Wireless HART is a wireless sensor technology based on the Highway addressable remote transducer protocol. The Highway Addressable Remote Transducer (HART) Protocol was developed to be used with a range of smart measuring instruments and has been used in industry since the mid-1980s.

WH-compatible devices are low-rate, low-power, and fully compatible with previous HART-certified devices at the application layer. The physical layer is the same as IEEE 802.15.4 in the globally free licensed 2.4GHz radio frequency and data rate of 250 kbps by means of an O-QPSK modulation. Here a channel hopping technique has been used to avoid network jamming, and data transfer occurs between different channels.

Its channels are numbered from 11 to 26, with a 5MHz gap between two adjacent channels. In terms of efficiency according to HART communication foundations, a well-established WH network has a typically very high communication reliability is almost 99.73% which is comparable with the wired network. Highly secure, messages are encrypted and verified using the AES-128 algorithm.

Each Wireless HART network includes four main elements, field devices, gateway, network manager, and security manager. The data link layer is the 2nd layer from the bottom to the top of the OSI model, its vital job is to provide node-to-node delivery of data. The primary role of the DLL is to check whether the transmitted data from one node to another node on the data link layer is error-free or not because sometimes data get corrupted due to external interference like thunderstorms and lightning, electrical signals, etc. If the transmitted data has any error the DLL will not accept the message from the sender and resend the data. This layer is responsible for reliable and efficient communication between the devices. The data packet travel from the network layer to DLL these data packets are further broken into frames, and frame size is chosen based on the network interface card used in the system. DLL helps to manage the traffic control of the data on the network by stopping the transmitted signal when the frame buffer is full, for the transmission information DLL uses devices such as switches or bridges.

The DLL is further divided into two sublayers LLC and MAC sublayers, the DLL is the topmost layer of the data link layer, and it deals with the communication between the lower layer and upper layer. While the bottom layer of the data link layer is MAC it provides multiplexing and controls the flow of the transmission data.

The main function of the data link layer is to provide HOP to HOP delivery of data. Data framing, and encapsulation of data packets obtained from the network layer. The data link layer detects the error in the data and correction of the error data. The data losses can be controlled by the stop-and-wait and sliding windows mechanism.

The MAC layer in WirelessHART utilizes Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) and Time Division Multiple Access (TDMA) methods. CSMA/CA ensures fair access to the wireless channel by checking for ongoing transmissions and deferring transmission if the channel is busy. TDMA allocates specific time slots to different devices for data transmission, maximizing throughput and minimizing collisions.

WirelessHART employs a superframe structure, dividing time into active and inactive periods. During the active period, devices transmit data or request synchronization, while the inactive period conserves energy and facilitates coordination activities. Synchronization is achieved through beacon signals transmitted by the network coordinator, ensuring coordinated access to the wireless medium.

Priority scheduling is implemented in the MAC layer, giving higher priority to critical or time-sensitive applications. Devices with higher priority are allocated more time slots or priority access to the medium, ensuring prompt and reliable transmission of important data.

Energy management mechanisms in the MAC layer optimize battery life for battery powered WirelessHART devices. Devices can enter sleep modes during inactive periods, conserving energy. Channel hopping is employed to mitigate interference and improve reliability by switching between multiple channels in a coordinated manner.

The MAC layer in WirelessHART supports various network topologies, such as star, mesh, and hybrid topologies. It facilitates the formation and maintenance of these topologies through network coordination, routing, and addressing mechanisms.

The application of the WirelessHART Data Link Layer and MAC extends to a wide range of industrial sectors. It is utilized in industrial process control systems, environmental monitoring, asset management, building automation, safety and security systems, water and wastewater management, pharmaceutical and biotechnology industries, as well as mining and oil exploration operations. The Data Link Layer and MAC ensure efficient and secure transmission of data, enabling real-time monitoring, predictive maintenance, and enhanced productivity in these sectors.

In conclusion, the MAC layer and Data Link Layer of WirelessHART provide the necessary framework for efficient and reliable wireless communication in industrial environments. Its utilization of CSMA/CA, TDMA, superframe structure, synchronization, priority scheduling, energy management, channel hopping, and support for various network topologies make it a preferred choice for process automation and control in diverse industries.

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