# White-Rabbit eXtensions for Instrumentation

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### Revision Table

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<td>20181006</td>
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## 1 Introduction

White-Rabbit eXtensions for Instrumentation (WRXI) is a synchronisation and real-time event communication protocol based on White Rabbit (WR) technology.

The aim of this document is to:

1. Define the packet format for real-time event messages, hereinafter referred to as *Event Messages (EM)*.

2. Provide a transport mechanism for the exchange of EMs between WRXI nodes, hereinafter referred to as *Nodes*. EMs are exchanged directly between Nodes over the WR network.

3. Define an Application Program Interface (API) for scheduling and controlling the timing of EMs, as well as for monitoring and controlling the WR network aspects of Nodes and WR switches (e.g. get the round-trip delay, link status, estimated fiber cable length, set IP address, VLANs, etc).

4. Define an entity with a supervising role over the WRXI, hereinafter referred to as *Supervisor*. 

1
2 Scope

WRXI is not a complete solution for remote control of electronic instrumentation (such as PXI, LXI, etc); instead, it can be seen as a timing and triggering protocol, which can be used on top of another instrumentation platform, to augment the latter with sub-nanosecond clock synchronisation and real-time event communication. As such, WRXI is platform-agnostic and can be used to synchronise and exchange messages between Nodes belonging to any instrumentation platform.

3 Architecture

WRXI defines a Supervisor and one or more Nodes interconnected using one or more WR network switches.

Although not strictly necessary, it is normally expected that the Supervisor, WR switches and Nodes are also interconnected over a management computer network, hereinafter referred to as the Management Network (MN).

If a Node does not have a standard network interface (e.g. a VME, PCI, USB device) then it is connected to the MN through a host controller, hereinafter referred to as the Host.

An example of a complete WRXI setup is shown in Figure 1. The various types of Nodes depicted in the image are explained in the next section.
3.1 Nodes

With respect to the way a Node communicates with the Supervisor, three classes of Nodes can be defined:

**Managed:** A Managed Node has a WR port and a local interface (e.g., VME, PCI, USB, etc) that connects the Node to its Host. The Host itself is connected to the MN. As such, the Nodes are reachable over the MN only via the Host. All configuration of the Node is done via the Host port, while the WR port is used for the exchange of EMs.

A typical example of a Host with Managed Nodes is a VME crate with a VME Host Controller (Host) and several SVEC cards (Nodes); each SVEC has its own WR port, and they all share the same VME bus.

**Standalone:** A Standalone Node has both a WR port and a MN port. In this scenario the Host and the Node are referring to the same entity. All configuration of the Node is done via the MN port, while the WR port is used for the exchange of EMs.

A typical example of a Standalone Node is an LXI device which, apart from its standard network interface, also has a WR port.

**Unmanaged:** An Unmanaged Node can only be reached through its WR port. Since WR is also a GbE network, it is possible to use the same link for EMs and configuration (e.g., by supporting LXI on the WR port).

A typical example of an Unmanaged Node is a custom piece of hardware, installed in a remote, hard to reach area (e.g., under the sea), where it is beneficial to use the WR link for more than timing.

Introducing Unmanaged Nodes in a WRXI setup can easily consume the bandwidth of the network, at the detriment of the provided services. For that reason, Unmanaged Nodes should only be enabled explicitly by the user, after careful consideration and tuning of priorities and potential dropping of low-priority, non-critical traffic.

**Bridging**

Nodes can also act as "bridges" between WRXI and other timing and triggering interfaces. A typical example of this would be a PXI or MTCA Node connecting WRXI to the triggering and synchronisation lines present in the PXI or MTCA backplanes. Another example would be any class of Node equipped with one or more TTL buffers sending/receiving pulses to/from other devices that are not part of WRXI (e.g., to/from a TTL external trigger input/output of an instrument).

3.2 Supervisor

The Supervisor is an entity connected to both the MN and WR networks. It is charged with the following tasks:
• Auto-detection of Nodes.
• Hosting of network-based drivers for Standalone and Unmanaged Nodes.
• Keeping track of the WR network topology.
• Monitoring of the whole WRXI setup, to prevent timing violations in scheduled EMs (and prevent new EMs from being scheduled if they would cause timing violations).
• Reconfiguration of the WR network (e.g., VLAN settings on WR network switches and Nodes) in order to guarantee the timing of EMs and optimise bandwidth usage.

4 Event Messages

4.1 Message Format

EMs follow the format specified in Section 4 of the LXI Event Messaging Extended Function specification, revision 1.0.

4.2 Transport

The transport mechanism for EMs over the WR network is the one specified in Section 3 of the LXI Event Messaging Extended Function specification, revision 1.0, with the exception that support for unicast TCP is optional in WRXI.

Ethernet frames carrying EMs shall also include a VLAN "tag", as specified in IEEE 802.1Q.

5 API

Every Node shall be accompanied by an IVI driver (preferably a specific IVI Class driver) and provide auto-detection ("plug and play") capabilities.

Managed Nodes shall provide a local IVI driver, to be installed in their respective Host.

Standalone Nodes shall provide a network IVI driver, to be installed in the Supervisor and provide an interface to the Node over the MN. It is recommended that such devices follow the full LXI specification (which includes the requirement for an IVI driver over the network).

Unmanaged Nodes shall also provide a network IVI driver as Standalone Nodes. However, in this case all communication will have to go through the WR network itself (if permitted).

In addition to providing the standard IVI driver features, every Node being part of a WRXI needs to also expose an API capable of monitoring and controlling:

1. Generation and handling of EMs
2. WR networking features
WR switches will also need to be managed by the Supervisor. As such, it is foreseen that they will also be accompanied by an IVI driver (by using a custom IVI class, or extending the Switch class, or introducing a new IVI class).

5.1 Generation and handling of EMs

Generation and Handling of EMs shall be done according to IVI-3.15 IviLxiSync specification.

5.2 WR networking features

WR networking features of the Node shall be exposed by extending the existing IviLxiSync-Time Subsystem of the IVI-3.15 IviLxiSync specification.

In particular, the API shall provide access all the objects defined in the PTP Management Information Base (MIB) supported by the Node.

Furthermore, the API shall allow setting VLAN tag information per EM, including the VLAN ID (VID) and the Priority Code Point (PCP) in the Tag Control Information (TCI) of the VLAN tag, as specified in IEEE 802.1Q. This mechanism allows different EMs to have different priorities.