

DISTRIBUTED IMAGE PROCESSING (DIP)

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Comission II, Working Group II/3

1.0 SUMMARY

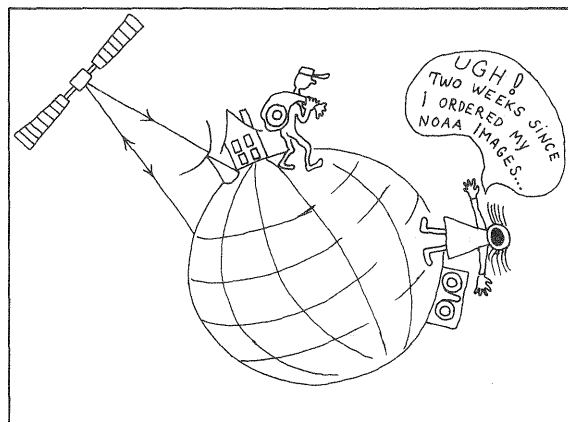


In this paper we will present the DIP project and its environments. The project is a contribution to the definition of a virtual image terminal, an analogous to a virtual text terminal. We have called it DVIT, which means DIP Virtual Image Terminal. This terminal is independent of physical terminal equipment and communication network.

DVIT will make it possible for application programs to present on a terminal screen local or distant digital images. The communication between the application and DVIT is interactive.

Our examples deal with satellite images, though other kinds of digital images such as medical and seismic images may be concerned as well.

We hope that at the end of 1988 our results will be a basis for further research by scientists and for further development by the data industry.



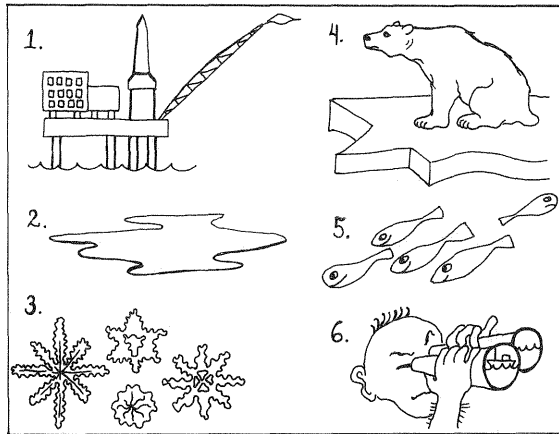
1.1 BACKGROUND

Large quantities of data from the atmosphere, sea and land are today registered by remote sensing satellites, stored by computers in ground based receiving centres and distributed to users on magnetic tape via the postal system.

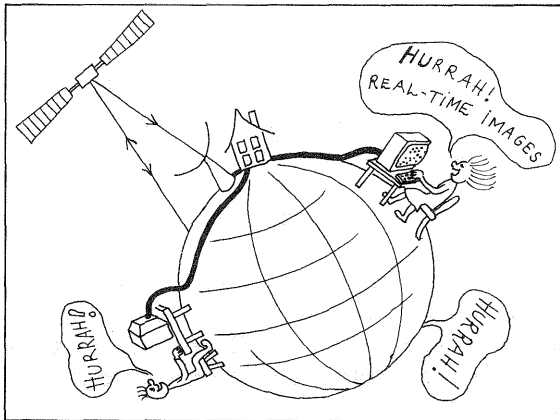
The increasing volume of data and the need for faster and more flexible services require new modes of distribution.

1.2 FUTURE USERS

A brief investigation has been carried out among users in Norway by the DIP project group. Some fields that require fast distribution were identified :

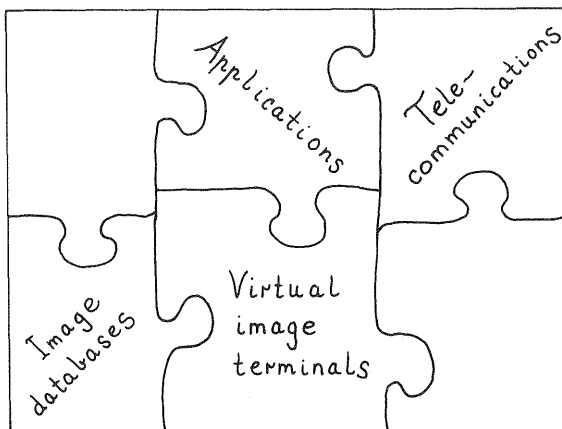


1. Wave and stream forecasting for offshore industry during critical installations.
2. Pollution detection.
3. Observation of the snowmelting in the mountains so that water reservoirs can be adjusted to avoid damage caused by floods.
4. Monitoring of the ice cover and ice edge for scientific expeditions.
5. Monitoring of sea surface temperatures in fish farming.
6. Detection of foreign ships by the coastguard.



1.3 VISION

Imagine that image terminals are spread all over the world, with connections to distant databases and satellite image acquisition stations via high-speed data networks. From the terminals the users may ask for a complete image, parts of an image, data compression, preprocessing, or encryption, as well as an estimate of the processing and communication costs to allow them to abort the transfer if it is too expensive. The terminals are of all categories from low cost Personal Computers to advanced image workstations or computer mainframes.



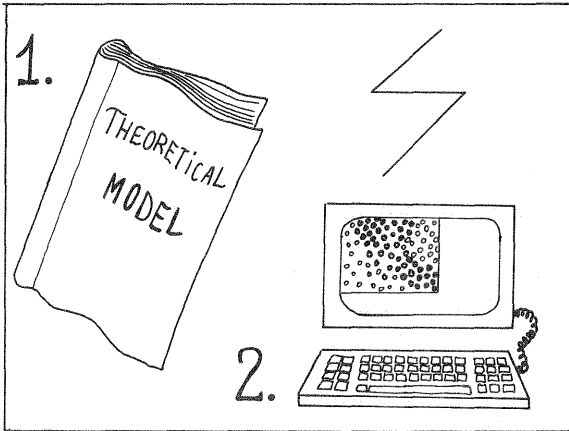
1.4 DVIT AS A PIECE OF A PUZZLE

For the vision to become a reality, several pieces of a puzzle have to be put together :

1. Digital image databases.
2. High-speed telecommunications.
3. Virtual image terminals.
4. User applications interfaced to the virtual image terminals.

DVIT, the DIP Virtual Image Terminal, belongs to this puzzle.

1.5 DIP GOALS



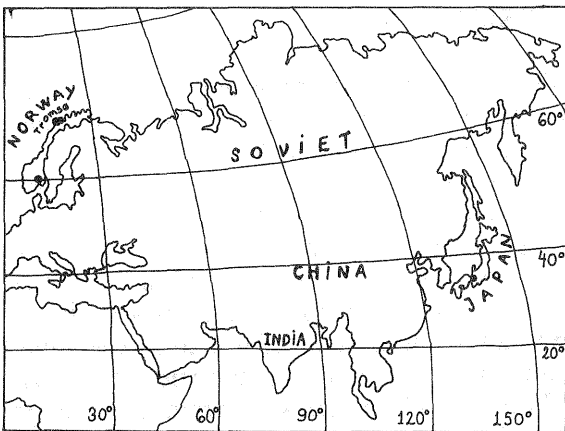
The project has two main goals:

1. To develop a theoretical model for a virtual image terminal.
2. To realize and demonstrate a simple version of such a terminal.

A virtual terminal is a model of a terminal that can be depicted into various real terminals.

The goals mentioned above will be presented in some detail in the following.

A third goal, to develop and demonstrate image file transfer services, is not presented here, but will be documented in the final report of the project.

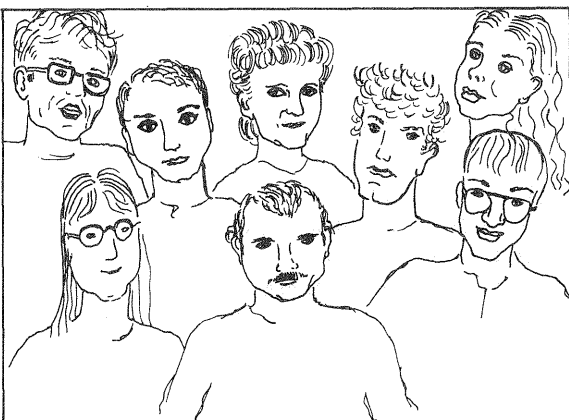


1.6 FACTS

The work is carried out in Norway, in the cities of Tromsø and Oslo. The Tromsø Satellite Station is receiving data from several resource satellites. Besides the station is a National Point of Contact for the European Satellite Agency.

The project started in 1986 and is financed by the Royal Norwegian Council for Scientific and Industrial Research and the Research Division of the Norwegian Telecommunications Administration.

The work-load is estimated at 10 manyears, and the project is to be completed in 1988.

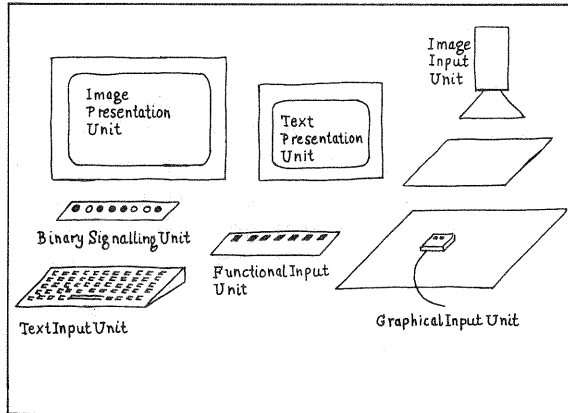


1.7 PARTICIPANTS

The following scientists from the two research foundations FORUT in Tromsø and the Norwegian Computing Center in Oslo, are working on DIP:

Kirsten Bjørnå, Øivind Buvang,
Eva Henriksen, Gunnar Johansen,
Ola M. Johnsen, Inge Lauknes,
Eivind Rinde and Gunn Skogseth.

2.0 THEORETICAL MODEL

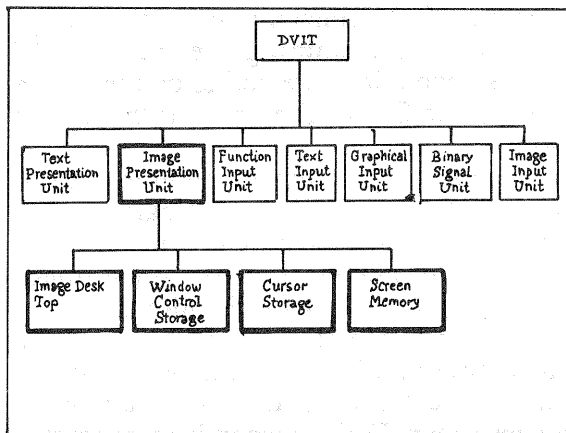


As mentioned previously, one goal is to develop a theoretical model for a virtual image terminal, which we have called DVIT.

The model defines the functional units in DVIT and the operations to apply on them, including the DVIT protocols, and the interface between DVIT and an application program. The DVIT protocol is located in the Application layer of the OSI (Open Systems Interconnection) reference Model.

Our concept is a terminal consisting of at least seven functional units.

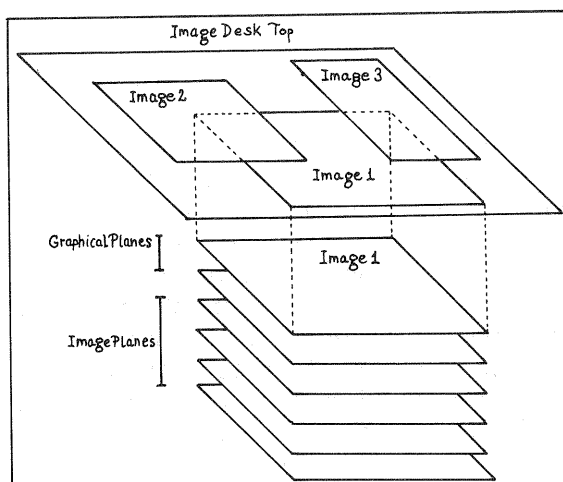
The Image Presentation Unit has been worked out in detail in our project, while some of the other units will be developed in later projects.



2.1 IMAGE PRESENTATION UNIT

This unit consists of four main parts :

Image Desk Top,
Window Control Storage,
Cursor Storage and
Screen Memory

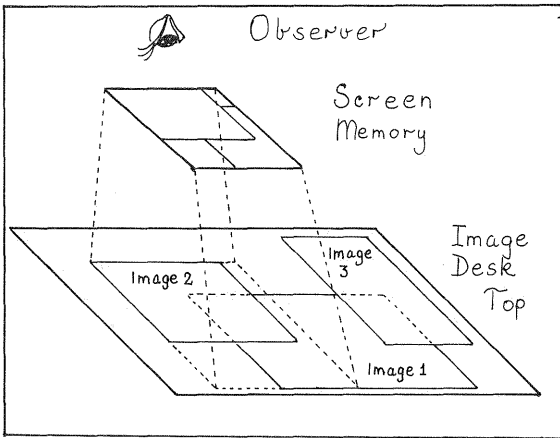


2.2 IMAGE DESK TOP

The Image Desk Top is a virtual storage into which digital images of any size are placed. An image may consist of several image planes and graphical planes. From the users point of view the storage appears as a table with printed photographs on it, where the photographs may overlap each other.

This model is suitable for satellite images consisting of several image planes, one per measuring instrument channel.

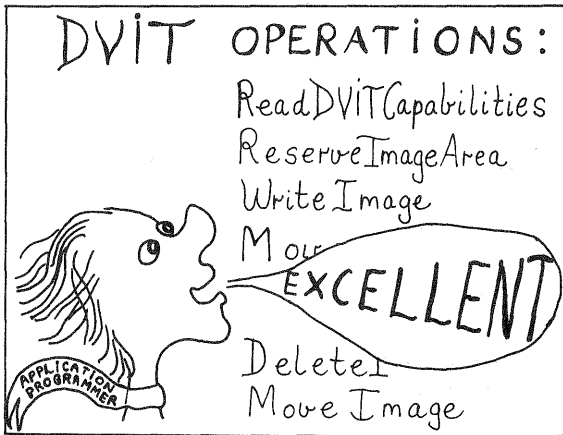
The graphical planes may be useful for drawing grids, text etc. to be overlayed the images.



2.3 WINDOW CONTROL STORAGE

The Window Control Storage completely controls what is shown on the image screen. Its functions could be compared to a lens with colour filters through which the user looks at the Images on the Image Desk Top. The lens can give magnification or reduction, the filters can give colours or grey level representation. The Window Control Storage is divided into a set of Windows. From the users point of view, each window can have its own lens, can be moved around on the screen and on the Image Desk Top, can be changed in size and can overlap other windows.

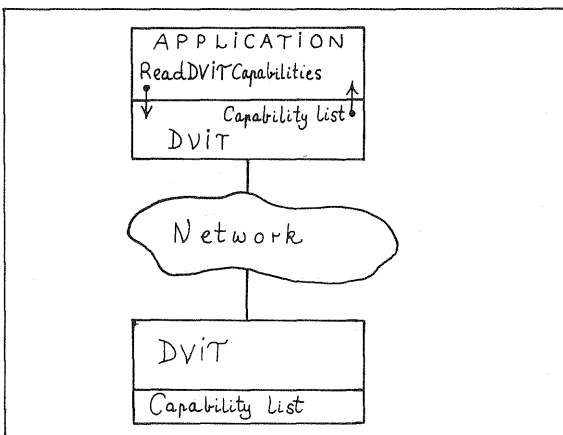
2.4 DVIT OPERATIONS



DVIT will offer a set of operations to an application. If we concentrate on the Image Presentation Unit, omitting the other DVIT units, these operations are acting on the Image Desk Top, the Cursor Storage and the Screen Memory .

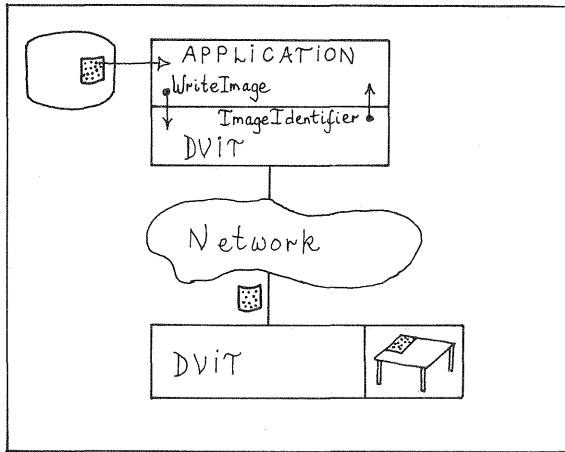
Thus, an interactive communication is enabled between DVIT and the application. For example, the application may order transfer of image planes or graphical planes to the Image Desk Top, movements of Windows on the image screen, selection of Cursors to be used, and presentation of Images in various colour representations and magnifications on the image screen. DVIT responds by executing the orders and returning proper parameters to the application.

Let us examine two of the operations :



2.5 OPERATION ReadDVITCapabilities

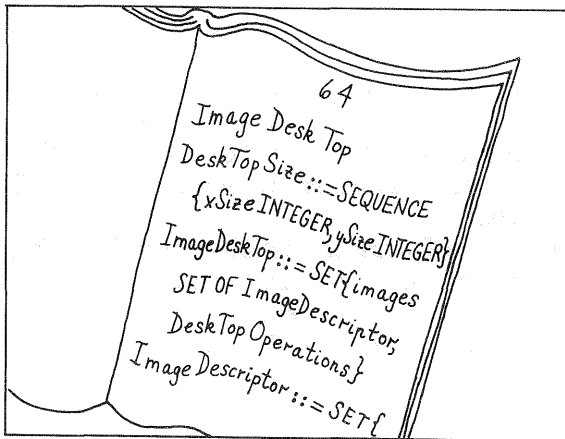
It is important that the application may take into account whether the physical terminal is advanced or simple or something in between. If an application asks for the service readDVITCapabilities, this activates DVIT to make available the list of capabilities of the actual physical terminal. An example is the maximum number of image planes and graphical planes allowed on the Image Desk Top. (The Capability list is set up once for all when DVIT is installed at the physical terminal.)



2.6 OPERATION WriteImage

If an application asks for the service WriteImage, this will activate DVIT to transfer the specified image to the Image Desk Top. But first the application should give the order ReserveImageArea to ensure enough space on the Image Desk Top.

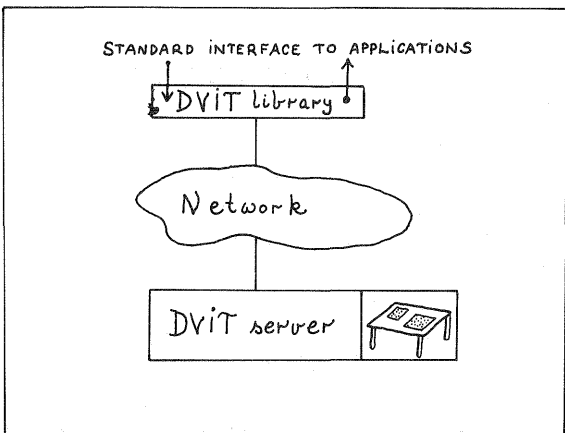
(The application itself has to execute a file access if necessary, to obtain the image to be transferred by DVIT.)



2.7 DOCUMENTATION

The data type definitions and operations of the DVIT theoretical model are described by the OSI language Abstract Syntax Notation One (ASN.1), equivalent to the CCITT X.409.

This description is found in the report "Distributed Image Processing" by Bjørnå, Lauknes, Johnsen, Skogseth and Buvang; FORUT, Nov. 1987.



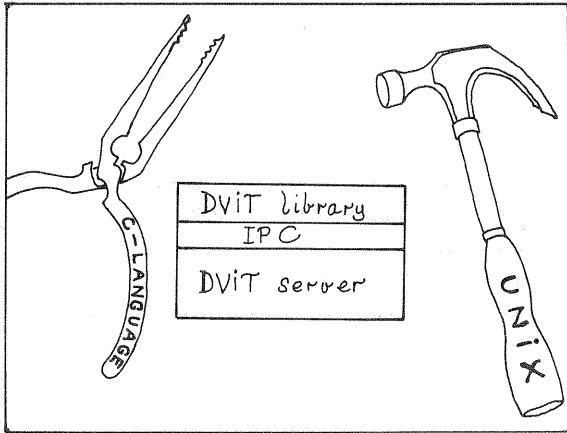
3.0 IMPLEMENTATION

The other DIP goal, as mentioned, is to implement the virtual image terminal DVIT on a real terminal.

The implementation consists of two processes, that is, two different programs running simultaneously: the DVIT library and the DVIT server. These communicate by means of the DVIT protocol and may therefore be separated physically by a data network when the physical terminal needs connection to a distant image source. The main task of the library is to be a standard interface to an application by offering a set of well defined operations, and when the application asks for the operations, the library handles them over to the server for execution.

The communication between the server and the library is described by the DVIT protocols, containing the ordered service, parameters, error messages etc.

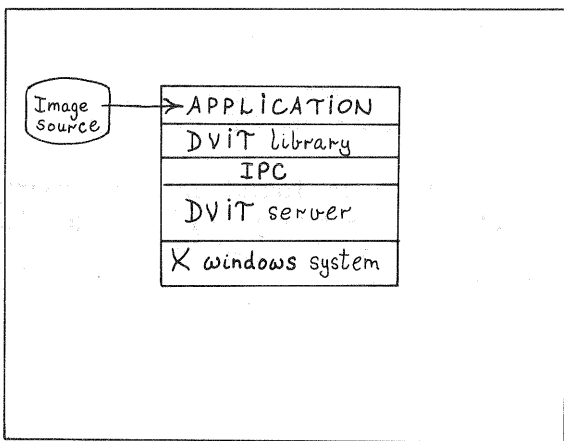
The Image Desk Top is located at the server side in order to minimize image data transfer over a network.



3.1 PROGRAMMING TOOLS

Only a small part of our model will be implemented, including the operations described previously.

We have chosen the C programming language and the Unix operating system as our programming tools. The IPC (Inter Process Communication) mechanism of Unix will be used as a link between the DVIT library process and the DVIT server process.

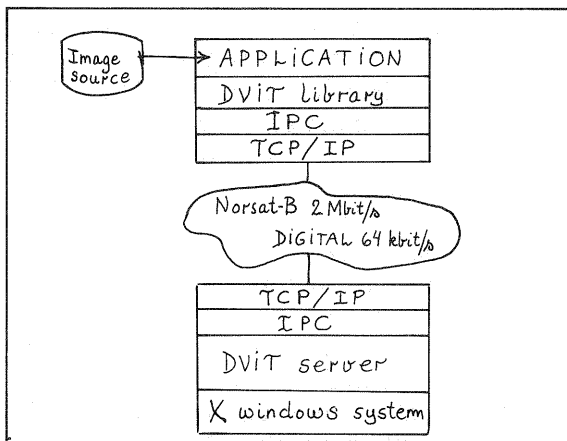


3.2 LOCAL IMAGE TERMINAL

An application has to be developed to test the DVIT. The X Window System (from Massachusetts Institute of Technology, USA) will be used, mainly to implement the DVIT Windows.

When this software is installed, it will enable the user to inspect images from a local digital image source on his screen.

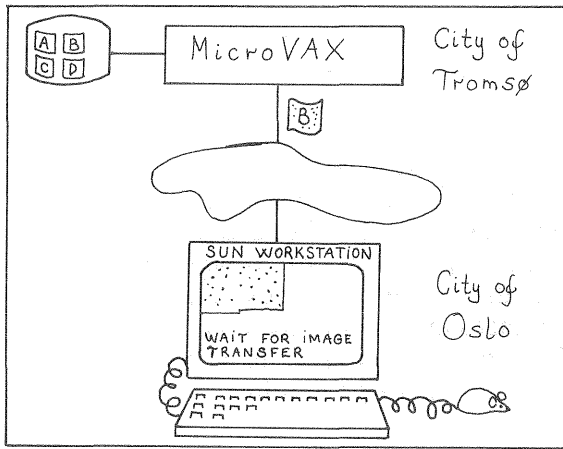
In this configuration DVIT seems to be a local image terminal.



3.3 DISTANT IMAGE TERMINAL

If the image source of interest is far away from the terminal, the DVIT library and the server should be physically separated and connected through a telecommunication network. Recall that the DVIT protocols maintain the DVIT server and the DVIT library communication.

We have chosen 64 kbit/s earthbound network as a first step, and 2Mbit/s satellite link as a second step. TCP/IP communication protocols (Transmission Control Protocols/Internet Protocols) will be used to connect the two computers, each being connected to an Ethernet local network.



3.4 HOW DOES IT WORK ?

Our simple application, together with the implementation of a small part of the DVIT model, should work as follows :

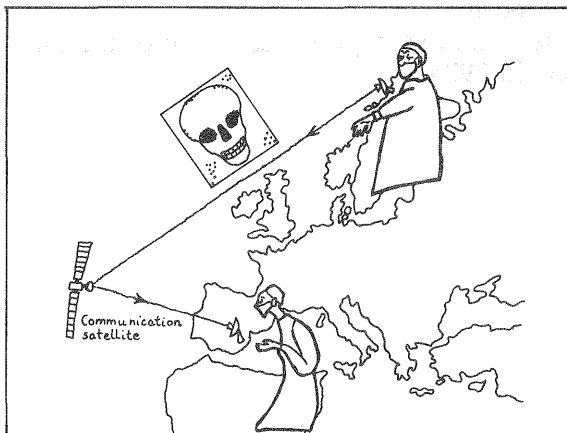
From a screen menu the user can choose between four equally sized satellite images. The menu choice SHOW IMAGE B results in a transfer of image B from the source to the Image Desk Top and a mapping of the latter on the screen. For simplicity, a maximum of three images are allowed to be placed edge by edge at the Image Desk Top. By means of the menu the user may move the screen window from one image to another or delete images, in both cases operating at the Image Desk Top.

4.0 APPLICATION POSSIBILITIES

Application programmers may use the DVIT in numerous ways and to transfer different types of digital images such as medical, digital seismic, and satellite images .

Image encryption for security, image compression for reduced communication time and costs, and estimation of the image and communication costs should be executed by the application or the network services. These are not DVIT operations.

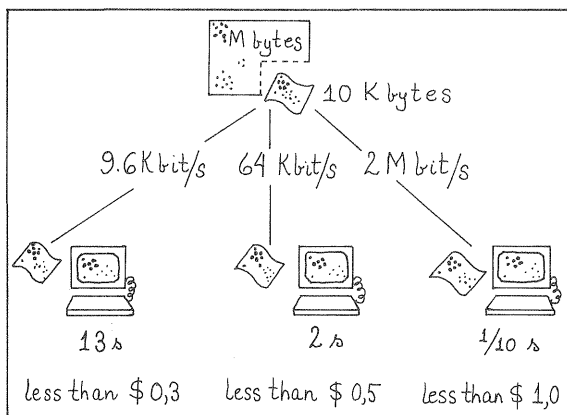
The DVIT task is to perform the image transport and presentation in a flexible dialogue with the user application.



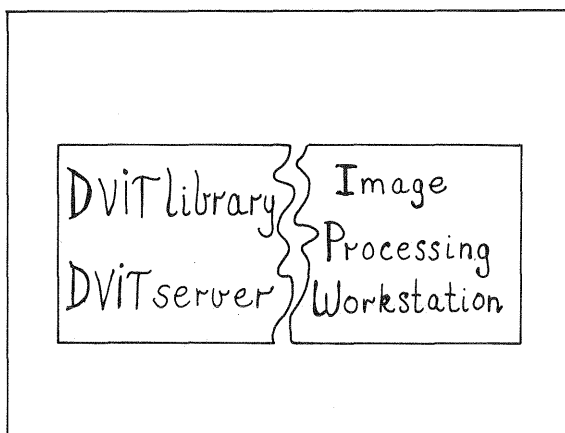
4.1 WHO CAN AFFORD DVIT ?

In Norway the telecommunication tariffs will give a considerable contribution to the total costs of digital image distribution. By using 2 Mbit/s, the communication tariffs of an image of 10 Kbytes (corresponding to a small piece of a satellite scene of typical several megabytes) amount to \$ 0.003 - \$ 1.00. Communication tariffs of 1 Mbyte amount to \$ 0.3 - \$ 100. Transfer of large data quantities per year means low fixed costs per byte, while transfer of small quantities means high fixed costs per byte, which explain the spread in costs.

Only the users that need digital images faster than can be conveyed by air transport today (6 hours), seem willing to pay for the telecommunication.



4.2 IMAGE PROCESSING WORKSTATIONS



DVIT and Image Processing Workstations seem to have several functions in common. Both present images on a screen. Nevertheless they are of a different nature. The main purposes of Image Processing Workstations are to process and manipulate local images and present them on the screen. DVIT, on the contrary, is a proposal to a standard virtual image terminal.

However, it might be an interesting and important task to adapt image processing applications to DVIT. This would enable the users to inspect distant images by means of DVIT, and then make local image processing (contrast enhancements, classifications, Fourier Transforms, etc.) by the image processing applications, provided that the images are stored locally.

This is of course beyond the scope of the DIP project in 1988.