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to the corresponding bits in each. In this context AND is often used for masking purposes, i.e. to select parts of data such as the address field.

graph A form of *graph or *tree used in problem solving and problem decomposition. The nodes of the graph represent goals and their successors are subgoals as either AND or OR branches. The successors are subgoals that must all be satisfied to satisfy the parent goal, while OR branches indicate alternative subgoals, any of which could satisfy the parent goal.

on See computer animation.

onym for artificial neural network.

tion Explanation added to a program to assist the reader. This may take the form of script additions to the program listing, more often takes the form of *comments added in the program text.

nous FTP A mechanism that allows a user to take copies of files from a network server, without having a named account on the server. The user "anonymous" is allowed to log into the server, and has limited privileges allowing him or her to initiate an outgoing file transfer. See also file transfer protocol.

A Acronym for analysis of variance.

ANSI American National Standards Institute, an organization, founded in 1918, that establishes US industrial standards. It accredits organizations to write these standards following the rules established by ANSI. It is the representative to *ISO (International Organization for Standardization). ANSI determines hardware-related and software standards.

aliasing Taking specific action to remove or subdue *aliasing effects. *Supersampling and smoothing the image by *filtering are techniques often used to reduce aliasing.

asymmetric relation A *relation R defined on a set S and having the property that

whenever $x R y$ and $y R x$
then $x = y$

where x and y are arbitrary members of S . Examples include "is a subset of" defined on

sets, and "less than or equal to" defined on the integers. See also asymmetric relation, symmetric relation.

any-time algorithms A class of algorithms intended for use in *real-time systems, in which, after a specified minimum period, a result is always available. The accuracy of the result increases with the time the algorithm has been running.

APA mode Abbrev. for all points addressable mode, usually applied to printers that can display graphical data. A mode of operation in which the printout is not constrained to rows of characters.

API Abbrev. for application programming interface. An interface that is defined in terms of a set of functions and procedures, and enables a program to gain access to facilities within an application. A typical example would be a *CASE tool that provides an API to enable users to develop special programs to utilize the information within the CASE tool's internal database. The use of such facilities enables users to customize the application for their own purposes and to integrate the application into a customized development environment.

APL Acronym for a programming language. Originally devised by Iverson as a mathematical notation in the mid-1960s, and only later implemented as a programming language, APL had a meteoric rise in popularity. The main feature of APL is that it provides a rich set of powerful operators for handling multidimensional arrays, together with the capability for users to define their own operators. The built-in operators are mainly represented by single characters using a special character set. Thus APL programs are very concise and often impenetrable.

APP Abbrev. for application portability profile.

Apple Computer Inc. A US-based producer of Macintosh ("Mac") personal computers and peripherals. It pioneered the *desktop and *windows metaphors for the user interface and was an early market leader in the field. The first commercial *spreadsheet, VisiCalc, was developed for its machines. As well as running Apple's own software, the

APPLICATIONS PROGRAM

computers can also run Microsoft *Windows and the PC applications it supports. Apple is number 10 in terms of revenue in the list of the world's top IT suppliers (1993 figures).

application A particular role or task to which a computer system can be applied, or, more usually, the software used for such a purpose. See application package, applications program.

application binary interface See ABI.

application generator A program – a *software tool – that is capable of creating a range of application programs in a particular domain. The generated program will be configured by information provided by the person using the application generator. Domains in which application generators are frequently encountered include simulation, process control, and user interface software. See also fourth-generation language.

application layer of network protocol function. See seven-layer reference model.

application package (software package)

A collection of programs or modules that is directed at some generic application and can be tailored (perhaps with some additions) to the needs of a specific instance of that application.

application portability profile (APP) A statement of the characteristics of a computer program that defines the facilities (of the *programming language, *operating system, *APIs, etc.) which it utilizes. This profile then defines the minimum set of facilities that must be available on any computer system to enable that program to be executed.

application programming interface See API.

applications program (or application program) Any program that is specific to the particular role that a given computer performs within a given organization and makes a direct contribution to performing that role. For example, where a computer handles a company's finances a payroll program would be an applications program. By contrast, an *operating system or a *software tool may both be essential to the effective use of the computer system, but neither makes a direct

An electric circuit must always contain an outward and a return path. For low-frequency signals the outward path can consist of a single conducting wire, with the return path carried by a common ground (earth) return, which can be shared by many different circuits. At higher frequencies this system is no longer effective, and it is necessary to provide both an outward and a return conductor. At still higher frequencies, the two conductors need to be kept close to one another, as in twisted pair, so that the outward current in one conductor is balanced by the corresponding inward current in the other; this reduces the amount of energy lost by radiation. *Screened cable* is a multipath electric cable with a surrounding screen usually formed from an interwoven fine wire mesh, and used for example in shielded twisted pair; the screen provides some isolation from external sources of electrical interference. *Multicore cable* is a multipath cable frequently containing a mixture of screened and single conductors; sometimes one or more coaxial cables are included to provide paths for high-frequency or other special signals.

cache (cache memory) A type of memory that is used in high-performance systems, inserted between the processor and memory proper. The *memory hierarchy on a system contains registers in the processor, which are the highest-speed storage, and, at a slightly lower level of accessibility, the contents of the main memory. The cache is intended to reduce the discrepancy in accessibility between these two types of unit, and functions by holding small regions that map the contents of main memory. The formal behavior of the cache corresponds closely to that of the *working set in a *paging system.

Some magnetic disk *controllers have a cache. The working of the cache is not visible to the main CPU, but again provides a mapping of the current contents of part of the disk units in order to provide improved performance.

Some magnetic tape units have built-in cache memory. In this case the aim is to allow a *streaming tape transport to emulate the behavior of a (more expensive) start-stop unit so that it can be attached to a system designed

to support only the latter without substantial software modification. The arrangement was introduced by Cipher in the early 1980s.

See also disk cache.

CAD *Abbrev. for computer-aided design.*

CADCAM *See computer-aided design.*

caddy A form of *cartridge used specifically for *CD-ROM optical disks. Unlike most cartridges, the operator can readily remove the disk and replace it with another.

CADMAT *See computer-aided design.*

CAE 1 *Abbrev. for computer-aided engineering.*

2 *Abbrev. for common application environment.*

CAFS *Abbrev. for content-addressable file system.* A development by ICL of *associative memory.

CAI *Abbrev. for computer-aided instruction.*
See computer-assisted learning.

CAIS-A *See* PCTE.

CAL *Abbrev. for computer-assisted learning.*

calculator A small electronic device by means of which arithmetic operations can be performed on numbers entered from a keyboard. Final solutions and intermediate numbers are generally presented on *LCDs. Calculators range from very cheap simple devices capable of performing the basic arithmetic operations to those whose capabilities extend to sophisticated mathematical and statistical manipulation and that may be programmed with large numbers of steps. Add-on memory modules containing sets of specialist programs for particular fields – engineering, navigation, or business for example – may be purchased as accessories to the more expensive calculators, as can small printers.

The dividing line between sophisticated calculators and small personal computers, such as *notebooks and *pocketbooks, is becoming less clear-cut; there are significant overlaps in both price and power.

call To transfer control to a *subroutine or *procedure, with provision for return to the instruction following the call at the end of execution of the subroutine/procedure.

call by name *See* parameter passing.

HE MODEL

space above the surface of interest used as a projection surface.

He model An illumination model that includes directional diffuse and ideal specular terms to account for surface reflection plus an ideal diffuse component to accommodate subsurface scattering (*see* diffuse reflection, specular reflection).

Hermite interpolation *See* interpolation.

hertz (symbol: Hz) The SI unit of *frequency. A periodic phenomenon has a frequency of one hertz if each cycle of the phenomenon repeats itself in a period of one second. A *megahertz* (MHz) is one million (10^6) hertz.

heuristic A "rule of thumb", based on *domain knowledge from a particular application, that gives guidance in the solution of a problem. Unlike algorithms, heuristics cannot have proven performance bounds owing to their open-ended dependence on specific application knowledge; an example is 'if the sky is cloudy then carry an umbrella.' Heuristics may thus be very valuable most of the time but their results or performance cannot be guaranteed.

heuristic search A search process that uses *domain knowledge in *heuristic rules or procedures to direct the progress of a search algorithm. It has the effect of pruning the search space and is used in applications where a *combinatorial explosion means that an *exhaustive search is not possible.

Hewlett-Packard A manufacturer of electronic instruments, calculators, data-gathering equipment, medical equipment, and high-performance workstations, based in California. It is noted as the first manufacturer of a hand-held calculator. It is a major developer of software for use in its own products and has exploited this fact by marketing development tools for its own workstations. In terms of revenue, it is the fourth largest IT company in the world (1993 figures).

hex *Short for* hexadecimal.

hexadecimal notation The representation of numbers in the positional number system with base 16. The sixteen hexadecimal digits are usually represented by 0-9, A-F. Any hex number can be simply converted into its

binary equivalent, and any binary number into its shorter hex equivalent.

hex pad A *keypad with 16 keys that are labeled 0-9, A-F so that they correspond to *hexadecimal notation.

hidden-line/hidden-surface removal (HLHSR) Removal of those parts of a scene that are obscured by objects nearer to the viewer. There is a whole range of methods for doing this operation. The *Z-buffer is often used to hold depth information concerning objects. *See* hidden-line removal, hidden-surface removal.

hidden-line removal An algorithm used in computer graphics to determine which lines should not be visible when a three-dimensional surface is displayed.

hidden-surface removal The process of eliminating the representation of surfaces in three-dimensional graphics that would be obscured by opaque foreground surfaces if photographed by a hypothetical camera.

hierarchical addressing *See* addressing.

hierarchical B-splines A sequence of *B-splines where the next in the sequence has a defined relationship to the previous one; it may, for example, be twice as fine. Hierarchical B-splines are used in adapting functions to local detail (*see also* wavelets).

hierarchical class structure *See* object-oriented programming.

hierarchical cluster analysis *See* cluster analysis.

hierarchical communication system 1. A physical organization of communications facilities, each higher level covering a wider or more general area of operation than the next lower level. As an example, a large bank might have a *local area network within each branch, connecting the teller stations. Several branches might be linked to a data *concentrator, connected to regional concentrators, which in turn link to the bank's main data processing center.

2. A logical organization of communication facilities, in which the lowest levels deal with the physical network while higher levels deal with the communication between specific applications. *See also* protocol.

of observing any value between x_1 and x_2 , is

$$F(x_2) - F(x_1)$$

tion leads, by differential calculus, uency function, $f(x)$, which is the tio of

$$F(x+h) - F(x) \text{ to } h$$

ies small, so that the probability of ation between x and $(x+h)$ is e most important continuous dis- s the *normal (or Gaussian) distri-

lity distributions are defined in *parameters, whose values deter- numerical values of the probabil-

ysis A statistical technique used to proportion of subjects responding length of an applied stimulus. The is often applied in a series of ; amounts in geometrical progres- the proportion responding is mod- e cumulative normal frequency dis- (see probability distributions). The estimates the *median effective stimu-* 50 and the *slope* of the response. It is ed in pharmacology, biology, and in e safety of products.

definition A precise statement of blem to be solved, with the empha- oviding a complete and unambigu- nition of the problem rather than an oduction to it.

description A self-contained r of some problem to be solved, per- th accompanying information on ts that the solution must respect, approaches to the solution, etc.

oriented language A programming e whose control structures and (in ar) data structures reflect in some e the characteristics of a class of prob- g, commercial data processing or sci- omputation. By contrast, the struc- a machine-oriented language reflect ernal structure of the underlying e.

ral abstraction The principle that eration that achieves a well-defined an be treated by its users as a single

entity, despite the fact that the operation may actually be achieved by some sequence of lower-level operations (see also abstraction). Procedural abstraction has been extensively employed since the early days of computing, and virtually all programming languages provide support for the concept (e.g. the SUBROUTINE of Fortran, the **procedure** of Algol, Pascal, Ada, etc.).

procedural cohesion See cohesion.

procedural language An *imperative *procedure-oriented language.

procedure A section of a program that carries out some well-defined operation on data specified by *parameters. It can be *called from anywhere in a program, and different parameters can be provided for each call.

The term procedure is generally used in the context of high-level languages; in assembly language the word *subroutine is more commonly employed.

procedure-oriented language A program- ming language that enables a program to be specified by defining a collection of *proce- dures. These procedures may call each other, and are called by the main program (which can itself be regarded as a procedure).

process 1. (task) A stream of activity. A process is defined by its code, i.e. the ordered set of machine instructions defining the actions that the process is to take, the contents of its *workspace, i.e. the set of data values that it can read, write, and manipulate, and its *process descriptor, which defines the current status of any resources that are allocated to the process.

2. To carry out the actions defined by the sequence of instructions that make up the code of a program.

process algebra The algebraic study of abstract computing processes. Suppose that there is a set A of basic computational actions (such as assignments, tests, sends, requests), and that these actions can be combined to form finite and infinite processes. There are a number of operations that, given two processes p_1 and p_2 , can form new processes; examples are the *sequential composition* $p_1.p_2$ and *parallel composition* $p_1 || p_2$ of the

processes. There is a great deal of freedom to define and interpret such operations and the processes they create, especially if the actions and processes may exist concurrently and communicate in various ways. Methods of communication and cooperation between processes are at the heart of process algebra. Process algebra studies semantic ideas using mainly standard algebraic methods, including: axiomatic theories whose axioms are often equations; equivalence relations (e.g. several kinds of bisimulation); algebraic constructions; and computable algebras. An example of a set of axioms for process algebra is the set ACP of J. A. Bergstra and J. W. Klop; this was developed from earlier work on *process calculuses by R. Milner and others, and has subsequently been extended and adapted to express the huge range of semantic phenomena exhibited in modern concurrent communicating systems.

The motivation behind process algebra is to model computing systems using processes and to specify the systems by equations based on appropriate operators on processes. Thus concurrent computing systems are specified by equations and their semantics are obtained by solving fixed-point equations. Various related semantic and logical methods are used, including: *initial algebra semantics; *operational semantics based on transition systems; metric space and topological methods; and *modal and *temporal logics for reasoning about processes.

Process algebra has the potential to become a general theory of computing, relevant to system modeling and parallel-program development. There is much research needed to develop its foundations, tools, and applications.

process calculus The study of abstract computing processes by means of various formal systems and calculuses. An early influential calculus was the calculus of communicating systems (CCS) of R. Milner. This has given rise to many adaptations and new approaches to a theory of processes. For example, it led to the systematic development of *process algebra to which many process calculuses may be said to belong, and it inspired an influential