Intermec

LLRP

Low-Level Reader Protocol

Programmer's Reference Manual

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Contents

Overview of the Low-Level Reader Protocol

This programmer's reference manual defines the architecture of the Low-Level Reader Protocol (LLRP) intended for use with Intermec RFID readers. LLRP Reader implementation provides control of RFID air protocol operation timing and access to air protocol command parameters. The design of this interface recognizes that in some RFID systems, there is a requirement for explicit knowledge of RFID air protocols and the ability to control readers that implement RFID air protocol communications.

The features and functions described in this reference manual apply to the base LLRP Reader software implementation. Actual supported functionality may vary among LLRP-supported products. All variations will be listed in product-specific documentation.

LLRP v1.0.1 Standard Compliance

The LLRP Reader implementation complies with all required features and functions of the LLRP v1.0.1 standard.

Additional Resources

Here is a list of third-party resources that you might find useful:

- LLRP v1.0.1 Specification: This document details the design and usage of the standard LLRP Client/Reader interface and can be found at **http://www.epcglobalinc.org**.
- LLRP Toolkit: This is an open-source project that provides software resources for development of LLRP applications, and can be found at **http://www.llrp.org**.
- Wireshark: This is an open-source tool used for monitoring and analyzing network traffic, and can be found at **http://www.wireshark.org**.

Capabilities

The capabilities listed in this section relate to the design and implementation details of the LLRP reader. In some cases, platform-specific limitations affect the listed capabilities.

LLRP Capabilities

The following table represents the capabilities reported by the LLRP Reader implemntation via the LLRPCapabilities parameter in the GET_READER_CAPABILITIES_RESPONSE message.

LLRP Capabilities

Feature	Support
RFSurvey Supported	Yes
Buffer Fill Warning Supported	Yes
Client Request OpSpec Supported	No
C1G2 State Aware Singulation Action Supported	Yes
Event and Report Holding Supported	Yes
Maximum Supported Priorities	0
Maximum ROSpecs[1]	500
Maximum specs per ROSpec[1]	50
Maximum InventoryParameterSpecs per AISpec[1]	50
Maximum AccessSpecs[1]	500
Maximum OpSpecs per AccessSpec[1]	50

1. These counts are the absolute maximum. In some cases, resources internal to the LLRP Reader will further limit the number of each of these specifications.

Air Protocol-Specific Capabilities

The following table represents the capabilities reported by the LLRP Reader implementation via the C1G2LLRPCapabilities parameter in the GET_READER_CAPABILITIES_RESPONSE message.

C1G2LLRP Capabilities

Feature	Support
C1G2 Block Erase Supported	Yes
C1G2 Block Write Supported	Yes
Maximum Filters per C1G2 Inventory Command	50

General Device Capabilities

The following table represents the capabilities reported by the LLRP Reader implementation via the GeneralDeviceCapabilities parameter in the GET_READER_CAPABILITIES_RESPONSE message.

GeneralDevice Capabilities

Feature	Support
Device Manufacturer Name	1963
Firmware Version	String matching platform version
Can Set Antenna Properties	No
Air Protocol Supported	EPCC1G2 only
Has UTC Clock Capability	Yes
Receive Sensitivity	No

Reader Identification

The Reader Identification field, reported via the GET_READER_CAPABILITIES_RESPONSE message, will contain the MAC address of the first Ethernet interface supported on the LLRP Reader platform.

Reader Identification

Field	Value
IDType	MAC_ADDRESS
ReaderID	001040aabbcc

RFSurvey Result Details

Details about the results contained in an RFSurvey report are specific to the radio module utilized by the LLRP Reader implementation.

IM5 Radio Module

LLRP implementations based on the IM5, for example the IF61 Fixed Reader, have the following characteristics:

- The bandwidth for RFSurvey operations is fixed at 500kHz.
- A filtered notch exists at the carrier frequency +/- 10kHz. This means that the IM5 might report a result of "no noise" in the unlikely event that the survey operation centers directly on a noise source of 20kHz bandwidth.

Note: Items such as supported frequencies, channel lists, and the UHFC1G2RFModeTable are specific to a radio module and the radio configuration. Many of these settings are subject to change among firmware releases; therefore, that documentation is outside the scope of this manual.

Default AntennaConfiguration and AntennaProperties

By default, the following configuration will be used for each supported antenna:

- Maximum transmit power.
- The default channel, as specified by the reader module.

Default EventsAndReports Configuration

The following section describes the default behavior for Event and Report messages generated by Intermec LLRP Reader devices. Variation from these defaults can be made through the use of the SET_READER_CONFIG message.

Default EventsAndReports Configuration

Feature	Default Configuration
HoppingEvents	Disabled
ROSpecEvents	Enabled

Default EventsAndReports Configuration (continued)

Feature	Default Configuration
AISpecEvents	Enabled
RFSurveyEvents	Enabled
GPIEvents	Enabled
AISpecEventDetails	Enabled
ReaderExceptionEvents	Enabled
AntennaEvents	Disabled
ReportBufferFillWarningEvents	Enabled
ShouldHoldEventsAndReports	Enabled

Note: LLRP Reader implementations based on the IM5R2 module, for example the IF61A, do not support AntennaEvents. LLRP Reader implementations based on the IM5R3 module, for example the IF61B Fixed Reader, fully-support AntennaEvents.

Default ROReportSpec Configuration

Default behavior related to ROSpec reporting is listed in the following table:

Default ROReportSpec Configuration

Feature	Default Configuration
ROSpecID	Yes
SpecIndex	Yes
InventoryParameterSpecID	Yes
AntennaID	Yes
ChannelIndex	Yes
PeakRSSI	Yes
FirstSeenTimestamp	Yes
LastSeenTimestamp	Yes
TagSeenCount	Yes
AccessSpecID	Yes
EPC C1G2 Memory Selector CRC	Yes
EPC C1G2 Memory Selector PC Bits	Yes

Implementation Details

This section describes the specific implementation details of the LLRP Reader that have been created because of one or more of the following issues:

- LLRP v1.0.1 specification ambiguities
- Limitations imposed by particular RFID radio hardware
- Intentional deviations from the LLRP v1.0.1 specification

TagObservationTrigger

Based on the LLRP v1.0.1 specification, the LLRP Reader implementation is allowed various interpretations of the meaning of the fields in the TagObservationTrigger parameter of an AISpecStopTrigger.

NumberOfTags

An LLRP Reader implementation may interpret the "NumberOfTags" field as:

- The number of total tag singulation events during AISpec operation, regardless of whether each singulation is produced by a unique tag.
- The number of unique tag singulation events, for example the number of unique tags singulated during AISpec operation.

The LLRP Reader implementation follows the second option above, requiring "NumberOfTags" unique tags singulated to satisfy the TagObservationTrigger condition.

Attempts

The LLRP Reader implementation interprets the "Attempts" field as the number of Inventory rounds performed by the AISpec, so the TagObservationTrigger condition will be met when "Attempts" inventory rounds has been performed.

No More New Tags

The LLRP Reader implementation interprets the timeout (T field) specified for the "Upon Seeing No More New Tags for Tms Or Timeout" trigger type as the number of milliseconds elapsed since the last unique singulation has occurred. Singulation of a tag that has been previously singulated during the AISpec operation will not reset this timer.

C1G2TargetTag Pointer Field

The 16-bit "Pointer" field of the C1G2TargetTag parameter, interpreted as the bit offset into the specified bank, supports only values evenly divisible by eight.

AccessReportTrigger

According to the LLRP v1.0.1 specification, when the AccessReportTrigger field of the AccessCommand parameter is set to "End of AccessSpec", a report should be generated only when the AccessSpec ends, or when the operation count has been exhausted.

The Intermec LLRP Reader implementation interprets AcessReportTrigger to generate a report at the end of any AISpec containing access results.

Optional Feature Support

This section describes the support of features marked as optional by the LLRP Reader v1.0.1 specification.

TagReportData Accumulation

The LLRP Reader implementation supports accumulation of tag report data, as described in the LLRP v1.0.1 specification section 13.2.3.1.

ROSpec Preemption

Preemption of ROSpecs is not possible, because only one priority is supported. If more than one ROSpec moves to the active state simultaneously, the first activated ROSpec will run to completion before the second begins.

Momentary Connections

The LLRP Reader implementation supports recovery of undetected abandoned LLRP connections through the use of momentary connections, as described in section 18.1 of the LLRP v1.0.1 specification.

Intermittent RFID Module Connections

The LLRP Reader implementation handles cases where an RFID module has an intermittent connection to the LLRP Reader, RFID Module resets, or the RFID module experiences a power cycle. In any of these cases, the LLRP Reader implementation performs the following sequence of actions:

1. A vendor-specific extension event, "IntermecResetStartEvent" subtype 16, is generated.
2. All existing client connections are terminated.
3. All ROSpecs are disabled and stopped.
4. The LLRP Reader implementation waits for the RFID module to re-establish communication.
5. Once the RFID module has re-established connection, all existing RFID module configurations are cleared.
6. The LLRP Reader implementation re-configures all ROSpecs and AccessSpecs.
7. A vendor-specific extension event, "IntermecResetCompleteEvent" subtype 19, is generated.

Note: After recovery from an RFID module disconnection/reconnection event, all ROSpecs and AccessSpecs will be disabled.

Any connected client is disconnected through the process described above, to handle this out-of-band change in configuration state without requiring the LLRP client to properly understand and handle the IntermecResetStartEvent or IntermecResetCompleteEvent. Because an LLRP client cannot assume persistence of state through a disconnect/reconnect cycle, the LLRP client will be forced to interrogate the LLRP reader to determine any configuration differences.

Because the LLRP client is disconnected through this process, events generated (the IntermecResetCompleteEvent) will be cached for retrieval upon the next client connection.

Out-of-Band LLRP Configuration

Configuration of all parameters and default values related to the LLRP protocol is performed in-band through the defined LLRP protocol. No configuration of LLRP parameters or defaults are provided out-of-band (from a platform web interface or Intermec SmartSystems).

Modification of parameters related to the LLRP Reader Service is allowed on a per-platform basis. A list of these parameters is as follows:

- Enable/disable secure (TLS) server
- Enable/disable unsecure server
- TCP port number for secure (TLS) server
- TCP port number for unsecure server

Listen-Before-Talk

The Listen-Before-Talk algorithm is supported through an out-of-band method and can be modified at runtime. When enabled or disabled at runtime, all existing ROSpecs will be modified to reflect the desired LBT configuration.

Note: Listen-Before-Talk is permanently disabled in 4 channel mode.

Client Termination

The LLRP Reader implementation allows an out-of-band method for terminating a connected LLRP client. For example, this may be implemented as a “Terminate Client” button in the platform’s web interface.

Network Layer Support

This section describes configurable parameters of the network layer.

TCP

By default, the LLRP Reader implementation listens for incoming LLRP client connections on the IANA assigned TCP port number, 5084. Configurability of this port number is available on a per-platform basis.

IPv6

According to the LLRP specification, IPv6 support is optional. The LLRP Reader implementation supports IPv6, and is available on a per-platform basis.

TLS

By default, the LLRP Reader implementation supports TLS (Transport Layer Security) on the IANA assigned TCP port number (5085) for LLRP/TLS. Configurability of this port number is available on a per-platform basis. The list of ciphers supported by LLRP/TLS is platform/product dependent. On the IF61, the LLRP/TLS cipher list is identical to the supported cipher list for the secure web server.

Reader-Initiated Connections

The LLRP Reader implementation supports reader-initiated connections through an out-of-band interface. For example, this may be implemented as a set of user-interface controls in a web interface, allowing the user to specify the client's IP address, TCP port, and security settings along with a "connect" button to perform the reader-initiated connection attempt.

Parse Errors

When encountering a parsing error in any received message, the LLRP Reader implementation will abort the parsing operation and generate a response message containing an LLRPStatus parameter with the StatusCode field set to an appropriate value and a description of the error. Because parsing aborts when the first error is detected, subsequent parsing errors within the same message are not reported.

After successful parsing and execution of a request message, the LLRP Reader implementation will generate a response message containing an LLRPStatus parameter with the StatusCode set to M_Success and an empty (zero length) ErrorDescription field.

Vendor Extensions

This section describes the vendor extensions supported by the LLRP Reader implementation. All vendor extensions are implemented through the use of the IANA assigned manufacturer ID for Intermec, 1963.

An XML file describing the extensions and their structure, conforming to the LLRP Toolkit (**http://llrp.org**) v1.0 XML schema, is available for download from the web interface on the IF61 Fixed Reader.

Support for vendor extensions, their effectiveness, and usefulness vary per platform and software release. Refer to product documentation for specific details about vendor extension support.

Extra Singulation Detail Reporting

The custom parameter IntermecCollectExtraTagSingulationDetails is used within the InventoryParameterSpec to enable collection of extra tag singulation information such as RNSI, phase angle, and extra RSSI information. When collection of any of the extra tag singulation details is enabled, the data will be reported through the IntermecTagReportData parameter, included in the RO_ACCESS_REPORT message.

Note: Extra Singulation Detail Reporting is not available on all platforms.

Spacial Identification Information Reporting

A set of custom parameters is provided to enable the ability to calculate and report spacial ID information for tags. Spacial ID information is calculated on a per-ROSpec basis. This feature is enabled by including one or more custom parameters in the creation of an ROSpec within the SpecParameter choice. Although the inclusion of these Spacial ID custom parameters within the SpecParameter choice is semantically incorrect, this is the only appropriate vendor extension point for enablement of Spacial ID features within an ROSpec.

Note: Spacial Identification Information Reporting requires a valid license on some platforms.

The following is a list of supported spacial ID custom parameters that are allowed within the SpecParameter choice. One or more of the following parameters is allowed in each ROSpec.

- IntermecEnableTagInZone (subtype 3)

  Enable/disable the calculation of a tag's in-zone confidence factor, measured in percent certainty that a tag is in the zone of interest. This result is reported through the custom parameter IntermecTagInZone (subtype 9).

- IntermecEnableTagMoving (subtype 10)

  Enable/disable the calculation of a tag's moving confidence factor, measured in percent certainty that a tag is moving in relationship to the reader. This result is reported through the custom parameter IntermecTagMoving (subtype 12).

- IntermecEnableTagNear (subtype 11)

  Enable/disable the calculation of a tag's nearness confidence factor, measured in percent certainty that a tag is closer to the reader than other tags. This result is reported through the custom parameter IntermecTagNear (subtype 13).

- IntermecEnableTagSpeed (subtype 14)

  Enable/disable the calculation of a tag's speed, measured in millimeters per second. This result is reported through the custom parameter IntermecTagSpeed (subtype 15).

- IntermecEnableTagDistance (subtype 20)

  Enable/disable the calculation of a tag's distance from the singulated antenna, measured in millimeters. This result is reported through the custom parameter IntermecTagDistance (subtype 21).

Note: Similar to the extra singulation detail reporting, all spacial ID information is reported through the IntermecTagReportData parameter, included in the RO_ACCESS_REPORT message.

Spacial Identification and EPCC1G2 MValue

The EPC C1G2 MValue for all air protocol operations performed by an ROSpec must be identical, because of a requirement in the Spacial ID filtering algorithms. This means that each AntennaConfiguration utilized by a spacial-ID-enabled ROSpec must use the same MValue. If this condition is not satisfied, creation of the ROSpec will fail.

Low-Level Logging

Note: The results of a Low-Level Log custom event are useful only to Intermec Engineering. For example, a Low-Level Log may be requested by Intermec Engineering to optimize an RFID installation.

A custom parameter is provided to enable low-level logging for an ROSpec. When enabled, a low-level log is accumulated throughout the execution of the ROSpec and a custom event is generated after the completion of the ROSpec, containing the low-level log results. Similar to the Spacial ID enablement custom parameters, the low-level logging enablement parameter (IntermecEnableLowLevelLogging, subtype 17) is specified within the SpecParameter choice of the ROSpec. The low-level log results are reported through the IntermecLowLevelLog event parameter, subtype 18.

ROSpec Looping

A custom parameter is provided to enable looping of all specs within an ROSpec. According to the LLRP specification, when all specs within an ROSpec (AISpecs and RFSurveySpecs) have completed, the ROSpec transitions from the "active" to the "enabled" state. If you want the ROSpec to continue execution of the contained specs, you should use the ROSpec Looping feature.

When ROSpec Looping is enabled, after an ROSpec completes execution of the last spec (AISpec or RFSurveySpec) in the SpecParameter choice list, the ROSpec continues by executing the first spec, and this behavior continues until the ROSpec stop trigger condition is met, or a Stop/Disable/Delete ROSpec message is received. Similar to the Spacial ID enablement custom parameters, the ROSpec Looping enablement parameter (IntermecEnableROSpecLoop, subtype 5) is specified within the SpecParameter choice of the ROSpec.

A-B Toggle

A custom parameter is provided to allow all tags to be singulated twice per channel. The first singulation will target the A flag, the second will target the B flag. This feature is useful for Spacial ID applications where a tag must be singulated more than once on a given channel in order to receive sufficient low-level spacial ID data. This custom parameter (IntermecEnableABToggle, subtype 7) is allowed in the C1G2InventoryCommand parameter within an AntennaConfiguration.

Reset Event

A pair of custom events are provided to notify the LLRP client that an internal LLRP reader reset event has occurred. In most cases, a reset event will be the result of a radio module reset or power loss. Immediately after the reset condition has been detected, the custom event IntermecResetStartEvent, subtype 16 will be generated. After the LLRP reader has recovered from the reset event, the custom event IntermecResetCompleteEvent will be generated. Following the completion of the reset event, all ROSpecs and AccessSpecs will be moved to the disabled state. During the process of handling the reset event, the LLRP client will not be allowed to create or modify the state of any ROSpec or AccessSpec.

ROSpecLoop Event

A custom event, ROSpecLoopEvent (subtype 22), is provided to notify the LLRP client each time an ROSpec begins a new loop (restarts execution of its SpecParameter list). For information about how to enable looping for ROSpecs, see **"ROSpec Looping" on page 16**.

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