Data Processing & Structures

The Things Network

Ethan Bellmer
IGNITION Living Lab

Table of Contents

JSON Structure & 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 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 data_dict frm_payload decoded_payload 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	

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 ontaining 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

UNF Repeating attributes indented	**1-NF** Remove repeating attributes and identify a primary key	**2-NF** Remove partial dependencies	**3-NF** 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	**Device GUID** device_name application_name dev_eui join_eui dev_addr	**Device GUID** **Application GUID*** device_name dev_eui join_eui dev_addr	**Device GUID** **Application GUID*** device_name dev_eui join_eui dev_addr
	Uplink GUID session_key_id f_port f_cnt data_dict frm_payload raw_bytes decoded_payload_warnings consumed_airtime	**Uplink GUID** **Device GUID*** session_key_id f_port f_cnt frm_payload sensor_name sensor_value raw_bytes decoded_payload_warnings consumed_airtime	**Uplink GUID** **Device GUID*** **Warning GUID*** session_key_id f_port f_cnt frm_payload consumed_airtime raw_bytes
	RX GUID 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	**RX GUID** **Uplink GUID*** **Location GUID*** 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	**RX GUID** **Uplink GUID*** **Gateway GUID*** 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
	Uplink Setting GUID bandwidth spreading_factor data_rate_index coding_rate setting_frequency setting_timestamp	**Uplink Setting GUID** **Uplink GUID*** bandwidth spreading_factor data_rate_index coding_rate setting_frequency setting_timestamp	**Uplink Setting GUID** **Uplink GUID*** bandwidth spreading_factor data_rate_index coding_rate setting_frequency setting_timestamp
	uplink_token	**RX GUID*** **Gateway GUID*** uplink_token	**RX GUID*** **Gateway GUID*** uplink_token
	Correlation GUID correlation_ids	**RX GUID*** **Correlation GUID** correlation_ids	**Correlation GUID** **RX GUID*** correlation_ids
	Hop GUID sender_address receiver_name receiver_agent	**Hop GUID** **Gateway GUID*** **RX GUID*** sender_address receiver_name receiver_agent	**Hop GUID** **Gateway GUID*** **RX GUID*** sender_address receiver_name receiver_agent
	received_at	**RX GUID*** **Uplink GUID*** **Hop GUID***	**RX GUID*** **Uplink GUID*** **Hop GUID***

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

Minimal Normalisation

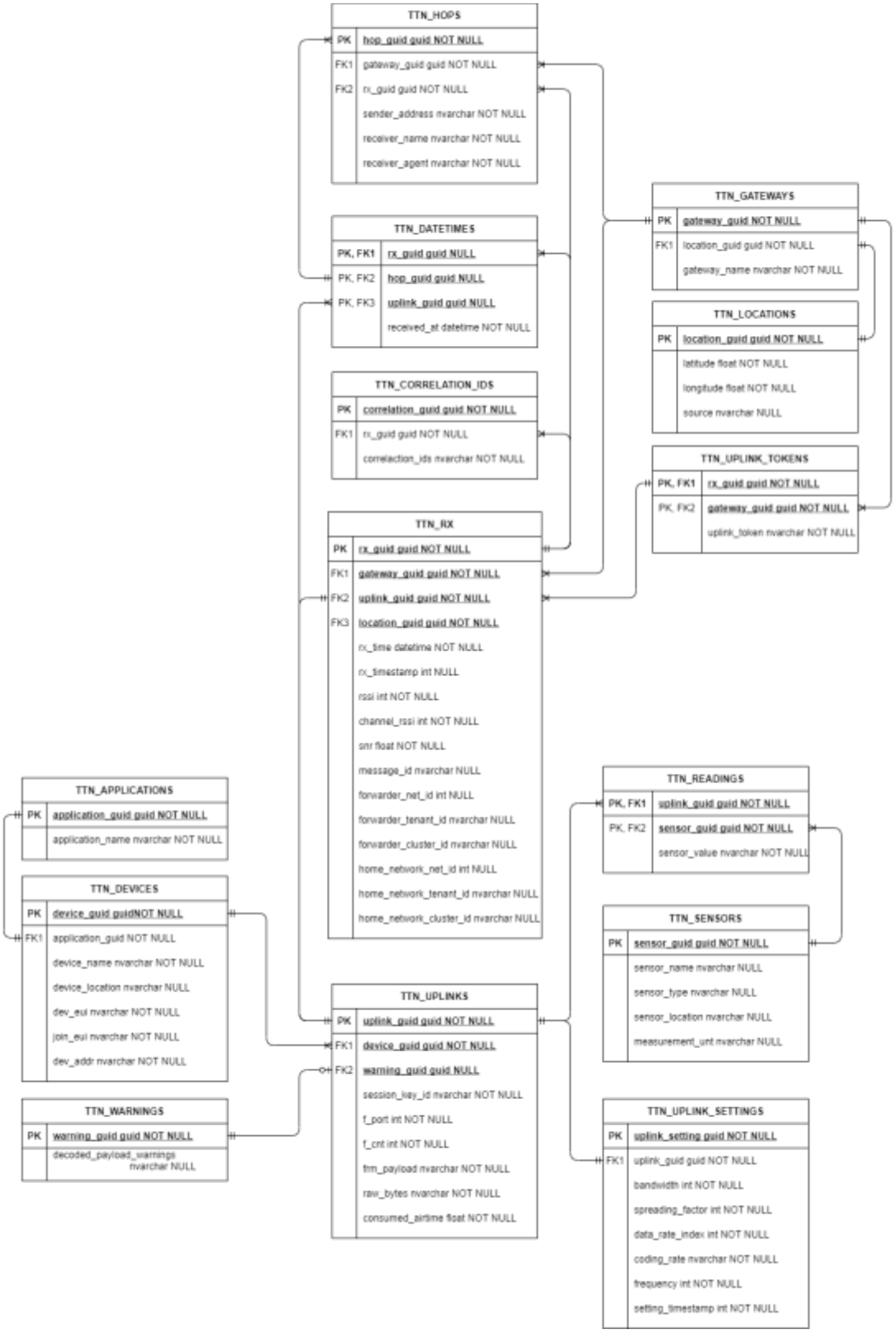
<table>
<tr><th>UNF
Repeating attributes indented</th><th>1-NF
Remove repeating attributes and identify a primary key</th><th>2-NF
Remove partial dependencies</th><th>3-NF
Remove non-key dependencies</th></tr>
<tr><td rowspan="5">device_name
application_name
session_key_id
f_port
f_cnt
frm_payload
sensor_name
sensor_value
decoded_payload
altitude
battery_voltage
bytes
humidity
pressure
rain_detect
solar_voltage
temp
decoded_payload_warnings

received_at
consumed_airtime</td><td>Device GUID
device_name
application_name</td><td>Device GUID
device_name</td><td>Device GUID
Application GUID*
device_name</td></tr>
<tr><td>Uplink GUID
session_key_id
f_port
f_cnt
frm_payload
sensor_name
sensor_value

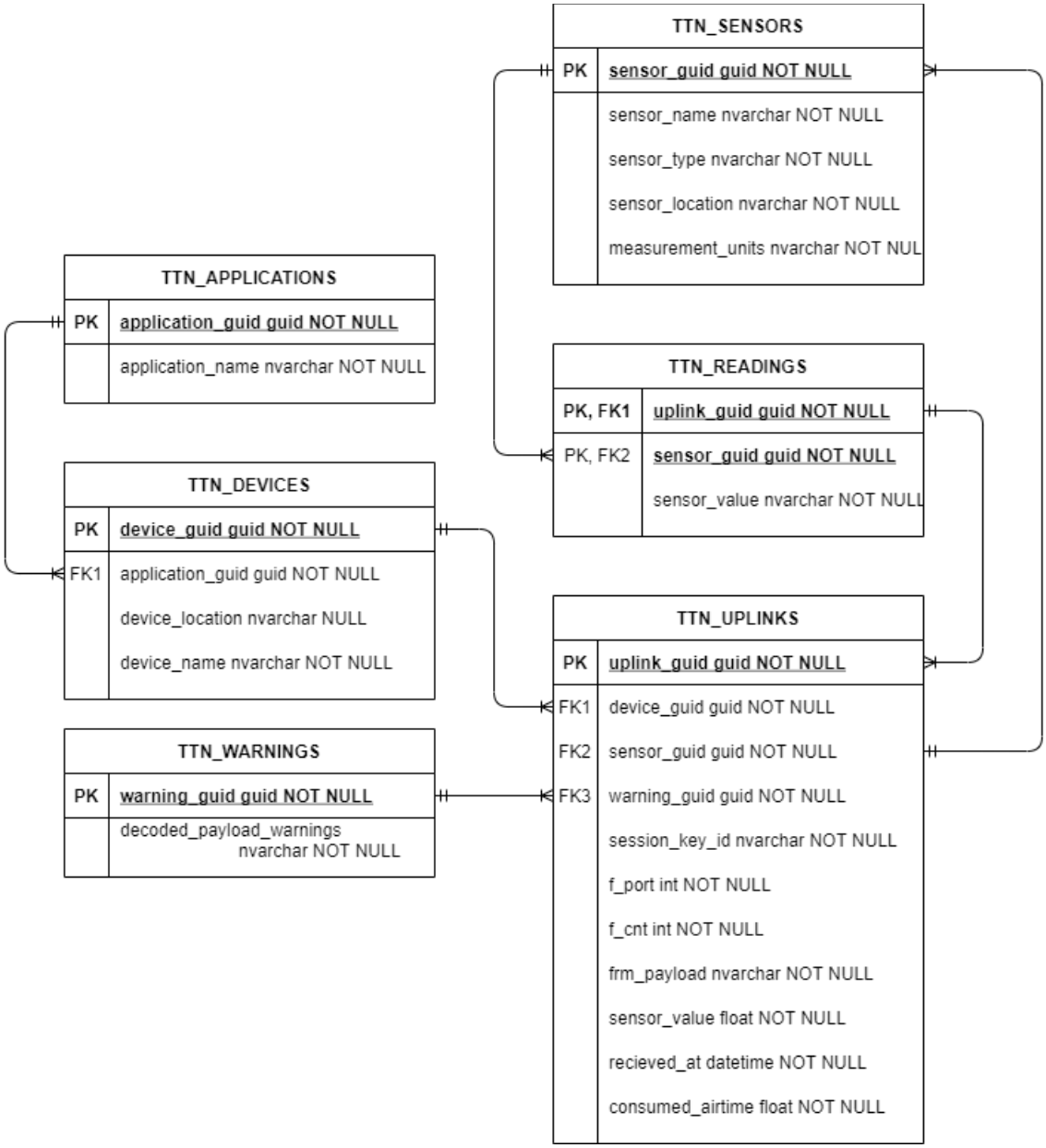
received_at
consumed_airtime</td><td>Uplink GUID
session_key_id
f_port
f_cnt
frm_payload
raw_bytes
sensor_value
received_at
consumed_airtime</td><td>Uplink GUID
Device GUID*
Sensor GUID*
Warnings GUID*
session_key_id
f_port
f_cnt
frm_payload
sensor_value
received_at
consumed_airtime</td></tr>
<tr><td rowspan="4">Warnings GUID
decoded_payload_warnings</td><td>Warnings GUID
decoded_payload_warnings</td><td>Warnings GUID
decoded_payload_warnings</td></tr>
<tr><td>Application GUID
application_name</td><td>Application GUID
application_name</td></tr>
<tr><td>Sensor GUID
sensor_name
sensor_type
sensor_location
measurement_units</td><td>Sensor GUID
sensor_name
sensor_type
sensor_location
measurement_units</td></tr>
<tr><td>Uplink GUID*
Sensor GUID*
sensor_value</td><td>Uplink GUID*
Sensor GUID*
sensor_value</td></tr>
</table>

Entity Relationship Diagrams

Full



Minimal


TTN_SENSORS
PK sensor_guid guid NOT NULL
sensor_name nvarchar NOT NULL
sensor_type nvarchar NOT NULL
sensor_location nvarchar NOT NULL
measurement_units nvarchar NOT NUL
TTN_APPLICATIONS
PK application_guid guid NOT NULL
application_name nvarchar NOT NULL
TTN_READINGS
PK, FK1 uplink_guid guid NOT NULL
PK, FK2 sensor_guid guid NOT NULL
sensor_value nvarchar NOT NULL
TTN_DEVICES
PK device_guid guid NOT NULL
FK1 application_guid guid NOT NULL
device_location nvarchar NULL
device_name nvarchar NOT NULL
TTN_UPLINKS
PK uplink_guid guid NOT NULL
FK1 device_guid guid NOT NULL
FK2 sensor_guid guid NOT NULL
FK3 warning_guid guid NOT NULL
session_key_id nvarchar NOT NULL
f_port int NOT NULL
f_cnt int NOT NULL
frm_payload nvarchar NOT NULL
sensor_value float NOT NULL
recieved_at datetime NOT NULL
consumed_airtime float NOT NULL
TTN_WARNINGS
PK warning_guid guid NOT NULL
decoded_payload_warnings nvarchar NOT NULL

Data Dictionaries

Full Normalisation

Devices

Database:	LIVING_LAB
Entity:	TTN_DEVICES
Definition:	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

Database:	LIVING_LAB
Entity:	TTN_UPLINKS
Definition:	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_airtime	-	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

Database:	LIVING_LAB
Entity:	TTN_RX
Definition:	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.
rssi	-	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_net_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_net_id	-	INT	NA	NA	Unknown.
home_network_tenant_id	-	NVARCHAR	8	NA	Unknown.
home_network_cluster_id	-	NVARCHAR	12	NA	Server region.

Uplink Settings

Database:	LIVING_LAB
Entity:	TTN_UPLINK_SETTINGS
Definition:	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

Database:	LIVING_LAB
Entity:	TTN_UPLINK_TOKENS
Definition:	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

Database:	LIVING_LAB
Entity:	TTN_CORRELATION_IDS
Definition:	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_id s	-	NVARCHAR	MAX	NA	The received correlation ID.

Hops

Database:	LIVING_LAB
Entity:	TTN_HOPS
Definition:	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_addre ss	-	NVARCHAR	15	NA	Name of the sending node of the hop.
receiver_nam e	-	NVARCHAR	40	NA	Name of the receiving node of the hop.
receiver_agen t	-	NVARCHAR	40	NA	Unknown.

Datetimes

Database:	LIVING_LAB
Entity:	TTN_DATETIMES
Definition:	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

Database:	LIVING_LAB
Entity:	TTN_APPLICATIONS
Definition:	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

Database:	LIVING_LAB
Entity:	TTN_WARNINGS
Definition:	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

Database:	LIVING_LAB
Entity:	TTN_LOCATIONS
Definition:	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

Database:	LIVING_LAB
Entity:	TTN_SENSORS
Definition:	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

Database:	LIVING_LAB
Entity:	TTN_READINGS
Definition:	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

Database:	LIVING_LAB
Entity:	TTN_GATEWAYS
Definition:	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

Database:	LIVING_LAB
Entity:	TTN_SENSORS
Definition:	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

Database:	LIVING_LAB
Entity:	TTN_READINGS
Definition:	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

Database:	LIVING_LAB
Entity:	TTN_APPLICATIONS
Definition:	Stores metadata about an application.

Attribute	Key	Data Type	Size	Input Mask	Definition
application_ guid	PK	GUID	NA	NA	GUID for an application.
application_n ame	-	NVARCHAR	NA	NA	The plaintext name for an application.

Devices

Database:	LIVING_LAB
Entity:	TTN_DEVICES
Definition:	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

Database:	LIVING_LAB
Entity:	TTN_WARNINGS
Definition:	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

Database:	LIVING_LAB
Entity:	TTN_UPLINKS
Definition:	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_airtime	-	FLOAT	NA	NA	The total amount of time required to complete the broadcast.

Additional Notes