NIDays

THE LabVIEW CONFERENCE

An Overview of

Data Communication in LabVIEW

Data Communication Options in LabVIEW

1. TCP and UDP
2. Network Streams
3. Shared Variables
4. DMAs
5. Web Services
6. Peer-to-Peer Streaming
7. Queues
8. Dynamic Events
9. Functional Global Variables
10. RT FIFOs
11. Datasocket
12. Local Variables
13. Programmatic Front Panel Interface
14. Target-scoped FIFOs
15. Notifier
16. Simple TCP/IP Messaging (STM)
17. AMC
18. HTTP
19. FTP
20. Global variables

… just to name a few …

NATIONAL INSTRUMENTS

Agenda

- Introduction of Data Communication
- Define Communication Types
- Identify Scope of Communication
  - Inter-process
  - Inter-target
- Next Steps

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NATIONAL INSTRUMENTS

Demonstration

The pitfalls of local variables

Common Pitfalls of Data Communication

Race conditions- two requests made to the same shared resource

Deadlock- two or more depended processes are waiting for each other to release the same resource

Data loss- gaps or discontinuities when transferring data

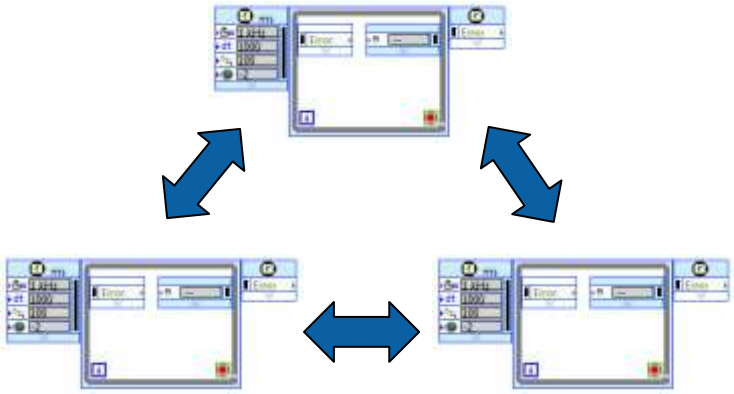
Performance degradation- poor processing speed due to dependencies on shared resources

Buffer overflows- writing to a buffer faster than it is read from the buffer

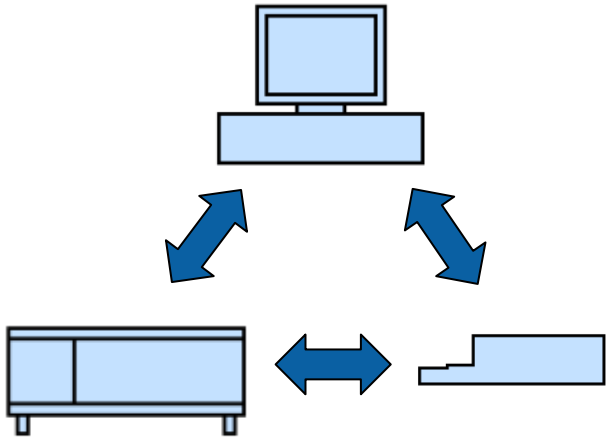
Stale data- reading the same data point more than once

Scope of Communication

Inter-process: the exchange of data takes place within a single application context

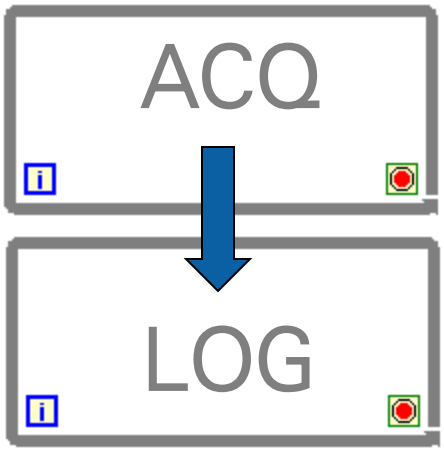


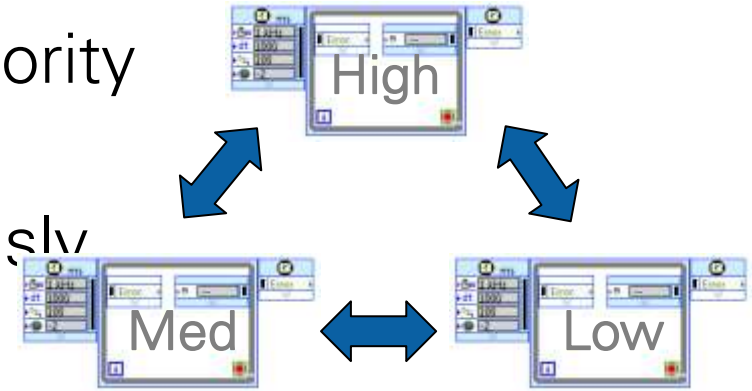
Inter-target: communication between multiple physical targets, often over a network layer



Defining Inter-process Communication

- Communication on same PC or Target
- Communicate between parallel processes or loops
- Offload data logging or processing to another CPU/Core/Thread within same VI/executable
- Loops can vary in processing priority
- Used to communicate synchronously and asynchronously

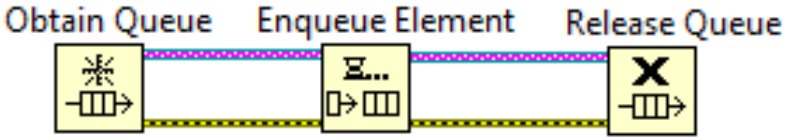




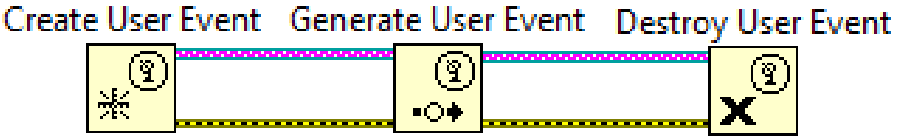
Inter-process Communication Options

Shared Variables
Update GUI loop with latest value

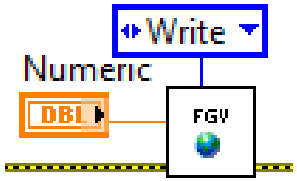
Queues
Stream continuous data between loops on a non-deterministic target



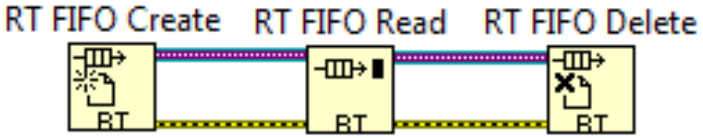
Dynamic Events
Register Dynamic Events to execute sections of code



Functional Global Variables (FGV)
Use a non-reentrant subVI to protect critical data



RT FIFOs
Stream continuous data between time critical loops on a single RT target



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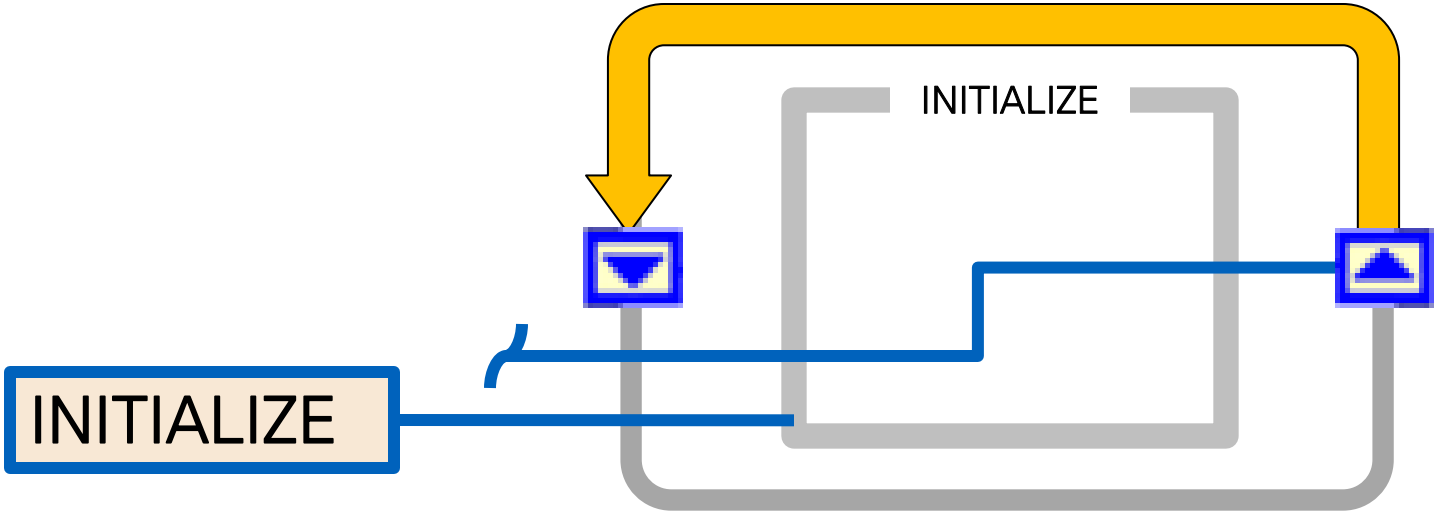
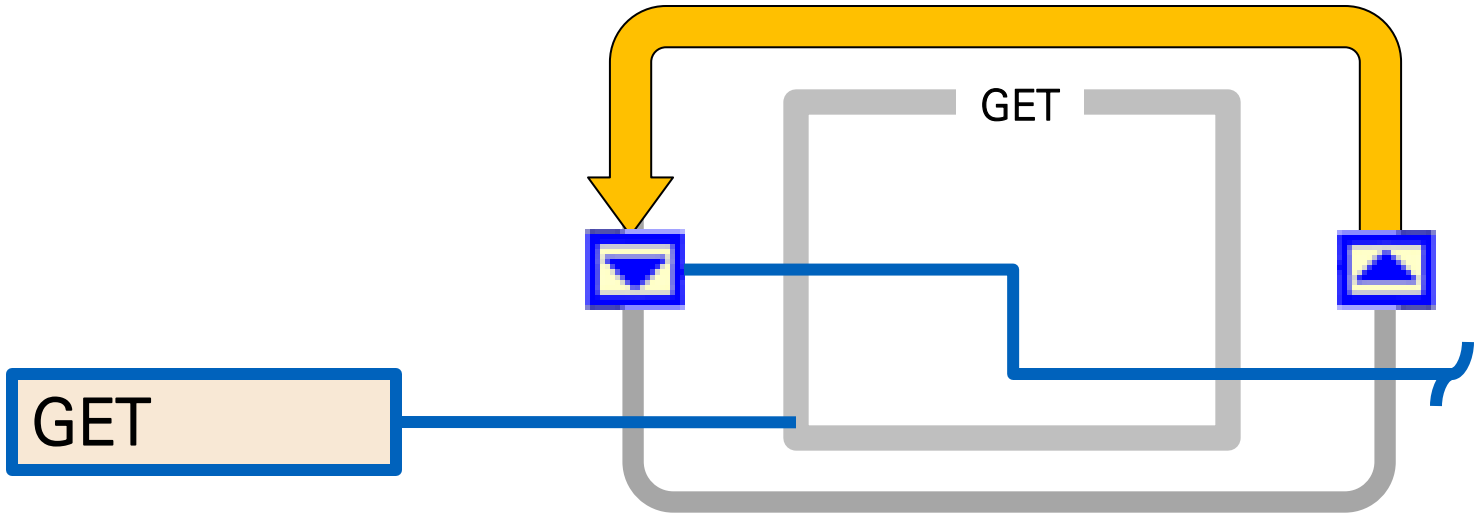
Basic Actions

- Set the value of the shift register



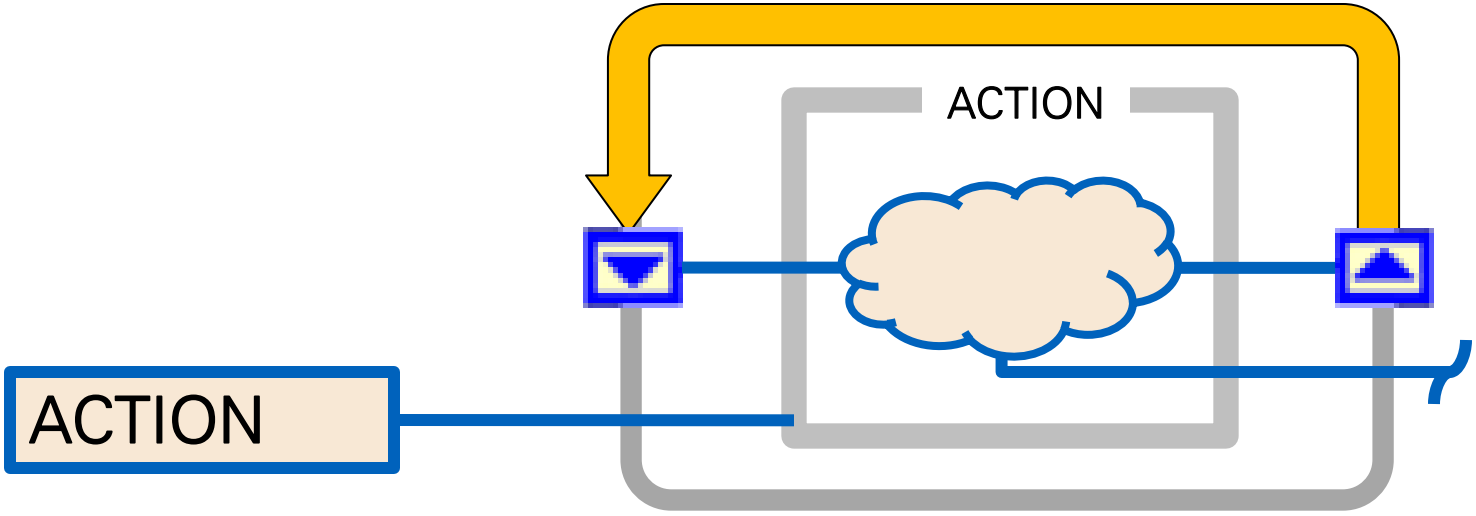
Basic Actions

- Get the value currently stored in the shift register



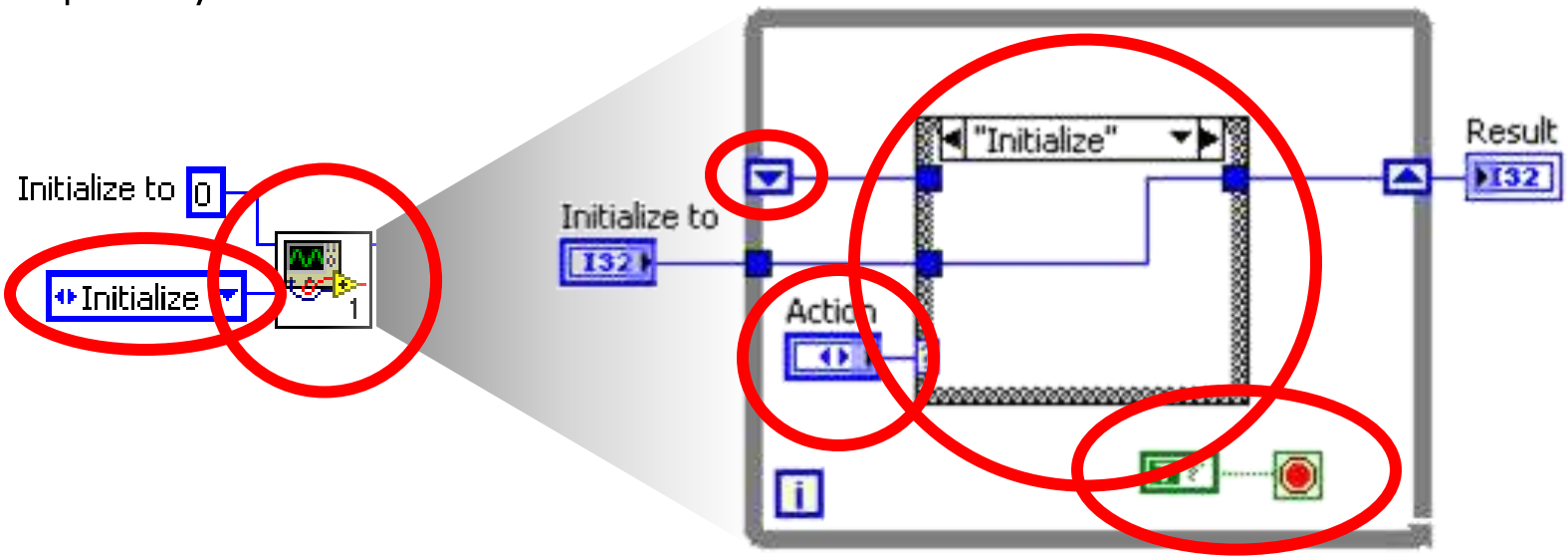
Action Engine

- Perform an operation upon stored value and save result
- You can also output the new value



How It Works

1. Functional Global Variable is a **Non-Reentrant** SubVI
2. Actions can be performed upon data
3. Enumerator selects action
4. Stores result in uninitialised shift register
5. Loop only executes once



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Benefits: Comparison

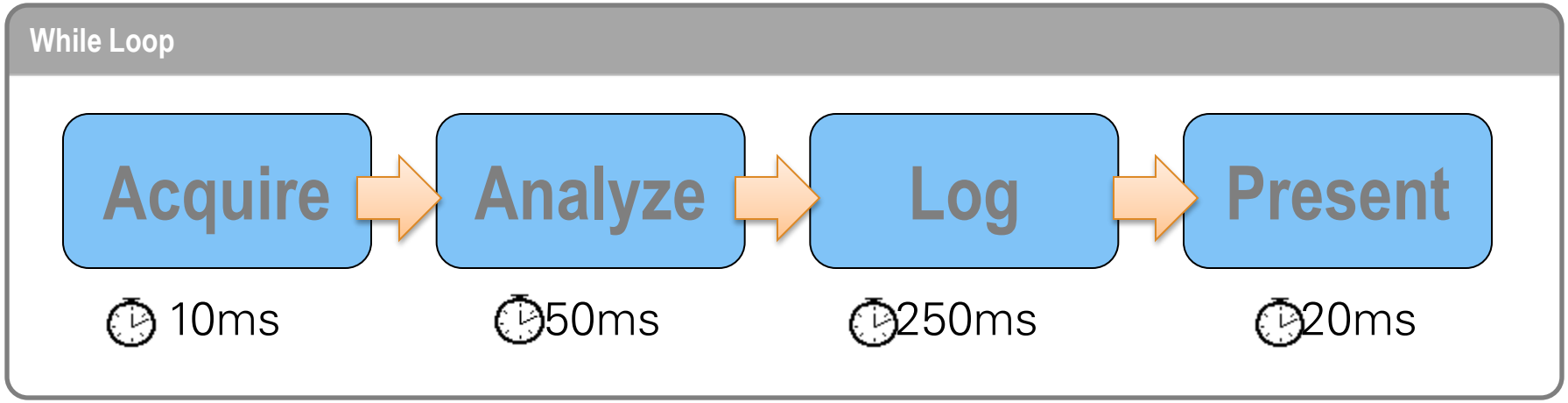
Functional Global Variables

- Prevent race conditions
- No copies of data
- Can behave like action engines
- Can handle error wires
- Take time to make

Global and Local Variables

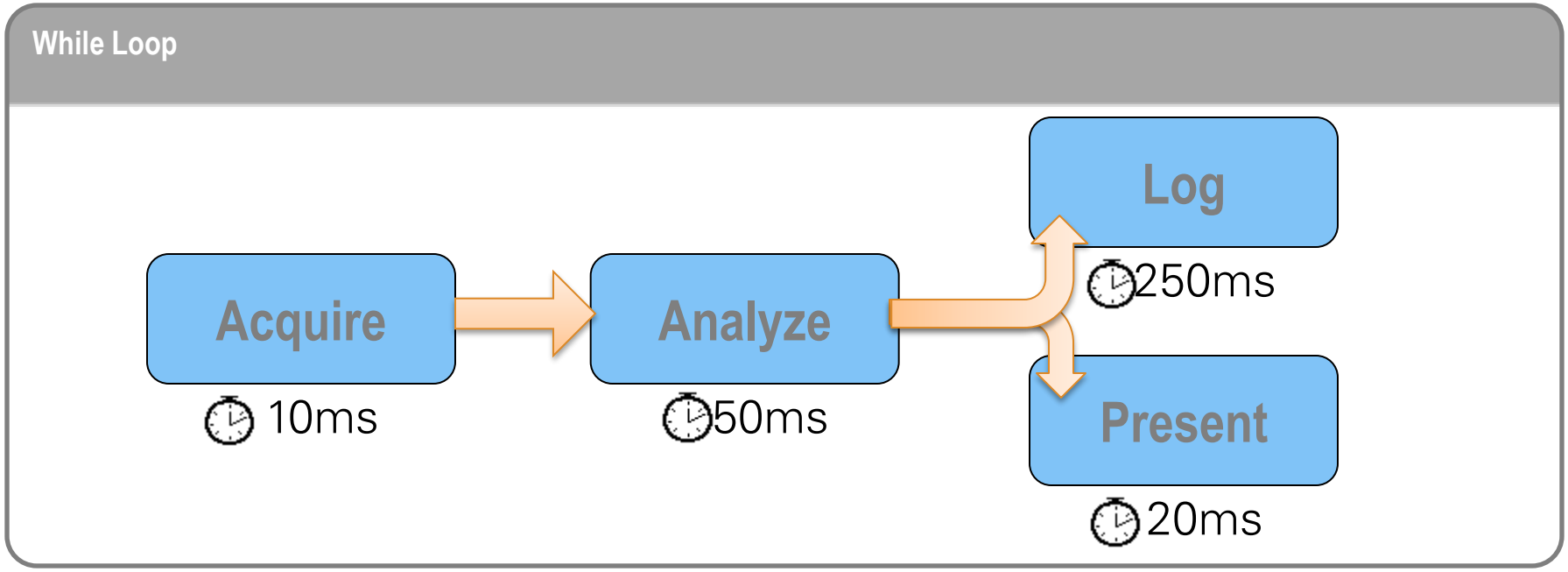
- Can cause race conditions
- Create copies of data in memory
- Cannot perform actions on data
- Cannot handle error wires
- Drag and drop

Doing Everything in One Loop Can Cause Problems



- One cycle takes at least 330 ms
- If the acquisition is reading from a buffer, it may fill up
- User interface can only be updated every 330 ms

Doing Everything in One Loop Can Cause Problems



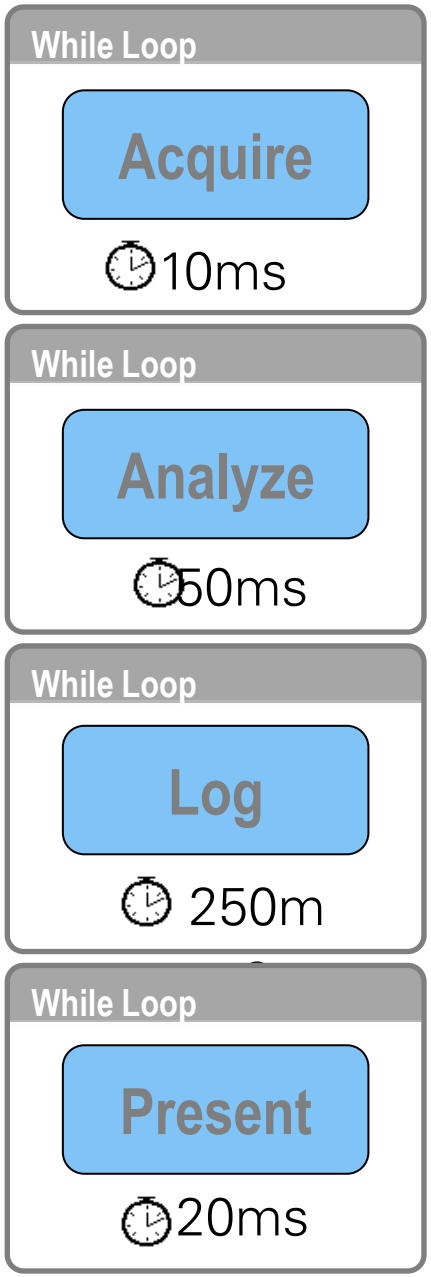
- One cycle still takes at least 310 ms
- If the acquisition is reading from a buffer, it may fill up
- User interface can only be updated every 310 ms

Inter-Process Communication:

ensures tasks run asynchronously and efficiently

How?

- Loops are running independently
- User interface can be updated every 20 ms
- Acquisition runs every 10ms, helping to not overflow the buffer
- All while loops run entirely parallel of each other



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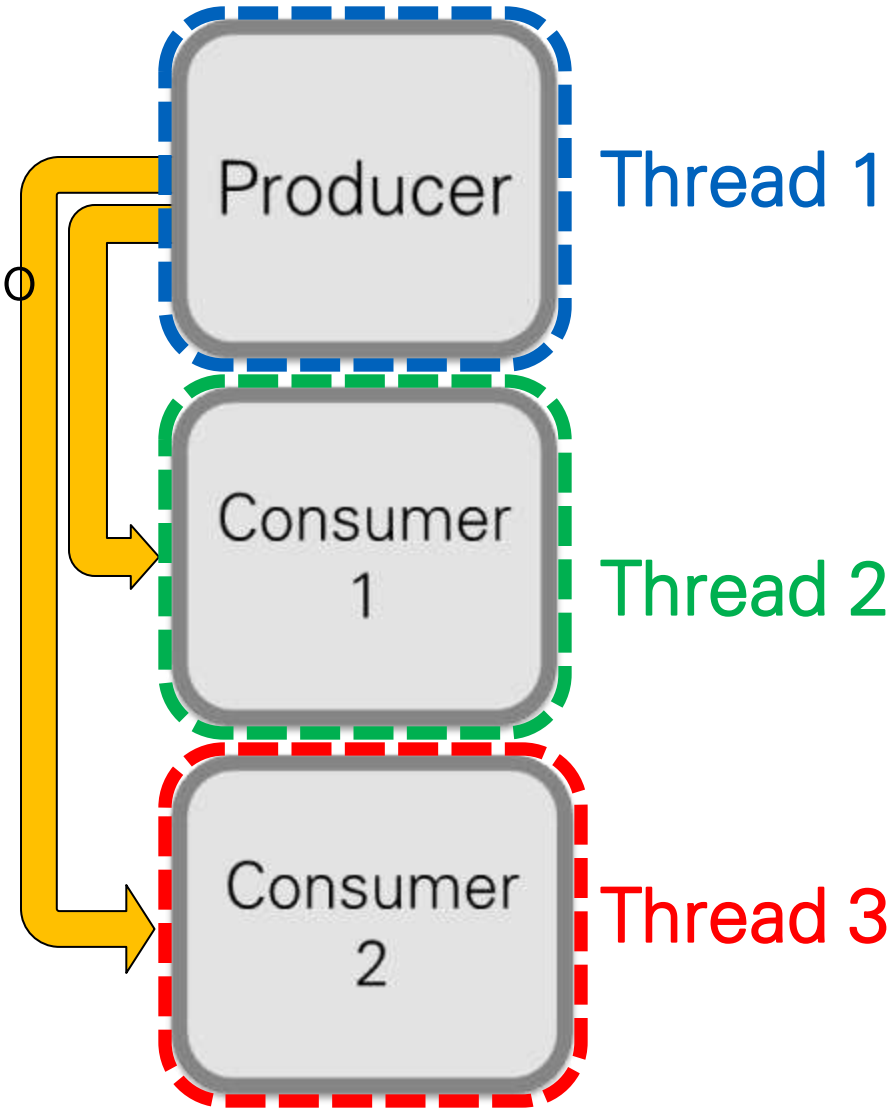
Producer Consumer

Best Practices

1. One consumer per queue
2. Keep at least one reference to a named queue available at any time
3. Consumers can be their own producers
4. Do not use variables

Considerations

1. How do you stop all loops?
2. What data should the queue send?



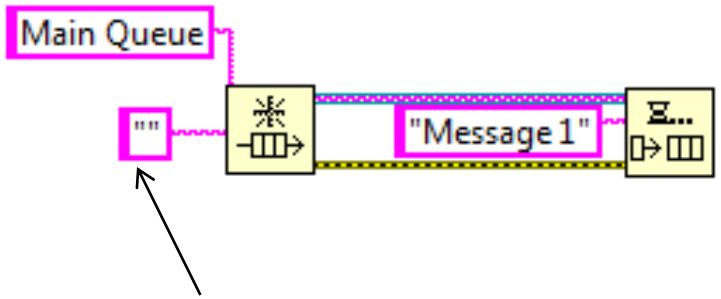
LabVIEW FIFOs

- Queues
- RT FIFOs
- Network Streams
- DMAs
- User Events

In general, FIFOs are good if you need lossless communication that preserves historical information

Queues

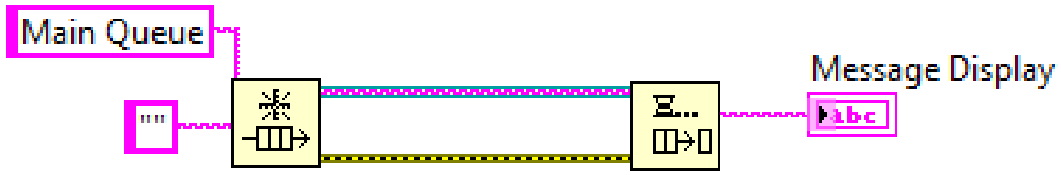
Adding Elements to the Queue



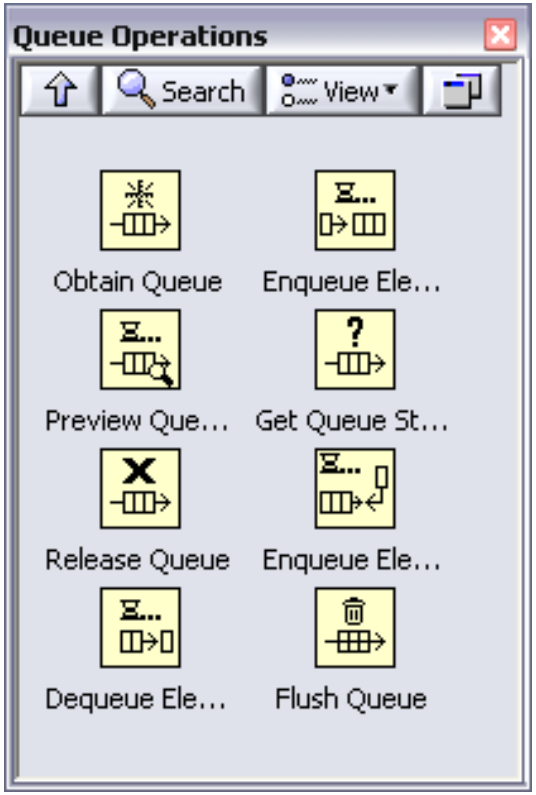
Select the data type the queue will hold

Reference to existing queue in memory

Dequeueing Elements



Dequeue will wait for data or time-out (defaults to -



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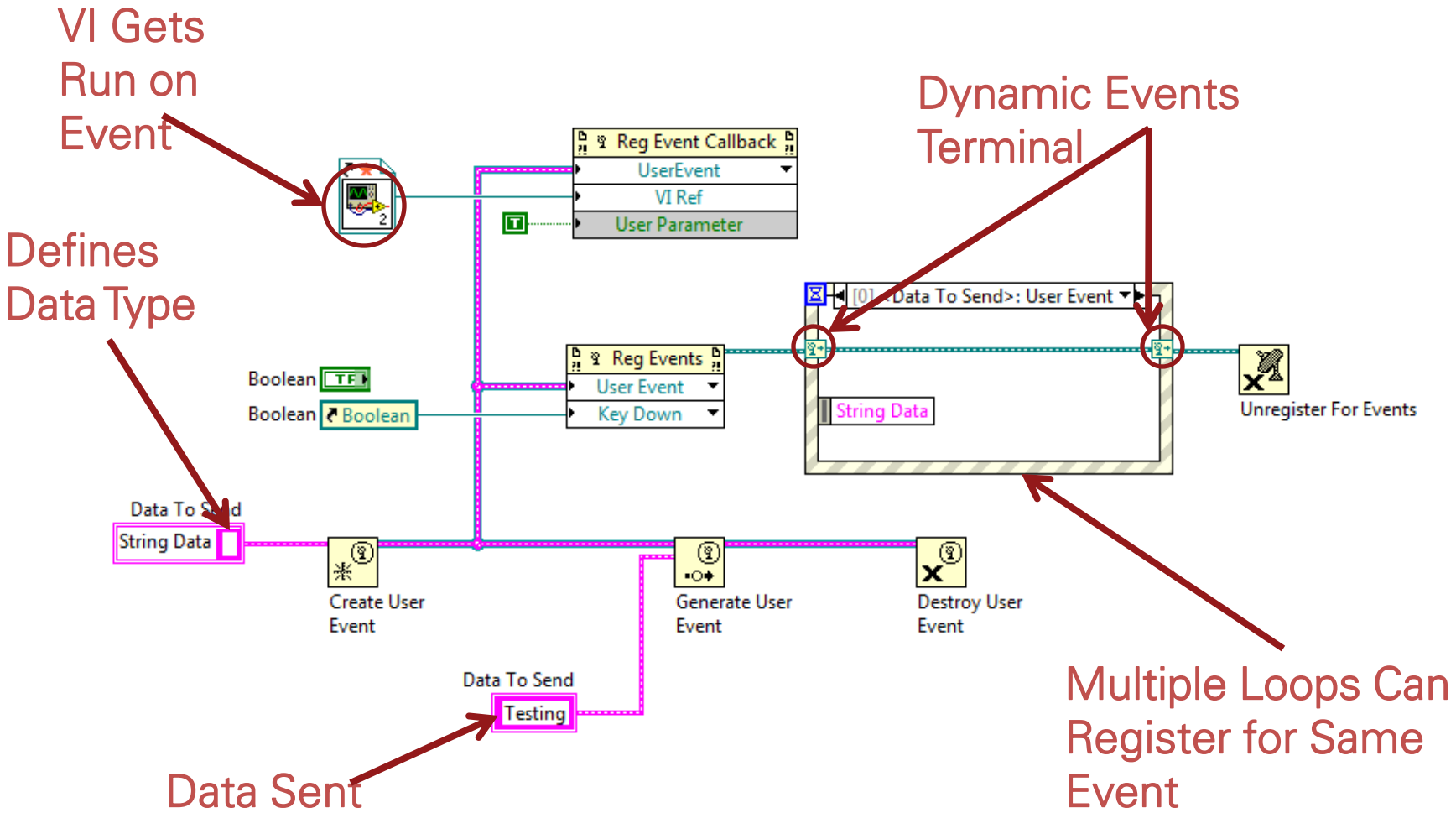
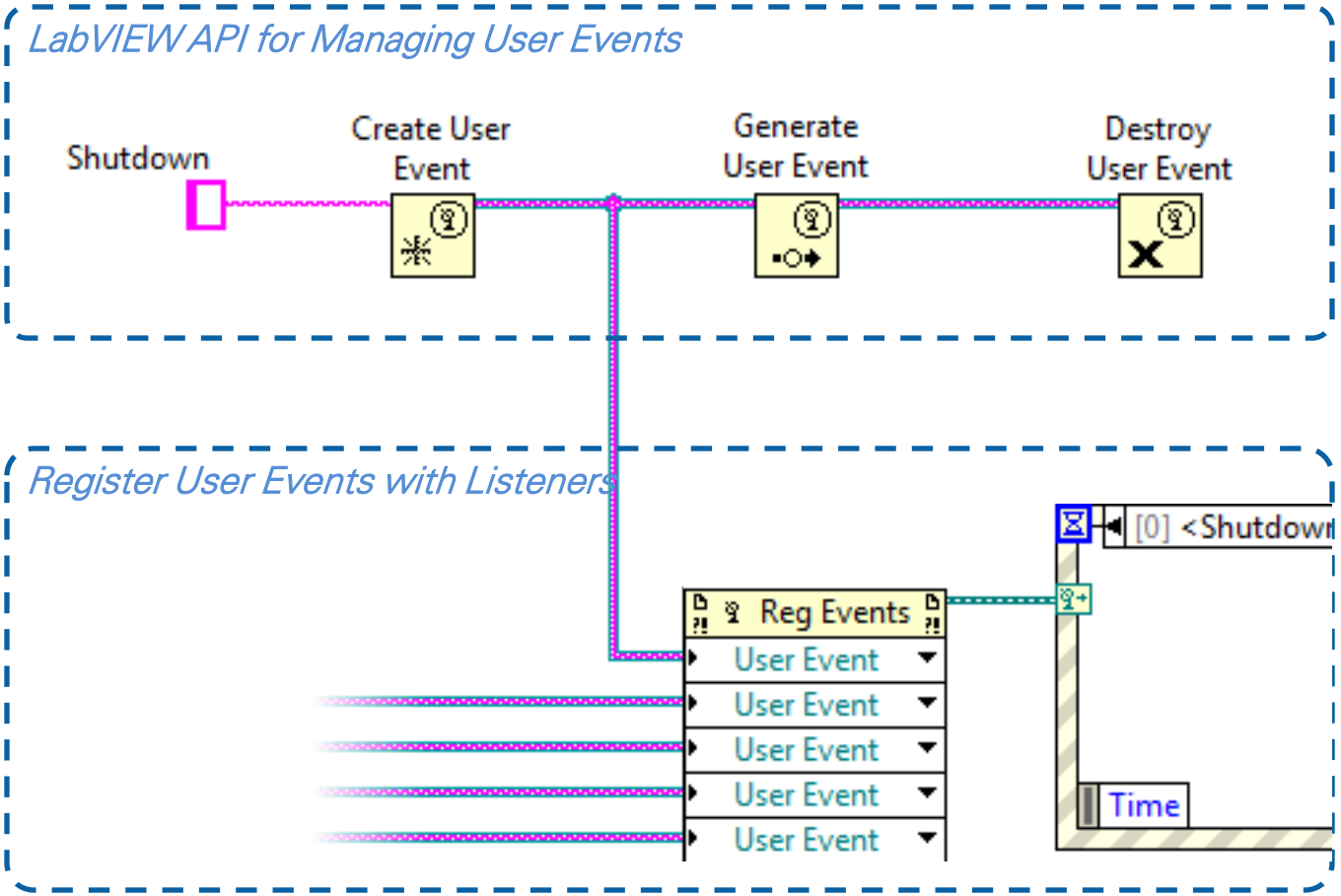
Demonstration

Introduction to LabVIEW Queues

The Anatomy of Dynamic Events



Using User Events



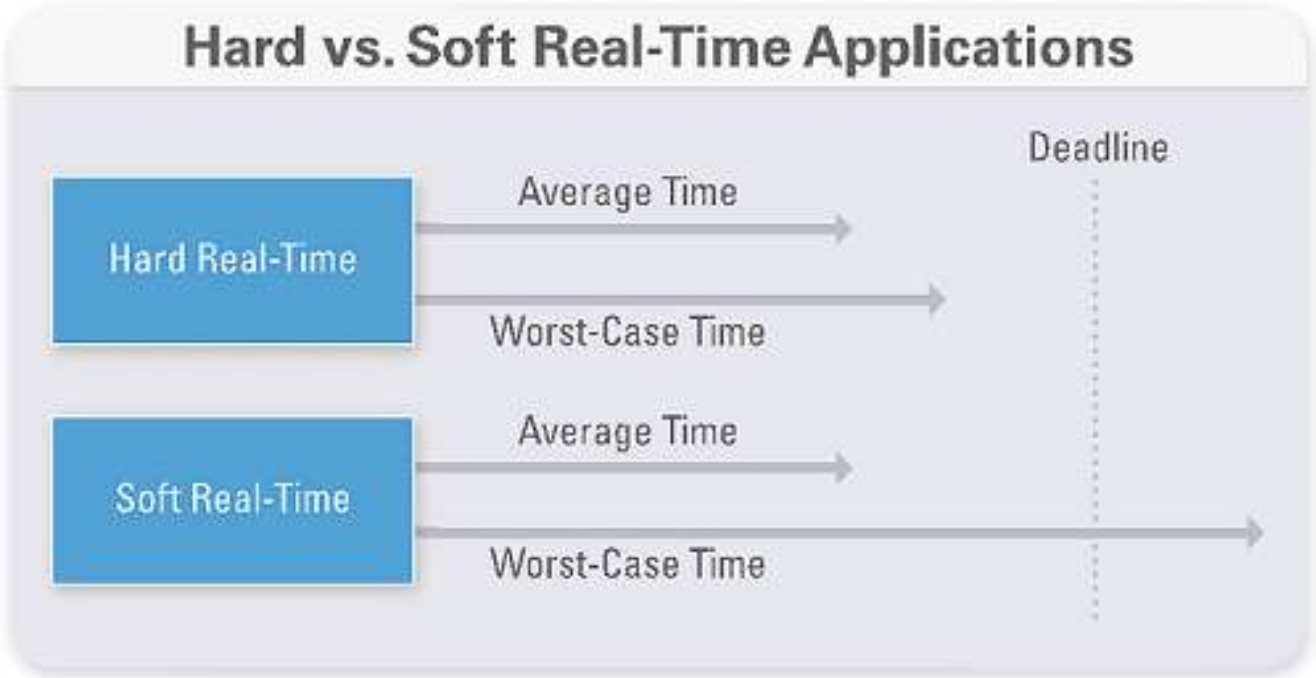
RT FIFOs vs. Queues

- Queues can handle string, variant, and other variable size data types, while RT FIFOs can not
- RT FIFOs are pre-determined in size, queues can grow as elements are added to them
- Queues use blocking calls when reading/writing to a shared resource, RT FIFOs do not
- RT FIFOs do not handle errors, but can produce and propagate them

Key Takeaway:

RT FIFOs are more deterministic for the above reasons

What is Determinism?



Determinism: An application (or critical piece of an application) that runs on a hard real-time operating system is referred to as deterministic if its timing can be guaranteed within a certain margin of error.

LabVIEW Real-Time Hardware Targets

LabVIEW Real-Time

CompactRIO

PXI

Desktop or Industrial PC

Vision Systems

Single-Board RIO

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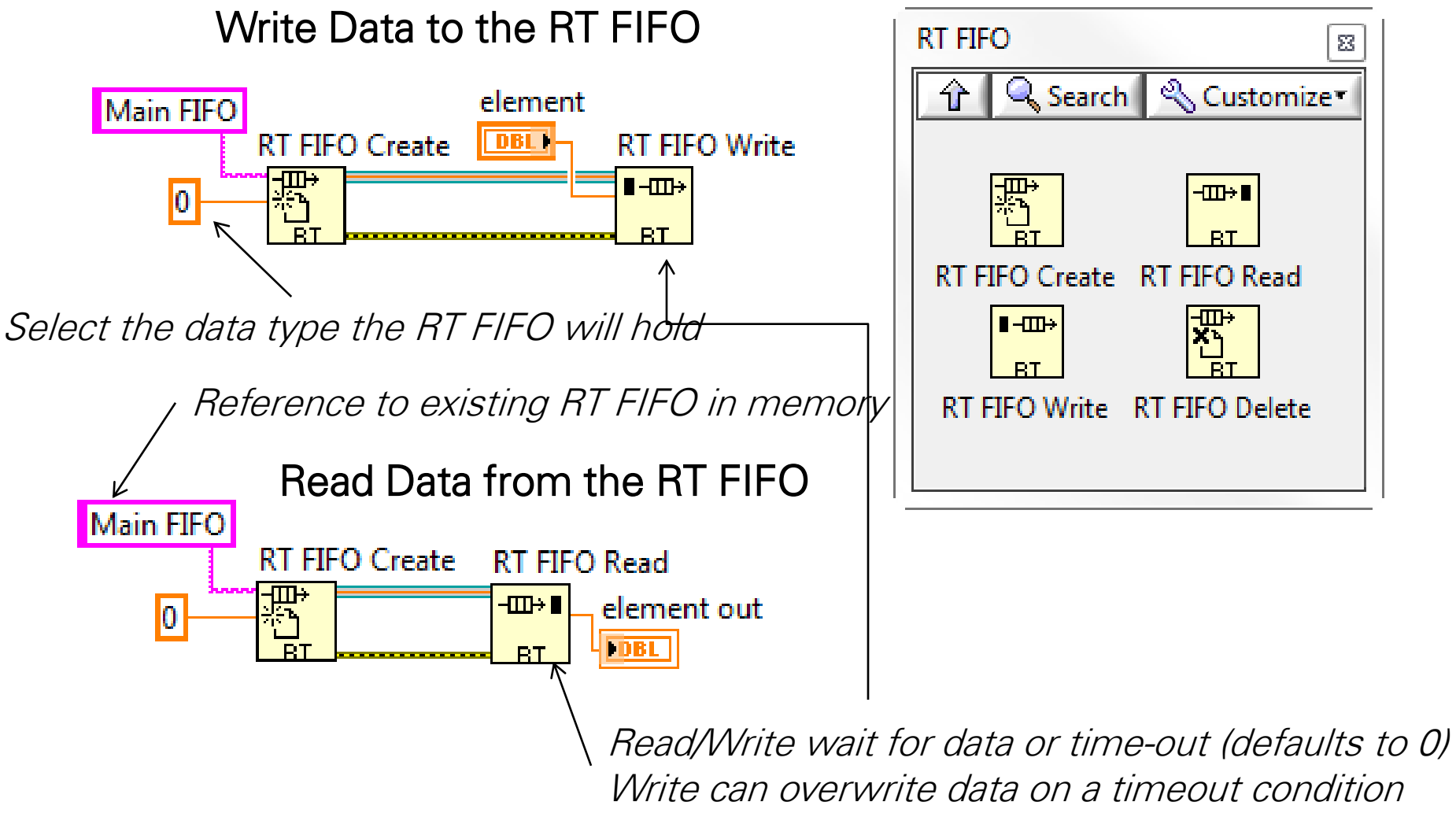
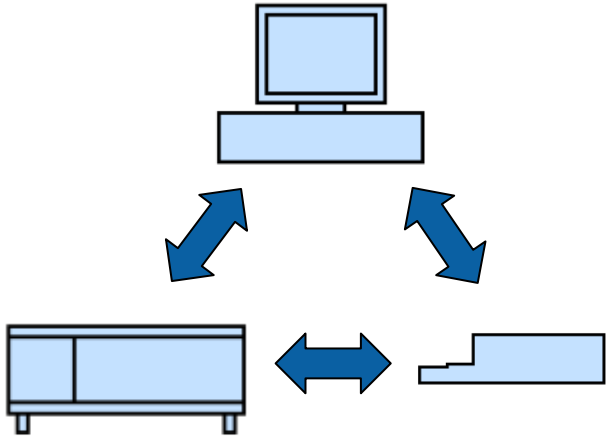
RT FIFOs


Write Data to the RT FIFO
Main FIFO
element
RT FIFO Create
DBL
RT FIFO Write
0
RT
RT
Select the data type the RT FIFO will hold
Reference to existing RT FIFO in memory
Read Data from the RT FIFO
Main FIFO
RT FIFO Create
RT FIFO Read
element out
0
RT
RT
DBL
Read/Write wait for data or time-out (defaults to 0)
Write can overwrite data on a timeout condition
RT FIFO
Search
Customize
RT FIFO Create
RT FIFO Read
RT FIFO Write
RT FIFO Delete

Defining Inter-target Communication

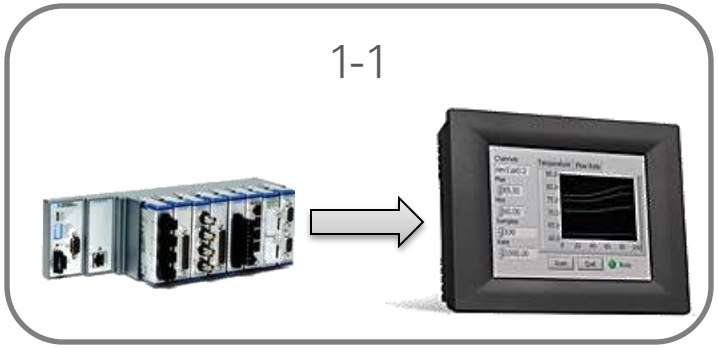
- PC, RT, FPGA, Mobile Device
- Offload data logging and data processing to another target
- Multi-target/device application
- Network based

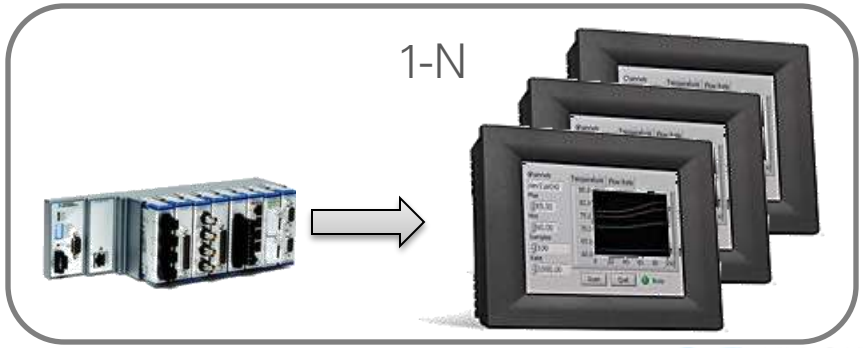


Common Network Transfer Policies

"Latest Value" or "Network Publishing"

- Making the current value of a data item available on the network to one or many clients
- Examples
  - I/O variables publishing to an HMI for monitoring
  - Logging temperature values on a remote PC
- Values persist until over written by a new value
- Lossy – client only cares about the latest value





Latest Value Communication

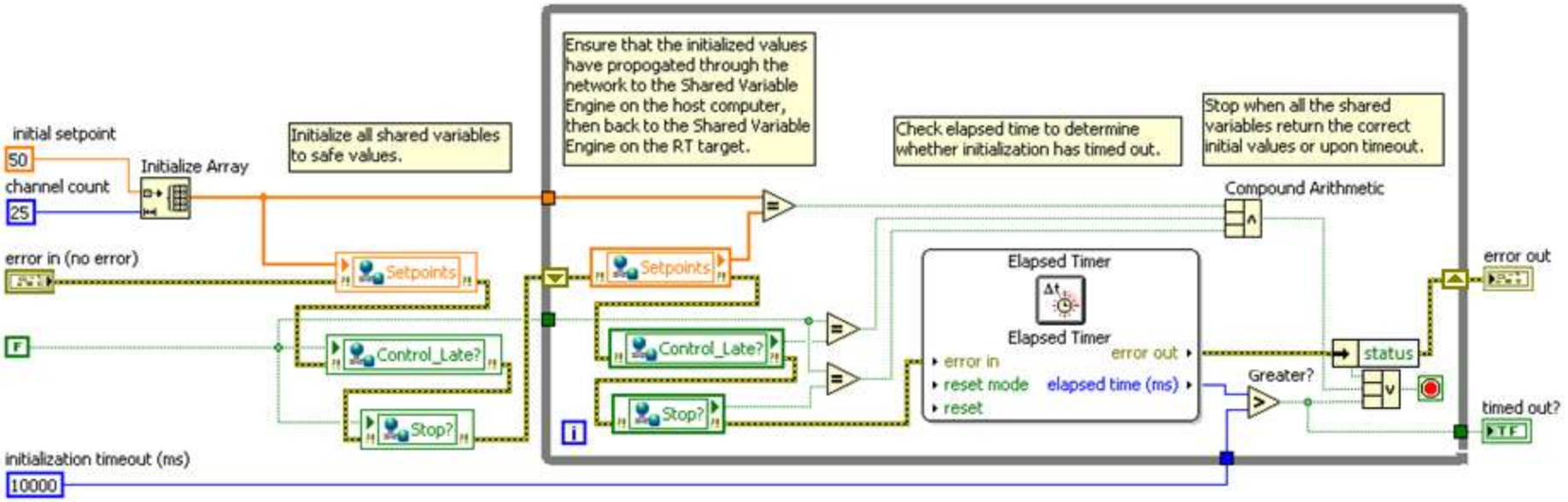
API	Type	Performance	Ease of Use	Supported Configurations	3rd Party APIs?
Shared Variable*	LabVIEW Feature			1:1, 1:N, N:1	• Measurement Studio • CVI
CCC (CVT)	Ref. Arch. *Publishes the CVT*			1:1	Yes (TCP/IP)
UDP	LabVIEW Prim.			1:1, 1:N, N:1	Yes

*Network buffering should be disabled

Using Shared Variables Effectively

Programming Best Practices:

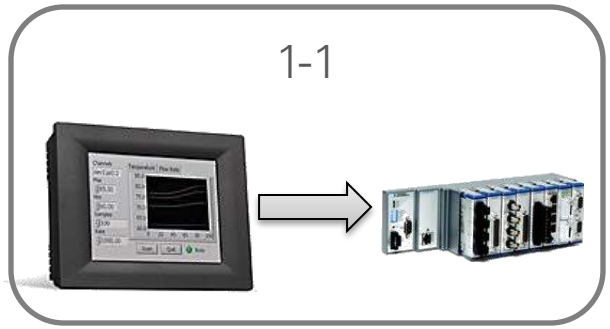
- Initialise shared variables
- Serialise shared variable execution
- Avoid reading stale shared variable data



Common Network Transfer Policies

"Streaming"

- Sending a lossless stream of information
- Examples
  - Offloading waveform data from cRIO to remote PC for intensive processing
  - Sending waveform data over the network for remote storage
- Values don't persist (reads are destructive)
- Lossless – client must receive all of the data
- High-throughput required (latency not important)



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Streaming Lossless Data

API	Type	Performance	Ease of Use	Supported Configurations	3rd Party APIs?
Network Streams NEW!	LabVIEW Feature	●	●	1:1	Not this year
STM	Ref. Arch.	●	○	1:1	Yes (TCP/IP)

What about the shared variable with buffering enabled?

NO!

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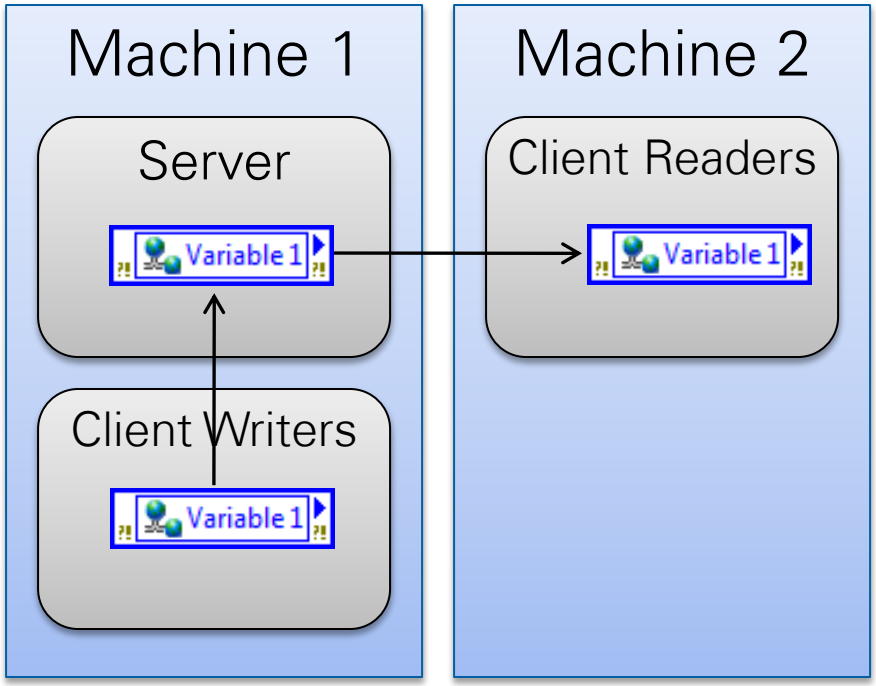
Pitfalls of Streaming with Variables

- Lack of flow control can result in data loss
- Data may be lost if the TCP/IP connection is dropped
- Data loss does not result in an error, only a warning



Network Streams

- Lossless transfer, even in connection loss*
- Can be tuned for high-throughput (streaming) or low-latency (messaging)
- Unidirectional, P2P, LabVIEW only
- Not deterministic

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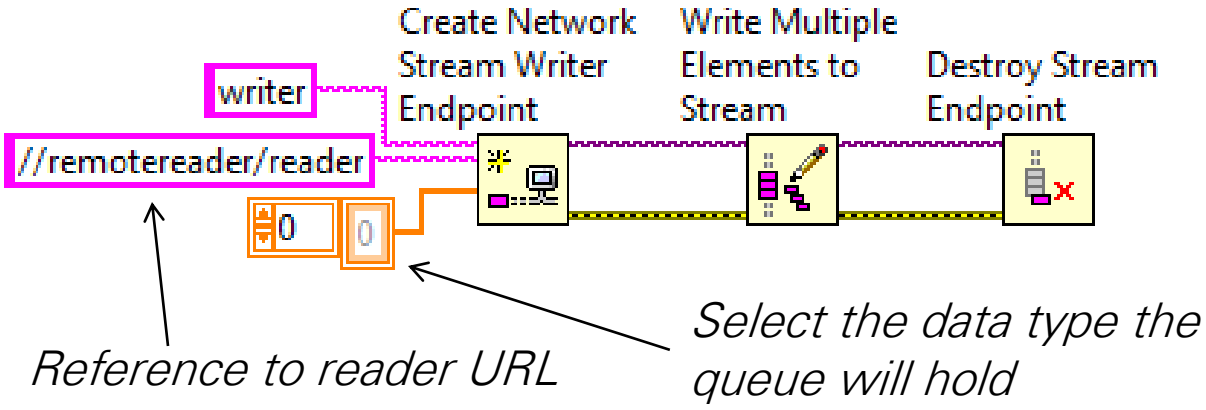
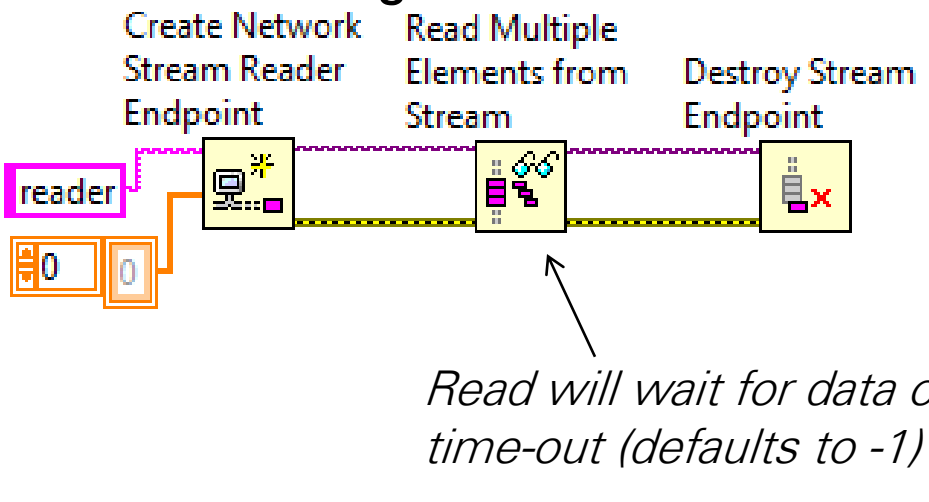
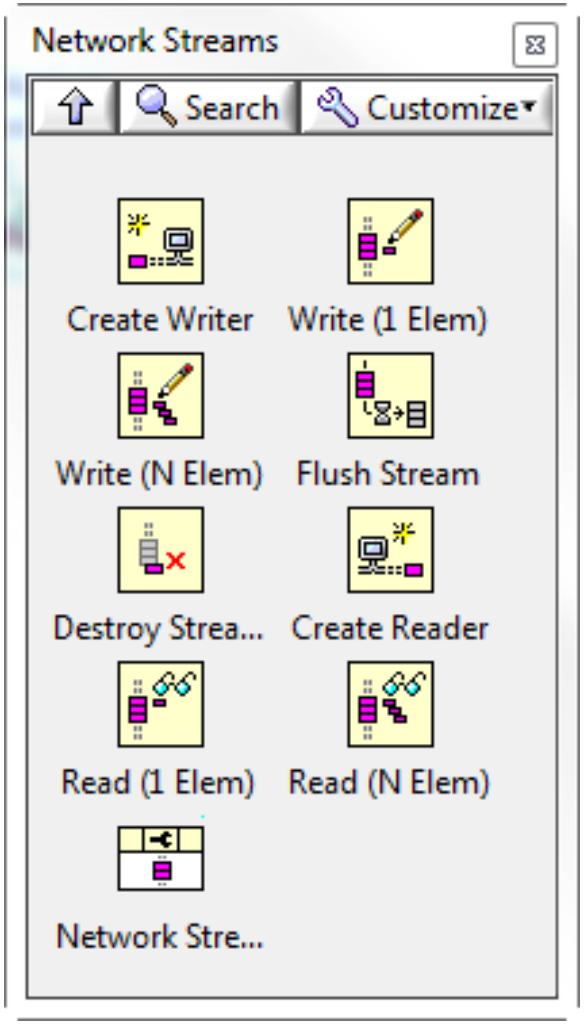
Network Streams

Writing Elements to the Stream



Reading Elements from Stream





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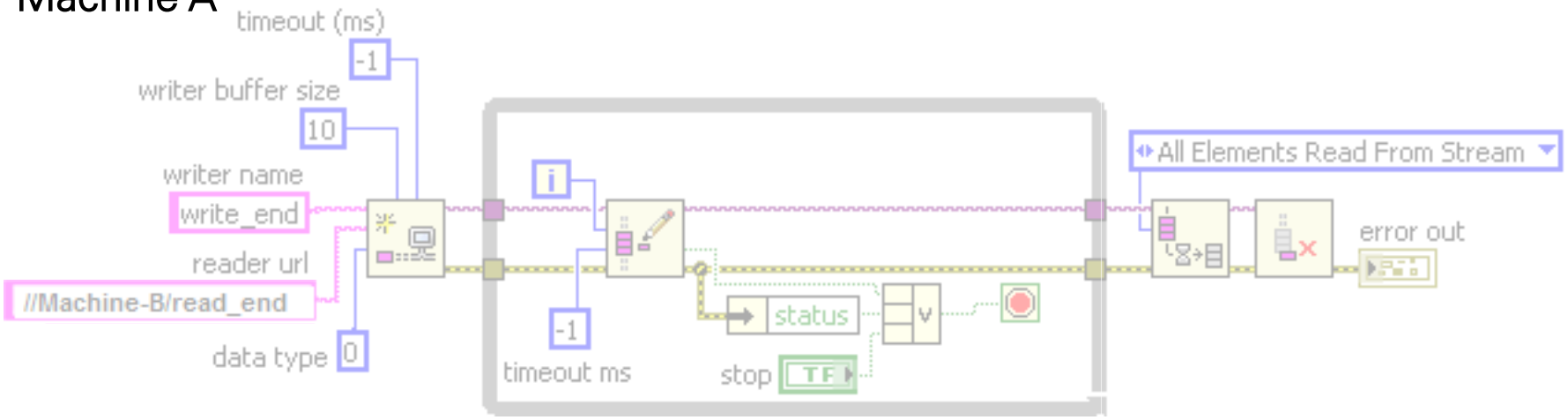
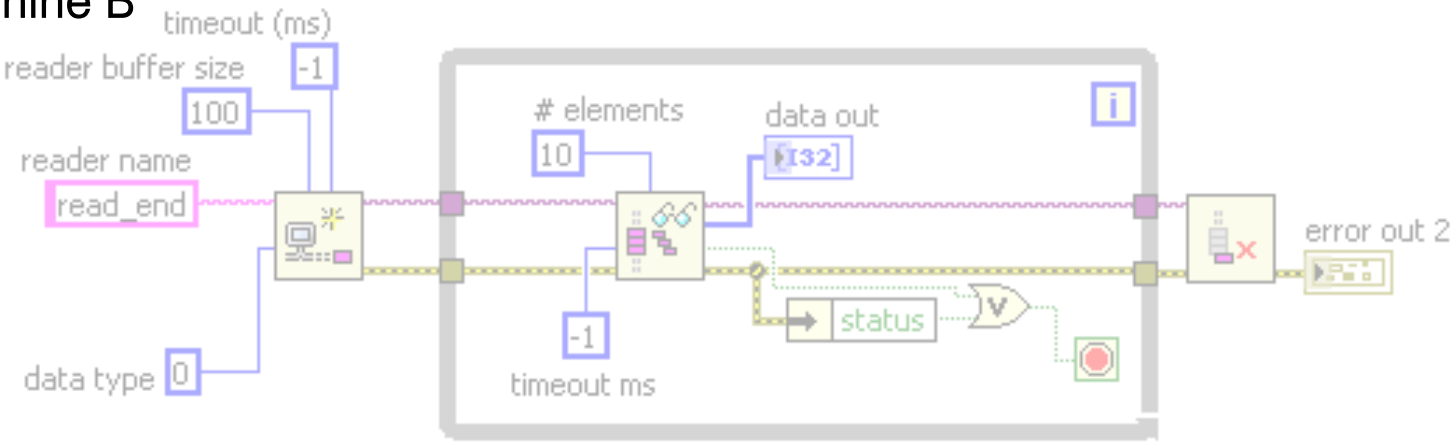
Network Streams NEW!

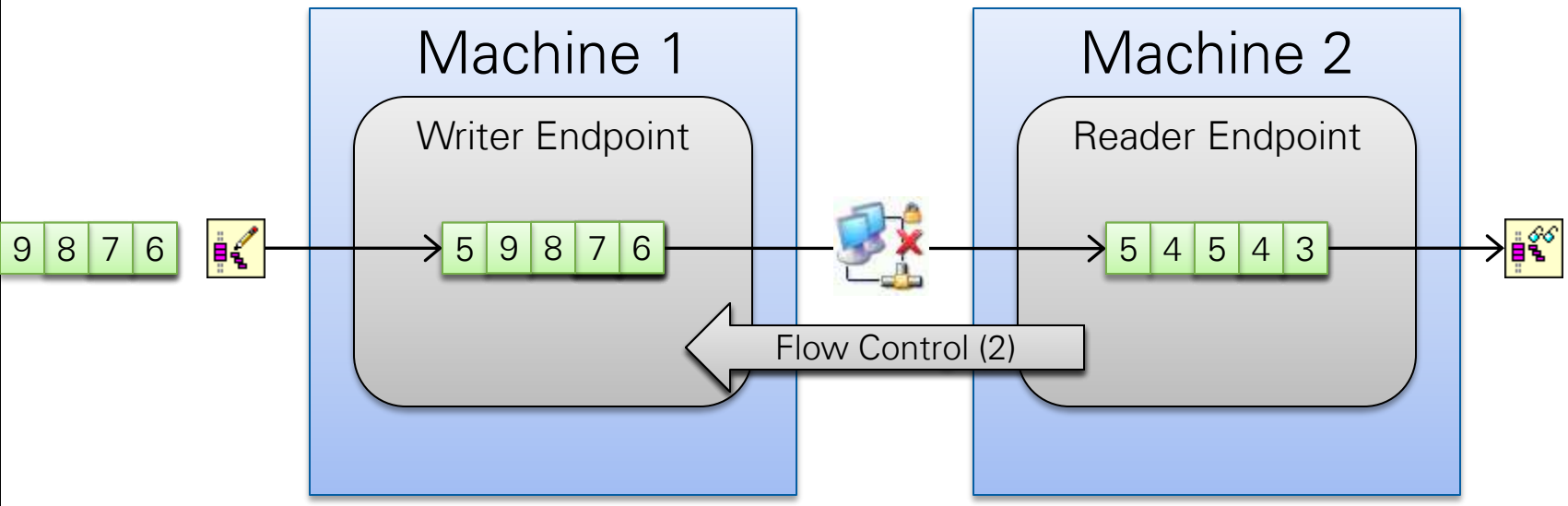
Machine A



Machine B



Network Streams in Action



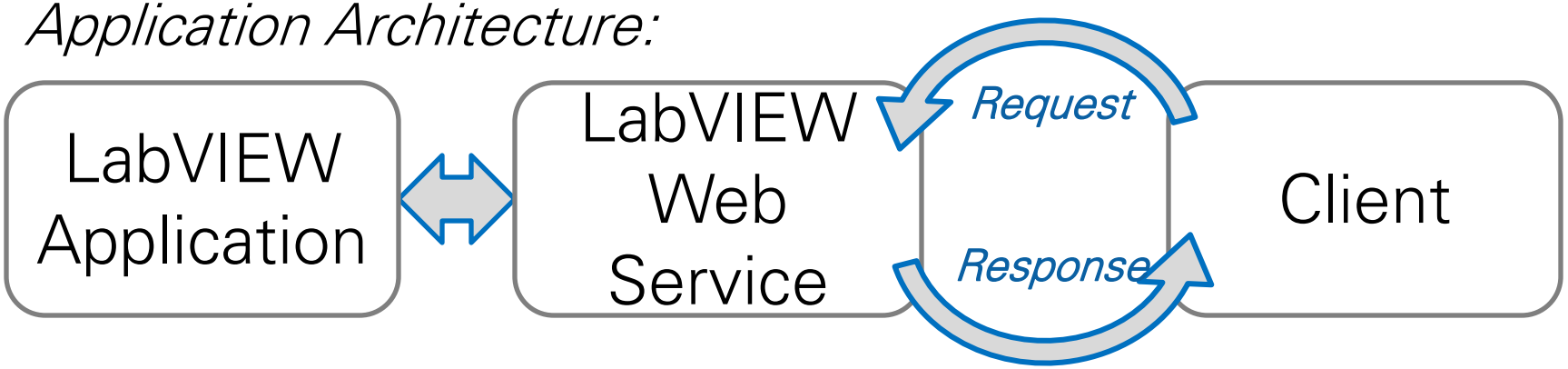
Use Streams!

Demonstration

Inter-target Communication Using Network Streams

LabVIEW Web Services

Application Architecture:



Sending Requests via URL:

Physical Location of Server
Name of Web Service
Mapping to a VI
Terminal Inputs (Optional)

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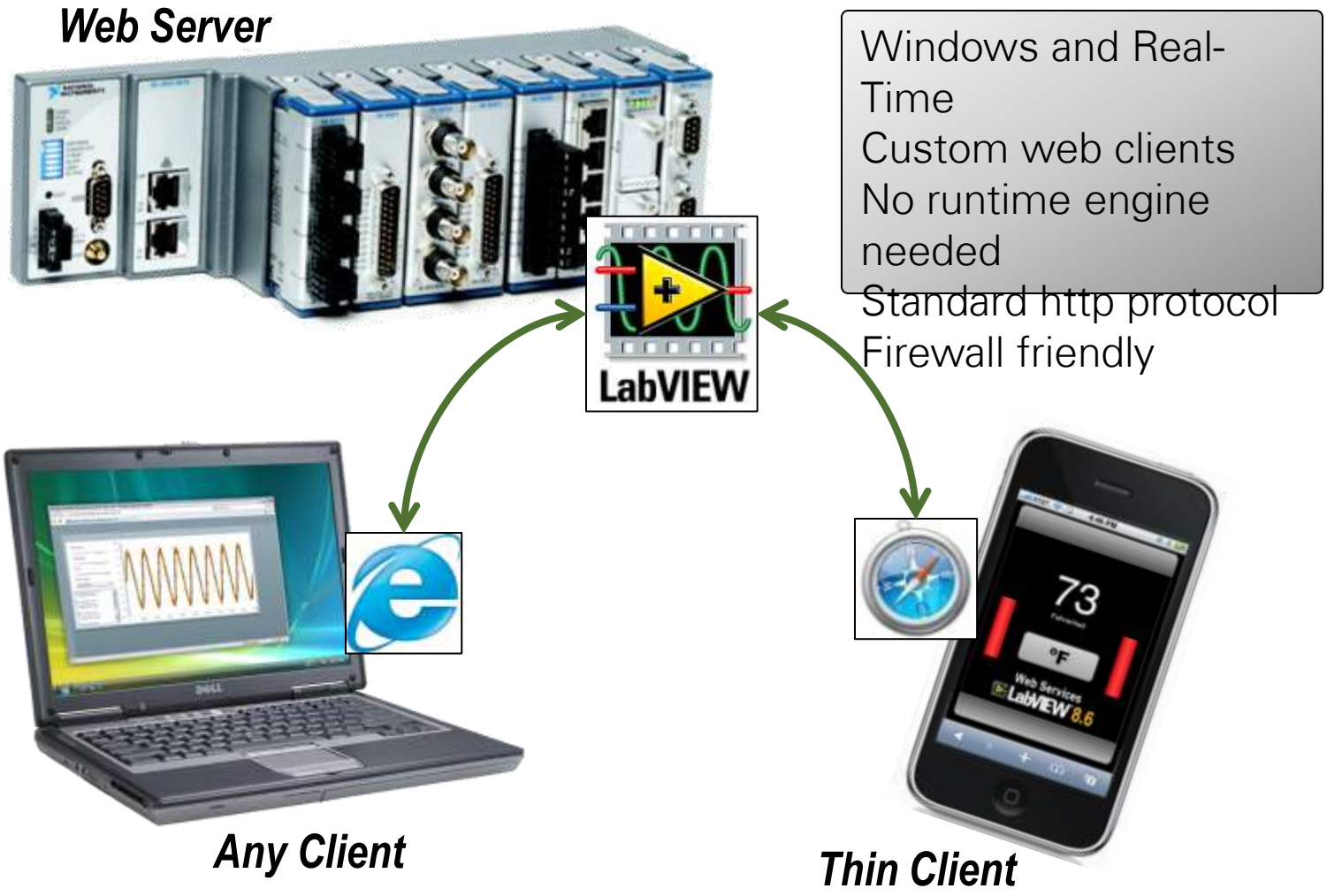
Web Services in LabVIEW



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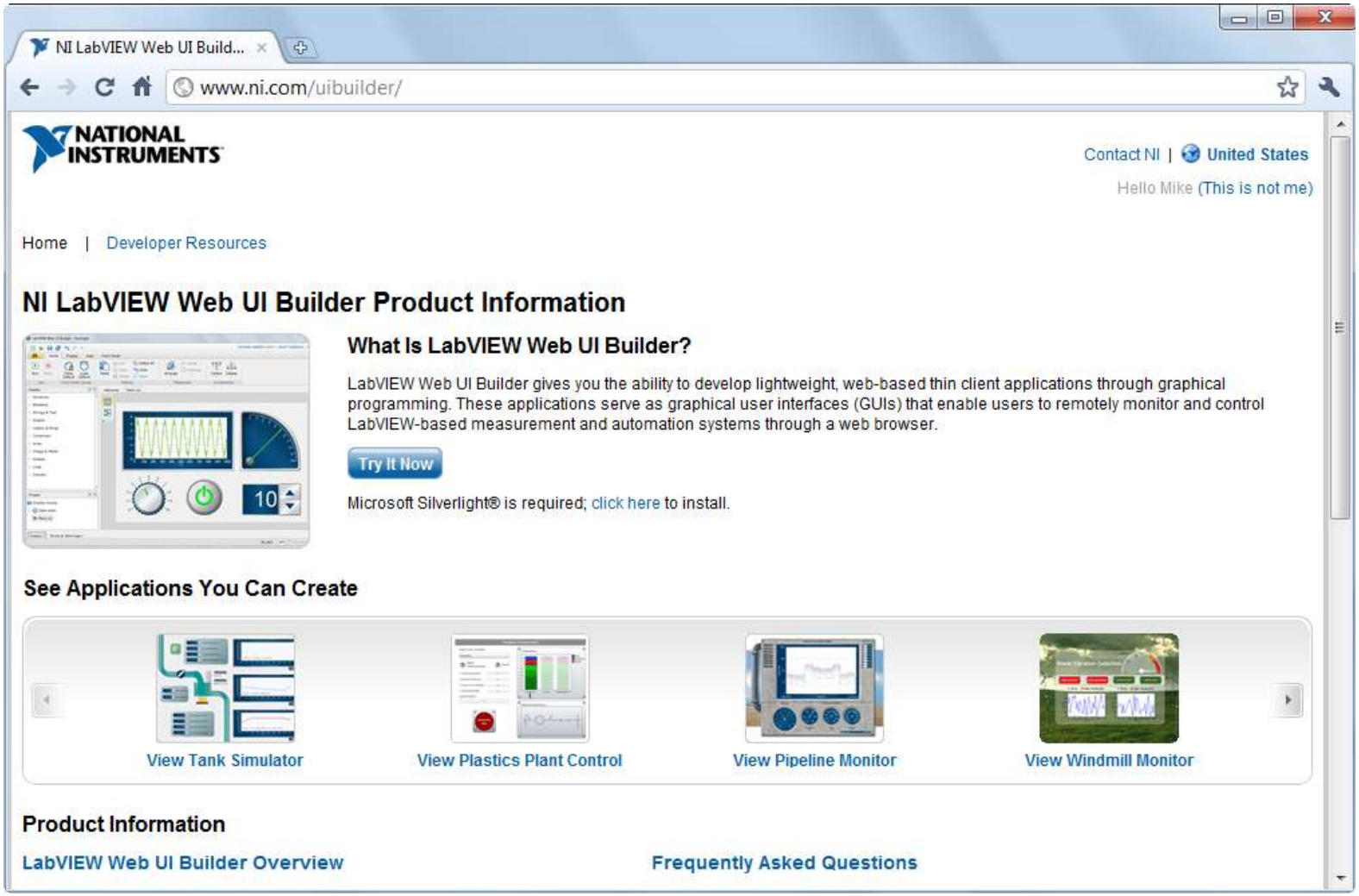


NATIONAL INSTRUMENTS

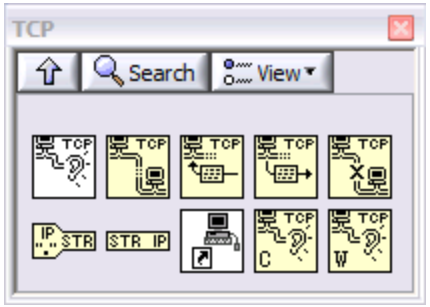
Early Access Release Details

- Anyone can evaluate for free
  - Fully functional except for ‘Build and Deploy’
  - License for ‘Build and Deploy’ is $1,499 per user
  - License is sold as one-year software lease
- Not part of Developer Suite or Partner Lease

Inter-Target Communication Options

TCP/IP and UDP

Define low-level communication protocols to optimise throughput and latency

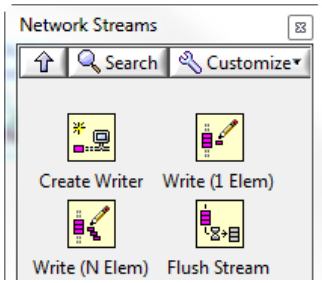


Shared Variables

Access latest value for a network published variable

Network Streams

Point to Point streaming in LabVIEW with high throughput and minimal coding



Web UI Builder

Create a thin client to communicate with a LabVIEW Web Service

DMAs

Direct memory access between to different components of a system

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Download Examples and Slides

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Software Engineering Tools


Development Practices


LargeApp Community