

Analysis of the OSI Model *vs.* TCP/IP Model and use-case of ANSI C12.22 / IEEE Std 1703™ over IP implementation

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ANSI C12.22-2012 / IEEE Std 1703-2012 over IP Editorial

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Avygdor Moise, Ph.D. – Future DOS R&D Inc.

Richard D. Tucker P.Eng. – Tucker Engineering Associates

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Introduction

- This presentation compares and contrasts the two main reference models that use the concept of protocol layering...
 - Open System Interconnection Model (OSI)
 - Transport Control Protocol /Internet Protocol (TCP/IP)
- And it explains how C12.22-2012 fits on top of OSI transport layer (4) or the TCP/IP transport layer in accordance with IETF RFC 6142

The “protocol stacks”

- The topics that we will be discussing are based on two protocol stacks, as shown in on the diagram below...

OSI	TCP / IP
Application (Layer7)	Application
Presentation (Layer6)	
Session (Layer 5)	
Transport (Layer 4)	Transport
Network (Layer 3)	Internet
Data Link (Layer 2)	Subnet
Physical (Layer 1)	

The ANSI C12.22-2012 Over IP Stack

- The ANSI C12.22-2012 Standard and equivalently IEEE Std 1703-2012 or MC12.22-2013 are based on the OSI reduced-stack reference model
- ANSI C12.22-2012 does not define OSI Network Layers 4-1*, nor does it define the TCP/IP transport, internet and subnet layers

OSI / C12.22– Reduced Stack	C12.22 over TCP / IP
Application (Layer 7) C12.22-2012 Tables (data)+EPSEM (service) ACSE (Association)	Application C12.22-2012 Tables (data)+EPSEM (service) ACSE (Association)
Null Transport (Layer 4)*	Transport
Null Network (Layer 3)*	Internet
Null Data Link (Layer 2)*	Subnet
Null Physical (Layer 1)*	

* However it does prescribe Local Port Layers 4-1 for ANSI Type 2 Optical Ports and Communication Module dedicated interfaces (see next slide).

C12.22 Communication Modules (note 1)

- The ANSI C12.22-2012 Standard also provides a full stack definition for a physical interface to an ANSI C12.22 Communication Module
- The ANSI C12.22-2012 Communication Module is a variation on the implementation, where there is a need to physically separate the service elements of a C12.19 Device (e.g. a meteorological or relay function) into two parts: The C12.22 Device (provides C12.22 service) and the C12.22 Communication Module (provides connectivity and an interface to any network)

C12.22 Device Side	Native (any Net) LAN Side
Optional Application (Layer7) C12.22-2012 Tables (data)+EPSEM (service) ACSE (Association)	Undefined Application (Layer7)
	Undefined Presentation (Layer6)
	Undefined Session (Layer 5)
Transport (Layer 4)	Undefined Transport (Layer 4)
Null Network (Layer 3)	Undefined Network (Layer 3)
Data Link (Layer 2)	Undefined Data Link (Layer 2)
Physical (Layer 1)	Undefined Physical (Layer 1)

C12.22 Communication Modules (note 2)

- The ANSI C12.22-2012 Standard also provides a full stack definition for a physical interface to an ANSI Type 2 Local Optical Port.
- The ANSI C12.22-2012 ANSI Type 2 Local Optical Port is a backward compatible variation on the implementation of an Optical Port per ANSI C12.18-2006 / IEEE Std 1701-2011 / MC12.18-2013, where there is a need to locally and physically communicate with C12.19 Device (e.g. a meteorological or relay function) using the C12.22 protocol stack.

C12.22 Optical Port Stack

Application (Layer 7)
C12.22-2012
Tables (data)+EPSEM (service)
ACSE (Association)

Null Transport (Layer 4)

Null Network (Layer 3)

Data Link (Layer 2)

Physical (Layer 1)

The Confusion in the Industry

- ANSI C12.22-2012 actually defines three ISO reduced stacks
 1. Common C12.22-2012 Application Services (Layers 7-5) that can interface to any transport layer (any network e.g. TCP/IP or UDP/IP)
 2. A C12.18-2006 compatible stack (Layers 7-1) than can interface to a local ANSI Type 2 optical port
 3. A C12.22-Device to C12.22 Communication Module (Layers 7-1) that is used strictly when there is a requirement to physically separate the communicating application services from the specifi network, i.e. The C12.22 Device (metrology unit or relay unit) and the C12.22 Communication Module (LAN interface)
- The role of the C12.22 Communication Module is to act as a gateway to the native LAN that service its C12.22 Device application
- The interface specification of the LAN side **is not** defined by the ANSI C12.22-2012 Standard
- Thus, implementers can supply C12.22 Communication Modules to interface their solutions to the application side of any ANSI C12.22 meter for the sake of independence of the physical network and interoperability
- The industry may also be confused by the special C12.22 Communication Module specification option (Layers 7-1) with the broader general purpose ANSI C12.22 Network Application that uses only layers 7-5, which is the relevant choice for ANSI C12.22 over IP whose layers 1-4 are prescribed by IETD RFC 6142

The ANSI C12.22 Reduced Stacks

C12.22 Local Port

C12.22 Device

External C12.22 Comm. Module

7-5

Application Layer
ANSI C12.19 Tables (data) + EPSEM (services) + ACSE (wrapper)

Segmentation Sub-layer (scatter/gather)

4 Transport Layer

2 Data-link Layer

1 Physical Layer
ANSI Type 2

4 Transport Layer

2 Data-link Layer

1 Physical Layer
Point-to-point

C12.22 Node

Any network
(e.g. TCP/IP or UDP/IP
transport layer)

4 Transport Layer

2 Data-link Layer

1 Physical Layer
Point-to-point

C12.22 Comm. Module Interface or
IEEE P1704 Interface (new 2015)

The Upper Layers

OSI	TCP / IP
Application (Layer7)	Application
Presentation (Layer6)	
Session (Layer 5)	

The Session (Layer 5)

The Session layer permits two parties to hold ongoing communications called a session across a network.

- Not found in TCP/IP model
- In TCP/IP, its characteristics are provided by the TCP protocol.
(Transport Layer)

The Presentation (Layer 6)

The Presentation Layer handles data format information for networked communications. This is done by converting data into a generic format that could be understood by both sides.

- Not found in TCP/IP model
- In TCP/IP, this function is provided by the Application Layer.

e.g. External Data Representation Standard (XDR)
Multipurpose Internet Mail Extensions (MIME)
Connectionless-mode Association Control Service Element (ACSE)

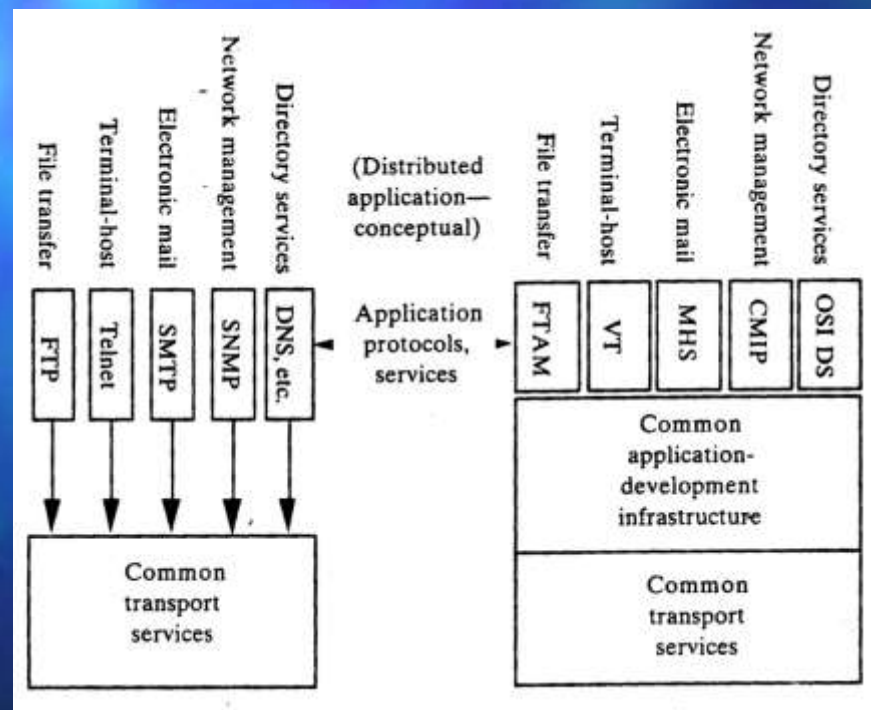
The Application (Layer 7)

The Application Layer is the top layer of the reference model. It provides a set of interfaces for applications to obtain access to networked services as well as access to the kinds of network services that support applications directly

- OSI - FTAM,VT,MHS,DS,CMIP,ANSI C12.22
- TCP/IP - FTP,SMTP,TELNET,DNS,SNMP,
 C1222-ACSE
- UDP/IP - DNS,SNMP,DHCP,C1222-ACSE
- Although the notion of an application process is common to both, their approaches to constructing application entities is different.

Approaches use in constructing application entities

- The diagram below provides an overall view on the methods use by both the OSI and TCP/IP model.



ISO Approach

- Sometime called Horizontal Approach
- OSI asserts that distributed applications operate over a strict hierarchy of layers and are constructed from a common tool kit of standardized application service elements.
- In OSI, each distributed application service selects functions from a large common “toolbox” of application service element (ASEs) and complements these with application service elements (e.g. ACSE) that perform functions specific to given end-user service (e.g. EPSEM).

TCP/IP Approach

- Sometime called Vertical Approach
- In TCP/IP (and in UDP/IP), each application entity is composed of whatever set of function it needs beyond end to end transport to support a distributed communications service.
- Most of these application processes build on what they need and assumes only that an underlying transport mechanism (datagram or connection) will be provided.

Transport Layer

OSI	TCP (or UDP) / IP
Transport (Layer 4)	Transport (TCP or UDP)

- The functionality of the transport layer is to provide “transparent transfer of data from a source end open system to a destination end open system” (ISO / IEC 7498: 1994).
- ANSI C12.22 does not provide Transport Layer for non C12.22 Communication Module based implementations
- TCP/IP provides a reliable Transport
- UDP/IP provides an un-reliable Transport

Transport Layer

- Transport is responsible for creating and maintaining the basic end-to-end connection between communicating open systems, ensuring that the bits delivered to the receiver are the same as the bits transmitted by the sender; in the same order and without modification, loss or duplication
- ANSI C12.22 does not provide Transport Layer for non-comm-module implementations

OSI Transport Layer

- It takes the information to be sent and breaks it into individual packets that are sent and reassembled into a complete message by the Transport Layer at the receiving node
- Also provide a signaling service for the remote node so that the sending node is notified when its data is received successfully by the receiving node
- ANSI C12.22 does not provide Transport Layer for non-comm-module implementations

OSI Transport Layer

- Transport Layer protocols include the capability to acknowledge the receipt of a packet; if no acknowledgement is received, the Transport Layer protocol can retransmit the packet or time-out the connection and signal an error
- ANSI C12.22 does not provide Transport Layer for non-comm-module implementations

OSI Transport Layer

- Transport protocols can also mark packets with sequencing information so that the destination system can properly order the packets if they're received out-of-sequence
- In addition, Transport protocols provide facilities for insuring the integrity of packets and requesting retransmission should the packet become garbled when routed
- ANSI C12.22 does not provide Transport Layer for non-comm-module implementations

OSI Transport Layer

- Transport protocols provide the capability for multiple application processes to access the network by using individual local addresses to determine the destination process for each data stream
- ANSI C12.22 does not provide Transport Layer for non-comm-module implementations
- ANSI C12.22 does not provide network addresses
- ANSI C12.22 (Application layer) provides Application Titles (ApTitles) and Application Invocation IDs that can be linked with the application process and host of the associated data stream

TCP/IP Transport Layer

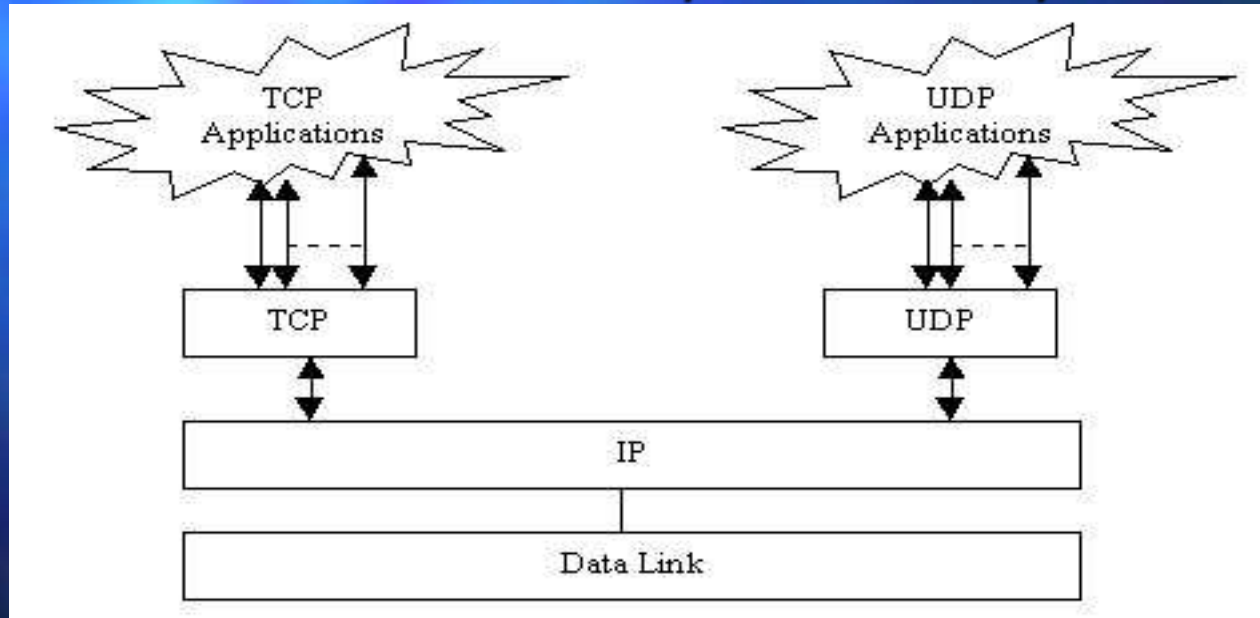
- Defines two standard transport protocols: TCP and UDP
- TCP implements a reliable data-stream protocol
 - connection oriented
- UDP implements an unreliable data-stream
 - connectionless
- ANSI C12.22 provides hints to network manager about its preference for connection-mode or connectionless-mode operations via the application layer registration service
- The registration service can be delivered interchangeably via either TCP or UDP on port 1153
- The governing ANSI C12.22 IP-based transport protocol is defined by IETF RFC 6142

TCP/IP Transport Layer

- TCP provides reliable data transmission
- UDP is useful in many applications
 - e.g. Where data needs to be broadcast or multicast
- Primary difference is that UDP does not necessarily provide reliable data transmission (however, ANSI C12.22 can provide reliability if needed)

TCP/IP Transport Layer

- Many programs will use a separate TCP connection as well as a UDP connection
- ANSI C12.22 uses TCP/IP or UDP/IP or both

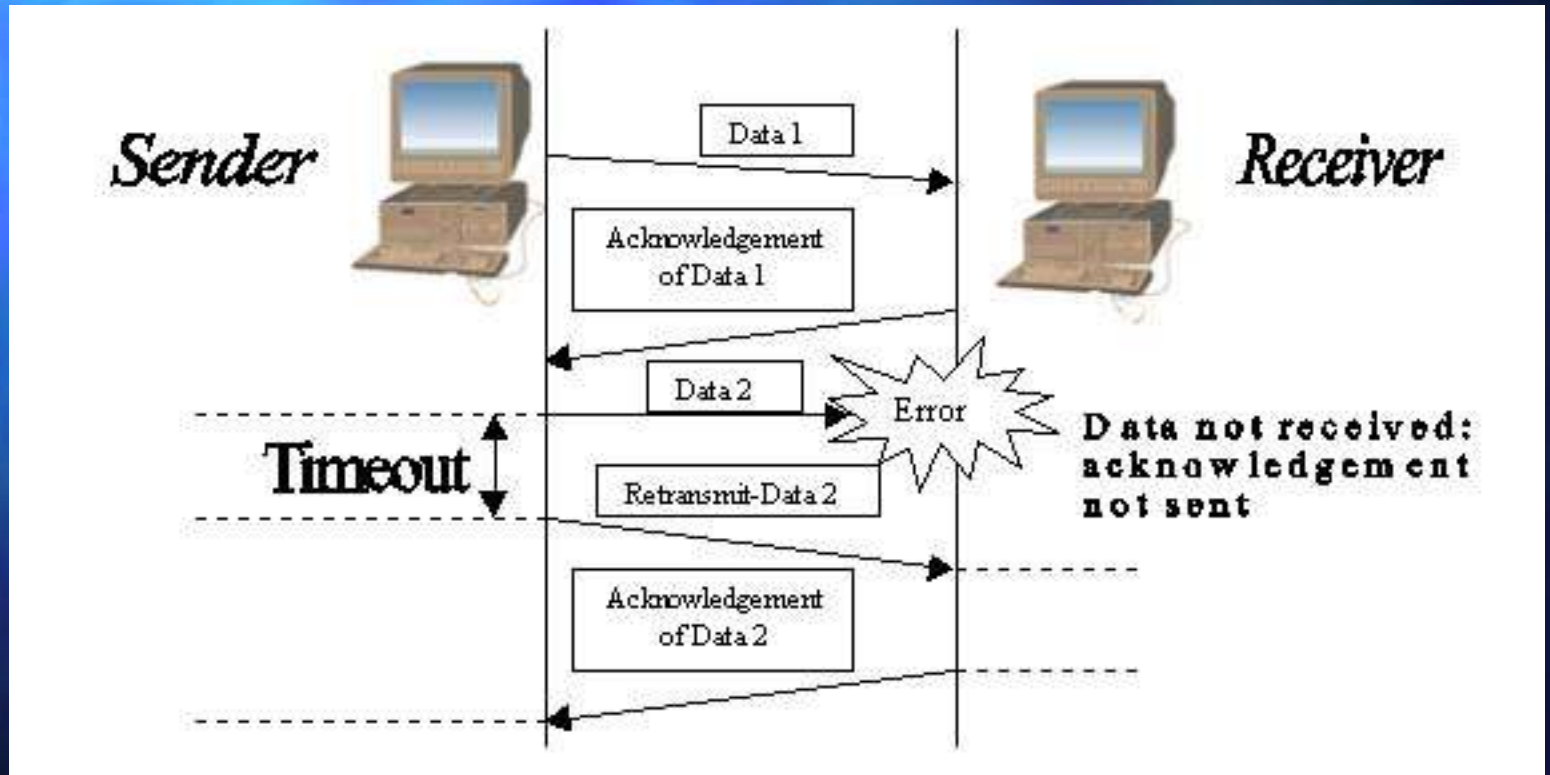


TCP/IP Transport Layer

- TCP is responsible for data recovery
 - by providing a sequence number with each packet that it sends
- TCP requires ACK (acknowledgement) to ensure correct data is received
- Packet can be retransmitted if error detected
- ANSI C12.22 does not provide Transport Layer for non-comm-module implementations
- These are internal features of TCP/IP and are not visible to the ANSI C12.22 Application

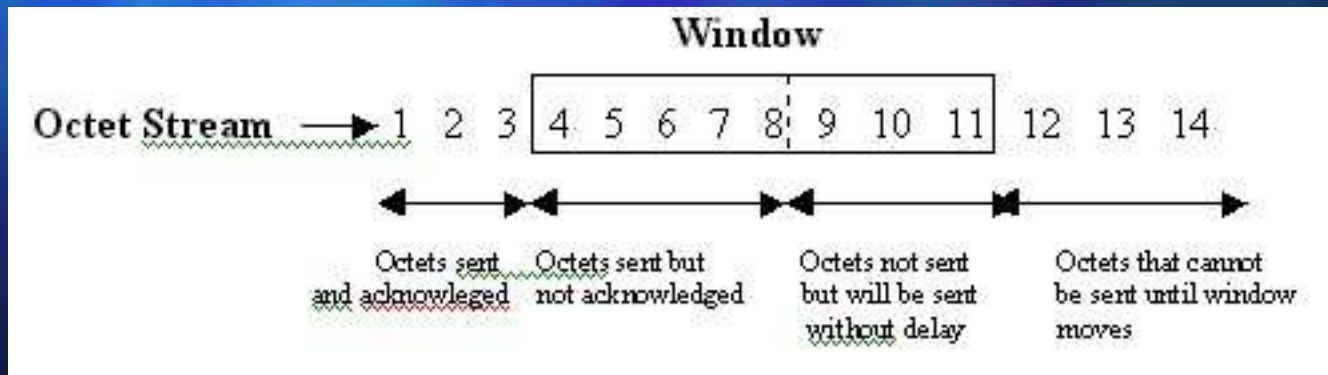
TCP/IP Transport Layer

- Use of ACK
- This is an internal feature of TCP/IP and not visible to ANSI C12.22



TCP/IP Transport Layer

- Flow control with *Window*
 - via specifying an acceptable range of sequence numbers
- This is an internal feature of TCP/IP and not visible to ANSI C12.22



TCP/IP Transport Layer

- TCP and UDP introduce the concept of *ports*
- Common ports and the services that run on them:

■ FTP	21 and 20
■ telnet	23
■ SMTP	25
■ http	80
■ POP3	110
■ C1222-ACSE	1153

TCP/IP Transport Layer

- By specifying ports and including port numbers with TCP/UDP data, *multiplexing* is achieved
- Multiplexing allows multiple network connections to take place simultaneously
- The port numbers, along with the source and destination addresses for the data, determine a *socket*
- ANSI C12.22 has an assigned TCP and UDP port number 1153, and can be re-assigned dynamically by C12.22 Node registration

Services or applications using port: 1153

- Protocol: TCP & UDP
- IANA* status: Official
- Range: Registered
- Traffic: inbound, outbound, both
- Notification: N/A
- Related Ports: N/A

*IANA — [Internet Assigned Numbers Authority](#)

C12.22 Multicast using port: 1153

- Protocol: UDP & IGMP
- IANA* status: Official
- Range: Registered
- Traffic: inbound, outbound, both
- Notification: N/A
- Related Addresses:
 - IPv4 "All C1222 Nodes" 224.0.2.4
 - IPv6 "All C1222 Nodes" FF0X:0:0:0:0:0:0:204

*IANA — Internet Assigned Numbers Authority

Comparing Transport for both Models

- The features of UDP and TCP defined at TCP/IP Transport Layer correspond to many of the requirements of the OSI Transport Layer. There is a bit of bleed over for requirements in the session layer of OSI since sequence numbers, and port values can help to allow the Operating System to keep track of sessions, but most of the TCP and UDP functions and specifications map to the OSI Transport Layer.

Comparing Transport for both Models

- The TCP/IP and OSI architecture models both employ all connection and connectionless models at transport layer. However, the internet architecture refers to the two models in TCP/IP as simply “connections” and “datagrams”. But the OSI reference model, with its penchant for “precise” terminology, uses the terms connection-mode and connection-oriented for the connection model and the term connectionless-mode for the connectionless model.
- In order to maximize interoperability over any network and minimize requirements, ANSI C12.22-2012 implements connectionless-mode ACSE so that it does not require a connection for its services (but it does not preclude it)
- For the above reasons the ANSI C12.22-2012 maintains “associations” between “peers” rather than connections

Network vs. Internet

OSI	TCP / IP
Network (Layer 3)	Internet

- Like all the other OSI Layers, the network layer provides both connectionless and connection-oriented services. As for the TCP/IP architecture, the internet layer is exclusively connectionless
- ANSI C12.22 does not provide a Network Layer
- ANSI C12.22 Application is designed around a connectionless-mode network

Network vs. Internet

- X.25 Packet Level Protocol – OSI's Connection-oriented Network Protocol

The CCITT standard for X.25 defines the DTE/DCE interface standard to provide access to a packet-switched network. It is the network level interface, which specifies a virtual circuit (VC) service. A source host must establish a connection (a VC) with the destination host before data transfer can take place. The network attempts to deliver packets flowing over a VC in sequence.

Network vs. Internet

■ Connectionless Network Service

- Both OSI and TCP/IP support a connectionless network service: OSI as an alternative to network connections and TCP/IP as the only way in use.

■ Internetworking Protocols

- OSI's CLNP (ISO/IEC 8473: 1993) is functionally identical to the Internet's IP (RFC 791). Both CLNP and IP are best-effort-delivery network protocols. Bit niggling aside, they are virtually identical. The major difference between the two is that CLNP accommodates variable-length addresses, whereas IP supports fixed, 32-bit address (IPV4).
- Also IPV6 is another parallel implementation

Network vs. Internet

■ Internet (IP) Addresses

- The internet network address is more commonly called the "IP address." It consists of bits, some of which are allocated to a high-order network-number part and the remainder of which are allocated to a low-order host-number part.
- The distribution of bits - how many form the network number, and how many are therefore left for the host number - can be done in one of three different ways, giving three different *classes* of IP address
- ANSI C12.22 does not provide IP addresses
- ANSI C12.22 considers IP addresses a native property of the underlying network IP layer ("native address")
- ANSI C12.22 relies on IETF RFC 6142 to specify the encapsulation and control elements of in the context of IPv4 and IPv6

Network vs. Internet

- OSI Network Layer Addressing
 - ISO/IEC and CCITT jointly administer the global network addressing domain. The initial hierarchical decomposition of the NSAP address is defined by (ISO/IEC 8348). The standard specifies the syntax and the allowable values for the high-order part of the address - the Initial Domain Part (IDP), which consists of the Authority and Format Identifier (AFI) and the Initial Domain Identifier (IDI) - but specifically eschews constraints on or recommendations concerning the syntax or semantics of the domain specific part (DSP).
- This has nothing to do with object identifiers used to tag ANSI C12.22 Application Titles (ApTitle)

Network vs. Internet

- OSI Routing Architecture

- End systems (ESs) and intermediate systems (ISs) use routing protocols to distribute (“advertise”) some or all of the information stored in their locally maintained routing information base. ESs and ISs send and receive these routing updates and use the information that they contain (and information that may be available from the local environment, such as information entered manually by an operator) to modify their routing information base.
- ANSI C12.22-2012 does not provide routing capability within one native network segment, such as the Internet (i.e. the entire internet appears to ANSI C12.22 as one contiguous network segment)
- ANSI C12.22-2012 provides **relaying** capabilities to bridge between different network segments (e.g. C12.22 over internet to C12.22 over SMS, or between public and private networks) when automatic-relaying capability is not present between the two incompatible native network segments

Network vs. Internet

■ TCP/IP Routing Architecture

- The TCP/IP routing architecture looks very much like the OSI routing architecture
- Hosts use a discovery protocol to obtain the identification of gateways and other hosts attached to the same network (sub-network)
- Gateways within autonomous systems (routing domains) operate an interior gateway protocol (intradomain IS-IS routing protocol), and between autonomous systems, they operate exterior or border gateway protocols (interdomain routing protocols).
- ANSI C12.22 **does not** provide routing services on the internet

Data link / Physical vs. Subnet

OSI	TCP / IP
Data Link (Layer 2)	Subnet
Physical (Layer 1)	

- Data link layer

- The function of the *Data Link Layer* is “provides for the control of the physical layer, and detects and possibly corrects errors which may occur” (ISO/IEC 7498:1994). In another words, the Data Link Layer transforms a stream of raw bits (0s and 1s) from the physical into a data frame and provides an error-free transfer from one node to another, allowing the layers above it to assume virtually error-free transmission
- ANSI C12.22 does not provide Data link Layer for non-comm-module implementations

Data link / Physical vs. Subnet

- Physical layer
 - The function of the Physical Layer is to provide “mechanical, electrical, functional, and procedural means to activate a physical connection for bit transmission” (ISO/IEC 7498:1994). Basically, this means that the typical role of the physical layer is to transform bits in a computer system into electromagnetic (or equivalent) signals for a particular transmission medium (wire, fiber, ether, etc.)
 - ANSI C12.22 does not provide Physical Layer for non-comm-module implementations

Data link / Physical vs. Subnet

■ Comparing to TCP/IP

- These 2 layers of the OSI correspond directly to the subnet layer of the TCP/IP model
- Majority of the time, the lower layers below the Interface or Network layer of the TCP/IP model are seldom or rarely discussed.
- The TCP/IP model does nothing but to highlight the fact the host has to connect to the network using some protocol so it can send IP packets over it. Because the protocol used is not defined, it will vary from host to host and network to network
- ANSI C12.22 does not provide Physical Layer for non-comm-module implementations

Data link / Physical vs. Subnet

■ Comparing to TCP/IP

- After much deliberation by organizations, it was decided that the Network Interface Layer in the TCP/IP model corresponds to a combination of the OSI Data Link Layer and network specific functions of the OSI network layer (e.g. IEEE 203.3)
- Since these two layers deal with functions that are so inherently specific to each individual networking technology, the layering principle of grouping them together related functions is largely irrelevant
- For this reason Smart Grid should not specify a preferred the physical layer

General Comparison

- Focus of Reliability Control
- Roles of Host System
- De-jure vs. De-facto

Focus of Reliability Control

- Implementation of the OSI model places emphasis on providing a reliable data transfer service, while the TCP/IP model treats reliability as an end-to-end problem
- Each layer of the OSI model detects and handles errors, all data transmitted includes checksums. The transport layer of the OSI model checks source-to-destination reliability
- In the TCP/IP model, reliability control is concentrated at the transport layer. The transport layer handles all error detection and recovery. The TCP/IP transport layer uses checksums, acknowledgments, and timeouts to control transmissions and provides end-to-end verification
- ANSI C12.22 application delegates all of the above to the network

Roles of Host System

- Hosts on OSI implementations do not handle network operations, but TCP/IP hosts participate in most network protocols
- TCP/IP hosts carry out such functions as end-to-end verification, routing, and network control
- The TCP/IP internet can be viewed as a data stream delivery system involving intelligent hosts
- For ANSI C12.22 over IP, the content of the data stream is an ACSE PDU

De-jure vs. De-facto (OSI)

■ OSI

- Standard legislated by official recognized body. (ISO)
- The OSI reference model was devised *before* the protocols were invented. This ordering means that the model was not biased toward one particular set of protocols, which made it quite general. The down side of this ordering is that the designers did not have much experience with the subject and did not have a good idea of which functionality to put in which layer
- Being general, the protocols in the OSI model are better hidden than in the TCP/IP model and can be replaced relatively easily as the technology changes
- Not so widespread as compared with TCP/IP (complex , costly)
- More commonly used as teaching aids
- However ANSI C12.22 is a Smart Grid reality not a teaching aid

De-jure vs. De-facto (TCP/IP)

■ TCP/IP

- Standards adopted due to widespread use. (Internet)
- The protocols came first, and the model was really just a description of the existing protocols. There was no problem with the protocols fitting the model, but it is hardly possible to be use to describe other models.
- "Get the job done" orientation.
Over the years it has handled most challenges by growing to meet the needs.
- More popular standard for internetworking for several reasons :
 - relatively simple and robust compared to alternatives such as OSI
 - available on virtually every hardware and operating system platform (often free)
 - the protocol suite on which the Internet depends.

The End

- Original OSI Documentation Project team members
 - **ANDREW TAN TENG HONG**
 - **MAH CHEE MENG**
 - **CHEE YEW WAI**
 - **TAN YOKE CHUAN**
 - **CHEONG KIM MING**
- Revised to include ANSI C12.22-2012 and IETF RFC 6142 & Comments
 - **Avygdor Moise**
 - **Richard D. Tucker**