Network Protocols

- Understand what network protocol is
- Understand Proprietary/Open/Standard Protocols
- Understand the OSI Model

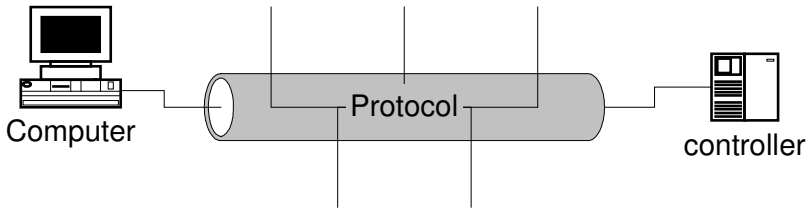
Reference:

•http://www.cisco.com/univercd/cc/td/doc/cisintwk/ito_doc/introint.htm#xtocid5

•http://www.inetdaemon.com/tutorials/theory/osi/index.html

Network Protocol Definition

Protocol is a set of rules which allows computers/controllers/devices to communicate from one to another



The key elements of a protocol define:

•Format of the data

•Information necessary for data conversion between machines

•Timing to define the data transmission speed and sequence

Three groups of protocols:

•Proprietary (e.g., N1 and N2)

•Open (e.g., LonWorks, BACnet and EIB)

•Standard (e.g., OSI)

Proprietary Protocols

- Developed by systems or computer manufacturer(s) to communicate to their OWN (proprietary) hardware and software over a recommended network

•Specifically designed and thoroughly tested for vendor-specific system(s) and for specific networks

•Not published such that other systems or computers cannot coexist on the same network

•Proprietary nature of systems assures systems reliability and integrity

•Precludes the end user from utilizing other vendor's off-the-shelf controllers or systems on the same network

•Competitively priced, well-supported

Open Protocols

- Opening up protocols means disclosing procedures, structures, and codes and allowing other system developers to write interfaces and share data on their network
- Acceptance of an open protocol depends on its quality, features, and services provided

If an open protocol widely used by systems designers and system integrators, it will become so-called de facto or industry standard protocols

De facto Standard Protocols

- Advantages:
  - Promising performance
  - Successfully tested in many applications
  - Refined by many improvements over time
  - Multi-vendors can co-exist on a single network easily
- Disadvantage:
  - Careful selection from many vendors is required, particularly for the customer lacking familiarity with the offerings

Proprietary, open, and industry protocols represent a “grass roots” movement, a development initiated by the computer, controls, and automation industry. The latter two also represent the desire of the end users for systems integration.

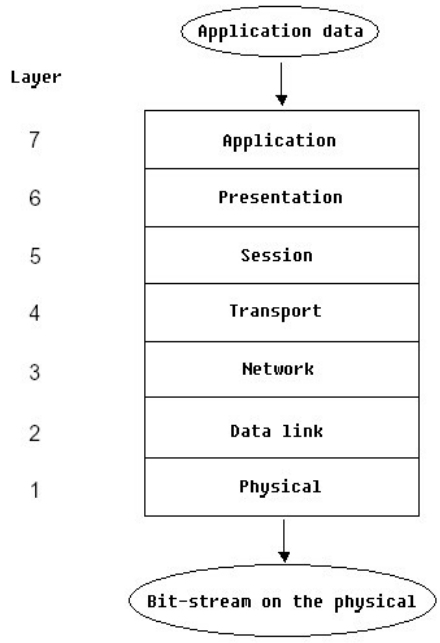
Standard Protocols

- It's very difficult to unify or define a "standard protocol" for all applications
- International Standards Organization (ISO) published a model for open systems interconnections (OSI)

The OSI model defines activities related to communication protocols in seven layers

The OSI Model

- Each layer has a defined set of functions
- The model provides a useful common reference to communication protocol
- Most communication protocols including those used in our field today use either all or some of the seven layers of the OSI model



- **A**ll-**P**eople-**S**eem-**T**o-**N**eed-**D**ata-**P**rocessing

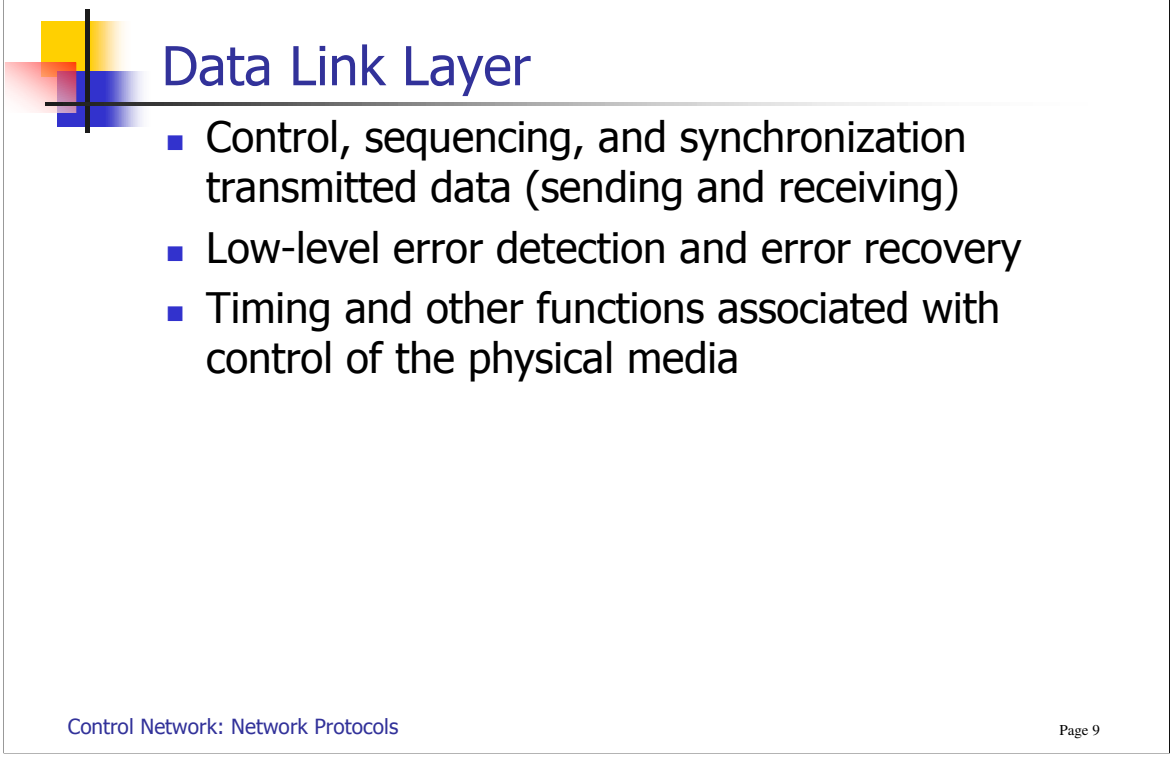
- **Basic concepts:**
  1. Network-capable Applications produce DATA.
  2. Each protocol layer adds a header to the data it receives from the layer above it. This is called ***encapsulation***. Encapsulated data is transmitted in Protocol Data Units (PDUs). There are Presentation PDU's, Session PDU's, Transport PDU's etc.
  3. PDU's are passed down through the stack of layers (called ***the stack*** for short) until they can be transmitted over the Physical layer.
  4. Any layer on one machine speaks the same language as the same layer on any other machine, and therefore can communicate via the Physical layer.
  5. Data passed upwards is unencapsulated before being passed farther up.
  6. All information is passed down through all layers until it reaches the Physical layer.
  7. The Physical layer chops up the PDU's and transmits the PDU's over the wire. The Physical layer provides the real physical connectivity between machines over which all communication occurs.

- Data from one layer is supposed to be passed down into the layer below it. In the 'real world', the process of encapsulation (adding a header) doesn't always occur at all layers.

Physical Layer

- Specify the communication path and physical media of the network
  - The actual transmission media (e.g., TP, coax, fiber, RF, etc.)
  - The electrical signal levels and drive capacity
  - The characteristics of the media (e.g., length, speed, bandwidth)
- The most widely used standards in the automation industry are the IEEE802 standards, and RS232/RS485 standards for serial communications

- The Physical layer provides for physical connectivity between networked devices. Transmission and receipt of data from the physical medium is managed at this layer.
- The Physical layer receives data from the Data Link Layer, and transmits it to the wire. The Physical layer controls frequency, amplitude, phase and modulation of the signal used for transmitting data, and performs demodulation and decoding upon receipt.
- Note that for two devices to communicate, they must be connected to the same type of physical medium (wiring). Ether to Ether, FDDI to FDDI etc. Two end stations using different protocols can only communicate through a multi-protocol bridge or a router.
- The physical layer is responsible for two jobs:
  1. Communication with the Data link layer.
  2. Transmission and reciept of data.



- The Datalink Layer is the second layer of the OSI model. The datalink layer performs various functions depending upon the hardware protocol used, but has four primary functions:
    1. COMMUNICATION with the Network layer above.
    2. SEGMENTATION of upper layer datagrams (also called packets) into frames in sizes that can be handled by the communications hardware.
    3. BIT ORDERING. Organizing the pattern of data bits before transmission (packet formatting)
    4. COMMUNICATION with the Physical layer below.

- This layer provides reliable transit of data across a physical link. The datalink layer is concerned with physical addressing, network topology, physical link management, error notification, ordered delivery of frames, and flow control.

Data Link Sublayers

- The Institute of Electrical and Electronics Engineers (IEEE) has subdivided the data link layer into two sublayers: Logical Link Control (LLC) and Media Access Control (MAC)
- This layer also determines which methods of communications control (master-slave, peer-to-peer, hybrid) are used on the network, provides error handling, and provides control of communication (data) flow

•LLC is implemented in the software, whereas MAC is is usually implemented in the hardware

•MAC hardware provides bit handling such as encoding, error detection and recovery, address detection and recognition, and functions associated with electrical signal levels and drive capability

Network Layer

- Establish and terminate connections between the originator and recipient of information over the network
- Assign unique addresses to each node (e.g., computer) on the network
- The addresses identify the beginning and end of the data transmission packets

•Outbound data is passed down from the Transport layer, is encapsulated in the Network layer's protocol and then sent to the Datalink layer for segmentation and transmission.

•Inbound data is de-fragmented in the correct order, the IP headers are removed and then the assembled datagram is passed to the Transport layer.

•The Network layer is concerned with the following primary functions:

1. Communication with the Transport layer above.
2. Management of connectivity and routing between hosts or networks.
3. Communication with the Datalink layer below.

Transport Layer

- Maintain reliability on the network and enhances data integrity by delivering error-free data in the proper sequence

- It is the transport layer's responsibility to see to the detection of errors, and retransmission of data to recover those errors or lost data.
- The Transport layer may use a variety of techniques such as a Cyclic Redundancy Check, windowing and acknowledgements.
- If data is lost or damaged it is the Transport layer's responsibility to recover from that error.
- Functions:
    1. Communicate with the Session layer above.
    2. Detect errors and lost data, retransmit data, reassemble datagrams into datastreams
    3. Communicate with the Network layer below.

Session Layer

- Establishes, manages, and terminates communication connections , also called ‘sessions’
- Provide prioritization (high, normal)
- Provide additional software error recovery of data

- The session layer tracks connections, also called 'sessions’.
- For example: keep track of multiple file downloads requested by a particular FTP application, or multiple telnet connections from a single terminal client, or web page retrievals from a Web server.
- In the World of TCP/IP this is handled by application software addressing a connection to a remote machine and using a different local port number for each connection.
- The session performs the following functions:
    1. Communication with the Presentation layer above.
    2. Organize and manage one or more connections per application, between hosts.
    3. Communication with the Transport layer below.

Presentation Layer

- Receiving, unpacking, decoding, and translating data into formats and codes that can be easily utilized by the application program, or vice versa

- The Presentation layer handles the conversion of data formats so that machines can 'present' data created on other systems.
- For example: handle the conversion of data in JPG/JPEG format to Sun Raster format so that a Sun machine can display a JPG/JPEG image.
- The Presentation layer performs the following functions:
    1. Communication with the Application layer above.
    2. Translation of standard data formats to formats understood by the local machine.
    3. Communication with the Session layer below.

Application Layer

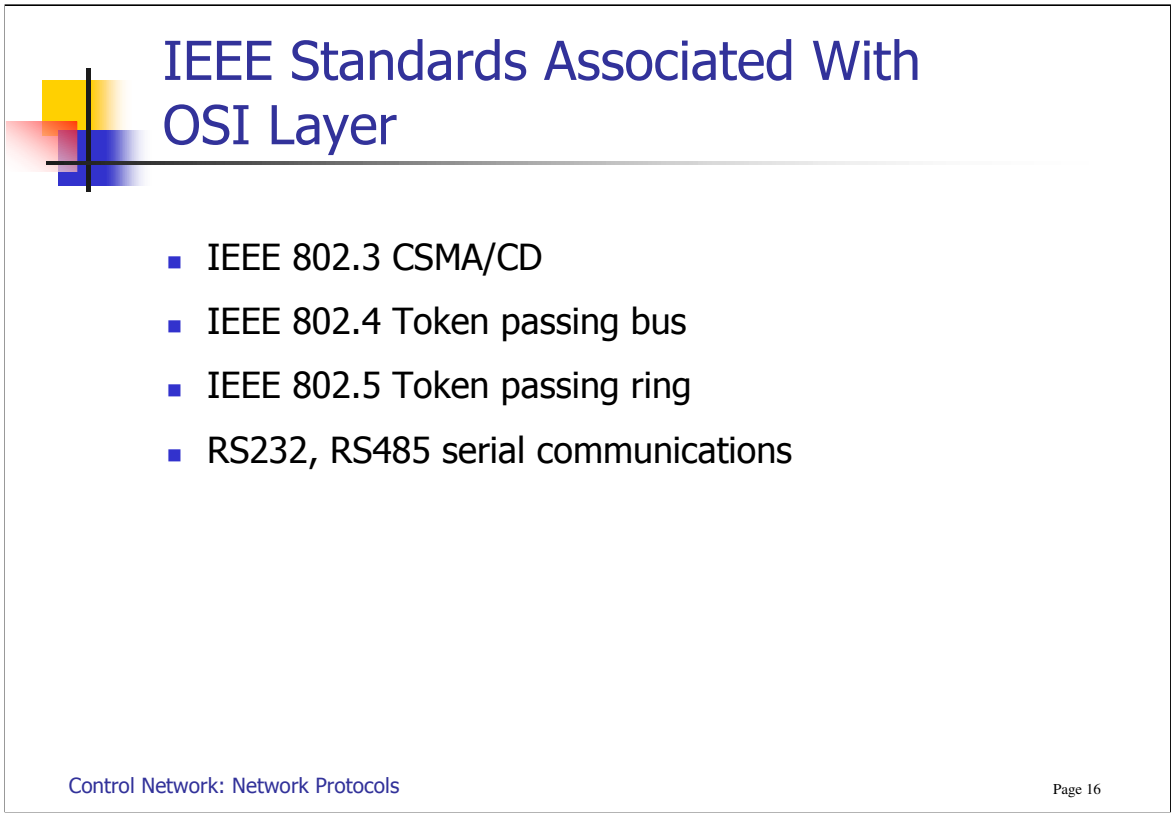
- Some examples of application layer implementations include Telnet, File Transfer Protocol (FTP), and Simple Mail Transfer Protocol (SMTP)

•The application layer is the application in use by the user.

•For example: a web browser, an FTP, IRC, Telnet client other TCP/IP based application like the network version of Doom, Quake, or Unreal.

•The Application layer provides the user interface, and is responsible for displaying data and images to the user in a recognizable format.

•The application layers job is to organize and display data in a human compatible format, and to interface with the Presentation layer.



Standards associated with layers of the OSI model:

Application:	ISO8650 Common Application Service Elements
	ISO9041 Virtual Terminal
Presentation:	ISO8823 Connection-oriented Presentation Protocol Specification
	ISO8825 Basic Encoding Rules for ASN.1
Session:	ISO8327 Connection-oriented Session Protocol Specification
Transport:	ISO8073 Connection-oriented Transport Protocol Specification
	ISO8602 Protocol for Providing Connectionless Transport Service
Network:	ISO8373 Protocol for Providing Connectionless Network Serivece
	Transmission Control Protocol
Data Link:	IEEE 802.2 Logical Link Control
	IEEE 802.3 CSMA/CD
	IEEE 802.4 Token passing bus
	IEEE 802.5 Token passing ring
Physical:	RS232, RS485 serial communications