European research's bit part in Ben Hur Live?

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(PhysOrg.com) -- Technology developed by European researchers is helping the stage production of Ben Hur Live in London's O2 arena.

It might only be a bit part, but technology developed by European researchers in the SHAPES project is playing a role in the stage production of the cinema classic, *Ben Hur Live*, premiering this week (17 September) in the O2 arena in London.

The SHAPES project developed new hardware and software that, in combination, dramatically extends the power of semiconductors for real-time, massively complex digital signal processing (DSP) problems.

Part of that technology, software developed to control sound distribution, will ensure that the Ben Hur Live audience hears the on-stage action perfectly, no matter where they are sitting in the theatre.

This is an audio application of digital signal processing, and it is an enormously complex problem. Imagine that you have an audio signal coming in, and then broadcasting that signal throughout a large theatre.

Loud, quiet... just right

Even though most theatres have special acoustic properties designed into the structure, sound does not reach each part of the room equally. It tends to be louder in front and quieter behind, and there are all sorts of localised effects like echo and reverberation.

Loudspeakers do allow for this, but to perfectly reproduce sound throughout the space, so that everybody hears exactly the same thing at the same volume and pitch, each loudspeaker must be modulated to project the sound to a specific area of the theatre at the right pitch and volume.

It must do this in real time, recalculating the sound emission for each second of the show. It has to sync perfectly with all the other loudspeakers. And there could be hundreds of loudspeakers.

It is a big challenge, and it is getting more complex as directors stage productions for larger spaces with more ambitious effects. Digital signal processing is finding it hard to keep up.

And that is just one domain. There are dozens of domains. DSP includes subfields like speech signals, sonar and radar signal processing, sensor array processing, spectral estimation, statistical signal processing, digital images, communications, biomedical signals and seismic data, among others. The list goes on and on.

No performance ceiling

“There is no processing power ceiling for the demand of low-consumption, low-cost, dense DSP for future embedded audio, video and human-centric applications,” states Thomas Sporer of Fraunhofer IDMT, a research leader at the SHAPES project.

The SHAPES project designed semiconductor DSPs for the future, to ensure an upgrade path for emerging and planned technologies. That future includes a Star Trek-inspired, handheld scanner.

“It would be an ultrasound scanner, for use in ambulances, but it is probably 10 years off,” explains Sporer. It means the world could see an early model of the Star Trek tricorder, first conceived in 1960, by 2020. The SHAPES technology enables ultrasound signal processing in small, low-cost systems.

And it is only conceivable because the SHAPES team developed hardware and software that can keep pace with the innovation curve. The team achieved this by developing massively parallel processing for DSP.

In the process the team has solved a problem that has plagued developers for decades. “One of the well-known attempts to do this sort of parallelisation was in the 1980s with an architecture they called transputer” explains Sporer. “They could create the hardware, but the software - the algorithms that make it all work - were not advanced enough at that time.”

Pushing back bottlenecks

Since then Sporer notes that every time researchers sought to attack the problem again, there was always some sort of bottleneck. But technology has now advanced to a point where researchers have the tools to develop massively parallel signal processing technology.

“Parallel processing, of a sort, exists on many general purpose processors like those made by Intel and AMD,” Sporer elaborates. “But those chips are not optimised for parallel processing. Very often elements within the chip are doing nothing, and they are only active when they are needed to handle a specific problem.”

But SHAPES puts its money on different chip behaviour: pure parallelisation, where all elements of all chips are working at the same time, in parallel, to very quickly solve problems. So quickly, in fact, that the SHAPES team is now envisaging extremely powerful petaflop systems.

Solving a 30-year-old hitch

In the meantime, SHAPES has solved a 30-year-old hitch by developing a pure parallel processing system with the required hardware and software to tackle extremely complicated problems in real time.

This is how they did it. SHAPES developed a tiled architecture, where each tile is a self-contained processing unit. Each tile contains a sophisticated signal processor, a central processor, local memory and network connections to other tiles. In the SHAPES project, there were four tiles on each chip. The tiles work in parallel on each chip, and the chips work in parallel with other chips. Two chips mean eight tiles, all working in parallel.

So far, so good. But executing that level of parallelisation requires software, and at the heart of the software are complex algorithms - mathematical formulae that divide up the task between processors and coordinate the results.

The combined approach of the SHAPES project, tackling hardware and software issues side by side, meant that each essential element of the problem kept pace with other developments in the overall system.

The impact has been immediate. The algorithms are so good that they can even make older signal processing units work more efficiently, and this is how the research will be deployed in Ben Hur Live, a production by Art Concerts.

A similar application, this time for a speakerphone or mobile phone loudspeaker, will ensure that sound quality remains clear even in very challenging conditions, such as a room with a lot of reverberation. “Because you want the earphone to cancel out the sounds coming from the speaker, so that you do not get interference,” clarifies Sporer.

Favourable industry reaction

And in the longer term, of course, there is the tricorder. But these applications are just very early examples of how this technology will impact the real world. There are dozens of areas where it is relevant.

Earthquake prediction, supercomputing, weather and climate analysis are all domains where SHAPES’ work could be applied. Even during the review phase, university reviewers were excitedly requesting the team to develop new modules to make it more relevant to their work.

“One researcher wanted a module to address larger memory [needs], to boost the local, tile-based memory when it is insufficient, so we developed that module,” reveals Sporer. “I have been a reviewer in other projects myself, and I’ve always thought it was the sign of a good project if the reviewer is disappointed not to [have been] a part of the project. One of our reviewers was very disappointed!”

Industry, too, has reacted favourably - and promptly - to the opportunities presented by the work, and currently consortium members are looking into follow-on projects to develop chips with eight tiles.

And, as a final benefit for Europe, the continent has developed enormous expertise in one of the most strategic technologies for future innovation.

More information:
http://ttp//shapes.atmelroma.it/twiki/bin/view/ShapesPublic/WebHome

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