5. Connecting Systems

UNDERSTANDING ITS/CVO TECHNOLOGY APPLICATIONS
Student Manual

MODULE 5 - CONNECTING INFORMATION SYSTEMS TO EACH OTHER AND TO USERS

US Dept of Transportation

Learning Objectives

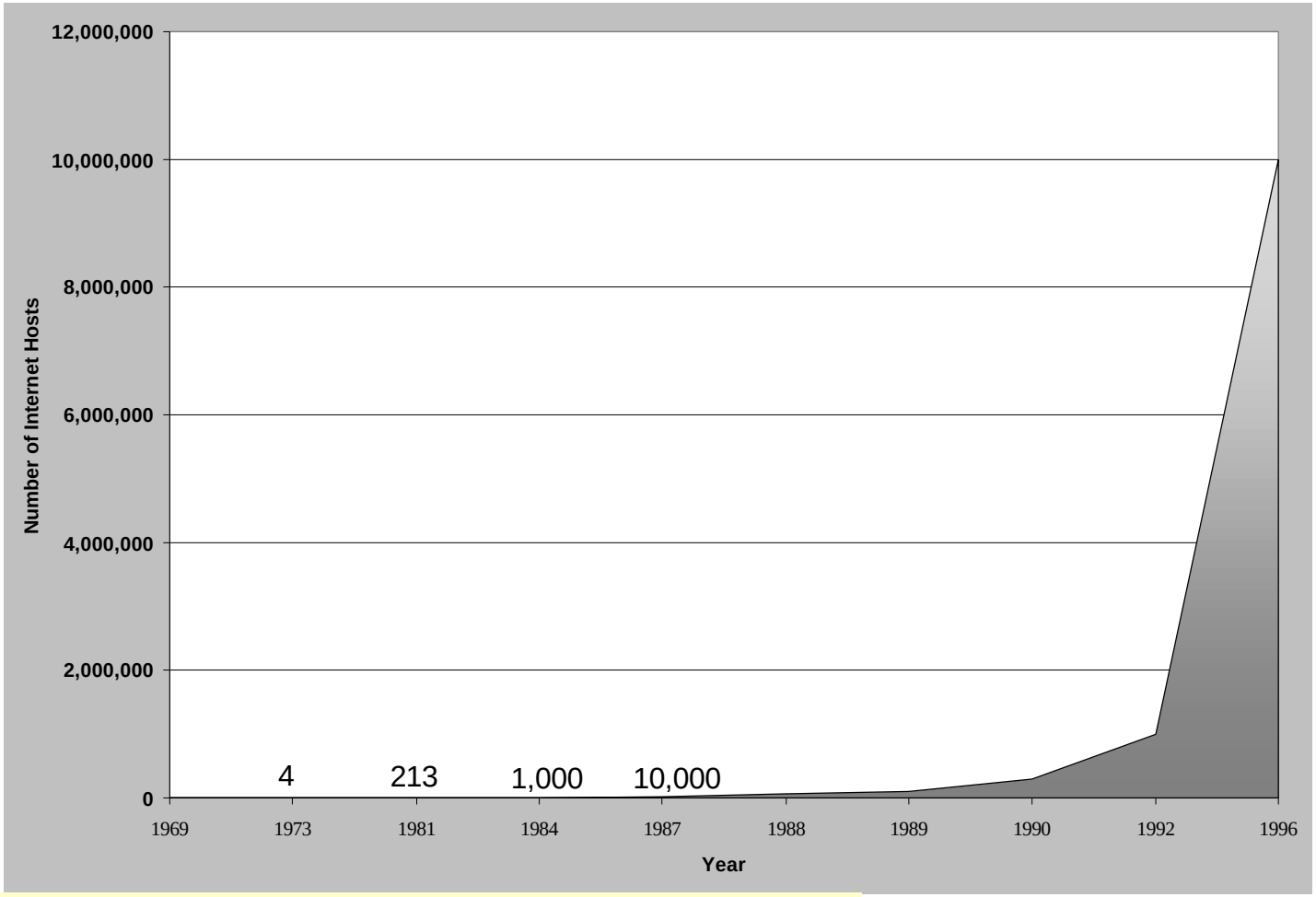
You will be able to:

- Explain the key differences among various network technologies
- Understand EDI
- Discuss common issues with connecting information systems
- Understand how to use the network design template

Module Structure

- Overview
- Networks
- BREAK
- Using the Internet to reach users
- EDI
- Issues - what issues arise when combining the technologies
- A concrete example: Midland - improving connectivity
- Questions & Recap

Computing and connecting computers have come a long way



The Internet started out as ARPANET, which had its roots in a research project linking 4 universities in 1969.

Historical Perspective

- 1960s Mainframe computers
- 1970s Information systems
  Databases
  Protocols for networks
- 1980s Personal computers
  Local Area Networks (LANs)
  Wide Area Networks (WANs)
  Internet
- 1990s Client/Server
  Internetworking LANs & WANs
  World Wide Web

Material taken from: Heterogeneous Internetworking, Networking Technically Diverse Operating Systems by Harry Singh and from http://www.pbs.org/internet/timeline/index.html

Communication protocols define rules for information systems to talk to each other

- A communication protocol may be defined as a public, formal specification of rules and guidelines in which two or more components of an information system communicate to accomplish a goal.

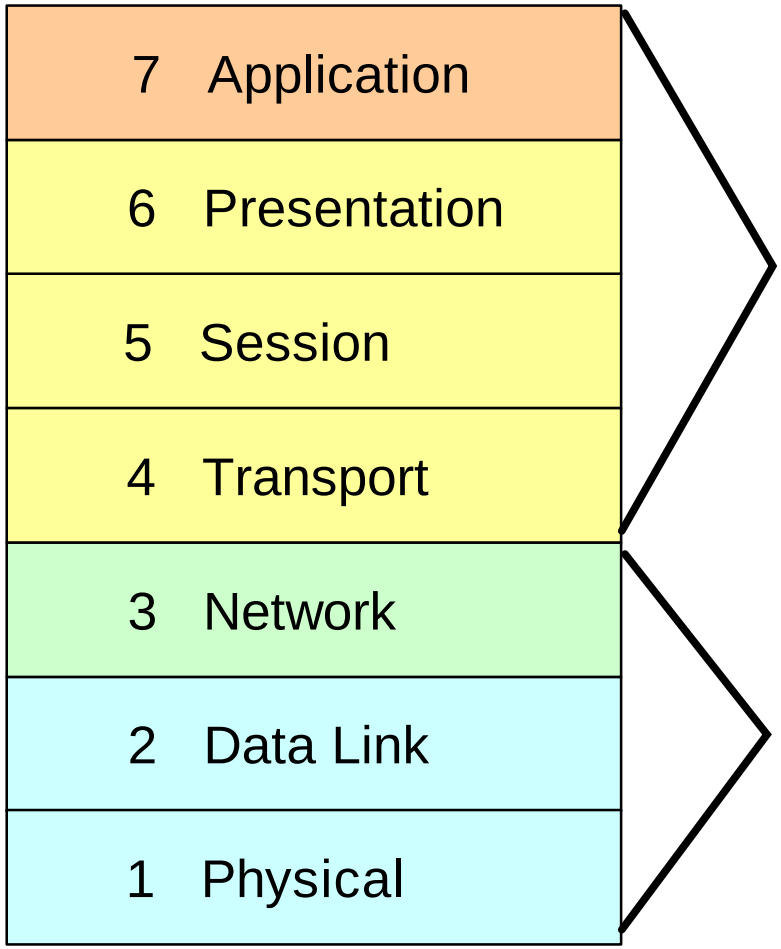
- Most protocols are formed in a layered fashion. All of the following have multiple layers (typically seven).
  - IBM's System Network Architecture (SNA)
  - Digital Equipment Corporation's DECnet
  - TCP/IP (Transmission Control Protocol/Internet Protocol)
  - International Standards Organization's (ISO) Open Systems Interconnection (OSI) Reference Model

Communication Protocols

- There are some characteristics applicable to most communications protocols.
  - First, the protocol must encompass the exchange of both data and control information.
  - Second, multiple layers of protocols are typically present in any substantial information system environment, particularly those that can be considered enterprise.

- On multiple protocols. . .
  - If the protocols used by a remote system are the same as those used by a local system, communication is easy to implement.
  - If the protocols differ, translation is needed.
  - If the architectural model is different, with different layers and different services (like SNA versus TCP/IP), the translation can be tricky.

The OSI (Open Systems Interconnection) Model describes a network architecture



The upper four layers deal with the end-to-end communications and data transfer.

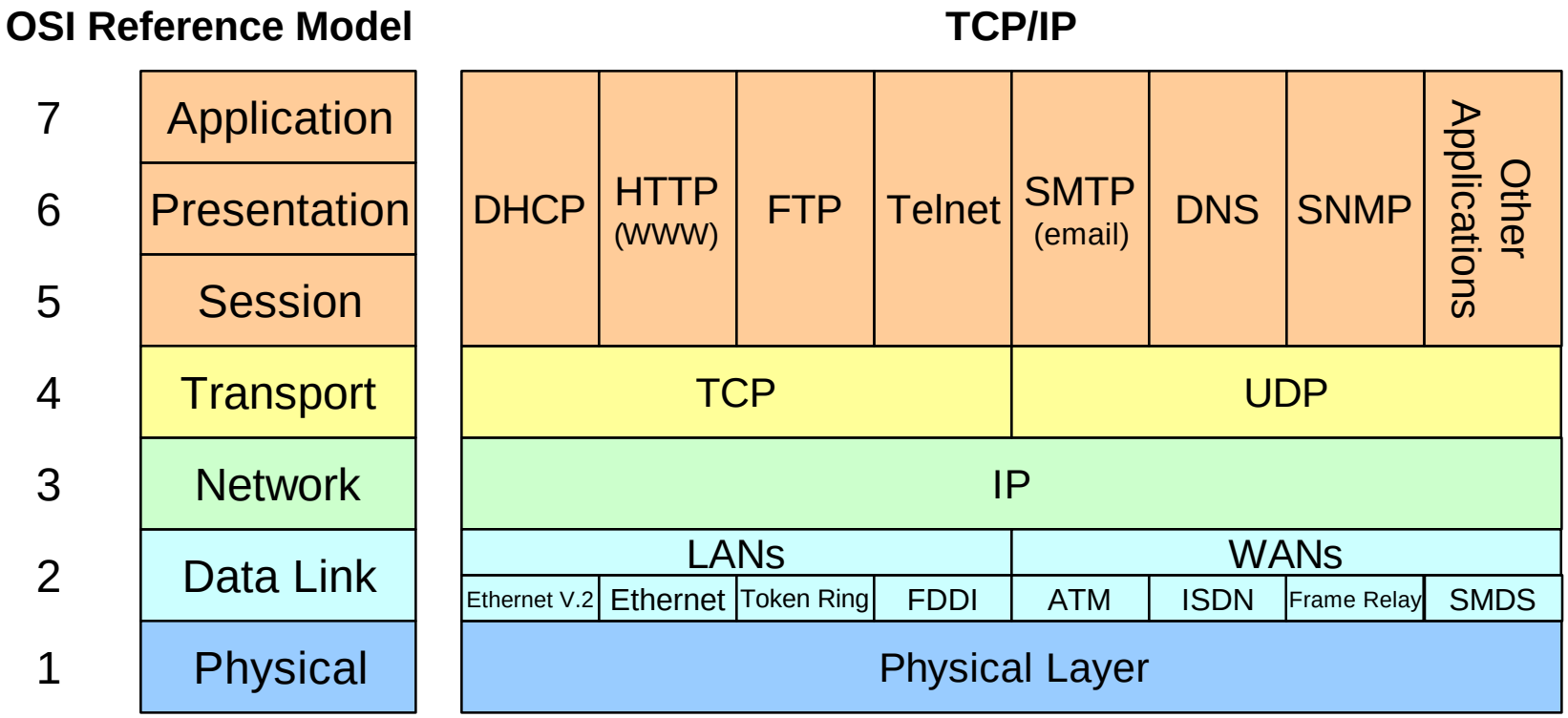
The bottom three layers are concerned with the node to node connection.

Open Systems Interconnection

- The application layer (layer 7): This is the layer at which a user and a computer interface to a network to view a message or data request or response. This is the direct interface for the application to request a service. This layer provides communications services to the end user.
- The presentation layer (layer 6): This is a layer, usually part of an operating system, that converts incoming and outgoing data from one presentation format to another (for example, from a text stream into a popup window with the newly arrived text). This is where format, code conversions, data representation, compression, and encryption are handled for the application.
- The session layer (layer 5): This layer manages the establishment of a continuing series of requests and responses between the applications at each end. The control of the direction of data transfer is handled here.
- The transport layer (layer 4): This layer manages the end-to-end control (for example, determining whether all packets have arrived) and error-checking. This layer also controls the connection for error recovery and flow control. It is responsible to assure error-free data delivery end-to-end in a cost-efficient manner.
- The network layer (layer 3): This layer handles the routing of the data (sending it in the right direction to the right destination on outgoing transmissions and receiving incoming transmissions at the packet level). This layer is responsible for the switching and routing of the connection and is also responsible to take the data that is to be shipped from node to node, not end user to end user, and break it into smaller pieces to accommodate the transmission system.
- The link (or data-link) layer (layer 2): This layer provides error control and synchronization for the physical level and does bit-stuffing for strings of 1's in excess of 5. It is responsible for the delivery of the information to the network medium.
- The physical layer (layer 1): This layer conveys the bit stream through the network at the electrical and mechanical level.

Material taken from
http://www.rad.com/networks/1994/osi/osi.htm and from
http://www.whatis.com/osi.htm

An in-depth look at the TCP/IP protocols and its layered architecture



Material taken from Understanding Data Communications From Fundamentals to Networking by Gilbert Held

Transmission Control Protocol/Internet Protocol (TCP/IP)

- Like OSI, TCP/IP protocols are also grouped into layers. As we can see, the OSI and TCP/IP architectural models share the same structural elements (see previous slide). Layers 1-4 are more or less equivalent for both OSI and TCP/IP. However, the differences between OSI and TCP/IP architectures relate primarily to the philosophy in the layers above the transport level. The OSI model has two additional layers, the session layer and the presentation layer. In TCP/IP, the functions of these two layers are viewed as part of the application layer.

- The top layer, the applications layer, provides application services to users and programs. The transport layer handles data consistency functions. The transport layer is supported by two protocols, TCP and UDP. The TCP provides a reliable delivery, whereas the UDP does not ensure delivery. Most TCP/IP applications like Telnet and FTP use TCP, while others like voice and video use UDP, since fast delivery is more important than reliability.

- The internet layer is the key layer. It has one protocol: IP. IP provides many of the same functions as the network layer, such as addressing and routing. IP provides a common address space across multiple lower-layer network protocols.

- The network layer contains whatever internetworking protocol will run over it, such as Ethernet, Token Ring, FDDI, and so on. A network layer routes packets across a network. The physical layer, the link, and the network layers in TCP/IP are combined to form a subnet layer.

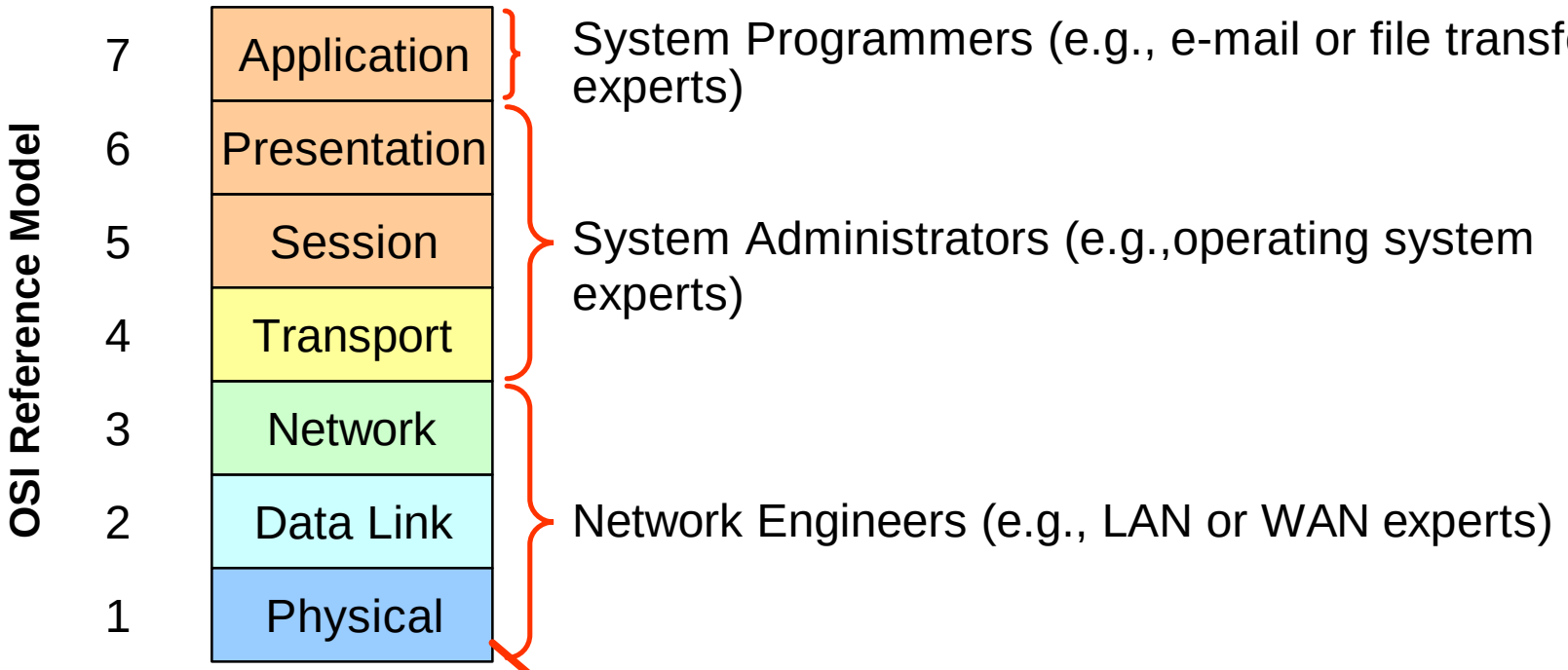
- The requirement for universal connectivity is supported by the Internet Protocol (the network layer). Another protocol, Internet Control Message Protocol (ICMP), a component of every IP implementation, transports error and diagnostic information for IP. In addition to the Transmission Control Protocol (TCP) at the transport level, the User Datagram Protocol (UDP) is also utilized by a host of networking solutions.

  Material taken from: Heterogeneous Internetworking, Networking Technically Diverse Operating Systems by Harry Singh and from http://www.whatis.com/osi.htm

Who are the experts on each layer?

User Software Products

Software Developers (e.g., C++ programmers who develop the “Forms” software from Module 4)



Who knows what

- Note that those who develop the software you use are not concerned with any layer of the network architecture model. Their “applications” use the protocols but they may not know much about how the protocols operate.

- Knowing who has what expertise can help point you in the right direction to tackle different problems.

- Job titles in your organization may be different.

Not all experts know all aspects of connectivity and networking

The major differences between a LAN and a WAN

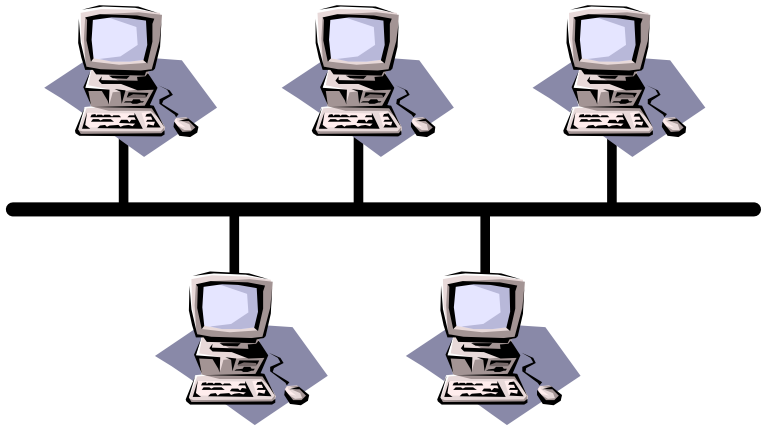
Characteristics	***Local Area Network***	***Wide Area Network***
Geographic area of coverage	Localized to a building, group of buildings, or campus	Can span an area ranging in size from a city to the globe
Data transmission rate	Typically 4 Mbps to 16 Mbps, with some metallic and fiber optic based networks operating at 100 Mbps	Normally operates at or below T1 and E1 translation rates of 1.544 Mbps and 2.048 Mbps
Error rate	1 in 10^7 to 1 in 10^8	1 in 10^6 to 1 in 10^7
Ownership	Usually with the implementor	Communications carrier retains ownership of line facilities
Data routing	Normally follows fixed route	Switching capability of network allows dynamic alteration of data flow
Topology	Usually limited to bus, ring, tree and star	Virtually unlimited design capability
Type of info. carried	Primarily data	Voice, data and video commonly integrated

LAN and WAN

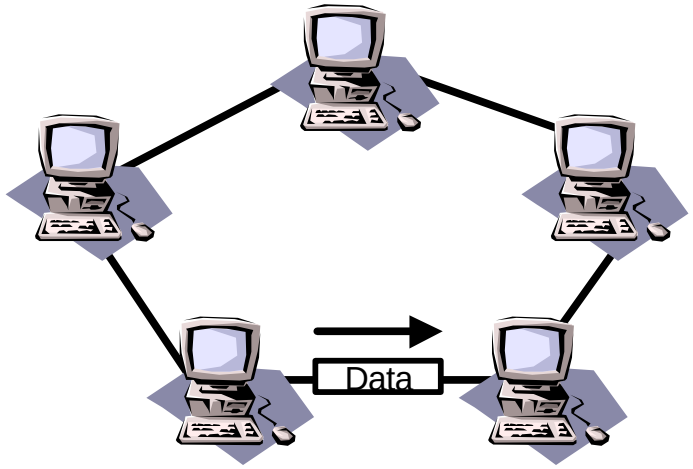
- LAN: high-bandwidth networks designed for geographically local areas, such as a building or a campus. A typical LAN can support hundreds of users from distances of 100 meters to over a kilometer and at speeds in excess of 10 Mbps.

- WAN: enterprise networks consist of LANs of various protocols, supporting myriad media and architectures, connected to wide area networks consisting of a variety of communication systems. These complex networks span cities, countries, and continents and are being influenced by emerging technologies driven by user demands and vendor innovations.

Two main LAN technologies: Ethernet and Token Ring



An Ethernet LAN



A Token Ring LAN

LAN technologies

- Ethernet is a base-band LAN specification that was invented by Xerox Corporation. Ethernet LANs employ a bus topology in which each station is directly connected to a common LAN media. Each station on the Ethernet transmits directly to the shared bus, so that all stations on the LAN receive the signal simultaneously. In Ethernet networks, multiple access is provided by the carrier sense multiple access/collision detect (CSMA/CD) algorithm. CSMA/CD allows a node to transmit a packet as soon as the LAN is available and arbitrates if there is contention for the LAN. Ethernet network operates at 10Mbps using CSMA/CD to run over coaxial cable.

- Token Ring: Token ring is another popular approach to local area networking. These networks have become synonymous with IBM, a driving force behind their development at the Zurich Research Laboratory. IBM unveiled the token ring network in 1985. The token ring is a series of point-to-point links closed up to form a logical ring that connects the stations. Each station is connected to the ring by a repeater, which is an active device that regenerates all the data flowing on the ring.

Three main WAN technologies

- Switching systems such as ATM
- Frame Relay systems
- ISDN

Internetworking with WANs

- ATM (Asynchronous Transfer Mode)
  - Packet-oriented transfer mode
  - Dedicated connection
  - Optimized to accommodate both real-time and non-real-time data efficiently and cost effectively
  - Not protocol dependent
  - Uses digital technology
- Frame Relay
  - Frame differs from a packet in its length and header.
  - A frame can be a bit or character oriented.
  - Frame relay uses separate channel for control characters or header/trailer information.
  - “Connected” only during transmission.
- ISDN (Integrated Services Digital Network)
  - Transmission over ordinary telephone copper wire as well as over other media.
  - Separate channels for control and user information. May have multiple channels for user information.
  - Integrated both analog or voice data together with digital data over the same network.
  - As envisioned, a future version of ISDN, Broadband ISDN (BISDN), will extend the integration of both services using fiber optic and radio media. Broadband ISDN will encompass frame relay and ATM.

Material taken from http://www.whatis.com/osi.htm

Major commercial WAN service providers

- A WAN may be composed entirely of private structures, but it may also include public networks.
- The biggest network providers are MCI, Sprint, and WorldCom.
- Value-Added Networks (VANs) often bundle other services with WAN connectivity:
  - automatic error detection and correction
  - protocol conversion
  - message storing and forwarding

Material from http://boardwatch.internet.com/ and
http://www.techweb.com/encyclopedia/defineterm?term=VALUEADDEDNETWORK

Commercial Internet service providers

- Market share
  - MCI ~30%
  - Sprint ~20%
  - WorldCom (UUNET/ANS/CompuServe) ~20%
  - AGIS ~4%
  - GTE ~4%
  - DIGEX ~2%
  - IBM <1%

  (statistics taken from http://boardwatch.internet.com/isp/introduction.html)
- There are over 4,500 network providers to choose from

How do AAMVAnet, CDLIS, and NLETS fit into the picture with the other WANs?

- AAMVAnet (American Association of Motor Vehicle Administrators network)
  - AAMVAnet provides value-added networking services to states.
  - Currently AAMVAnet utilizes the IBM Global Network as their network provider.
- CDLIS (Commercial Driver's License Information System)
  - This system is operated by AAMVAnet.
- NLETS (National Law Enforcement Telecommunications System)
  - This is a state-owned store & forward controlled message switching system. It uses point-to-point digital private lines.

AAMVAnet, CDLIS, NLETS

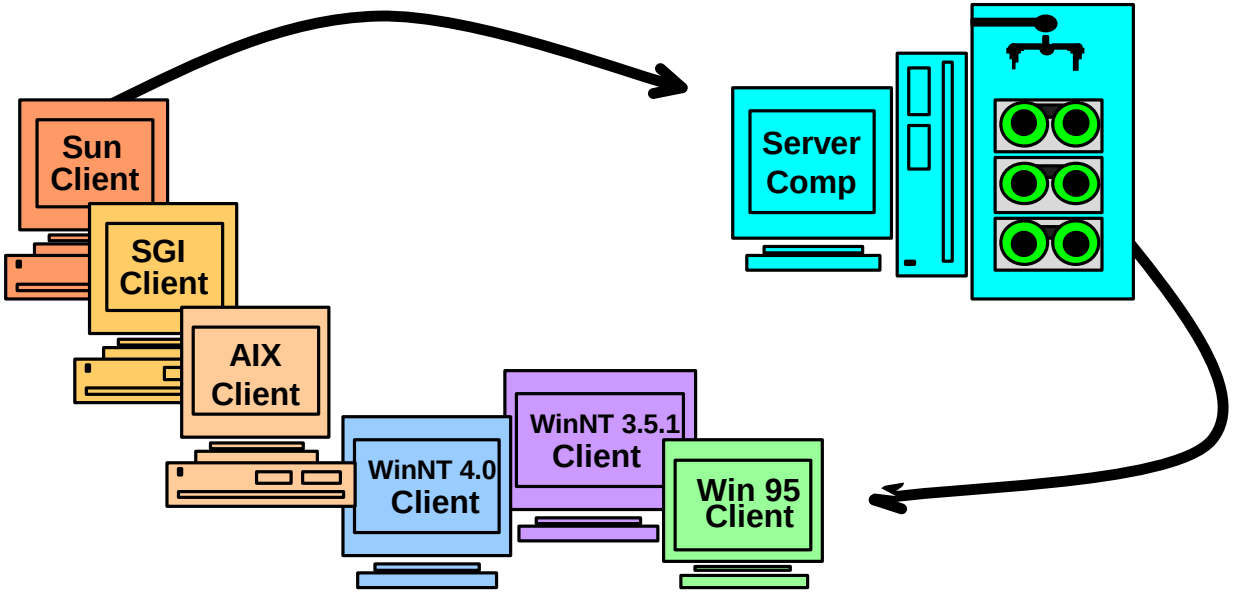
- AAMVAnet -- a value-added network service provider for state government agencies. AAMVAnet operates CDLIS.

- Commercial Driver's License Information System (CDLIS) -- A nationwide linkage of State driver license systems, CDLIS allows quick access to license status and violation history for any CDL driver in North America. CDLIS is used during roadside inspections to identify drivers with revoked, suspended, or bogus licenses.

- National Law Enforcement Telecommunications Systems (NLETS) -- Links together state, local, and federal law enforcement and criminal justice agencies to exchange information.

Client/Server Computing

- The term *client/server* has multiple meanings and is sometimes used interchangeably with the term distributed processing.



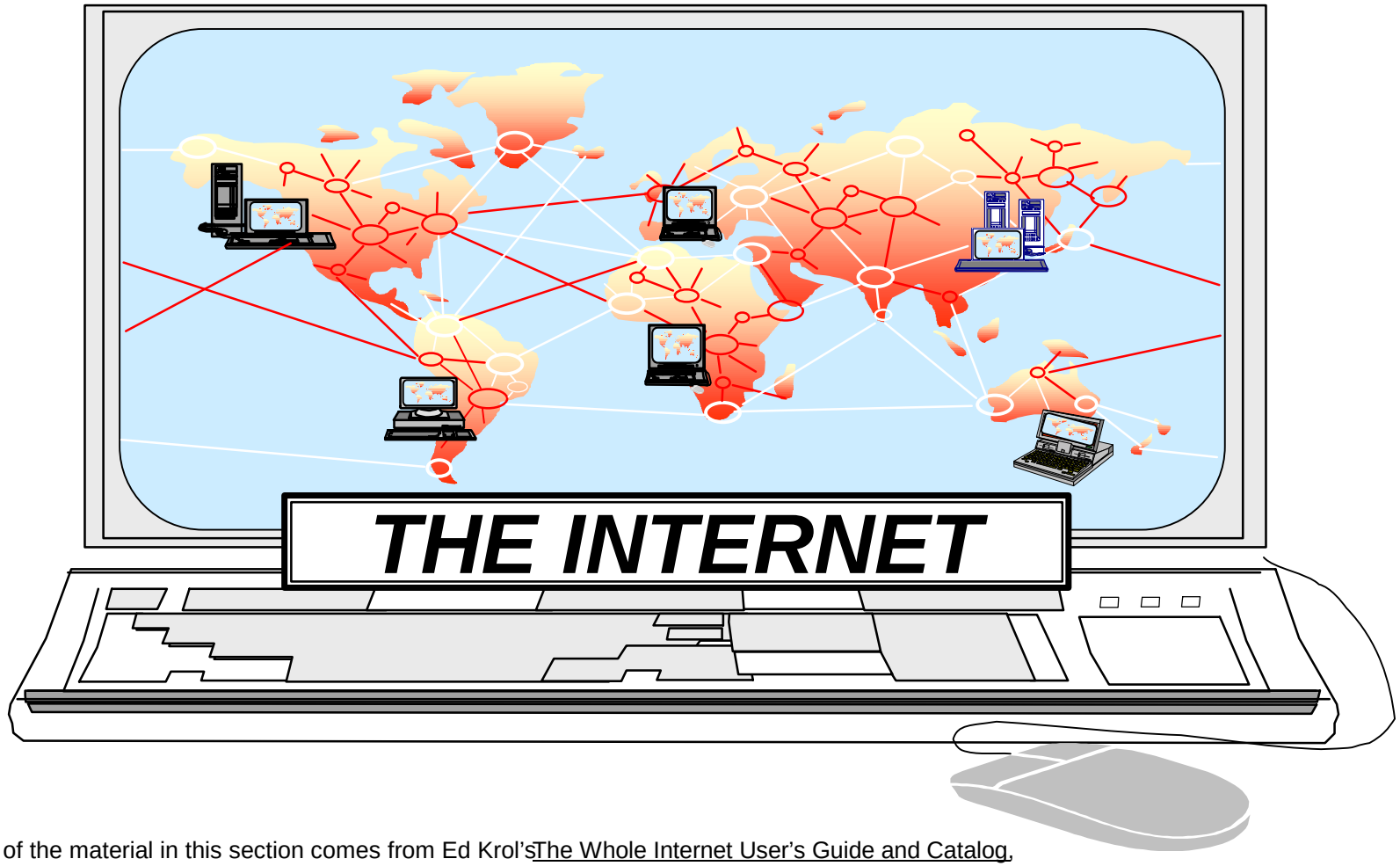
- One definition of client/server computing involves client computers (capable of processing data and running applications) relying on a server computer for shared data and peripherals. In these environments, the server machines are generally powerful PCs set aside to perform the task of a server.

Client/Server Computing

- The *server* provides logically centralized services to one or more *clients* either in the same physical machine or remotely connected in a LAN or a WAN environment. C*lient/server* computing encompasses numerous underlying technologies:
  - Desktop systems (personal computers and workstations)
  - Local area networks
  - Wide area networks
  - Communications interoperability
  - Graphical user interfaces (GUI)
  - Database management systems (DBMSs)

- Client/server computing can be contrasted with*stand alone* or *terminal-host* computing.

The Internet is a world-wide network of computers



Most of the material in this section comes from Ed Krol's The Whole Internet User's Guide and Catalog, especially Chapter Two: What is the Internet? and Chapter Three: How the Internet Works

What is the Internet?

- "Internet" is the word used to describe a world-wide network of computers.
- The word "internet" literally means "network of networks".
- The Internet is comprised of thousands of smaller regional networks scattered throughout the globe.
- On any given day the Internet connects roughly 20 million users worldwide.
- The World-Wide Web is the most-used part of the Internet. It includes all the resources and users that are using the Hypertext Transport Protocol (HTTP).
- The Web refers to a body of information - an abstract space of “pages” and links to pages accessible via the Internet, while the Internet refers to the physical side of the global network, a giant mass of cables and computers.

What makes up the Internet? Who governs the Internet?

- What makes up the Internet? - answer changes over time

- Who governs the Internet? - the ultimate authority for where the Internet is going rests with the Internet Society (ISOC)

What makes up the Internet?
Who governs the Internet?

- What makes up the Internet? The IP-based networks include various federal networks, a set of regional networks, campus networks, and some foreign networks.
- To connect to non-IP-based networks (e.g., Bitnet, DECnets, etc.), they use gateways, which merely serve to transfer electronic mail between the two networks.
- ISOC is a voluntary membership organization whose purpose is to promote global information exchange through Internet technology.
- IAB is a group of invited volunteers who are responsible for the Internet standards; it decides when a standard is necessary and what the standard should be.
- IETF is another volunteer organization comprised of “working groups”. A working groups is setup when the IETF considers a problem important enough to merit concern. A working group usually produces a report.

The Internet is more like the Postal Service than the telephone system

- Telephone System
  - Circuit Switched Network

- Postal Service
  - Packet Switched Network

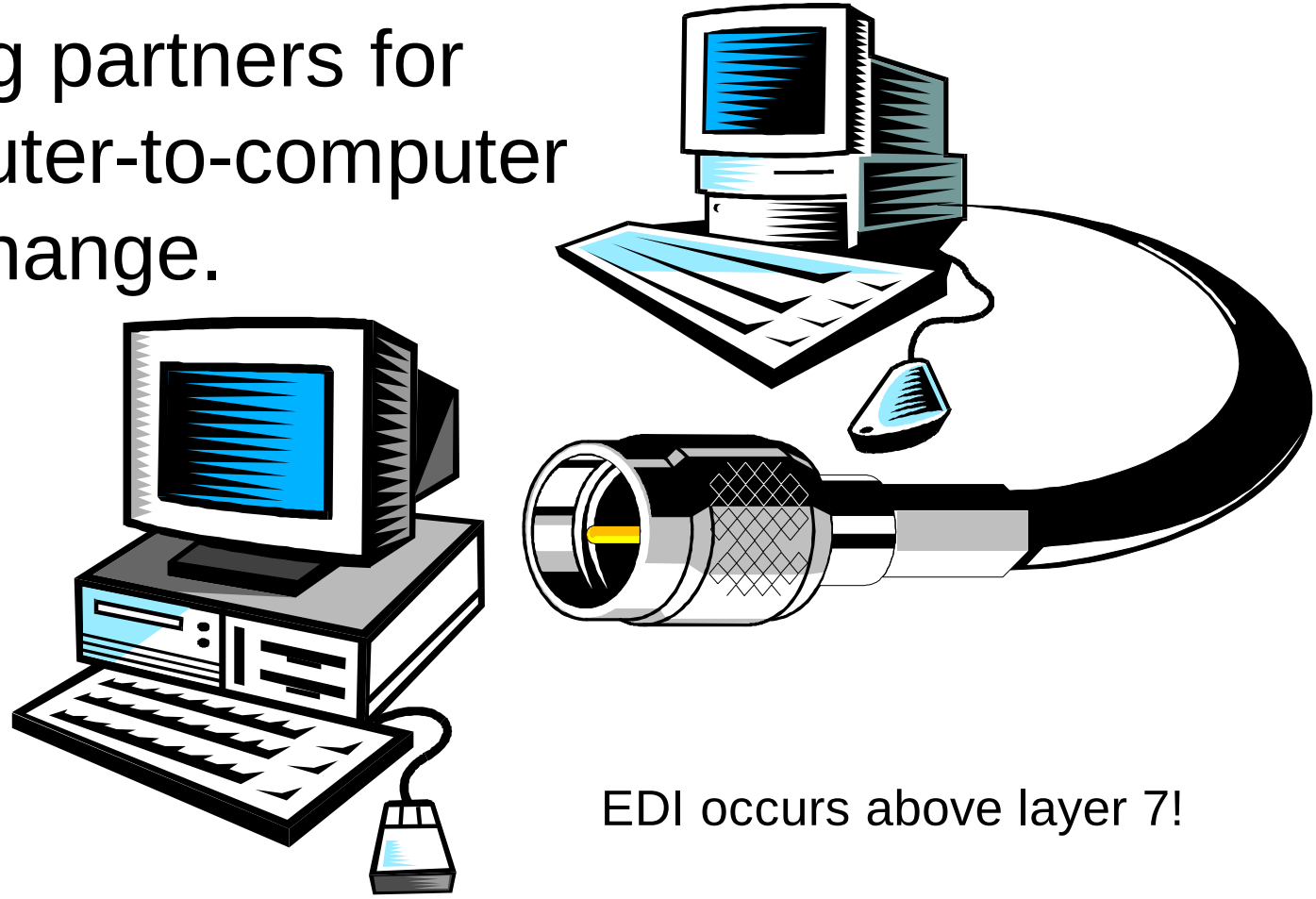
How the Internet works

- There are various levels to any computer network. These can be simplified into the link, transport and application levels. The link level includes the actual physical connections, wires, fiber optic, microwave, etc. The Internet uses a packet switching scheme to transport the data over the various links. The data is broken up into packets, each of which has its own identification and destination. The packets mix with other packets, much like cars on a motorway. Once they reach their destination, the packets are reassembled. Packets do not need to arrive in sequence, nor travel by the same route.

- Applications on the Internet work on a client/server arrangement. The client application (usually with a human directly involved) requests to send or receive data to or from a server application (usually an autonomous process). The client and server can be next door, or on different continents, it makes no difference with the Internet. The client can access any of the tens of thousands of servers on the Internet, the servers can handle requests from any of the tens of millions of clients. This many-to-many synergy is making a fundamental change in the way companies and their customers interact.

Electronic Data Interchange (EDI) is used between trading partners

EDI is used between trading partners for computer-to-computer interchange.

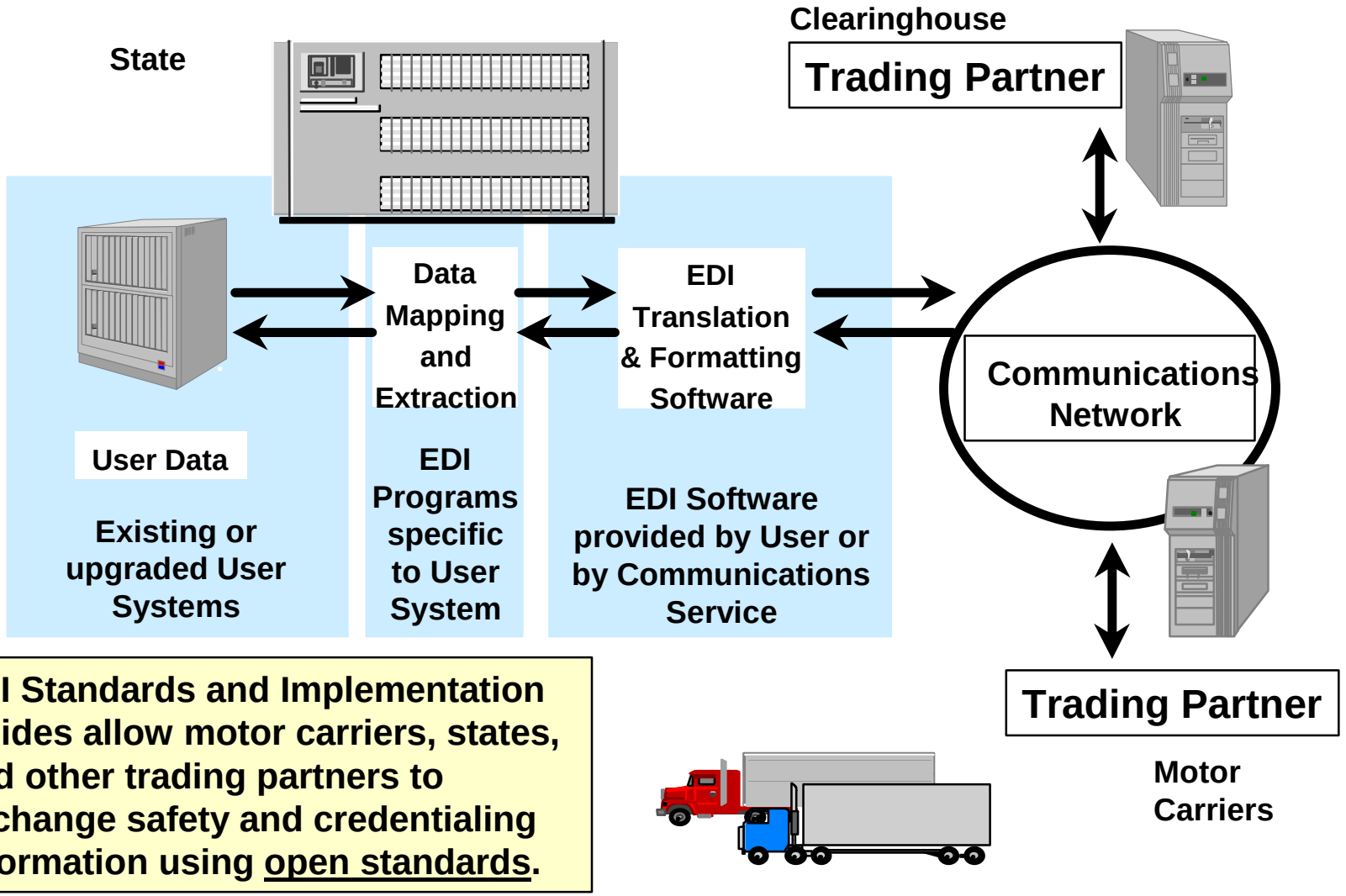


EDI occurs above layer 7!

What is EDI?

- Electronic Data Interchange (EDI) is the electronic exchange of business information in a format that permits computer generation and processing of the message
  - Reduces or eliminates paper transactions
  - Allows automated processing & storing of data
- EDI *standards* and user *implementation guides* define the structure and meaning of messages passed between trading partners.
- American National Standards Institute (ANSI) provides an infrastructure for defining & maintaining open EDI standards.
- Each ANSI standard defines structure for a message serving a defined purpose. (There are currently about 250 such standards.)
- A common implementation is to couple existing systems to an EDI *translator* software package & commercial network.

EDI allows exchange of business transactions between trading partners' systems



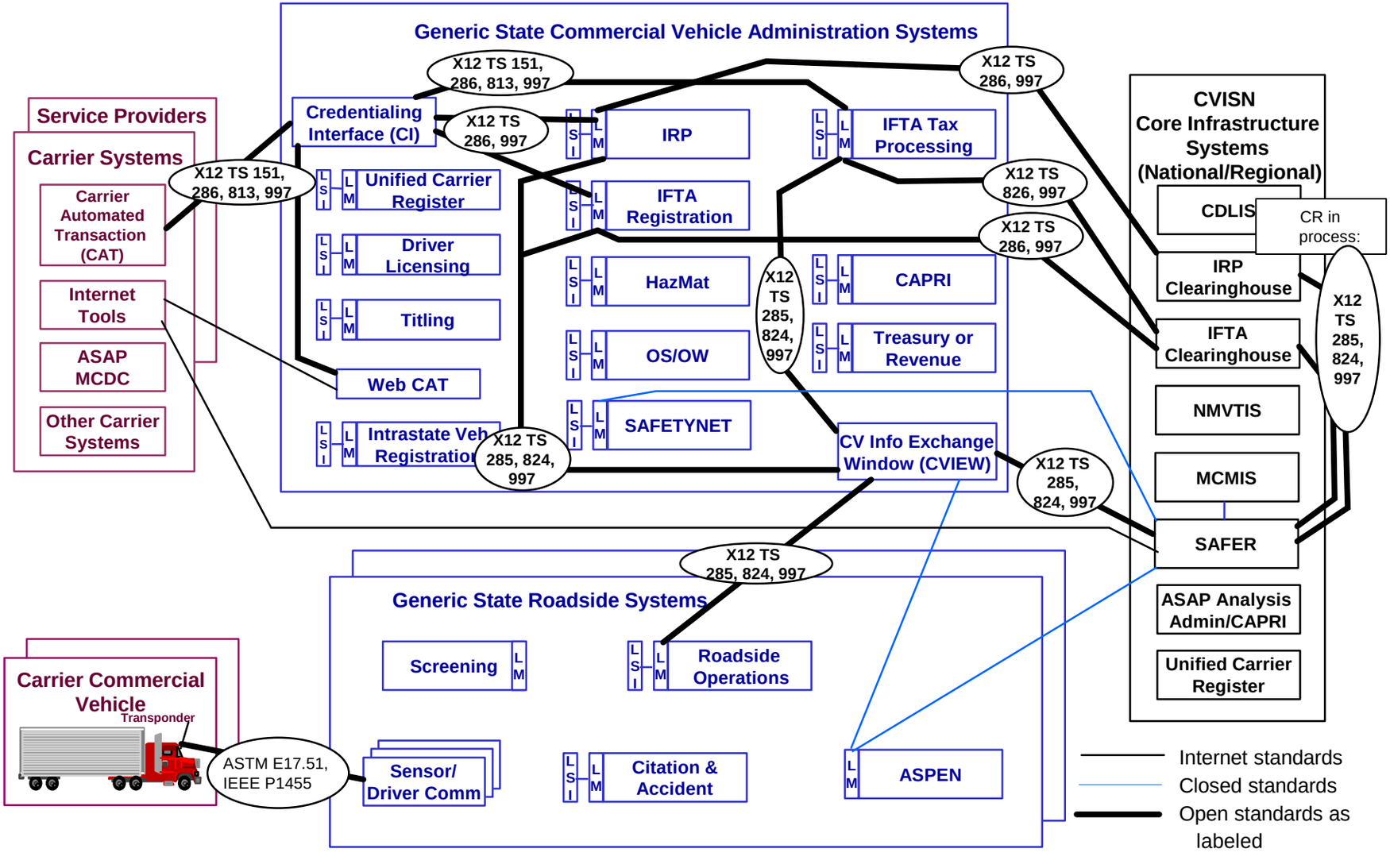
EDI Standards and Implementation Guides allow motor carriers, states, and other trading partners to exchange safety and credentialing information using open standards.

Why Use EDI?

or… What is wrong with the paper process?

- There are generally many steps involved in a typical business transaction (creating an order, filling the order, and making payment on the order).
- Data are keyed into the process at many different points in the process.
- The repeated keying of identical information in the traditional paper-based method of business communications creates a number of problems that can be eliminated or significantly reduced through the use of EDI.
- These problems include:
  - Low Accuracy
  - Increased Time
  - High Labor Usage
  - “Lost” Data
  - High Uncertainty

CVISN Level 1 Interface Standards



CVISN Level 1 EDI interface standards

ANSI ASC X.12 EDI Standard Transaction Sets

- TS 151 Electronic Filing of Tax Return Data Acknowledgement
- TS 284 CV Safety Reports (Inspections)
- TS 285 CV Safety & Credentials Information Exchange (Snapshots)
- TS 286 Commercial Vehicle (CV) Credentials
- TS 813 Electronic Filing of Tax Return Data
- TS 826 Tax Information Exchange
- TS 824 Application Advice
- TS 997 Functional Acknowledgement

Lessons Learned from early EDI implementations

- EDI does in fact allow multiple vendors to implement interfaces according to open standards. States can choose which products to use.
- EDI 286 TS will support IRP administration (other credentials still being validated).
- EDI is a specialized technical discipline - expertise must be acquired or developed.

Other lessons learned?

Combining the technologies/issues

- EDI on the Internet
- State Web CAT or PC CAT or Client/Server CAT
- LANs and WANs working together

Combining the technologies/issues

- EDI on the Internet
  - What role does Internet EDI play?
  - If Internet EDI is so advantageous, why haven't more companies adopted it?

- State Web CAT or PC CAT or Client/Server CAT
  - Who would use a Web-based CAT?
  - What are the pros and cons of each alternative?
  - How would you decide what to do (first)?

- LANs and WANs working together
  - How to work the compatibility issues?
  - What are the cost drivers?
  - How can you define performance parameters?

What can I do about making my state's networks more secure?

- VPN - Virtual Private Networks
- IPSec - Internet Protocol Security
- Industry efforts for VPN-styled protocols

Details of Security

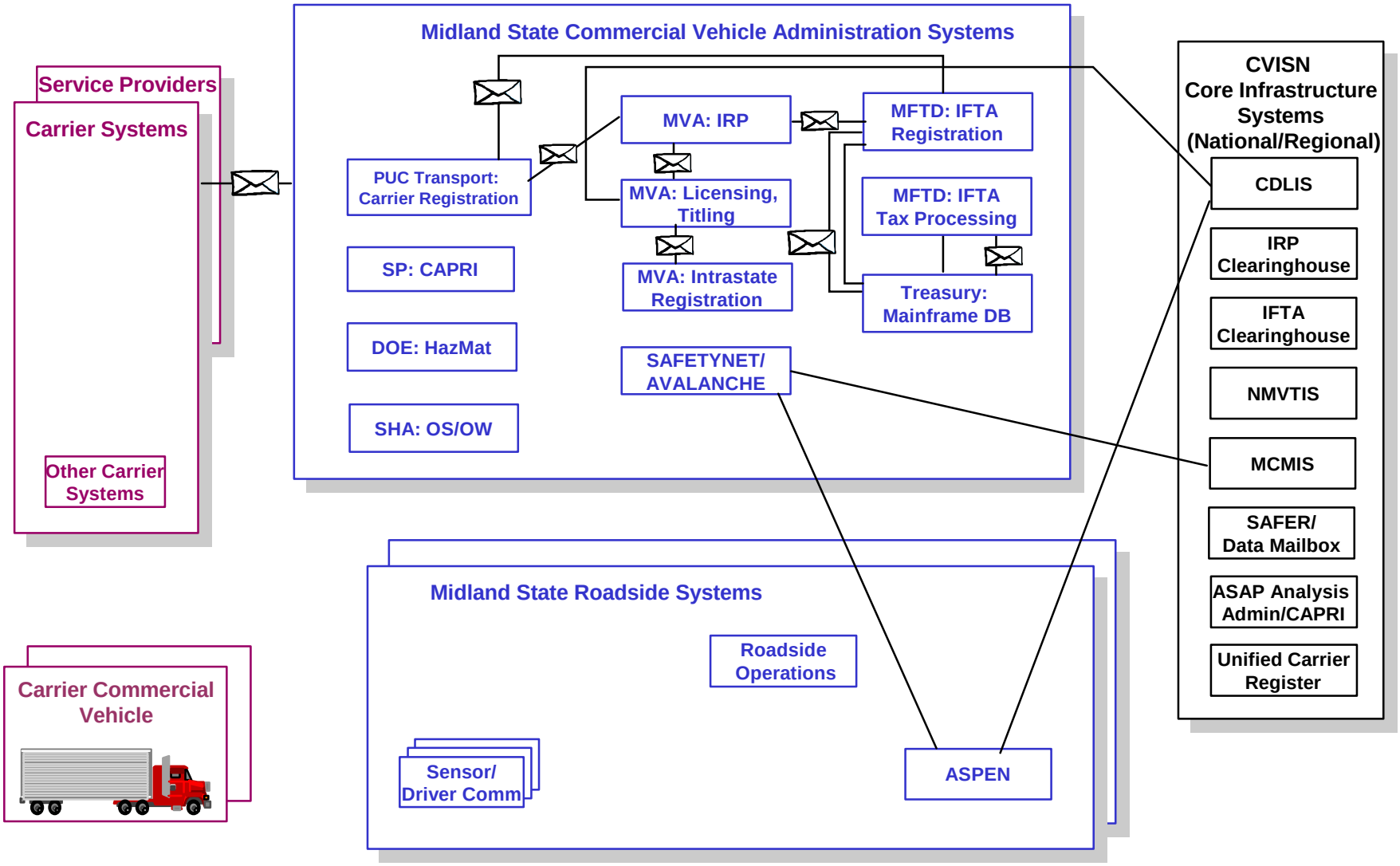
- A virtual private network (VPN)
  - Is a private data network that makes use of the public telecommunication infrastructure, maintaining privacy through the use of a tunneling protocol and security procedures.
  - Makes it possible to have the same secure sharing of public resources for data.
  - Applies to both extranets and wide-area intranets.
  - See http://whatis.com/vpn.htm and http://www.teledotcom.com/0597pl/tdc0597plvpn.corp.html

- IPSec (Internet Protocol Security)
  - Is a developing standard for security at the network or packet processing layer of network communication (as opposed to the application layer).
  - Applies to virtual private networks and for remote user access through dial-up connection to private networks.

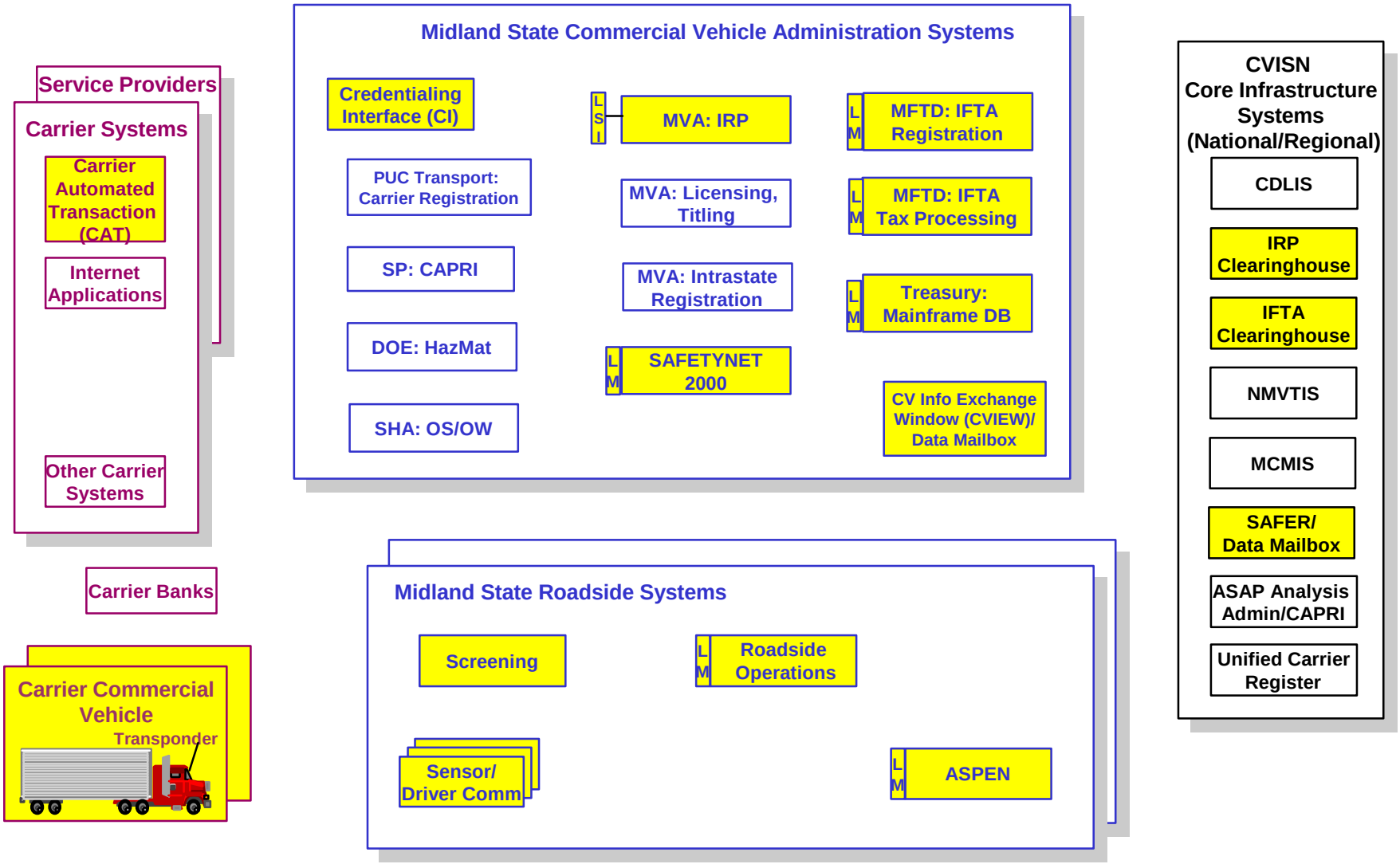
- IPSec (continued)
  - Provides two choices of security service:
    - Authentication Header (AH): authenticate the sender of data
    - Encapsulating Security Payload (ESP): authenticate the sender and encrypt the data
  - See http://whatis.com/ipsec.htm and http://www.cisco.com/warp/public/732/Security/

- Industry is developing protocols to use the internet as part of a private network:
  - ATMP (Ascend Tunnel Management Protocol) (Ascend)
  - PPTP (Point-to-Point Tunneling Protocol) (Microsoft)
  - L2F (Layer 2 Forwarding) (Cisco Systems)
  - L2TP (Layer 2 Tunneling Protocol) (Microsoft and Cisco combined)
  - See http://www.interlinkweb.com/~main/vpn-virtual-private-network-encryption-pdf.htm, http://www.microsoft.com, and http://www.cisco.com

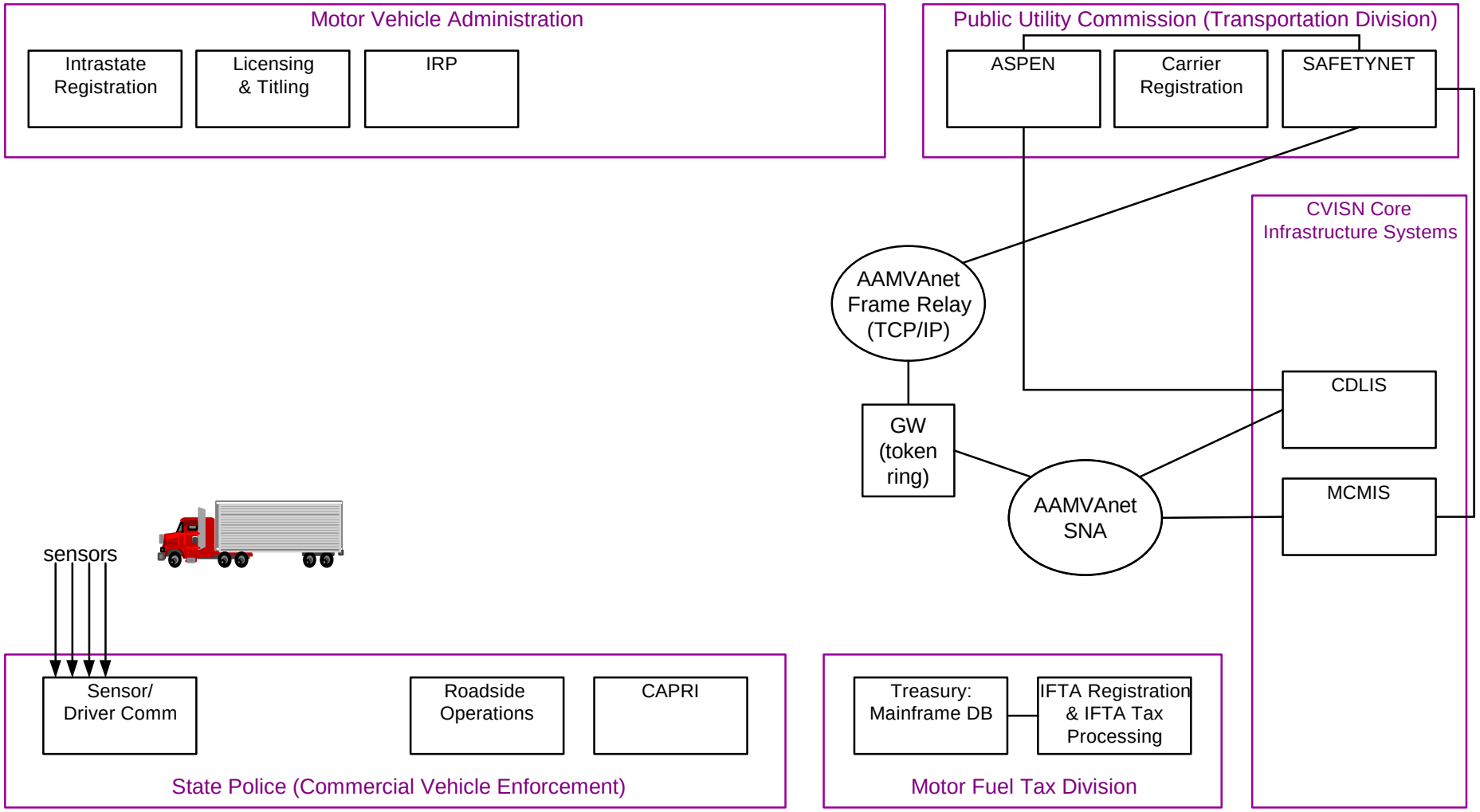
Current Midland design - many paper interactions



Proposed Midland system design template



Current Midland network template



Current Midland network template

- There are five “areas”, indicated by the large rectangles:
  1. Motor Vehicle Administration
  2. Public Utility Commission
  3. CVISN Core Infrastructure
  4. Motor Fuel Tax Division
  5. State Police

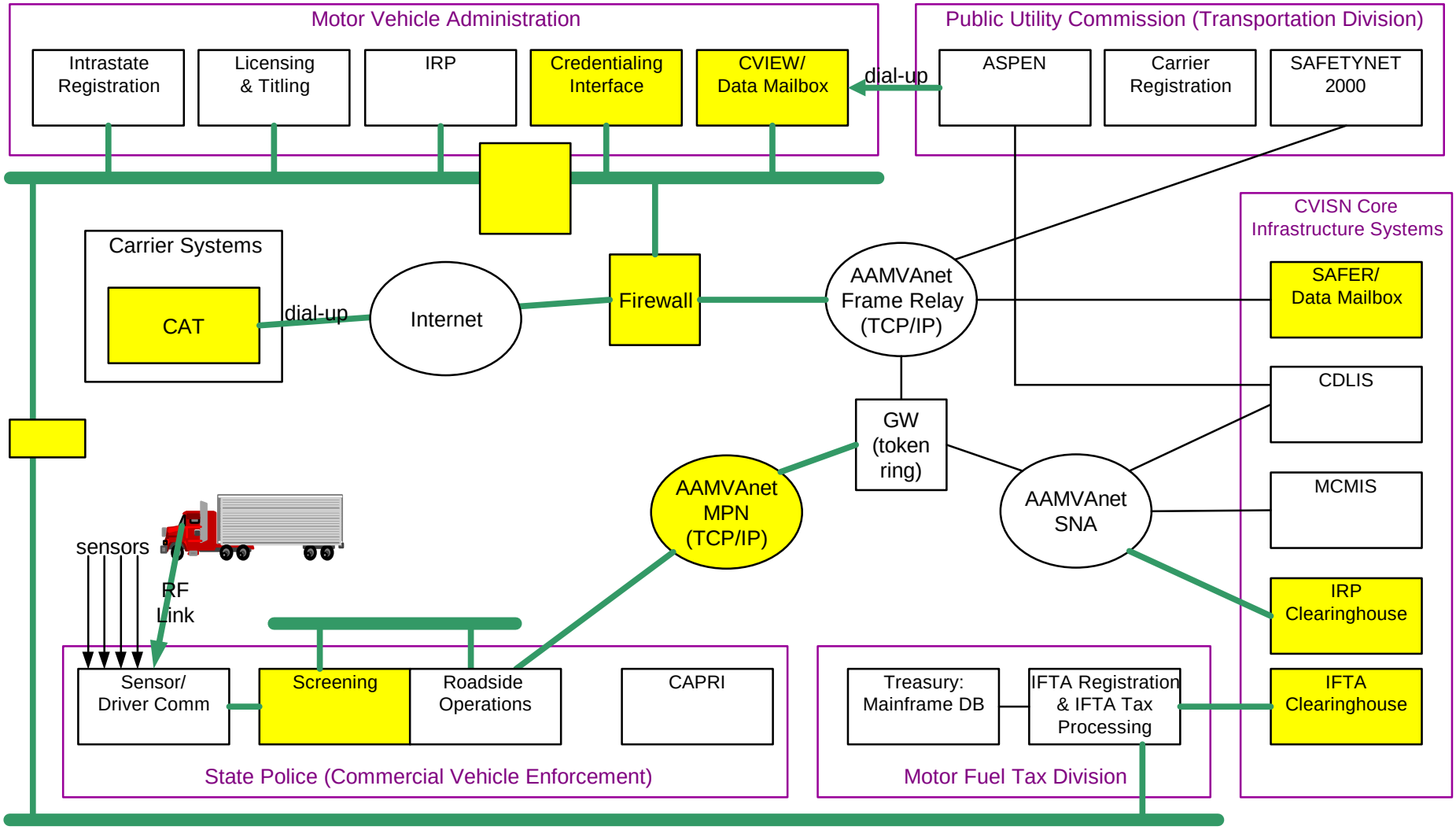
- Each small box drawn with solid lines represents a computer system. The software applications running on the computer are listed inside the box.

- There is currently, only one external network: AAMVAnet SNA.

- The solid lines indicate which computers are currently connected to each other:
  a) ASPEN is connected to SAFETYNET and CDLIS
  b) SAFETYNET is connected to ASPEN and MCMIS
  c) CDLIS is connected to ASPEN and MCMIS
  e) MCMIS is connected to SAFETYNET and CDLIS

- Notice that there are no other connections on this current network.

Proposed Midland network template



Proposed Midland network template

- New networks and network connections are shown in **GREEN dashed lines**.
- New computer systems and new networks are highlighted in **YELLOW**.
- There are still the five original areas, but there are new/additional computer systems:
  1. CI
  2. CVIEW
  3. Screening
  4. IFTA Clearinghouse
  5. IRP Clearinghouse
  6. SAFER
- There are new network pieces:
  1. Gateways or Repeaters to connect different types of networks.
  2. The Firewall between the Internet and the AAMVAnet Frame Relay.
  3. The AAMVAnet Multi-protocol Network (MPN)
  4. The RF link between the commercial vehicle and the Sensor/Driver Comm
  5. The new LAN in the MVA area.
  6. The new LAN in the State Police area.
  7. The dial-up connections between ASPEN and CVIEW and between ROC and the AAMVAnet MPN.
  8. The new LAN/WAN to connect the Motor Fuel Tax Division and the MVA.

  Note that we don't show exactly what kinds of network components will be used . . . yet.
- There are many new network connections between the Midland computer components.
- CVISN Core Infrastructure systems and their existing connections have been added.
- The Carrier Automated Transactions (CAT) product and its connections for electronic credentialing have been added.

Recap and Questions

The objectives . . .

- Explain the key differences among various network technologies
- Understand EDI
- Discuss common issues with connecting information systems
- Understand how to use the network design template

Any questions?