

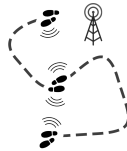
ESP32-Smartphone via LoRa & BLE communication protocol specification

Enzo MOLION, Léo VALETTE

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Abstract

The aim of this paper is to specify the protocol developed as part of the *UltraTeam* RICM4 project taking place in place in Polytech Grenoble. This protocol shall allow smartphones and ESP32 to communicate via LoRa and Bluetooth Low Energy.

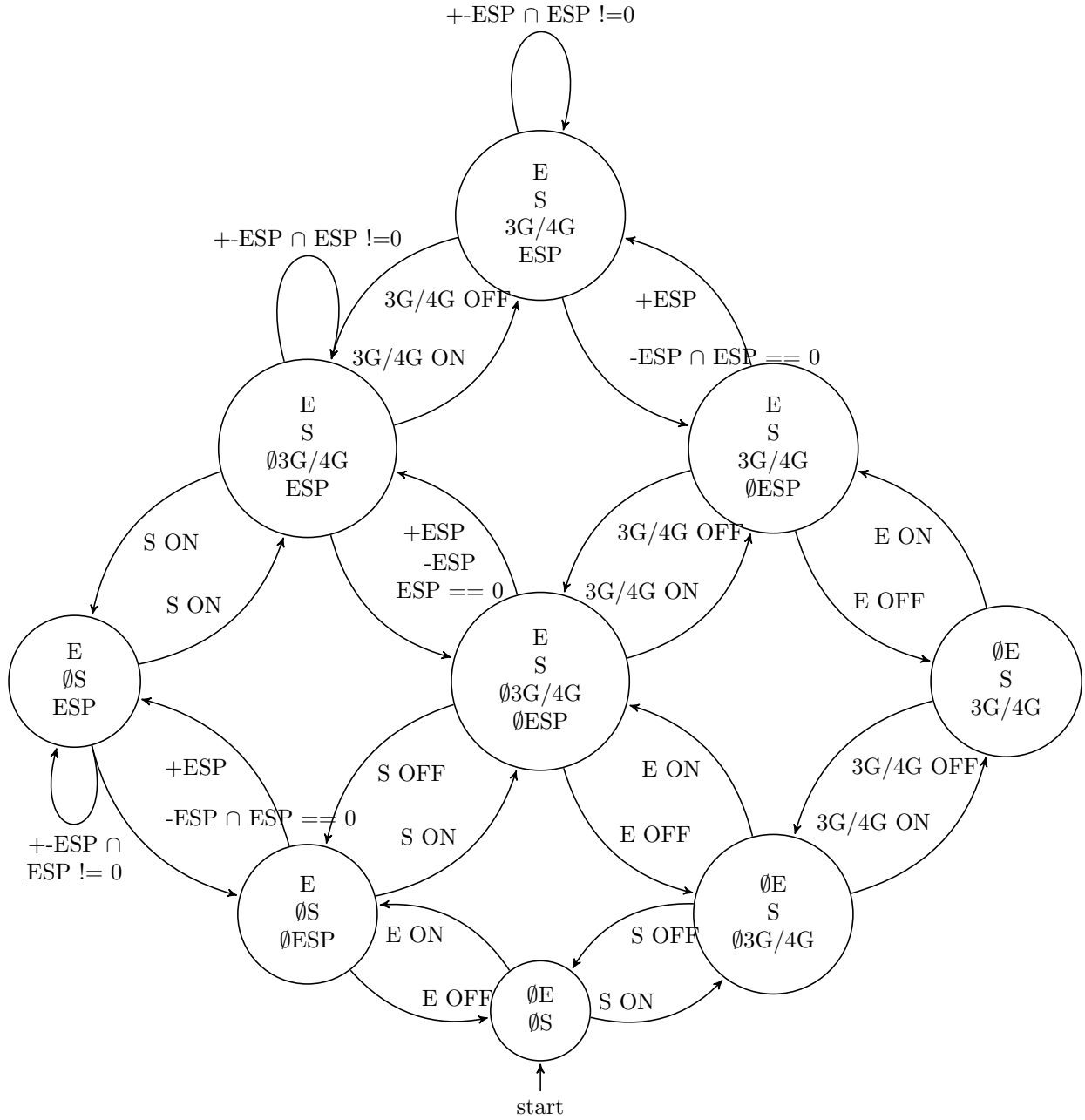


Logo courtesy of Lucas Reygrobellet

1 General overview

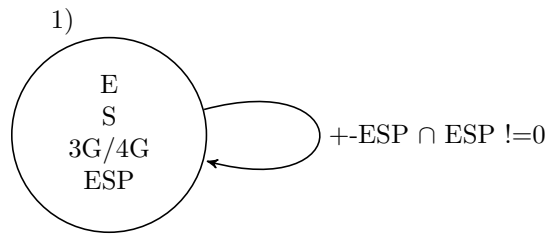
Let us display this protocol automaton with the given legend :

- E means that the user's ESP is ON and running the application,
- S means that the user's smartphone is ON and running the application,
- 3G/4G means that the user has got a 3G or 4G connection on his smartphone,
- ESP means that the user's ESP is connected to another ESP via LoRa,
- \emptyset before one of the previous items means its opposite,
- $\langle X \rangle$ ON (resp. OFF) means that the device or connection X was powered on (resp. off),
- +-ESP means that connection to a ESP via LoRa is made/lost,
- $\text{ESP} \neq$ (resp $\text{ESP} ==$) 0 means that there is (resp. no more) at least one ESP connected to user's via LoRa.

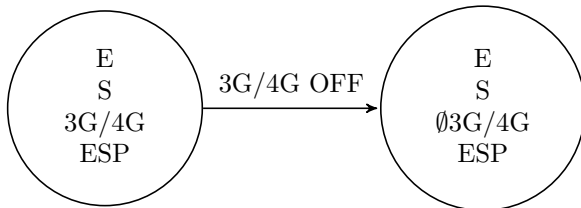


2 Transitions : descriptions & respective management

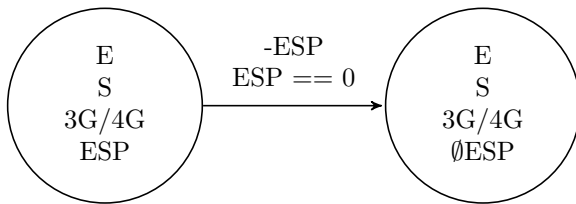
Let us now display a detailed description and a list of needed actions for every state change.



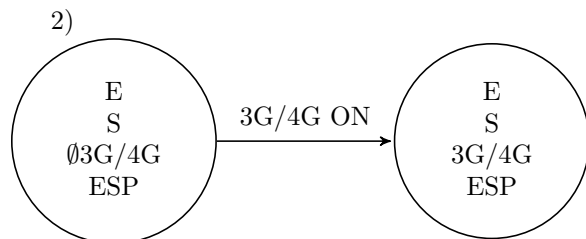
Description : 1-1 : Staying in the "ideal" state. Loosing/acquiring a LoRa ESP connection.
 Management : Update (add new / remove old) the reachable ESP list.



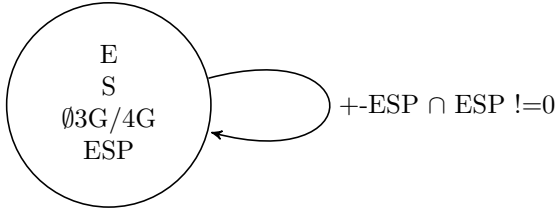
Description : 1-2 : Leaving the "ideal" state by loosing the 3G/4G connection.
 Management : Request a LoRa broadcast to send position



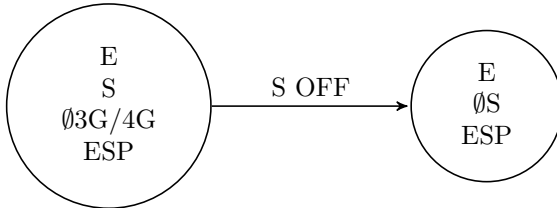
Description : 1-3 : Leaving the "ideal" state by loosing the only LoRa ESP connection.
 Management : Immediately download and upload data via 3G/4G



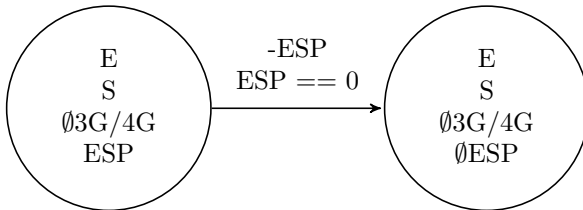
Description : 2-1 : Reaching the "ideal" state by getting a 3G/4G connection.
 Management : Immediately download and upload data via 3G/4G



Description : 2-2 : Staying in same state, loosing/acquiring an ESP LoRa connection.
 Management : Update (add new / remove old) the reachable ESP list.

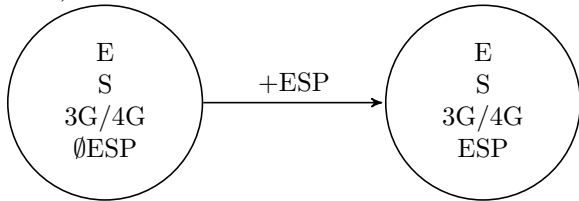


Description : 2-4 : Reaching a "phone off" state. The smartphone powered off.
 Management : Immediately request a LoRa broadcast to send position and inform that smartphone died.

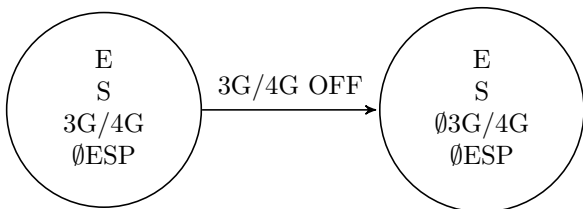


Description : 2-5 : Reaching a "no connection" state. Lost the last ESP LoRa connection and still don't have any 3G/4G connection.
 Management : Immediately sync ESP and smartphone via BLE.

3)

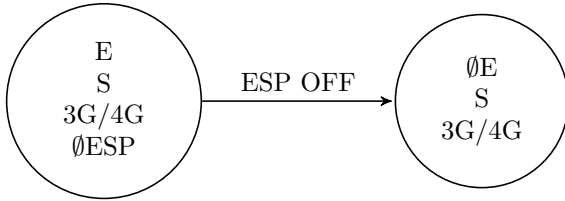


Description : 3-1 : Reaching the "ideal" state by getting a first ESP connection .
 Management : Update (add new / remove old) the reachable ESP list. Immediately request a LoRa broadcast to send position.



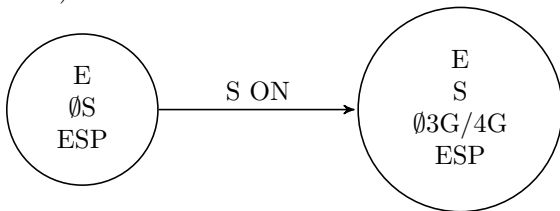
Description : 3-5 : Reaching a "no connection" state by loosing the 3G/4G connection.

Management : Immediately sync ESP and smartphone (to be as up-to-date as possible in case of a device powering off).

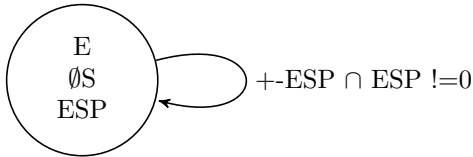


Description : 3-6 : Reaching a "ESP off" state. The ESP powered off.
 Management : Upload data more frequently.

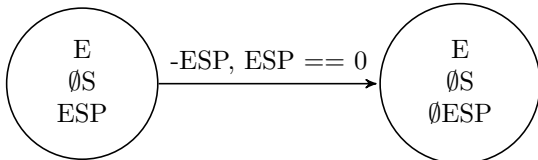
4)



Description : 4-2 : Reaching an "Everything is on, only ESP connection" by powering smartphone on.
 Management : Immediately sync ESP and smartphone via BLE.

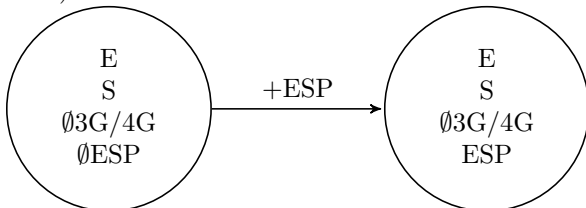


Description : 4-4 : Staying in a "ESP only" state. Loosing/acquiring a LoRa ESP connection.
 Management : Update (add new / remove old) the reachable ESP list.

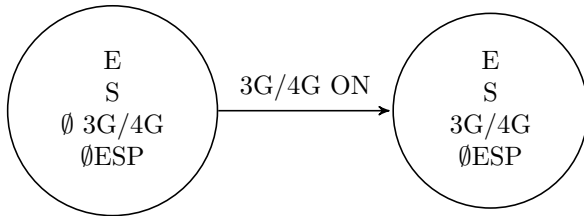


Description : 4-7 : Reaching a "no connected" state. Loosing the only ESP LoRa connection.
 Management :

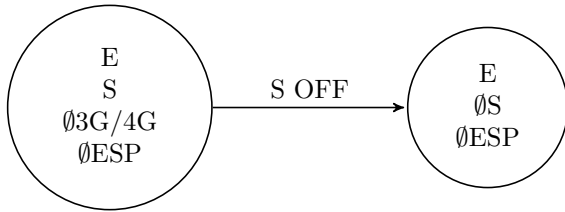
5)



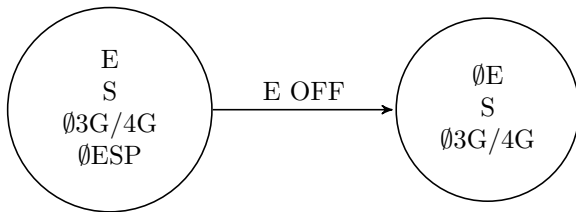
Description : 5-2 : Reaching an "ESP connected, smartphone on" state by getting a LoRa connection.
 Management : Immediately request a LoRa broadcast to send position.



Description : 5-3 : Reaching an "everything is ON but only 3G/4G connection" by getting the 3G/4G connection.
 Management : Immediately sync ESP & smartphone via BLE. Then download & upload data.

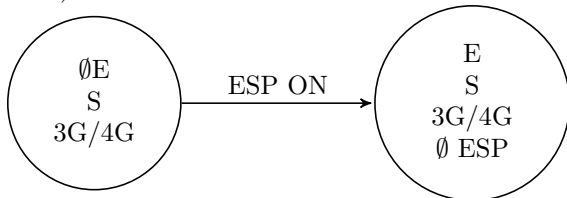


Description : 5-7 : Reaching an "ESP only with no connection" state by powering smartphone off.
 Management :

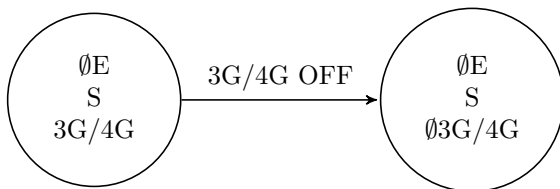


Description : 5-8 : Reaching a "ESP off & no connection" state. The ESP powered off.
 Management :

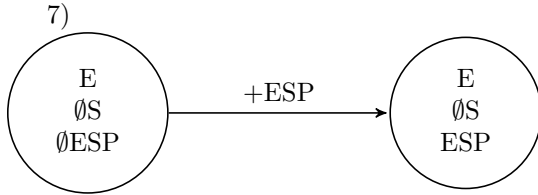
6)



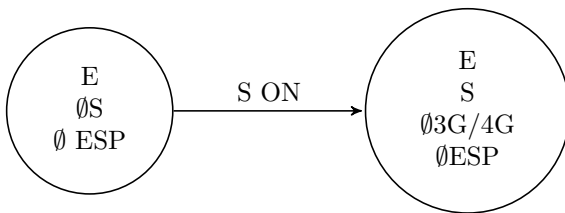
Description : 6-3 : Reaching a "Everything is on, only 3G/4G connected" state. The ESP powered on.
 Management : Immediately sync ESP & smartphone via BLE.



Description : 6-8 : Reaching a "no connection, ESP off" state by loosing 3G /4G connection.
 Management :



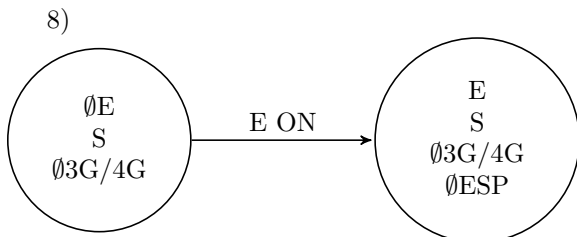
Description : 7-4 : Reaching an "ESP connected, no smartphone" state by getting a LoRa connection.
 Management : Update (add new / remove old) the reachable ESP list. Immediately request a LoRa broadcast to send position.



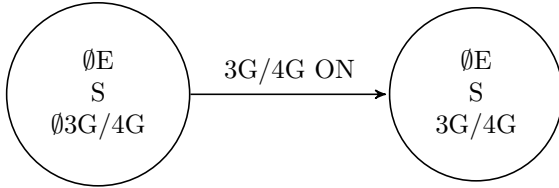
Description : 7-5 : Reaching an "Everything is on, no connection" state
 Management : Sync ESP & smartphone via BLE.



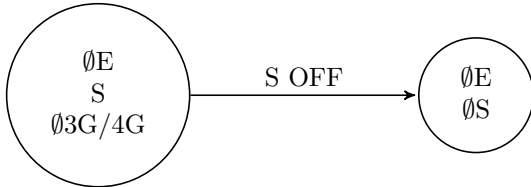
Description : 7-9 : Reaching the "worst" state. The ESP is turned off.
 Management :



Description : 8-5 : Reaching an "Everything is on, no connection" state.
 Management : Sync ESP & smartphone via BLE.



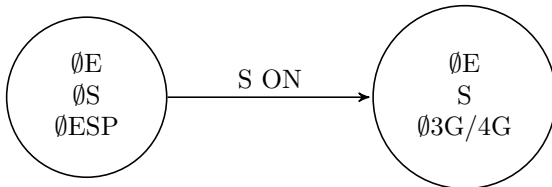
Description : 8-6 : Reaching a "smartphone on and connected" state by getting a 3G/4G connection.
 Management : Sync with server.



Description : 8-9 : Reaching the "everything off" state. The smartphone powered off
 Management :



Description : 9-7 : Reaching an "ESP on, no connection" state. The ESP powered on.
 Management :



Description : 9-8 : Reaching a "smartphone on, no connection" state. The smartphone get powered on.
 Management :

3 Miscellaneous notes

The user's smartphone is responsible for logging data and sending it via cellular network periodically. The ESP is only responsible for sending it via LoRa. Only the last geolocation is sent via LoRa (to save "LoRa bandwidth"), history is only uploaded via smartphone.

If ESP's memory gets full before it is flushed, then write over one every two entry (hence keeping all the path, just less precisely).

Use ESP flags : when the ESP can send data again, wait for a "LoRa broadcast request" (b/c state changed or there was big enough movement of the user) or a "LoRa timer elapsed" to actually send again.

Periodically, for all states :

- E & S : sync ESP and Smartphone via BLE (i.e. transfer logs to smartphone if there are and flush them)
- E : send broadcast to send position
- S : sync with server.

Effect on timers :

- If ESP is powered OFF (resp. ON), smartphone must sync with server more (resp. less) often