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Modification of the Group 4 Validation System C-DCA100-91-C-0031

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This task was performed to modify the Group 4 Validation System to align it with revised CCITT Recommendations pertaining to Group 4 facsimile equipment. Section 2 of this report provides a general description of Group 4 Validation System. Section 3 discusses the system design in detail and Section 4 discusses the revisions to CCITT Recommendations pertaining to Group 4 facsimile equipment. Section 5 summarizes modifications to the Group 4 Validation System and suggests future areas of modification.

32

Group 4 Facsimile
Validation System

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NATIONAL COMMUNICATIONS SYSTEM

TECHNICAL INFORMATION BULLETIN 91-14

MODIFICATION
OF
THE GROUP 4 VALIDATION SYSTEM

DECEMBER 1991

OFFICE OF THE MANAGER
NATIONAL COMMUNICATIONS SYSTEM

ARLINGTON, VA 22204-2199

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MODIFICATION OF THE GROUP 4 VALIDATION SYSTEM

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FOREWORD

Among the responsibilities assigned to the Office of the Manager, National Communications System, is the management of the Federal Telecommunication Standards Program. Under this program, the NCS, with the assistance of the Federal Telecommunication Standards Committee identified, develops, and coordinates proposed Federal Standards which either contribute to the interoperability of functionally similar Federal telecommunication systems or to the achievement of a compatible and efficient interface between computer and telecommunication systems. In developing and coordinating these standards, a considerable amount of effort is expended in initiating and pursuing joint standards development efforts with appropriate technical committees of the International Organization for Standardization, and the International Telegraph and Telephone Consultative Committee of the International Telecommunication Union. This Technical Information Bulletin presents and overview of an effort which is contributing to the development of compatible Federal, national, and international standards in the area of facsimile. It has been prepared to inform interested Federal activities of the progress of these efforts. Any comments, inputs or statements of requirements which could assist in the advancement of this work are welcome and should be addressed to:

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CONTENTS

ILLUSTRATIONS

TABLES

1.0 INTRODUCTION

This document summarizes work performed by Delta Information Systems, Inc., for the Office of Technology and Standards of the National Communications System, an organization of the U.S. Government, under Task 2 of contract number DCA100-91-C-0031. The purpose of this task is to modify the Group 4 Validation System to align it with revised CCITT Recommendations pertaining to Group 4 facsimile equipment.

Section 2.0, "Group 4 Validation System Overview," provides a general description of the Group 4 Validation System. The description outlines the software and hardware design taken to satisfy the CCITT Recommendations governing the Group 4 facsimile telematic protocol structure.

Section 3.0, "Validation System Design," discusses the system design in detail. It reviews the hardware and software design approaches for implementing the telematic protocol structure.

Section 4.0, "CCITT Group 4 Recommendations Revisions," discusses the revisions to CCITT Recommendations pertaining to Group 4 facsimile equipments.

Section 5.0, "Summary and Areas of Future Study," summarizes modifications to the Group 4 Validation System and suggests future areas of modification.

1.1 Group 4 Background Information

Group 4 is the latest set of CCITT facsimile Recommendations, and was primarily designed for operation on digital, error-free, high-speed networks such as public data networks, packet-switched networks, and the ISDN. Moreover, there are three types of Group 4 equipments with characteristics as shown in Table 1-1:

Class 1: A terminal able to *send* and *receive* facsimile documents.

Class 2: A terminal, in addition to having Class 1 capabilities, able to *receive* teletext and mixed-mode[1] documents.

Class 3: A terminal, in addition to having Class 1 and Class 2 capabilities, able to *generate* and *send* teletext and mixed-mode documents.

Table 1-1. Group 4 Class Characteristics

	Class		
	1	2	3
Pel-density of scanner-printer (pels/25.4mm)	200	300	300
Pel transmission density (pels/25.4mm)	200	200/300	200/300
Pel transmission conversion capability	not required	required	required
Mixed-mode capability	not required	not required	required
Optional pel density of scanner-printer	300/400	400	400
Combined with pel transmission density (pel/25.4mm)	200/300/400	200/300/400	200/300/400
Storage	not required	not required	required

1 Mixed-mode documents contain a mixture of teletext and facsimile data on the same page. For example, a page consisting of line art and text could be sent as a mixed-mode document; the line art could be sent as facsimile data, and the text could be sent as teletext data.

These three classes provide a wide range of capability. For example, Group 4 Class 1 is similar to Group 3 (low capability), while Classes 2 and 3 permit interoperation with Teletex and mixed-mode equipments (higher capability). Nevertheless, being Group 4 compliant does not mean different classes of Group 4 equipments can interoperate. For instance, a careful examination of Group 4's communication protocols (See Figure 1-1) reveals slight differences which prevent communications between Class 1 and Class 3 equipments (T.521 versus T.522, etc.).

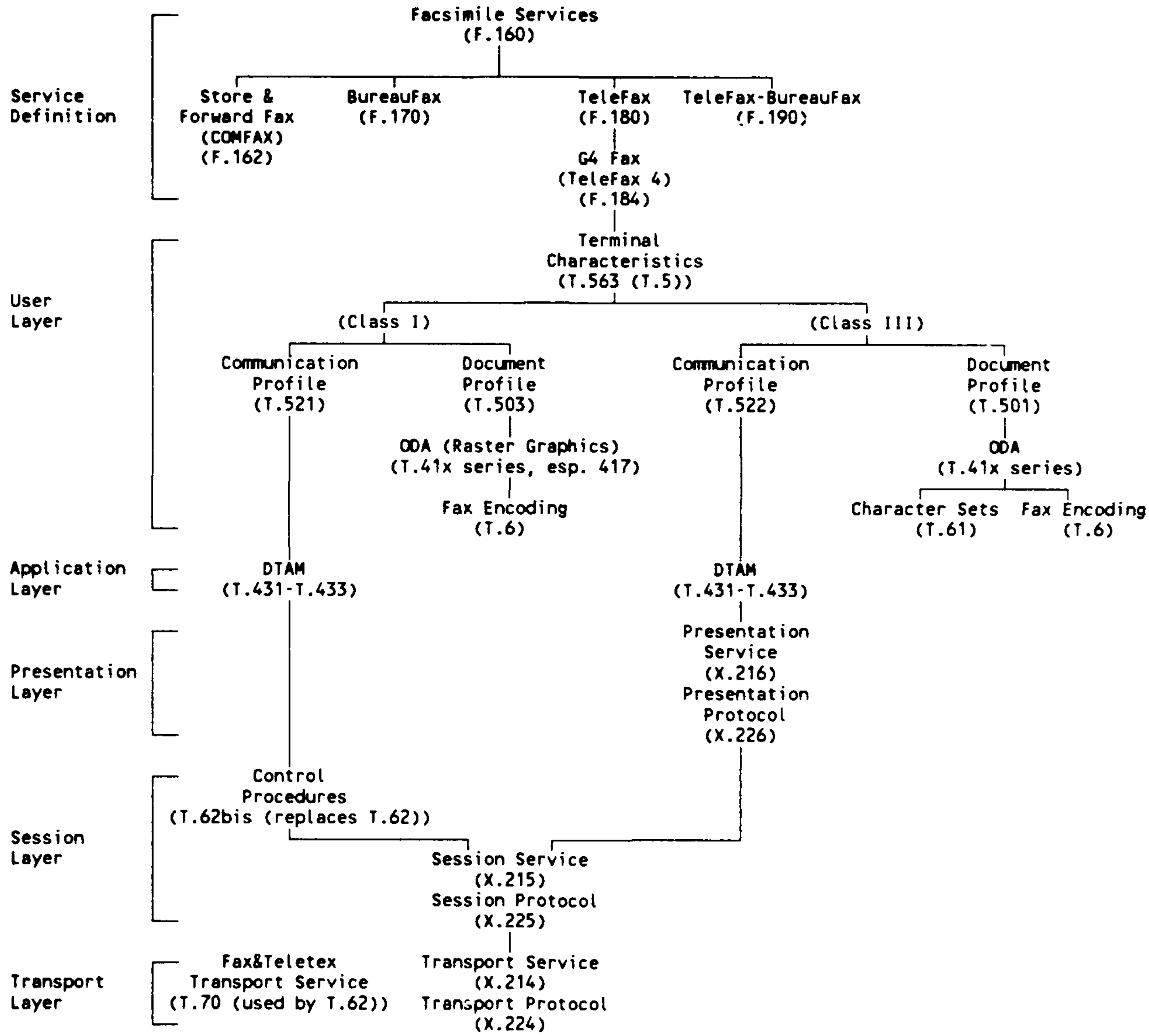


Figure 1-1. Hierarchy of CCITT Recommendations for Group 4 Facsimile

1.1.1 Communication Protocol

The development of the protocol structure for Group 4 has followed a rather rocky road and as a result its protocol and classes were fractured into two camps. One (Group 4 Class 1) uses a protocol designed specifically for Group 4 facsimile, while the other (Group 4 Classes 2 and 3) uses a protocol designed to connect to many different types of systems and equipments (computer systems, facsimile equipments, etc.). This fracture occurred for two main reasons: 1) the CCITT's Document Architecture Recommendations (DTAM), upon which Group 4 depends, were published prematurely (Recommendation T.73), and 2) the protocol for Group 4 Class 1 equipments was not made identical to the protocol for Group 4 Classes 2 and 3 when DTAM was later revised. The premature publishing of the DTAM Recommendations allowed several manufacturers to build Group 4 equipments (especially Class 1) with the underlying assumption that the CCITT Group 4 Recommendations, of which DTAM is a part, were stable. Unfortunately, this was not true. At this same time, the CCITT was considering incorporating into Group 4 the concepts embodied by the International Organization for Standardization's (ISO) Open Systems Interconnection (OSI) standard OSI is designed to permit many different types of systems to communicate with one another (especially computer systems), and is not tailored towards any particular equipment or system.[1],[2] The CCITT decided to make Group 4 OSI compliant, and as a result revised DTAM (now Recommendations T.431-433). This created a dilemma. The equipments made according to the original Recommendations (T.73, etc.) would no longer be Group 4 compliant. So, the manufacturers who had already made these equipments requested that Group 4 Class 1 equipments keep their original protocol, and they were accommodated. As a result, the CCITT also, inadvertently, excluded Group 4 Class 1 equipments from using the newer, OSI compliant protocol (Both protocols should probably have been allowed). Since then several attempts have been made to bring Group 4 Class 1 equipments in line with the revised DTAM Recommendations, and the OSI standards (See Figure 1-1, change from T.62 to T.62bis, and change from T.70 to X.215, etc.). Nevertheless, Group 4 Class 1 equipments are still unable to communicate with Group 4 Class 2 or Class 3 equipments, or vice versa.

In addition, Group 4, regardless of the protocol stack used, adheres to the CCITT's Open Document Architecture (ODA) concept. The ODA facilitates the interchange of documents to permit the following items:

- different types of content, including text, image, graphic, and sound, can coexist within a document.
- the intentions of a document originator with respect to editing, formatting, and presentation is communicated effectively.

To this end, ODA defines three forms of document representation:

Formatted Form	-	Documents are presented as intended by the originator.
Processable Form	-	Documents may be edited and formatted.
Formatted Processable Form	-	Documents may be presented, edited, and reformatted.

Of these three, Group 4 uses the formatted form.

1.1.2 Encoding Algorithm

The basic coding scheme is the same, in principle, as Group 3's two-dimensional coding scheme. Major differences between the two are 1) Group 4 does not use one-dimensionally coded lines, and 2) Group 4 does not use "end of line codes" except as end of facsimile information indicators (i.e., they are not present on a line by line basis). To jump start a document's facsimile encoding, Group 4 places an imaginary white line at the beginning of the facsimile data.

1.1.3 Transmission Rate

Intended Group 4 transmission rates are 56 kb/s and 64 kb/s (ISDN). If an 8½ x 11, 400 pel per inch document is sent compressed (say 10:1) at 64 kb/s, it will take 23.3 seconds for it to arrive at its destination. If it were a 200 pel per inch document, it would take 5.8 seconds.

1.1.4 Planned Future Expansion

The CCITT would like Class 3 terminals to be able to present documents, and permit editing and reformatting (Formatted Processable form).

In addition, the CCITT would like equipments adhering to the different classes to be able to interoperate. Some administrations are considering a new Group 4 Class 1 which would be able to interoperate with Classes 2 and 3, and which would coexist with today's Group 4 Class 1.

Finally, like Group 3, efforts are underway to simplify or permit Group 4's operation in audiographic conferencing, as well as permitting the transmission of gray scale and color documents.

2.0 GROUP 4 VALIDATION SYSTEM OVERVIEW

The primary purpose of the Group 4 Validation System (G4VS) is to test and evaluate Group 4 facsimile equipments. It verifies that Group 4 facsimile equipments, the units under test (UUTs), properly implement layers 3 through 7 of the telematic protocol structure for Group 4 facsimile equipments and conform to allowable parameter variations within each protocol layer (e.g. buffer sizes, timeouts, etc.). The telematic protocol structure adheres to the seven layer Open Systems Interconnect architecture (OSI). Testing of layers 1 and 2, the physical and link layers, is assumed to be done by other means. Nevertheless, protocol violations or unrecoverable errors are reported to the higher layers. Originally, the G4VS was implemented with layers 3 through 7 and all necessary control routines using Delta's HP 1000 processor. At present, it resides on an IBM compatible PC, and is being vigorously tested.

OSI is being evolved by the International Organization for Standardization (ISO) whose primary goal is to define standards to allow different systems to communicate, with a secondary goal of retaining existing standards whenever possible.

OSI consists of a seven-layer model or framework which ensures that all new communication standards are compatible. Secondly, a system obeying the OSI model in its communication with other systems is termed an "open system". The OSI open systems concept allows application processes to interact with any other application process anywhere in the world. The seven layers of the OSI model are divided among three different functions: user interaction, interface, and communication network interaction (See Figure 1-2).

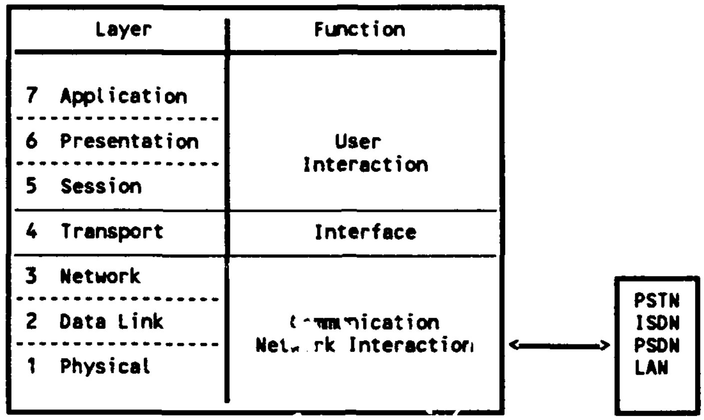


Figure 1-2. The OSI Model

The seven layers have the following definitions:

Application	-	The highest level. It is the user interface between services and the OSI environment.
Presentation	-	The presentation layer handles session establishment and termination requests, and it preserves the meaning of data while resolving syntax differences.
Session	-	The session layer establishes, manages, and releases the communication connection.
Transport	-	Acts as a consistent interface between the application-related functions and the transmission-related functions.
Network	-	Provides routing and relaying through switched telecommunication media.
Data Link	-	Reliably transfers all information over the physical transmission media.
Physical	-	Deals with the transmission of a bit stream, regardless of its meaning, across a physical communication medium.

The G4VS consists of four main parts: a system executive, a test controller, a Group 4 terminal emulator, and a pseudo Group 4 UUT. The system executive, test controller, and terminal emulator are the heart of the G4VS. The pseudo Group 4 UUT (controlled by the system executive) permits a thorough testing of the system on a stand-alone basis. For "live" tests, a real UUT replaces the pseudo UUT. The system executive controls the execution of selected tests and verifies that the Group 4 UUT is operating correctly. The terminal emulator simulates a "model" Group 4 terminal and performs all operations as requested by the system executive and test controller.

Software for the G4VS was written in Fortran 77 to maximize transportability between operating systems. Furthermore, its design and development used top-down structuring techniques which produced software that is highly modular and easily modified. An advantage when attempting to keep the software aligned with evolving CCITT Recommendations.

3.0 VALIDATION SYSTEM DESIGN

3.1 System Concept

Since the basis for Group 4 Facsimile equipment is the Telematic protocols as described in the CCITT recommendations, listed in Figure 3-1, the validation system software's primary responsibility is the implementation and validation of these protocols. Along with this requirement, the validation system must also be capable of specifying and testing the different parameters/variables allowed within each of the protocol layers as defined in the recommendation for that layer. Shown in Figure 3-2 is a functional block diagram of the validation system software. From an overall point of view, the validation system drives two (2) operations - the UUT and the G4 terminal emulator - and compares the results. The emulator acts as a "golden" model against which the performance of the UUT is compared, giving due allowance for permissible variations in operation. By substituting another copy of the emulation and its interface for the UUT, the validation software itself can be tested, with the help of both proper and selected improper variation controls applied to the "UUT" emulation. In operation, the system executive functions as the user layer (a pseudo layer 7.5), along with the operator interface and the test package data. An event queue functions as the command and data channel, in both directions, between the system executive and the two validation instantiations; the queue, in effect, functions as the link between the software portion of the system resident on the validation processor and the UUT. The system executive starts and stops processes, in response to commands via the operator interface and completion (successful or not) indications from the validations, and also examines the event queue to determine which modules to poll for action. Each module, when polled, modifies a state (or substate) or moves data as appropriate; the comparator is then called to determine if the action taken was permissible, via comparison with the "good" model, in some cases forcing the latter to match the actual UUT's (or in test mode, the possibly faulted validation's) action, if a permissible variation.

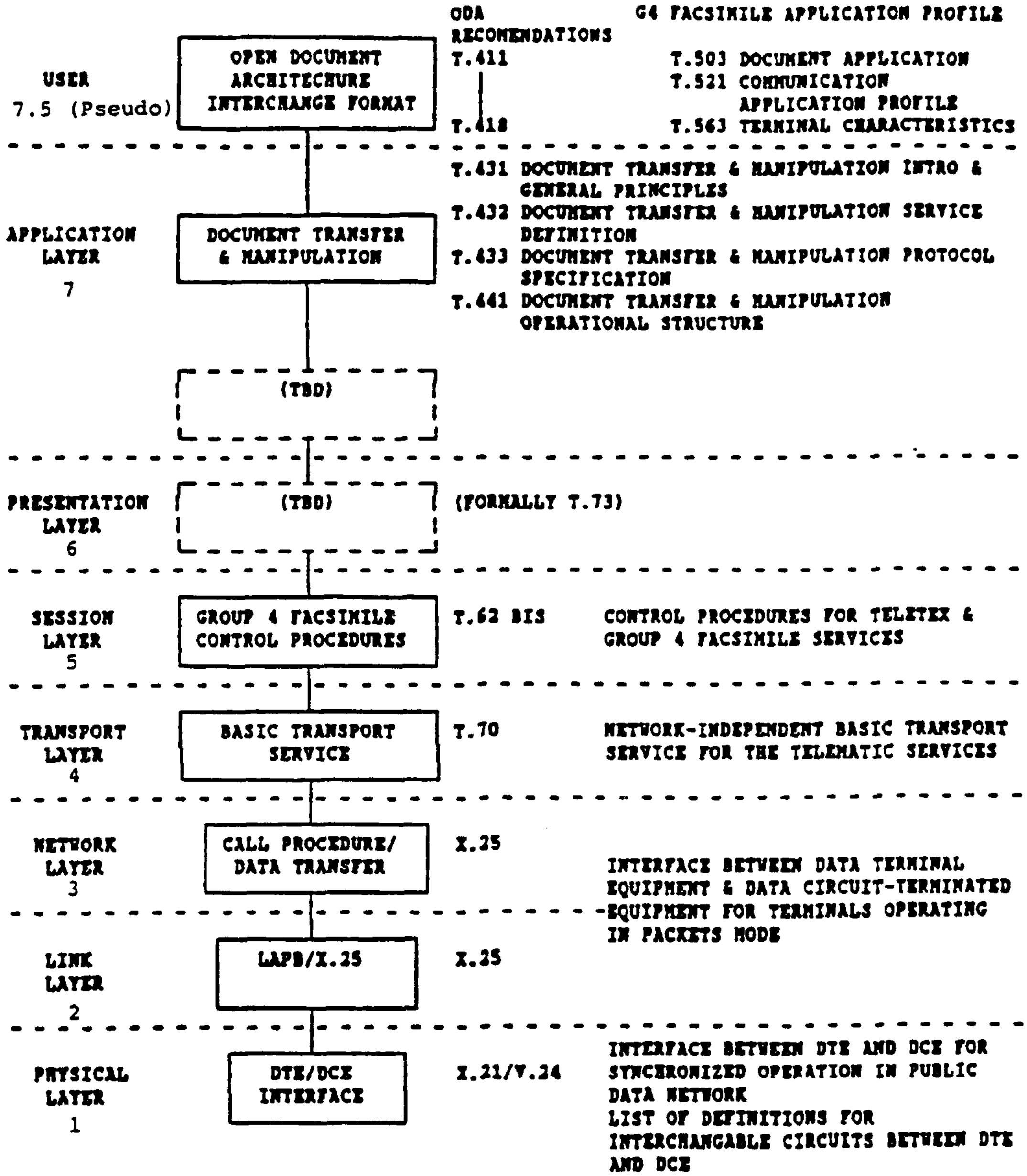


Figure 3-1. CCITT "Blue Book" Recommendation by Layer for Class I Group 4 Facsimile

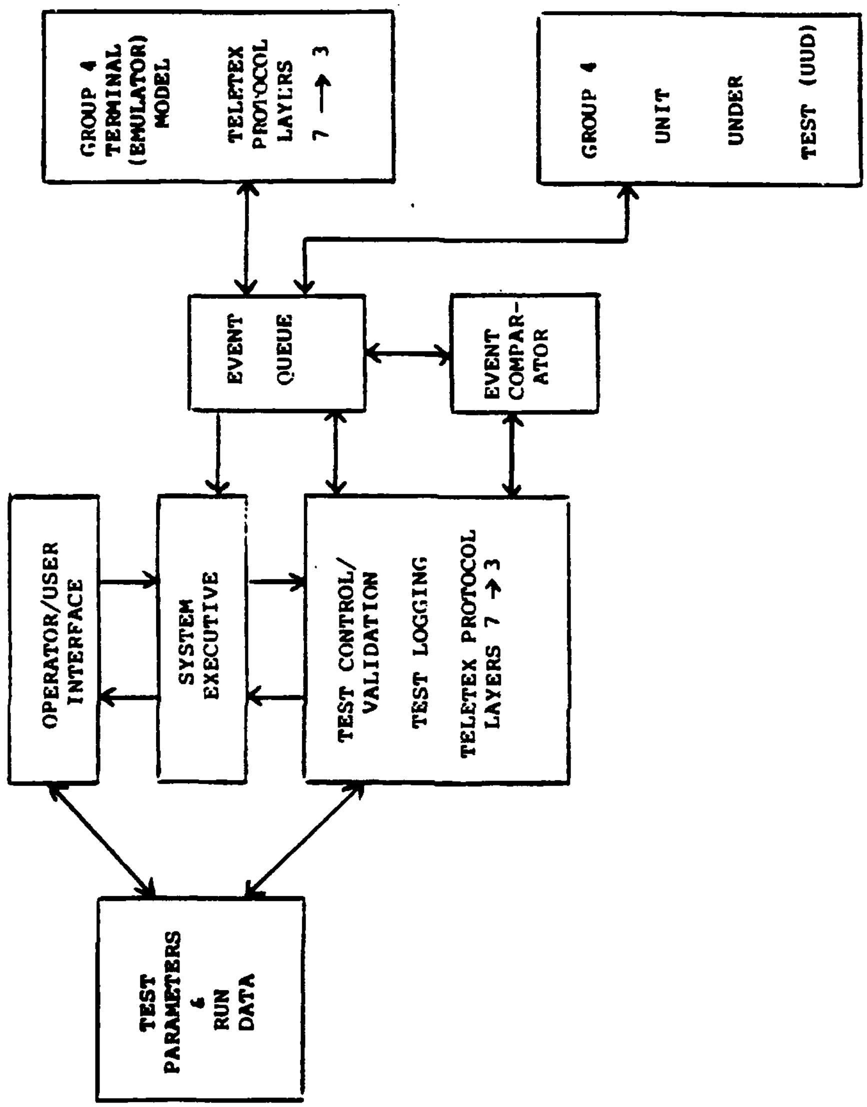


Figure 3-2. Group 4 Functional Block Diagram

3.1.1 Design Philosophy

Thoroughness of testing, and the fineness of detail in the results obtained from tests, were the driving principles in the design of the system. This consideration, reinforced by structured programming principles, dictated that all actions which are significant (in protocol terms) be made visible by small modules. In order to make the system capable of maintenance and enhancement, modules were aligned to the layering (in the OSI sense) and to the CCITT protocol recommendations which they implement. In this way, the scope of the system as a whole can be easily broadened, and modifications to the CCITT protocols have been incorporated with relative ease. Fortran 77 was chosen as source language for the validation system because of its portability, efficiency, and its structuring (especially with MIL-STD-1753 enhancements). Its support for serially reusable modules permits modules dedicated to protocol functions which are usable by both the UUT and the emulation subsystems, on both sides of the interface. The use of reusable modules are strongly advised by redundancy and inconsistency considerations. Fortran's COMMON blocks are used to store states, substates, and overall status. The event queue is used not only as a "mailbox" between modules for interlevel commands, but also as a journal for the actions taken by the UUT and emulations of it. With the use of multiple linked lists, each corresponding to a specific event, maintained by well tried "heap" storage management techniques, each module quickly performs its intended function. In coding the various modules, strict adherence to ANSI X3.9-1978 extended by MIL-STD-1753, both in letter and spirit, was followed. This policy not only guarantees relative ease in porting software from processor to processor but also guarantees the reusability of modules as mentioned above. Module reentrancy was not relied upon, but has been taken advantage of (usually by multitasking) where available.

3.1.2 Design Approach

A top-down methodology was followed in the software design of the system. The system itself was structured as "open-ended", using small modules. Each module when coded was essentially complete, but those of its functions which were not needed in the present description of the system resulted in direct or indirect invocations of "stubs" or placeholder modules. When it is necessary to add a given function to the system, the modules completing that function can be substituted for the stubs. The event queue approach was chosen to bring as many protocol actions as feasible out into the open, where the performance of the UUT can be compared in detail with a properly acting model supposedly compatible with it. It permits detailed error reports which not only back up invalidity decisions but also aid the agency requesting the validation, without the use of difficult-to-implement protocol conformance evaluations in the large. The approach also enhanced the open-endedness of the system, particularly with regard to added functionality and CCITT recommendation revisions. Other service routines were specified and implemented as the need for them became apparent.

3.2 Validation System Description

From a functional point of view, the validation system is comprised of the following parts:

Operator Interface
Test Package
System Executive
UUT Subsystem and status/buffer stores
Emulator Subsystem and status/buffer stores
UUT/Emulator Comparator
Event queue and allied management software

The following details the part played in the operation by each of these subsystems.

3.2.1 Operator Interface

This set of modules provides the means by which specific tests can be selected and initiated, and the results of tests returned, in the form and in detail requested by the operator. It also provides the operator step-by-step instructions for normal UUT validations, including selection of alternate protocols where appropriate. For maintenance and diagnostic purposes, the operator may also choose between parallel and serial UUT and emulation operation, and may also compare a selectively faulted emulation with an unfaulted model. Internal to the system, this subsystem maintains a table of testing options, and calls the system executive to start, resume, or wrap up a test as instructed.

3.2.2 Test Package

While no modules are strictly part of the test package, this must be considered part of the system as a whole. This package will normally reside on auxiliary storage, and can be easily substituted for special purposes. Basically, it consists of test data for transmission, plus control information for selecting modes of operation on various levels. These modes include not only permissible alternatives but also invalid ones to test the UUT's capability to react properly to protocol errors.

3.2.3 System Executive

When invoked by the operator interface, the system executive initiates the selected task by obtaining testing information from the test package, storing it and initializing the event queue as appropriate. Thereafter, it polls the linked lists which make up the event queue and calls the appropriate modules to take action. On test completion or an abort condition signaled by the comparator subsystem, the general nature of the test result is passed to the operator interface, so that detailed test result data can be printed or otherwise provided. Executive polling can be done in two ways, roughly describable as parallel and serial. In the parallel mode, the UUT and the emulation are kept essentially in step with one another; the UUT is blocked from getting more than a single significant protocol event ahead of the emulation. In this mode, the UUT does not proceed to step N+1 until the emulator has taken step N and its action compared with the corresponding UUT step. This mode is particularly useful for detailed examination of operation, especially in debugging. The serial mode, on the other hand, allows UUT actions to have priority over emulation actions, letting the UUT "run free", so to speak. The emulator, and the comparison of its actions with the UUT, are handled as time is available, using the event queue as the UUT "history" medium. Serial mode may be required for some terminals and modes of operation; for emulation-to-emulation comparisons, the parallel mode is obviously preferable.

3.2.4 UUT Subsystem

This subsystem consists of a set of modules, shared with the emulator subsystem, which implement the protocols and functions called for at each layer of the OSI model. What actually dedicates it to the UUT (or an emulation of one) is the functional incorporation of the UUT and its hardware interface into the system, and the stored status, buffers, and linked lists specifically associated to the UUT or its standin. The procedure modules, as such, function as routines dedicated to their protocol implementation and transmission functions, rather than that of interfacing to the UUT or providing a control against which the UUT performance can be evaluated.

Each module performs one or more actions corresponding either to protocol-specified change of state or substate, or performs inter-layer translation functions. A module is thereby identified with specific sections or subsections of the protocol recommendation which it implements; its actions, rather that being "hard-coded", are driven by a decision table closely reflecting the "state diagrams" included with some of the CCITT protocol recommendations, even to the state numbers and other annotation. When unavailable, the decision tables reflect the intended purposes of the associated recommendations. The decision tables, fixed at compile time, are supplemented by parallel mask and vector tables which can modify actions either to reflect alternative actions or transmission paths, or to force improper actions to be taken, either to test the UUT's reaction to them, or for debugging purposes, especially in emulation vs emulation tests. These supplementary tables are modified during execution to implement alternate protocol choices, hardware vs software module implementations, and "error-force" option selections.

The heart of the UUT subsystem, as such, is the stored data which reflects the current states and substates of the UUT transmission in progress, the linked lists containing, by layer and direction, the history of the transmission, and the transmitted data itself. Substates, as far as the software is concerned, simply provide a more detailed description that the CCITT-defined states as such; the designation was chosen to keep the coarser states in line with the CCITT specifications. Relative to states, substates record such details as timeout counts, intermediate status in combine/divide operations, and other data needed to define fully the status of a given transmission.

The linked lists provide the main mechanism by which the protocol modules communicate with one another. In operation, the executive polls all linked lists for unhandled events; when one is found, the appropriate protocol module "handles" the event, usually marks it as "done" and places another event on another linked list for some other module to handle, modifying the stored status accordingly. In cases where the correspondence between "input" and "output" events is not one-to-one, the module may delay "signing off" on the input event or placing another event on its own input linked list as is appropriate, to guarantee that is be polled to complete its function. In any case, the action taken by a protocol module on one invocation is scaled down to a maximum of one event in or out.

3.2.5 Emulator Subsystem

The emulator subsystem shares all its protocol procedure modules (except where replaced by hardware/firmware links) with the UUT subsystem; the difference is in the status and buffer stores dedicated to the subsystem, the linked lists which provide layer interfaces, and the method by which supervisory control over it is exercised. Each protocol module is ignorant whether it is performing its function for the UUT emulator, but is provided with the status tables, linked lists, etc., peculiar to one or the other by the calling executive. The basic decision tables used are the same as for the UUT, but supplementary mask and vector tables may differ, according to the purpose of particular tests, and the double use of emulator modules on both the DTE and DCE sides of the transmission, for example when the effect of one sided protocol errors are being tested. The difference in supervisory control is implemented by the comparator subsystem, working with the executive, as described below.

3.2.6 UUT/Emulator Comparator

The job of the comparator subsystem is to keep the UUT and emulator systems in line with another, comparing their actions on an event by event basis, and reporting on serious discrepancies. In order to do this, actions taken by protocol modules on both sides are "filtered" through a comparator module which takes differential actions, depending on the "side" from which the action emanates. On the UUT side, in serial mode actions are allowed to proceed; in parallel mode, an action may be held up until the emulator side has reacted to the corresponding stimulus. This is accomplished by the protocol module placing its generated events on the comparator module's stimulus list; the comparator will pass it on (by relinking) when and if appropriate. Once both sides have reacted to corresponding stimuli, results are compared. If they match, the process is allowed to continue with no special action being taken. If the action taken by the UUT side is a valid alternative to that of the emulator, the latter's action is modified to match the UUT. Otherwise, an error report is generated and the entire process is aborted or modified and force to continue as is appropriate to the seriousness of the error and pertinent operational modes as set by the operator.

In cases where only one side is a software module whose stimuli and responses are available to the comparator (for example, the DTE-end emulator paralleled to the UUT itself), no attempt is made to keep actions in line. Instead, the "small" actions on the "soft" side are assumed to match the other side, and alignment and comparison are deferred to a layer where both sides are available. No error reports are generated where mismatches can not be diagnosed, of course; however, the comparator subsystem, through suitable interface modules, will merge error detections passed on by hardware/firmware modules into the same error report list used by software/software mismatch reports.

3.2.7 Event Queue and Associated Management Facilities

Although each event "belongs" to a specific side, layer, and module at any given time, its structure is common to the overall process itself. Storage for each event is allocated in space available to all modules, via common allocation/garbage collection routines. For auditing purposes, all events are linked by time of generation; for functional purposes, a second linkage is used to connect them with previous and successive events at the same and neighboring layers. This latter connection is modified (by relinking) by comparator modules in order to let a process continue or to "roll back" a given action.

Each event contains, at a minimum, the following information:

(1) An indication of the nature of the event, including codes for layers involved;
(2) An indication of the "side" (UUT vs. emulation), "end" (DCE vs. DTE), and direction of the event;
(3) Clock time for the event;

(4) List linkages (on time and functional bases);

(5) Linkages to data, where appropriate;

(6) Indications of state changes associated with the event.

Associated with the event queue is not only the allocation routines mentioned above, but also other service routines performing such tasks as relinking lists and similar functions. A real time clock of adequate precision is used to provide event timing for timeout sequences and similar functions. Similarly, for reporting purposes, routines are required for editing compact error reports from the comparator subsystem into terms the operator can recognize.

4.0 CCITT GROUP 4 RECOMMENDATION REVISIONS

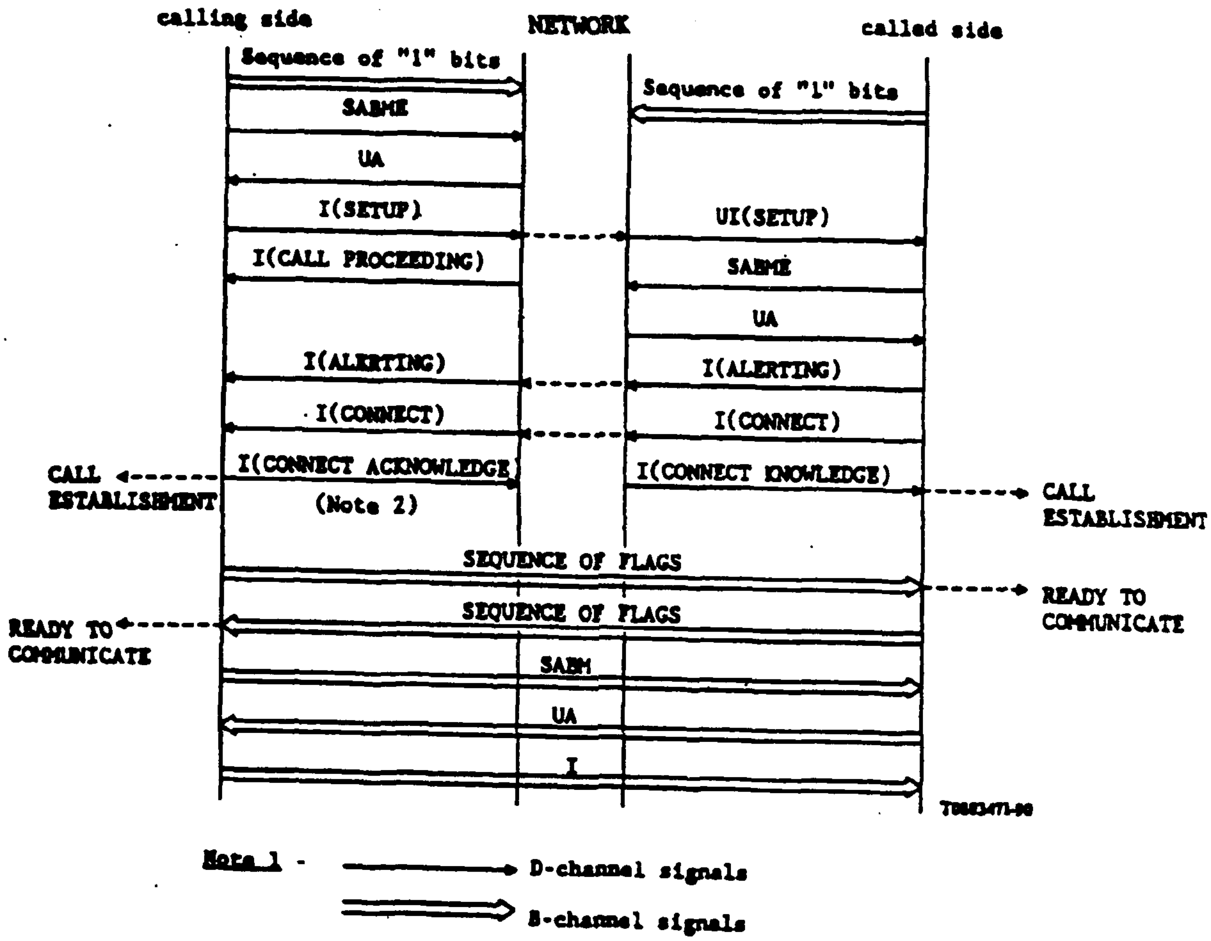
Recent revisions to the CCITT Recommendations concerning Group 4 facsimile include North American legal and North American ledger document sizes, definition of bit ordering, and the interfacing of Group 4 to ISDN. Of these only page formats have been approved, and approval for the recommendation for interfacing Group 4 to ISDN (T.90) is being sought under resolution 2 procedures. Work has also begun on gray scale and color.

4.1 ISDN

ISDN has its roots in the development of digital telephone networks, and whose purpose is to provide end-to-end digital connections to support a wide range of telecommunication services (including fax). ISDN provides users with two 64 kb/s (B) channels for data independent of signalling, and one 16 kb/s (D) channel of which 10 kb/s may be available for Packet Switched Communication. The two B channels make it possible to conduct two simultaneous, and unrelated, communications. Moreover, additional packet-switched information can flow over the D channel, if the local exchange is equipped to handle it. Normally, the D channel is used for call control, keeping the B channels completely free for information transport. The ISDN allows the telephone companies to provide users with three types of connection capabilities: circuit-switched (telephony), packet-switched (data communication applications), and permanent circuits for private network applications.

The maturing T.90 Recommendation defines how telematic equipments may use ISDN. Recent proposed modifications include defining synchronization, procedures for B-channel negotiation of layer 2 parameters, and how facsimile terminals interwork on ISDN.

Within ISDN there is no end-to-end signalling concerning activation of the protocol instances. To ensure an instance of the data link protocol only sends its first frame when the peer entity is ready to receive it, a proposed synchronization modification recommends sending "1" bits over the B channel until the B channel is connected. (See Figure 4-1.) Procedures for B-channel negotiation of layer 2 parameters defines the Exchange Identification (XID) Frame for exchange of layer 2 parameters (i.e., modulo and k parameter). The XID is an element of



Note 2 - The provision of the CONNECT ACKNOWLEDGE signal is optional.

Figure 4-1. Synchronization Sequence on Layer 2

the ISO-standardized High-Level Data Link Control procedures (HDLC), as realized in CCITT Recommendations Q.920/Q.921 (LAPD).

The interworking of facsimile terminals on ISDN recommends that, in general, Group 2 and Group 3 equipments should use a 3.1 kHz audio bearer capability. Group 4 may use either "circuit-mode 64 kb/s unrestricted 8 kHz structured" or "virtual call" or both.

4.2 Gray Scale and Color Documents

A color Group 4 expert group under Question 4 of Study Group VIII is working on producing a first draft of a Group 4 color facsimile Recommendation for the CCITT.[3] They are evaluating issues like coding algorithms and color spaces with respect to certain performance objectives. Possible performance objectives are continuous-tone color images, 64 Kb/s transmission rates, and transmission of an A4 page in one minute or less at 200 pixels/inch. A number of color spaces are being considered. In general, except for high-end applications that require very high quality printing and where a specific color space (e.g., CMY(K)) is needed, luminance-chrominance spaces are considered as the most appropriate for other applications, with YCbCr and CIBLAB being the best candidates. YCbCr is well known and widespread and is consistent with videotelephony, and videotex; however, it is ill-defined, is dependent on the gamma properties of display screens, and may have conversion problems with other color spaces. CIELAB is a uniform space, is a more accurate representation of color, and is supported by ISO and ODA; but it is less widespread and is incompatible with some applications.

The Joint Photographic Experts Group (JPEG) and the Joint Bi-Level Experts Group (JBIG) coding techniques are under consideration for the coding algorithm; but should be considered as independent options. In general, JPEG has lossy and lossless modes with the baseline system being lossy. JBIG is only lossless and permits coding of color documents by coding bitplanes. A comparison of JBIG and JPEG (in lossless mode with arithmetic coding) shows the best performance with JBIG for documents with less than 8 bits/pixel. So JBIG could be an alternative to JPEG for lossless coding. For continuous-tone and lossy coding, JPEG appears to be more appropriate.

4.3 Tiling

Although there has been no formal work in CCITT Study Group VIII regarding tiling in Group 4 facsimile, some have expressed interest in adding this capability in the future. Tiling

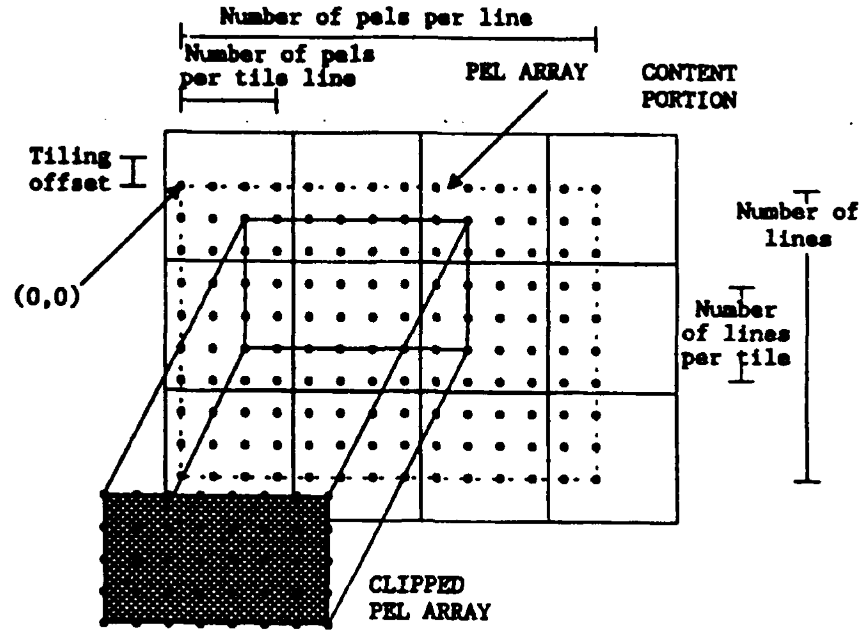


Figure 4-2. Tiles and Pel Arrays

segments a pel array into a two dimensional array of non-overlapping rectangular regions called tiles. (See Figure 4-2 and Figure 4-3.) Tiling permits the independent coding of the content information of each tile. Second, tiling makes it easier to access or process portions of the pel array independent of the remaining portions. Each tile is encodable using T.4, T.6, or bitmap encoding. The default is T.6. If the pels within a tile are either all foreground or all background, the tile may be omitted. The capability to encode each tile separately as bitmap, compressed or null maximizes the possible compression to the tiled pel array.

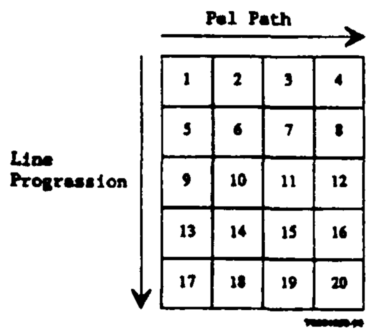


Figure 4-3. Tile Ordering

5.0 SUMMARY AND AREAS OF FUTURE STUDY

The Group 4 Validation System has been installed on two systems: the HP 1000 and an IBM PC compatible. Both support layers 3 and up, and on the HP 1000, hardware is provided for layers 1 and 2. At present, Delta is testing the IBM PC compatible version.

With the exception of items like some new page formats (e.g., North American legal), most Recommendation efforts concerning Group 4 facsimile are still changing. Color and gray scale recommendations concerning Group 4 fax are in early stages of development and are likely to change as they mature. The proposed Recommendation for interfacing Group 4 to ISDN (T.90) has just recently been agreed upon and approval is now being sought using resolution 2 procedures. For Recommendations that are stable (e.g., page formats) or proposed revisions with possibly low risk, the Group 4 Validation System was modified to accurately reflect those recommendations.

Future modifications to the Group 4 Validation System could include a ISDN interface (once T.90 is approved), and could include color and gray scale imagery as recommendations concerning them get closer to approval.

This report has presented a general overview of the Group 4 Validation System. For the complete history of the Group 4 Validation System and detailed information concerning its development, please refer to the following reports:[4],[5],[6]

"*Development of a Validation System for Group 4 Facsimile Equipment*," 1985
"*Modification of Group 4 Validation System*," 1989
"*Modification of the Group 4 Validation System*," 1990

REFERENCES

[1] "*Data Communication Networks Open Systems Interconnection (OSI) Model and Notation, Service Definition*," Blue Book, Volume VIII, Fascicle VIII.4, Recommendation X.200, pp. 3-56, CCITT, 1988

[2] Kenneth R. McConnell, Dennis Bodson, Richard Schaphorst, "*FAX, Digital Facsimile Technology & Applications*," pp. 85-99, Artech House, 1989

[3] "*Meeting Report of the Color Group 4 Facsimile Expert Group*," Color Group 4 Facsimile Expert Group, 26-30 August 1991

[4] "*DEVELOPMENT OF A VALIDATION SYSTEM FOR GROUP 4 FACSIMILE EQUIPMENT*," National Communications Systems, NCS-TIB-85-8,November, 1985

[5] "*Modification of Group 4 Validation System*," National Communications System, NCS-TIB-89-13, December 1989

[6] "*Modification of the Group 4 Validation System*," National Communications System, NCS-TIB-90-20, December, 1990