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RapidNet IP protocol based Electronic Shelf Label(ESL) Solution

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Motivation

- The motivation to develop protocol being develop a network capable of updating 12000 ESL node's display per hour with communication robustness.
- 2-way communication with update acknowledge
- Over the air programming
- Low power mode to ensure 7-year battery life with cr2450 x2
- Long Range
 - 500m with 2 hops and configuration setting dependent



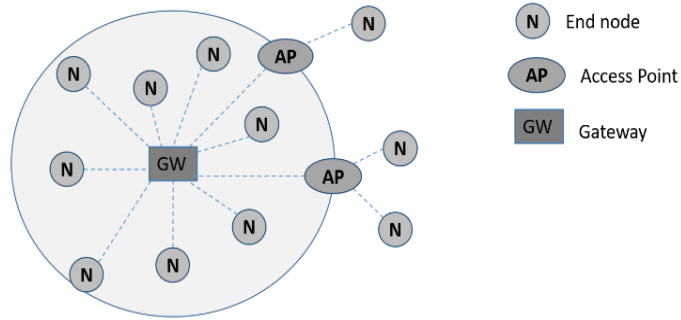
Motivation

- The main challenge for this protocol being considered is congestion control in a very large network and time synchronized communication between nodes and gateway.
- The currently available solution in the market with IR communications requires continuously powering of the nodes which will terminates 7-year battery life requirement. The other low power wireless protocol solutions are not capable of handling larger networks efficiently. Hence there was a requirement to develop a high throughput, low Power & long-range wireless networking solution.



RapidNet IP Protocol

RapidNet IP is a complete point-to-multipoint wireless networking solution operating in the sub-GHz frequency. The wireless protocol uses a time synchronized, star-repeater network topology.

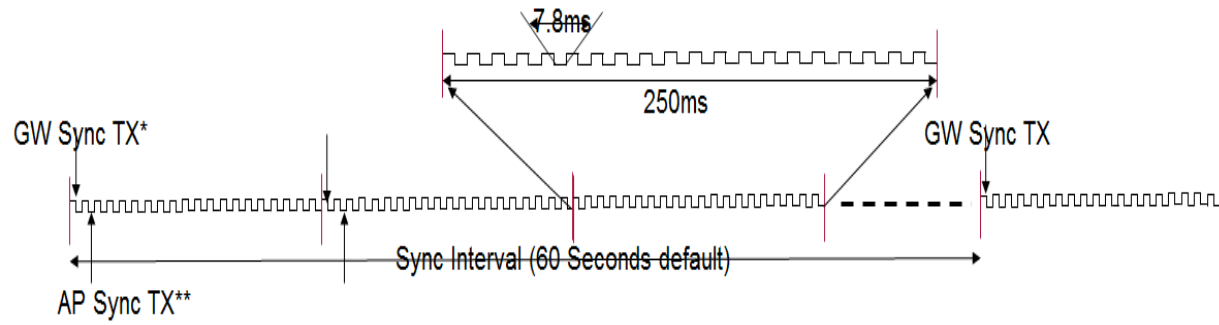


The RapidNet IP wireless network consists of 3 network components: gateway, access point and end node.

End nodes will be interface with ESL display device. The PNG image to be displayed on the ESL tag is sent from the gateway.

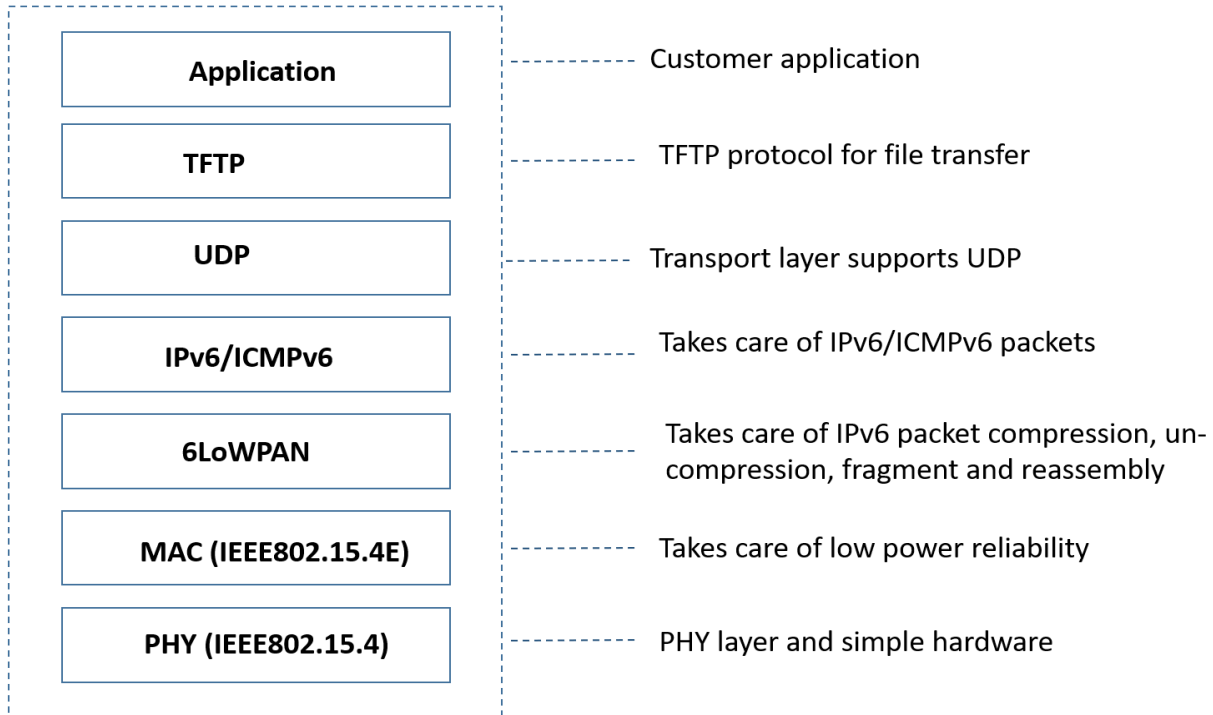


RapidNet IP synchronization



- Each slot is 7.8125ms and 32 slots will make one channel block(250ms).
- Channel hopping occurs every 250ms.
- Every slot interval (currently 15 sec), gateway/access point(AP) will send the send the sync message. The sync message between them is 16 slots(125ms) apart.
- Multiple AP's will send Sync messages on different channel offsets.
- Nodes will sync to the network on reception of sync message. Using this message nodes will adjust drift, get information for the next communication.
- Sync message also has the operating mode for next sync interval.

RapidNet IP stack



PNG file compression

Palette indexed color method

- The PNG file is decompressed to RGB values which has multiple color values.
- The RGB values are compressed as 3 color information, since only 3 colors are supported in the displays supported by the ESL.
- The three colors information stored in a separate piece of data is called a palette. These palettes correspond to the indexes of each color and thus provides prominent level of compression by storing the color information in the form of indexes

Sliding window of LZ77 compression optimization

In this method, by default the PNG compression sliding window is of 32768 bytes. But end node is a memory constrained device, it does not support 32KB of sliding window. Hence one level of optimization is provided at the gateway by reducing the sliding window to 1024 bytes.

PNG file decompression

Line by line Decoding Technique

- This approach works by reorientation of the PNG image thus achieved to reduce the RAM memory from 150kb to 10kb.
- Decompress only one line of PNG file at once this corresponds to the width bytes of the PNG file.
- Send the one line of decoded pixels to the display without storing it in the frame buffer. This process repeats for height number of times.

Sliding window of LZ77 decompression optimization

Sliding window set to 1024. This is possible because we are compressing the data at the gateway using the 1024 sliding window and the same can be decoded at the node.



Experimental Results

Network formation and image download period are tabulated for different network size.

Network Size	Network formation time in seconds	Image download period for 1KB in seconds
16 nodes	4	4.5
32 nodes	8.5	9
64 nodes	16.5	17
128 nodes	33	33.5
256 nodes	64	64.5



Conclusion

This paper presents a network which provides congestion free traffic for large number of nodes with enabling low power solution. The proposed design methodology is verified in a mote farm setup of 250 nodes which joins the network and update of the end node happens within the expected time.



References

- IEEE 802.15.4 standard
- RFC 6550. RPL: IPv6 Routing Protocol for Low-Power and Lossy Networks.
- RFC 1350. Trivial File Transfer Protocol (Revision 2)

