

Chip Multiprocessors

The scale of future VLSI technology is going to enable the building of highly complex systems on a single chip. One direction which is receiving serious attention is the integration of multiple CPU cores in order to achieve high performance processor systems. This direction is motivated both by the belief that current Instruction Level Parallelism (ILP) architectural approaches are reaching their limits and that we may finally be reaching the point where issues such as power density and clock distribution will slow advances in circuit speeds.

The initial approaches to chip multiprocessors have built on the experience of conventional SMP systems. Several commercial processors are now available, which are intended for server applications, where the applications are naturally threaded and can readily be distributed across the cores. However, attention is turning to the problem of harnessing the power of multiple cores on more general purpose applications. There is much evidence that the major microprocessor manufacturers regard this as a crucial direction for future products.

Many general purpose applications have large components which are naturally single threaded and will not easily be expressed in the sort of parallel languages used by current high performance parallel machines. However, the integration of cores on to a single chip promises to provide an environment where very high speed communication is possible. This in turn opens the way for novel parallel hardware structures which can take advantage of this to produce parallel systems with desirable characteristics. One of the most important of these is the ability to spawn and control very lightweight threads with minimal overheads.

The exploitation of parallelism without programmer intervention is a hard problem and has exercised the research community for many years. The difficulties are concerned with software at least as much as with hardware. However, there are opportunities to tailor a hardware/ software solution to these problems by combining research in chip multiprocessor architecture with new software developments in compiler optimisation associated with approaches such as dynamic compilation.

Significance

- The research is directly relevant to the microprocessor industry but also provides opportunities for major novel research in computer architecture and system software.
- The major criterion for success will be the ability to produce parallel on-chip systems whose performance is increased significantly as a function of the hardware resources provided.
- This is a central area of interest in the industry and should therefore be of major interest to the research community.
- The technology may be difficult to explain in detail to general public but, if successful its effects would have major impact.
- The developments will enable industry to continue to produce higher performance computing systems when limits imposed by current approaches

are reached. The area can provide very interesting research challenges in academia.

Scale

- Chip multiprocessor research is already of interest on a global scale. However, there are many opportunities for novel work.
- Because such work requires many advances in both Hardware and Software technology, there are ample opportunities for staged developments.
- The major relevant disciplines are those of Electronic Engineering and Computer Science.

Timeliness

- This work is likely to be a long term effort where initial exploitation of ideas could occur within as little as 4 or 5 years. However, it is likely that the work will need refining over a much longer period, probably several tens of years before efficient exploitation of highly parallel systems will be achieved.
- The major microprocessor manufacturers have only expressed the view, that this is an essential way forward, in the last year. It is clear that they do not have solutions to the major problems. However, there are many interesting avenues of research that can be addressed starting at this time.
- The research area is known to be difficult and, although there appear to be major opportunities to be explored, it is not obvious that efficient solutions will be easy to find. There is therefore a major risk, but the topic is too important to ignore.