

## Genera Concepts

### Genera — The Best Software Environment Available

To all our new users: Welcome.

This conceptual introduction explains what your Symbolics computer is all about. We urge you to at least skim it before you start daily work with the system. We try here to summarize some of the "big picture" concepts in your new software environment; knowing about this framework will help you in learning its details more efficiently.

Most new users of Symbolics machines have worked on traditional time-sharing systems, such as VAX/VMS, or on microcomputers or conventional UNIX workstations. ("Genera Comparison Charts" shows some equivalents between these systems and Genera.) If you feel somewhat uneasy about learning how to use the most advanced software environment around, relax!

You don't have to learn everything at once in order to do anything — look at this as a long-term, incremental learning project. You don't have to learn everything by yourself. Our documentation and Genera itself are here to help you.

Genera and Symbolics Common Lisp dramatically increase your productivity and efficiency by providing many built-in software facilities (similar to library routines) that you would otherwise have to write yourself. Our edit-compile-debug cycle happens so fast that you are virtually editing, compiling, and debugging simultaneously. The editor, compiler and debugger are all *resident* utilities, available anytime, anywhere.

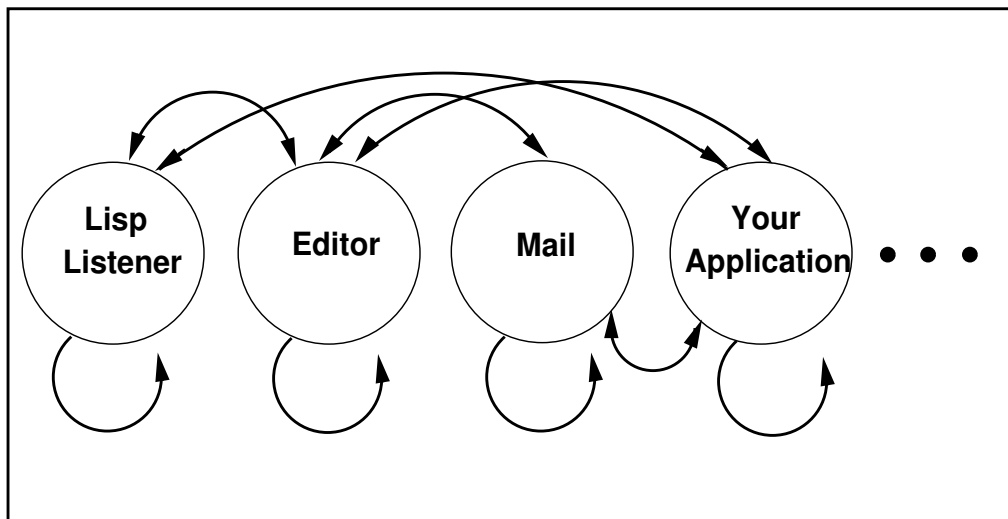


Figure 6. Your view of Genera's command level.

Genera has no "command levels" or separate "command environments;" you *can* get there from here. You can move directly from any application to any other application, usually with just two keystrokes. You do not have to close one application to enter another. (See Figure 6.)

Many different *activities*, such as the editor and electronic mail, run at the same time in separate *processes*. That means you can move around the system from one application to another without affecting the state of other applications. For example, you can move directly from editing a file to reading online documentation to sending mail and back to editing the file.

To illustrate the basic environmental concept, suppose for a moment the house you live in were like a conventional software environment. The electricity would be in one room, the telephone in another, the heat in another, and the tap water in another. To access one facility, you would have to leave the other behind, moving back to a central access hallway that opened onto all the other rooms.

Suppose you were talking on the telephone in the telephone room. If you wanted to turn on the light in order to write something down, you would have to leave the telephone room, and go to the electricity room. If you then wanted to wash your hands, you would have to leave the electricity room and go to the water room. It would be unthinkable to use the heat, light, or telephone in the water room.

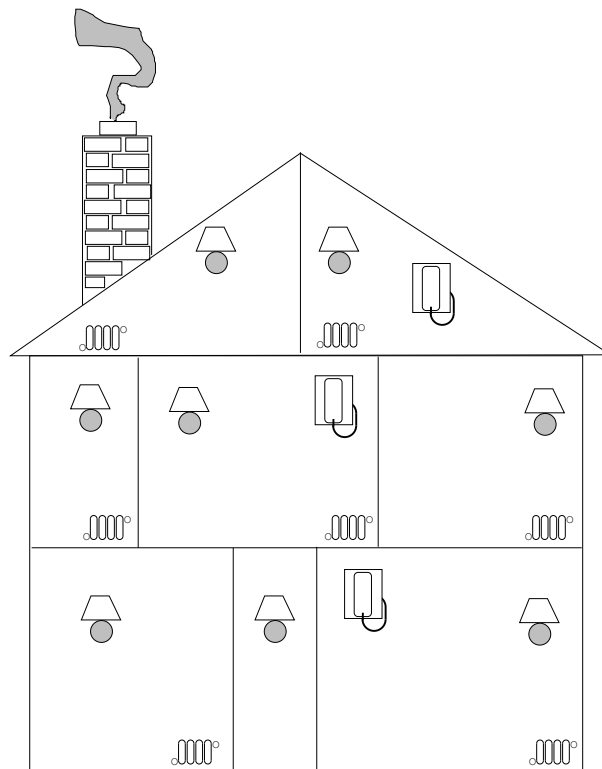


Figure 7. House as Operating System. This house design has central heating, electricity in every room, and so on. That is, basic services are available or accessible in every context.

Continuing this analogy, with a house designed like Genera, you could access electricity, heat, water, telephone, vacuuming, and so forth, from *every* room (Figure 7)! As you will see when you learn more about Genera, you can access a Genera activity in many different ways as well.

In a conventional computer system, the *operating system* is the foundation and other separate software application programs are layered on top of the operating system. The command level (exec, monitor, or shell) controls access to the operating system's facilities as well as access to (*invoking and terminating*) the application programs (Figure 8).

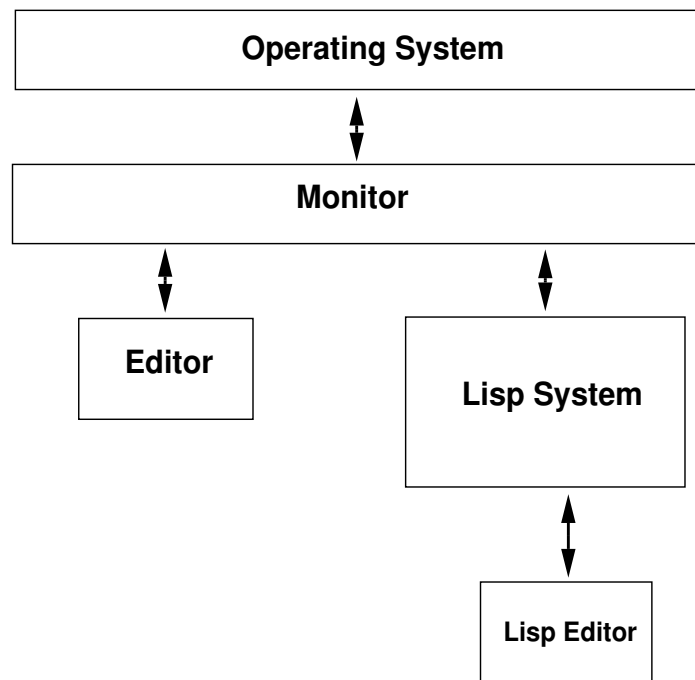


Figure 8. Traditional operating systems require the user to interact with a command monitor in order to access applications and the facilities of the operating system.

Genera is your whole environment; it encompasses what you normally think of as an operating system as well as *everything* else — system commands and all other activities. From where you look at it, there is no "top-level" controller or exec.

All Genera activities are themselves Lisp functions, based on a pool of thousands of Lisp functions, all implemented in Lisp. Below those, it's just the hardware — you never need to deal with a lower-level internal implementation language.

Genera is *intelligent*. Its many processes can communicate with each other, and they all automatically share data. Genera keeps an internal record of the *history* of almost everything that happens in the system — command history, output history, process history, window history, and so on.

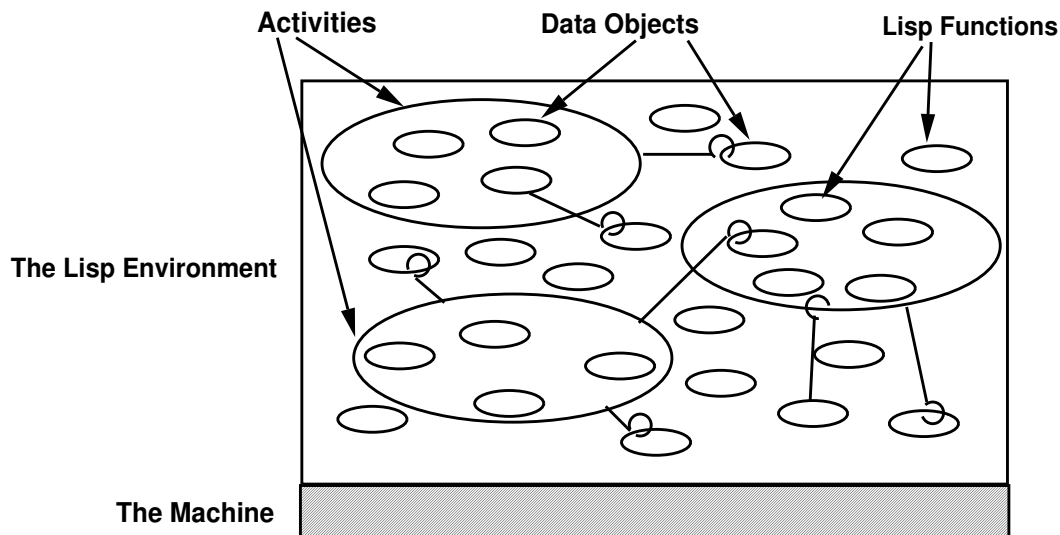


Figure 9. The Lisp Environment, consisting of all the function and data objects in virtual memory. Activities are just collections of functions and data.

Histories make it possible to use previous output on a window as input to a command. The mouse can select a relevant piece of output anywhere on the screen because the history mechanism keeps track of the data object types of all the output. As a result, the reusable output is completely context-sensitive.

For example, clicking on a filename in a directory listing displays the contents of the file. When a command needs a filename argument, clicking on that same filename gives the file to the command as an argument. The meaning of the clicks is both context-sensitive and intuitive. You can scoop up a piece of output in one activity and enter it as input to another activity in a matter of seconds. With just a few keystrokes, you can find, modify, and reuse a command that you entered earlier in the day.

The key to Genera's intelligence is the sharing of knowledge and information among all activities. At any time, the collection of all the state of all the processes is called the *environment* (Figure 9). Any function running in any process can use any piece of data in the environment directly. You do not need laborious special-purpose protocols or intermediate files.

The entire software environment, in its pristine unused state, ready for booting, is saved on disk as a *world*. A world consists of all the Lisp objects (functions, variables, windows, processes, and so on) that make up the software environment. The world contains the fully initialized environment, ready to boot and use.

Genera doesn't draw any boundaries around itself. It is *customizable* and *extensible* by design. Unlike most software, it has an open architecture; you can change anything that is part of Genera. In fact, we encourage you to take advantage of this and to build your applications as extensions of Genera.

The extensibility of the system is possible thanks to both its modular design and its implementation, using highly flexible, object-oriented data structures called *fla-*

*vors*. Any data object defined by a flavor or class can be customized or extended cleanly.

Object-oriented data structures are at the heart of *symbolic processing* because they allow abstract descriptions of data and operations in terms that fit well with the application. The data objects are essentially models of the real-world objects they are implementing. Thus programming uses a problem-solving vocabulary that matches the terminology of the problem domain.

Genera itself was designed to be extended in a number of different ways. You can set customizing variables and create simple files of personal initializations (called *init files*), or you can extend or replace parts of Genera itself in order to create your own special application.

When you write a program, it becomes an extension of Genera itself (Figure !). What you do becomes part of the world and enriches the software environment. Because you have loaded a world into your own standalone machine, you can customize and extend the system without affecting the work of others. To get a fresh world, simply boot your machine again.

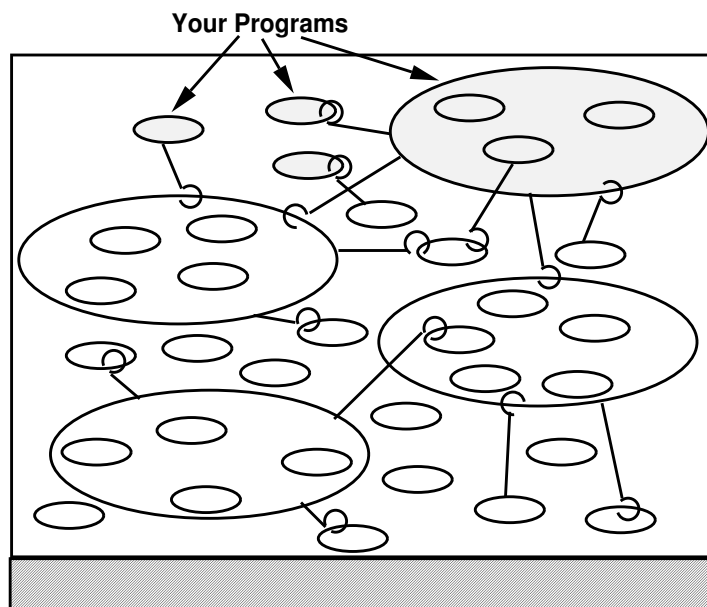


Figure 10. Your Programs Become an Extension of Genera.

To sum things up, its built-in features, open architecture, intelligence, and extensibility make Genera a new breed of software environment. Genera can help you perform tough software development tasks more quickly than you ever imagined possible.

As you delve deeper into the conceptual material in the next chapters, and then begin to get hands-on practice with Genera in the workbook, do not feel overwhelmed. You shouldn't put pressure on yourself to learn all about a revolutionary new software environment in a day or two. Take it easy. Try things out. Master a little at a time. Genera fosters an incremental approach in all things, including its own mastery.

Genera has amazing functionality and flexibility — often you can perform any task in any application in several different ways. But do not equate high flexibility and functionality with low usability! Genera is also ultimately the most usable software environment available. We want you to explore our functionality at your own pace. There is virtually no limit to the capabilities you will discover in Genera. And Genera will not place artificial upper limits on your creativity.

## Genera — A Short Conceptual Tour

### The Road to Symbolic Computing

What's the central philosophy behind the evolution of computing in general and Genera in particular?

Free programmers from thinking about unnecessary details and they can accomplish more. The more abstractly they are allowed to think, the bigger and harder the problems they can solve.

Some major advances in the history of conventional computing were motivated by this philosophy:

- **Assembly language.** To avoid having to program in ones and zeros, assemblers were invented and programmers were able to express instructions to the computer mnemonically.
- **High-level languages.** To avoid having to think about the computer hardware and instructions when solving a problem, high-level programming languages such as FORTRAN were invented. These allowed programmers to express solutions to problems without regard for the particular organization of the hardware and instruction set.
- **Dynamic memory allocation.** To free programmers from having to plan the storage needs of their programs in advance, dynamic memory allocation became available in programming languages like Pascal and C.

Genera takes this philosophy of supporting programmers much farther, providing the ideals of abstraction and generality in a number of ways.

- *Generic operations.* When you need to add two numbers, you do not need to care about whether one number is an integer and another is a floating-point number. Just use the generic operation "+" all the time, and Genera figures out how to do "+" correctly. There is no performance penalty for this flexibility and freedom from detail — it is handled by special hardware.

- *User-defined generic operations.* One of the principal gifts that object-oriented programming gives you is the ability to define your own generic operations. With the powerful and efficient Flavors system, or the Symbolics implementation of CLOS, object-oriented programming is not expensive, either; you don't pay any performance penalties for using the power.
- *Automatic storage management.* Pascal and C provide dynamic memory allocation at a price. To make use of that feature in conventional languages, you must construct your program carefully to manage the allocation and deallocation of memory. The details of explicit storage management have nothing to do with the conceptual problems that the program is trying to solve, but it's necessary to complicate your program with those details on conventional computers.

In Genera, programmers need not explicitly allocate or deallocate memory. Storage space is made available to a program implicitly as it is needed and is reclaimed automatically when it is not needed. This is called garbage collection. You don't have to think about it at all; you can focus your attention on the problem you are trying to solve.

Automatic, dynamic memory allocation is one of the things that makes it easy to write large Lisp programs. The coupling of special hardware and ingenious software on our machine makes garbage collection very practical and inexpensive; it is neither of those things on other machines.

- *Dynamic linking.* To run a program on conventional computers you have to compile it and link and load it. On ours you just have to compile the thing. Why think about linking? It's free, courtesy of symbolic computing.
- *Definition editing.* Programmers often work on big programs, involving thousands of routines defined in hundreds of files. The logistics of that are staggering on conventional computers. When you need to modify a function, you have to find it first; you end up being a bookkeeper as well as a programmer.

In Genera, that's not necessary. All you need to know in order to modify a function is its name. You can say "Edit the definition of this function" and Genera takes care of the bookkeeping. That's the right way to do it, because otherwise bookkeeping stands between you and the problem at hand.

- *Generic networking.* Symbolics supplies impressive networking capabilities. The name of the game is "heterogeneous". We can speak DECnet to VAXes, TCP/IP to many different kinds of computers, and SNA 3270 to IBM computers.

There are actually quite a few ways of making another vendor's machine talk to your Symbolics machine. The good news is that most Symbolics Genera users do not need to know anything at all about any of these network protocols in order to use them.

The substrate of all of our networking products is called the "Generic Network System." It does for networking what generic operations do for programming itself. Namely, you don't have to think about how you're going to talk to another computer; you think only about what you want to do. Here are examples of using Chaosnet, DECnet, and TCP/IP for file transfer:

```
Command: Copy File TE:RDP;Speech.Text W:>RDP>Speech.Text
```

```
Command: Copy File TE:RDP;Speech.Text GUMB0:[RDP]SPEECH.TXT
```

```
Command: Copy File TE:RDP;Speech.Text Acme:/usr/rdp/speech.txt
```

As this example shows, you always use the network the same way, whether the other machine is another Symbolics machine, a VAX running VMS, or something running UNIX. There's no difference between machines on a local network and those at a remote site. As long as the appropriate network connections exist, you just issue the commands with the names of the files you want and generic networking takes care of the details. No special "file transfer program" is ever needed.

The simplicity and uniformity are there not only for Genera users but also for programmers who are developing distributed applications that use a network. Our system makes that very simple; no non-essential details come between you and your real goal.

- *Program-building assistance.* Genera provides a high-level substrate for building the user interfaces of application programs. You can define commands that work just like the other Genera commands, with full error-checking, reprompting, and context-sensitive help. They will work like Genera commands, but you can design them to look like anything you want; the tools do not limit in any way the kinds of interfaces you can build.

The mouse is an important part of Genera's user interface. When you use the standard mechanisms for defining commands in an application, mouse sensitivity comes along for free. You get command menus, reusable output, and context-sensitive mouse documentation automatically as a result of using these high-power tools for defining your program.

Maybe you can't move the world with a computer, but Genera running on a Symbolics machine makes it easier to try.

### **Genera Does It Better**

Symbolics Genera is an advanced software development environment that integrates the features normally found in an operating system, its utilities, and the applications running under it. Genera is written in Lisp and supports program development in Lisp and in a number of other languages, including conventional algorithmic ones such as Pascal and C.



Genera has evolved expressly for providing full life-cycle support for major development projects. It includes facilities for the following classes of activities:

- Exploring ideas
- Developing prototypes
- Communicating with other project members
- Consolidating diverse exploratory efforts
- Testing and refining a product
- Distributing, maintaining, and retiring the final product

Genera was designed for advanced, complex applications. By their very nature, this kind of program is not well understood by its designers; understanding grows incrementally with time and experience. Genera provides the support necessary for this kind of evolutionary growth of a complex program.

With the rich substrate of reusable functions, you can create a working prototype in a fraction of the time you were accustomed to needing. With the modular design encouraged by object-oriented methodology, you can replace parts of the prototype cleanly whenever new understanding permits. As the application grows, configuration management tools keep the complexity under control.

Genera was designed specifically to support the evolutionary software methodology. Both the basic architecture and the software itself were built for managing the details of program structure and compilation.

- Data-level integration. All functions and data exist in virtual memory that is *shared* by all processes.
- Open system. All parts of the system are available for inspection, reuse, extension or replacement.
- Support for incremental change. Continual, small changes are supported in designs, in work procedures, and in quality enhancement.
- Reusability. Along with the reusability made possible by the open architecture, source code is available for most of the system, to aid in understanding and extending Genera.
- Extensibility. The work environment is designed to be tailored to support users' own styles and preferences.
- "Self-revealing" system. Information about the internal workings of the system is always available.

### Data-level Integration

In Genera, all functions and data share the same virtual memory. This shared memory is treated by the software as containing a set of data objects, not uninterpreted bits or bytes. Data objects are both simple (like characters) and structured (like arrays). In addition, you can have data types defined by applications, containing both state information and operations.

Each data object contains knowledge of its own type. For simple objects, some of this type knowledge is captured in hardware tag bits. Data objects in the object-oriented Flavors and CLOS languages also know their own types and the generic operations that apply to them.

All functions running on the machine can access a common pool of data structures; your functions and data are indistinguishable internally from those provided by the system. Integration in the environment is at the level of the data. A number of different programs can operate on the same data and programs can communicate with each other via shared data. In conventional systems, programs usually have to communicate with each other through the medium of files (see Figure !).

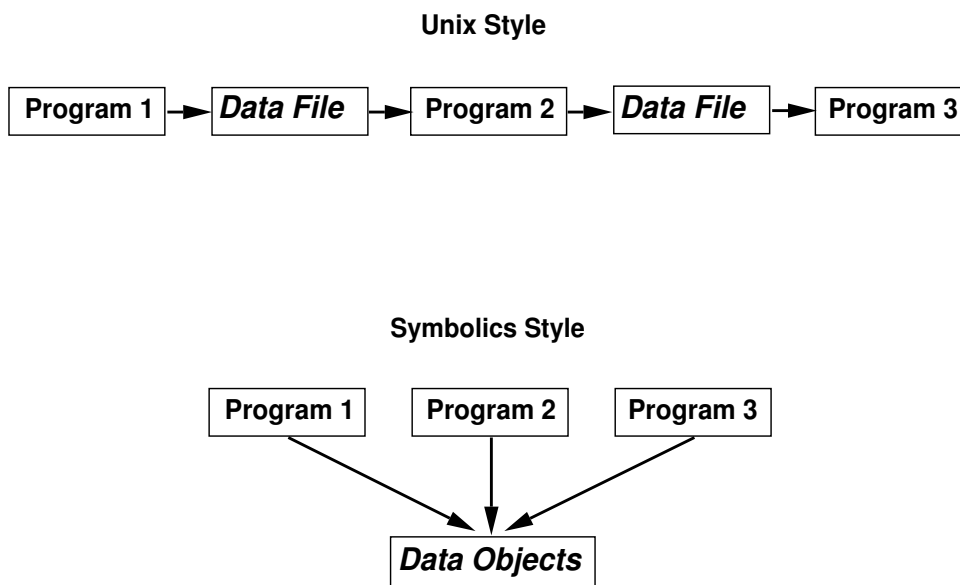


Figure 11. The Value of Integration

### Open Architecture

Most conventional operating systems have a core or kernel that is protected from modification or even use by application programs. Genera has no such barriers; everything is open for use or modification. Figure ! diagrams the fundamental difference between open and closed systems.

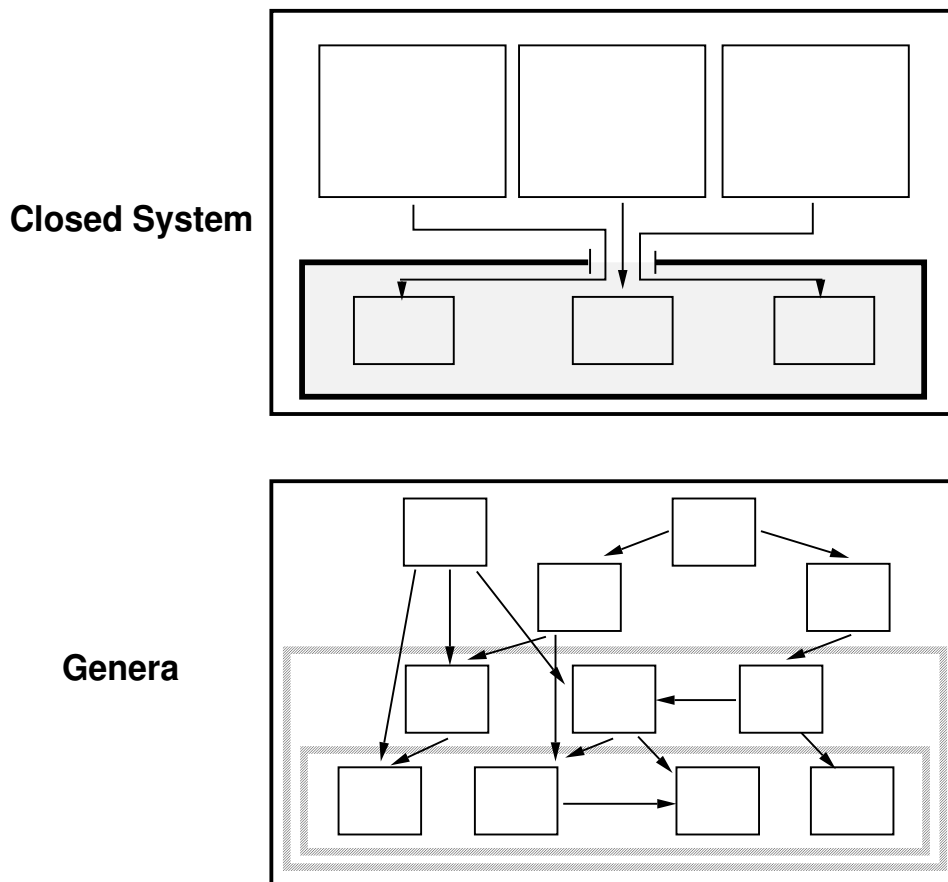


Figure 12. A closed system erects barriers to application programs. Its facilities are available only through specific restricted interfaces and most of the internals are invisible. Genera instead offers layers of functionality to its application programs. The layers are "permeable", so all the internal facilities are available to any application.

- *Use what's there.* The system provides a huge set of capabilities from high-level substrates to the very bottom-level primitives, all equally accessible.
- *Use what's almost there.* Take what the system provides and extend it: add some operations or exploit some hooks. The Flavors, CLOS, and object-oriented programming systems were designed specifically to meet the goals of abstract data integration and extensibility.

Using Flavors or CLOS, it is possible to have several specialized versions of an existing data type that do not interfere with each other or with the original type. You can create specialized versions of data structures without having to modify any of the original source code and even without first understanding all of the original program.

- *Replace what's there.* Major parts of the system can be (and have been) replaced by users interested in exploring research issues or enhancing performance in special situations. The open but layered structure of the software allows you to bypass higher-level interfaces in favor of lower-level interfaces. As a very simple example, you could provide an alternate file system, using documented disk access primitives.

How can a system work reliably without a protected kernel? Why don't multiple programs sharing the single virtual address space interfere with each other?

- Data-level integration means that memory contains structured data objects, not merely uninterpreted bits. This ensures that programs automatically share the semantics as well as the objects and makes it impossible for one program to misuse the data structures of another.
- The hardware provides run-time array bounds checking, data-type checking, and automatic reclamation of unused storage. In traditional systems, programs need to be protected against other programs' "wild" stores due to out-of-bounds array references, uninitialized pointers, data structures not in the assumed format, or releasing storage that is actually still in use. The hardware checking in a Symbolics machine prevents these conventional sources of damage from buggy programs.
- One program can extend or replace part of Genera for its own purposes without interfering with the operation of other programs. The principal mechanisms for extension are per-process dynamic state and flavor specialization. Replacing part of the open system is usually done by bypassing the original (rather than removing or changing it) so that it remains available to other programs.

This means you can change everything, opening up a rich environment and permitting you to go far beyond the usual notions of customizing. The modifications you can make are limited only by your imagination and programming ability.

### **Nothing up Our Sleeve — Information is Out in the Open**

Along with the open software architecture, Genera was designed to let you know what is going on. This has led to a principle of "maximally informative interfaces", with commitment to supporting exploration and investigation and to supplying feedback and documentation.

Right on the keyboard you'll find a HELP key. Pressing this key causes help information, appropriate to your current context, to be displayed. As a programmer, you can write specialized help within your own application or simply depend on the system-supplied facilities, which provide many kinds of help information automatically.

Without any action on your part, many kinds of status information are always visible (but unobtrusive) at the bottom of the screen:

- Date and time.
- Running process name.
- Current *package* (context in which symbols are read).
- State of the current process.
- Progress of file writing, compilation, or other lengthy computations.
- Documentation of the function of each mouse button, based on the position of the mouse and the state of the program.

In addition to this constant information, you can use an application program designed for displaying system status information. This utility, called Peek, can display the states of all processes, windows, network connections, servers, network hosts, virtual memory areas, and so on.

So much for the status of the environment. What about your programs? You can look at your data structures, either statically or dynamically. The Flavor Examiner shows definitions, inheritance relationships, and methods in the object-oriented programming system. The Inspector lets you see or manipulate any aspect of the current state of a complex data object. Both of these utilities operate symbolically — you are looking at the names of the slots in the data structures not at mysterious, numeric representations of them.

Most important of all, you can always suspend any computation at any time. Stop it just to find out what it is currently doing — use the Debugger to inspect the data objects, call stack, and other aspects of the running program and then resume it from where you left off. Again, data-level integration is the basis for this capability as the Debugger process automatically has access to the objects and state of the suspended process.

Genera offers several kinds of context-sensitive documentation. Any time you are typing a function name, a single key command displays either its arguments or full reference documentation. The argument information comes from information maintained automatically by the compiler. Reference documentation is supplied by Document Examiner, an application that lets you use the whole documentation set online.

As in many systems, the action taken when you click the mouse buttons depends on where the mouse cursor is on the screen. Unique to Genera, however, is the mouse documentation display that is maintained continually by the user interface management system. As you move the mouse across the screen, the mouse documentation line changes continually with the input context and with the nature of the object beneath the mouse.

## **One Environment, Many Processes**

Genera supports multiple, independent processes in a single address space, with an event-driven scheduler. For an appreciation of how Genera itself uses processes, take a look at the Processes subwindow of Peek, the system status window.

After you have used Genera for a while, you will find yourself carrying on many different activities "at the same time". As far as you are concerned, some activities occur in parallel, such as editing a file while compiling another file and loading new mail in the background. You will find yourself time-slicing also, jumping from one activity to another as you think of things to do in each one. There are no penalties for hopping around — when you select a new activity, the one you just left is simply suspended until you next select it. You never lose any aspect of context when moving between activities in Genera.

The software environment supports this mental view by maintaining the state of any number of processes concurrently. You don't exit one and return to command level in order to start or resume another; you simply select the process implementing the next-desired activity. In each case, when you resume an activity, it is in exactly the same state as when you last left it.

This structure of multiple independent processes based on shared data structures is a strong foundation for the activities involved in software development. Debugging is one situation that often requires using a number of different applications during the search for a problem.

When a program running in Genera encounters a problem unanticipated by the programmer, it automatically enters the Debugger. Both the Debugger and the erring program are processes, and the Debugger process has access to all the state information about the erring process.

In debugging a problem, you can move with one keystroke (or at most two) to a number of different utilities:

- *Display Debugger*. This multi-pane window appears with all the relevant backtrace and argument information visible.
- *Editor*. The editor appears with the buffer containing the erroneous function read in and positioned to the right place.
- *Flavor Examiner*. This utility shows you the static definition of your object-oriented data structures.
- *Bug mail*. A mail window appears, initialized with the relevant mailing list name and a full backtrace of the erring process.

In debugging a problem, you would normally employ several other processes, from editor to online documentation to mail system, and so on. Finally, you would select the process that had entered the Debugger and decide what to do next. The choices are many:

- Just aborting that execution attempt

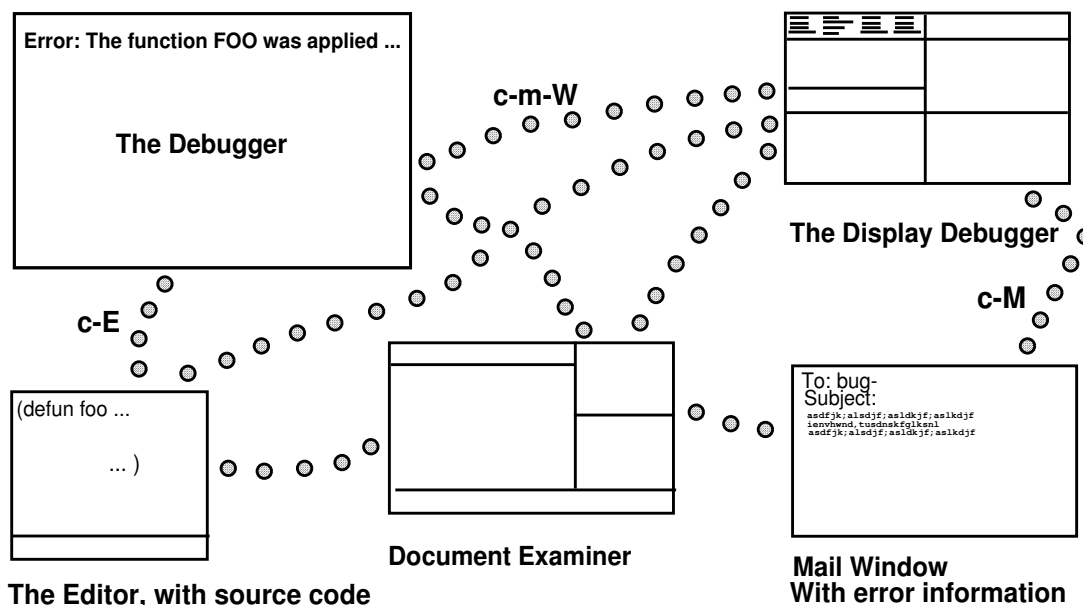


Figure 13. You can use a number of utilities as you debug a problem.

- Choosing one of the proceed options provided by the original program designer
- Returning a plausible value from the erroneous function and resuming execution
- Changing the value of an argument and reinvoking the function
- Editing and recompiling the erroneous function and invoking it again on the current arguments

In the Debugger, you make repairs using the normal source language rather than an error-prone, numeric patch-up technique. In very large computations, you can save a lot of time by carefully repairing the state of the running program rather than having to restart it.

### How is Genera Connected?

Genera's programming environment rests on a rich set of information, maintained by a number of agents, as shown in Figure 1.

Unless you want to know about this, you can remain largely unaware of the complex information structure underlying the commands and facilities you use. This complex information structure has profound implications, however, enabling the following kinds of unique capabilities:

- The compiler maintains a database of caller information. The editor uses this information to let you edit each of the callers of a function. As a result, you don't

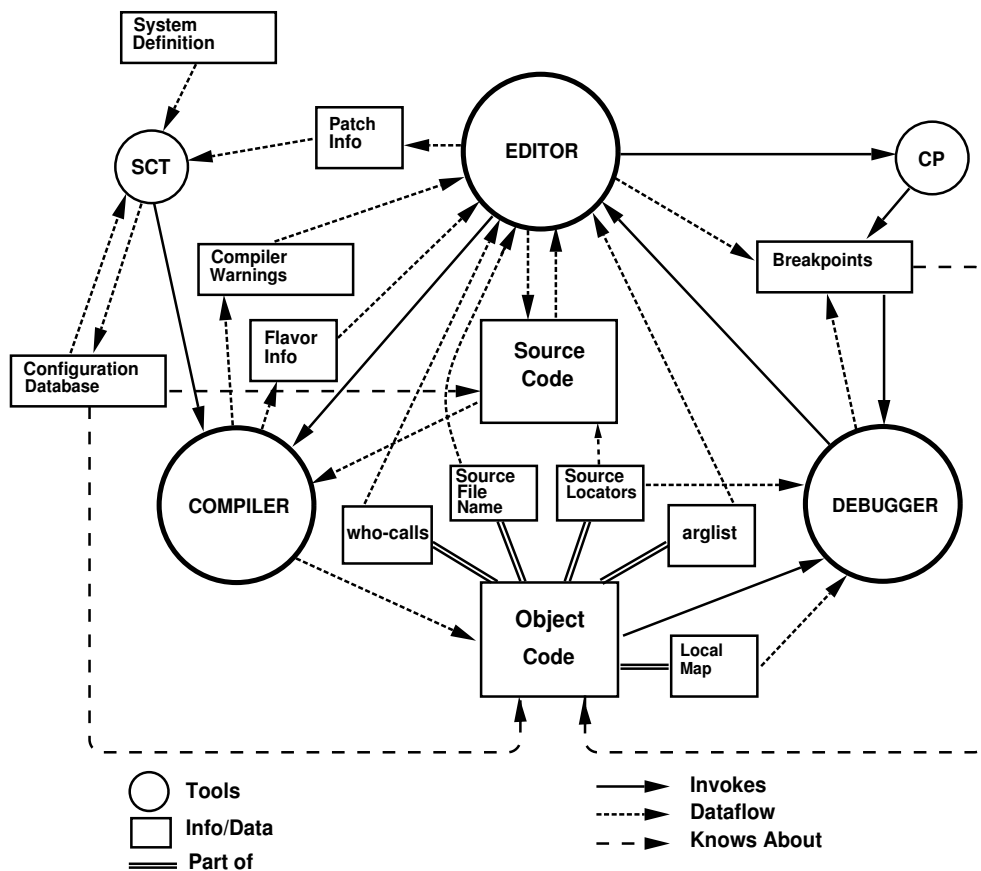


Figure 14. The Genera Development Environment

need concordances, program listings, or separate CREF (cross-reference) programs.

- The compiler maintains a database of source location information, which the editor uses to let you edit functions by name. The Debugger uses the source location information to offer single key commands that invoke the editor on the function for the current stack frame. As a result, you are freed from awareness of the names of files or particular file structures involved in any software project.
- The compiler maintains a database of argument list information that the editor, Debugger, Lisp Listener, and other tools use to offer fast online help concerning arguments. You do not need to memorize details of call sequences since you can always check quickly when you need to know.
- The editor maintains a structured view of source code information, enabling it to offer commands for compiling only the definitions that have changed in any particular buffer. You can make a number of related source changes and then ask to compile only the definitions that have changed.



- During compilations, the compiler maintains a database of warnings and messages. The editor uses this database to offer a command for dealing with the warnings. It puts the message in one buffer and the relevant source code in another. That way, you are freed from the burden of writing down errors or having to find the relevant definitions manually.
- The configuration manager, SCT, maintains a database of the file names and file versions that constitute any software system and of the various compile- and load-time dependencies between the files. This database is used in full system compilations, in incremental patching, in system distribution, and so on. As a result, you are freed from manual operations and potential costly errors in shipping software products. In addition, many operations can be performed on "a system" without your needing to remember any of the files that it contains.

### **Incremental Change — The Answer to Developing Large Systems**

Complex, experimental software systems are too large to work on all at once. In Genera, various strategies help you manage complexity by dividing the work into small steps, each of which is small enough that it is easy to understand it completely. You'll use this "divide and conquer" strategy in three ways:

- *Design.* As the design of a new project evolves, you transform the software from one stable state to another, one step at a time. The software emerges as a sequence of programs, each of which can do something and is partially complete.

At each stage, you can run the program and see what the results of the changes were, using that to decide whether any changes in direction are needed or whether to simply proceed with the next step of the design. This cycle of incremental feedback and guided design applies not only for early experiments but for the entire development of the program.

It is important to realize that you need an overall design for the program when this process starts. Incremental design does not mean that "you make it up as you go along"! Rather, it means that the overall design can be modified to a slightly different overall design, which might mean backing up and rewriting portions of the software. Incremental development does not replace the need for careful design. But it allows the design to be modified promptly, based on early feedback, so that you spend less time working on inappropriate designs, with a resulting increase in productivity.

- *Quality enhancement.* In the early stages of software development, you learn what the requirements really are, finalize the design, and rough out an implementation. In the later stages, you "fill out" the design. The quality enhancements added late in a project are those needed to transform a program into a product. These include improving the design of the user interface, changing data structures to improve performance, and providing better handling of errors and exceptional conditions. Each of these steps can be done without major

changes or rewrites; the program can be tested after each change. The "prototype" turns into the product; it is not thrown away.

- *Procedure.* Genera's software tools operate on individual definitions rather than files. For example, you can compile an individual function, then immediately run the function alone to test it. Since so little is being compiled, the compilation is fast. Linking and loading occur automatically as part of compilation. This provides fast interaction both for developing the design, for enhancing quality, and for fixing bugs.

Traditional environments require compiling entire files or groups of files. Compilation and relinking therefore take a long time, so you find yourself "batching up" the changes between recompilations. As a result, you keep track of too many details mentally and can end up forgetting some of the details you were trying to test.

### **Configuration Management — The Answer to Managing Large Systems**

Keeping track of source code, object code, documentation, test cases, and revision levels for a large program is a difficult clerical task. Genera's System Construction Tool (SCT) handles most of the job.

- *Dependencies.* A large program is described in a definition file. This *system definition* records all source and object files in the system, tells which must be compiled first and which must be loaded first, and specifies any other dependencies.
- *Recompilation.* When you compile a software system, SCT examines change dates and dependencies for source files to determine which must be recompiled to produce consistent object files.
- *Versions.* SCT maintains records of all of the file versions that contribute to a particular system version. As a result, you can easily revert to a previous version or make a tape to distribute a specific system version.

All this facilitates many operations that must be performed on a system as it passes through various phases of its development life:

- *Definition and design.* As a system grows, you register your new files with SCT simply by adding additional entries to the system definition.
- *Refinement.* You make changes to individual functions as you work on your software. You can make those changes available to your co-workers through the incremental update procedure known as *patching*. You designate the several functions to update and SCT takes care of all the bookkeeping details needed.

- *Compilation.* SCT uses the system definition to produce its own plan for compilation of a system, in keeping with the specified compilation and load dependencies.
- *Housekeeping.* Related data files can be registered in the system definition as non-compiled, non-loaded components. When you need to operate on the whole system, for example, moving it from one file server to another, SCT knows exactly which files to copy.
- *Distribution.* You don't have to be a developer in order to ship or install a system. SCT provides you with commands for making tapes of your software system and for installing the software simply at a new site.

At each of these steps it is only necessary for the person performing the operation to know the system name and possibly the desired system version.

### **A Few Words to the Wise**

The conceptual introduction to Genera is a description of its philosophy and guiding vision. Like any complex, real-world system, the reach sometimes exceeds the grasp; some parts of Genera do not fully implement the vision as we have expressed it. Genera contains some artifacts of its development history that are not exemplary of the design philosophy. We hope that the small failures of the philosophy will not distract you very much in your appreciation of the large successes.

Genera's approach to software development is not without its hazards. Once the initial euphoria has passed, be wary of the temptation to change everything just because you can do it! You'll encounter a number of problematic issues, which are not unique to Genera but which are certainly made more evident by an open software architecture.

- *Open systems have no "keep out" signs.* An open software architecture is a boon but only if you understand its risks. Without a formal system/user distinction, you can find yourself attempting to solve a problem using primitives instead of facilities more appropriate to the problem.
- *Finding the right level.* The system software has been designed with calling interfaces at various levels of abstraction. It is very rare for Genera users to be forced to use "bit-banging" programming practices. If you find yourself using facilities that feel like or are documented as internal primitives, take another close look at the alternatives. There is likely to be a calling interface defined at the level of abstraction you need.
- *Documentation.* The fact that you can use any internal feature anywhere in Genera increases the size and complexity of the document set. Where practical, the documentation describes the levels of abstraction and the protocols for using appropriate levels of functionality for a problem. The documentation for internal functions is accessible, just like the functions themselves are accessible. But that doesn't mean you should necessarily use them!

- *Compatibility issues.* You want Genera to continue evolving and improving; at the same time, you want your own code, which might be based on changes you've made to Genera's internals, to keep working! Because of the extremely high level of integration within Genera, it often is not possible for us to support both old and new approaches in parallel. The right protection is for you to use the highest practical level of abstraction of the facilities that Genera provides for your problem. The higher-level interfaces are much more resistant to change than are the internals.

People moving from other environments to Genera report gains in both personal productivity and job satisfaction due to the following attributes of the software environment:

- Data-level integration permits the construction of integrated, communicating tools, the direct result of which is reduced mental overhead for you, the user.
- Reusability permits you to start a new project from a much higher base; you put your major early effort into understanding the application requirements rather than into building subprimitives to support the tasks.
- Open architecture allows you to explore an idea as far as your own creativity takes you rather than as far as the Genera developers will let you go.

### **Genera Comparison Charts**

This section shows some equivalents between Genera and several popular operating systems. Look it over to get a feeling for how Genera differs from what you are accustomed to. Of course, Genera and the other systems all have far more capability than these charts cover; the main purpose here is to let you see an overview of how Genera compares with your prior working environment. For the full story on Genera commands, see the section "Communicating with Genera".

**UNIX to Genera**

* (wildcard)	*
Logging in	Login <i>username</i>
logout, c-D	Logout
help	Press the HELP key. It offers context-dependent help.
cat	Show File
cd	You don't need to connect explicitly to another directory hierarchy, you can access any file you want directly and usually with very little typing, thanks to default pathnames. It or supply a different argument. See the section "Workbook: Pathnames".
cp	Copy File
date	The date and time are always visible at the left side of the status line at the bottom of the screen; no explicit command is needed.
diff	Show Differences
find	Use wildcards with Show Directory.
finger	Show Users
grep	Find String
ls	Show Directory
man	Show Documentation
mkdir	Create Directory
more	Show File
mv	Rename File
lpr	Hardcopy File
pwd	Genera has no "working directory" concept. Instead it has a context-sensitive default filename, based on the last filename you used. Commands that need a directory argument tell you what the default is. You can accept it or supply a different argument. See the section "Workbook: Pathnames".
rm	Delete File. Note, rm actually does what in Genera is a Delete File followed by an Expunge Directory. Genera supports <i>soft deletion</i> (when the filesystem is capable of that), so Delete File only marks the file as deleted, it does not irretrievably remove it.
talk	Use Converse, SELECT C.

time	The Status Line and Mouse Documentation Lines display information about your process state all the time.
wall	Use Converse or <b>chaos:notify-all-lispms</b> .
who	Show Users
whois	Show Namespace Object
write	Use Converse, SELECT C.
Using pipes	Add the :Output Destination keyword to the command that you want to redirect to another place.

**VAX/VMS to Genera**

* (wildcard)	*
LOGIN <i>username</i>	Login <i>username</i>
HELP	Press the HELP key. It offers context-dependent help.
BROADCAST	Use Converse, SELECT C.
CLEAR	Press the REFRESH key.
Control-T	The status line and mouse documentation lines display information about your process state all the time.
Control-U	Press the CLEAR-INPUT key.
Control-Y	Press C-ABORT.
COPY	Copy File
CREATE	You create files in Genera by entering the Editor and inserting the text. See the section "Workbook: Zmacs".
CREATE/DIRECTORY	Create Directory
Del key	Use the RUBOUT key.
DELETE	Delete File. Note, DELETE actually does what in Genera is a Delete File followed by an Expunge Directory. Genera supports <i>soft deletion</i> (when the filesystem is capable of that), so Delete File only marks the file as deleted, it does not irretrievably remove it.
DIR	Show Directory
EDIT	Edit File
PRINT	Hardcopy File
PURGE	Clean File
RENAME	Rename File
RUN	You don't have to start a program explicitly. Preloaded programs (those that are part of the system, either from Symbolics or loaded at your site) are usually "started" (entered, really) by a SELECT key choice or by using the Select Activity command. To RUN a private Lisp program, use Load File and then call the top-level Lisp function.
SET DEFAULT	You don't need to set your default directory or device. Commands that need a directory or device tell you what the default is. You can accept it or supply a different argument.
SHOW TIME	The date and time are always visible at the left side of the status line at the bottom of the screen; no explicit command is needed.

SHOW USERS	Show Users
TYPE	Show File



**MS-DOS to Genera**

* (wildcard)	*
A:, B:	It is not necessary to change drives or devices, you can access any device without having to explicitly connect to it.
Backspace key (backarrow)	Use the RUBOUT key.
Break key	Use the ABORT key.
CHDIR, CHANGE DIRECTORY	You don't need to connect explicitly to another directory hierarchy, you can access any hierarchy you want directly.
CLS, CLEAR SCREEN	Press the REFRESH key.
COMP, COMPARE FILE	Show Differences
COPY	Copy File
DATE	The date and time are always visible at the left side of the status line at the bottom of the screen; no explicit command is needed.
DELETE	Delete File. Note, DELETE actually does what in Genera is a Delete File followed by an Expunge Directory. Genera supports <i>soft deletion</i> (when the filesystem is capable of that), so Delete File only marks the file as deleted, it does not irretrievably remove it.
DIR, DIRECTORY	Show Directory
EDLIN	Press SELECT E.
Enter key	Use the RETURN or END keys. For Lisp input, the closing right parenthesis starts execution.
ERASE	Delete File. Note, ERASE actually does what in Genera is a Delete File followed by an Expunge Directory. Genera supports <i>soft deletion</i> (when the filesystem is capable of that), so Delete File only marks the file as deleted, it does not irretrievably remove it.
FIND	Find String
Function keys	Use the mouse. Clicking the right mouse button brings up a menu in most contexts. The mouse documentation lines at the bottom of the screen tell you what mouse functions are available at all times.
MKDIR	Create Directory
PRINT	Hardcopy File

PURGE	Clean File
RENAME	Rename File
RMDIR	Delete Directory
TIME	The date and time are always visible at the left side of the status line at the bottom of the screen; no explicit command is needed.
TYPE	Show File
Using pipes	Add the :Output Destination keyword to the command that you want to redirect to another place.