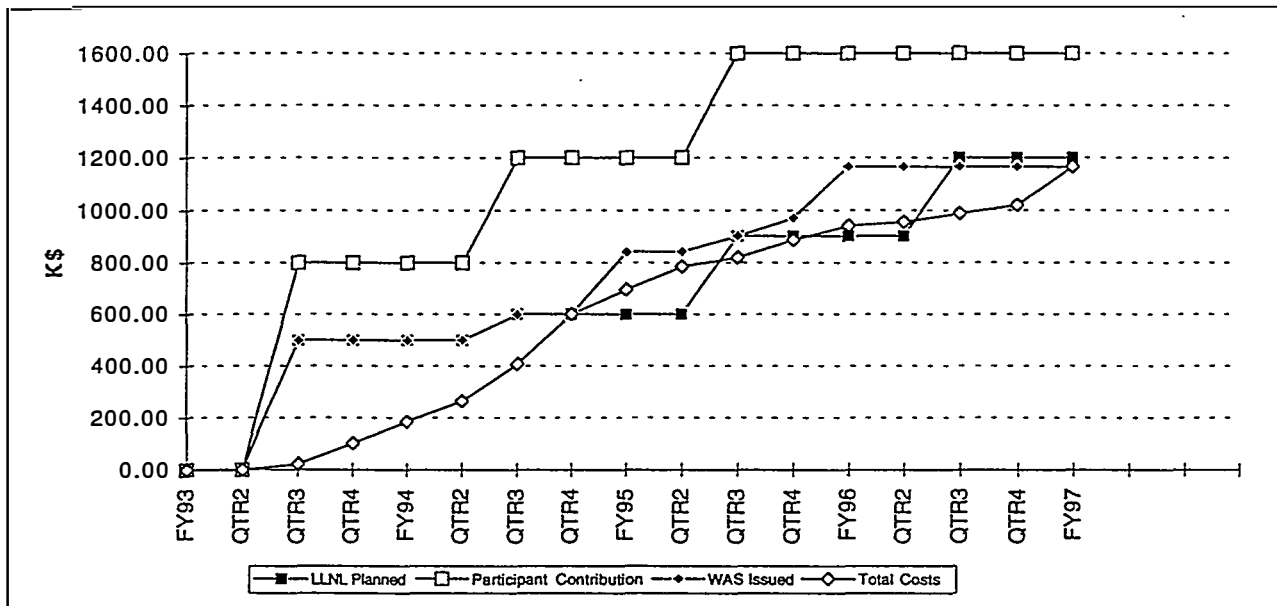
Scheduled Ending Date: 5/8/96

Project Completed: 12/31/96

B & R Code (S): DP0301

35DP03

	FY93	FY94	FY95	FY96	FY97	Total
LLNL Planned	500	100	300	300	0	1200
Participant In-Kind	800	400	400	0	0	1600
Participant Funds-In	0	0	0	0	0	0
WAS DP0301	400	100	369	216	0	1085
WAS 35DP03	100	0	0	-21	0	79
Total Costs	101	499	285	134	145	1164



DP0301	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	FYTD
FY93	0	0	0	0	0	0	0	0	17	16	36	26	95
FY94	26	18	15	18	24	38	44	39	60	48	48	48	426
FY95	21	41	34	33	29	26	9	9	16	18	32	18	285
FY96	25	20	10	5	4	7	13	13	5	15	7	10	134
FY97	35	100	10	0	0	0	0	0	0	0	0	0	145

1085

35DP03	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	FYTD
FY93	0	0	0	0	0	0	0	0	6	0	0	0	6
FY94	24	0	0	0	0	0	0	0	0	49	0	0	73
FY95	0	0	0	0	0	0	0	0	0	0	0	0	0
FY96	0	0	0	0	0	0	0	0	0	0	0	0	0
FY97	0	0	0	0	0	0	0	0	0	0	0	0	0

79

STAFF w/phone:

Lab PI: Tim Voss (510)422-0452

Participant: See Attached

Resource Manager: Nancy Moore (510) 422-9341

DOE OAK: Jerry Scheinberg (510) 637-1653

DOE HQ: A. Larzelere (202) 586-1101

Lawrence Livermore National Laboratory

Reporting Period : 07/01/95 - 12/31/96
DOE TTI No.: 93-LLNL-047-C1
CRADA No.: TC-0340-92

Page 2

Milestones and Deliverables:

List the complete set of milestones for all phases of the CRADA. Continue on a separate page if necessary.
Report any changes from the original CRADA or previous quarterly report on the CRADA Change Form.

Completion Date:
Scheduled _____ Actual _____

2
3
4
5
6
7
8

See previous Milestone charts for each CRADA partner and LLNL.

Verification of participants' in-kind contribution was made in
accordance with LLNL policy. Explain basis of verification:

Please initial: YES X NO _____

List any subject inventions by either party (include IL# for LLNL inventions), additional background intellectual
property, patents applied for, software copyrights, publications, awards, licenses granted or reportable economic impacts

Verification that all equipment and proprietary information has
been returned to the initial owner or permanently transferred

Please initial: YES X NO _____

Accomplishments

Describe Technical/Non-Technical lessons learned and other observations.
Summarize causes/justification of deviations from original scope of work.

Reviewed by CRADA project Program Manager:

Date: _____

Reviewed by Karena McKinley, Acting Director, LLNL/IP&C:

Karena McKinley Date: 3/20/00

Direct questions regarding this Report to IP&C Resource Manager, Susan Springer, at (510) 422-5507