



# Data Processing & Structures

The Things Network

Ethan Bellmer

IGNITION Living Lab

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## JSON Structure &amp; Reduction

Raw JSON Raw output from the webhook	Reduced Form Removed JSON headers	Pruned Form Spaced out for clarity	Condensed Form Minimalised form keeping only the most relevant fields
end_device_ids device_id application_ids application_id dev_eui join_eui dev_addr correlation_ids received_at session_key_id f_port f_cnt uplink_message session_key_id f_port f_cnt frm_payload data_dict decoded_payload altitude battery_voltage raw_bytes humidity pressure rain_detect solar_voltage temp  decoded_payload_warnings  rx_metadata gateway_ids gateway_id time timestamp rssi channel_rssi snr location latitude longitude source uplink_token gateway_ids gateway_id packet_broker message_id forwarder_net_id forwarder_tenant_id forwarder_cluster_id home_network_net_id home_network_tenant_id  home_network_cluster_id hops received_at sender_address receiver_name receiver_agent received_at	device_id application_id dev_eui join_eui dev_addr correlation_ids received_at session_key_id f_port f_cnt frm_payload data_dict altitude battery_voltage raw_bytes humidity pressure rain_detect solar_voltage temp  decoded_payload_warnings  gateway_id time timestamp rssi channel_rssi snr latitude longitude source uplink_token gateway_id message_id forwarder_net_id forwarder_tenant_id forwarder_cluster_id home_network_net_id home_network_tenant_id home_network_cluster_id hops received_at sender_address receiver_name receiver_agent uplink_token bandwidth spreading_factor data_rate_index coding_rate frequency timestamp received_at consumed_airtime	device_id application_id dev_eui join_eui dev_addr  correlation_ids received_at  uplink_message session_key_id f_port f_cnt  frm_payload session_key_id f_port f_cnt data_dict frm_payload  decoded_payload altitude battery_voltage decoded_payload_warnings  altitude battery_voltage raw_bytes humidity pressure rain_detect solar_voltage temp  decoded_payload_warnings  rx_metadata gateway_id time timestamp rssi channel_rssi snr location latitude longitude source uplink_token  packet_broker message_id forwarder_net_id forwarder_tenant_id forwarder_cluster_id home_network_net_id home_network_tenant_id home_network_cluster_id hops received_at sender_address receiver_name receiver_agent uplink_token  settings data_rate	device_id application_ids application_id  uplink_message session_key_id f_port f_cnt  frm_payload data_dict raw_bytes decoded_payload altitude battery_voltage decoded_payload_warnings  received_at consumed_airtime

sender_address receiver_name receiver_agent received_at sender_address receiver_name receiver_agent time rssi channel_rssi snr uplink_token settings data_rate lora bandwidth spreading_factor data_rate_index coding_rate frequency timestamp received_at consumed_airtime		lora bandwidth spreading_factor data_rate_index coding_rate frequency timestamp received_at consumed_airtime	
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## Normalisation

### Notes

#### JSON Reduction to Normalisation Forms

There are some intermediary differences between the JSON reduced dataset and the dataset used for normalisation, and this is a result of the data undergoing processing and transformation before normalisation.

#### *data\_dict*

The 'data\_dict' variable from the JSON form is transformed into two separate variables for the normalisation process, namely 'sensor\_name' and 'sensor\_value' as the 'data\_dict' is a dictionary containing these two values.

#### *Absent Variables*

Some values from the JSON form will also be absent from the normalised form because they relate to section headings from the JSON file and don't contain data, so they aren't needed for database storage.

#### *Variable Name Changes*

During processing some variables will be renamed to more descriptive names, the following table will list the affected variables.

Original Variable Name	Updated Variable Name
device_id	device_name
application_id	application_name
gateway_id	gateway_name
frequency	{TABLE NAME}_frequency
timestamp	{TABLE NAME}_timestamp

## Full Normalisation

<b>UNF</b> Repeating attributes indented	<b>1-NF</b> Remove repeating attributes and identify a primary key	<b>2-NF</b> Remove partial dependencies	<b>3-NF</b> Remove non-key dependencies
device_name application_name dev_eui join_eui dev_addr correlation_ids received_at session_key_id f_port f_cnt data_dict frm_payload altitude battery_voltage raw_bytes humidity pressure rain_detect solar_voltage temp decoded_payload_warnings gateway_id rx_time rx_timestamp rssi channel_rssi snr latitude longitude source uplink_token message_id forwarder_net_id forwarder_tenant_id forwarder_cluster_id home_network_net_id home_network_tenant_id home_network_cluster_id received_at sender_address receiver_name receiver_agent uplink_token bandwidth spreading_factor data_rate_index coding_rate setting_frequency setting_timestamp received_at consumed_airtime	<b>Device GUID</b> device_name application_name dev_eui join_eui dev_addr	<b>Device GUID</b> <b>Application GUID*</b> device_name dev_eui join_eui dev_addr	<b>Device GUID</b> <b>Application GUID*</b> device_name dev_eui join_eui dev_addr
	<b>Uplink GUID</b> session_key_id f_port f_cnt data_dict frm_payload raw_bytes decoded_payload_warnings consumed_airtime	<b>Uplink GUID</b> <b>Device GUID*</b> session_key_id f_port f_cnt frm_payload sensor_name sensor_value raw_bytes decoded_payload_warnings consumed_airtime	<b>Uplink GUID</b> <b>Device GUID*</b> <b>Warning GUID*</b> session_key_id f_port f_cnt frm_payload consumed_airtime raw_bytes
	<b>RX GUID</b> gateway_id rx_time rx_timestamp rssi channel_rssi snr latitude longitude source message_id forwarder_net_id forwarder_tenant_id forwarder_cluster_id home_network_net_id home_network_tenant_id home_network_cluster_id	<b>RX GUID</b> <b>Uplink GUID*</b> <b>Location GUID*</b> gateway_id rx_time rx_timestamp rssi channel_rssi snr message_id forwarder_net_id forwarder_tenant_id forwarder_cluster_id home_network_net_id home_network_tenant_id home_network_cluster_id	<b>RX GUID</b> <b>Uplink GUID*</b> <b>Gateway GUID*</b> rx_time rx_timestamp rssi channel_rssi snr message_id forwarder_net_id forwarder_tenant_id forwarder_cluster_id home_network_net_id home_network_tenant_id home_network_cluster_id
	<b>Uplink Setting GUID</b> bandwidth spreading_factor data_rate_index coding_rate setting_frequency setting_timestamp	<b>Uplink Setting GUID</b> <b>Uplink GUID*</b> bandwidth spreading_factor data_rate_index coding_rate setting_frequency setting_timestamp	<b>Uplink Setting GUID</b> <b>Uplink GUID*</b> bandwidth spreading_factor data_rate_index coding_rate setting_frequency setting_timestamp
	uplink_token	<b>RX GUID*</b> <b>Gateway GUID*</b> uplink_token	<b>RX GUID*</b> <b>Gateway GUID*</b> uplink_token
	<b>Correlation GUID</b> correlation_ids	<b>RX GUID*</b> <b>Correlation GUID</b> correlation_ids	<b>Correlation GUID</b> <b>RX GUID*</b> correlation_ids
	<b>Hop GUID</b> sender_address receiver_name receiver_agent	<b>Hop GUID</b> <b>Gateway GUID*</b> <b>RX GUID*</b> sender_address receiver_name receiver_agent	<b>Hop GUID</b> <b>Gateway GUID*</b> <b>RX GUID*</b> sender_address receiver_name receiver_agent
	received_at	<b>RX GUID*</b> <b>Uplink GUID*</b> <b>Hop GUID*</b>	<b>RX GUID*</b> <b>Uplink GUID*</b> <b>Hop GUID*</b>

		received_at	received_at
		<b>Application GUID</b> application_name	<b>Application GUID</b> application_name
		<b>Warnings GUID</b> decoded_payload_warnings	<b>Warnings GUID</b> decoded_payload_warnings
		<b>Location GUID</b> latitude longitude source	<b>Location GUID</b> latitude longitude source
			<b>Sensor GUID</b> sensor_name sensor_type sensor_location measurement_units
			<b>Uplink GUID*</b> <b>Sensor GUID*</b> sensor_value
			<b>Gateway GUID</b> <b>Location GUID*</b> gateway_name

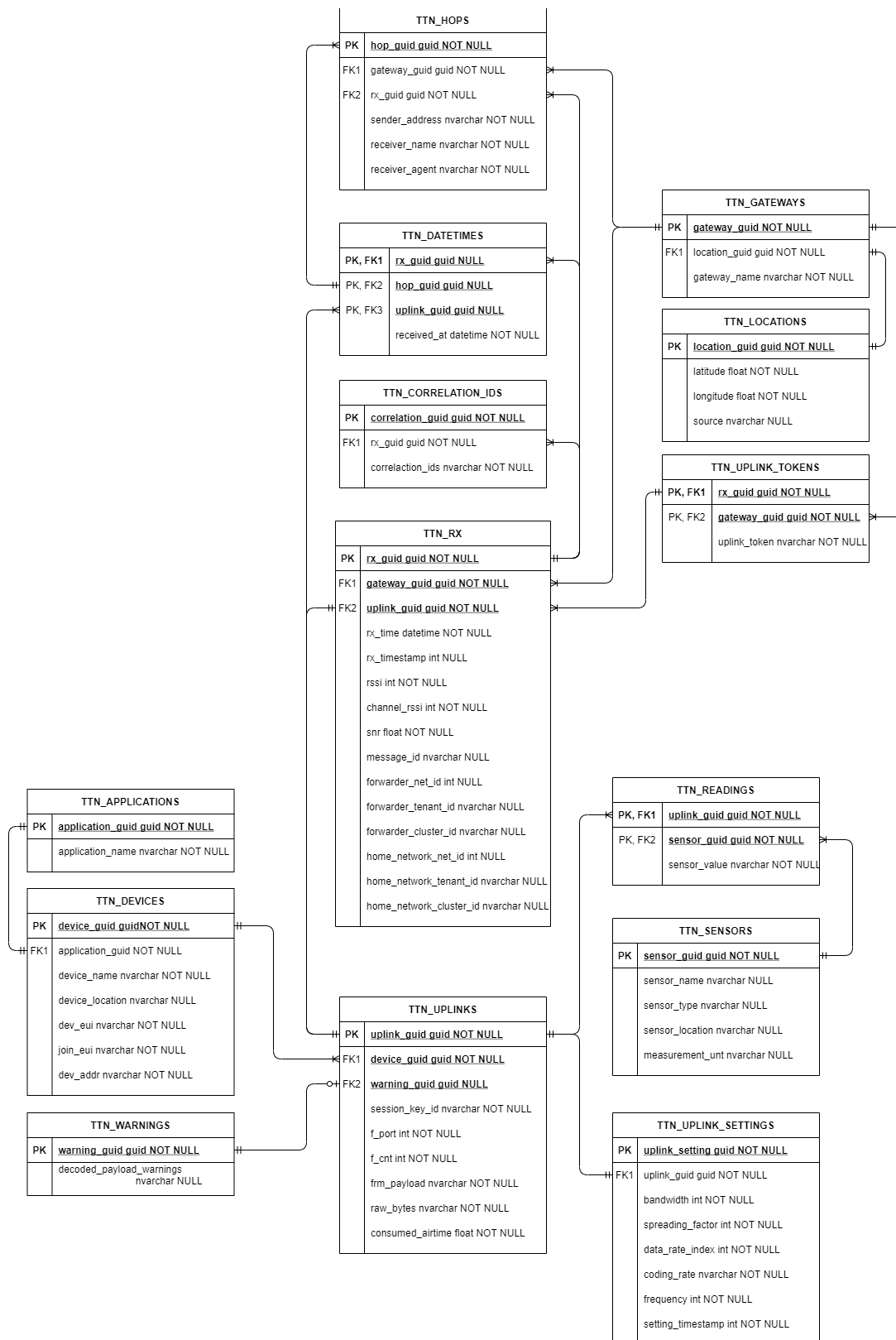
## Minimal Normalisation

<b>UNF</b> Repeating attributes indented	<b>1-NF</b> Remove repeating attributes and identify a primary key	<b>2-NF</b> Remove partial dependencies	<b>3-NF</b> Remove non-key dependencies
device_name application_name session_key_id f_port f_cnt frm_payload sensor_name sensor_value decoded_payload altitude battery_voltage bytes humidity pressure rain_detect solar_voltage temp decoded_payload_warnings  received_at consumed_airtime	<b>Device GUID</b> device_name application_name	<b>Device GUID</b> device_name	<b>Device GUID</b> <b>Application GUID*</b> device_name
	<b>Uplink GUID</b> session_key_id f_port f_cnt frm_payload sensor_name sensor_value  received_at consumed_airtime	<b>Uplink GUID</b> session_key_id f_port f_cnt frm_payload raw_bytes sensor_value received_at consumed_airtime	<b>Uplink GUID</b> <b>Device GUID*</b> <b>Sensor GUID*</b> <b>Warnings GUID*</b> session_key_id f_port f_cnt frm_payload sensor_value received_at consumed_airtime
	<b>Warnings GUID</b> decoded_payload_warnings	<b>Warnings GUID</b> decoded_payload_warnings	<b>Warnings GUID</b> decoded_payload_warnings
		<b>Application GUID</b> application_name	<b>Application GUID</b> application_name
		<b>Sensor GUID</b> sensor_name sensor_type sensor_location measurement_units	<b>Sensor GUID</b> sensor_name sensor_type sensor_location measurement_units
		<b>Uplink GUID*</b> <b>Sensor GUID*</b> sensor_value	<b>Uplink GUID*</b> <b>Sensor GUID*</b> sensor_value

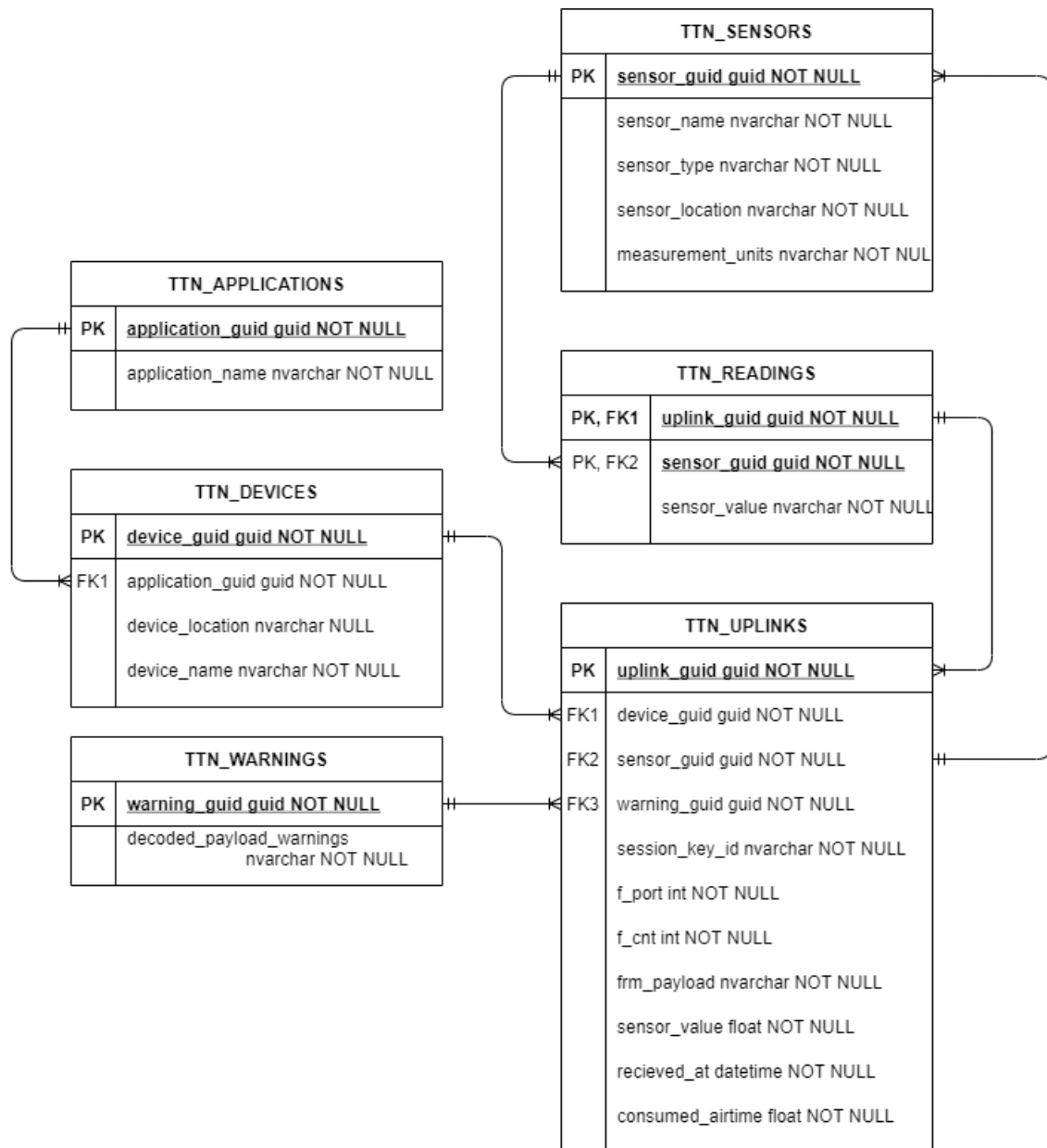


## Entity Relationship Diagrams

## Full



## Minimal



## Data Dictionaries

### Full Normalisation

#### Devices

<b>Database:</b>	LIVING_LAB
<b>Entity:</b>	TTN_DEVICES
<b>Definition:</b>	A device is a central device transmitting the data to the network, with sensors being connected to a device.

Attribute	Key	Data Type	Size	Input Mask	Definition
device_guid	PK	GUID	NA	NA	GUID for a broadcasting device.
application_guid	FK	GUID	NA	NA	GUID for an application, broadcasting devices are all associated to an application.
sensor_location	-	NVARCHAR	30	NA	Physical location of an installed sensor platform.
device_name	-	NVARCHAR	100	NA	Readable name associated with a broadcast device.
dev_eui	-	NVARCHAR	30	NA	Used for joining sensor to TTN network.
join_eui	-	NVARCHAR	30	NA	
dev_addr	-	NVARCHAR	15	NA	

## Uplinks

<b>Database:</b>	LIVING_LAB
<b>Entity:</b>	TTN_UPLINKS
<b>Definition:</b>	An uplink is the message that's being transmitted through the network and contains all the data being sent.

Attribute	Key	Data Type	Size	Input Mask	Definition
uplink_guid	PK	GUID	NA	NA	GUID for an uplink block from a broadcast.
device_guid	FK	GUID	NA	NA	GUID for a broadcasting device.
warning_guid	FK	GUID	NA	NA	GUID for a reported warning from a broadcasting device.
session_key_id	-	NVARCHAR	40	NA	Unknown.
f_port	-	INT	NA	NA	Unknown.
f_cnt	-	INT	NA	NA	Unknown.
frm_payload	-	NVARCHAR	50	NA	Raw transmitted data in its encoded form.
consumed_air_time	-	FLOAT	NA	NA	The total amount of time required to complete the broadcast
raw_bytes	-	NVARCHAR	50	NA	The raw transmitted data in its raw dict form cast to string.

## RX

<b>Database:</b>	LIVING_LAB
<b>Entity:</b>	TTN_RX
<b>Definition:</b>	Contains metadata relating to the how the uplink was sent, usually details of the intermediate gateways relaying data through the TTN system.

Attribute	Key	Data Type	Size	Input Mask	Definition
rx_guid	PK	GUID	NA	NA	GUID for the RX block of a transmission.
uplink_guid	FK	GUID	NA	NA	GUID for an uplink block from a broadcast.
gateway_guid	FK	GUID	NA	NA	GUID of the gateway originating the transmission from a device into TTN.
rx_time	-	DATETIME	NA	NA	Datetime of when the transmission was broadcast from the gateway.
rx_timestamp	-	INT	NA	NA	Epoch of when the transmission was broadcast from the gateway.
rsi	-	INT	NA	NA	Signal strength of the device transmitting to the gateway.
channel_rssi	-	INT	NA	NA	Unknown.
snr	-	FLOAT	NA	NA	Level of background noise.
message_id	-	NVARCHAR	30	NA	Message identifier
forwarder_network_id	-	INT	NA	NA	Unknown.
forwarder_tenant_id	-	NVARCHAR	8	NA	TTN backplane version in use.
forwarder_cluster_id	-	NVARCHAR	15	NA	TTN backplane version in use with server base region.
home_network_id	-	INT	NA	NA	Unknown.
home_network_tenant_id	-	NVARCHAR	8	NA	Unknown.
home_network_cluster_id	-	NVARCHAR	12	NA	Server region.

## Uplink Settings

<b>Database:</b>	LIVING_LAB
<b>Entity:</b>	TTN_UPLINK_SETTINGS
<b>Definition:</b>	Uplink settings relate to the technical details of the uplink message, typically data regarding the protocol versions used for broadcasting the uplink.

Attribute	Key	Data Type	Size	Input Mask	Definition
uplink_setting_guid	PK	GUID	NA	NA	GUID for the uplink settings of a transmission.
uplink_guid	FK	GUID	NA	NA	GUID for the origin transmission for the settings block.
bandwidth	-	INT	NA	NA	LoRa bandwidth for the transmission, in bps (inferred).
spreading_factor	-	INT	NA	NA	Spreadign factor for the LoRa transmission
data_rate_index	-	INT	NA	NA	The LoRa data rate standard used to transmit over the LoRa network.
coding_rate	-	NVARCHAR	5	NA	Used for forward error correction of the transmission.
frequency	-	INT	NA	NA	Frequency used to transmit data over the LoRa network in hertz (inferred).
setting_timestamp	-	INT	NA	NA	Epoch for the transmission from the TTN backplane handler.

## Uplink Tokens

<b>Database:</b>	LIVING_LAB
<b>Entity:</b>	TTN_UPLINK_TOKENS
<b>Definition:</b>	Contains uplink tokens received for a particular uplink session.

Attribute	Key	Data Type	Size	Input Mask	Definition
rx_guid	PK/FK	GUID	NA	NA	GUID for an RX block.
gateway_guid	PK/FK	GUID	NA	NA	GUID for a gateway entry.
uplink_tokens	-	NVARCHAR	MAX	NA	Uplink token from a transmission RX block.

## Correlation IDs

<b>Database:</b>	LIVING_LAB
<b>Entity:</b>	TTN_CORRELATION_IDS
<b>Definition:</b>	Stores correlation id entries from a transmission.

Attribute	Key	Data Type	Size	Input Mask	Definition
correlation_guid	PK	GUID	NA	NA	GUID for a recorded correlation ID.
rx_guid	FK	GUID	NA	NA	GUID for an RX block from a transmission.
correlation_ids	-	NVARCHAR	MAX	NA	The received correlation ID.

## Hops

<b>Database:</b>	LIVING_LAB
<b>Entity:</b>	TTN_HOPS
<b>Definition:</b>	Stores data relating to the server hops a transmission has taken (legacy, not included in TTNv2 broadcasts)

Attribute	Key	Data Type	Size	Input Mask	Definition
hop_guid	PK	GUID	NA	NA	GUID for the server hop in the TTN network.
gateway_guid	FK	GUID	NA	NA	GUID for the gateway originating the transmission from a device through TTN.
rx_guid	FK	GUID	NA	NA	GUID for the RX block of the transmission.
sender_address	-	NVARCHAR	15	NA	Name of the sending node of the hop.
receiver_name	-	NVARCHAR	40	NA	Name of the receiving node of the hop.
receiver_agent	-	NVARCHAR	40	NA	Unknown.

### Datetimes

<b>Database:</b>	LIVING_LAB
<b>Entity:</b>	TTN_DATETIMES
<b>Definition:</b>	Stores datetime readings from a broadcast

Attribute	Key	Data Type	Size	Input Mask	Definition
rx_guid	PK/FK	GUID	NA	NA	GUID of the RX block where the datetime occurs.
uplink_guid	PK/FK	GUID	NA	NA	GUID of the uplink block where the datetime occurs.
hop_guid	PK/FK	GUID	NA	NA	GUID of the hop where the datetime occurs.
received_at	-	DATETIME	NA	NA	The datetime stored in DATETIME format.

### Applications

<b>Database:</b>	LIVING_LAB
<b>Entity:</b>	TTN_APPLICATIONS
<b>Definition:</b>	Stores metadata about an application.

Attribute	Key	Data Type	Size	Input Mask	Definition
application_guid	PK	GUID	NA	NA	GUID for an application.
application_name	-	NVARCHAR	35	NA	The plaintext name for an application.



### Warnings

<b>Database:</b>	LIVING_LAB
<b>Entity:</b>	TTN_WARNINGS
<b>Definition:</b>	Stores warnings received from a broadcast device.

Attribute	Key	Data Type	Size	Input Mask	Definition
warning_guid	PK	GUID	NA	NA	GUID for a reported warning from a broadcasting device.
decoded_payload_warnings	-	NVARCHAR	MAX	NA	The decoded warning from the payload

### Locations

<b>Database:</b>	LIVING_LAB
<b>Entity:</b>	TTN_LOCATIONS
<b>Definition:</b>	Contains location data for a device or platform

Attribute	Key	Data Type	Size	Input Mask	Definition
location_guid	PK	GUID	NA	NA	GUID associated with a location
latitude	-	FLOAT	NA	NA	Latitude of the broadcasting device
longitude	-	FLOAT	NA	NA	Longitude of the broadcasting device
source	-	NVARCHAR	100	NA	Unknown (TTN v1 legacy, dropped in TTN v2)

## Sensors

<b>Database:</b>	LIVING_LAB
<b>Entity:</b>	TTN_SENSORS
<b>Definition:</b>	Stores data of sensors connected to a device or platform.

Attribute	Key	Data Type	Size	Input Mask	Definition
sensor_guid	PK	GUID	NA	NA	GUID associated with a sensor
sensor_name	-	NVARCHAR	30	NA	Descriptive name for an installed sensor
sensor_location	-	NVARCHAR	30	NA	Physical location of an installed sensor platform.
sensor_type	-	NVARCHAR	15	NA	What is the sensor monitoring e.g. temperature, humidity, etc.
measurement_units	-	NVARCHAR	5	NA	Units for a sensor reading e.g. C, mm, %, etc.

## Readings

<b>Database:</b>	LIVING_LAB
<b>Entity:</b>	TTN_READINGS
<b>Definition:</b>	Stores the actual readings taken by sensors and transmitted by devices.

Attribute	Key	Data Type	Size	Input Mask	Definition
uplink_guid	PK	GUID	NA	NA	GUID for the uplink block of the transmission.
sensor_guid	FK	GUID	NA	NA	GUID of the sensor that recorded the value.
sensor_value	-	NVARCHAR	MAX	NA	The actual recorded value of a sensor stored as a cast string to preserve original format.

### Gateways

<b>Database:</b>	LIVING_LAB
<b>Entity:</b>	TTN_GATEWAYS
<b>Definition:</b>	Stores metadata for the gateways used to connect devices to the LoRa network.

Attribute	Key	Data Type	Size	Input Mask	Definition
gateway_guid	PK	GUID	NA	NA	GUID of the gateway handling the transmission into TTN.
Location_guid	FK	GUID	NA	NA	GUID for the location of a gateway
gateway_name	-	NVARCHAR	30	NA	The plaintext name of the gateway.

## Minimal Normalisation

### Sensors

<b>Database:</b>	LIVING_LAB
<b>Entity:</b>	TTN_SENSORS
<b>Definition:</b>	Stores data of sensors connected to a device or platform.

Attribute	Key	Data Type	Size	Input Mask	Definition
sensor_guid	PK	GUID	NA	NA	GUID associated with a sensor
sensor_name	-	NVARCHAR	30	NA	Descriptive name for an installed sensor
sensor_type	-	NVARCHAR	15	NA	What is the sensor monitoring e.g. temperature, humidity, etc.
measurement_units	-	NVARCHAR	3	NA	Units for a sensor reading e.g. C, mm, %, etc.

### Readings

<b>Database:</b>	LIVING_LAB
<b>Entity:</b>	TTN_READINGS
<b>Definition:</b>	Stores the actual readings taken by sensors and transmitted by devices.

Attribute	Key	Data Type	Size	Input Mask	Definition
uplink_guid	PK/FK	GUID	NA	NA	GUID for the uplink block of the transmission.
sensor_guid	PK/FK	GUID	NA	NA	GUID of the sensor that recorded the value.
sensor_value	-	FLOAT	NA	NA	The actual recorded value of a sensor stored as a cast string to preserve original format.

### Applications

<b>Database:</b>	LIVING_LAB
<b>Entity:</b>	TTN_APPLICATIONS
<b>Definition:</b>	Stores metadata about an application.

Attribute	Key	Data Type	Size	Input Mask	Definition
application_guid	PK	GUID	NA	NA	GUID for an application.
application_name	-	NVARCHAR	NA	NA	The plaintext name for an application.

### Devices

<b>Database:</b>	LIVING_LAB
<b>Entity:</b>	TTN_DEVICES
<b>Definition:</b>	A device is a central device transmitting the data to the network, with sensors being connected to a device.

Attribute	Key	Data Type	Size	Input Mask	Definition
device_guid	PK	GUID	NA	NA	GUID for a broadcasting device.
application_guid	FK	GUID	NA	NA	GUID for an application, broadcasting devices are all associated to an application.
device_name	-	NVARCHAR		NA	Readable name associated with a broadcast device.

## Warnings

<b>Database:</b>	LIVING_LAB
<b>Entity:</b>	TTN_WARNINGS
<b>Definition:</b>	Stores warnings received from a broadcast device.

Attribute	Key	Data Type	Size	Input Mask	Definition
warnings_guid	PK	GUID	NA	NA	GUID for a reported warning from a broadcasting device.
decoded_payload_warnings	-	NVARCHAR	NA	NA	The decoded warning from the payload

## Uplinks

<b>Database:</b>	LIVING_LAB
<b>Entity:</b>	TTN_UPLINKS
<b>Definition:</b>	An uplink is the message that's being transmitted through the network and contains all the data being sent.

Attribute	Key	Data Type	Size	Input Mask	Definition
uplink_guid	PK	GUID	NA	NA	GUID for an uplink block from a broadcast.
device_guid	FK	GUID	NA	NA	GUID for a broadcasting device.
sensor_guid	FK	GUID	NA	NA	GUID of the sensor reporting a reading.
warnings_guid	FK	GUID	NA	NA	GUID for a reported warning from a broadcasting device.
session_key_id	-	NVARCHAR	NA	NA	Unknown.
f_port	-	INT	NA	NA	Unknown.
f_cnt	-	INT	NA	NA	Unknown.
frm_payload	-	NVARCHAR	NA	NA	Raw transmitted data in its encoded form.
sensor_value	-	FLOAT	NA	NA	The raw transmitted data in its raw dict form cast to string.
received_at	-	DATETIME	NA	NA	Datetime that the transmission was received at the gateway from the device.
consumed_air_time	-	FLOAT	NA	NA	The total amount of time required to complete the broadcast.

## Additional Notes