

Evolution of Graphics Standards

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Summary: This paper describes the current status of graphics standards from the market point of view. It explains the current shortcomings and what is being done to cope with them. Finally, the tendencies are considered to which end graphics standards may evolve in the future.

1. Problems When Applying Graphics Standards

About two years ago, GKS officially became an ISO standard and has internationally largely been accepted by industry, research and science. Today, more application programs based on GKS than on any de facto graphics standard exist world-wide. GKS has most of all been established with large companies which thus standardized the graphics basis for mainframes and workstations. Therefore, every major supplier of computers offers a GKS implementation.

The success of GKS has produced direct problems for all those involved which are described below:

- The market offers many graphics devices such as plotters, graphics printers, digitizers, graphics cards, graphics terminals with less or more local graphics intelligence, microfilm equipments, type setting machines etc. GKS is to run on all these devices though the GKS drivers of the various GKS suppliers are not compatible. The manufacturers of devices cannot offer drivers since an interface is not defined. Therefore, some of them offer their own GKS implementations thus adding to the confusion for how to connect these implementations with other devices?

- A graphics standard such as GKS requires a certain overhead as to storage capacity and execution time; on average, less than 50 functions out of the total of 210 are usually used. Since part of every portable GKS implementation is written device-independently and therefore not as optimized as the device-specific graphics libraries of the manufacturers. This can only be balanced by intensive optimization by the suppliers of GKS which is a process only few suppliers will be able to survive. However, the problem of overhead is reduced by the fall in hardware prices; this parallel development has considerably encouraged the acceptance of graphics standards.
- The possibility of defining and displaying pictures results in the necessity of standardized picture transfer. Though GKS defines the GKS Metafile. This has never been part of the standard which often led to a certain uncertainty among the users.
- A standard defines the 'state of the art' at the time it is developed. Having been published it is to remain stable for a certain time. However, the average life time of a product is today less than 12 months with graphics hardware products. This requires to continuously extend and interpret the standard. The relevant implementations have to keep up with the hardware development; therefore, the average release cycle of GKS implementations is approx. six months. Certain problems have to be solved such as
 - embedding GKS into window management systems (e. g. X-Windows)
 - realizing new user interfaces with GKS (e. g. "pop-up menus")
 - using the growing intelligence of graphics processors
 - flexible distribution of GKS systems on different processors (host-PC environment, several processors on one bus, transputers)
- A rapidly increasing use of graphics software requires a growing functionality. Graphics applications to generate lifelike pictures with the computer are especially spreading in the USA. The fields of applications are, for instance:
 - CAD-systems to display the construction results as exactly as possible, e. g. in aircraft construction, ship building, car construction
 - simulation of operations, such as the simulation of movements, steering mechanisms for aircraft, ships, and cars, or computer games
 - animation of scenes, e. g. in film and advertising industries.

These applications, for instance, require three-dimensional displays, efficient surface graphics, and algorithms for shading and lighting. The GKS standard does no longer suffice.

- The development of modern man-machine-interfaces starts leading to practical applications. When designing interactive systems importance is increasingly attached to screen and dialogue layout. Window standards have simultaneously been developed with computer graphics being originally designed to facilitate operation on workstations and PCs. They mainly allow to perform several independent processes operating at the same time with every process having its own window. When designing graphics applications for user interfaces the screen often requires to be divided into several windows some of them remaining unchanged while others change during program execution. The question is how to use window systems for graphics applications, i. e. how to integrate window and graphics standards.

2. Current Proposals For Solution

To solve the problems described above, the standards committees are working on new graphics standards as well as on supplements of existing standards. A short description of the current state of the committees' activities is given below.

2.1 The Computer Graphics Metafile (CGM)

The GKS Metafile (GKSM) is not part of the standard, originally probably out of the standards committees' policies. In the meantime, CGI has developed to a standard which can be (and is) applied completely independently of GKS. It can be embedded in a GKS environment but with certain restrictions only. On the other hand, CGM does not fulfil all functions required of GKS.

CGM has been an ISO standard (ISO IS 8632) since early 1987. It defines a device- and computer-independent picture description in different encodings (binary, character, and clear text encodings). CGM contains the output elements and attributes of GKS and has more definitions of general display elements such as circle, ellipse, curves, etc. and enlarged raster functions.

Neither has CGM a possibility for structuring a picture nor can it be used as a protocol file. The interface to GKS is only defined so far that CGM may be interfaced to GKS as an output workstation. The CGM interpretation has to be done separately.

The CGM standard is readily accepted especially with word processing systems, picture exchange between different CAD-systems, desk-top publishing, documentation, and data base systems, etc.

2.2 Computer Graphics Interface (CGI)

CGI defines a standardized interface for the functions of graphics devices. The definition comprises various encodings (binary, character, and clear text encodings). To use CGI for direct programming the definition of language bindings is to be provided.

As to functionality, CGI is characterized by the GKS standard. It covers all functions of a GKS workstation. However, apart from the GKS functions, CGI also supports raster functions (which are also required for window systems) and extended input functions which are very useful to realize UIM-systems.

Today, CGI is supported in its minimum form of CGI/VDI by most manufacturers of graphics boards, such as Intel, Texas Instruments, AMD, Motorola, NDI, Number Nine, etc.

The complete CGI set is also offered by a number of board, terminal, and workstation manufacturers, such as Motorola, Calcomp, Ramtek, Westward, and SUN.

2.3 Three-dimensional Standards (GKS-3D, PHIGS)

GKS-3D is about to be accepted as international standard (ISO-DIS 8805), the DIS status is still expected this year. The committees agreed on the transformation pipelines being identical with GKS-3D and PHIGS. The incompatibilities remaining between PHIGS and GKS-3D mainly relate to segments/segment structures, the main graphics storage and the possibility of editing, as well as the workstation handling. GKS-3D is beginning to meet with response with the European users; for instance, our GKS-3D implementation is installed at about 30 customers though we do not have any information on other commercial GKS-3D implementations. However, GKS-3D is not yet supported by the hardware manufacturers neither in terminals nor on workstations.

PHIGS is a proposal for standard (ISO GP 9592) and is to be passed as international standard in 1988. The original aim to keep PHIGS upward compatible to GKS-3D is no longer pursued. The PHIGS proposal is strongly supported and encouraged by the hardware manufacturers. For instance, HP, SUN, and SiliconGraphics showed the PHIGS-implementation FIGARO on their 10 MIPS workstations on this year's SIGGRAPH. Apollo, Raster Technology, NEC, Prime, etc. announced PHIGS-support. IBM supports the implementation Graphics which is similar to PHIGS as strategic product. Several workstation manufacturers, including DEC, are working on the development of PHIGS. European workstation manufacturers are also greatly interested in PHIGS.

Surprisingly, PHIGS is not so successful with the users. This may be due to the few computers and graphics devices supporting PHIGS or because PHIGS has less interactive capabilities than GKS and GKS-3D with today's terminal and workstation generation.

3. Tendencies In The Development Of Graphics

Four striking developments of the last months are described below each standing for one respective tendency to show the development of graphics systems and thus graphics standards-to-be:

- the readiness of the market to accept the TI-graphics chip TMS 34010
- the introduction of new workstations on a RISC-architecture with 10 MIPS computer capacity by three major manufacturers at the same time
- the de facto standardization of the X-Window system
- the developments almost already applicable to generate lifelike pictures

The tendencies behind are as follows:

- a) First of all, the special processors in Silicone are developed into programmable processors on a chip-set basis in graphics hardware. Programming can be done in standard languages such as "C". A graphics board can pack enough memory to locally load and perform a program such as the CGI standard. Thus the transformation of a "plain" graphics board into a CGI terminal remains a question of a few man-weeks development for the manufacturer or OEM. Consequently, only few costs arise, the increase in performance is very high since the host does not need to process graphics commands. On the SIGGRAPH '87, Motorola, NDI, Matrox, and Number Nine - to name but a few - showed these possibilities along with TI.

Further development shows that the graphics boards will have CPUs such as Motorola 68030, Intel 80386, NSC-CPU's, or special chips to support complex operations such as 3D-transformations, chips operations, area shadings, ray tracing, etc. It will not take but a few years that graphics boards with computer capacities of several 100 MIPS will be available (systems with 40 MIPS already exist) which can carry out complex picture displays in real time. The "local intelligence" required will be developed in a software standard language and loaded onto the board or kept there in the EPROM.

- b) The demonstrations of the new RISC workstations showed that it is now possible for the first time to perform a program to control a flying object (start, flight, landing) in real time on a "standard workstation". The application program was written in FORTRAN on a device- and computer-independent FORTRAN implementation of the graphics standard PHIGS (it could just as well have been written in GKS-3D without any performance differences). This clearly shows the following: First, the advantages of programming with a graphics standard package can also be used to develop applications which some years ago required machine programming on special hardware (e. g. with gambling machines). Second, the doubts about the performance of standard packages often mentioned become completely irrelevant if using clear programming techniques.
- c) Some important workstation and terminal manufacturers have agreed on a standard for window management systems (X-Windows). The basic version of X is Public Domain Software and can be installed on Unix environment within a few man-weeks. This rather inefficient version serves a quick spreading; the workstation manufacturers, above all DEC, are optimizing the respective version of X for their hardware. However, with graphics software this window management system is most inefficient (X then produces direct bitmap data even with intelligent graphics processors). Therefore, the X-definition is presently enlarged by the necessary 2D and 3D graphics functions by several companies in the USA and in Europe. This will probably lead to a period of incompatibility to be finished with a new standard.
- d) For the most part, research has left behind the fields of vector and raster graphics and is now entirely working on systems to generate lifelike illustrations of models held on the computer. Ray tracing, shading and lighting algorithms have been developed so far as pictures generated on the computer can hardly be distinguished from photographs. These capacities for animation of objects (such

as the modelling of facial expressions), simulation of events (such as flight simulators) or CAD/CIM-applications (to display objects designed partly in hardware and real time) can now be offered by workstation manufacturers. They have only been supplied by the super computer manufacturers until now. Having been established these functions have to be included in a graphics standard. The American workstation manufacturers have already thought about this and defined PHIGS+ which contains some of the functions mentioned above. In ISO, the GKS review is started which is to lead to a new standard "GKS 199x". This will probably include the discussion of the GKS extension by new important display elements and forms.

4. The future

Where does the development of graphics systems lead to - if only glancing at it?

At first sight, several tendencies can be made out which would all prefer to be detached from the others - "we cannot use the others' developments for our applications".

Above all, there are the manufacturers of graphics boards. This market is developing positively despite the enormous fall in prices. These boards solely serve OEM-purposes and are mainly integrated into systems with a standard bus (IBM-PC, VME-Bus, Multibus, Q-Bus, etc.).

The application software or existing graphics packages on the host usually have to directly operate the graphics functions of the card. Therefore, a standard functionality is essential. For this reason, all manufacturers offer all standards and de facto standards relevant for their market such as CGI/VDI, GEM/VDI, EGA, CGA, Herkules, DGIS. Apparently, Tektronix emulations are hardly offered any more.

These suppliers are obviously GKS-orientated. PHIGS is much too complex, windowing is supported by hardware (X would then run very inefficiently), standards do not yet exist for picture processing.

The workstation manufacturers feel restricted in their possibilities of technological progress by standards such as CGI and GKS; PHIGS+++ may still offer certain advantages on the market. X-windows are accepted as basic systems, however, the compatibility will be limited to the own operating system being a superset of X-windows.

For manufacturers of mainframes the graphics component is of less importance. Computer architectures are generated which solve numeric calculations extremely fast. Graphics standards such as GKS are basic requirements accepted, speed is especially demanded in picture processing. Therefore, super computers are used to generate movies or to quickly display objects with ray tracing methods. Graphics and window standards are the interface to the peripheral devices.

The tendency towards standardization is continuously growing even on the technology market in the USA. Taking the current developments the following scenario of graphics standards in the next three years becomes apparent:

- a) The concept of CGI, supplemented by some ideas of PHIGS, will be accepted. The future graphics boards will process three-dimensional output elements with the relevant display attributes. They will perform any transformations, clipping at any level and hidden line/hidden surface functions. First, the elements will be taken from GKS-3D/PHIGS, then more complex surface elements will be added with shadings, lighting, transparency, etc. of the PHIGS+ (possibly GKS 199x), and finally display elements of a higher order.

Graphics software will be integrated with a window standard (X-windows with 3D-extensions). The board will be supplied with the data via X; the display speed will amount to more than 100,000 polylines per second; thus, a picture refresh from the standard picture elements will be possible, i. e. transformations, clipping, hidden surface, and displaying of elements will take place with every picture set-up; with the picture refresh the system is supplied with the necessary data "from above".

- b) Graphics standards such as GKS, GKS-3D, and PHIGS will become application-orientated tools based on device standards (CGI+).

The functionality of the three systems will be combined in one standard showing several upgrades. A applicant for such a system is GKS 199x which will be developed with the GKS-Review within the next few years.

Application systems will use the standard tools according to their requirements:

- GKS 2D or 3D if the application objects can be displayed in a plane picture structure
- PHIGS if the data structure can be displayed on hierarchic graphics structures
- CGI+ if the application data structure cannot be applied to any of these picture structures; the application system will then contain a tool to connect its data base which converts graphics objects into display calls of the standard device driver.

Obviously, there may be changes to above names dependent on many political issues.