

# The Fox Project: Advanced Development of Systems Software

R&D STATUS REPORT  
1 JULY TO 30 SEPTEMBER 1996

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Carnegie Mellon University  
Pittsburgh, PA 15213

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**DTEC QUALITY INSPECTED 1**

The long-term objectives of the Carnegie Mellon Fox Project are to improve the design and construction of systems software and to further the development of advanced programming languages. We use an advanced programming language in the design and construction of systems software, including operating systems, network protocols, and distributed systems. The language is based on Standard ML (SML), a modern functional programming language that provides polymorphism, first-class functions, exception handling, garbage collection, a parameterized module system, static typing, and a formal semantics. This Project involves several faculty members and spans a wide range of research areas, from (1) experimental development of systems software to (2) advanced compiler development to (3) language design.

## 1 Research Progress

For each of the three areas listed above, we report on the research accomplishments during the third calendar quarter of 1996, and the research objectives for the fourth quarter of 1996.

### 1.1 Experimental Development of Systems Software

#### Accomplishments (Jul-Sept):

- Completed and made available release 2 of the Fox Net. The new release runs on both Alpha/OSF and MIPS/Ultrix architectures.
- Developed a prototype system for "proof-carrying code" for the DEC Alpha, and used it to implement a collection of safe and fast network packet filters.

#### Objectives (Oct-Dec):

- Complete the analysis and performance improvement for the Fox Net release 2.
- Add Kerberos security to the FoxNet implementation of the telnet protocol.
- Use building block protocols to produce a complete implementation of the IP v6 protocol.

#### Noteworthy publications:

- George Necula and Peter Lee. Safe Kernel Extensions Without Run-Time Checking. Accepted to *Second USENIX Symposium on Operating System Design and Implementation (OSDI'96)*.

## 1.2 Language Design

### Accomplishments (Jul-Sept):

- Completed development of a core calculus for higher-order modules with sharing by producing a revised type-theoretic account of Standard ML 1996. This account consists of a syntax-directed translation of SML-96 programs into a typed intermediate language. The intermediate language is an explicitly-typed lambda calculus with product, sum, recursive, and module types.

### Objectives (long-term):

- Develop a preliminary implementation of the "ML1996" core language; specifically, develop a type checker for the modules system.

### Objectives (Oct-Dec):

- Complete a realistic implementation of refinement types for ML, structuring the implementation so that the modal system for staged computation can also be incorporated.

### Noteworthy publications:

- Robert Harper and Chris Stone. A Type-Theoretic Account of Standard ML 1996 (Version 2), Tech Report TR-CS-96-136R, School of Computer Science, Carnegie Mellon University.

## 1.3 SML Compiler and System Development

### Accomplishments (Jul-Sept):

- Completed development of a preliminary version of a front end to the TIL compiler for Standard ML 1996. This front end is based on type theory and makes use of inference rules.

### Objectives (Oct-Dec):

- Evaluate the performance of the TIL compiler on systems and networking code and compare it to the performance of SML/NJ.
- Extend the Fabius prototype compiler to handle assignable references.
- Extend the TIL compiler to compile the SML modules language.

## 2 Capital Equipment Purchases

- 6 Seagate 4GB Disk Drives, \$6,360.00.
- 2 WS-C2080 Catalyst 2800 25-Port 10Base-T Switches, \$7,395.00.
- 2 EXB8505 Exabyte 7-14GB 8MM Tape Drive Subsystems w/Cable and Terminator \$3,940.00.

### 3 Key personnel changes

- Chris Colby has completed his dissertation on "Trace-Based Program Analysis" and is now an Assistant Professor at Loyola University in Chicago.
- Chris Okasaki has completed his dissertation on "Purely Functional Data Structures" and will begin his position as a Research Associate with the Fox Project, starting October 1, 1996.
- Mark Leone has left the project to begin a teaching position in the Computer Science Department at Indiana University. He plans to complete his dissertation on "Automatic Lightweight Run-Time Code Generation" while teaching at Indiana.

### 4 Noteworthy meetings

- Robert Harper, Peter Lee, and Chris Okasaki participated in the IFIP Working Group 2.8 meeting in Mohonk, New York, September 22-27. Peter Lee talked about "Proof-Carrying Code" and Chris Okasaki talked about "Catenable Double-Ended Queues".

### 5 Administrative Data

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F19628-95-C-0050

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Hanscom Air Force Base

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The Fox Project: Advanced Languages for Systems Software

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08 JUN 95

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FY95	922,250				
FY96	0	964,201			
FY97	0	0	1,008,341	423,046	
FY98	0	0	0	0	444,260
TOTAL	922,250	964,201	1,008,341	423,046	444,260

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31 DEC 96

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Base Effort	PLANNED	PROVIDED	DELTA
Funding for 7/96-9/96	0	0	0
Funding for 10/96-12/96	0	0	0
FY96 Base	0	0	0

Option 1	PLANNED	PROVIDED	DELTA
Funding for 7/96-9/96	276,227	276,227	0
Funding for 10/96-12/96	276,227	276,227	0
FY96 Option 1	552,454	552,454	0

Funding for 1/97 - 3/97	205,873	0	205,873
Funding for 4/97 - 6/97	205,874	0	205,874
FY97 Option 1	411,747	0	411,747

Option 2	PLANNED	PROVIDED	DELTA
Funding for 7/97 - 9/97	252,085	0	252,085
Funding for 10/97 - 11/97	168,057	0	168,057
FY97 Option 2	420,142	0	420,142

Option 3	PLANNED	PROVIDED	DELTA
Funding for 7/97 - 9/97	105,761	0	105,761
Funding for 10/97 - 11/97	70,508	0	70,508
FY97 Option 3	176,269	0	176,269

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