Sons and daughters of APM

The past

The APMs were developed within the CS department as a systems design exercise. When developed, they were introduced as teaching machines and over 60 machines produced. The operating system now on it, was developed as a bare bones system with the intention of porting MUSS onto it, and it was also the intention to look at the problems of running a distributed operating system. Problems were found in making the new operating systems sufficiently robust, and no work has been carried out on this for nearly a year. The processors are being upgraded to 68010s with virtual memory support chips. Also a number of 6809 boards are being manufactured to assist in the teaching of assembly language programming etc.

Some of the ICs used in the APM are becoming obsolete and the backplane and ethernet do not conform to any standard. Problems exist with the backplane as it does not have a ground plane, and lacks proper termination, this has prevented multi-master machines being built. Most faults are cured by removing and reinserting boards, indicating a failure in the backplane connector, surprisingly few faults however have been attributed to connectors, although there was a rough type that has now been replaced. The rest of the faults are resolved by component replacement. These are mostly TTL parts, with a life expectancy of over 10 years. Since most machines were built about 5 years ago, we can expect the hardware still to be maintainable until the mid 1990s. The system therefore will become harder to maintain, is difficult to expand, will continue to have a limited file capacity and will have no significant software upgrades in the future.

The original purpose of the APM development was to keep up to date with current thinking on mainstream thinking in computer design. This role was compromised when they became a teaching machine, as the requirements of a stable teaching platform prevented continued design.

The present

As teaching devices the APMs act as stand alone units, as well as being versatile graphics workstation. Being rack based it also allows other boards to be added. The roles the APM fulfils is given below.

Workstation role There are over 60 workstations within the department of which about 30 are available for student teaching. These have medium resolution 8 plane graphical displays separate from the monitor interfaces. Software support is through Fred graphics. These machines support the following courses:-

- 3rd year / Msc graphics
- 3rd year VLSI course using ILAP
- General graphics support for 4th year projects

Bare bones system One extremely valuable role that the APM has fulfilled is to teach operating system design. 3rd year students at present write the virtual page memory manager part of an operating system as their operating system practical. This is made possible by the low level nature of the monitor level and ease of mounting and running ones own software.

Rack based system The APMs perform two roles, because they are rack based. Firstly, they are a suitable platform for forth year student projects, which require hardware support while being integrated into a general purpose system. The projects this year that use the APMs are:-

1. Speech synthesizer and voice recognition unit for APM
2. Graphics board for APM
3. APM graphics board using Acorn RISC
4. Extra processor board for APM

Secondly, being rack based, extra boards such as the 6809 processor card for the real time teaching, can be added. This board allows students to write assembler for the target processor then run it in emulator mode, with the main processor monitoring its performance. This is used for the real time systems teaching.

With the APMs becoming obsolete, it is essential that we now plan the for the replacement of its roles by new equipment or teaching policies over the next 5 to 10 years. At present we are fortunate that student numbers are growing within the department giving us an opportunity to introduce a nucleus of new equipment for the more taxing teaching requirements, freeing up the APMs for classes where they are sufficiently versatile, and there is insufficient resources to fulfill current requirements. The effect of increasing student numbers, rigidity of current software etc. will mean though that our APMs will prove inadequate for some of the tasks in the future, and we must plan now for their future demise.

The future

The workstation role will slowly be taken over by an expanded cluster of SUN's. At present we have 14 for student use, supported by two file servers. These are at present used to support the MSc courses and 4th year projects. It is intended to extend their use to all fourth year teaching. Taking a projected student increase of 20about 30 graphics APMs in the machine halls, we should require up to 40

SUNs or similar machines to fulfill our requirements. This may over estimate our pure workstation needs as the SUNs would not necessarily fulfil the other roles of the APMs and also, being multiuser machines, they can have remote terminal access.

In order to replace the need for APM's for student project work, we would require 3 or 4 new rack based processors. If these were to be VME bus based then the cost to us would be about £4000 per machine. This would provide a high end processor, memory disc and graphics, although a minimum system would only cost about £2000. In both cases we could expect to mount a UNIX or real time operating system on them. Alternately we could look to supporting student projects on PC's or a single master bus such as STE. These would appear to be more sensible as none of the students have taken advantage of the multi master facility in the past, and are unlikely to do so in the future. The overhead of coping with a complex bus seems inappropriate to student projects who usually have enough on their plates to start with. This might not be true for research staff, but then a single test-bed would suffice. The cost of either of these options would be about £1000 per station.

For supporting the real time course, by providing a target processor that will run machine code, we could mount a board either on an RS232 link, or on the SCSI bus of the SUNs. In both cases the monitor would need to be more sophisticated than at present, and the board would need its own power supply. These could be achieved by using the current 6809 board with a simple processor plugged into its bus connector.

The hardest teaching role to replace for the APM's is as a software test bed for the operating systems practical. We need considerable resources and sufficient cut down machines to allow students the chance to implement some major feature of an operating system such as demand page virtual memory. If however we see future operating systems practicals coping with the problems of multi processor architectures, than we will need multi processor machines to run the practicals on. These could run off the SCSI bus interface of the SUNs or we might have to look at simple stand alone boards that would fulfill this function. It is probably only this aspect of teaching that could gain from any hardware produced by a development program.

While the APM was under development it provided the department with an active systems development that feed through to teaching etc. Looking back we can see that this concept of an individual workstation with ethernet link was the correct vision of future developments. By having this work going on then, we as a department can now teach about workstations, communications, the problems of remote filestores and distributed operating systems from first hand experience. If we are to look to a replacement project for the APM to keep our interest in present and future mainstream thinking, then we will need to make a guess at what we believe will be required in the 1990's and beyond.

There is of course a growing amount of systems design work with the sparse processor and POSIE processor cards under development. Neither of these though is

in the mainstream and we could not envisage this current work fulfiling the same role the APMs did. We therefore need to make a guess at the future interesting trends, and become involved.

Making the guess

Main stream thinking is looking to expand the workstation concept. Modern workstations are moving away from rack based systems with complex buses, to a single board, much as televisions did about ten years ago. There has been a number of RISC processors developed that have introduced previously considered main frame features such as data and memory cache as well as high speed floating point processing. The Motorolla offering extends this to allow multi processors to share the same memory. With the introduction of 16M byte dynamic RAM chips and the more easily interfaced peripheral chips, we can now envisage single card machines capable of 100 MIPS. The present SUN's spend a lot of their processor time managing the screen, clearly this parallelism will enhance graphics performance without compromising the general purpose nature of the machine.

We could therefore develop a single card that would support a significant number of processors, with large amounts of memory, some of it perhaps being for graphics work. The purpose of this would be to give a work-horse to look at the problems of compiling programs for multi processors and looking at shared memory multi processor operating systems. An obvious way of developing this concept is to build child cards on a fixed format, say 3 inches square to plug onto a daughter card. In the first instance this daughter card would have a VME interface and the unit would be plugged into a SUN. In future we might try to build a stand alone system but then the overheads of an operating system would have to be overcome.

The current SUNs, especially the colour ones spend most of their time handling the screen. This produces slow screen updates and poor overall performance. The future therefore requires more powerfull support processing for handling the graphics. There are two solutions to this problem. Either specialist processors can be used such as the TMS34010, to relieve the burden on the main processor or the significant increases in the processor power can be used to improve this process.

Conclusions

1. The SUN cluster should continue to grow until all our workstation requirements are fulfilled by them.

2. We should be starting to consider ways to teach the real time systems.

3. The purpose and nature of the operating systems practical should be reassessed.

4. A suitable hardware development should be begun immediately.

These conclusions are provisional and it is hoped that comments from members of staff will be forthcoming to propose suitable targets early in the new year.

Douglas Rogers
19th December 1988