MDLC - COMMUNICATION PROTOCOL OVERVIEW

1. MDLC - MOTOROLA DATA LINK COMMUNICATION PROTOCOL

The MOSCAD family facilitates establishment of a highly sophisticated hybrid data communication network for SCADA utilizing a variety of radio and/or line communications links. Radio links can include conventional radio (VHF and UHF), Direct FM radio, trunked radio and microwave links (both analog and digital). Line links can include private or leased lines, Public Service Telephone Networks (PSTN) voice links via dial-up modems, and Local Area Networks (LANs).

The MDLC protocol is optimized for operation in point-to-multipoint communications networks, such as radio networks or multidrop links, rather than point-to-point communications networks. The protocol facilitates communications between all sites in the system, including an extensive diagnostic traffic.

High data transmission rates (up to 9600 bps) combined with the optimized MDLC protocol ensure high network throughput even if the network is spread over a large geographical area.

The most important of the advanced and unique MDLC protocol features are given in Table 1.

Table 1: MDLC features

Feature	Description
Data Integrity	Sophisticated recovery procedures built into various network layers to ensure a high degree of end-to-end data transmission safety
Access Control	A comprehensive multi-level password scheme results in high level of data privacy
Data Upload and Download	Each RTU can be downloaded from the center with application and configuration software to ensure minimal commissioning time and to ease database update and re-configuration procedures. Locally configured RTU database can be easily uploaded to update the MCC or the SCC
Store-and-Forward and Network Nodes	Each RTU can become an intelligent tandem processing node to provide optimum use of the existing communications network

The MDLC protocol is designed for optimal operation in SCADA systems which operate with diverse communications media such as radio, wire-line, LAN, etc. .
In order to achieve reliable and efficient communications over such a variety of links, the MDLC is designed as a highly sophisticated communications protocol, based on the Open Systems Interconnection (OSI) seven layer model as defined by International Standards Organization (ISO). The MDLC protocol comprises all seven recommended layers and is optimized for SCADA applications. The seven layers of the protocol and their functions are summarized in Table 2.

Table 2: MDLC - Seven Layers Summary

Layer	Function
Layer 1: Physical	The *physical layer* caters for communications over conventional radio, trunked radio, data radio, serial channels, modems or telephone lines. Since radio communication uses a shared channel, the radio physical layer is responsible for the channel access and collision control.
Layer 2: Link	The *link layer* ensures proper communications over a physical link. To this end the link layer arranges the data in variable-length frames and attaches addresses, frame sequence numbers, and Cyclic Redundancy Code (CRC) to the frames.
Layer 3: Network	The *network layer* is responsible for the establishment of end-to-end communication path in a network. This is necessary since communications can take place via more than one link and a message can travel via several transit nodes (repeaters, store-and-forward RTUs) until it reaches its final destination.
Layer 4: Transport	The *transport layer* ensures end-to-end integrity of the information flow between two nodes in the network. This is achieved by means of remote end acknowledgment that data has been received completely and transmitted in the correct order to the upper layer.
Layer 5: Session	The *session layer* allows the definition of any number of entities capable of conducting simultaneous sessions with a parallel entity in a remote unit. This enables transparent communications between multiprocessing machines without interference between the applications.
Layer 6: Presentation	The *presentation layer* structures the information received from or sent to various applications. This layer also performs format conversion.
Layer 7: Application	The *application layer* performs the task of interfacing to the various applications such as data transfer, configuration downloading, application software monitoring, remote diagnostics, etc.

The importance of the MDLC protocol for the user is that MDLC is a transparent protocol which liberates the user from technical constraints and complexities of the network operation and allows him to concentrate on the application. This fundamental division between the network and the application usually occurs at the Network Layer. The functionality provided by the three lower layers is known as the Network Service.

The Network Service layers (1-3) are those communicating with the intermediary sites (relay systems) while the upper layers are not involved in the network function and are communicating directly, each layer with its corresponding layer in what is called Peer-to-Peer Protocols.

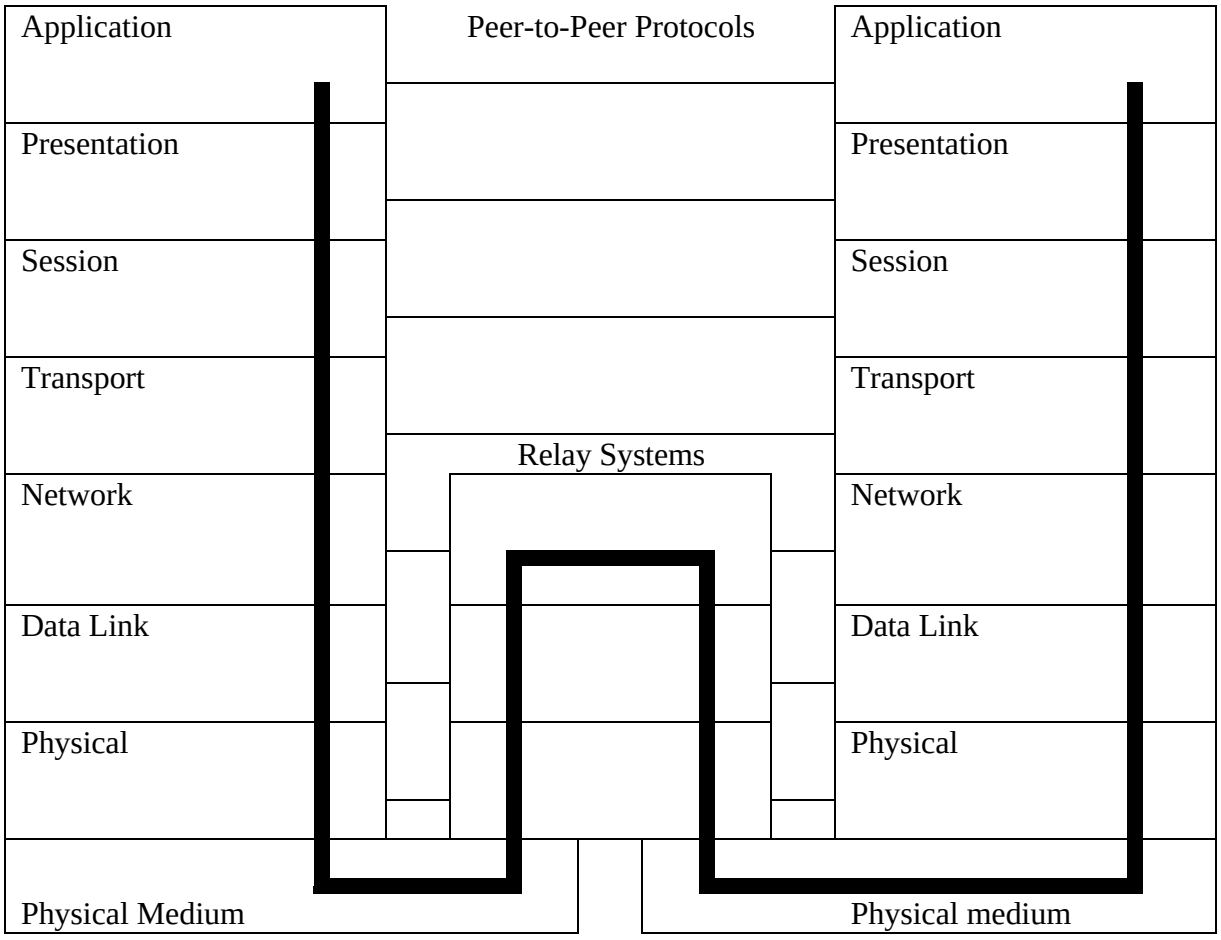

Figure 1: MDLC Layers - Overview

The MDLC protocol is among the most advanced, allowing communication with up to 65,000 RTUs using a flexible-length word structure adapted to the quantity of information in a single transmission.

Every transmission is automatically accompanied by an ACK message, ensuring message integrity. The protocol also provides a sophisticated repetition mechanism to ensure complete data reception.

2. MDLC - STRUCTURE OF COMMUNICATIONS SOFTWARE

An overview of the detailed functions performed in each layer is given in Table 3.

Table 3: MDLC Seven Layers - Detailed Functions

Function	Layer
1. Bidirectional data transfer 2. Configuration of modules, ports & network 3. User process application downloading & monitoring 4. Events and short messages handling 5. Broadcasting 6. Remote diagnostics of hardware & software 7. Retrieval of error messages from site logs 8. Calibration of I/Os in A/D and D/A modules 9. Communication analysis and statistical data accumulation	Application Layer
1. Structure Rx/Tx 2. Format conversion	Presentation Layer
1. Session control and sync 2. Message control & error handling 3. Single frame messages	Session Layer
1. End-to-end completeness 2. Frame sequencing, checking and acknowledgement 3. Multiplexing logical channels	Transport Layer
1. Data routing between links 2. Store & Forward to same link 3. Communication fail handling and rerouting	Network Layer
1. Frame sequencing, checking and acknowledgement 2. From/to addressing 3. Broadcasting 4. Channel access priorities	Multi-link Layer
CRC	
1. Bit level encoding & decoding 2. Data and flags (frame sync) 3. FSK, MSK, DPSK , Direct FM modulation 4. Channel access: conventional radio, trunked radio, data radio, microwave, wire-line, dial-up modem, RS-232, RS-485, LAN etc.	Physical Layer

3. MDLC - LINK, NETWORK, TRANSPORT AND SESSION LAYERS.

- Transmitted data is packed in frames (packets) with a special bit pattern at the beginning and the end of each frame.

  * The receiver rejects data frames without these frame-sync patterns.
  * Frame length is adjusted for maximum throughput in radio communications.
  * Each frame has a sequence number.

- Each received frame is acknowledged using a special ACK frame.

  * Missing frames or frames received with errors are retransmitted.
  * Only the missing frames are retransmitted.

- Each frame contains a CRC with a Hamming distance > 4 (using BCH cyclic code plus overall parity).

  * The receiver rejects words that don't pass the CRC-check and asks for retransmission.

- Each frame contains the site address for maximum security in radio communications.

  * Up to 65,000 different addresses per channel.
  * The receiver rejects frames with incorrect site address.

- Up to four simultaneous independent sessions per channel from one site.

  * Center-to-RTU data transfer
  * RTU event reporting by contention
  * RTU-to-RTU communication
  * Broadcast (set-call)

- SCADA oriented protocol.

  * No limits on data size, format or structure.
  * Other protocols can also be supported - consult factory.

4. MDLC - PRESENTATION LAYER.

- The center transmits a "spec" to the RTU describing the transaction that is about to take place.

- As a response to the "spec", a bi-directional data transaction takes place.

- If the "spec" includes qualification formula(s), special directives are added to the data stream to indicate which row "passed" the qualification filter.

- Data capacity:

Up to 65,000 sites
Up to 127 tables per site
Up to 250 subtables per site
Up to 250 sub-subtables per site
Up to 250 rows per (sub)table
Up to 8 fields (columns) per row

NOTE: Each variable in the tables may be of any one of the following sizes: bit, byte or any byte multiple.