Open source answers the

Open source microcontroller core steps in to power third generation chip for cellular repeater. By **Roy Rubenstein.**

Nextivity, which makes cellular repeaters that boost indoor signal coverage, has already developed two generations of chips for its Cel-Fi signal booster products. Its latest device, the Cel-Fi RS3xx, supports the Long Term Evolution (LTE) wireless standard.

Whilst the two previous devices used the Altera/Synopsys Nios risc core, the latest chip has been developed using an open source risc core. Instead of continuing with the 32bit Nios core or licensing the ARM9, the company has chosen the OR1200 core for cost reasons, especially as the RS3xx uses six such cores.

The OpenRISC OR1200 core, developed by the OpenCores community, can be downloaded free of charge. Nextivity says there are advantages in adopting an open source core approach, but adds it requires expertise – and time – to create the development environment and to prove the core's workings.

"From a [processing] performance point of view, Nios, OR1200 or an ARM9 will all do the job," said Michiel Lotter, chief technology officer at Nextivity. "We were looking for a way to get something cheaply and not have to worry about whether we were going to use two, three or six cores."

The Cel-Fi signal booster sits between the base station and a user's wireless device. "It grabs the signal from the basestation, cleans it up as much as it can and retransmits it to the handset," said Lotter. Cel-Fi also handles the uplink path, for handset transmissions to the base station.

Cel-Fi is an alternative to technologies such as femtocells, that also improve indoor signal coverage. But, while a femtocell needs a DSL or broadband connection to the network, the signal booster needs only a cellular signal. Signal boosters are now recognised as one of the various small cell approaches by telecom regulatory bodies and industry organisations such as the Small Cell Forum, said Werner Sievers, Nextivity's ceo.

The signal booster's functionality is split into a window unit and a coverage unit. The window unit, typically placed on an upper floor, receives the base station signal, processes it to improve the signal to noise ratio and rejects unwanted signal feedback. It also listens to the base station to determine the surrounding radio environment.

"We know how far away we are from the base stations, what [mobile] operators they belong to and so on," said Lotter. "We use this information to drive various self optimising networking algorithms."

The window unit transmits the cleaned up signal to the coverage unit, several of which may be used in a building. The signal is transmitted across the unlicensed 5GHz radio band and down converted by the coverage unit before retransmitting the 3G and LTE signals locally. In the reverse path, the coverage unit performs the same tasks undertaken by the window unit.

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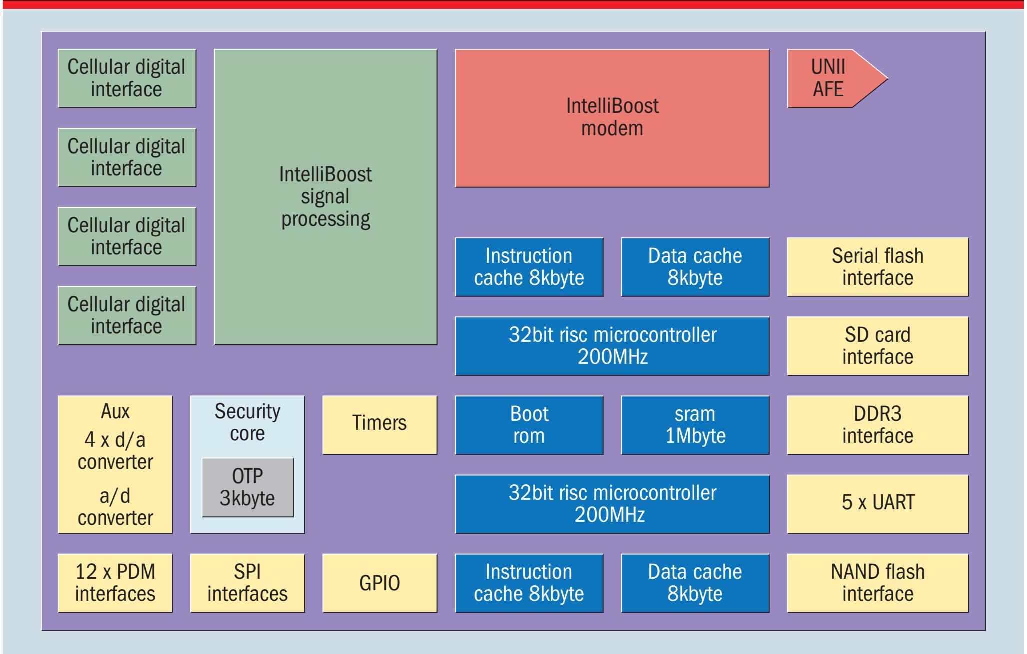
Michiel Lotter

Nextivity set three goals for the RS3xx chip: it had to support the 3rd Generation Partnership Project's Release 10 specification that includes the high speed packet access (HSPA) and LTE standards; it needed to improve signal coverage performance; and it had to be general enough to enable the company to address other markets, such as small enterprise and luxury cars. "The maximum gain would be the same [as Nextivity's second generation chip], but the median gain would be increased; getting closer to the maximum possible gain more often," said Lotter.

The RS3xx comprises two key

Fig 1: Block diagram of the RS3xx smart signal booster



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functional blocks: the IntelliBoost signal processor and the IntelliBoost modem (see fig 1).

The IntelliBoost signal processor performs three main tasks: filtering; equalisation; and digital echo cancellation. Filtering separates the signal of interest from adjacent channels, while equalisation tackles the phase. "The system is characterised end to end and all the group delay variation is taken out," said Lotter, ensuring the best signal to noise ratio at the output.

Because the coverage unit transmits the output signal at the same frequency as the received base station signal at the window unit, echo cancellation is needed. "The repeater is just like any amplifier with feedback," said Lotter. "The signal feeds back all the way to the input of the window unit; that gives you a feedback loop." The echo cancellation rejects the feedback signal. By improving the chip's echo cancellation algorithms, Nextivity has increased the overall median gain and hence indoor coverage quality.

The RS3xx supports four cellular frequency bands, which vary with region and mobile operator. Each band is implemented using an independent signal processing chain comprising dedicated hardware and an OR1200. Dedicated hardware is needed because the system must have tight latency: the signal booster unit must not introduce a delay greater than 8µs. So, while the OR1200 core supports DSP instruction extensions, these were not used. Instead, each chain's OR1200 implements fast gain control algorithms.

The IntelliBoost modem supports 35MHz of relay bandwidth. "It's the total amount of spectrum we can amplify," explains Lotter. For example, the 35MHz can comprise a 20MHz LTE channel and three 5GHz wideband

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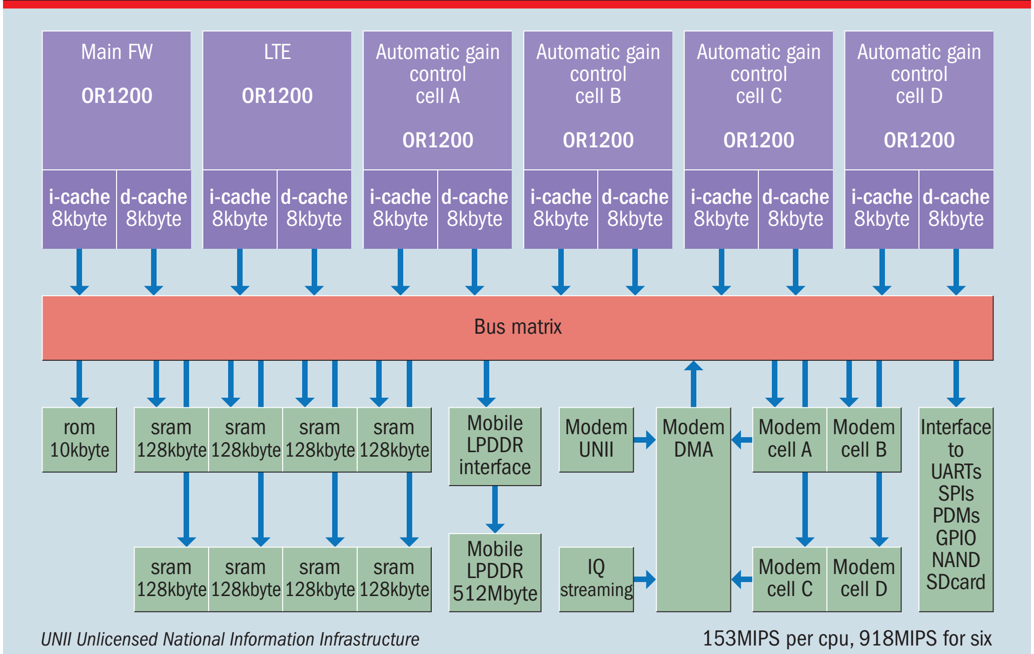
Fig 2: The Cel-Fi processor's multicore architecture



CDMA channels. Overall, the IntelliBoost modem supports two 40GHz bands, one for the uplink and one for the downlink. Each 40MHz band is split between 35MHz of relay bandwidth and 5GHz for digital control information sent between the units to keep the Cel-Fi system stable.

Two further OR1200 cores are included on chip; one to control the 5GHz modem link, the other for LTE processing. Nextivity has added its own instructions to the basic core to help decode LTE signals when the Cel-Fi unit listens to the base station environment.

Other core changes include adding management functions to enable the six cores to share common memory. "We needed to take care of coherency issues," said Lotter. "Inside the core, we didn't do much; taking all the cores and being able to operate in a multicore environment, we added some other features."

As to the risk involved in basing its latest Cel-Fi product on an unfamiliar, unsupported 32bit core, Lotter points out the Nios core first came with limited Jtag debugger tool support. "We had a lot of debugger infrastructure in place that didn't really rely on the [Nios] processor itself, and that helped a little," said Lotter.

Nextivity's ASIC team spent time getting the OR1200 running on an FPGA before committing the design to silicon. "We took our second generation product, ripped out Nios, put in the OR1200 and figured out all we needed to get it to run in that environment," said Lotter.

There were instances where aspects of the core didn't work. "There were bugs in the code drop from the open source website," he said. But the issues were solved. "After that investment, including some ASIC engineering time, we now have a core we can trust and we can use as much as possible," said Lotter.

The company now plans to broaden its technology beyond smart boosting of cellular radio. "There are many indoor wireless technologies that could benefit from intelligent boosting," Sievers concluded. "Satellite is one, but there are others."