# LXI Programmatic Interface

Joe Mueller (Agilent)

Agilent Technologies

# LXI IVI API

## Trigger/Arm

- Provides uniform control of HW and LAN triggers
- Set alarms for use as trigger/arm or elsewhere

## Event

- Allows arbitrary events in the instrument to be transmitted via arbitrary mechanism (TCP/UDP/HW)

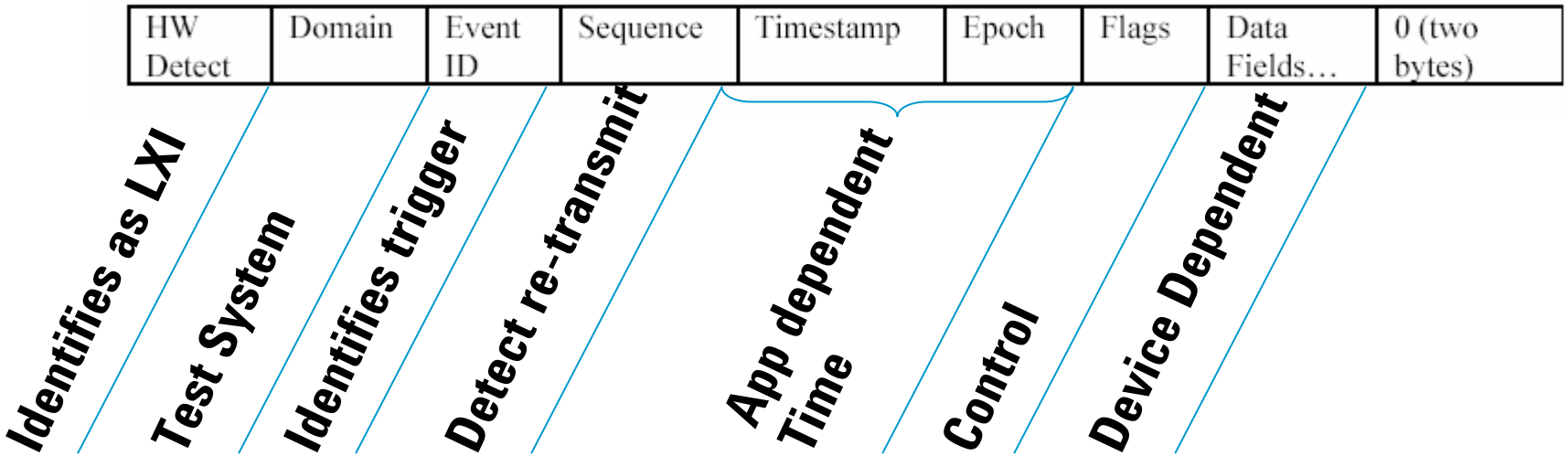
## 1588 Clock

- Read time
- Verify synchronized

## Event Log

- Debug

# LXI LAN Events



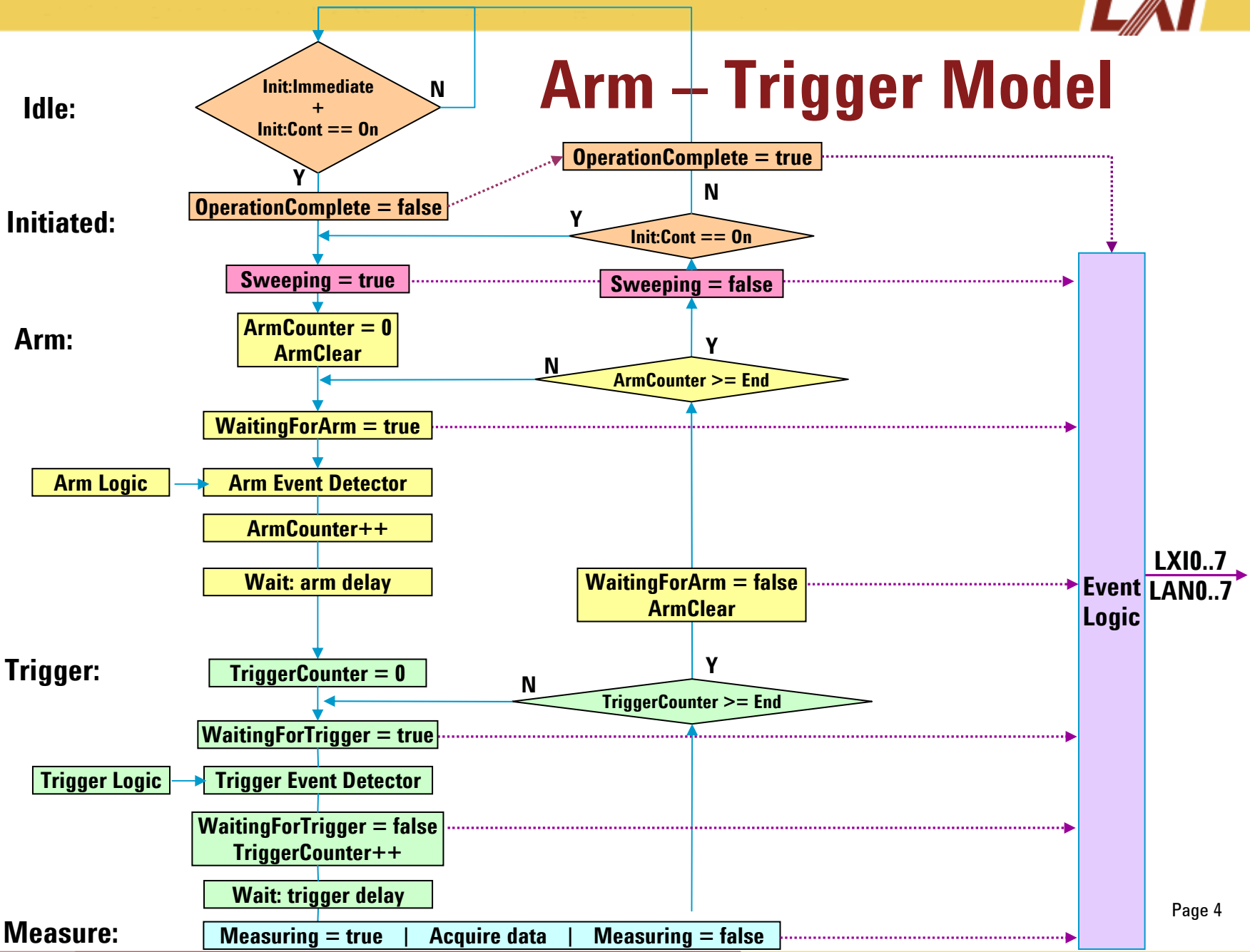

**UDP Event**

- **Multicast trigger (IANA designated multicast address)**
- **Reasonably reliable multicast mechanism**

**TCP Event**

- **Point-point**
- **Reliable**

# Arm – Trigger Model

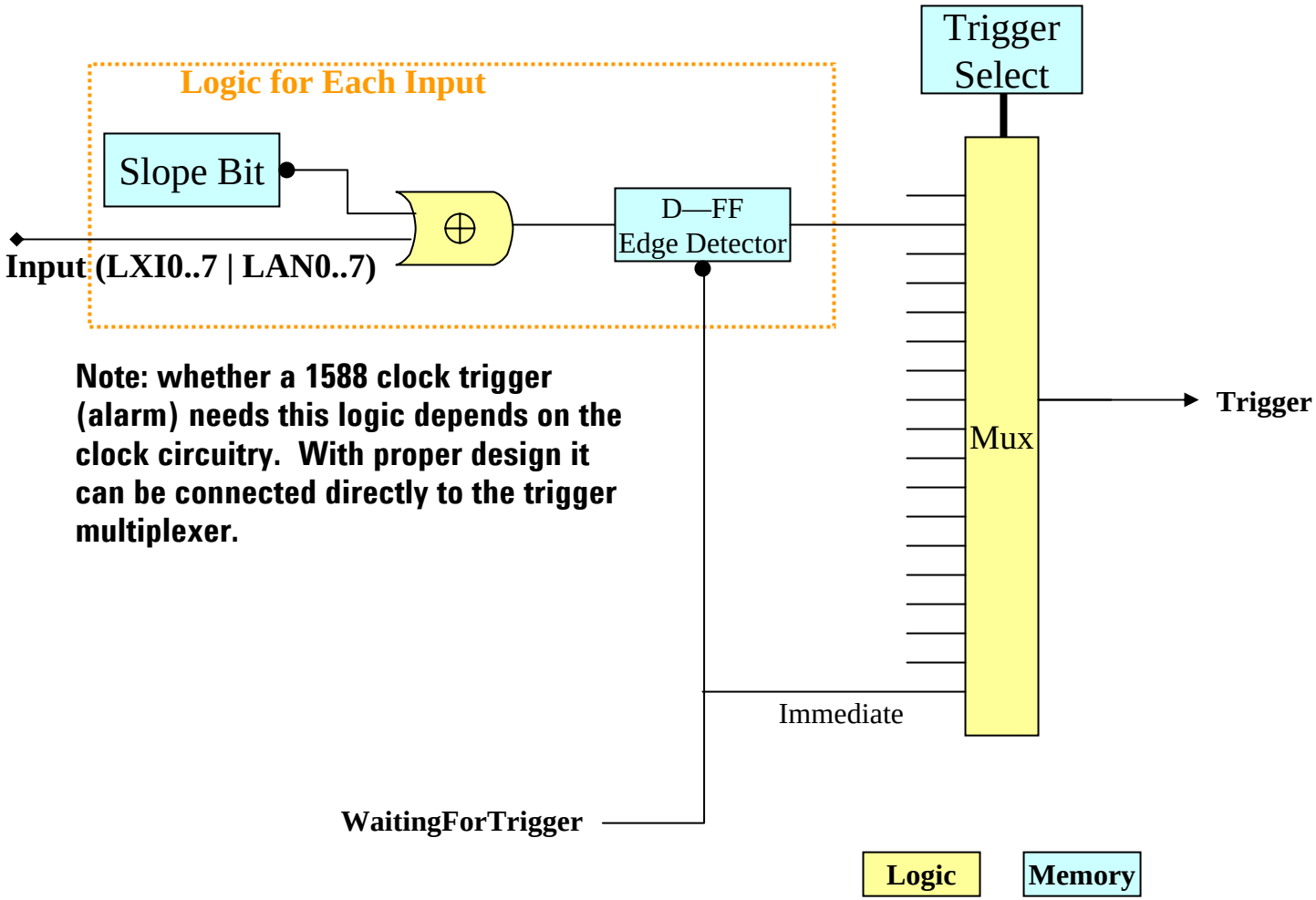






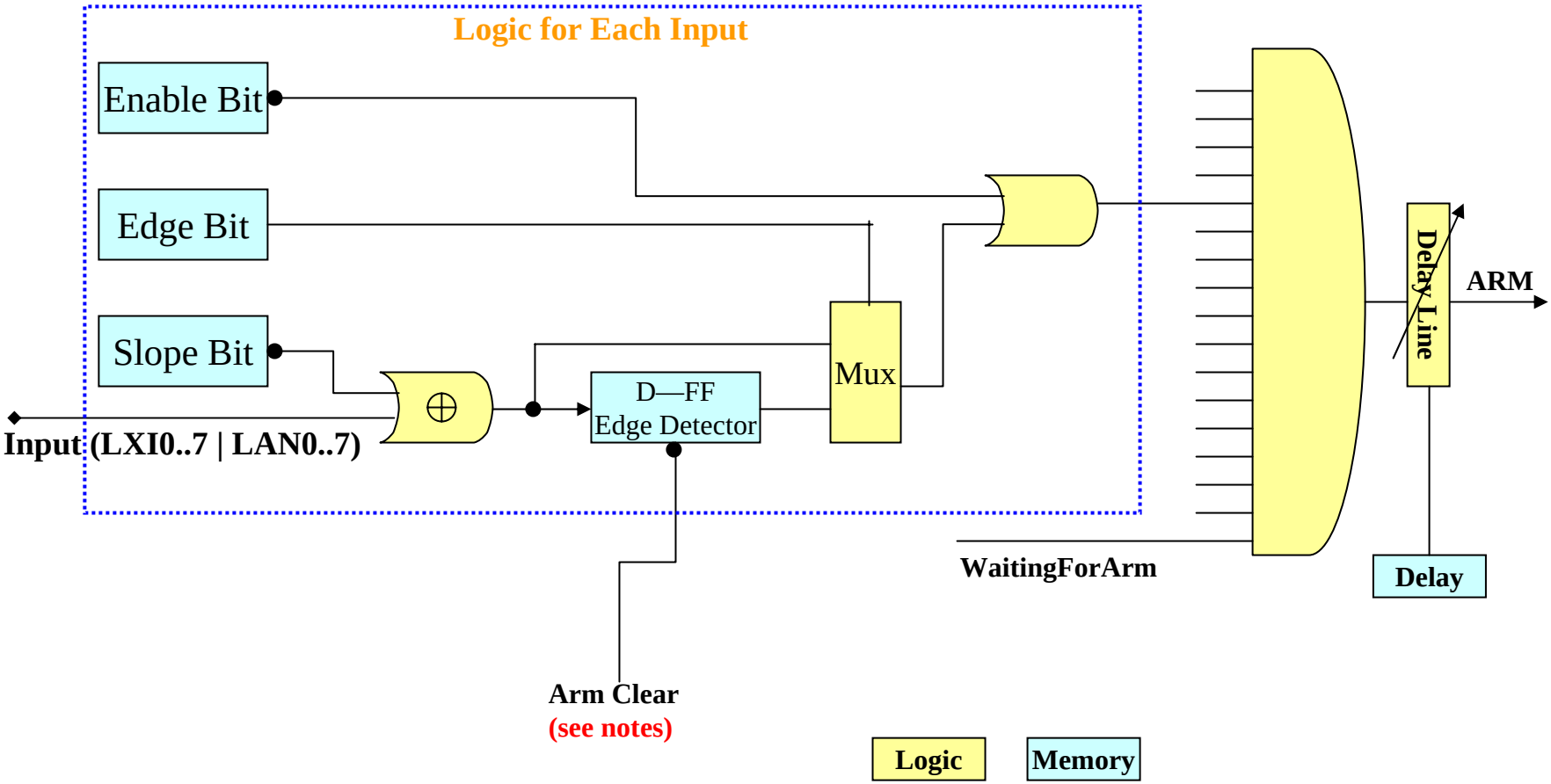
LAN eXtensions for Instrumentation

# Trigger In Logic




**Note: whether a 1588 clock trigger (alarm) needs this logic depends on the clock circuitry. With proper design it can be connected directly to the trigger multiplexer.**

# Arm Logic: LXI0..7 & LAN0..7

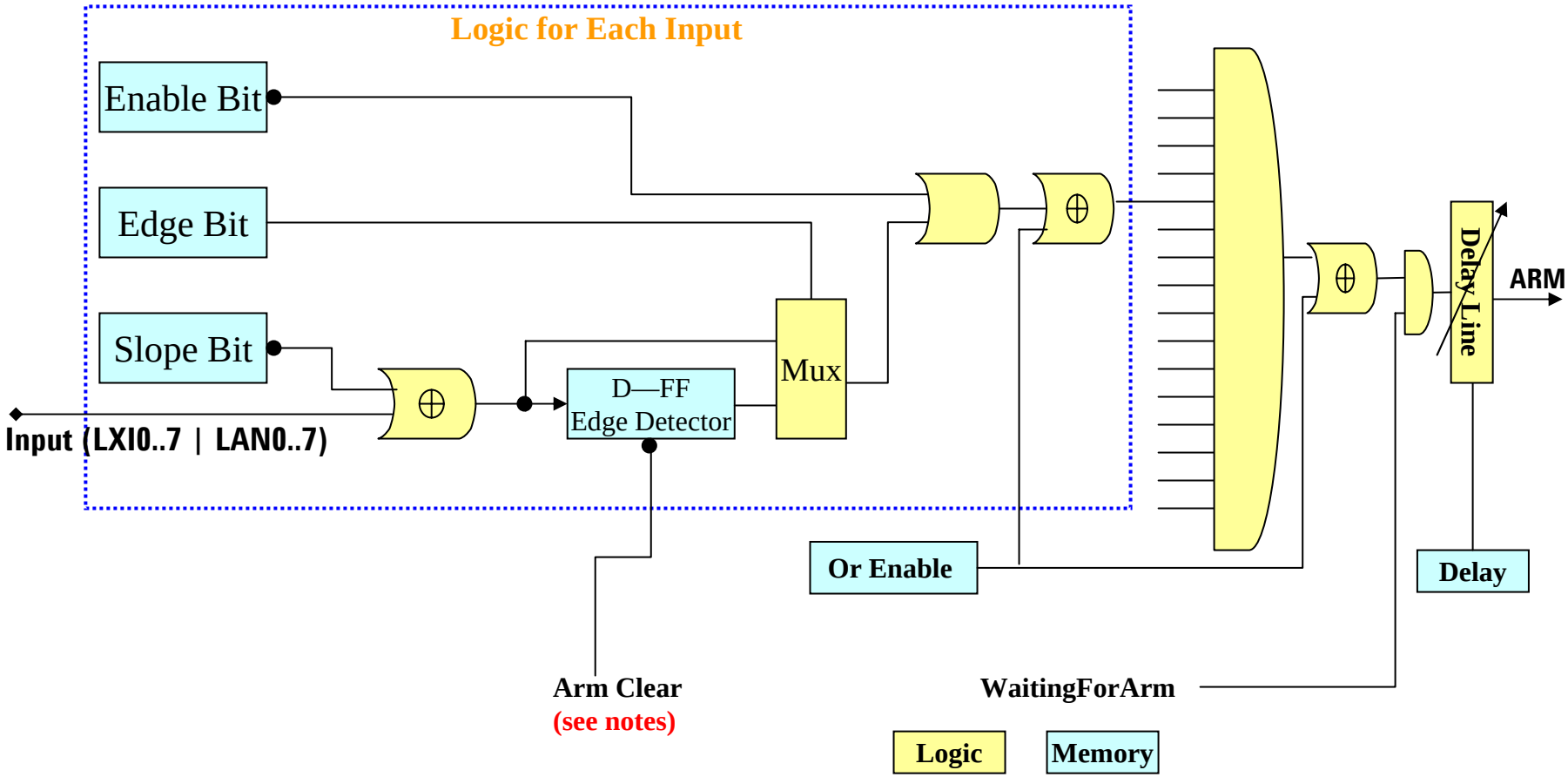






LAN eXtensions for Instrumentation

# Arm Logic: LXI0..7 & LAN0..7 Selectable And & Or Summing







LAN eXtensions for Instrumentation

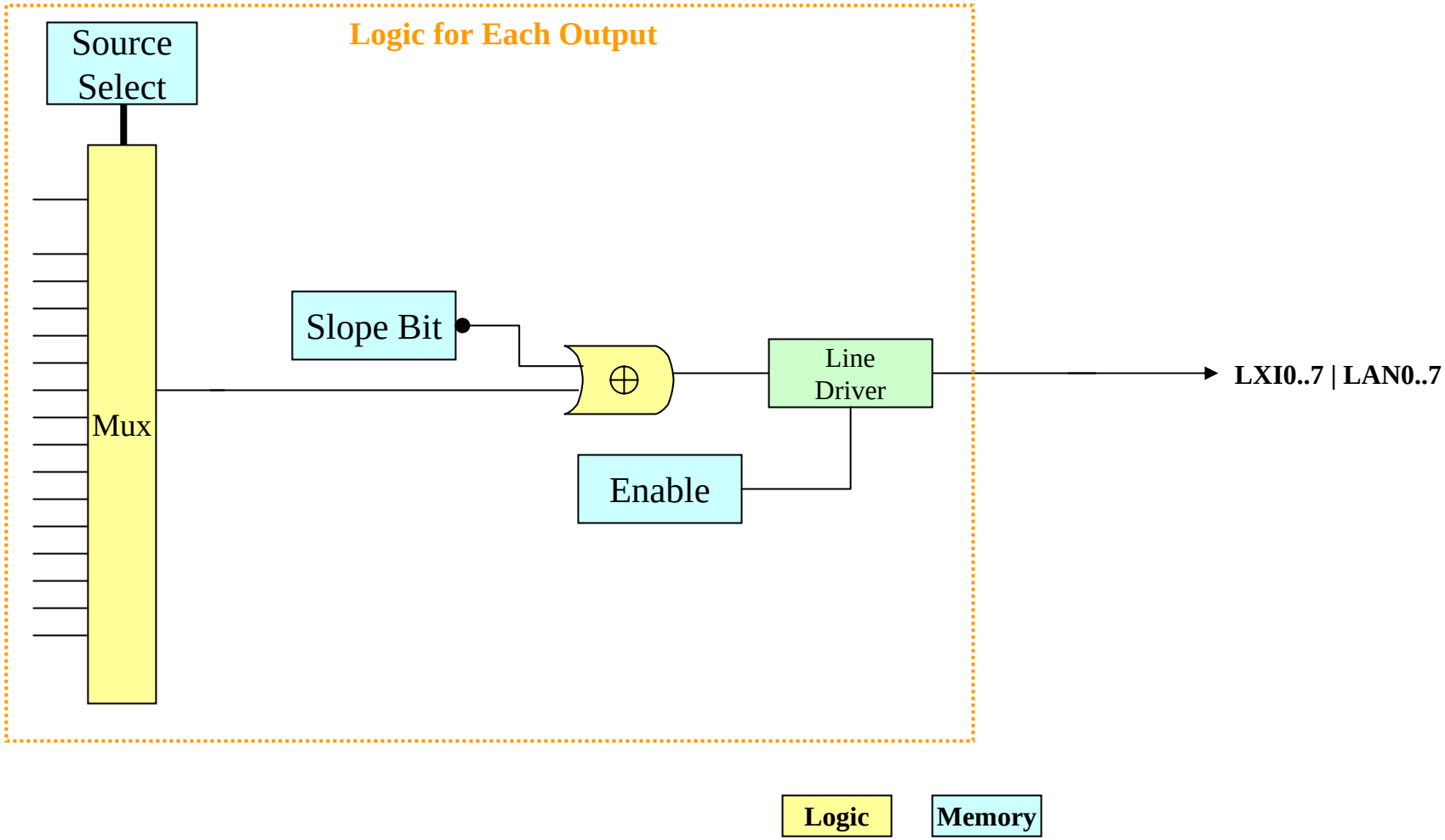
# Trigger Subsystem

- Can accept trigger source signals on LXI0..7 and LAN0..7
  - Custom trigger sources supported via extensible repeated capabilities
- Trigger source configuration options
  - Delay specifies trigger delay
    - Negative value implies pre-trigger acquisition
  - Slope (positive or negative)
  - Filter restricts the senders that will be accepted
    - Details on upcoming slide
- Trigger in response to Alarm condition (aka “Clock”)
  - Details in upcoming slide
- TriggerCount property controls the number of times the trigger has to occur to complete a measurement

# Arm Subsystem

- Can accept arm source signals on LXI0..7 and LAN0..7
  - Custom arm sources supported via extensible repeated capabilities
- Arm source configuration options
  - Edge detection or level detection
  - Delay to accommodate electrical delay in the signal path
  - Slope (positive or negative)
  - Filter restricts the senders that will be accepted
    - Details on upcoming slide
- Arm in response to Alarm condition (aka “Clock”)
  - Details on upcoming slide
- ArmCount property controls how many times arm-trigger cycle repeats

# Event Out (Trigger Out) Logic







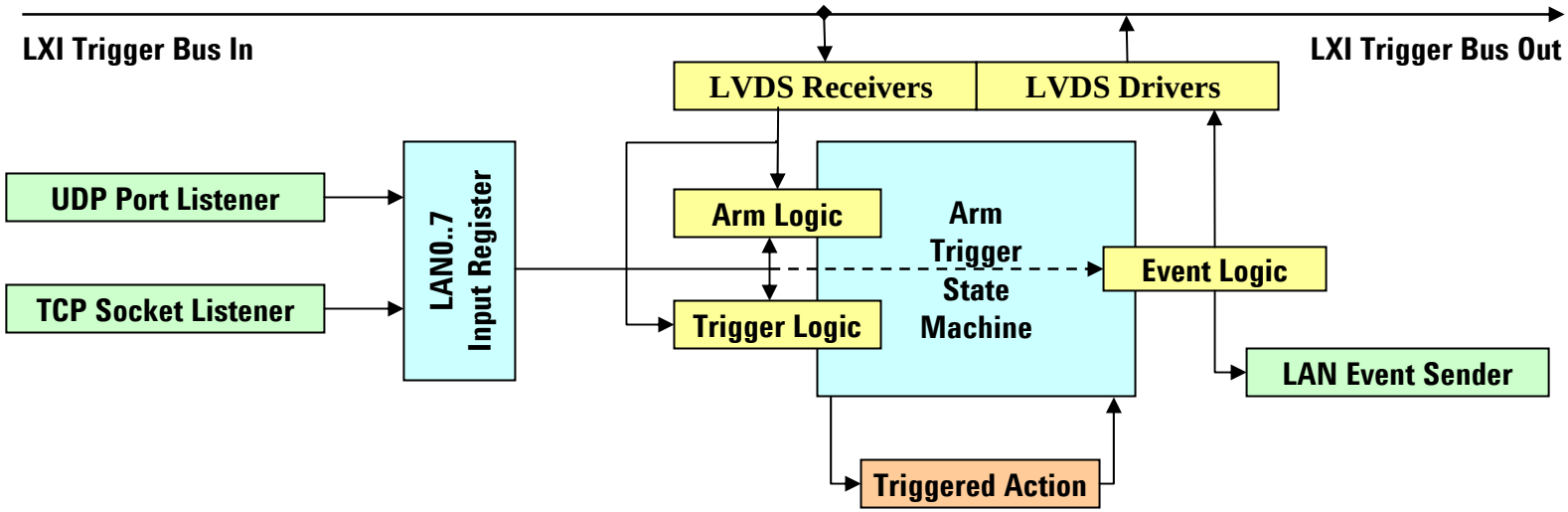
LAN eXtensions for Instrumentation

# Events Subsystem

- Event *sources* cause an event to be transmitted
- Six built-in (reserved) events sources
  - OperationComplete
  - Measuring
  - Settling
  - Sweeping
  - WaitingForArm
  - WaitingForTrigger
- Events transmitted on LXI0..7 or LAN0..7 or custom LAN event
  - Referred to as *destination*
  - TCP broadcast supported


LAN eXtensions for Instrumentation

# How the Pieces Fit Together: for a Simple Module







LAN eXtensions for Instrumentation

# Alarm Subsystem

- Applies to Trigger and Arm subsystems
- Provides a signaling mode in addition to trigger bus and LAN events
- "Clocking mechanism"
- Two timing modes
  - Specify an absolute 1588 time
  - Specify a period and repeat count
    - Repeat count of zero => no repeat (single-shot)

# Primary APIs to Configure Trigger/Event

```
Arm.Sources.Item(<name>).Configure(Bool Edge,
                                   Bool Enabled,
                                   LxiSyncSourceSlopeEnum Slope);

Trigger.Sources.Item(<name>).Configure(double Delay,
                                       LxiSyncSourceSlopeEnum Slope);

Events.Item(<name>).Configure(BSTR Source,
                              BSTR DestinationPath,
                              LxiSyncEventEnabledEnum Enabled,
                              LxiSyncSourceSlopeEnum Slope);

Trigger.Alarms.Item(<name>).Configure(double TimeSeconds, double
TimeFraction, double Period, long RepeatCount);
```

# Tell: Digitizer to output WaitingFor Trigger on LXI1
## Arb to trigger when that event arrives

```
digSync.Events ("LXI1").Configure(
    "WaitingForTrigger", "",
    LxiSyncEventEnabledEnum.LxiSyncEventEnabledOn,
    LxiSyncSourceSlopeEnum.LxiSyncSourceSlopePositive);

arbSync.Trigger.Sources ("LXI1").Configure(
    0,
    LxiSyncSourceSlopeEnum.LxiSyncSourceSlopePositive);

arb.Trigger.Source = "LXI1";      // in instrument specific interface
```

# LAN Triggers work similarly

```
digSync.Events (“LAN1").Configure(
    "WaitingForTrigger", "",
    LxiSyncEventEnabledEnum.LxiSyncEventEnabledOn,
    LxiSyncSourceSlopeEnum.LxiSyncSourceSlopePositive);

arbSync.Trigger.Sources (“LAN1").Configure(
    0,
    LxiSyncSourceSlopeEnum.LxiSyncSourceSlopePositive);

arb.Trigger.Source = “LAN1";
```

# Trigger and Arm Source Filtering

- Specifying a filter restricts the arm sources that will be accepted by a particular receiver
  - Only allow authorized sources => security mechanism
- *Accepted* senders are specified using a special syntax
  - Empty filter means packets from any port on any host are accepted
  - Specifying only the port means that any host communicating on that port can send events

Filter == [host[port]][,Filter]

| | |
|---|---|
| "192.168.0.1:23" | Port 23 on host at IP 192.168.0.1 |
| "A_SIGGEN1:23, A_SPECAN2:23" | Port 23 on host at DNS A_SIGGEN1 and port 23 on host at DNS A_SPECAN2 |
| "192.168.0.1" | Any port on host at IP 192.168.0.1 |
| ":23" | Any host communicating on port 23 |
| ":23, A_SPECAN2" | Any host communicating on port 23 and any port on host at DNS A_SPECAN2 |

# IVI Repeated Capabilities

- LxiSync API makes heavy use of IVI *repeated capabilities*
- Used extensively in IVI to model collections of things
  - "Channels" in an oscilloscope
  - "Traces" in a spectrum analyzer
- LxiSync defines five repeated capabilities
  - LxiSyncArmAlarm
  - LxiSyncArmSource
  - LxiSyncTriggerAlarm
  - LxiSyncTriggerSource
  - LxiSyncEvent
- Standard collection interface contains three well-known properties
  - Count: returns number of items in collection
  - Item: returns a specific item by name
  - Name: returns the name of an item at a specified one-based index

# Extensible Repeated Capabilities

- Drivers must support several required repeated capabilities using reserved words
  - "LXI0", "LXI1", ... "LXI7"
  - "LAN0", "LAN2", ... "LAN7"
  - These are registered in the IVI Configuration Store
- Trigger, Arm, and Event subsystems use extensible repeated capabilities for the "Sources" collection
  - Allows users to add custom LAN events (or even other custom hardware events)
- Extensible repeated capabilities contain three well-known methods
  - Add: add a new item to the collection
  - Remove: remove a specific item from the collection
  - RemoveAllXXX: remove all *custom* items from the collection


LAN eXtensions for Instrumentation

# LXI 1.0 Rules and Recommendations

6.1 Provide IVI driver (C or COM)

6.2 Initialize driver with VISA compatible string

6.3 IVI API should have "Source" as property

6.4 8 LAN Events for Arm/Trigger (inbound) and Events (outbound)

6.5 Time representation (2 64-bit floats)

6.5.2 All data time-stamped (property names)

6.6 Domain Property

6.7 TCP and UDP for events

6.8 Rec: Event Log

6.9 Rec: API to IDENT light

6.10 – 6.11 Roadmap locking requirements

# Event

## Sources

1588 Clock (see notes)

Calibration

Settling (red = required)

Ranging

Sweeping

Measuring

Waiting For Arm

Waiting For Trigger

Correcting

Operation Complete

Error

Data

LXI0..7 (see notes)

LAN0..7 (see notes)

## Destinations

LXI Trigger Line 0..7

LAN Trigger 0..7 on host:port

Error on host:port

Data on host:port

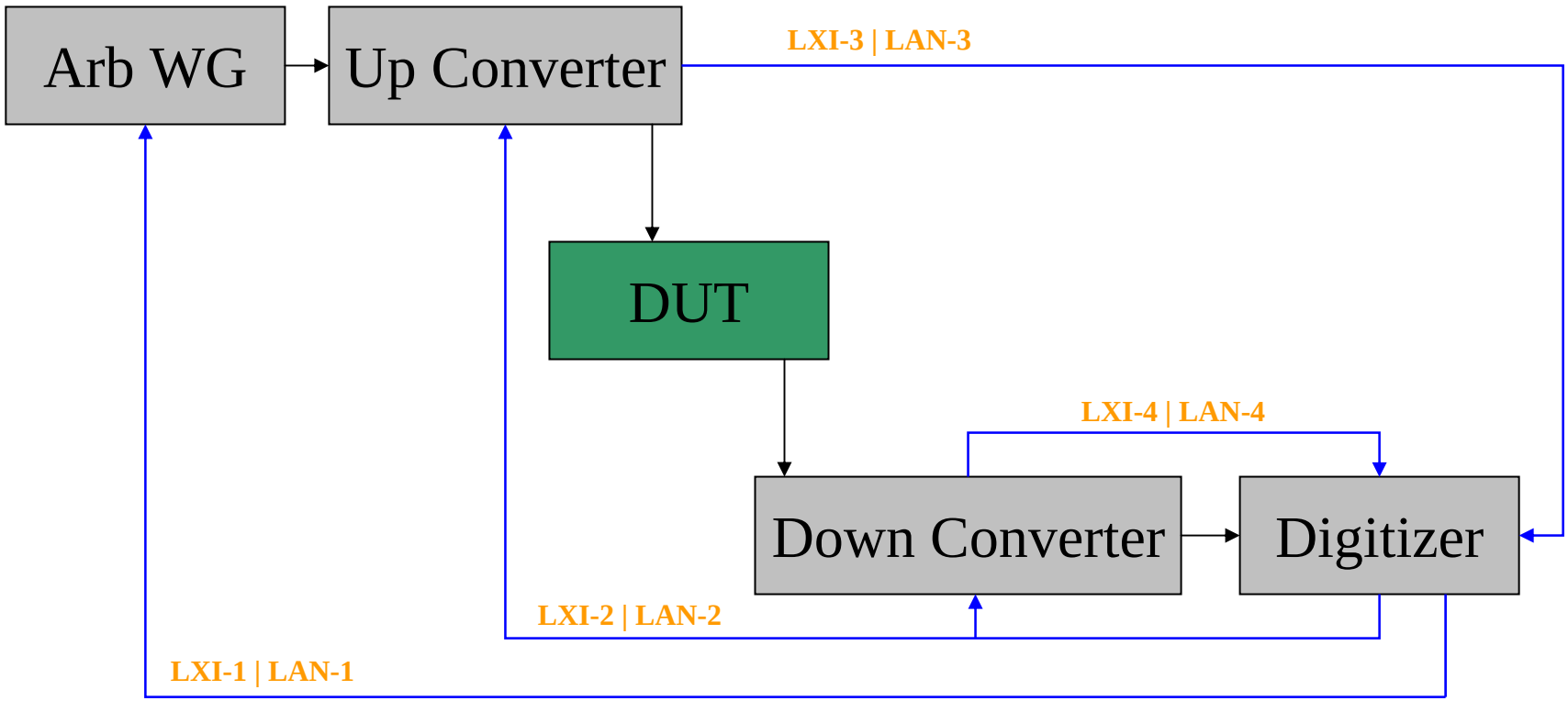
### Destination Path Syntax:

[host[:port]][/name][, Destination Path]

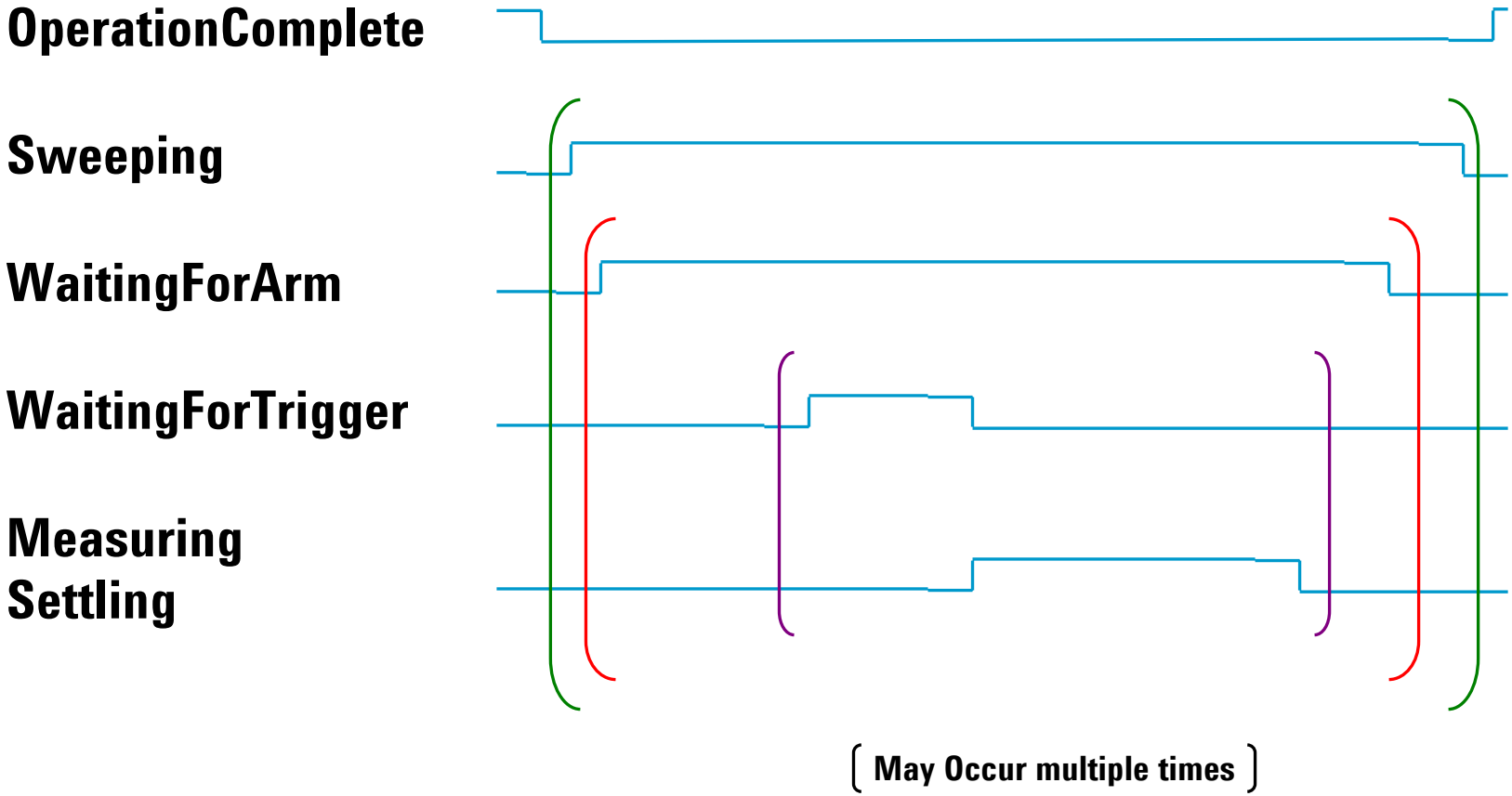
If no host is specified, use local module.
If host is 'ALL', send a UDP broadcast.
If no port is specified, use IANA default.
If no name is specified, use Event Name (LXI0..7 | LAN0..7 | Data |..).
[optional item]

# END

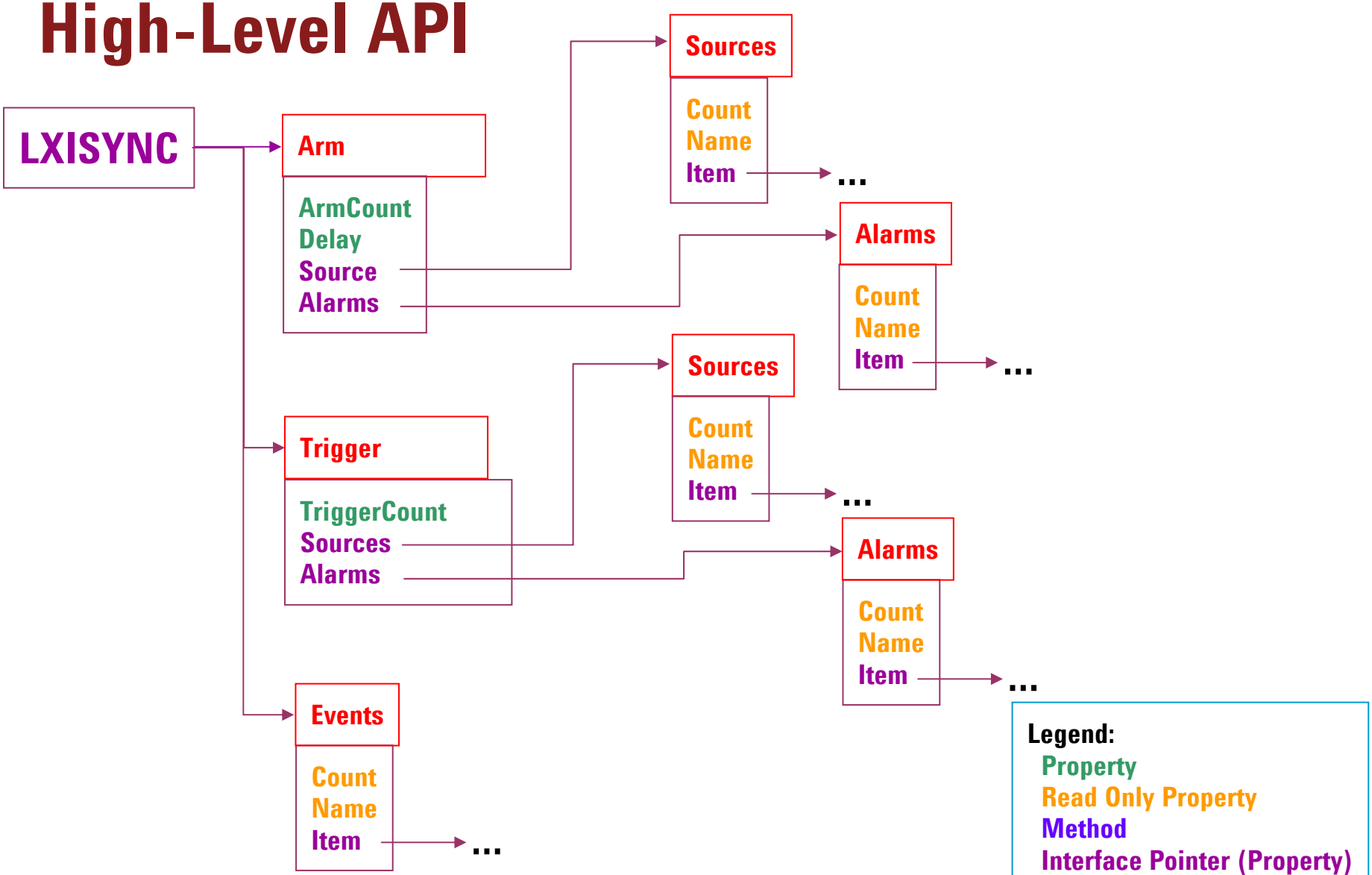
# LXI Trigger Use Case: Stimulus Response Test
# Block Diagram



# Arm-Trigger State Machine Signal Relationships



# High-Level API

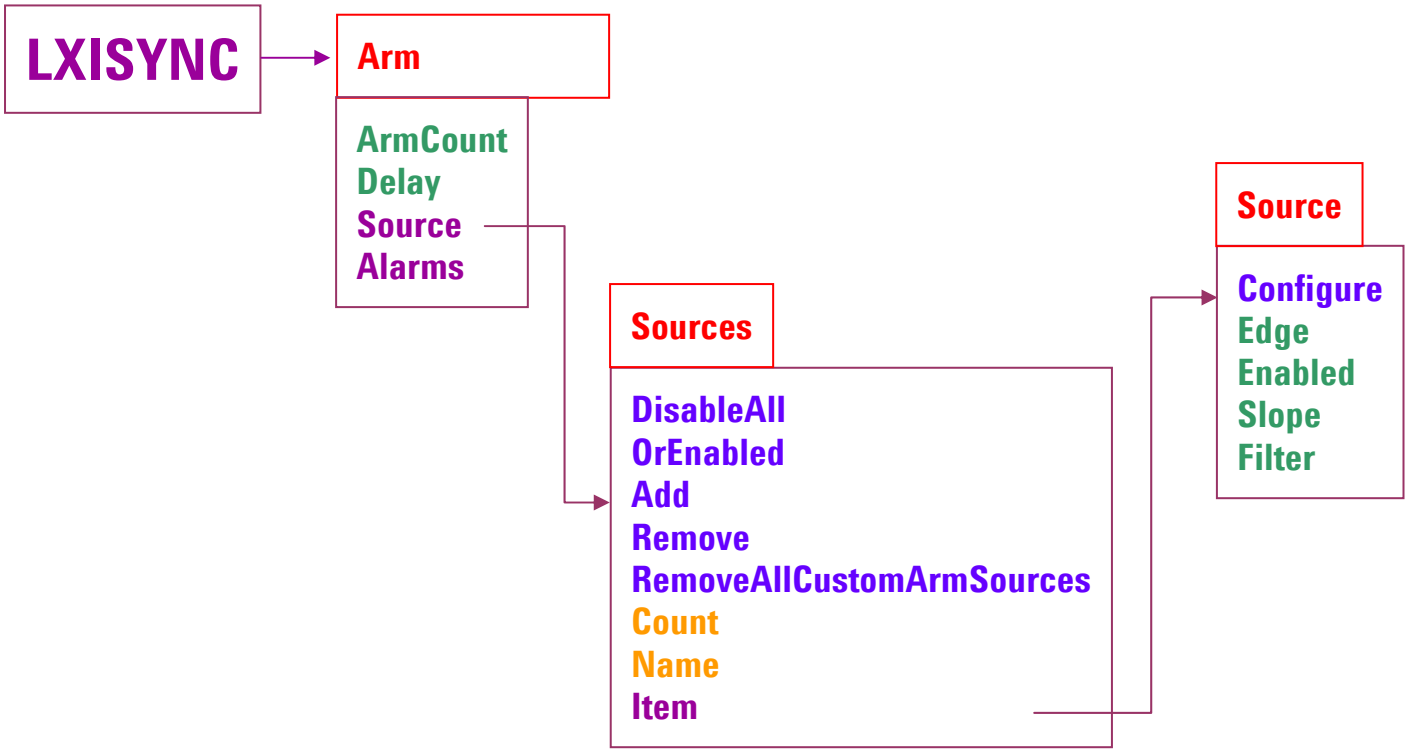






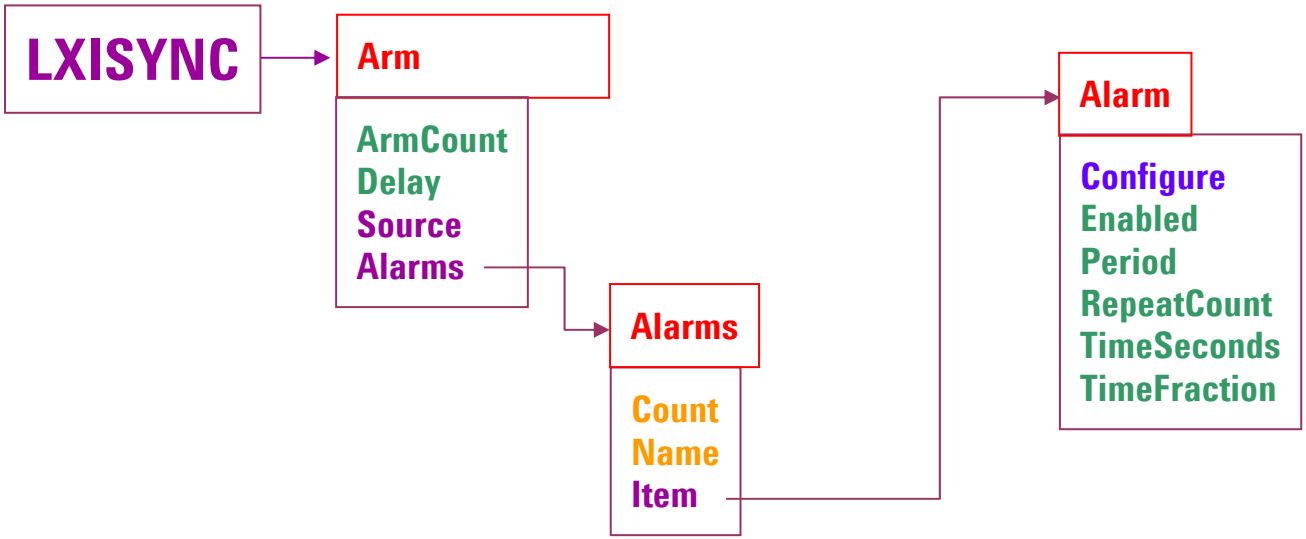

LAN eXtensions for Instrumentation

# Arm Sources



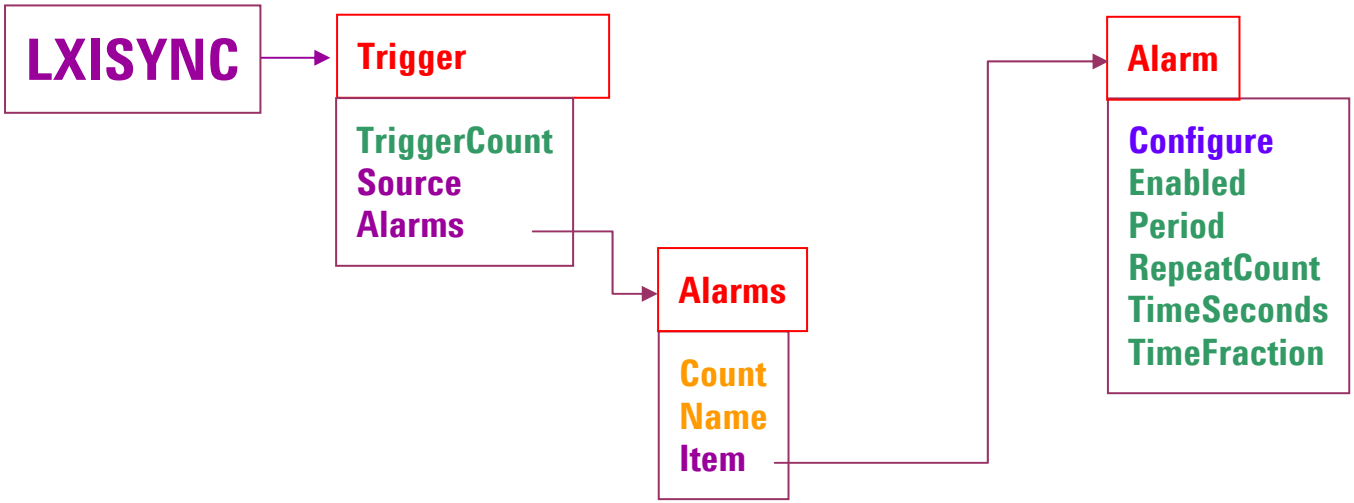

**Legend:**
- Property
- Read Only Property
- Method
- Interface Pointer (Property)
- Interface

# Arm Alarms



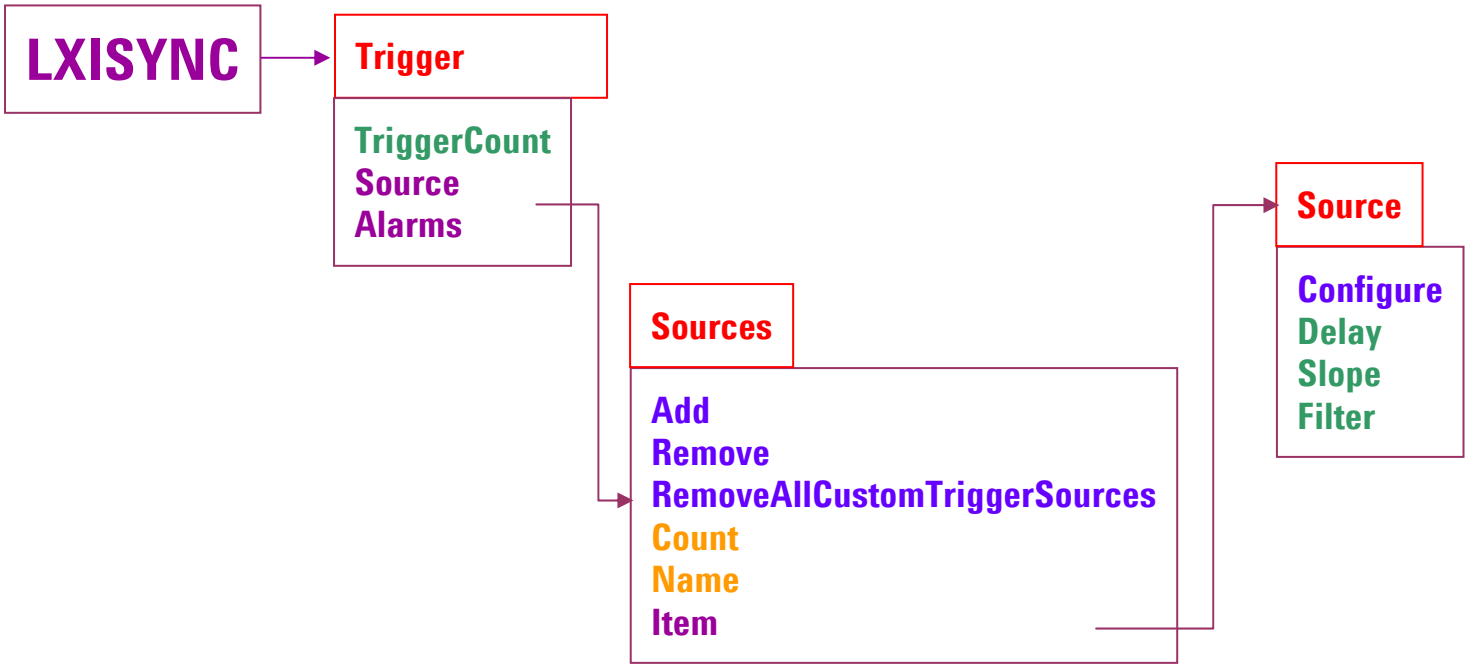

**Legend:**
- Property
- Read Only Property
- Method
- Interface Pointer (Property)
- Interface

# Trigger Alarms



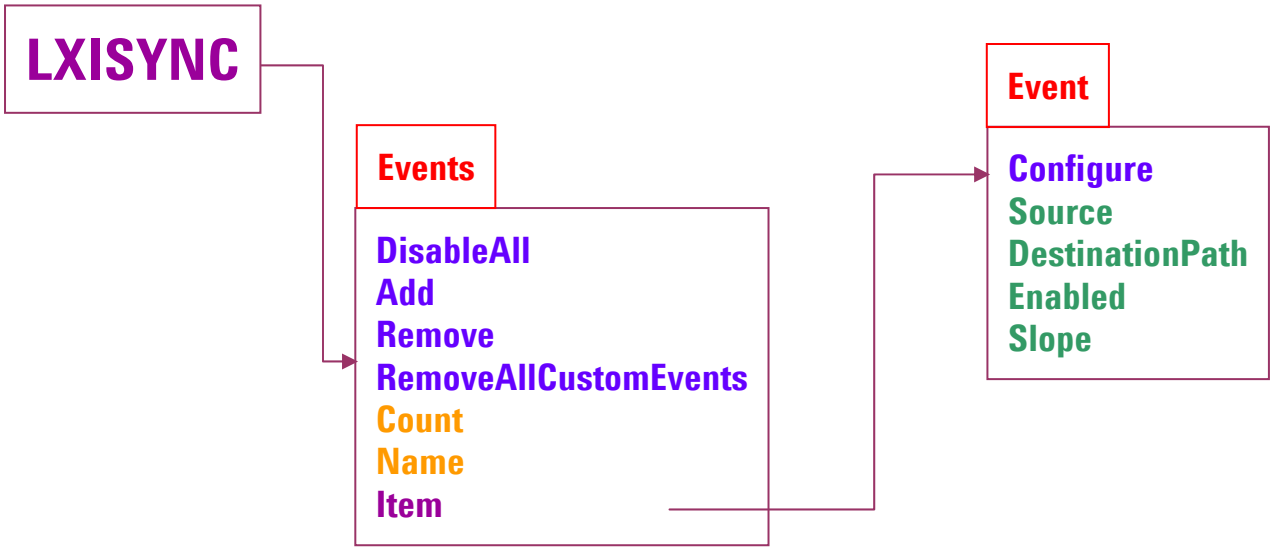

**Legend:**
- Property
- Read Only Property
- Method
- Interface Pointer (Property)
- Interface

# Trigger Sources



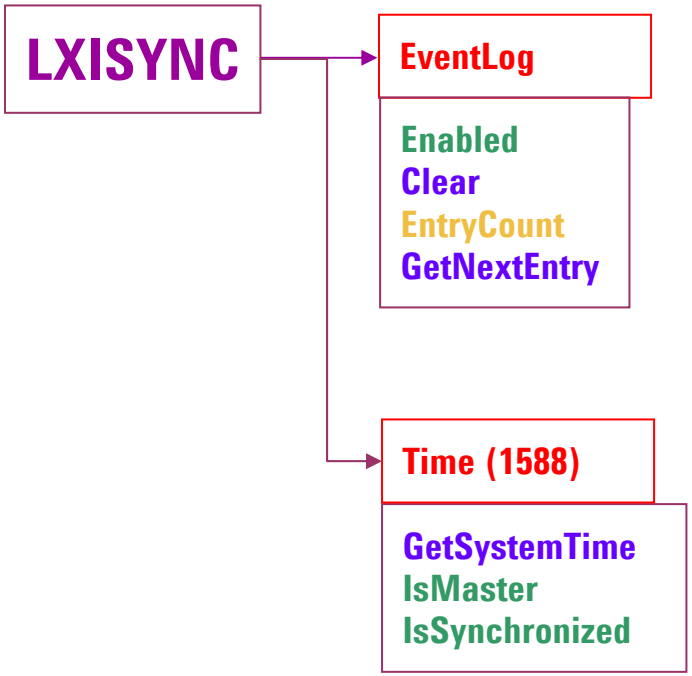

**Legend:**
- Property
- Read Only Property
- Method
- Interface Pointer (Property)
- Interface

# Events



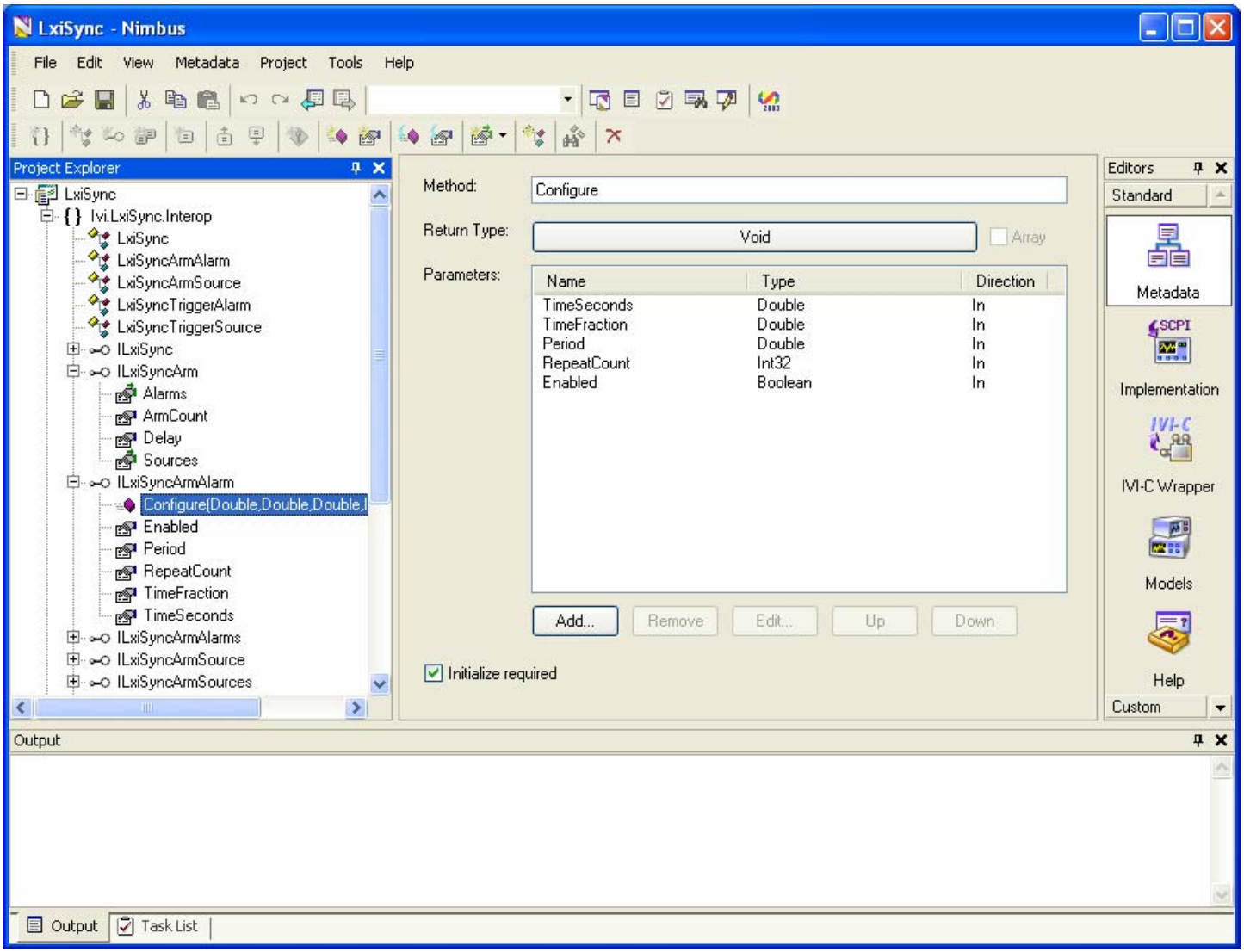

**Legend:**
- Property
- Read Only Property
- Method
- Interface Pointer (Property)
- Interface

# High-Level API (cont.)




**Legend:**
- Property
- Read Only Property
- Method
- Interface Pointer (Property)
- Interface

# LxiSync and Nimbus

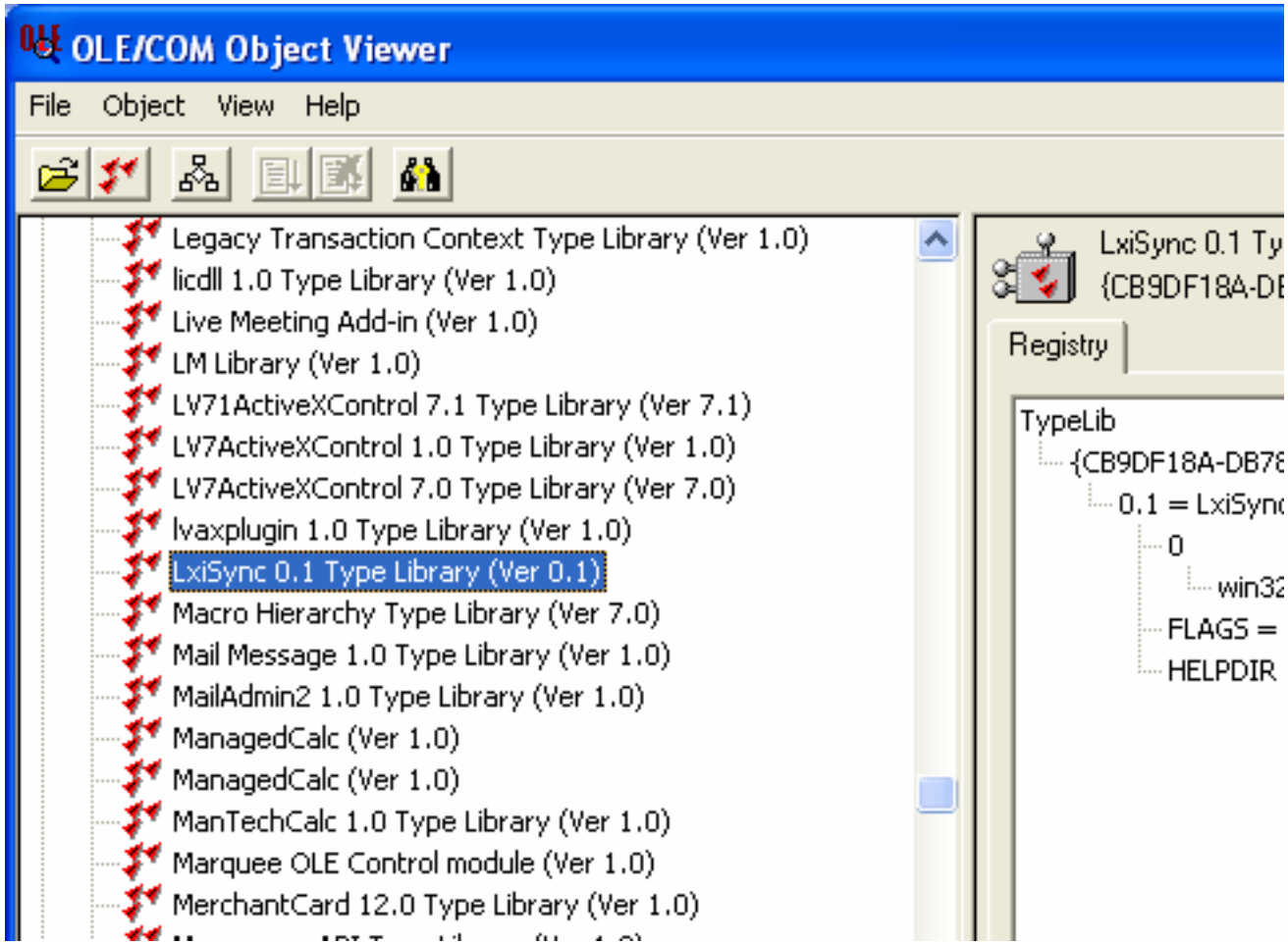




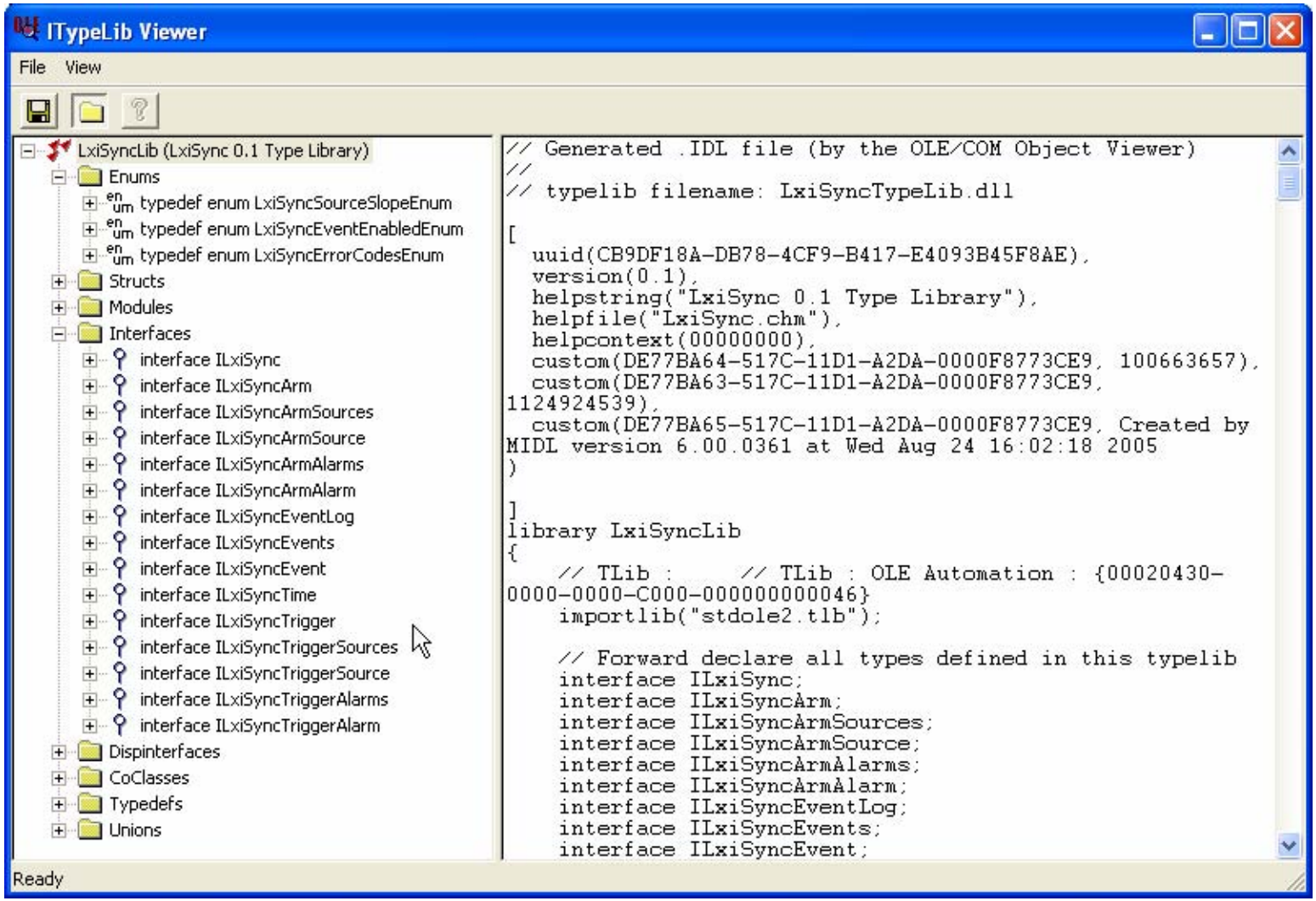


LAN eXtensions for Instrumentation

# LxiSyncTypeLib in Oleview



# LxiSyncTypeLib in Oleview (cont.)

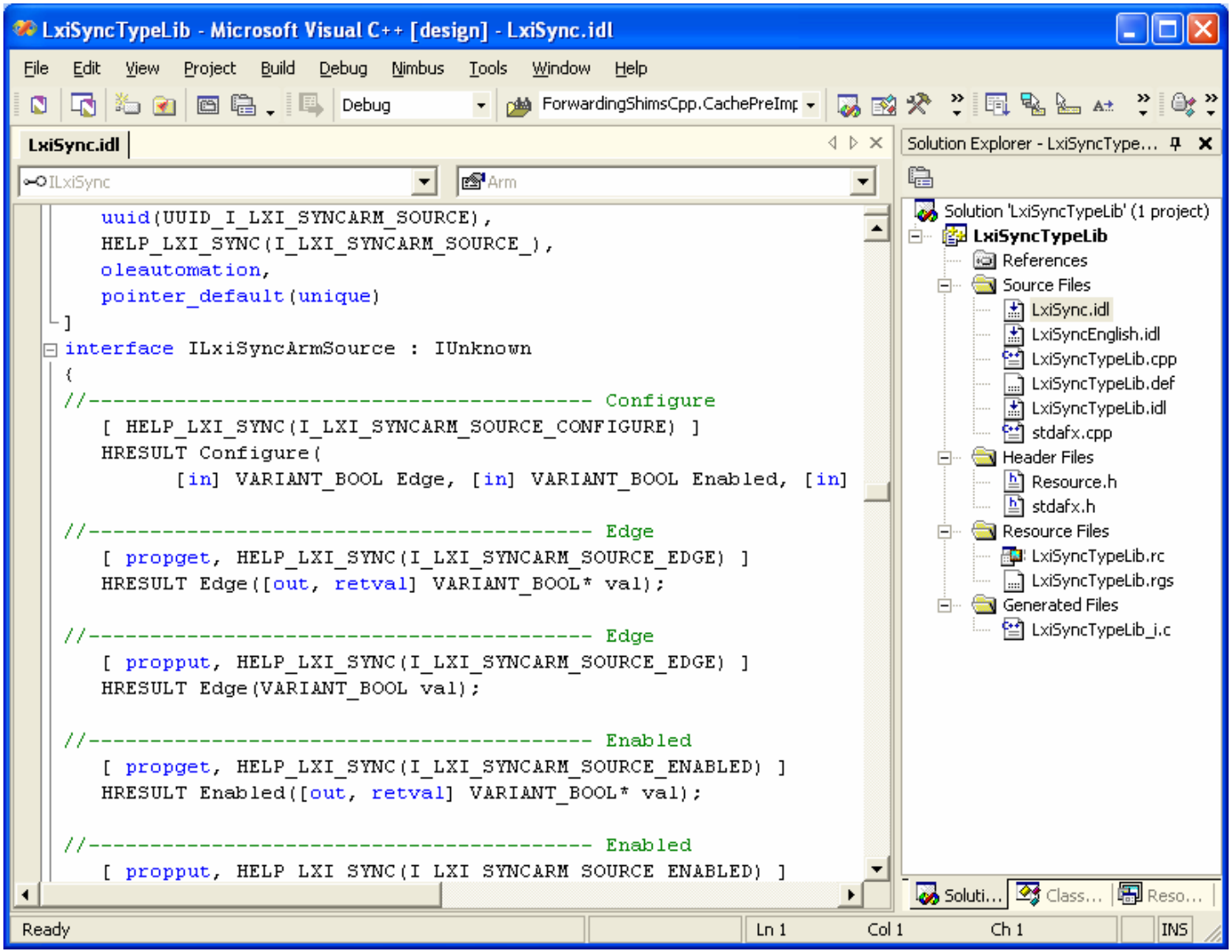






LAN eXtensions for Instrumentation

# LxiSync Visual Studio Project







LAN eXtensions for Instrumentation

# Arm digitizer when both upconverter and downconverter done settling

```
// tell up-converter to output Settling on LXI3 for use by digitizer
upSync.Events.get_Item("LXI3").Configure("Settling", "",
        LxiSyncEventEnabledEnum.LxiSyncEventEnabledOn,
        LxiSyncSourceSlopeEnum.LxiSyncSourceSlopeNegative);

digSync.Arm.Sources.get_Item("LXI3").Configure(true, true,
      LxiSyncSourceSlopeEnum.LxiSyncSourceSlopePositive);

// tell down-converter to output Settling on LXI4 for use by digitizer
downSync.Events.get_Item("LXI4").Configure("Settling", "",
      LxiSyncEventEnabledEnum.LxiSyncEventEnabledOn,
      LxiSyncSourceSlopeEnum.LxiSyncSourceSlopeNegative);

digSync.Arm.Sources.get_Item("LXI4").Configure(true, true,
      LxiSyncSourceSlopeEnum.LxiSyncSourceSlopePositive);
```

# Relationship to IVI Classes

- Add LXI trigger sources to existing trigger source
  - LXI Sync API used to configure sources
  - Existing classes use either strings or enums – initially these will require custom API's to unify triggering.
    - LXI Sync will recommend how to handle for consistency
- Trigger Arm
  - Arm functionality not in existing classes
  - When enabled, becomes an additional precondition on instrument classes
    - Applications that don't touch Arm methods will work the same
- Events, Logging, Alarm setup, Time access
  - Independent of existing IVI Class interfaces

# LXI Sync Specification Status circa 8/19

- Phase 1 complete including
  - All APIs specified and documented
  - COM and IVI-C hierarchy documented
  - Error values documented
  - Substantial review completed
  - Type Library (currently coding against this in lieu of prototypes