1. FAN PROTOCOL STACK OVERVIEW

Figure 1 describes the architecture of the FAN in accordance with the layered Open System Interface (OSI) reference model **Error! Reference source not found.**. The FAN specification is based on various Internet Engineering Task Force (IETF), Institute of Electrical and Electronic Engineers (IEEE) and American National Standards Institute / Telecommunications Industry Association (ANSI/TIA) specifications supporting ipv6 on low power and lossy networks [2]-[16].

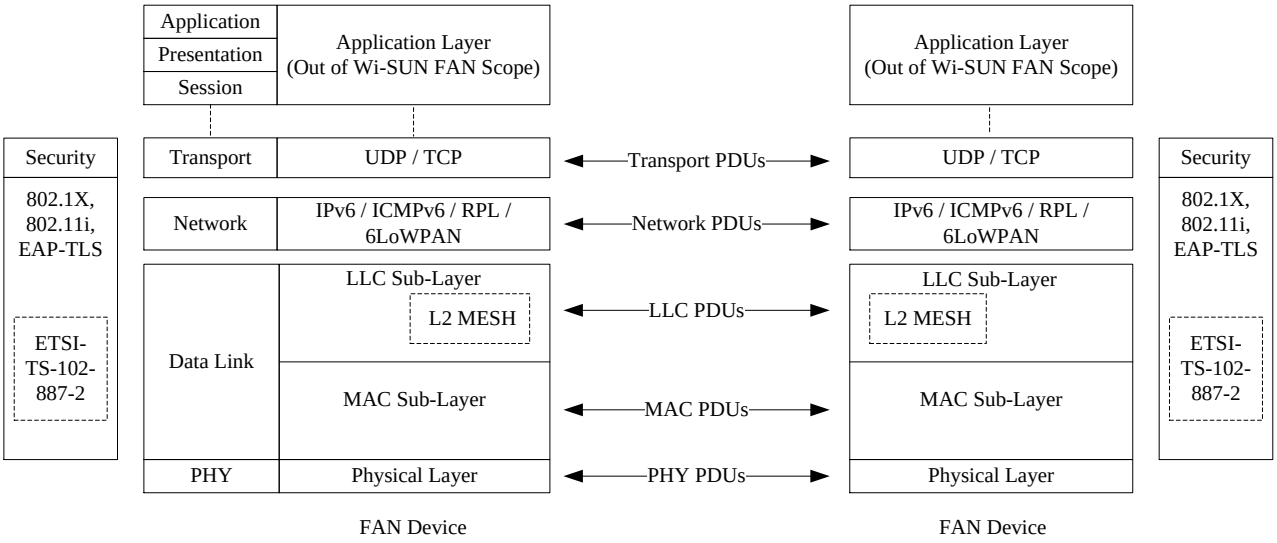

Figure 1 - FAN Communications Reference Model

The Transport Service supports User Datagram Protocol (UDP) [2] or optionally Transmission Control Protocol (TCP) [3].

The Network Service is provided by IPv6 [4] with 6LoWPAN adaptation [5], [6]. IPv6 packet routing is achieved using Routing Protocol for Low-Power and Lossy Networks (RPL) [7] at Layer 3. Additionally, Internet Control Message Protocol (ICMPv6) [9] is used for control plane information exchange.

The Data Link Service provides both control/management of the Physical layer and data transfer / management services to the Network layer. These services are divided into Media Access Control (MAC) and Logical Link Control (LLC) sub-layers. The LLC sub-layer provides a protocol dispatch service which supports 6LoWPAN and an optional MAC sub-layer mesh service using the Multi-Hop Delivery Specification (MHDS) [8] The MAC sub-layer is constructed using data structures defined in IEEE 802.15.4 [10]. Multiple modes of frequency hopping are defined. MAC payloads are encapsulated using IEEE802.15.9 [11] Information Elements to enable LLC protocol dispatch.

The PHY Service is derived from the Smart Utility Network (SUN) Frequency Shift Keying (FSK) specification in IEEE 802.15.4 [10]. The 2-FSK modulation schemes, with channel spacing range from 200 to 600 kHz, provide data rates from 50 to 300kbps, with optional Forward Error Coding (FEC).
The Security Service supports Data Link layer network access control, mutual authentication, and establishment of a secure pairwise link between network nodes and the corresponding border router. It

is implemented with IEEE802.1X [12] and EAP-TLS [13] using secure device identity as described in IEEE802.1AR [14]. Certificate formats are based upon RFC 5280 [15]. A secure group link between a Border Router and a set of FAN nodes is established using an adaptation of the IEEE802.11 four-way Handshake. A set of 4 group keys is maintained within the network, one of which is the current transmit key. Secure, node to node links are supported between one-hop FAN neighbors using ETSI-TS-102-887-2 [16]. FAN nodes implement Frame Security as specified in IEEE802.15.4 [10].

2. NETWORK TOPOLOGY

The Network-layer-routed FAN contains one or more sub-networks. Within each sub-network, nodes assume one of three operational roles:

1. A Border Router provides Wide Area Network connectivity to the sub-network. The Border Router maintains source routing tables for all nodes within its sub-network, provides node authentication and key management services, and disseminates information such as broadcast schedules.
2. Router nodes provide upward and downward packet forwarding. Routers also provides services for relaying security and address management protocols.
3. Leaf nodes provide minimum capabilities of discovering, joining a sub-network, and send/receive IPv6 packets.

3. REFERENCES

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