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Use of PCs in Hydrology

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Abstract : *PC family of computers, comprising IBM compatible PC, PC-XT and PC-AT, are a powerful tool, not only for mathematical computation but also for information processing. But hydrologists, in India, have so far used PCs only for computational purposes. PCs' power for information processing has not been sufficiently exploited. Further developments in the field of artificial intelligence parallel processing, expert systems will make PCs even more useful. To take advantages of these developments, hydrologists will have to give more attention to software development. As of now software development is not treated as an independent activity, the software that is presented in various forums is usually a by-product of some other work Software that has not been validated by competent software specialists can lead to disastrous consequences, as it already has in some other fields.*

1. What is a PC ?

1.1 Abbreviation PC expands to simply Personal Computer. Any desk top, single user computer system is a PC. But over the years the term has become synonymous with IBM PC and its compatibles. This is particularly true in the context of engineering applications because other PCs, like Apple Macintosh, are mostly used for non-engineering applications such as desk top publishing etc. Therefore, for the purpose of this paper, PC will imply IBM compatible PCs.

1.2 IBM PC, first released in 1981. used Intel 8088 micro processor for its Central Processing Unit (CPU). This CPU has a 16 bit internal architecture but communicates with the external devices in 8 bit mode. Initially a typical PC had a random access memory (RAM) of 256 K Bytes and had two floppy drives, each 360 KB. This was soon followed by PC-XT (XT stands for Extra) which also used 8088 for CPU but had the RAM increased to 640 KB and one floppy drive was replaced by a hard disk of 10 to 20 MB capacity. Next improvement was replacing CPU chip 8088 by 80286 which is fully 16 bit, internally as well as externally. This model was given the name PC-AT (AT for Advanced Technology). 80286 was followed by 80386 and 80486 both of which are 32 bit CPUs. Systems with 32 bit CPUs are rarely used as single user systems. They are usually used for multi-user environments or as host computer for networks with dumb/jntelligent terminals.

1.3 Although there are some differences between PC, PC-XT and PC-AT, we wiil treat them ac one for the purpose of this paper. PC is s powerful machine that can be used to run almost all applications encountered in an engineering office. Its main advantages are low cost, sufficient speed and power, rugged design, takes little space, very low power consumption, flexibility of application, excellent range of software available, upgradability and the fact that most users are familiar with its operating system, MS-DOS.

2. Uses in hydrology

2,1 Applications of a computer. any computer, for hydrology can be grouped into the following types.

(a) Ordinary Computations, like statistical computations, rainfall runoff correlation by different methods, unit hygrograph studies, reservoir sedimentation studies, design flood and water availability computations.

(b) Intense Computations, like calibration of parametric models, multiple reservoir optimization etc.

(c) Graphics : Hydrology involves lot of plotting work and graphics can be considered as task by itself.

(d) Data storage and retrieval : Magnetic media is ideally suited for storage, processing and retrieval of large volumes of data.

(e) Office automation : Like word processing, networking, electronic mail, data based management systems etc.

2.2 Each task requires a different type of software. For type (a) applications the programs are usually written by user. The language commonly used by most hydrologists in India is FORTRAN or occasionally BASIC. This is unfortunate because these languages are not suitable for development of professional quality software. One of the main reasons of poor availability of ready made software for hydrology applications is perhaps excessive reliance on FORTRAN as the programming language.

2.3 Selection of a programming language is a topic that deserves a full length paper by itself and is beyond the scope of this paper. Suffice to note that all languages, FORTRAN, BASIC, Pascal and C can be implemented on a PC with 640 K RAM and just one single floppy drive. For less a hard disk, even a second floppy drive is not necessary.

2.4 CPU speeds are measured in such units as MIPS (Million Instructions Per Seeond) or MFLOPS (Million Floating point Operations Per Second), These units are used by hardware engineers to compare performance of different CPUs. In absolute terms they do not convey much to the end user. The speed of a PC is more than adequate for applications listed at (a) above.

2.5 Type (b) applicetians do need considerable speed. Calibration of a conceptual rainfall-runoff model with 5 parameters may require several hundred trials of the model. Each trial may take several minutes. This may be too much for a simple PC or PC-XT. A PC-AT works more than twice as fast as a PC and the addition of 80287 maths co-processor further increases the speed of arithmetic by a factor of about 10 to 20. If care is taken to add a maths co-processor at the time of hardware purchase, then it may be possible to run on a PC-AT many, though not all, compute intensive applications.

2.6 Type (c) applications (graphics) can be easily implemented on a PC. Bit image mode available on most of the dot matrix printer gives good quality graphic hard-copies to serve most purposes. For more critical applications a multi-color plotter can be used. Plotters are available in the market with standard interfaces compatible with PCs.

2.7 Type (d) and (e) applications fall in the category of information processing. These applications involve storage of large amount of data. In addition to standard 360 K Byte Floppy drive and the Hard Disk, PCs can use High Density 1.2 M Byte floppy disk. 3.5'' dia 1.44 M Byte floppy disk and magnetic catridge tapes for storage of voluminous data. The data can be entered in the computer at the level of gauging division itself. All further processing of that data, estimation of missing data, consistency checks, preparation of water year books and variovs abstracts can be done on the PC.

2 8 For information processing, the computers need to be networked, i.e. they should be interconnected so that the computers can talk to each other. This requires lot of standardization in terms of hardware and software. In the early days of computer revolution, the lack of compatibility was used by the manufacturers as a marketing strategy. This strategy was based on the premise that if compatibility of hardware and software is kept restricted then every piece of hardware sold creates a captive market for compatible software.

2.9 The strategy did pay for some time. But after introduction of personal computers, the picture changed. A large number of relatively smaller producers entered the market with software of excellent quality yet at affordable prices. As the software got more and more standardized, buyers started asking whether a machine can run a particular software, instead of asking which software can a machine run. Software guided the selection of hardware rather than other way round. It now became necessary for the hardware producers to make their machines compatible with the available software. This trend continues and last few years have seen a shift towards 'open ended systems'. These are systems which are so designed that they can communicate with other systems, not necessarily of the same manufacture.

2.10 With computers being able to communicate with each other, the stand alone systems are being replaced by LANs (Local Area Networks and WANs (Wide Area Networks). A network is a configuration involving many computers communicating with each other and sharing their hardware as well as software resources. The prefix local or wide only indicates spatial dimensions of the network. Indian manufacturers are offering a number of network systems based on PCs. Each terminal of the network can function as an independent computer as well as participate in the network.

2,11 Amongst type (e) applications, the only one popular in Indian offices, is word processing. Use of computer as a device for information processing, for communication and for data based management is yet to take root. There are many reasons for this, the most important one is that advancement in a career in India, particularly in Government department, does not demand expertise in computer use. In contrast to this, it may be of interest to quote a study in USA. Business management students in USA have to take a certain minimum number of courses in use of computers. But a study revealed that a majority of students optionally took more than the prescribed minimum courses. Because in USA, dexterity with computers is necessary for survival and success in the rat race. Things will change with time in India too. For the purpose of this paper we note that excellent LAN (Local Area Network) and WAN (Wide Area Network) implementations are available for PC environment.

3 Present Utilization

3.1 A seminar on use of computers in Hydrology and Water resources (CHWR) was planned for Feb. 1991 though for some administrative reasons it could not be held as scheduled. More than 100 papers were received for presentation at the seminar and pre-seminar proceedings (Vol. I & II) are available, An examination of these papers indicates extensive use of PC for hydrology, hydraulics and water resources engineering. [1]

3,2 It must be pointed out at this point that suitability or otherwise of PC can not be decided by a frequency analysis of the use of PC in various offices. A user will use the computer his/her office provides. Many offices may have installed hardware other than PC and therefore software developed by them will be for their specific hardware. But that does not mean that similar software can not be run on a PC. In many cases the authors have not mentioned the hardware they are using.

3.3 A better picture can be projected by examining the capabilities of a PC, examining requirements of different problems, and then estimating what can be done, rather than merely counting what is being done, Papers received for the CHWR seminar indicate that PCs capabilities have been exploited for the following applications.

(i) Real time systems : Flood forecating, control of reservoirs, communications, irrigation scheduling, canal operations etc.

(ii) Office analysis. Flood frequency analysis, dam break modelling, water management, crop water requirement, FEM, Integrated River Basin Planning and Management techniques, water quality modelling, hydraulics etc.

(iii) Office automation : Word processing, data management, contour plotting and quantity computations, water year book preparation.

3.4 Areas which are yet to tap full potential of computers, PCs or others, are mainly those of information processing. Although communication is mentioned above as an area exploited, the usage is still restricted mainly to NICNET. Modem based communication (described in paragraph 4.7 that follows) among stand-alone PCs and networking is not yet popular,

4. Future Trends

4.1 A PC is a powerful tool and its applications are limited only by the imagination of the users. The applications for a computer can be classified in two groups. In some cases it is known that computerization will be useful and the actual application awaits evolution of a suitable hardware and software. Examples of this group are defense applications, space research, meteorology etc. But there is another set of applications which were found to be suitable for computerization after hardware and development software for the same became available. Examples of this set are Word Processing, Railway, Airline and Hotel reservation services, Banking industry, Storage and forwarding of Telexes, computer based learning packages for schools etc.

4.2 It is for the technology leaders in each sector to take a stock of available hardware/ software and see how best it can be made use of in their fields. Private industry's emphasis on efficiency and optimization of man power usually results in private sector setting the trend. Typical example is banking sector where a PC can be seen at every counter in a private bank.

4.3 But Hydrology is usually a preserve of Government and semi Government agencies, and a few educational institutions. This is particularly true in India where private consultancy in the field of Hydrology is almost nil. Therefore hydrologists have no models to follow. They will hava no themselves take the lead and set their own pace. Otherwise they could end up lagging behind rest of the technology sectors in use of computers. Recent reductions in prices of PC hardware coupled with improvement in technology that allows installation in what was till recently considered as hostile environment, has thrown up an opportunity waiting to be explored,

4.4 To fully exploit the potential of PCs, two major changes are necessary. One is a change in perspective and other a change in policy First requirement is that hydrologists must get rid of the obsolete notion that a computer is a tool for mathematical computations only. Computer is an equally powerfut tool for informatton collection, processing, storage and retrieval. In fact the envelop term used for hardware and sottware technology is information Technology or IT for short. The 'nodal agency under Central Government for computer related matters is called NIC for National Informatics Centre, and not, National Computer Centre or some such thing. Similarly the representative body

of computer manufacturere in India calls itself MAIT. Manufacturers' Association for Information Technology, All these are just pointers, for those who need it, to draw attention to the fact that there is more to computers than just number crunching. It is a fool information.

4.5 Thers is a tremendous scope for application of PC in office work. A recent news report indicated that that CMC is planning to construct a new office building for themselves in Bombay which will be what is called a 'paper less office'. All work in this office will be done on terminals, paper use will be minimized Hence the name 'paper less'.

4.6 Coming to hydrology. there are many appiications to exploit the potential of PC. For example take the case of water year books. At present these are printed on paper and circulated as per a specified mailing list. This is necessary because, in an office where these are used, one can not predict when one will need a particular water year book and therefore must stock all of them. As a first step the water year book can be circulated on magnetic media, say a floppy. Th·s will eliminate printing costs, printing delays, errors in proof reading and requirement of storage space at the rceiving end. And saving of paper is not only saving money but saving of more precious forests.

4.7 In the second step the data can be sent on a telephone line instead of physically transporting the floppy. All offices can be equipped with a modem. (MOdulator-DEModulator) an inexpensive device that allows very high speed communication between computers using an ordinary telephone line. The communication netwcrk so created will be useful for other purposes also.

4.8 In the third and final step. the water year book need not be circulated at all. either through modems. These can remain, on magnetic media, with the gauging division or a central library and any one who wants to refer to it can call up relevant portion only, on his PC via a modem over a telephane line.

4.9 In this example, mathematical computation are involved only at the stage of compilation of water year book using raw data. There after the storage of that data, accees to it, communication ot the data on modems etc. are all instances of application of information processing, not computations. Newer technologies like remote sensing, data logging instruments etc. are capable of generating huge volumes of information. But unless protocols are finalized to store, process and retrieve this information, the same can not be made use of.

4.10 The policy change that was mentioned as necessary relates to enforcing computer literacy. There is always a resistance to adopt to any thing new, even if the change is beneficial. That is human nature and can not be scoffed at. Introduction of metric system faced stiff resistance and even scientifically advanced countries took a long time to abandon FPS system. Using computers requires some efforts on part of users to learn the operating system. various software packages etc. Some incentives, and may be even dis-incentives, become necessary to enforce a minimum level of familiarity with computer,

5. Action Plan for future

5.1 Software packages will have to be developed for common applications. Availability of ready to use software increases use of computer because there exists a large section whose familiarity with computer is limited to using a ready to use software but does not extend to writing programs. Software writing is a specialized field. Till about early 1960s it was thought that programming is an art, i.e. it is a question of aptitude and instinctive talent. During middle 1960s it was realized, which now is an accepted fact, that writing software is a science, not art. There are well defined rules on DOs and DON'Ts.

While priority should be given to in-house software development, if it does not yield software of requisite quality then software specialists outside the user department will have to be called in,

5.2 Software development should be seen as an activity in its own right and every organization should have a separate unit to develop software. At present, in the context of hydrology, software is usually a by product of some other activity. An engineer is required to solve a problem, say a flood routing problem, he uses a computer for solving it, and after he has completed the primary task, of flood routing. he finds he has with him a computer program which he then attempts to hawk as 'software'. Such by-product software can never be of requisite quality because it is usually written in an unplanned manner to satisfy some other primary objective.

5.3 Sometimes serious consequences can through use of software which has not been thoroughly tested and validated. There are instances on record where software errors have resulted in 'spectacular' consequences.

> In 1965 the Gemini V space craft splashed down miles from it : predicted point because of a programming error.
>
> The Three Mile Island incident was partly caused by a software design error.
>
> The majority of problems encountered in the space shuttle program can be attributed to software errors.
>
> In 1978 a software error caused radar screens to go blank for operators tracking air traffic between New York and Philadelphia. [2]

5.4 Data are not available to comment whether software error by a hydrologist has ever caused any such serious/tragic result. But the possibility of such an eventuality, arising out of a computer generated result, which looks acceptable prima-facie, but is actually garbage, always exists. The danger is more acute in hydrology because, as already mentioned above.

> Hydrologists in India have a touching faith in FORTRAN, a language known to be extremely error prone
>
> Absence of organized activity for software development, testing and validation.
>
> Left-over and by-product programs being dished out as 'software packages', by persons who may be good hydrologists but whose credentials as software technologists may be unconfirmed.

5.5 Hydrologists will have to come to terms with the situation that software development and testing is a specialized branch and to make effective use of the computer either some of them will have to in addition to hydrology, study the software engineering, or software specialists will have to be co-opted on the teams entrusted with the development of soft ware. How is foregoing discussion of specific relevance to use of PCs ? The irony here is that the very advantages of PCs, listed in para 1.3 above, are a source for concern. PCs provide an easy accessibility to computers and computing for one and all. In such a situation the risks and software of doubtful value being unleashed on unsuspecting users are intensified.

5.6 All the discussion above pertained to present leval of technology. But the technology itself is developing at a very fast rate and newer applications will arise out of this development. Progress in the field of Artificial Intelligence (AI) will make expert systems as common place as ordinary software is at the moment. Drudgery in hydrological analysis will then reduce. Just like water year book example cited above, the hydralogy chapter of a Detailed Project Report (DPR) may consist of a floppy. The official preparing the DPR need only give the data and list the programs, which should be standardized, that transformed

this body of data into water availability or design flood estimates. This authorities checking the DPR only need to insert the floppy in their own PC and run the same programs to verify if the results tally.

5.7 Parallel processing techniques have already been introduced in India during last year. A few companies are now offering commercial versions of transputers base parallel processing computers. These increase power of a PC many fold. Applications which till now were considered too big for a PC. may now be implemented on parallel processing PCs.

Conclusions

PC family of computers has sufficient speed and power, the costs are affordable. the construction is rugged, and wide range of software is available. Almost all hydrological applications can be implemented on PCs. Those which are too large for a PC as of now may be implemented on PCs in near future when parallel processing technology takes root.

Certain policy changes will be necessary to ensure that hydrology does not lag other fields in making best use of advances in informat on technology. Present trend of stand alone computer will have to make way for LANs and WANs. Work culture will have to be changed so that introduction of LAN does not end with installation of hardware. It will be necessary to re-classify data files and study reports enabling free access to encourage scientific research and technology development in Hydrology. A series or incentives and dis-incentives will have to be offered to enforce computer literacy.

Development and standardization of high quality software will have to be undertaken, as an independent and major activity, to provide a library of proven ready to use software packages. Special attention will have to paid to software quality. So far whenever a new software is mentioned the users ask the question what does it do ?" In addition they will have to start asking what ever the software does, how does it do it ?

References

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