Invited Paper

SIGMA (Software Industrialized Generator and Maintenance Aids) Project

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The SIGMA project is a joint effort to build up an infrastructure or platform for software development in order to achieve better productivity.

The following approaches have been adopted in the project:

(1) Advocacy of a common software development platform on which software development tools and technologies are provided.

(2) A focus on efforts to integrate existing technologies and methods and make them available for use in industry.

(3) Development of a system that is flexible enough to allow advanced technology and newly developed techniques and tools to be easily incorporated into the platform.

The common platform for software development will be as independent as possible of the various execution environments, and will provide better portability and interoperability of tools and software assets as well as technologies.

As well as providing necessary functions and features for software development, the operating system and networking facilities will play the important role of making all the workstations produced by different manufactures equally usable as components of the platform.

The project defines only the external specifications of the hardware and operating system. The participating companies are expected to implement their own products in accordance with the specifications.

On the platform, a set of tools can be selected for developing specific applications or performing specific activities. It is expected that many good tools will be provided by software vendors, and that the platform will evolve as well.

The results of the projects have been passed to a newly established commercial body for dissemination, maintenance, and enhancement. Internationalization and standard-related activities are indispensable for the platform, and are expected to continue.

1. SIGMA System

1.1 Outline of The System

The SIGMA system is an software development system whose purpose is to improve development productivity by computerizing activities in software development. The project aims to establish:

1. A standardized distributed software development environment independent of the various target system environments
2. A nation wide SIGMA network for effective data exchange among software developers.

1.2 SIGMA System Configuration

The SIGMA system consists of SIGMA user sites, the SIGMA network, and the SIGMA Center (see Fig. 1).

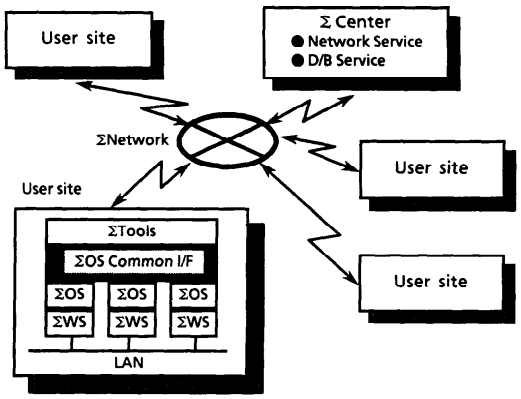

Fig. 1 Overview of the SIGMA system.

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Table 1 Services of the SIGMA Center.

Network services
● Electronic bulletin boards
● Electronic conferencing
● Administration and distribution of sites' network addresses
● Gateways to external networks and commercial databases
Database services
● Database clearance information
● Tool catalogs (SIGMA tools, other tools)
● Application information (SIGMA tools, other tools)
● System software information
● Technical reference information

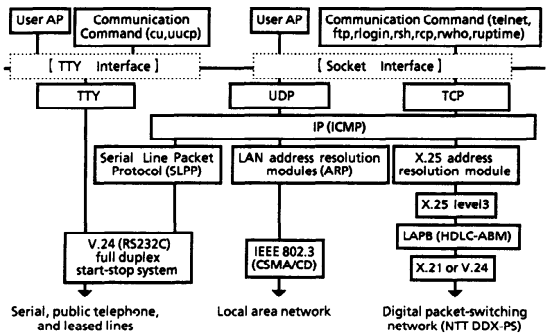

Fig. 2 Communication functions and configuration.

1.3 The SIGMA Center

The SIGMA Center provides network and database services (see Table 1).

1.4 SIGMA Network

The SIGMA network is a UNIX-based network that connects individual user sites. Software enginners using the network can benefit by sharing data and information. The SIGMA system provides three types of network service (see Fig. 2):

● *Message communication functions:*

Electronic mail, electronic newsletters, electronic conferencing, bulletin boards, and electronic talk.

The system can handle Japanese characters.

● *File transmission functions:*

Rapid and reliable transmission and distribution of data, programs, and documents.

● *Target machine access functions:*

Access to target resources from SIGMA workstations. For example, users are able to test their programs in the environment of a target computer system by remote log-in to computers connected to the SIGMA network. These functions also include file transmission and remote job entry.

The project uses the DIgital Data Exchange Packet Switching (DDX-PS) network for physical implementation of the SIGMA network (see Fig. 2).

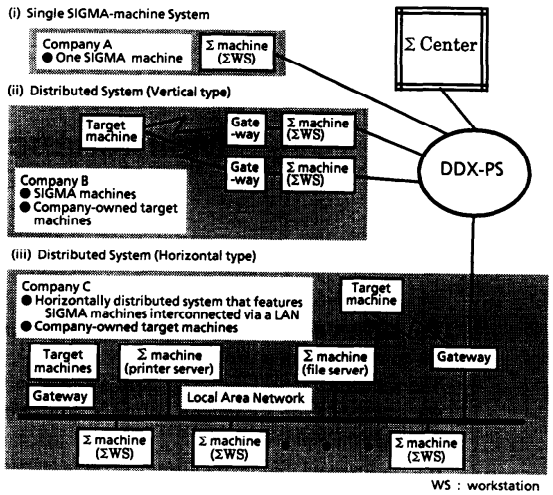

Fig. 3 Examples of SIGMA User Site Configurations.

1.5 SIGMA User Sites

A typical SIGMA user site includes SIGMA workstations with SIGMA OS (operating system), a local area network, and the SIGMA gateway (see Fig. 3).

1.6 SIGMA Workstation

The basic user hardware facilities are SIGMA workstations. Although there are various models and brands of SIGMA workstations, all can be equipped with software tools that have similar functions, and all use the same communication protocols. This allows SIGMA users to select and install their own selection of multi-vendor SIGMA workstations and to construct sites that range in size, from simple single-machine sites to complex sites with hundreds of workstations, in accordance with their requirements.

The SIGMA project advocated that every software engineer should have his or her own SIGMA workstation. The proposed specifications for SIGMA workstations are shown in Talbe 2.

The actual development and marketing of SIGMA workstations are entrusted to computer manufacturers.

The hardware requirements were characterized with the aim of promoting the use of workstations of the kind. Later, the requirements for portable-type workstations were added. At present the hardware requirements are not compulsory, since most workstations on the market already meet these requirements.

1.7 SIGMA Operating System

One of the most important activities of the SIGMA project is to establish a *de facto* standard OS interface to ensure the portability of SIGMA tools. The SIGMA project did not develop OS, but defvined its external specification, and encouraged manufacturers to develop their own workstation products. All the advanced

Table 2 Hardware Requirements of SIGMA Workstations.

[Control mechanism]	
◆CPU	◆32-bit internal register
◆Floating point calculator	◆A floating point calculation function, internal expressions are in IEEE format
◆Main memory	◆4 MB (minimum)
◆Logical area	◆8 MB (minimum)
[File mechanism]	
◆Hard disk	◆Minimum user area is 20 MB
◆Floppy disk	◆3.5″(2HD), 5″(2HD) or 8″(2D) for data transfer
Back-up	◆System must have back-up function
[Display mechanism]	
◆CRT resolution	◆Graphic display: 1024 × 768 dots or more Text display (Kanji: 24 × 24 dots) 40 characters × 24 lines
◆Keyboard	◆Key layout is JIS standard 10 function keys (min.)
◆Mouse	◆Two or more buttons
◆printer interface	◆Sigma page printer specification
[External interface]	
◆Serial interface	◆Two RS232C (V. 24) (min.)
◆Parallel interface	◆Centronics interface (option)
◆LAN interface	◆IEEE 802.3 standard
◆Interface for DDX-P	◆V.28(x.21 bis) or V.11(x.21)
◆GPIB interface	◆SIGMA ICE interface (option)

technologies relevant to hardware could be incorporated at the manufacturer's discretion. The common OS interface ensures the portability of software on the platform. The SIGMA project provides manufacturers with a verification service for SIGMA OS interface.

(1) The SIGMA OS interface is based on the UNIX system. The functions of SIGMA OS are derived from both AT&T UNIX System V and BSD. SIGMA OS includes all System V interfaces and those from BSD that are considered to be beneficial for software development.

(2) As the UNIX system did not satisfy all the requirements for SIGMA OS, additional interfaces for features such as Japanese language processing, graphics, multi-windows, and databases were defined.

(3) Interfaces for new functions in future versions of the UNIX system, as well as new technology trends, will be considered for incorporation in later versions of the SIGMA OS interface.

UNIX is a registered trade mark of UNIX System Laboratories Inc.

1.8 SIGMA Tools

The SIGMA project provided software development tools for use on SIGMA workstations. Functionally, these tools can be categorized into two major types (see Fig. 4): common tools and application development tools. The common tools can be used all through the phases of software development, and are independent

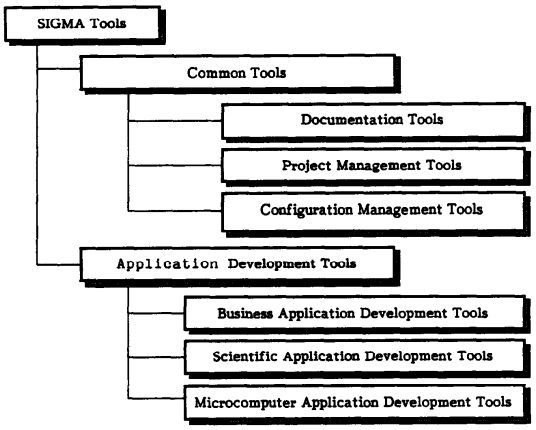

Fig. 4 Overview of the SIGMA tool structure.

of the varieties of applications and the development phases. The development tools meet the various requirements of the development phases and application types.

(1) Common tools

(i) The documentation tools

The documentation tools allow users to write and manage documents easily. Documents may include Kanji, Kana, alphanumeric, symbol characters and formulas. Moreover, graphics that consist of combinations of lines and circles, tables and diagrams are also handled by these tools.

(ii) Project management tools

The project management tools allow users to control the schedule, cost, and quality. Significant features of the project management tools are

- Project database definition function
- Customization function for screen display and report format
- Import and export interface for the project database, to be adaptable to a variety of user-dependent man-machine interfaces.

(iii) Configuration management tool

Any data derived by using the SIGMA tools can be controlled by the configuration management tool. Uwers can define a hierarchical configuration schema and can control each instance of data in accordance with the schema.

(2) Application development tools

(i) COBOL, Fortran, C, and a few microprocessor assembly languages re supported.

(ii) Business applications, scientific applications, process control applications, and embedded microcomputers applications are supported.

(iii) Design, coding, and test phases are broadly supported.

2. SIGMA SYSTEM, INC.

For the project period, 192 companies participated in

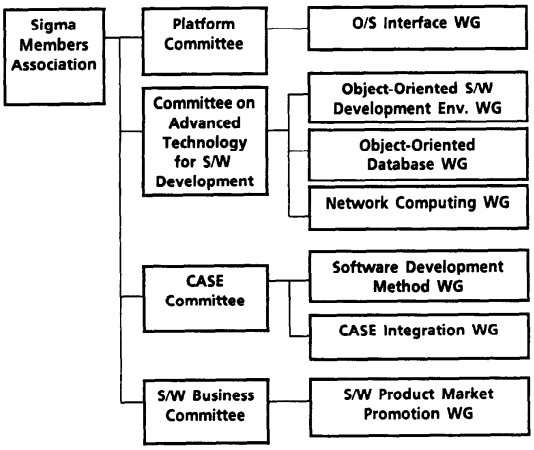

Fig. 5 Structure of the SIGMA Members Association.

the project. These companies invested in or donated to the project and provided various types of technical support. This included sending their outstanding engineers to the project office to design, coordinate, and manage the project. The total number of engineers who worked on assignment at the office for the full period of the project was 116. A much larger number worked on various aspects of the project such as survey, design, development, and reviewsl Engineers from more than 100 companies took part in these activities.

In March 1990, the first, development, phase of the SIGMA project was completed. Since it is planned to make the results of the project available for practical use in industry, activities for maintenance and enhancement are necessary. For this purpose, a company called "SIGMA SYSTEM, INC." was established in April and all the project's assets and activities have been passed to this company. The company, although a commercial body, emphasizes activities related to maintaining the platform, namely those relevant to standardization and internationalization, which are unavoidable factors to keep the platform significant for users and vendors.

2.1 Business Overview

The company's activities fall into two major categories. One is dissemination of the products of the SIGMA project. This includes maintenance and enhancement of the SIGMA tools. The other is maintenance and promotion of the platform. This includes conformance to various standards, either *de jure* or *de facto*. Conformance means modifying the common interface defined by the SIGMA project and also activities to reflect the requirements of the Japanese marketplace.

The business goals of SIGMA SYSTEM, INC. are as follows:

(1) Maintenance and improvement of the platform

Since establishing the platform has been one of the most important objectives of the project, it is also an important objective for the company to maintain and improve the platform. The platform should conform to technical and industrial trends and to market requirements. The company continues to work with international standard organizations and to listen to the requirements and opinions of users and member companies.

(2) System improvement

The software development environment should also be advanced by adopting new technologies. The company will study and follow the technology and market trends and keep the SIGMA system updated to meet the latest requirements.

(3) Dissemination of SIGMA products

To provide the users with products for a better software development environment, the company will also maintain and improve the SIGMA products, namely SIGMA tools. The aim of the project is not only to license tools but also to keep promoting the concept of a software development environment.

2.2 Forming Industry Consensus

To achieve the above business goals, the company should have the support and consensus of industry and the marketplace. Though the company is a private commercial body, it organizes the SIGMA Members Association and the SIGMA Users Group, through which the requirements of industry and the marketplace are effectively reflected in the policies and activities of the company.

Figure 5 shows the structure of the SIGMA Members Association.

3. Future Tasks

The project set a very high goal of establishing a software development environment. The development period of the first phase achieved its objectives. However, as has been stated elsewhere, the goal has to be accomplished with further, continuous efforts to promote, market, maintain and improve of the project's results.

The relationship with international trends and activities is becoming far more important; for example, the platform must be compatible with those marketed overseas.

On the other hand, the Japanese marketplace imposes some unique requirements. Thus, the frame of the platform is required to be common or adjustable to local requirements.

Ensuring portability and interoperability by establishing a fixed platform contradicts the aim of ensuring flexibility, incorporation of new technologies, and differentiation of products in the marketplace. Sensitive coordinations is needed to obtain a trade-off between these two objectives.

Another project objective is to promote widespread use of the products based on the project philosophy. This is also a basic necessity for active network usage. Realization of a computer network for business use is necessary, and further efforts will be made to maintain and manage network activities.

Acknowledgement

The SIGMA project was supported by approximately 190 participating companies and 100 experimental users of the SIGMA system prototype. The project could not have been completed without the intensive participation and efforts of the hundreds of the engineers working directly and indirectly for the project. The author would like to9 thank all these people for their participation in the project and for their personal help.

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