Architecting embedded software to power HetNets

A conversation with Renuka Bhalerao, Senior Product Line Manager Radisys

By Frank Rayal

Frank Rayal. Hello, and welcome to this conversation with Renuka Bhalerao from **Radisys**. I'm Frank Rayal. This conversation is part of a Senza Fili report on deployments of heterogeneous networks and the latest solutions from the wireless ecosystem that will make HetNets a reality.

Today we're speaking with Renuka Bhalerao, Senior Product Line Manager, Small Cells and Trillium Software, at Radisys.

Radisys is a market leader enabling wireless infrastructure solutions for telecom, aerospace and defense applications.

Renuka, I would like to start by asking you to give us an overview of Radisys.

Renuka Bhalerao. Radisys has been in the telecom domain for the last 25 years. We provide embedded wireless infrastructure solutions that translate into the software portfolio for end-to-end wireless network architecture, complemented by our hardware platforms for various network elements. In a nutshell, we have been in the wireless industry for a long time now, and have been taking care of software and components spanning from the radio access side all the way across into the core network.

Frank Rayal. When it comes to embedded solutions, what are you doing specifically for HetNets?

Renuka Bhalerao. HetNet is a multilayer network. It is slightly different from what we have been seeing for the traditional macro base station–dominated network architecture. We have different flavors of base stations here. Along with the macro base stations, we have compact base stations with low power. That's where the Radisys solution comes into the picture. Radisys provides 3G as well at LTE small-cell solutions. These are targeted all the way from the residential and indoor enterprise base stations to the outdoor pico-cell version of small cells. This is provided in the form of complete, integrated software that is available on different leading silicon platforms in the small-cell market.

Frank Rayal. What particular layers does the software cover?

Renuka Bhalerao. The software is a comprehensive integration from Layer 2 and above that includes the protocol stack for RLC, MAC, the MAC scheduler, Layer 3, with radio resource management, and components like SON and OAM. It is encompassing everything but the baseband or the PHY for the small cells. It's integrated software that takes care of the protocol stack as well as application components such as the RRM, SON and OAM.

Frank Rayal. You sell to many telecom equipment vendors, and system providers. What's your sense of where we are in terms of HetNet deployments with the operators?

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Renuka Bhalerao. We are actually into HetNet deployments with many of our customers right now. You are aware of technology advancements in Korea, in the area of LTE specifically. Radisys provides solutions for the small-cell market over there. The deployments are for the enterprise or the indoor public access small cells. The market is moving very fast towards other versions of small cells, such as outdoor pico cells or a closed-access residential indoor type. HetNet deployments are not only happening in Korea, but I would also mention that in other regions, our customers are bringing out the HetNet layers of pico cells, the enterprise small cells and small-cell solutions for all other segments. So it's a reality. The HetNet is the new architecture for the network.

Frank Rayal. You mentioned that right now there's a pickup, especially in indoor small cells, and it's moving toward the outdoor small cells. Which specific segment do you see on the indoor? Is it residential, or enterprise, or some other special applications?

Renuka Bhalerao. The initial definition of the small cell itself was for indoor coverage: a solution for indoor coverage that the consumer can put right into the home. From that time on, the small cells have now evolved into a capacity solution. So what we are seeing now is an indoor version more suited for the enterprise structure. We are talking about office space, but we're also talking about places like airports, stadiums, coffee shops and so on.

The next step to that is to actually take the small cell outdoors and mount it on a lamppost. That's the other smart option of providing capacity as well as coverage into the existing macro network.

Frank Rayal. What do you see as some of the major challenges to HetNet deployment?

Renuka Bhalerao. Going back to when the femto cells were for indoor coverage, they were deployed as standalone indoor boxes, not so much as part of the overall network itself. Though they were operator-

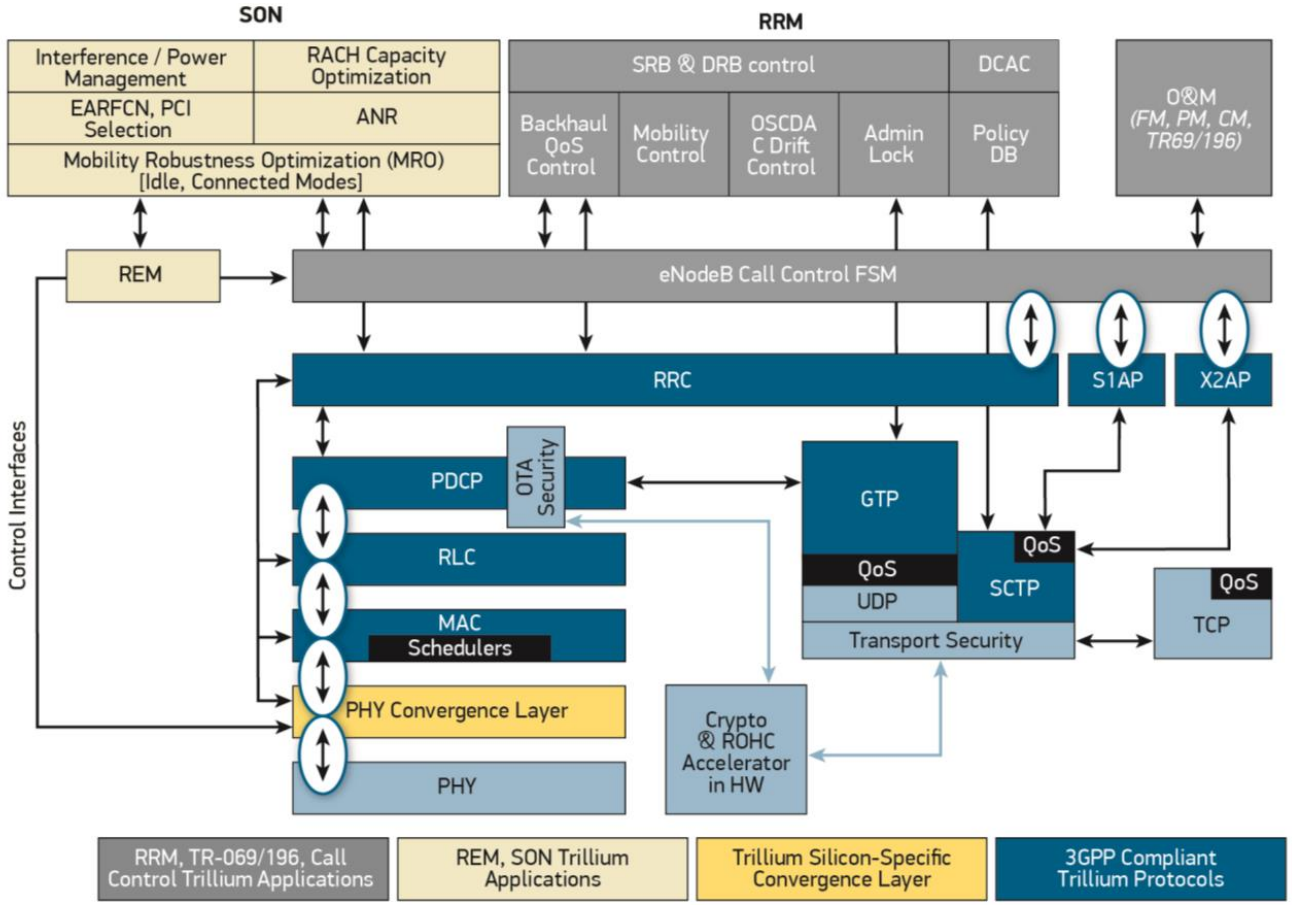

Figure 1. LTE eNodeB architecture. Source: Radisys

driven solutions, they were not really embedded into the network.

When we bring small cells outdoors in the form of open-access base stations, we are talking about a complex scenario. We have a large number of these small cells coming up as capacity-enhancing hotspots. That raises the key challenge of interference. Operators were concerned right from the start when the small cells began to come into outdoor and open-access domains.

Interference has two aspects: first, small cells will be deployed very close to each other, and second, they will be sharing the frequency with the macro cells. More coordination is needed between the macro base stations and small cells when we have them coexisting as part of the same network. That becomes a key challenge.

The other challenge is that small cells are very different than macro cells when it comes to the planning and rollout of the radio access network. The huge number of these low-power nodes being put into the network needs automatic provisioning, configuration and initialization of how the small cells will interact with the existing nodes in the network. That brings another challenge, that of the rollout itself, and a need for what we call the self-optimizing and self-organizing network.

Frank Rayal. If I go back to the issue of interference, what specifically are you doing in that space to solve this issue?

Renuka Bhalerao. We at Radisys have seen this problem first hand. As you are aware, our solution is in deployments right now. The operators have come to this interference challenge and started to see it, even in the initial rollouts. Being right next to our customers and looking at the operator's problems and challenges firsthand, we have been looking at how we can provide an effective way to mitigate interference.

That's where the eICIC-like features have become part of the small-cell interference mitigation function. So apart from just achieving Layer 3 protocol specifications compliance, we have been actively working on advanced techniques that include eICIC and other SON algorithms.

Frank Rayal. But there are different forms of eICIC. What do you see as the one being most sought out or the one most promising right now?

Renuka Bhalerao. eICIC is more about how do you maximize the coordination between the macro cells and the small cells. Initially, ICIC functions were introduced to tackle this problem, and that was more for coordination in the frequency domain. We saw that that solution wasn't really enough. The different way or angle of implementing it was to go into time domain–based synchronization. That's where the key aspect of eICIC is. We call it ABS, or almost-blank sub-frames. It's again all about coordinating the transmissions between the macro cells and the small cells so they know the existence of each other, and then they give each other a way of maximizing their transmission whenever that is possible, all while minimizing the interference.

To make it work, you have to exchange pattern coordinates between the macros and the small cells. The X2 interface plays a key role here and helps to exchange that coordination information between the base stations, which you can then apply on the radio interface. That way, the small cells not only add capacity, but also give the best performance in terms of cell-edge throughput, as well as the actual data rates that they provide to the small-cell subscribers.

Frank Rayal. Speaking of data rates, what do you think is the improvement to the throughput or to the average network capacity with ABS or LTE Release 10 features, versus the older LTE Release 8 features?

Renuka Bhalerao. Great point, now you're bringing up the topic of LTE-Advanced. The key areas the standards have focused on in LTE-Advanced are interference mitigation and how to get even higher data rates. So with that in mind, LTE-Advanced has features like carrier aggregations, eICIC and CoMP, where you can have coordinated transmission. All of those features come into the picture. Even a concept like relay nodes comes into LTE-Advanced networks. These are the set of features that translate LTE into LTE-Advanced.

We can see that LTE-Advanced has accelerated very quickly. It's not something the operators were hesitant to take into the field. The initial excitement about LTE got them to look at not just its theoretical advantages but the practical aspects as well. So that's where it is going right now. They're taking up LTE-Advanced features in phases and making them part of their

networks to solve challenges faced in the field, as well as to enhance the end-user experience.

Frank Rayal. I would like to ask you a question about carrier aggregation. Are there any specific frequency bands that you're seeing people use? Also, do you see people using part of the TDD spectrum to do carrier aggregation with the FDD band? By doing so, operators can get two downlink channels and one uplink channel. This way they can get more capacity on the downlink path.

Renuka Bhalerao. There are two key aspects here. Carrier aggregation itself came out as an attractive feature for operators. Part of the reason was the practical use that it brings. Operators had the spectrum available in chunks, and carrier aggregation technology shows the best way of making efficient use of this spectrum and at the same time, giving the advantage of higher data throughput.

Operators are even interested to add carrier aggregation for the residential segment – for example, doing a 5 plus 5 MHz combination to get a 10 MHz bandwidth. Next is taking this all the way, for outdoor deployments, to a 20 plus 20 MHz scenario. This can, actually, be taken five times, all the way up to 100 MHz of bandwidth.

Now, how do we tie that to TDD? TDD itself by its nature is a way to have that flexible transmission for uplink and downlink. An inherent aspect of TDD is to be able to select how much bandwidth to assign for uplink versus downlink, making it suitable for downlink-heavy applications, even for applications like multicast and broadcast, for example. That itself makes it more of a new version of LTE that the operators are very interested in taking up in the next stage. And the technology advancements have in fact already come up to that stage, where we will soon be seeing TDD networks rolling out in the Far East region initially and then catching up in Europe and America.

When you tie the carrier aggregation and TDD together, you get a twofold benefit; you still have that flexible way of how you can divide the bandwidth between uplink and downlink based on the traffic pattern. You can also add carrier aggregation into the picture to combine the spectrum chunks. That takes you to a combination of higher throughput, higher bandwidth, plus the flexibility of the asymmetric nature that TDD brings in.

Frank Rayal. Wi-Fi has been considered as part of the heterogeneous network. Where are we in terms of integrating Wi-Fi? Especially in terms of the standards and the work that you're doing, how is Wi-Fi being integrated into LTE and 3G networks?

Renuka Bhalerao. Wi-Fi is looked at as the option for providing a low-priced version of unlicensed spectrum to subscribers. And so, yes, Wi-Fi does remain part of the HetNet structure.

We have seen collaboration with LTE technology where the small-cell product itself becomes an access point, with Wi-Fi as well as LTE and, in some cases, 3G all part of the same box. To that extent, we see interactions at multiple levels in the small-cell solution, where you can have that added advantage of taking care of Wi-Fi related radio-resource management, for example, when you're doing the overall resource management for the small cells.

Radisys provides a very innovative solution where you can do the bandwidth management or the policy management on the small cells very effectively, taking into consideration the various radio access technologies that may be available at hand – e.g., Wi-Fi resources or 3G combined with LTE; with this solution you can offer a better control of prioritizing the traffic and the users on the small cells.

An example would be to keep the low-priority traffic on Wi-Fi when you can, and then use the premium LTE resources for your premium-paying subscribers, to ensure that real premium service to them at all times. These kinds of use cases come up with multiple radio access networks – Wi-Fi, 3G and LTE, for example, coming together. We have been actively engaged in providing such algorithms for our customers.

Frank Rayal. Basically the traffic will be routed according to its priority on whatever network is best, or according to the policy settings by the operator.

Renuka Bhalerao. Exactly. It gives much more control to the operator in terms of controlling their network resources – not only on the air interface, but also on the network side to manage the backhaul bandwidth. So they get that add-on control and the add-on policy use cases when we talk about an RRM or SON for this kind of multi–radio access network environment.

Frank Rayal. Are these features available today, or you're working on developing them and they will be available soon?

Renuka Bhalerao. They are actually available today. We have already tested them out in certain use cases with Wi-Fi and LTE, for example, as a combination. And you can extend it. The framework is such that you can extend it to provide an intelligent radio resource management or SON component for a multilayer, multivendor solution.

Frank Rayal. When we talked about challenges, you mentioned interference. That was one aspect. The other aspect was the planning and rollout. You mentioned SON. How do you see the demand for SON by operators or even by your customers, the equipment vendors?

Renuka Bhalerao. SON is one of the major focus areas for operators. The operators see it as a mandatory feature for small-cell deployments. The reason behind it is that RF network planning has become complex, compared with what it was for a static definition of a macro-cell network.

With a large number of small cells, and for that matter even Wi-Fi access points, there is a need to minimize the effort of RF planning. There is also a need for real-time dynamic optimizing or healing of the network. That's where SON takes us, and that's why operators say they need a SON solution as they roll out small cells.

Now, SON is a very wide term. We are talking about different phases of how SON could be applied to HetNets and how SON brings advantage into the small-cell rollout.

SON was initially seen as a necessary feature for the initial configuration and provisioning of small cells without much operator intervention. We call it the self-configuration aspect of SON, where you're looking at the configuration of the PCIs and resolution of any confusion because of PCI collision: aspects of zero-touch configuration of that small cell when the consumer – in a residential case, for example – is able to take it and plug it in inside the home, and it has to start working right then. Self-configuration is then to the extent that you should be able to remotely download the software and the patches on the box. Again, it's all about handling the scale factor with small cells: it's going to be a large number of these base stations coming up. So there is only so much that the operators can control manually. It translates into less cost for them to do it all via SON in the rollouts.

Frank Rayal. Do you think SON will eliminate the need for radio planning?

Renuka Bhalerao. I see that SON is actually making radio planning much more efficient. So we're saying that radio planning will still be needed. The HetNet doesn't exclude the macros at all. SON just makes it easier for the operators to add small cells. So it's just the next level of optimized radio planning.

Frank Rayal. I would like also to ask you about the trust level that operators have in SON solutions. Where we are on that, and what sort of progress are we making?

Renuka Bhalerao. Very good progress, I'll say again, bringing it back to the network deployment that we are in at various places with our solution. We are at an advanced stage of field trials and deployments in Korea, in terms of LTE small cells.

The practical challenges that operators have seen make them want to take SON solutions like eICIC algorithms to the actual product stage. So it's not something that they're shying away from or just evaluating in labs right now and trying to validate. They are actually making it part of their product as we speak.

Frank Rayal. You work with a lot with different silicon vendors, these are your customers. What do you see coming from the silicon space that will help HetNets and will help more efficient networks in the future?

Renuka Bhalerao. The silicon providers offer products that are targeted towards different segments of the HetNet. So silicon providers have their platform targeted for a Wi-Fi plus LTE radio and again for different capacity solutions: these range from the smallest version for indoor access compared to all the way up to a 200-user-plus version for outdoor pico cells, which are not exactly macro base stations but somewhere in the middle. All of that is advancing now towards the next level of RAN evolution, in the form of cloud RAN – exploring multiple radio access technologies coming together on that low-BOM, small-

sized platform, and giving them more flexibility from the software side.

Frank Rayal. Renuka, thank you very much for this informative conversation.

This conversation is part of the Senza Fili report on HetNet deployments and the latest solutions from the wireless ecosystem that will make HetNets a reality. The report can be downloaded from the Senza Fili website at **www.senzafiliconsulting.com**.

Acronyms

3G	Third generation
3GPP	Third Generation Partnership Project
ABS	Almost-blank sub-frame
ANR	Automatic neighbor relation
BOM	Bill of materials
CM	Configuration management
CoMP	Coordinated multipoint
DB	Database
DRB	Data radio bearer
EARFCN	E-UTRA absolute radio frequency channel number
eICIC	Enhanced intercell interference coordination
eNodeB	Evolved Node B
E-UTRA	Evolved UMTS terrestrial radio access
FDD	Frequency-division duplex
FM	Fault management
FSM	Finite state machine
GPRS	General packet radio service
GTP	GPRS tunneling protocol
HetNet	Heterogeneous network
HW	Hardware
LTE	Long term evolution
MAC	Medium Access Control [layer]
MRO	Mobility robustness optimization
O&M	Operations and management
OAM	Operation, administration, maintenance
OTA	Over the air
PCI	Physical cell ID
PDCP	Packet data convergence protocol
PHY	Physical [layer]
PM	Performance management
QoS	Quality of service
RACH	Random access channel
RAN	Radio access network
REM	Radio environment monitoring
RF	Radio frequency
RLC	Radio link control
ROHC	Robust Header Compression
RRC	Radio resource control
RRM	Radio resource management
S1AP	S1 application part
SCTP	Stream control transmission protocol
SON	Self-organizing network
SRB	Signaling radio bearer
TCP	Transmission control protocol
TDD	Time-division duplex
TR	Technical report
UDP	User datagram protocol
UMTS	Universal Mobile Telecommunications Service
X2	Interface between two LTE base stations
X2AP	X2 application part

About Senza Fili

Senza Fili provides advisory support on wireless data technologies and services. At Senza Fili we have in-depth expertise in financial modelling, market forecasts and research, white paper preparation, business plan support, RFP preparation and management, due diligence, and training. Our client base is international and spans the entire value chain: clients include wireline, fixed wireless and mobile operators, enterprises and other vertical players, vendors, system integrators, investors, regulators, and industry associations.

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About the interviewer

Frank Rayal is founding partner at Xona Partners, a boutique management and technology advisory firm specializing in telecom, media and technology. He is a telecom industry professional with more than 20 years of experience working with network operators and system vendors to develop and deploy innovative wireless solutions. Frank co-founded small-cell backhaul pioneer BLiNQ Networks. He held senior product management, marketing and business development positions at Ericsson, Redline, and Metawave. He holds a BS in electrical engineering from Case Western Reserve University, Cleveland, Ohio, and an MASc in electrical engineering and an MBA from the University of Toronto, Canada. He is a senior member of IEEE, and a member of Professional Engineers Ontario.