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NATIONAL INSTRUMENTS

TAKING ADVANTAGE OF MULTICORE PROCESSORS FOR RELIABLE REAL-TIME APPLICATIONS

Agenda

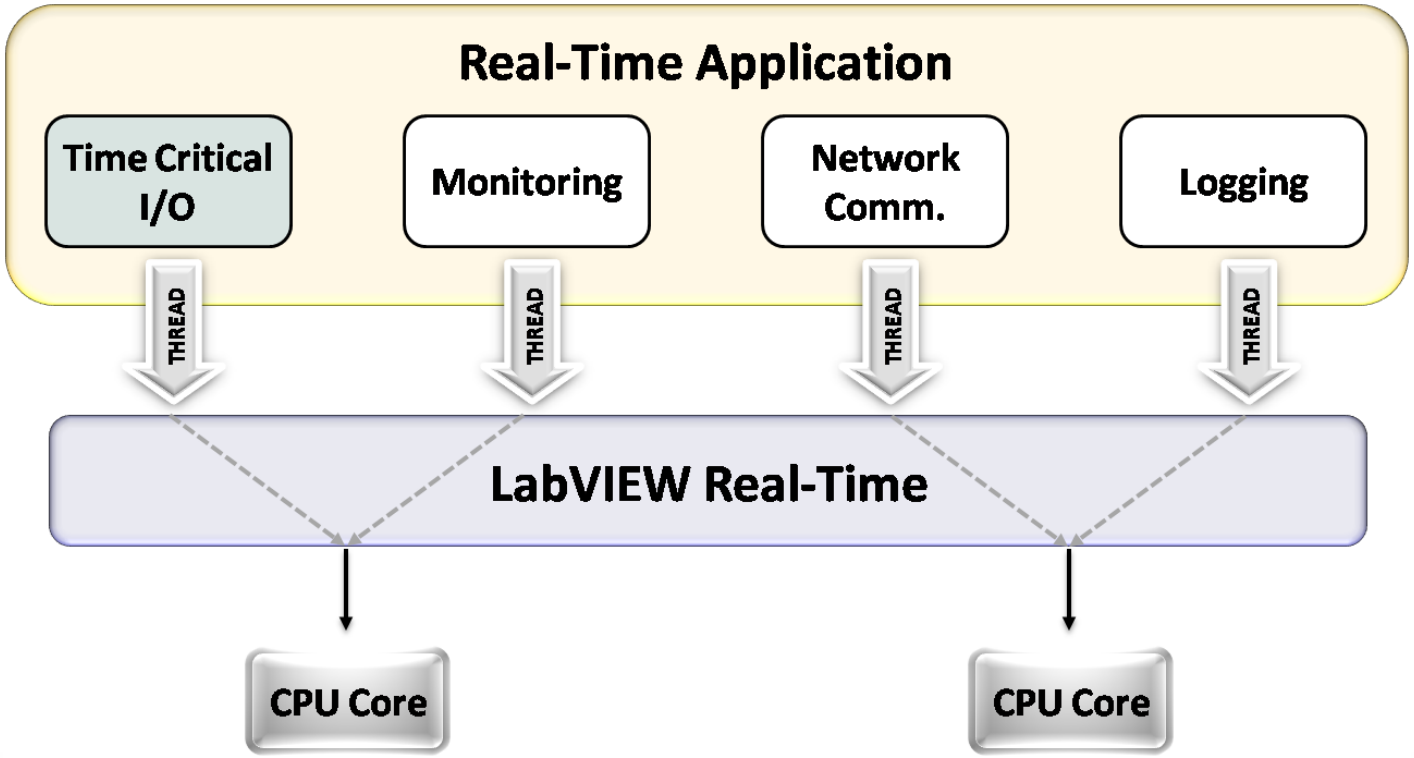
- Real-Time Goes Multicore
- Debugging Real-Time Applications with the Execution Trace Toolkit
- Application Use-Cases
- More New Features in LabVIEW 8.5 Real-Time
- Resources

Real-Time SMP

Real-Time Execution Trace Toolkit

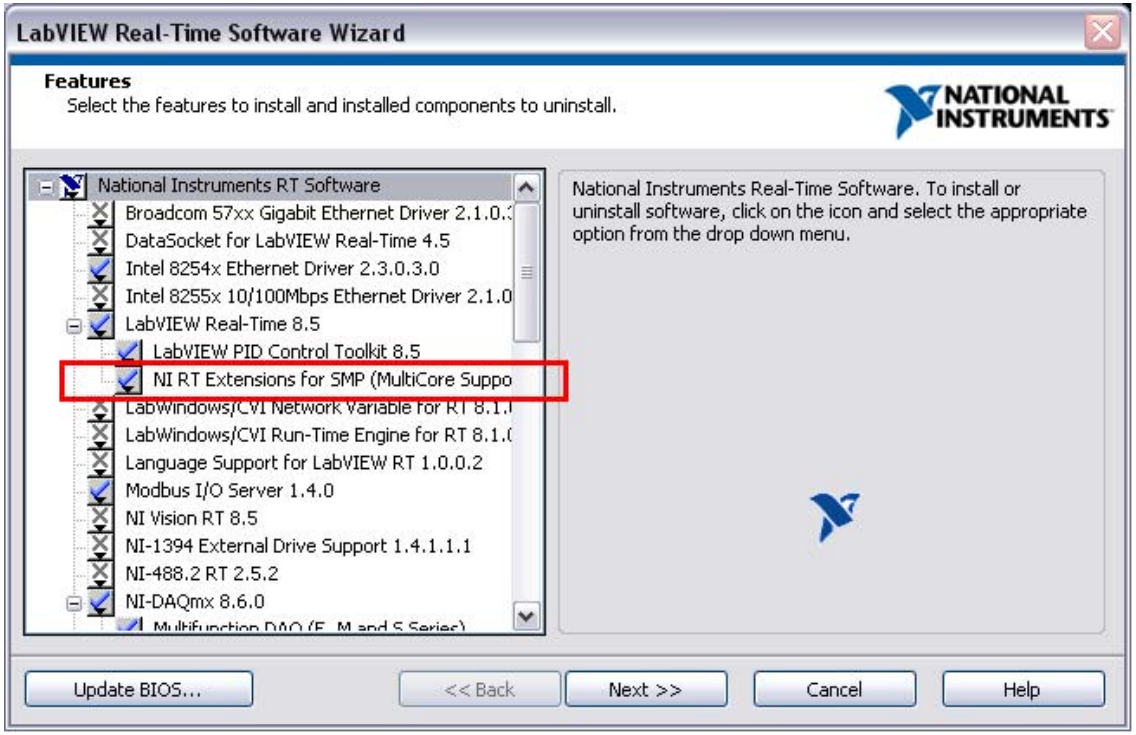
Symmetric Multiprocessing (SMP)

- LabVIEW 8.5 adds Symmetric Multiprocessing (SMP) for real-time systems.



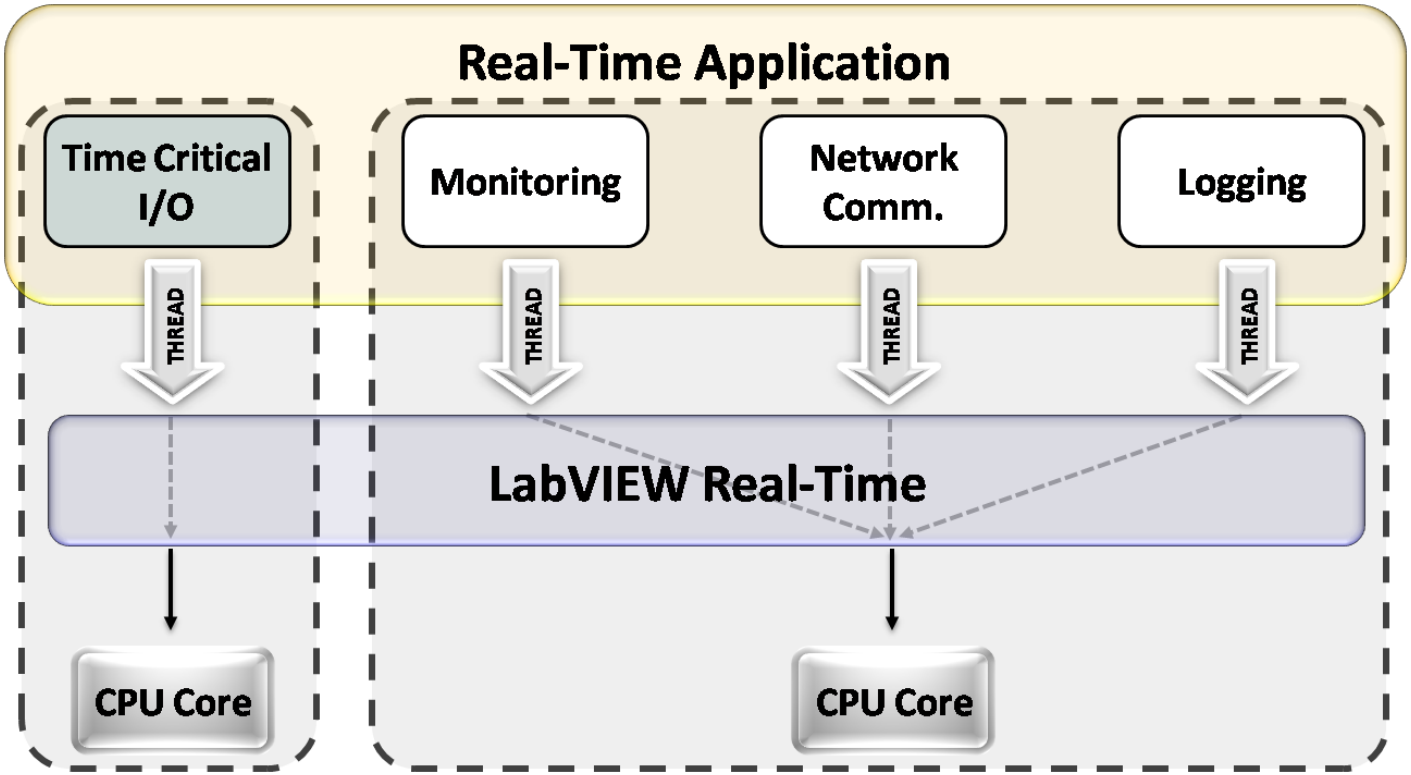
Installing from MAX

- From MAX, developers can choose to download SMP support to targets that support it



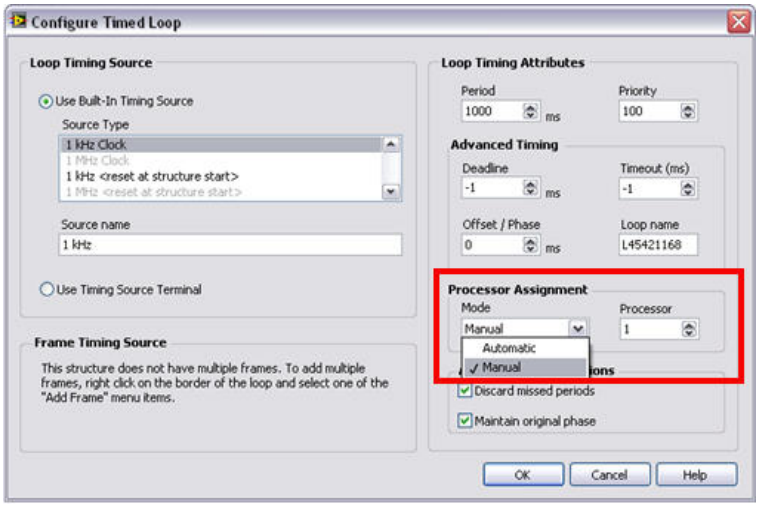
Assigning Tasks to Specific Cores

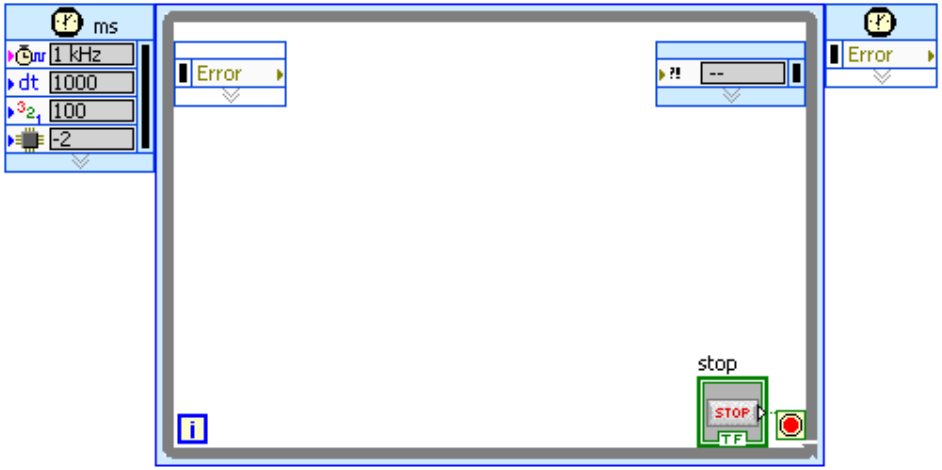
- In LabVIEW 8.5, users can assign code to specific processor cores using the LabVIEW Timed Loop.



Processor Affinity with the Timed Loop

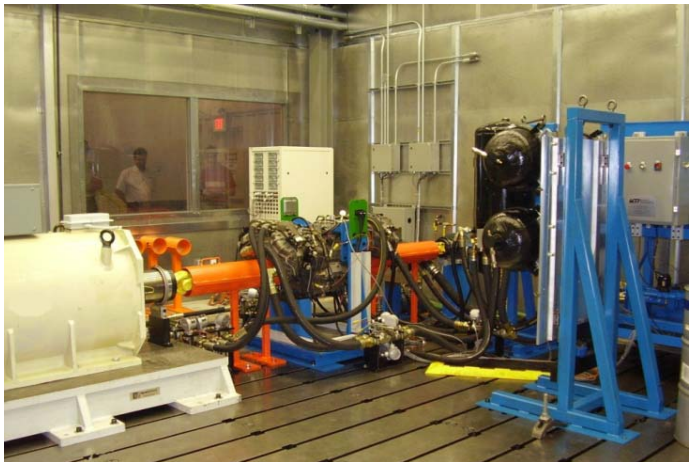
- Recommended for Real-Time development
- Under special use-cases can be used on Windows (example: cache optimization)





Performance Results from Wineman

- Wineman Technology creates closed-loop test solutions
  - Hardware-in-the-loop simulation
  - Dynamometer test
  - PXI 8106 Real-Time controller



WINEMAN TECHNOLOGY INCORPORATED

- "With LabVIEW Real-Time 8.5, we [increased] our maximum loop rate by 40% by utilizing both processor cores..."

Performance Results from NASA

- Wind Tunnel Safety-of-Flight system at NASA Ames Research Center
- Benchmarks Results
  - Ran on PXI-8106 RT Controller
  - Time-Critical loop was reduced from **43% CPU load** to **30% CPU load** on one CPU of the PXI-8106RT
  - A core leftover for processing of non-critical tasks.

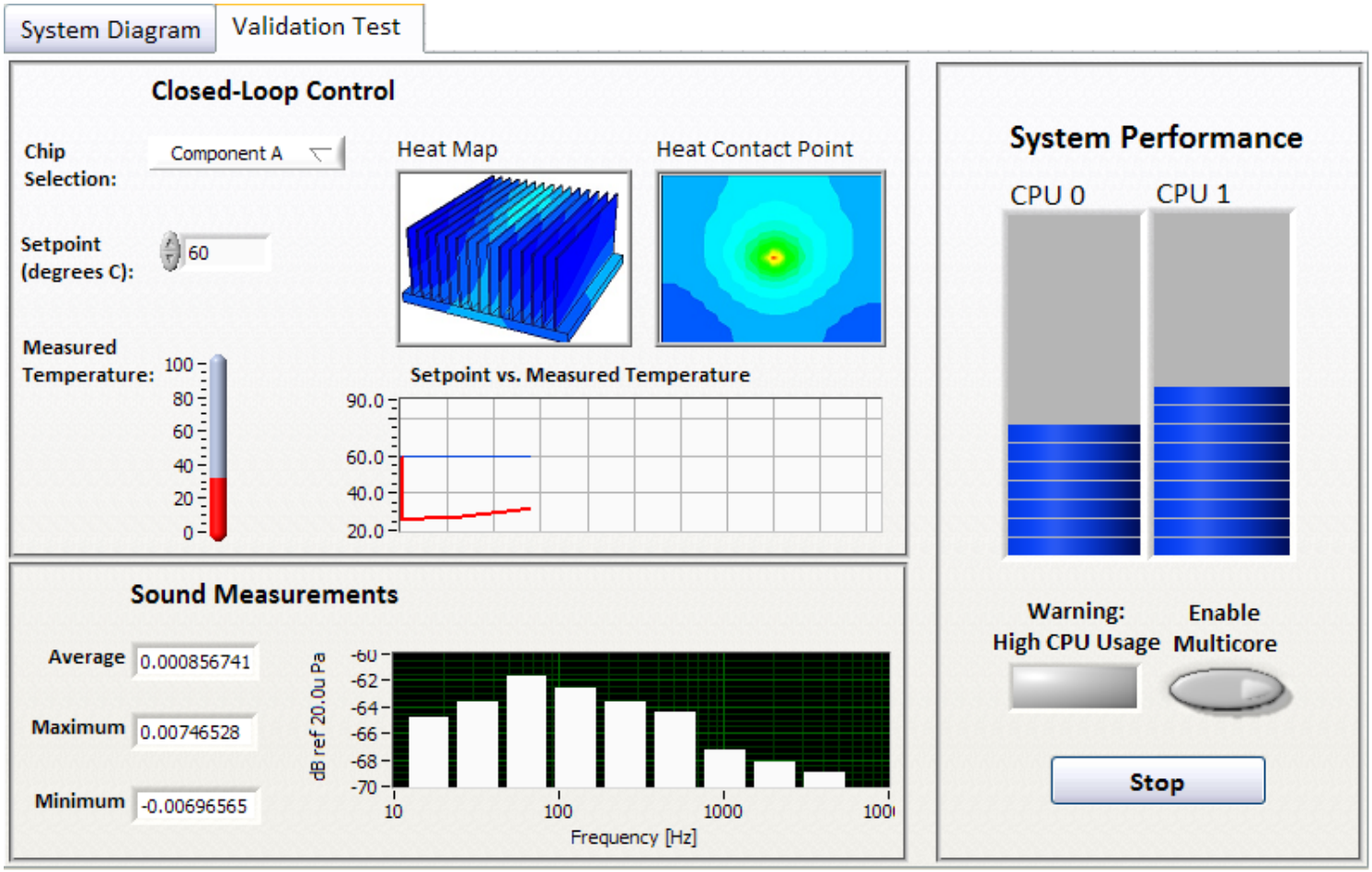
National Aeronautics and Space Administration

Image Source: http://windtunnels.arc.nasa.gov

LabVIEW Real-Time Software Stack

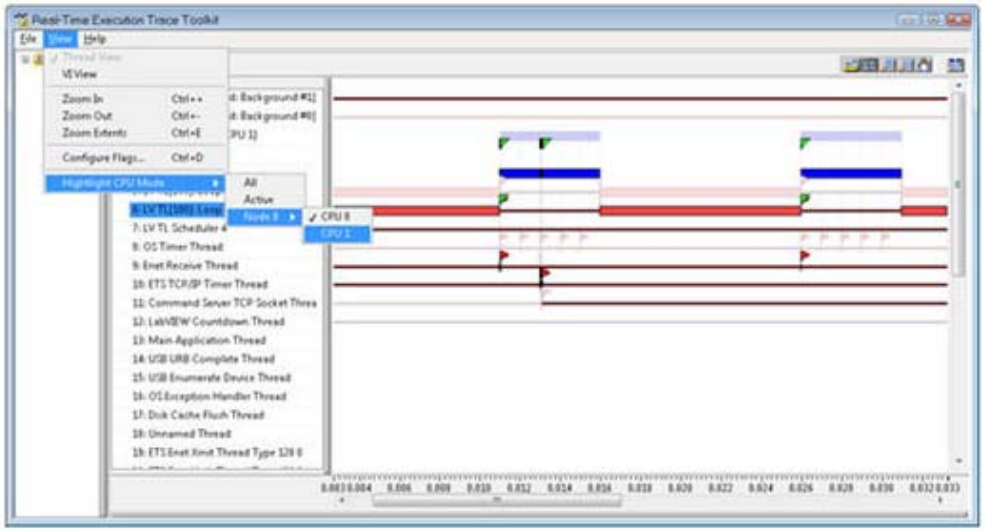
Software Stack	Meaning of "Multicore-Ready" for Real-Time
Development tool	Support is provided on RTOS, tool allows for threading correctness and optimization. Debugging and tracing capabilities are provided to analyze real-time multicore systems.
Libraries	Libraries are thread-safe and can be made re-entrant so they may be executed in parallel. Algorithms are in place so as to not cause memory allocation and induce jitter into system.
Device drivers	Drivers designed for optimal multithreaded performance
Operating system	RTOS supports multithreading and multitasking, and can load balance tasks on multicore processors with SMP.

Demo: Real-Time SMP



Execution Trace Toolkit 2.0

- 30-day evaluation
- Compatible with LabVIEW 7.1 and higher
- New Features in Version 2.0
  - Performance improvements
  - Trace Activity Sorting
  - New debugging flags (priority inheritence)
  - Multicore support



Instrumentation VIs

Use Instrumentation VIs to add tracing to a LabVIEW Real-Time application.

 Start Trace

 Stop Trace and Send

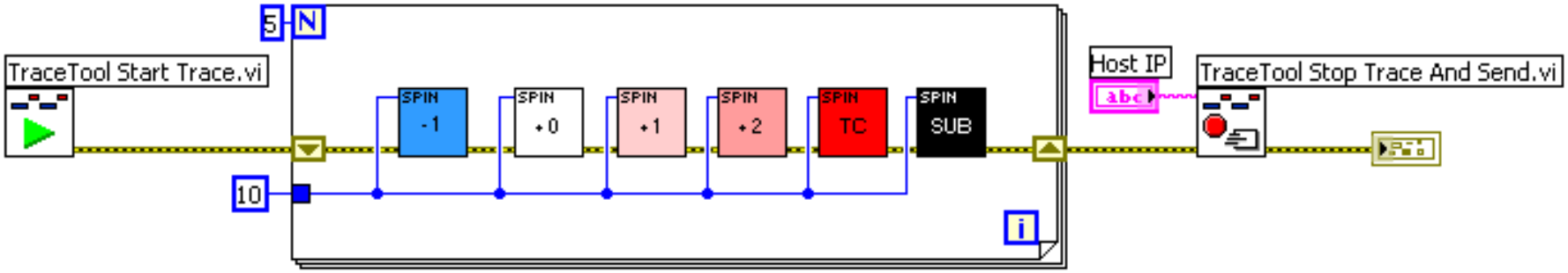
 Stop Trace and Save

 Load Trace and Send

 Log User Events

How Does it Work?

VI Running on RT Target



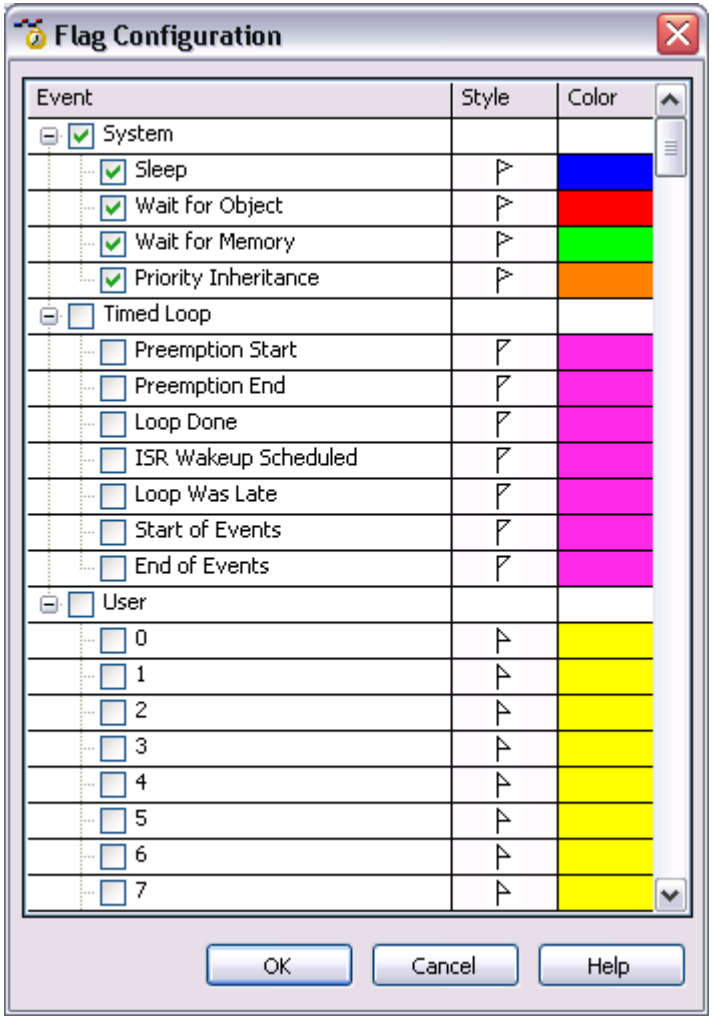
Events are logged to a memory buffer

Events are sent to the host for viewing

- Log buffer is circular
- Instrumentation VIs don't have to bookend

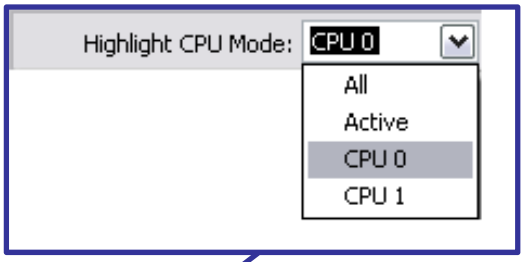
Flag Configuration

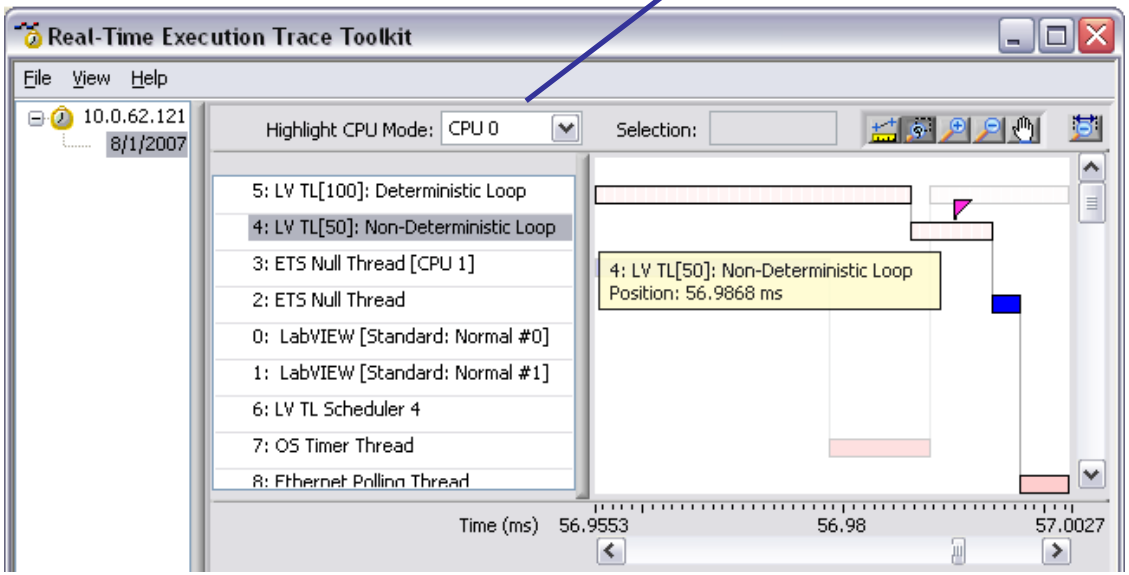
- System
  - Sleep
  - Wait for Object
  - Wait for Memory
  - Priority Inheritance
- Timed Loop
  - Loop was Late
- User
  - 0-255



Debugging Multicore Applications

- Highlight CPU Mode
- Simultaneously View traces running on separate cores





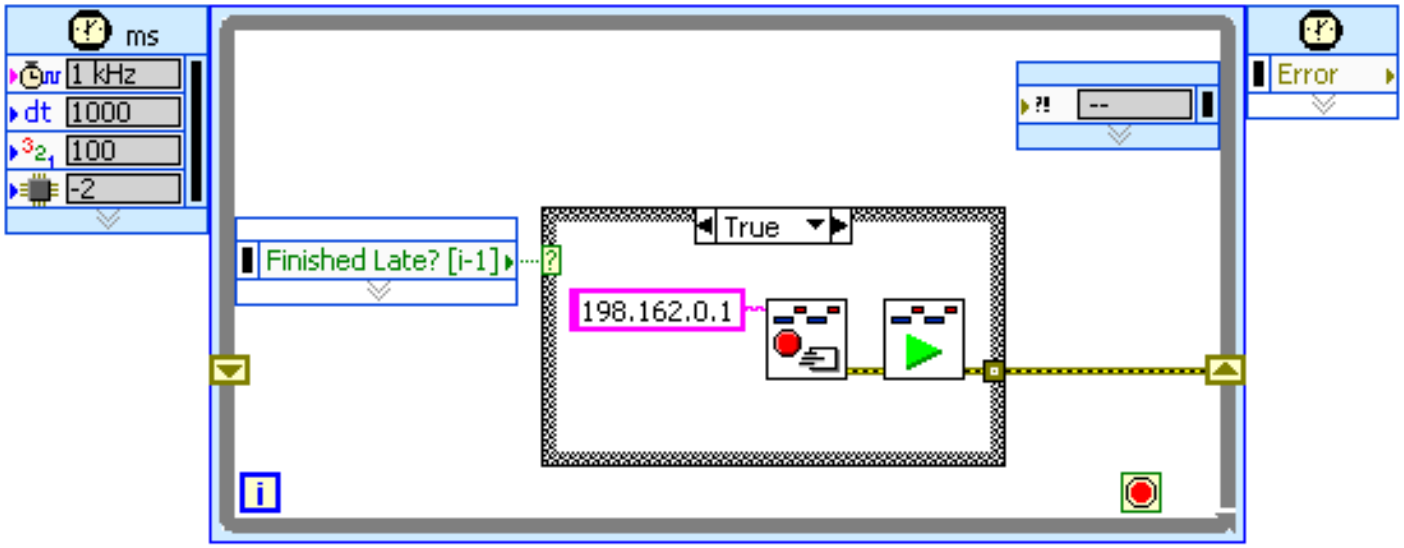
Key Concept: Finding Shared Resources

- Examples
  - Memory Manager
  - Non-reentrant shared subVIs
  - Global variables
  - File system
- Shared Resource lead to priority inversions
  - Priority Inheritance Flags
  - Thread Coloring changes

Trace Tool Debugging Tips

- Simplify Code
- Expect to debug; Build debugging into your code
  - Asserts
  - Conditional Disable Structure
  - INI Token
- Stop tracing and send when unwanted behavior occurs
  - Timed Loop late
  - Error condition

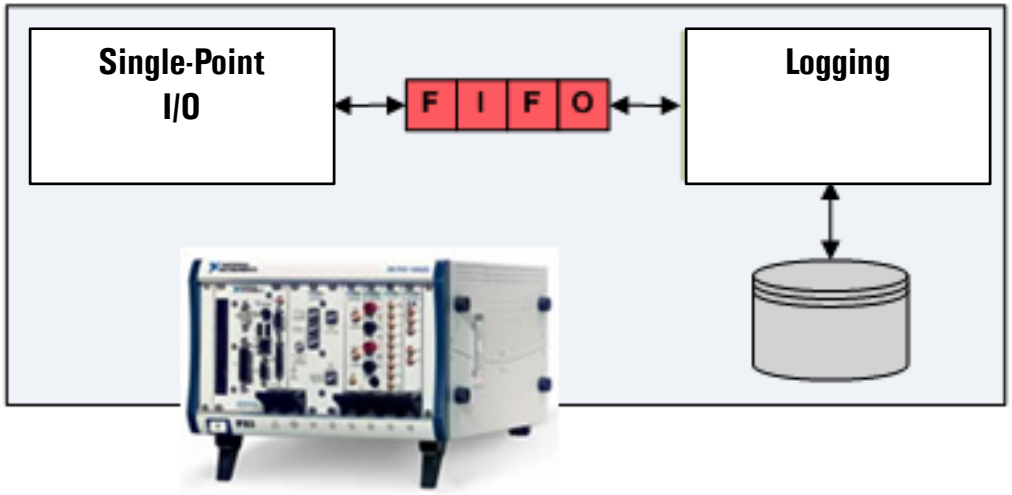
Trace Tool Debugging Tips



Application Use-Case: Single-Point I/O and Logging

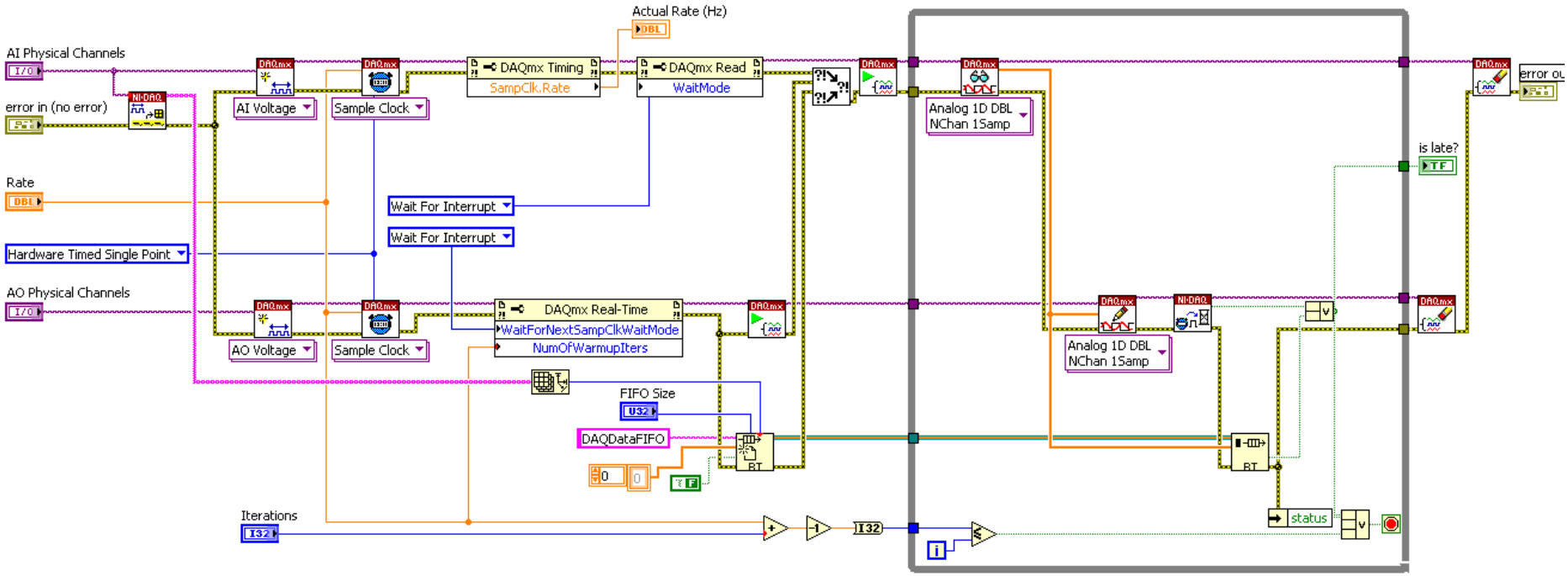
Tasks:

- Single-Point AI and AO
- Log to Disk



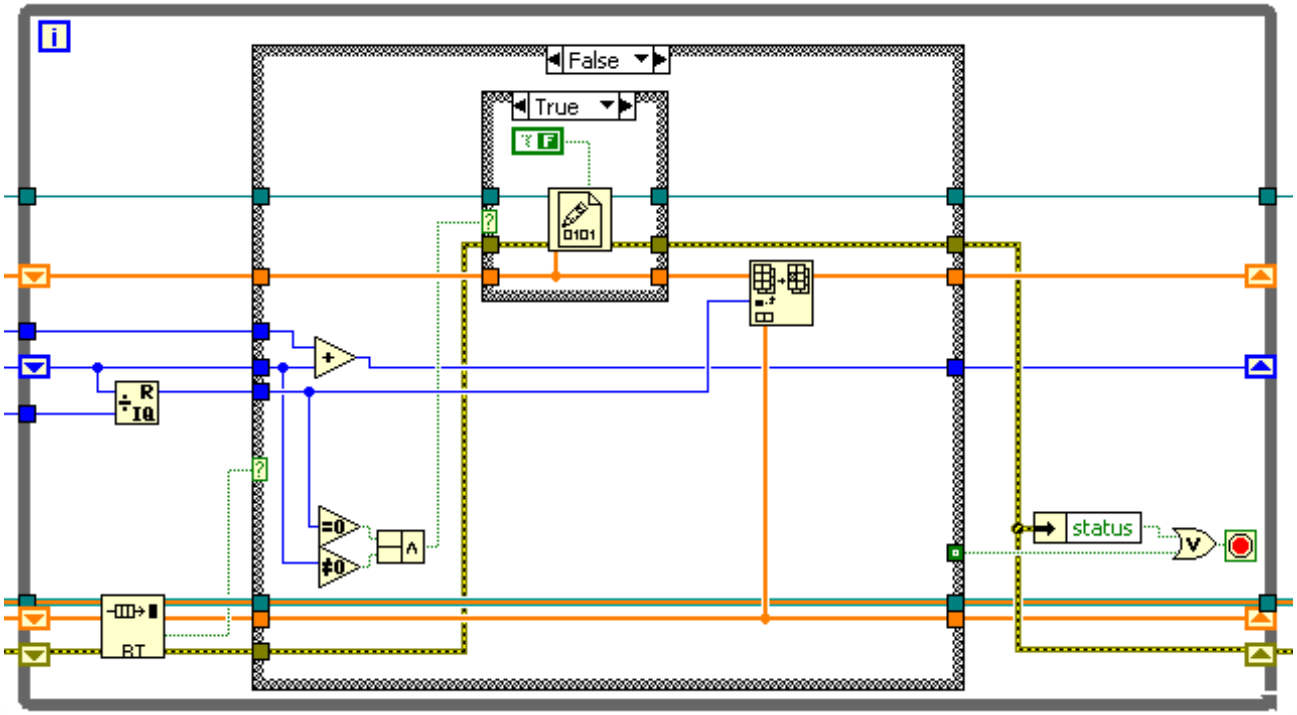
Application Overview: Time Critical VI

- Performs single-point AI and AO
- Sends value to RT FIFO



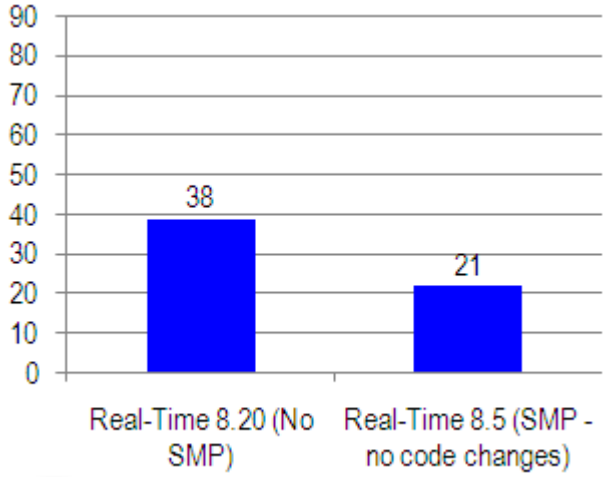
Application Overview: Non-deterministic loop

- Reads values from RT FIFO
- Performs write to disk operation



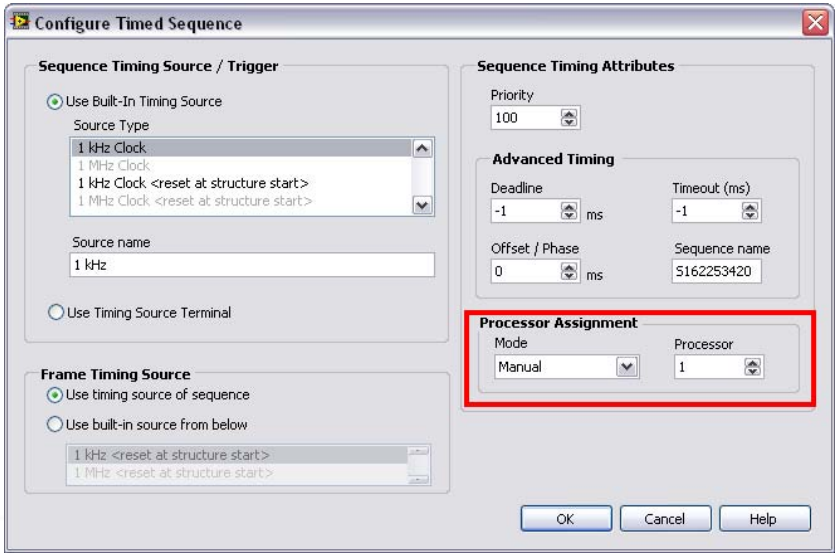
Comparison of LabVIEW 8.20 vs. LabVIEW 8.5 SMP

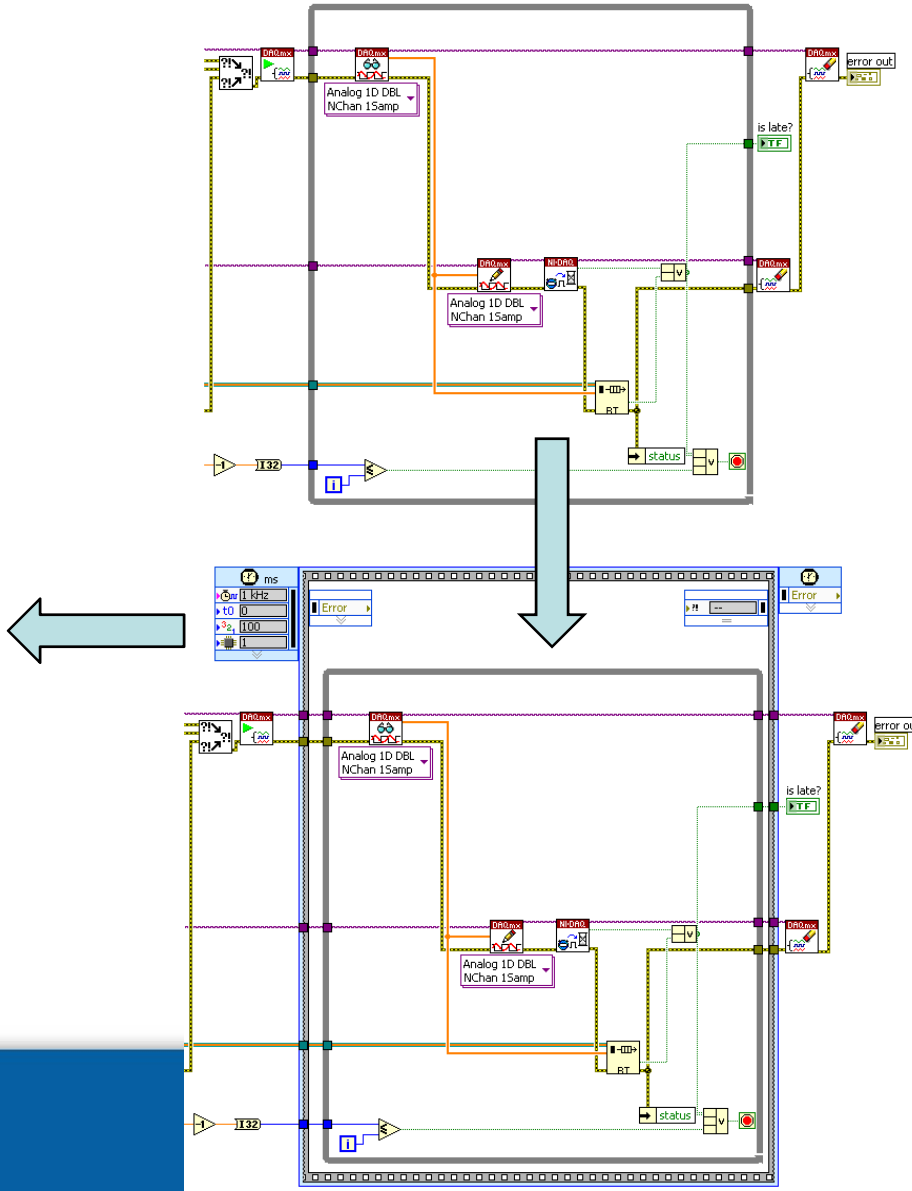
- No optimizations have been made for SMP
- LabVIEW Real-Time will run in default behavior, attempting to load-balance tasks
- Overhead of scheduling degrades performance



Code Change #1

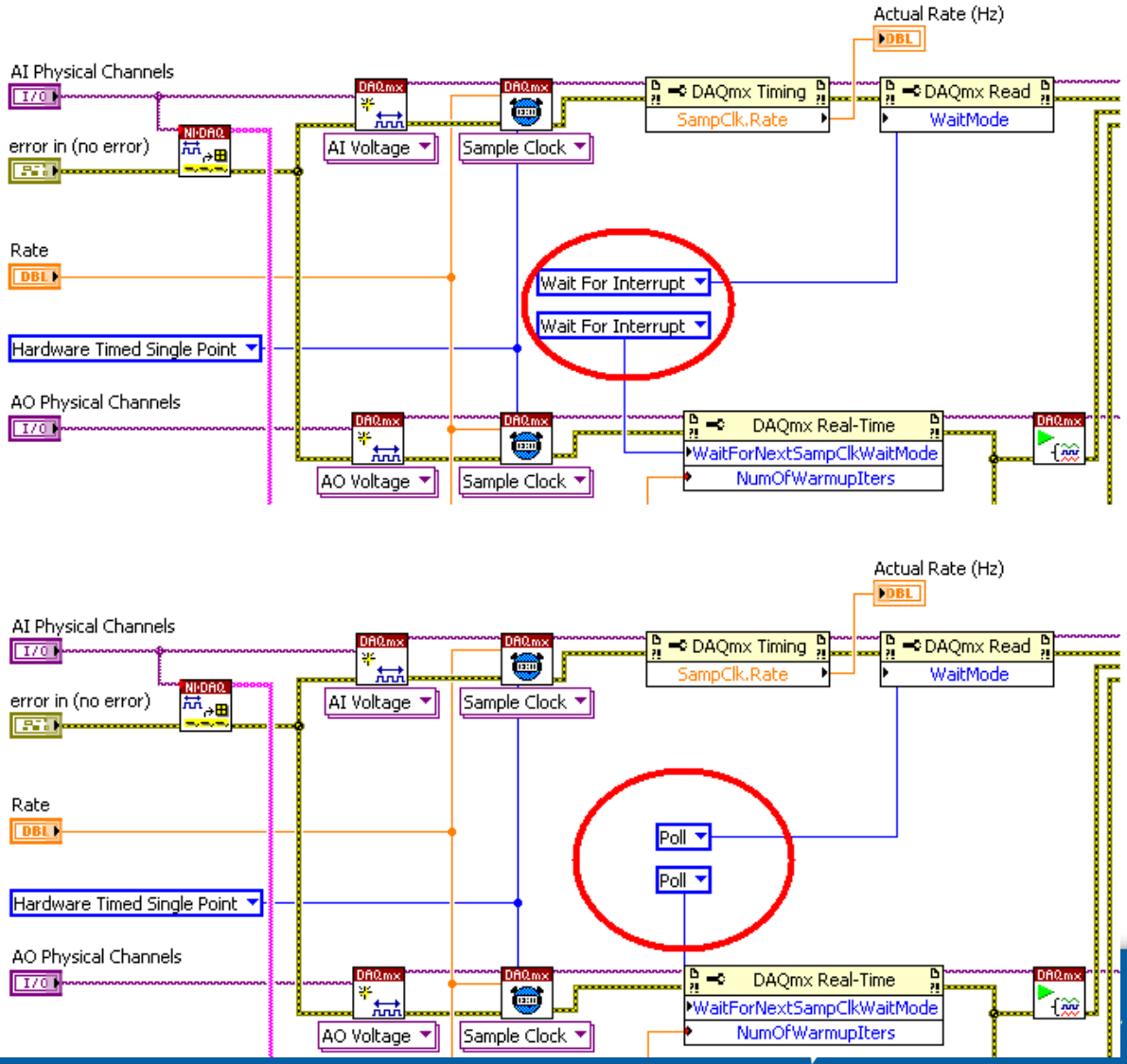
- Assign Time-Critical Task to a CPU1



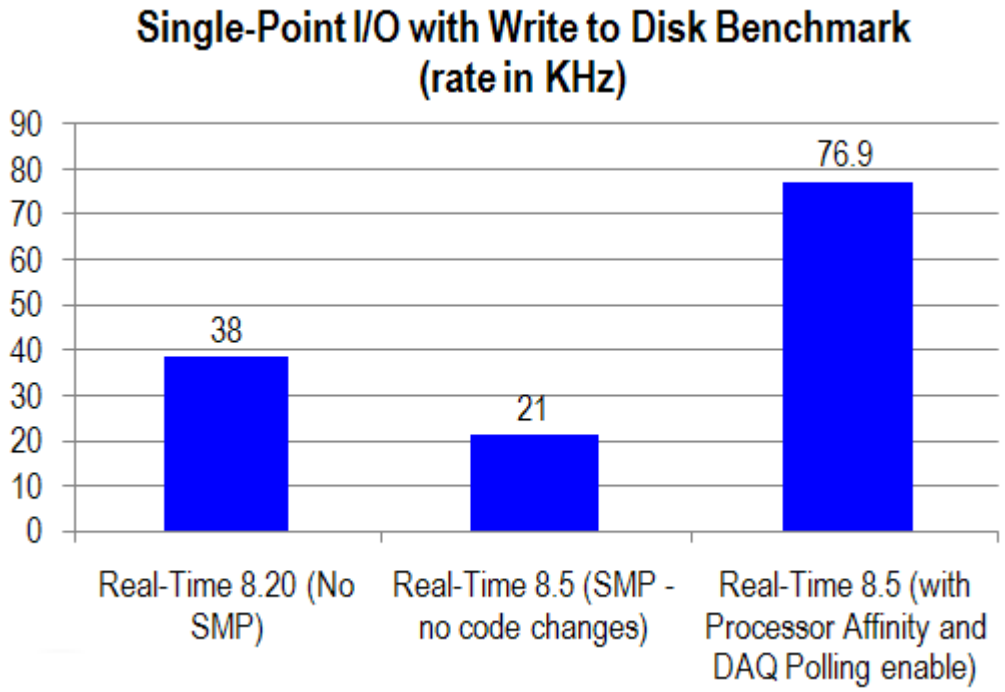


Code Change #2

- Change DAQ mode from Interrupt to Polling



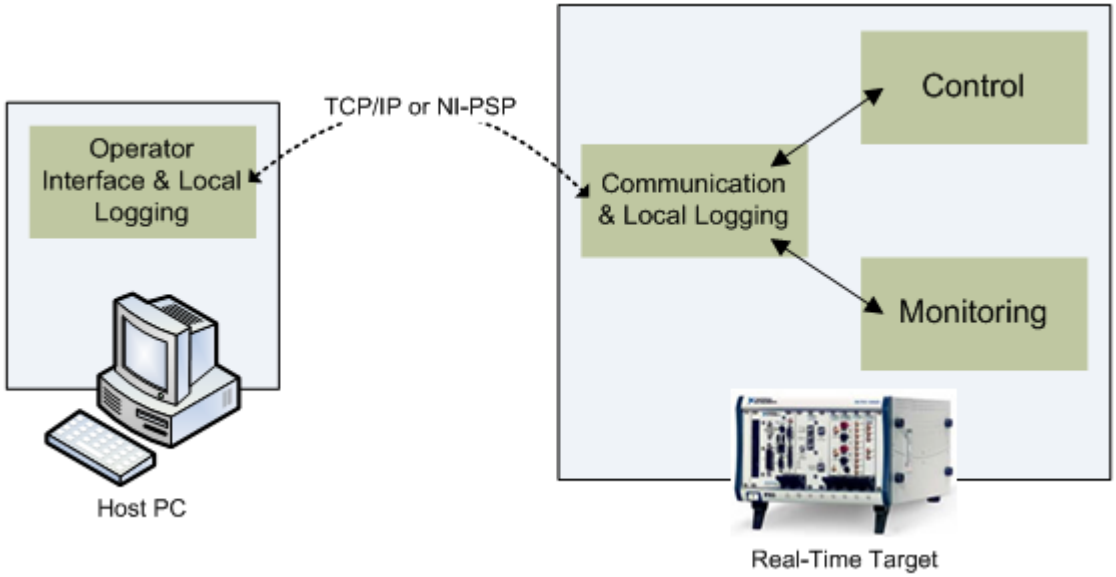
Final Benchmark with DAQ Polling enabled



Application Use-Case: Large Control Application

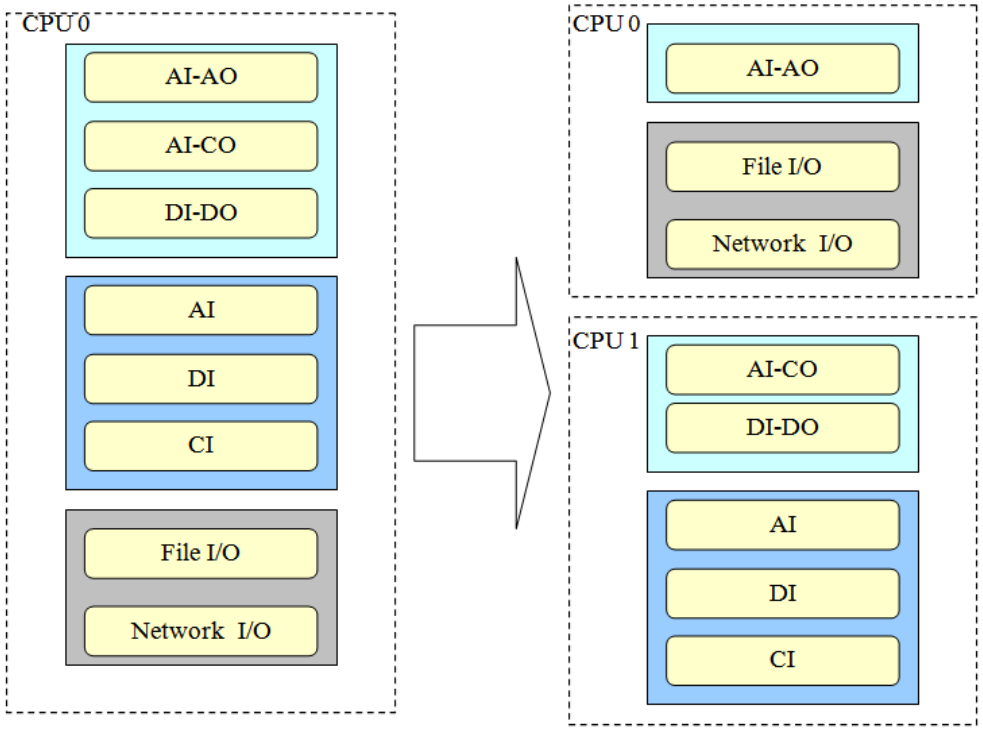
Tasks:

- Control
- Monitoring
- Network Communication
- Logging



Necessary changes to see 25% Speed-Up on 8106RT

- Split control loop
- DIO and AI/Counters (added another board for AI) (CPU 1)
- AI/AO (CPU 0)
- Communication loop forced to CPU 0
- Monitoring Loop forced to CPU 1



Key Take Aways from Application Use-Cases

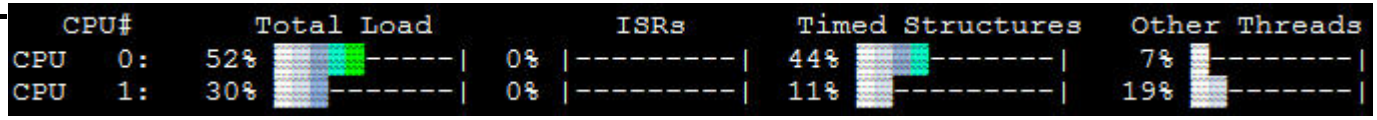
- Run code first and compare results with no code changes – it may get faster
- If slower or the same, try using Processor Affinity on time-critical loop to assign task to it's own CPU.
- With SMP support, DAQ polling mode can now be used in the time-critical loop for I/O

Further optimize for Multicore Performance

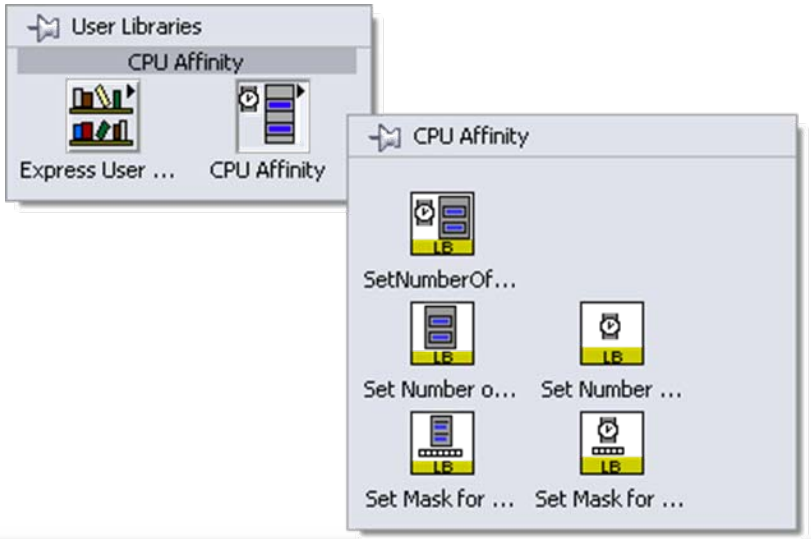
- Implement Parallel Programming Techniques:
  - Task Parallelism
  - Data Parallelism
  - Pipelining

Other New Features in LabVIEW 8.5 Real-Time

- On-Screen CPU Monitor
  - For real-time targets with VGA outputs (PCI and Desktop)



- CPU Affinity VIs
  - Available for download from www.ni.com



Multicore Real-Time Targets

- PXI-8106 RT (dual-core)
  - Recommended for Single-Point
- PXI-8130e RT (dual-core)
  - Recommended for Streaming Large Datasets
- PXI-8351
  - 1U Real-Time Server
- Desktop PCs (N core)
  - Can be used for high-end multicore systems (i.e. 8 core)

Resources

- Whitepapers
  - Introduction to LabVIEW Real-Time SMP
  - Debugging Real-Time Applications with Execution Trace Toolkit 2.0
- Benchmarks for LabVIEW 8.5 RT and Latest Hardware
  - Large DAQ Application Benchmarks
  - Single-Point I/O
  - Shared Variable

Resources

www.ni.com/multicore

Multicore Programming Resources

Questions? Get real-time assistance now!

Multicore processors present new software challenges that must be overcome to fully take advantage of processing capabilities in test, control, and embedded design applications. Explore the following resources to learn how engineers and scientists can use graphical programming to implement parallel programming strategies and harness the power of multicore processors.

Multicore Programming Fundamentals

View the Multicore Programming Whitepaper Series

Browse the library of whitepapers to learn about multicore programming strategies, key concepts, and performance benchmarks.

Develop High-Performance Real-Time Systems with Multicore Technology

Technical Resources

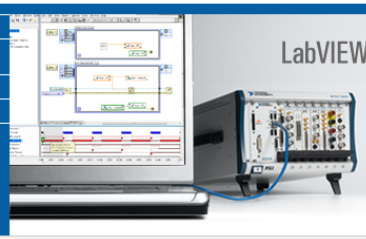
- Overcoming Multicore Programming Challenges with LabVIEW
- Programming Strategies for Multicore Processing: Task Parallelism
- Will my LabVIEW program run faster when I upgrade to a multicore computer?

www.ni.com/realtime

Real-Time Measurement and Control

Questions? Call (800) 531-5066

- What Is Real-Time?
- Introduction to LabVIEW Real-Time
- Latest Features and Products
- Real-Time Application Notes
- Real-Time Third-Party Products



National Instruments real-time products combine the NI LabVIEW graphical development environment with LabVIEW Embedded technology to achieve the deterministic performance of dedicated real-time and FPGA targets. Deliver applications that run predictably in time with increased reliability and offer stand-alone operation.

Real-Time Application Areas

Test and Validation
- Integrated test and control
- Destructive testing
- Endurance testing
- Autonomous operation

Industrial Control
- Process control
- Environmental control
- Predictive maintenance
- Industrial inspection

Control Design
- Rapid control prototyping
- Hardware-in-the-loop testing
- Dynamic simulation
- Model-based design

Highlights

Real-Time Execution Trace Toolkit 2.0
View the tutorial to learn about real-time software debugging

Real-Time Hardware Deployment Options
Download the white paper

What's New in LabVIEW 8.5 Real-Time
View the webcast to explore new features