Distributed Control Systems at SSRL
Constraints for Software Development Strategies

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Overview

Computing Environment at our Beam Lines
- Need for cross-platform development.
- Need for distributed architecture.

Beam Line Software
- Need for collaborative software.
- Need for high performance software.

Software Development Strategy
- Constraints on our strategy.
- Our current strategy.
User Environment at Beam Line

Display 1 (20"

Display 2 (24"

Display 3 (20"

Display 4 (24"

Video Camera 1

SGI 1

Backup Devices

SGI 2

Backup Devices

Video Camera 2

Video Camera 3

Video Camera 4

Experimental Hardware

X Terminal

Detector

Hutch
Network Architecture of a Beam Line

Central SSRL Network

X Terminal

SGI 1

SGI 2

DEC UNIX

Private Network

Detector

VMS

NT

Galil

Galil

Galil

Galil

Beamline Optics

Experimental Hardware
Problem 1: Multiple Hardware Hosts

Diagram:
- VMS Computer
  - CAMAC Crate
    - SSRL Standard Control Electronics
      - Beamline Optics
    - Custom Control Electronics
      - Experimental Apparatus
- NT Computer
  - Galil
  - Galil
  - Galil
Problem 2: Multiple, Simultaneous User Interfaces

- CCD Data Collection Software
  - CCD Detector
  - Goniometer
- Beamline Configuration Software
  - Fast Shutter
  - Ion Chambers
- Beamline Monitoring Software
  - Beamline Optics
Solution: Distributed Control System (DCS)
Beam Line Universal - Integrated Configuration Environment (BLU-ICE)
BLU-ICE Motor Scan Windows

Screen shot of the BLU-ICE Motor Scan Windows interface with a focus on the selected motor "mirror_pitch". The interface includes options for defining scan parameters such as scan axes, detectors, timing, and filters. The graph on the right shows a plot of the scan results with time on the x-axis and mirror_pitch on the y-axis.

11 Mar 1999 12:27:54 NOTE: Connecting to server bl921 on port 3175...
11 Mar 1999 12:28:00 define_scan
11 Mar 1999 12:29:34 select_motor slit_l_vert_gap
BLU-ICE Motor Configuration Windows

[Image of software interface showing motor configuration options and settings]
Advantages of Writing BLU-ICE in Tcl/Tk

Command Prompt with Scripting
- Tcl was originally designed to be an embedded scripting language, so it is easy to give the user a command prompt and a full featured programming language for scripting.
- User can script any operation in BLU-ICE using control structures, variables, procedures, and even classes.

Platform Independent GUI
- Tcl/Tk runs on any Unix, VMS, Mac, and 32-bit Windows computer.
- Scripts can be distributed without compilation and run on any computer Tcl/Tk has been installed on.
- Scripts can also be bundled with Tcl/Tk binaries and distributed as a single executable file. In this case, Tcl/Tk does not have to be installed on the target machine.

Rapid Development
- Tcl/Tk GUIs can be written with only a fraction of the code necessary in typical system programming languages such as C, C++, or Java.
- GUIs can be quickly written and are easy to maintain in Tcl.
- This characteristic is critical in the rapidly changing environments of our beam lines.

Object Orientation
- The [Incr Tcl] extension to Tcl provides object-oriented features such as classes.
- The [Incr Widgets] extension provides an object oriented framework for building complex widgets from built-in Tcl widgets.

Extensible in C/C++
- Tcl was designed to be extended readily in C. Extensions can be loaded dynamically.
- High performance code, multiple threads and so on are best implemented in extensions.
Data Collection with the New BLU-ICE
DCSS Performance Now Critical
Cross-Operating System Library (XOS)

Features

- **Supports portable, multithreaded, distributed programs**
  - Network communication using a much simplified socket object.
  - Thread creation and synchronization with mutexes and semaphores.
  - Memory mapped files and hash tables.
  - Interthread communication using message queues and Win32-style messages.

- **Compile-time approach**
  - Header file xos.h loads appropriate, system-dependent include files.
  - Objects hide architectural differences.

Advantages

- **Portability**
  - Compile code on Digital Unix, IRIX, OpenVMS, Windows NT/95.
  - Easy to port to new platforms similar to any of the above.

- **Reliability**
  - Simpler APIs leads to more reliable code.
  - Less need to study different platforms.

- **Performance**
  - Native system calls on each platform for maximum performance
  - No runtime overhead for platform independence.
Constraints for Software Development Strategies

Cross-Platform
- Multiple operating systems needed at beam lines; future needs unknown.
- Remote users of the collaboratory may have many different operating systems.
- Other synchrotron labs and even users’ home labs may use our software.
- Must support VMS because other SSRL beam lines use it nearly exclusively.
  ➔ Use XOS (Cross-Operating System) Library for low-level software and Tcl/Tk for GUI components when feasible.

Distributed
- Applications must integrate services provided by different computing platforms.
- User interfaces must be kept separate from other components.
  ➔ Use TCP/IP socket interfaces between all application components.

High-Performance Server Processes
- Server software must be extremely fast and take advantage of multiple processors.
  ➔ Write multithreaded C++ programs with XOS for portability.

Open Source
- Must be able to distribute all software freely without licensing issues.
- Installation distributions, source code and documentation should be nicely packaged.
- Document well enough that other groups can use and extend our solutions on their own.

Low Maintenance Overhead
- Write packages in layers that mix and match.
- Wrap packages in clean APIs that do not require knowledge of underlying code.
- Avoid requiring complex infrastructures. Make it easy for novice programmers.