Chapter 2

SNA STRUCTURE

SNA functional layer [3]

The SNA structure specifies the responsibilities of functionally discreate layers in every node. SNA describes the interaction of each layer with a peer layer in other node. Figure below show the relationship between each component in SNA and non-SNA structure

```
      SNA STRUCTURE                        NON-SNA STRUCTURE

------------------------------    -------------------------------
]Application Layer (Program) ]    ] Application processing      ]
]----------------------------]    ]-----------------------------]
]Function Management Layer   ]    ]     ]  Formatting of data   ]
]                            ]    ]     ]  and device control   ]
]----------------------------]    ]     ------------------------]
]Transmission Subsystem Layer]    ] Management of control unit  ]
]                            ]    ] and connection link         ]
------------------------------    -------------------------------
              ]                                 ]
              ]                                 ]
              ]                                 ]
              ]                                 ]
------------------------------    -------------------------------
]Transmission Subsystem Layer]    ]       Control  unit         ]
]----------------------------]    ]-----------------------------]
]Function Management Layer   ]    ]        Device               ]
]----------------------------]    -------------------------------
]Application Layer (Program) ]
------------------------------
```

Figure 2-1 Comparison of SNA and non-SNA structure

Each layer communicate with a counterpart layer in another node. SNA describe the means by which these peer layers communicate. This type of communication is shown in figure below as peer layer communication , which had been used in the ARPA* network.

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*ARPA : Advanced Research Project Agency of The Department of Defense.

```
+--------------------------------+
]Application Layer (Program)   B ]<------+
]------------------------------↕-]       ]
]Function Management Layer     B ]<---+  ]    A = peer layer
]------------------------------↕-]    ]  ]        communication
]Transmission Subsystem Layer  B ]<+  ]  ]
+--------------------------------+ ]  ]  ]
                                   ]  ]  ]
                                   ]  ]  ]
                                   A  A  A    B = adjacent layer
                                   ]  ]  ]        communication
                                   ]  ]  ]
+--------------------------------+ ]  ]  ]
]Transmission Subsystem Layer  B ]<+  ]  ]
] -----------------------------↕-]    ]  ]
]Function Management Layer     B ]<---+  ]
]------------------------------↕-]       ]
]Application Layer (Program)   B ]<------+
+--------------------------------+
```

Figure 2-2 Communication between layers

The communication between adjacent layers in the same node is defined by the individual product. SNA describes functional relationship between these layers but does not define the format for adjacent layer communication. For example, SNA does not define the Virtual Telecommunication Access method (VTAM) macro instructions that a System/370 application program uses to access the network . So, formats and protocols for adjacent layer communication within a system would not be standardized.

SNA and International Standards.

In the International Organization for Standardization (ISO), a provisional architecture model has been introduced as in figure below. The model consists of seven functional or control level. For example, the first level is the CCITT interface recommendation X.21 for leased and switch circuit services. The second level is the 'ISO' high level data link control (HDLC) procedures. The CCITT interface recommendation X.25 for packet-switch series is an example of an implementation at all of the first three levels.

```
 ---------------------------------------
 ]  7 Application                      ]
 ---------------------------------------
 ]  6 Presentation Control             ]
 ---------------------------------------
 ]  5 Session control                  ]
 ---------------------------------------
 ]  4 Transport end to end control     ]
 ---------------------------------------
 ]  3 Network Control                  ] <-----
 ---------------------------------------      ]
 ]  2 Link control                     ]      ]
 ---------------------------------------      ]
 ]  1 Physical control                 ]      ]    peer to peer
 ---------------------------------------      ]    protocol
                                              ]
                                              ]
 ---------------------------------------      ]
 ]  1 Physical control                 ]      ]
 ---------------------------------------      ]
 ]  2 Link control                     ]      ]
 ---------------------------------------      ]
 ]  3 Network Control                  ]  <----
 ---------------------------------------
 ]  4 Transport end to end control     ]
 ---------------------------------------
 ]  5 Session control                  ]
 ---------------------------------------
 ]  6 Presentation Control             ]
 ---------------------------------------
```

Figure 2-3 Peer to Peer protocel

The seven ISO levels have SNA counterparts (figure 2-4). This functional corespondence ensures structural compatibility of SNA and the model. However, the formats and protocols do not matching bit by bit.

```
                    ISO model                                 SNA
          +-+-------------------------------+   +-+----------------------+
control   ]7]Application                    ]   ]7]End user              ]
level     ]6]Presentation Control           ]   ]6]Presentation service]
          ]5]Session control                ]   ]5]Transmission and      ]
          ] ]                               ]   ] ]data flow control     ]
        ( ]4]Transport end to end control]      ]4]                      ]
Trans-  ] ]3]Network Control                ]   ]3]Path control          ]
 port   < ]2]Link control                   ]   ]2]Link control          ]
service]  ]1]Physical control               ]   ]1]Physical control      ]
        ( +-+-------------------------------+   +-+-----------------------
```

Figure 2-4 ISO model and SNA counterparts

Level 1, or physical control layer, is the physical interface between system components called data transmission equipment (DCE) and data circuit terminating equipment (DCE). Current examples of level 1 standards are CCITT recommendation V.24 for telephone networks and X.21 for data networks. SNA products currently implement V.24 (and V.25 for autocall on switched telephone network in some cases). The implementation of X.21 in SNA provide IBM's products to be attach to data networks.

Level 2, or link control layer, provides transmission over a single data link between two user systems. Current examples are ADCCP, ISO HDLC and IBM SDLC which is a subset of HDLC.

Level 3, or network control layer, provides control between two adjacent nodes. For example, the packet level of X.25 provides networks control between an end user node and an access node of a public data network. Path control in SNA provide a function similar to ISO level 3.

Level 4, or transport end to end layer, provides control from user node to user node access a network included addressing, data assurance, and flow control. In SNA, the composite of path, link anf physical control layer is called transport subsystem or transmission subsystem.

Level 5, or the session control layer, establishes, maintains , and terminates logical connections for transfer of data between end users. In SNA, the functions of this level are provided by transmission control and data flow control . Transmission control activates and deactivates SNA session between end users . Data flow control enforces dialog control between end users.

Level 6, or the presentation control layer, provide data formats that might includes the control words for display screens or printers, also the code translations. In SNA, the function of ISO level 6 are provided in presentation services. These SNA services may include transformation (such as data compression), additions (such as column heading for display screen), and translations (such as program commands into local terminal language). Example of presentation services in IBM software can be found in Customer Information Control System (CICS) and the Information Management System (IMS).

Level 7 is the application layer.ISO standard for this level are not yet defined. In SNA, the end users provides this functional level. The end user is a person or process that want to use an SNA network; and end user may be internal or external to an SNA node, External end users may be human operation, internal user may be application programs resident in a node.

SNA Network Node [17]

The early computer networks emphasized communication between a terminal and a program in the computer. SNA networks continue this support but are also designed to support communication between programs in different nodes. SNA distinguishes different types of nodes by their network capabilities and logical relationship rather than by geographical location or physical configuration. There are four types of SNA node.

1 Host node (CPU)
2 Communication controller node
3 Cluster node
4 Terminal node

A host node is a job oriented general purpose computer supporting the SNA formats and protocols. A current implementation is the System/370 virtual storage computer with Virtual Telecommunication Acess Method (VTAM). The application program uses facilities of the host function management and transmission subsystem layers to communicate with end users in other node. Most channel attached input/output devices such as card readers and printers are part of the host node. These devices are controlled by programming in the host.

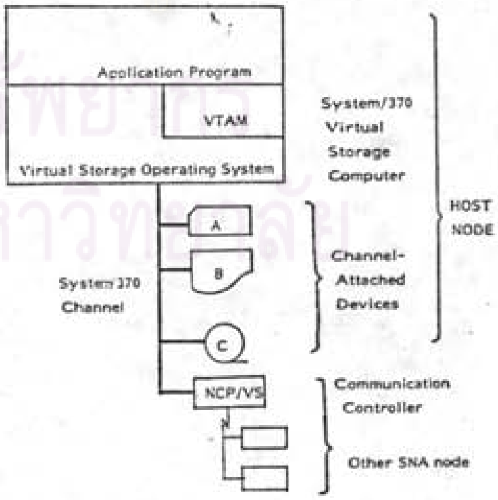

Figure 2-5 Coexistence of SNA nodes and host devices.

In figure 2-5 devices A,B,C are the parts of host node rather than individual nodes. These devices are not directly addressable from other nodes of the network.

A communication controller node supports end user communication by interconnecting other networks nodes . The transmission subsystem of this node reduces the network management responsibilities of the host node. The communication controller contributes important intigrity and recovery characteristics to an SNA network. It can provide two basic facilities. As a relay facility, the communication controller acts as an intermediate node that routes the message to the next node in the path through the network. As a bounary facility, the communication controller node shield the cluster from the complixities of network operation. It can converts full network address into simple formats for cluster operation and paces data flow based on the dynamic requirements of the cluster.

A cluster node has two basic components, the cluster control unit and terminals. The cluster control unit is usually a specialized subsystem which has the concept of programmable device. Some clusters can be a computer which have several devices connected to them. Figure 2-6 shows how the clusters can attatch to the system. Some clusters can be attatched by either directly to a System/370 channel or to a communication line. The application program communicates with end users of the channel attached cluster and remotely cluster in the same way.

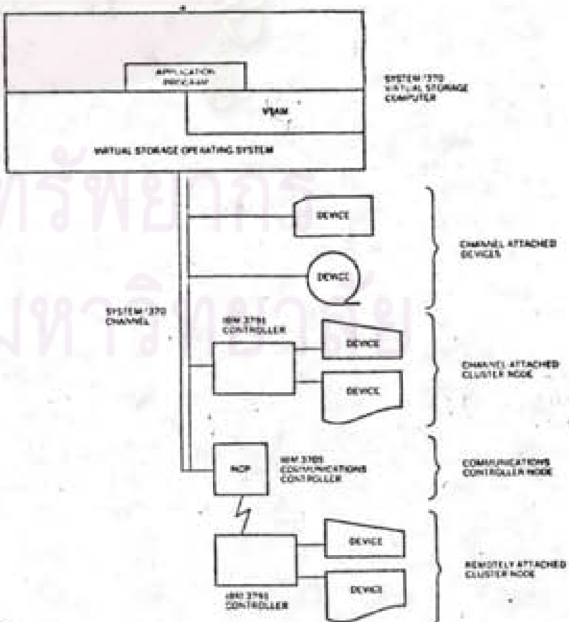

Figure 2-6 Channel and remote attachment of cluster

The layered structure of the host and cluster nodes is compared in figure 2-7. The architectural organization of the two nodes is identical but the capability of each layer and the details of the implementation depend on the specific functions of each node. Cluster logic can consists of hardware logic and application programming. Some programmable clusters are not small control units, but can support multiple applications simultaneously, for example the Distributed Data Processing System.

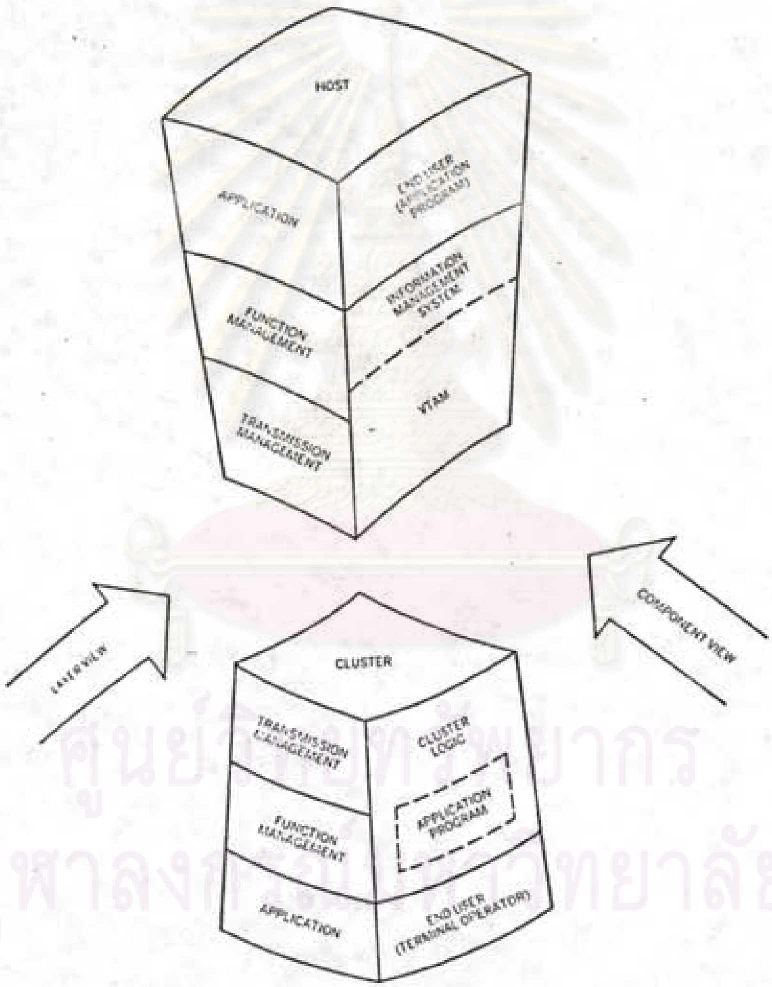

Figure 2-7 Structure of host and cluster nodes

Public data networks.

Public data networks are first available in 1973. Each country has its own public data networks; for example TELENET, TYMNET, ATC ACS in United States, TRANSPAC in France, NPSS in United Kingdom or DDX in Japan Since there is no public data network available in Thailand now, the only way to attach to the network was made by means of EIA RS232C or CCITT 'V' series interfaces which had been developed for attachment to analog facilities. RS232 circuits and functions are generally equivalent to CCITT V.24/V.28 interface recommendations. To enable automatic call set up on circuit switched networks (dial lines), RS232 was supplemented by a autocall interface, RS366, and V.24 by V.25. This section will brief how to connect SNA networks node to public data network.

Interface to Public data networks.

Public data network may be considered as a structure of ISO model. Figure 2-8 illustrates the X.25 case where the Data Terminal Equipment (DTE) has the full ISO model complement of seven levels, and network nodes have only three levels needed to provide X.25. Since the protocols above level 3 are not directly involved in the network to DTE interface, the four upper level will not be discussed in this section. Only 3 levels will be emphasized: X.21 at level 1,HDLC (i.e. SDLC) at level 2,and X.25 at level 1,2,3.

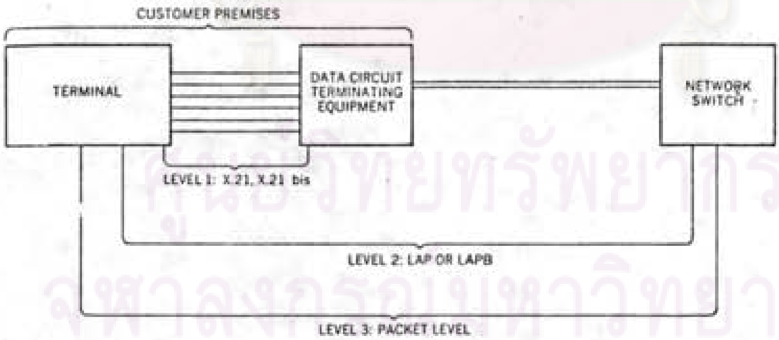

Figure 2-8 X.25 levels

Level 1, the X.21 interface can be used for point to point,leased private line services. New drivers and terminators circuits, connectors and cables will be required in DTE to take advantage of improved technical characteristics such as greater noise immunity and higher bit rates offered by X.21. However , SNA products with new interface adapters will operate with X.21 leased service without architecture modification.

Since SNA has already handled circuit-switched service (similar to dial circuit) the necessary SNA extensions for X.21 switched services are minor. Needed extensions are some small additions to the SNA in inoperative command.

Enhancements to X.21

X.21 functionally replaces the terminal to modem and automatic calling interfaces EIA RS232C (CCITT V.24) and EIA RS366 (CCITT V.25) as shown in figure 2-9. Some advantages of the X.21 over the older interface.

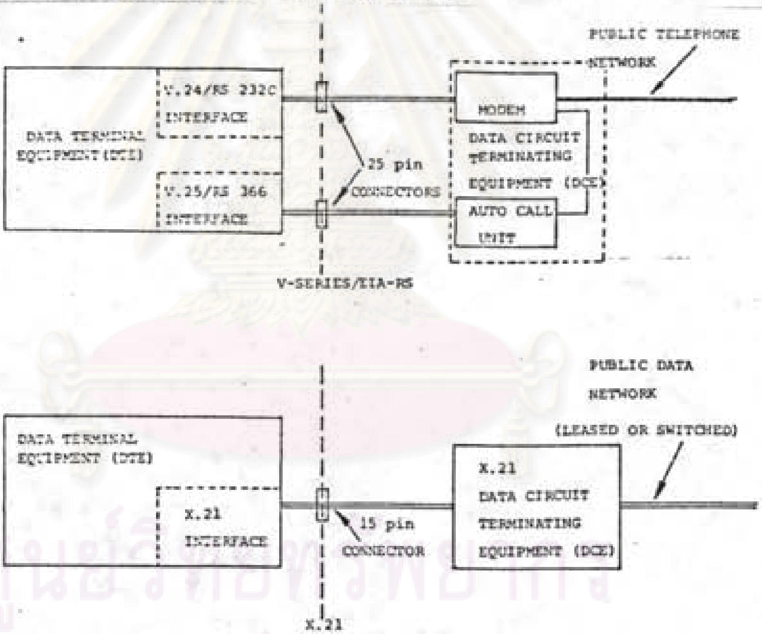

Figure 2-9 Comparison of CCITT V series and X.21 interface

1 Fewer interchange circuits and pins, A maximun of 6 interchange circuits and one 15 pin connector are utilized, as compared to about 30 interchange circuits and two 25 pin connectors for RS232C/RS366 when these interfaces are used in auto-call configuration. In X.21 terminal and network control signals are sent by code strings on the receive and transmit circuits rather than by discrete circuits as in

RS232C or V.24. This factor permits the number of interchange circuits to be reduced and also provides for possible future extension of control signals.

2 To improve electrical characteristics. X.21 incorporates a provision of the physical interface for newly developed, LSI-compatible, balanced circuits, capable of operation up to 1000 meters, at bit rates up to 100 kilobits per second and up to 10 megabits per second at 10 meters. This operation is a major improvement over a typical RS232C or V.24 operation, which operates only 50 feet or less at bit rates below 20 kilobits per second.

3 Enhanced functional capability without sacrifice of data transparency. One of the unique features of public data networks utilizing the X.21 interface is the ability of the network to communicate detail call states information directly to the using terminal. Call progress signals such as number busy, access barred, and changed number are passed from the network to the call originating terminal to tell a user why a particular call was not completed. These signals also indicate call clearing due to network problems and normal completions. The utility of circuit-switched networks using CCITT X series recomondations is futher enhanced by their promission of a variety of a network implementation, activation of the desired facilities may be accomplished either when subscribing to the network by means of the attached terminal. At this time, seven user facilities for circuit-swithed services are included in the applicable CCITT X.2 is described on table 2-1

User facility	*Function*
Direct Call	Calling subscriber is connected to a predesignated subscriber. No selection (dial signals) needed.
Closed User Group	Subscriber will only accept calls from predesignated subscribers and can only make calls to predesignated subscribers.
Closed User Group with Outgoing Access	As Closed User Group but can call any subscriber.
Calling Line Identification	Network advises called subscribers of who is calling before data transfer phase is entered. Called subscriber can reject call.
Called Line Identification	Network confirms to calling subscriber the number of called subscriber with whom connection is about to be made.
Abbreviated Address Calling	Requires fewer characters than the full address when initiating a call. Network expands abbreviated address to full address.
Multiaddress Calling	Data is sent to multiple subscribers.

Table 2-1 X.2 user facilities for circuit switched PDNs.

X.21 describes the recommended operation in four phases that are listed below. The network provides bit clocking to the terminal during all phases.

1 Quiescent Phase: Applicable to both circuit-switched and leased-circuit service, this is the nonactive phase during which the network and terminal indicate ready or not ready status.

2 Call establishment Phase: to establish a circuits switched connection, the terminal communicates with the network by way of the transmit and receive circuits using the characters of CCITT International Alphabet Number 5-IA5 is basically similar to ASCII. SYN characters are used to obtain and maintain chracter synchronization between the terminal and network during this phase.

3 Data Transfer Phase: Indicated by a unique state of the X.21 interface control circuits, a full-duplex transparent transmission path is maintained between user terminals for circuit-switched and leased-circuit services.

4 Clearing Phase: To release a circuit-switched connection, either the terminal or the network initates a clear-request. The network will then clear the connection, and the interface will return to quiescent state (Phase 1).

Figure 2-10 shows an example of the sequence of events at the terminal (DTE) to network (DCE) interface for a call and clear operation on a circuit-switched network. T (Transmit), C (Control), R (Receive), and I (Indication) are four of the six interchange circuits previously mentioned, and their binary states are shown during operations. The circled numbers and titles beside them are X.21-defined states. The operational sequence flow down the diagram in Figure 2-10.

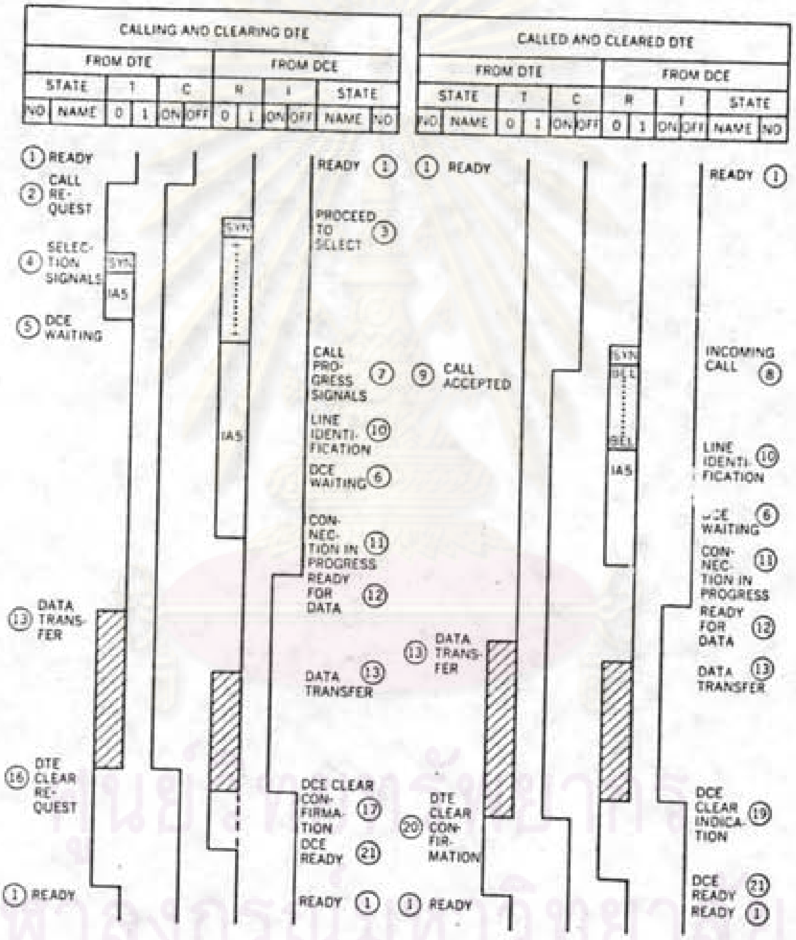

Figure 2-10 X.21 Interface signal sequence diagram

CCITT recommendation X.21 bis is an interim interface designed to allow terminals using RS232C and RS366 (CCITT V.24,V.25) to operate in the new X.21 networks with no changes in their design; however, they will not be able to take advantage of many new functions, such as call progress signals and facility requests, available with X.21. A network interface unit providing the X.21 bis interface converts V.24 (RS232C) signal sequences to sequences and waveforms compatible with the digital

At level 2, a single data-link control is implemented for each X.25 interface. This may be either LAP or LAP-B. According to the CCITT survey published in November, 1978, there are 11 countries planning LAP- B and three that have both versions. The existing SNA implementation of X.25 uses LAP to match specification for the two networks to which it provides an interface. However, provision for the LAP-B would not be difficult in the current SNA implementation; moreover, the trend toward LAP-B observed in the CCITT survey is sound because it should lead to SDLC compatibility.

The conceptual base for Level 3 of X.25 is the virtual circuit . When an X.25 virtual call is set up, one of 4095 virtual circuits is assigned to the call. Interleaved packets are used to set up and clear virtual call as well as to transfer data packets on individual virtual circuits. Since each virtual circuit has its own flow control , any one circuit user can be prevented from excessively degrading service to other circuit users. Another important user advantage in virtual circuits is that a central processing site may communicate with many remote terminals by means of a single X.25 interface. In effect, a single real circuit can be treated as multiple virtual circuits. Although the theoretical limit of 4095 simultaneous virtual calls will not be achieved in practice, the multiple-call capability brought by the virtual-circuit concept is useful.

To achieve the advantages of virtual circuits at Level 3 of X.25, several diverse implementations of an SNA to X.25 interface are possible. Figure 2-11 is a simplified overview of implied design decisions related to architecture,network services and implementation technique.

From an architecture perspective, the many possible design of an SNA-X.25 interface may be typified by three: protocol insulation, link level mapping, and session level mapping. Protocol insulation implies encompassing every SNA frame completely within the data fields of X.25 packets.

Figure 2-11 indicates one example of using X.25 permanent virtual circuits, virtual call ,or both. Once a decision in favor of link level mapping is made, adaptations to both permanent virtual circuits and virtual calls may be provided. THe same SNA mechanisms that handle conventional private and switched lines can readily adapted to their X.25 analogs when link level mapping is used.

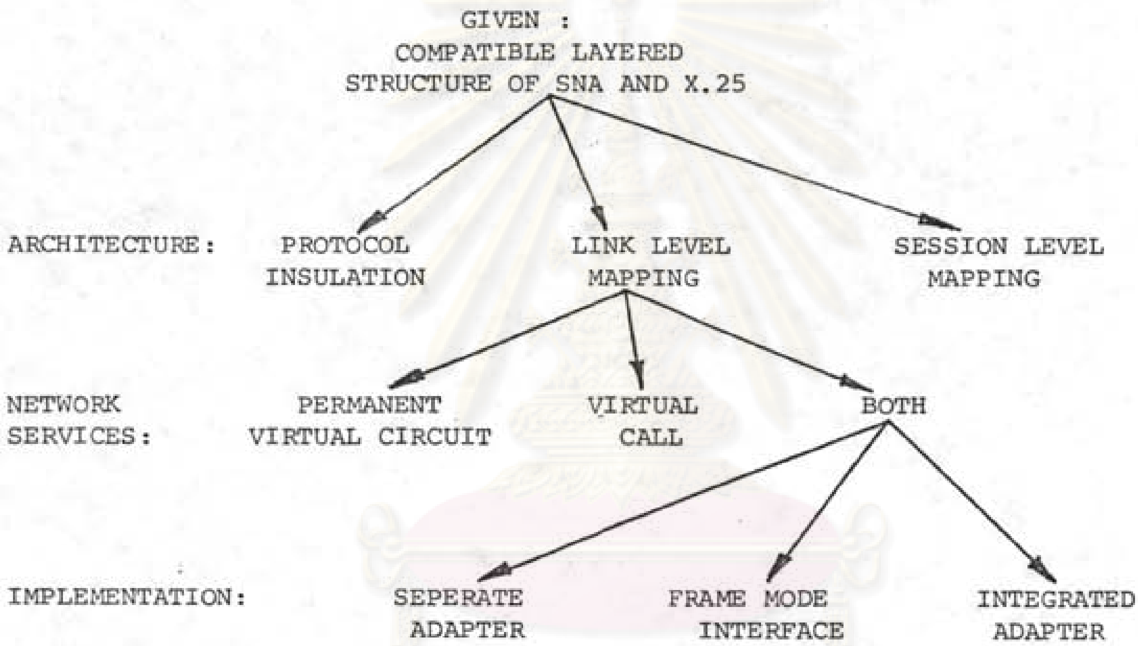

Figure 2-11 Simplified decision tree for design of the X.25 interface in SNA

The other choice in Figure 2-12 is the alternative for implementation. the X.25 interface at a host location is best handled by modified system software. However, the implementation of X.25 at a terminal location may be done in any of three ways . At the left of Figure 2-12, a seperately housed adapter unit performs a protocol transformation. This transformation protocol accepts a frame from SNA terminal or cluster controller fully adhering to

SNA formats and protocols. Then the unit breaks the message into correct X.25 packet sizes and creates appropriate X.25 packet headers. Since Level 2 protocol between the adapter and SNA terminal is SDLC normal response mode, the adapter unit polls the terminal. The terminal reacts to the poll just as it would if received from a distance host; data may flow in either direction between terminal and adapter unit. The separate adapter unit the converts to the version of X.25 Level 2 line control that the packet network designer chooses. None of the network Level 2 procedures employs polling; therefore, no packets with polls are transported across the network.

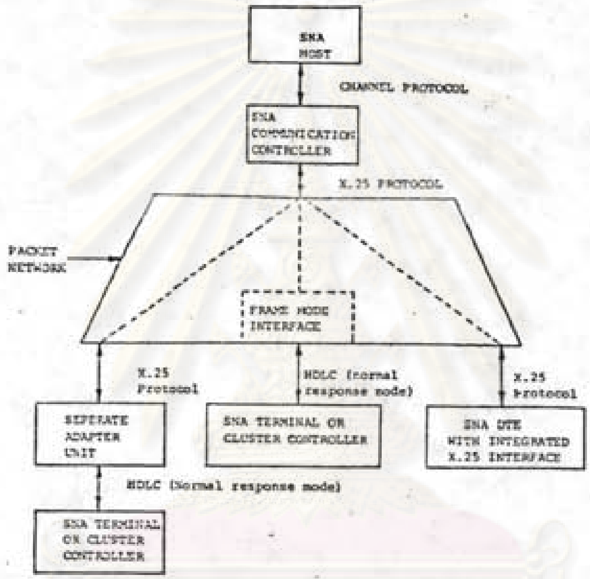

Figure 2-12 Three implementation alternatives for SNA terminals and cluster controllers.

At the right of Figure 2-12 is a second implementation example where the function of the adapter unit is integrated directly into the SNA DTE. This integration would probably mean adding X.25 microcode within the terminal in such a way that the code would be logically bypassed when the terminal uses leased-circuit or circuit-switched facilities. The elimination of a piece of equipment is clearly advantageous; however , each SNA terminal would have its own characteristics in terms of available microcode memory and logic cars space. According to a recent analysis for the Transpac packet network in France, there eleven manufacturers providing an intergrated X.25 terminal adaptation and nine (including IBM) providing a separate adapter unit.