

1 **LoRaWAN Application Layer Clock Synchronization Specification v1.0.0**

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LoRaWAN Application Layer Clock Synchronization Specification

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91 1 Conventions

92

93 The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD",
94 "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be
95 interpreted as described in RFC 2119.

96

97 The octet order over the air for all multi-octet fields is little endian (Least significant byte is
98 sent first).

99

100 **2 Introduction**

101
102 This document proposes an application layer messaging package running over LoRaWAN to
103 synchronize the real-time clock of an end-device to the network's GPS clock with second
104 accuracy. Synchronizing the end-device(s) clock is very useful of many applications like:

- 105 • Get all end-devices of a multicast group switching to classC temporarily and
106 synchronously at the beginning of the slot
- 107 • Get many sensors to synchronously perform a measurement (get water meter
108 reading of all meters at midnight every day for example)
- 109 • Enabling end-devices to transmit time-stamped events (the door was opened this
110 morning at 8:00AM) with a unified clock

111
112 This package is useful for end-devices which do not have access to other accurate time
113 source. An end-device using LoRaWAN 1.1 or above SHOULD use DeviceTimeReq MAC
114 command instead of this package. ClassB end-devices have a more efficient way of
115 synchronizing their clock, the classB network beacon. They SHOULD NOT use this package
116 and directly use the beacon time information. End-devices with an accurate external clock
117 source (e.g.: GPS) SHOULD use that clock source instead.
118

119 All messages described in this document are transported as application layer messages. As
120 such, all unicast messages (uplink or downlink) are encrypted by the LoRaWAN MAC layer
121 using the end-device's AppSKey.

122

123 The package uses a dedicated port to separate its traffic from the rest of the applicative
124 traffic.

125 3 Clock synchronization Message Package

126
127 The identifier of the clock synchronization package is 1. The version of this package is
128 version 1.

129
130 The following messages are sent to/from each end-device individually using Unicast uplink
131 or downlink on a port specifically used for the clock synchronization package. The default
132 port value is 202. These messages MUST NOT be sent using multicast. If these messages
133 are received on a multicast address the end-device MUST drop them silently.

134
135 All unicast control messages use the same format:

Command1	Command1 Payload	Command2	Command2 payload
----------	------------------	----------	------------------	------

136
137 A message MAY carry more than one command. The length of each command's payload is
138 fixed and a function of the command. Commands are executed from first to last. Each
139 command MUST be individually acknowledged by the end-device.

140
141 The following table summarizes the list of the clock synchronization messages

CID	Command name	Transmitted by		Short Description
		End-device	server	
0x00	PackageVersionReq		x	Used by the AS to request the package version implemented by the end-device
0x00	PackageVersionAns	x		Conveys the answer to PackageVersionReq
0x01	AppTimeReq	x		Used by end-device to request clock correction
0x01	AppTimeAns		x	Conveys the clock timing correction
0x02	DeviceAppTimePeriodicityReq		x	Used by the application server for 2 purposes: Set the periodicity at which the end-device shall transmit AppTimeReq messages and request an immediate transmission of end-device time
0x02	DeviceAppTimePeriodicityAns	x		
0x03	ForceDeviceResyncReq		x	Used by the application server to the end-device to trigger a clock resynchronization.

143 **Table 1: Clock Synchronization messages summary**

144
145
146
147
148

149 3.1 PackageVersionReq & Ans

150

151 The *PackageVersionReq* command has no payload.

152 The end-device answers with a *PackageVersionAns* command with the following payload.

153

Field	PackageIdentifier	PackageVersion
Size (bytes)	1	1

154

Table 2: PackageVersionAns

155 *PackageIdentifier* uniquely identifies the package. For the “clock synchronization package”
156 this identifier is 1.

157 *PackageVersion* corresponds to the version of the package specification implemented by the
158 end-device.

159 3.2 AppTimeReq & Ans

160

161 The *AppTimeReq* message is transmitted by the end-device to request a clock correction
162 from the application server. The message is meant to be transmitted periodically by the end-
163 device. The default periodicity is a function of the accuracy required by the application and
164 the maximum clock drift speed of the end-device.

165 This message SHALL only be transmitted a single time with a given DeviceTime payload, as
166 the network reception time stamp will be used by the application server to compute the
167 require clock correction. Therefore the “clock synchronization” package SHALL first
168 temporarily disable ADR and set NbTrans=1 before transmitting this message, then revert
169 the MAC layer to the previous state.

170

171 The *AppTimeReq* command has the following payload.

172

173

Field	DeviceTime	Param
Size (bytes)	4	1

174

Table 3: AppTimeReq

175 Where:

176

Param Fields	RFU	AnsRequired	TokenReq
Size (bits)	3bits	1bit	4bits

177

Table 4: Param fields

178

179 *DeviceTime* is the current end-device clock and is expressed as the time in seconds since
180 00:00:00, Sunday 6th of January 1980 (start of the GPS epoch) modulo 2^{32} . Note that this
181 is the same format as the Time field in the beacon frame. The time is captured immediately
182 before transmitting the radio packet. The processing delay between the clock time capture
183 and the transmission of the packet should be minimized. The intent is to provide second
184 accurate timing therefore the delay SHALL be $< 250\text{mSec}$.

185

186 *TokenReq* is a 4 bits counter initially set to 0. *TokenReq* is incremented (modulo 16) each
187 time the end-device receives and processes successfully an *AppTimeAns* message.

188

189 If the *AnsRequired* bit is set to 1 the end-device expects an answer whether its clock is well
190 synchronized or not. If this bit is set to 0, this signals to the AS that it only needs to answer if
191 the end-device clock is de-synchronized.

192

193 The application server MAY respond to the **AppTimeReq** command with an **AppTimeAns**
194 with the following payload:

195

196

Field	TimeCorrection	Param
Size (bytes)	4	1

197

Table 5: AppTimeAns

198 Where:

199

Param Fields	RFU	TokenAns
Size (bits)	4bits	4bits

200

Table 6: Param fields

201

202 *TimeCorrection* is a signed 32-bit integer, stipulating the time delta correction in seconds.

203

204 If the *AnsRequired* bit is 0 the application server MAY respond if the end-device indicated
205 current clock timing drifts above a certain application specific threshold. If the end-device's
206 clock is well synchronized, the application server does not need to answer. The application
207 server uses the network time stamp of the uplink frame to compute the required timing
208 correction.

209 If the *AnsRequired* bit is 1 the application server SHOULD respond to the **AppTimeReq**
210 command. Not responding to the end-device very probably triggers a retransmission of
211 AppTimeReq by the end-device until it receives an answer. This retransmission strategy is
212 application specific.

213

214 When the application server answers:

215 *TokenAns* MUST match the *TokenReq* value of the AppTimeReq message which is being
216 answered. If the *TokenAns* & *TokenReq* fields do not match the end-device SHALL ignore
217 the AppTimeAns message.

218

219 If the two tokens match, then the end-device SHALL increment its *TokenReq* internal
220 counter (modulo 16) and *TimeCorrection* MUST be added to the current end-device clock to
221 be synchronous with the network clock. The end-device SHALL immediately perform the
222 correction on its clock. Any following transmission of the **AppTimeReq** message SHALL
223 reflect the timing correction and the incremented *TokenReq* value to avoid unnecessary
224 downlinks.

225 3.3 DeviceAppTimePeriodicityReq & Ans

226

227 Each end-device's application MAY come with a different default periodicity for the
228 transmission of the **AppTimeReq** message.

229

230 The **DeviceAppTimePeriodicityReq** command is used by the application server to modify
231 this periodicity and/or get an instant reading of the end-device's clock value. The message
232 payload is:

233

234

Field	Periodicity
Size (bytes)	1

235

Table 7: DeviceAppTimePeriodicityReq

236

237 Where:

238

Periodicity Fields	RFU	Period
	Size (bits)	4bits

239

Table 8: DeviceAppTimePeriodicityReq Periodicity field

240

241

242 *Period* encodes the periodicity of the **AppTimeReq** transmissions. The actual periodicity in
 243 seconds is $128.2^{Period} \pm rand(30)$ where *rand(30)* is a random integer in the +/-30sec
 244 range varying with each transmission.

245

246 The end-device responds with the **DeviceAppTimePeriodicityAns** message containing the
 247 following payload.

248

Field	Status	Time
	Size (bytes)	1

249

Table 9: DeviceAppTimePeriodicityAns

250 Where:

251

Status Fields	RFU	NotSupported
	Size (bits)	7bits

252

Table 10: DeviceAppTimePeriodicityAns Status field

253

254 *NotSupported* bit is set to 1 if the end-device's application does not accept a periodicity set
 255 by the application server and manages the clock synchronization process and periodicity
 256 itself.

257

258 *Time* is the current end-device's clock time captured immediately before the transmission of
 259 the radio message.

260

261 3.4 ForceDeviceResyncReq

262

263 The **ForceDeviceResyncReq** message is transmitted by the application server to the end-
 264 device to trigger a clock resynchronization.

265

266

267

268

269

270

271

An example of condition that may trigger this transmission is the McClassCSessionAns message sent by the end-device in response to a classC setup command from the application server. If the server detects that the end-device's clock is not well synchronized it should force the end-device to re-synchronize its clock else the end-device will miss the multicast slot.

272 The **ForceDeviceResyncReq** command has a single byte payload.

273

Field	ForceConf
Size (bytes)	1

274

Table 11: ForceDeviceResyncReq

275 Where:

276

ForceConf Fields	RFU	NbTransmissions
Size (bits)	5bits	3bits

277

Table 12: ForceConf fields

278 There is no **ForceDeviceResyncAns** message. The end-device responds by sending up to
 279 *NbTransmissions* **AppTimeReq** messages with the *AnsRequired* bit set to 0. The end-
 280 device stops re-transmissions of the **AppTimeReq** if a valid **AppTimeAns** is received. If the
 281 *NbTransmissions* field is 0, the command SHALL be silently discarded.

282 The delay between consecutive transmissions of the **AppTimeReq** is application specific.

283

284 **4 Glossary**

285

286 AS Application Server

287 GPS Global Positioning System

288

289 TBD To Be Done

290

291 **5 Bibliography**292 **5.1 References**

293 [LoRaWAN 1.0.2]: LoRaWAN™ 1.0.2 Specification, LoRa Alliance, July 2016

294 [LoRaWAN 1.1]: LoRaWAN™ 1.1 Specification, LoRa Alliance, October 11, 2017

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