10 Base 2 An *Ethernet connection method, now obsolete, using RG58-AU coaxial cable and operating at 10 Mbps (sometimes known as **Cheapernet** or **Thin Ethernet**). Using a bus topology there each connection to a computer's network card is made by means of a 'Tee connector'. The transceiver is built into the network card.

10 Base 5 The earliest form of *Ethernet connection (now obsolete): a special type of RG-8 coaxial cable of approximately ½-inch diameter. Each device was attached via a transceiver with a drop cable to the network card.

10 Base FX A form of fast *Ethernet using fiber-optic cables.

10/100/1000 Base-T An *Ethernet connection method using twisted pair cables and operating at 10, 100, or 1000 Mbps. A star connection topology is used with the individual cables terminating at a *hub, *switch, or *router. *See also* CAT-5, UTP, STP.

8421 code A *weighted code in which each decimal digit 0 through 9 is represented by a four-bit codeword. The bit positions in each codeword are assigned weights, from left to right, of 8, 4, 2, and 1. *See also* BINARY-CODED DECIMAL, EXCESS-3 CODE, BIQUINARY CODE, HEXADECIMAL NOTATION.

419 fraud *See* ADVANCED FEE FRAUD.

4GL *Abbrev. for* fourth-generation language.

7-Zip A file archiving and compression program that works in a similar fashion to PKZIP. Its **7z format** gives high compression ratios.

A* algorithm A member of the class of *best-first *heuristic search techniques that attempt to find a "best" path from a given start node to a designated goal node in a problem *graph. An *evaluation function is used to estimate the cost of the (unknown) distance from the current node being explored to the goal and this is then added to the (known) cost of the shortest path from the start node to the current node to give a figure of merit for the current node. At each iteration the node with the best cost figure is used to pursue the search. The operation of the algorithm displays a behavior that is a mixture of *depth-first and *breadth-first searching.

ABC **1.** *Abbrev. for* Atanasoff–Berry computer. **2.** An interactive programming language designed as a replacement for Basic by CWI (Centrum voor Wiskunde en Informatica – the National Research Institute for Mathematics and Computer Science in the Netherlands). It is a useful teaching language and also influenced the development of *Python.

abduction An *inference process widely used in *artificial intelligence, particularly in *expert systems and *rule-based systems. In diagnosis, for example, there may be a rule like "if measles then red spots" so that, when the symptom red spots occurs, we may use the rule in reverse to conclude that measles is present. However, unlike *deduction, abduction is not logically sound because of inherent uncertainty that can lead to false conclusions – note that measles is not the only cause of red spots. Abduction is an example of a *plausible-reasoning technique.

abelian group (commutative group) *See* GROUP.

ABI *Abbrev. for* application binary interface. Definition of the binary-level interface between application programs and the operating system, including the format of executable files. Compiled binary applications can be ported between systems with the same ABI.

ablative Designating an optical recording technique in which the heat generated by the recording beam melts or vaporizes a small area of the recording medium, leaving the underlying layer (with a different reflectivity) exposed.

abnormal termination A termination to a *process brought about by the operating

a

system when the process reaches a point from which it cannot continue, e.g. when the process attempts to obey an undefined instruction. In contrast, a process that reaches a successful conclusion terminates normally by issuing a suitable supervisor call to the operating system. It is common practice to inform the initiator of the process as to whether the termination was normal or abnormal.

ABONE The Asian–Pacific Internet *backbone network that connects users throughout East and South Asia without the need to send data via European or North American networks.

abort (of a process) To undergo or cause *abnormal termination. Abortion may be a voluntary act by the process, which realizes that it cannot reach a successful conclusion, or may be brought about by the operating system, which intervenes because the process has failed to observe system constraints.

absolute address A unique number that specifies a unique location within the *address space where an operand is to be found/deposited, or where an instruction is located. It generally specifies a memory location but in some cases specifies a machine register or an I/O device. In the case of a binary machine, it is an n-bit number specifying one of 2^n locations. The result of calculating an *effective address is usually an absolute address.

absolute code Program code in a form suitable for direct execution by the central processor, i.e. code containing no symbolic references. *See also* MACHINE CODE.

absolute link A hyperlink specified by its full path. If the file containing the hyperlink destination is moved, the browser will be unable to locate the document.

absolute path The full path to a file, comprising the *drive identifier, *directory tree (if any), and ending with the *file name (e.g. C:\Documents\ABuser\MyDocuments\jobs\cv.doc).

absolute URL *See* URL. *See also* RELATIVE URL.

absolute value The magnitude of a number, regardless of its sign (positive or negative). For example, 25 is the absolute value of 25 and –25. Most *spreadsheet programs include a *function that returns the absolute value of a number.

absorption laws The two self-dual laws

$$x \vee (x \wedge y) = x$$

$$x \wedge (x \vee y) = x$$

(*see* DUALITY) that are satisfied by all elements x,y in a *Boolean algebra possessing the two operations $\vee$ and $\wedge$.

abstract computability theory The theory of functions that can be computed by algorithms on any *algebra. Its aim is to explore the scope and limits of computation on any kind of data. It is a generalization to arbitrary many sorted algebras of the theory of the effectively calculable or recursive functions on the natural numbers.

Abstract computability theory starts with an analysis and classification of many models of computation and specification that apply to algebras. This reveals the essential features of methods, and results in a **generalized *Church–Turing thesis** that establishes which functions on an *abstract data type are programmable by a *deterministic programming language. Comparisons can be made between computations on different algebras, modeling data types and their implementations. The theory also provides a foundation for new theories of computation for special data types, such as algebras of real numbers, which can be used in applications.

The **while** programming language is a simple example of a method for computing functions on any many-sorted algebra A (that possesses the Booleans). On the natural numbers it can compute all *partial recursive functions. Computation is based on the operations of the algebra – sequencing, branching, and iteration – and has available a limited means of searching A. However, a vital missing component is the capacity to compute with finite sequences of data from A. On the natural numbers fininte sequences can be simulated using pairing functions, but it is not possible to simulate finite sequences on an algebra A. Finite sequences and operations for every data set in A are therefore added to A to make a new algebra A^*. It turns out that **while** programs on A^* (i.e. **while** programs equipped with finite sequences) have all the essential properties of the computable functions on A. This class of

functions is the subject of the generalized Church–Turing thesis.

Most of the main results in the theory of computability on the natural numbers can also be proved for abstract computability theory on any finite generated *minimal algebra.

abstract data type A *data type that is defined solely in terms of the operations that apply to objects of the type without commitment as to how the value of such an object is to be represented (*see* DATA ABSTRACTION).

An abstract data type strictly is a triple (D,F,A) consisting of a set of domains D, a set of functions F each with range and domain in D, and a set of axioms A, which specify the properties of the functions in F. By distinguishing one of the domains d in D, a precise characterization is obtained of the *data structure that the abstract data type imposes on d.

For example, the natural numbers comprise an abstract data type, where the domain d is

{0,1,2,…}

and there is an auxiliary domain

{TRUE,FALSE}

The functions or operations are ZERO, ISZERO, SUCC, and ADD and the axioms are:

ISZERO(0) = TRUE

ISZERO(SUCC(x)) = FALSE

ADD(0,y) = y

ADD(SUCC(x),y) = SUCC(ADD(x,y))

These axioms specify precisely the laws that must hold for any implementation of the natural numbers. (Note that a practical implementation could not fulfill the axioms because of word length and overflow.) Such precise characterization is invaluable both to the user and the implementer. Sometimes the concept of function is extended to procedures with multiple results.

abstract family of languages (AFL) There are many useful types of *formal language, and classes often have similar properties. An AFL is a class of formal languages that is closed under all the following operations: *union, *concatenation, Kleene-plus (*see* KLEENE STAR), *intersection with *regular set, Λ-free homomorphic image, and inverse homomorphic image (*see* HOMOMORPHISM). An AFL is **full** if it is also closed under Kleene star and homomorphic image. The motivation for the concept of an AFL is to investigate properties of classes of languages that follow merely from the assumption of these *closure properties. Each member of the *Chomsky hierarchy is an AFL; all except for the class of context-free languages are full.

abstraction The principle of ignoring those aspects of a subject that are not relevant to the current purpose in order to concentrate solely on those that are. The application of this principle is essential in the development and understanding of all forms of computer system. *See* DATA ABSTRACTION, PROCEDURAL ABSTRACTION.

abstract machine A machine can be thought of as a collection of resources together with a definition of the ways in which these resources can interact. For a real machine these resources actually exist as tangible objects, each of the type expected; for example, addressable storage on a real machine will actually consist of the appropriate number of words of storage, together with suitable address decoders and access mechanisms. It is possible to define an abstract machine, by listing the resources it contains and the interactions between them, without building the machine. Such abstract machines are often of use in attempting to prove the properties of programs, since a suitably defined abstract machine may allow the suppression of unneeded detail. *See* VIRTUAL MACHINE.

abstract reduction system (abstract rewrite system, abstract replacement system) A general characterization of the process of deriving or transforming data by means of rules. It is an abstraction based primarily on examples of *term rewriting systems: it is simply a reflexive and transitive binary relation $\rightarrow_R$ on a nonempty set A. For $a,b \in A$, if $a \rightarrow_R b$ then a is said to **reduce** or **rewrite** to b.

Using this abstraction, it is easy to define a range of basic notions that play a role in computing with rules.
(1) An element $a \in A$ is a **normal form** for $\rightarrow_R$ if there does not exist b, different from a, such that $a \rightarrow_R b$.
(2) The reduction system $\rightarrow_R$ is **Church–Rosser** (or **confluent**) if for any $a \in A$ if there are $b_1,b_2 \in A$ such that $a \rightarrow_R b_1$ and

a

$a \rightarrow_R b_2$ then there exists $c \in A$ such that $b_1 \rightarrow_R c$ and $b_2 \rightarrow_R c$.
(3) The reduction system $\rightarrow_R$ is **weakly terminating** (or **weakly normalizing**) if for each $a \in A$ there is some normal form $b \in A$ so that $a \rightarrow_R b$.
(4) The reduction system $\rightarrow_R$ is **strongly terminating** (or **strongly normalizing** or **Noetherian**) if there does not exist an infinite chain

$$a_0 \rightarrow_R a_1 \rightarrow_R \ldots \rightarrow_R a_n \rightarrow_R \ldots$$

of reductions in A wherein

$$a_i \neq a_{i+1} \text{ for } i = 0, 1, 2, \ldots$$

(5) The reduction system $\rightarrow_R$ is **complete** if it is Church–Rosser and strongly terminating.
(6) A reduction system is Church–Rosser and weakly terminating if, and only if, every element reduces to a **unique** normal form.
Let $\equiv_R$ denote the smallest equivalence relation on A containing $\rightarrow_R$. If $\rightarrow_R$ is a Church–Rosser weakly terminating reduction system then the set $NF(\rightarrow_R)$ of normal forms is a transversal for $\equiv_R$, i.e. a set that contains one and only one representative of each equivalence class.

abstract specification A specification for software expressed in a (mathematically) *formal language such that the specification is completely independent of, and does not imply, any design and implementation method and languages. It does not normally express the constraints that the final software must satisfy. *See also* FORMAL SPECIFICATION.

A-buffer A buffer used with a *Z-buffer to hold information concerning the visible transparent surfaces to be considered at each *pixel of an image. The A-buffer originated in an *anti-aliased *hidden-surface removal algorithm developed by Loren Carpenter around 1984. It resolves visibility among an arbitrary collection of opaque, transparent, and intersecting objects. The algorithm was developed for the REYES system at Lucasfilm Ltd. Road to Point Reyes was a famous image produced by the system.

AC97 A specification by Intel for a *codec providing audio input and output for a computer. It allows low cost audio and is fitted as a standard feature on many personal computers. *See also* INTEL HIGH DEFINITION AUDIO.

accelerated graphics port (AGP) A port specification that facilitates the high-speed high-resolution display of graphics. Developed by Intel, it provides a direct connection for data transfer between an AGP-compatible display adapter and the system's main memory. As a result, images are displayed more quickly and smoothly than is otherwise possible over a system's *PCI bus. The AGP standard is being superseded by *PCI Express.

acceleration time (start time) The time taken for a device to reach its operating speed from a quiescent state.

accelerator key A key, or combination of keys, on a keyboard that can be used to perform a particular operation. For example, in many applications pressing ctrl+a (holding down the control key and pressing letter 'a') is 'select all'. Other examples are ctrl+c (copy), ctrl+x (cut), and ctrl+v (paste). The *function keys are single accelerator keys.

accent-sensitive Requiring or making a distinction between accented and unaccented forms of a letter and between different accents. In any situation where a computer program is reading characters, a decision has to be made whether to treat each accented form of a letter as a different character. In most cases it is appropriate to do so; however, accents are often ignored in alphabetical sorting and in indexed searches. Modern database management systems generally offer extensive facilities to specify which data is accent-sensitive and which is not.

accept (recognize) a formal language. *See* AUTOMATON, FINITE-STATE AUTOMATON.

acceptable use policy (AUP) The set of rules governing the use that can be made of a network. All network users are expected to conform to any existing legislation, and to any commercial conditions that form part of any contract for the use of commercial networks. In the case of academic or research networks there are also likely to be constraints on using the network to carry commercial traffic, and these will be embodied in the AUP.

acceptance testing *See* TESTING. *See also* REVIEW.

access **1.** The reading or writing of data, with the connotation that the content of the reading or writing is taken into account. The

word is most commonly used in connection with filed information and is often qualified by an indication as to the types of access that are to be permitted. For example, read-only access means that the contents of the file may be read but not altered or erased. **2.** The right or opportunity to read or write data or programs. The UK *Computer Misuse Act 1990 states that "a person secures access to any program or data held in a computer if by causing a computer to perform any function he alters or erases the program or data, copies or moves it to any storage medium other than that in which it is held or to a different location in the storage medium in which it is held, uses it or has it output from the computer in which it is held (whether by having it displayed or in any other manner)". **3.** To gain entry to data, a computer system, etc. In the US, to access strictly means to instruct, communicate with, store data in, retrieve data from, or otherwise obtain the ability to use the resources of a computer or any part thereof.

Access *Trademark* A *relational database management system for PCs produced by Microsoft.

access control A *trusted process that limits access to the resources and objects of a computer system in accordance with a *security model. The process can be implemented by reference to a stored table that lists the *access rights of subjects to objects, e.g. users to records. Optionally the process may record in an *audit trail any illegal access attempts.

access method Any algorithm used for the storage and retrieval of records from a *data file or *database. Access methods are of two kinds: those that determine the structural characteristics of the file on which it is used (its *file organization) and those that do not (as in secondary indexing (*see* INDEXED FILE) and *data chaining). In the first case essentially the same algorithm is used for the retrieval of a record as was used for its original physical placement, whereas in the second these algorithms are quite distinct. Hence in the first case the same term may be used interchangeably (and loosely) for both the access method and the file organization (*see* RANDOM ACCESS (DEF. 2), sequential access).

access path The name given to the set of names of devices, *directories, *subdirectories, and a specific *file, by means of which the file-management system is able to reach the specified file. Depending on the details of the file-management system actually in use, the access path may start with the name of a physical or logical device, which holds a number of directories that associate the identity of an object with its location on the device; these objects may in turn be further directories (usually then known as subdirectories) or they may be files containing end-user data. The complete set of intermediate objects, in the order in which they are used, is the access path.

access point (wireless access point) A device that acts as the core of a wireless network. It communicates with wireless nodes within its range and provides the necessary facilities for them to network successfully. Access points commonly also manage a link to a wired network, allowing their nodes to link with corporate networks, the Internet, etc.

access provider An organization, usually a commercial company, that offers Internet access services. *See* ISP.

access rights (access privileges) A classification of the modes of access to an object granted to particular subjects, or groups of users. Thus, the owner of a file will typically have rights to read, write, or delete the file. Some or all these rights may also be granted to other users on the system. *See* ACCESS CONTROL.

access time The time taken to retrieve an item of information from storage. The access time may be counted in nanoseconds for a semiconductor device, in milliseconds for a magnetic disk, or in minutes if the file containing the required data is on magnetic tape.

In the case of disk storage, the access time is the average time taken for a disk drive to provide the first byte of data, measured from the time the host issues a read command. To a good approximation, the average access time is the sum of the average *seek time, the command overhead, and the average *latency. *See also* MEMORY HIERARCHY.

access vector A vector that is used in the representation of a *ragged array. For example, the elements of a row-ragged array, A, would be stored row by row in a vector B.

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The *i*th element of the access vector would then point to the position in *B* where the first element of the *i*th row of *A* was stored (see diagram overleaf). A column-ragged array would be similarly represented using an access vector referring to the beginning of columns and a listing of the elements column by column.

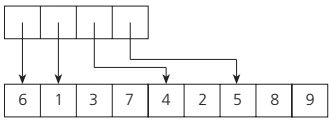
6

1 3 7

4 2

5 8 9

row ragged array



representation using an access vector

Access vector.

account The environment in which a user interacts with a computer system. Each account has a unique name, which the user specifies when logging in. System data associated with an account controls what resources (files, programs, networks, etc.) the user can access and in what ways (e.g. whether files that are normally writeable are read-only for particular users) and to what extent (e.g. the total size of files a user creates may be limited). Where applicable, a record can be kept of the resources used for billing purposes.

accountable file A file that will be taken into account when evaluating system usage. An example is a user's permanent file holding the text of a program. Files that have only a transient existence, for example to hold spooled files, will not be accountable.

accounting file A file that contains records of the resources used by individual jobs. These records are required both to regulate the amount of resource used by a job and, in a commercial environment, to manage the charging for use of the system. As each job is started, an entry is opened in the accounting file into which records concerning system utilization are written as the job is processed. *See also* SYSTEM ACCOUNTING.

accumulator A *register that is implicitly specified by one-address format instructions and is used to contain the results of an operation performed by the *ALU. It can normally be one of the inputs to the ALU, thus the results of a number of successive operations may be built up – hence the name. In addition to holding results, the accumulator commonly has the ability to perform the various *shift and *circular shift instructions. It may be part of the *processor status word.

accuracy *See* PRECISION.

ACE *Acronym for* Automatic Computing Engine. An electronic stored-program computer designed in 1945–46 by Alan *Turing while he was at the National Physical Laboratory (NPL), near London. The prototype version **Pilot ACE** was built at the NPL, ran its first program in 1950, and was in full-time use in 1952. The final version was working by 1957. A production model of Pilot Ace, called **DEUCE**, was marketed by the English Electric company.

ACIA *Abbrev. for* asynchronous communications interface adapter. *See* UART.

ACID *Acronym for* Atomicity, Consistency, Isolation, Durability. These are the essential qualities of a *transaction in database processing: either all or none of the subtasks composing the transaction must be performed (atomicity); the database satisfy all its *constraints both at the beginning and at the end of the transaction (consistency); no other database user can access the data being manipulated by the transaction while it is an intermediate, and possibly inconsistent, state (isolation); and, once completed, the effect of the transaction will not be reversed, for example by a system crash and subsequent recovery (durability).

ACK The "acknowledge" control character. *See* ACKNOWLEDGMENT.

Ackermann benchmark A use of the *Ackermann function to provide a *benchmark for computer performance. Typically in excess of 100 000 recursive calls to the function are made and the number of completed calls per second measured. The benchmark gives a good indication of the overhead associated with procedure and function calls.

Ackermann function The *function *A*

defined inductively on pairs of nonnegative integers in the following manner:

$A(0,n) = n + 1$

$A(m+1,0) = A(m,1)$

$A(m+1,n+1) = A(m,A(m+1,n))$

where $m,n \geq 0$. Thus

$A(1,n) = n + 2$

$A(2,n) = 2n + 3$

$A(3,n) = 2^{n+3} - 3$

The highly recursive nature of the function makes it a popular choice for testing the ability of *compilers or computers to handle *recursion. It provides an example of a function that is general *recursive but not *primitive recursive because of the exceedingly rapid growth in its value as m increases.

The Ackermann function may also be regarded as a function **Ack** of a single variable:

$\mathbf{Ack}(n) = A(n,n)$

where A is defined as above.

acknowledgment **1.** A message that describes the status of one or more messages sent in the opposite direction. A **positive acknowledgment (ACK)** confirms that the previous messages were received correctly. A **negative acknowledgment (NAK)** indicates that the previous messages were not received correctly and should be retransmitted. In some *protocols, acknowledgments are also used as a simple form of *flow control: sending an ACK implies that another message may be sent in the same direction as the message being acknowledged.

Different layers of a protocol hierarchy may have their own acknowledgment systems operating simultaneously. For example, an end-to-end transport protocol may be used to send a message reliably from one host to another in a packet switching network. When the message reaches its destination, an acknowledgment will be generated and sent in the opposite direction. Both the original message and its acknowledgment will cause data link layer acknowledgments to be generated as they travel from node to node in the network. *See also* BACKWARD ERROR CORRECTION. **2.** Output to the operator or user of a graphics system that indicates that some input has been received. *See also* PROMPT, ECHOING, FEEDBACK.

ACM Association for Computing Machinery, a US organization founded in 1947 and dedicated to the development of information processing as a discipline, to the exchange of information about the subject, and to the responsible use of computers in an increasing diversity of applications. It publishes a wide range of influential scholarly and professional journals, the best known of which are the Communications of the ACM and the Journal of the ACM. Although based in the USA, the Association has branches (known as chapters) in many countries.

SEE WEB LINKS

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acoustic coupler A type of *modem that converts serial digital data into a *frequency shift keyed sound signal in the audio range for transmission down telephone lines, and decodes similar incoming sound signals. The connection between the acoustic coupler and the telephone system is made by means of a small microphone and loudspeaker held close to the earpiece and mouthpiece of an ordinary telephone handset in a sound-absorbent enclosure.

Although largely superseded by devices that connect directly to the telephone network, acoustic couplers are still used. The lack of any electrical connection between terminal and phone lines is of benefit when obtaining the approval of the PTT for the use of such a device. The quality of ordinary switched voice circuits normally limits the speed of transmission to 300 baud or less.

acoustic delay line *See* DELAY LINE.

acoustic memory *An alternative name for* acoustic delay line.

Acrobat *Trademark* A program produced by Adobe Systems Inc. for the production and manipulation of *portable document format (PDF) files. **Acrobat Reader** is a utility for reading, displaying, and printing PDF files, and is available free. Most personal computers have a version of Acrobat Reader and most browsers now allow download and display of a PDF file using Acrobat. The full version of Acrobat (which is not free) provides a number of other features. It was originally called **Acrobat Exchange** (up to version 3) and includes a number of other features, in particular **Acrobat Distiller** (a program for converting *PostScript files into PDF files). The program also has facilities for

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combining, splitting, or rearranging documents, adding bookmarks, notes, etc.

action selection The decision problem of choosing between several competing goals, when each has conflicting characteristics, time is limited, and the environment is dynamic. Action selection, which is a topic in *artificial intelligence, may seem to be a technical issue but is in fact a deep and fundamental problem faced by all *agents in complex environments. Animals, mobile robots, and software agents must all respond to changing events in their worlds and they must opportunistically decide which goals are best to pursue, and when to interrupt action towards current goals and divert resources to new goals.

active *Another term for* running.

Active Directory *Trademark* An implementation of *directory services for Windows. It was introduced with Windows 2000 Server edition and has been developed in subsequent Windows releases.

active filter A combination of operational amplifiers and reactive elements that performs a variety of *filtering functions.

active-matrix LCD *See* LCD.

Active Server Pages (ASP) A technology from Microsoft to generate *server-side *dynamic web pages. Its core is an extension to *HTML syntax that allows program fragments written in a scripting language (usually *VBScript) to be embedded in web page templates; these scripts are executed by an ASP-aware web server and their results are combined with the template to form the web page sent to the client. Introduced in 1996, ASP is now part of the *.NET framework (**ASP.NET**) and web pages can be created in any .NET programming language. *See also* JAVASERVER PAGES.

active star A network topology in which the outer *nodes connect to a single central node that processes all messages in the network, including messages that it forwards from one outer node to another. A failure of the central node causes the entire network to fail. *See also* PASSIVE STAR, STAR NETWORK, NETWORK ARCHITECTURE.

active transition of a clock signal. *See* CLOCK.

active vision A subfield of computer vision where controlled movement of the viewpoint of the imaging camera is an integral part of the image-processing task. Previously in computer vision research, in order to reduce the enormous complexity of visual data, fixed camera geometry and static images have been beneficial in constraining and simplifying the image-processing tasks. Active vision takes a different approach and, by analogy with animal vision, does not avoid movement but gains information from the dynamics of changing viewpoints to resolve ambiguities, gain depth information, and establish relationships between visual sensing and action.

active widget A *widget that both displays its current value and achieves the relevant action.

ActiveX *Trademark* A ***COM** (def. 2) technology developed by *Microsoft.

activity network (activity graph) A graphical method for showing dependencies between tasks (activities) in a project. The network consists of *nodes connected by arcs. Nodes denote events and represent the culmination of one or more activities. Arcs represent activities and are labeled with the name of the activity and have an estimated time to complete the activity. Dummy unlabeled arcs with zero completion time are used to fan out from one event to other dependent events. Before progress can be made from one event to another, all activities leading to that event must have been completed. The longest path through the activity network gives the completion time for the project represented by the network. *See also* CRITICAL PATH METHOD, PERT CHART.

actor language An *object-oriented language in which objects exist as concurrent processes (*see* CONCURRENCY).

actors An early message-passing model of concurrent computation in artificial intelligence. The model has many features that relate to *object-oriented programming and conceptual similarities with the language *Smalltalk. *See also* ACTOR LANGUAGE.

actual parameter Information passed to a *subprogram at the *call. *See also* PARAMETER, ARGUMENT.

actuator of a disk drive. The mechanism that causes the head carriage and heads to be moved to the desired track. The **voice coil**

actuator gains its name because its operating principle is similar to that of a moving-coil loudspeaker. This type of actuator invariably forms part of a closed loop servosystem. The reference information may be provided by a disk with a dedicated servosurface: the servohead positions itself symmetrically between two servotracks by sensing positioning information from both tracks (di-bits) and moving in such a way that the amplitudes of the two signals are equal. A second method records the servo information in a fixed number of equiangular "spokes"; this technique is known as **embedded servo**. Dedicated servo drives suffer head stack and/or disk stack tilt, due to temperature variations – especially after being powered-on. This causes heads located further away from the servo head to be misaligned from the corresponding data track centerline. Accordingly, these drives must interrupt the data flow to the host system to carry out regular calibrations. Embedded servo drives do not need to interrupt the data flow and so are better suited to applications that must provide a continuous data stream, e.g. video-on-demand systems. As track densities have increased embedded servo techniques have become more common.

acyclic graph A *graph possessing no *cycles; when the term is applied to directed graphs the direction associated with the edges must be taken into account. *See also* TREE.

Ada *Trademark* A programming language developed at the behest of the US Department of Defense for use in *real-time systems containing *embedded computers. The name commemorates Augusta Ada King, Countess of Lovelace, who assisted Charles *Babbage and has some claim to be the world's first programmer.

The original version (now known as **Ada 83**) was designed by international competition, published in 1980, and adopted as an ANSI standard in 1983 and as an ISO standard in 1987. It incorporated ideas of *modular programming, *concurrent programming, and separate compilation to support the development of large programs. It also introduced the idea of a programming support environment (*APSE) whereby program development tools are specified along with the language as an integral whole. However, the absence of agreement on specific tools has led to a number of different and incompatible support environments for Ada.

From 1986 use of Ada was made mandatory for US military applications (unless the contractor could show "good cause" for a waiver), and several European countries have followed suit.

The language was revised in the early 1990s (when it was called **Ada 9x**) and adopted by ISO in 1995; this version is now known as **Ada 95**. In spite of differences in presentation, Ada 95 is virtually a superset of Ada 83, so almost all Ada-83 programs are valid Ada-95 programs. The core of Ada 95 includes facilities for *object-oriented programming and facilities for synchronized access to shared data (protected objects). There are annexes for distributed systems, informations systems, real-time systems, systems programming, safety and security, numerics, and interfaces to other languages. The current standard, **Ada 2005**, is a corrected and amended version of Ada 95.

SEE WEB LINKS

- The Ada 2005 Language Reference Manual

Ada 95, Ada 83, Ada 2005 *See* ADA.

Adams methods *See* LINEAR MULTISTEP METHODS.

adaptive channel allocation A process by which the capacity of a communication channel is multiplexed (shared) among several sources depending upon their relative requirements. The resource distribution varies with time to match changing requirements. *See* MULTIPLEXING.

adaptive compression (adaptive compaction) A *compression technique that chooses between different techniques depending on the information to be compressed. *See also* STATISTICAL COMPACTION.

adaptive-control system An automatic (process) control system that uses adaptation as part of its prediction of process behavior in order to optimize the control. *See* ADAPTIVE PROCESS.

adaptive interface A human-computer interface (*see* HCI) that adjusts to user skill.

adaptive maintenance *See* SOFTWARE MAINTENANCE.

adaptive meshing Meshing an area where each element of the *mesh can be in-

a

dependently subdivided to ensure a desired effect is achieved. For example, *finite-element calculations will require more detailed meshes where there are rapid changes in the structure or the parameter of interest is changing rapidly.

adaptive process The process of performing computations on a set of measured or presented data (believed to be) from a physical, i.e. natural, source in such a way as to develop a "best" parametric model of that physical source, i.e. one that best fits the observed data according to some error criterion. *See also* ADAPTIVE-CONTROL SYSTEM, SELF-ORGANIZING SYSTEM.

adaptive quadrature *See* NUMERICAL INTEGRATION.

adaptive ray tracing *See* RAY TRACING.

ADC *Abbrev. for* analog-to-digital (A/D) converter.

ADCCP *Abbrev. for* advanced data communication control procedure. A bit-oriented *data link control protocol developed by ANSI and similar to *SDLC and *HDLC.

A/D converter (ADC) *Short for* analog-to-digital converter. A device that can accept an analog, i.e. continuous, signal whose amplitude lies within a given range, and produce an equivalent digital signal, i.e. an n-bit parallel binary word that represents this analog signal. The analog signal is "examined" at discrete fixed intervals of time by means of a *sampling process in order to produce the digital signal. Analog signals originating from devices such as analog sensors or tachogenerators may thus be converted into a form that can then be processed by, say, a microprocessor.

The **resolution** of an A/D converter gives the smallest change in analog input that can be discriminated by the device. If the resolution of an n-bit A/D converter is ΔV, then its range is either

$$0 \text{ to } \Delta V(2^n - 1)$$

or

$$\pm\Delta V(2^{n-1} - 1)$$

according as it is *unsigned or *signed. In practice, the value of n is usually 8, 10, 12, 14, or 16. Since the resolution is finite, the conversion process introduces quantization noise (*see* DISCRETE AND CONTINUOUS SYSTEMS). A/D converters are available in integrated circuit form. *See also* D/A CONVERTER.

adder In its simplest form, a digital electronic device that performs the operation of addition on two binary digits, the **augend** and the number to be added, the **addend**. It is therefore also known as a **binary adder**. This operation is exemplified by the truth table shown in the diagram, where Σ is the sum and C_o is the carry. From this it can be seen that binary addition may generate a carry to subsequent stages.

A **full adder** has provision for inputs of addend, augend, and a carry bit and is capable of generating sum and carry outputs. These adders may be cascaded when it is desired to add binary words greater than one bit in length by connecting the carry inputs of each stage to the carry output of the previous stage.

A **half-adder** is an implementation of an adder that has provision only for input of addend and augend bits and is capable of generating sum and carry outputs. These devices cannot directly be cascaded as can full adders but may be made to perform a similar function by including additional logic gating.

See also PARALLEL ADDER, SERIAL ADDER, CARRY LOOKAHEAD.

A	B	Σ	C_o
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Adder. Truth table of binary half-adder

add-in card (add-on card, expansion card) A *printed circuit board that plugs into an *expansion slot in a computer to provide some extra facility. The sockets normally connect to a *bus, and the type of connector and the use to which each contact is put are strictly defined to ensure compatibility between the card and the computer. Cards are available that provide extra memory, communications interfaces, sound I/O capabilities, device interfaces to extra disks, for instance, or perhaps extra processors in multiprocessor systems. *See also* PCMCIA.