I-RSO

Inter-RAN Spectrum Optimizer

[Provisional Patent Application]

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[October 14, 2011]

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Summary Statement

The Inter-RAN Spectrum Optimizer (I-RSO) is a concept in which Radio Frequency resources – a finite commodity in very high demand – are instantaneously maximized based directly on the collective supply and demand of aggregate mobile networks in any given location.

The cornerstone of the platform is the Session Manager which consists of a Host in the network core, and numerous Controllers, at the network edge. The role of the Controller is to evaluate spectrum supply and demand in real time, and assign resources accordingly. The platform can accommodate variations on this basic operational concept based on predefined business, engineering and operational rules. Finally, the Controllers deliver Charging Data Records (CDR) to a clearing and settling environment at the Host for reconciliation and delivery to the respective billing systems of the participating Mobile Network Operators (MNOs).

Background

Radio spectrum suitable for use in mobile Radio Access Networks (RAN) is in finite supply. In recent years demand for wireless voice services has either increased marginally, or in some markets leveled off. Coinciding with this trend, however, has been an exponential increase in demand for data services.

Over and above the sheer increase in demand, data sessions behave very differently from voice calls.

- Voice is circuit switched, data is packet switched.
- Voice is full-duplex, whereas data can be full or half duplex, or even simplex in certain applications.
- Data sessions are based on protocols that tolerate a degree of network disruption without the application failing or closing. On the other hand, a mere syllable lost in a voice call is perceptible, and unacceptable to the user.
- The routing of data packets is highly dynamic whereas the routing of voice sessions is rigidly predefined and predictable.

These, and other characteristics, present both challenges and opportunities in terms of mobile service radio spectrum utilization. While the entire wireless network is impacted by the demand for data, in this filing we are strictly focusing on opportunities to use the RAN – the link between end user and the wireless network base station – in new, unconventional ways.

While there will be evolutionary improvements in the techniques used to maximize radio frequency spectral efficiency, it is broadly believed that no revolutionary developments (new modulation schemes for example), are in the offing. Recent quotes from leading wireless network market research firm Maravedis characterize the current situation:

"New radio access technology and additional spectrum alone will not provide sufficient additional mobile capacity."

"Per capita mobile data-usage will grow 10,000% in the next five years."

One mitigating approach to the exhaustion of RAN resources is to offer the user an alternate RAN. AT&T has done this recently by deploying Wi-Fi Access Points (AP) as a means of offloading traffic in certain congested areas.

There are a number of important characteristics inherent in Wi-Fi that lead to a departure from the experience a user expects from a Mobile Network Operator (MNO):

1. Small coverage (originally intended for use within a home or small business).
2. Unlicensed, meaning there is no reliable way of managing interference.
3. Non-assured service quality (best effort).
4. Performance rapidly deteriorates as the number of users increases.
5. No support for mobility.
6. Unpredictable and inconvenient support for nomadic user behavior.
7. User confusion/uncertainty with regards to whether they are on the cellular network (being charged), or Wi-Fi (no charge, but no service level assurance) at any given instant.
8. Often impractical for the MNO to charge for Wi-Fi in macro network service areas.

With a history of priding themselves on network performance, diverting subscribers to Wi-Fi is a desperate measure by the MNOs and is certainly not a long term solution. In fact, many would argue that even in the short term, it's a poor solution. Once again, to quote Maravedis:

"Heavy Smartphone markets require carriers adopt new approaches to RAN (Radio Access Network) deployment and management"

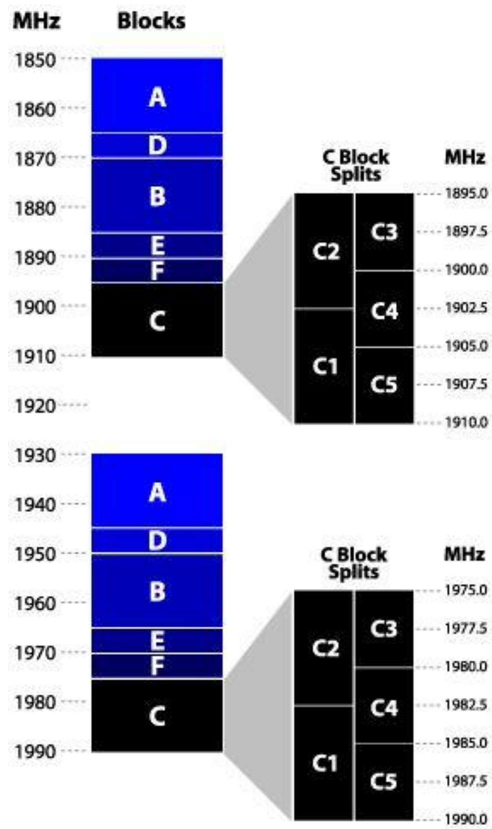
"Self-Organizing Networks will become a necessary component of networks as service providers are forced to increase the number of base stations in their network in the face of comparatively modest revenue growth"

Concept: Exploiting the Chaos Inherent in the Radio Access Network

The approach herein detaches from the constraints associated with legacy telecommunications network design principles, many based on century-old approaches used to support voice services.

Today, and since the inception of cellular based networking, wireless network operators are licensed blocks of radio frequency spectrum for their RAN. With that in mind, at a given instant, in a given location, the operator in Block A (diagram next page) may experience a lull in RAN demand for data services, while the operator in Block B is overwhelmed with traffic. The next moment, the reverse could be true. After that, both RANs could be momentarily idle.

This dynamic is multiplied by the number of wireless operators and active bands operating in a given service area. Because of the transient, episodic nature of data communications, there is a chaotic nature to the demand for, and availability of, RF resources.



North American 1.9 GHz Band

In the wireless industry, RF spectrum is viewed much in the way valuable property is viewed in real estate. Traditional business models supported by longstanding regulatory policies reinforce the paradigm. To put this in perspective, MNOs operate on a spectrum allocation model that goes back a quarter-of-a-century and is based entirely on the provision of voice services. In turn, *that* model emulates landline duplexing which goes back to around the time of the First World War.

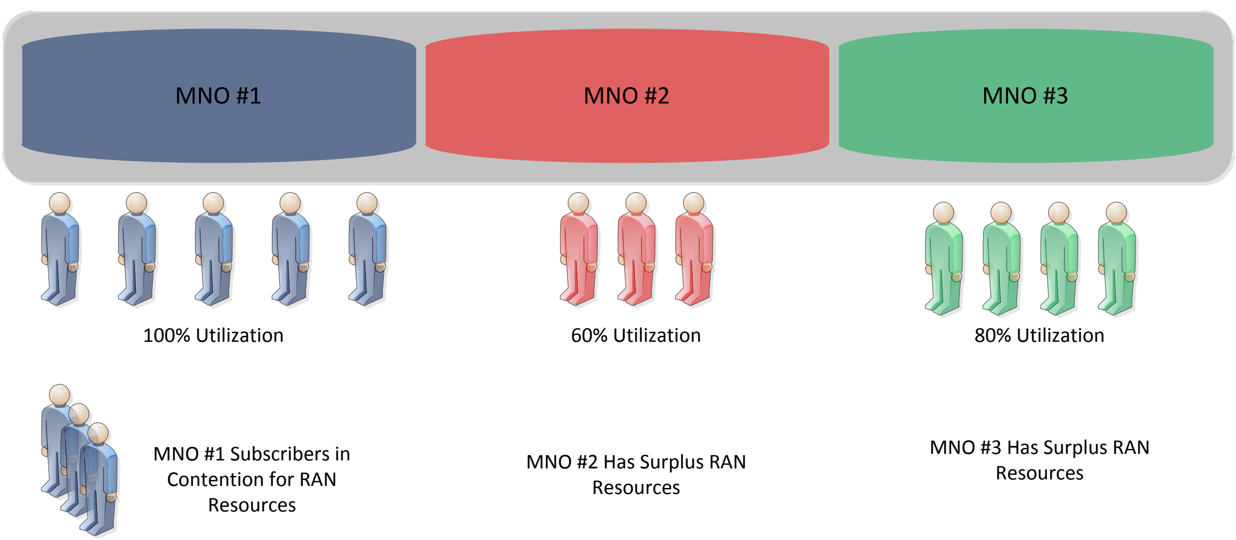
A Clean Slate

If we ignore these models for a moment, and look at all usable RAN spectrum as one large pool, and at the same time look at the user community as one large pool, we'd see a substantial opportunity to improve RAN availability on a per user basis. By extension, the collective user community would enjoy much greater throughput by virtue of increased bandwidth. In addition, transient 'bursts' based on surplus RAN resource availability could provide enormous instantaneous performance improvements. The concept of sharing RAN resources (the MNO's prime real estate) with their competitors may seem absurd today, but we believe it will be inevitable at some point in the future.

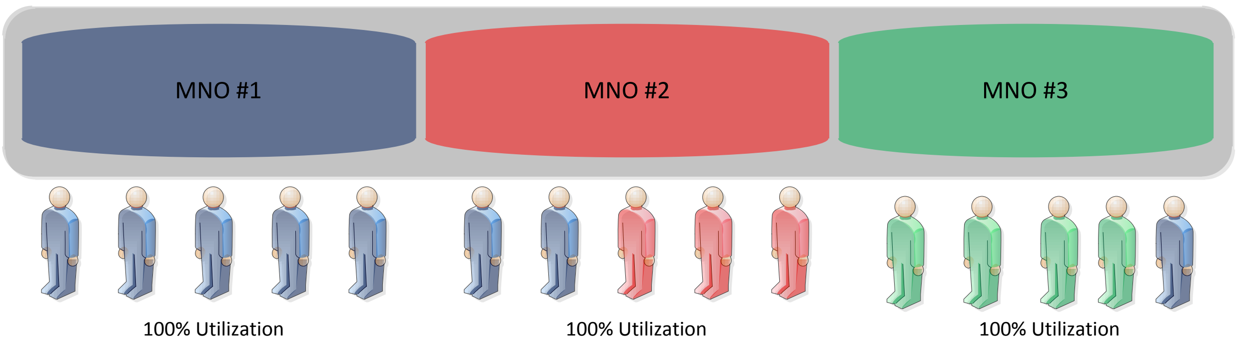
This filing is intended to view the collective RAN as pooled resource that all wireless operators in a given service area share. The intent is to have aggregate RAN utilization evenly distributed such that congestion on a given channel is dramatically reduced, or ideally, eliminated.

Usage Models

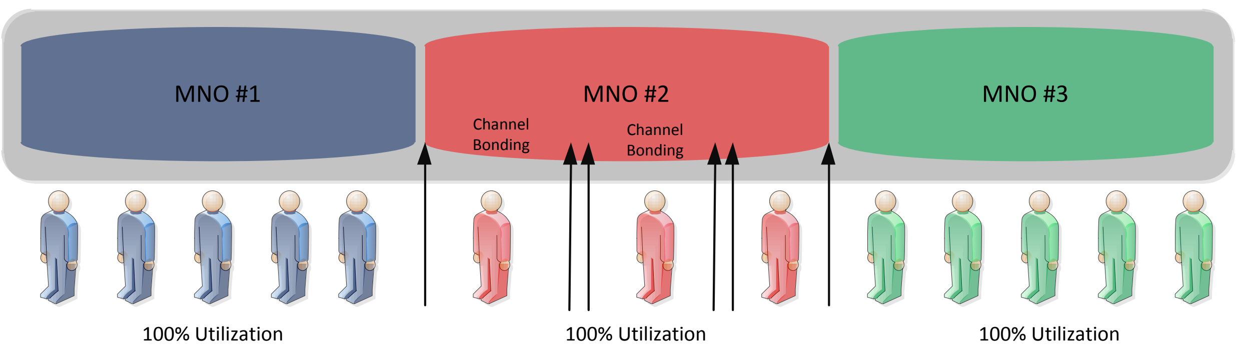
The diagram below depicts a fictitious (and greatly simplified) single RAN band where each MNO is licensed an equal amount of spectrum. This is the model used throughout the world today. At this given location, in this given moment in time, MNO #1 has exhausted its RAN resources. In fact, there is contention amongst MNO #1's subscribers for RAN resources. In the meantime, MNO #2 and #3 have surplus RAN capacity. In addition to being spectrally inefficient, this is naturally a source of aggravation for MNO #1's subscribers.



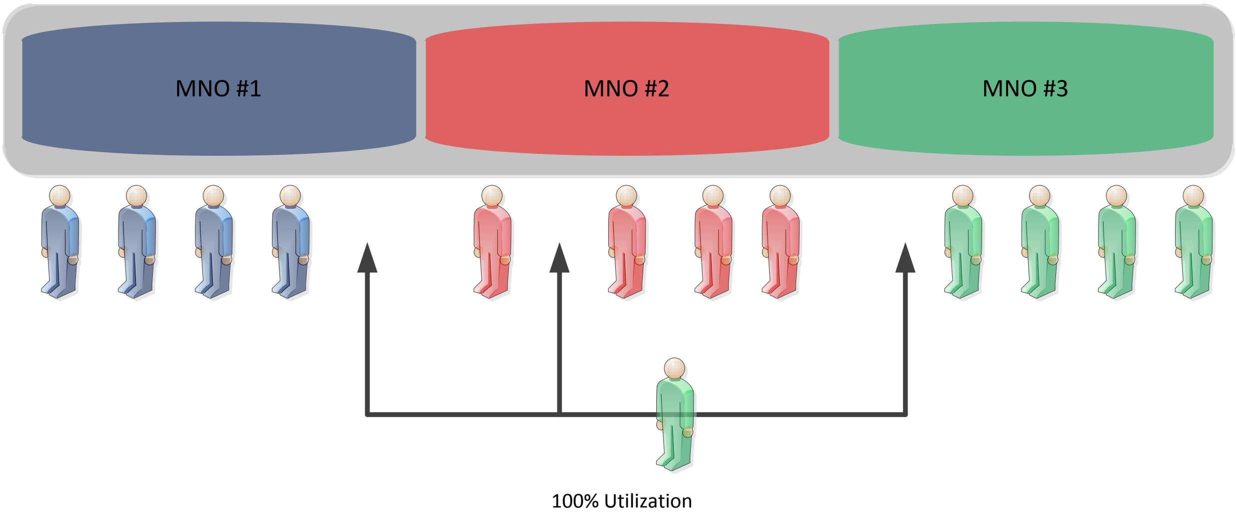
Many would agree that in an ideal world, the RAN user base would be distributed as shown below. This is a service provider agnostic model where RAN supply and demand are optimally matched. It is also more spectrally efficient.



Taking the concept a step further, imagine that MNO #1 and #3 are at 100% utilization, but MNO #2 for an instant in time, at a specific location, has surplus RAN capacity. As depicted below, through intelligent intra-MNO channel bonding, the user base could enjoy a performance improvement as a result of this spare capacity. Once again, we'd see 100% utilization of the band.



The ultimate demonstration in pooling RAN resources is to provide inter-MNO channel bonding. In the diagram on the following page, a subscriber with MNO #3 gets maximum access to collective RAN resources regardless of where those resources reside (in other words, MNO agnostic). We can see that a channel from each MNO (including his/her 'home' MNO) is bonded to provide an aggregate of three channels of bandwidth.



We also see that band utilization is at 100%. The concept of engineering a network to maintain 100% utilization for as much of the time as possible is a shift from traditional circuit switched voice channel engineering where network resources are provisioned for 'busy hour'. With this usage model, many of the resources are idle outside of busy hour – either generating no revenue, or perhaps being repurposed for lower revenue applications and services.

Session Management: The I-RSO Platform's Key Function

A powerful Session Management platform is essential in instantaneous assessment of RAN resources, along with the subsequent decisions with regards to assignment of RAN resources. The session manager is MNO agnostic in that RAN resources are assigned based on aggregate supply and demand. Also, demand isn't merely the request for an RF channel. In the environment envisioned, OSI Layer 6 and 7 help define the nature of the application, and with that, reserve and assign bandwidth accordingly. The examples below have different network resource requirements.

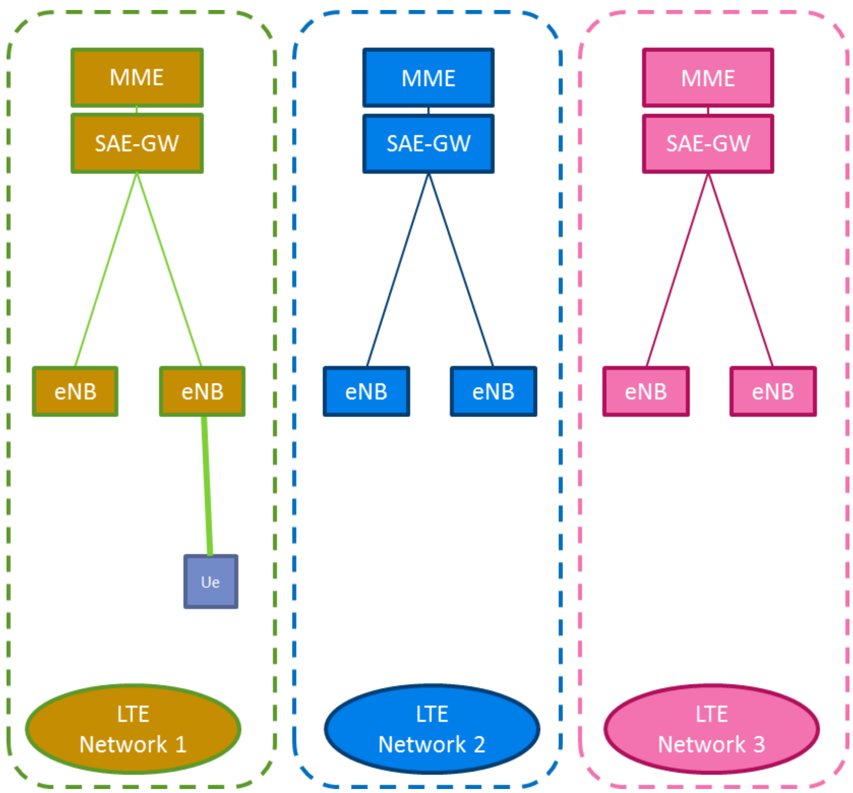
Activity	Duplex Mode	Symmetry	Bandwidth Required
Web Browsing	Half/Full	Asymmetrical	Low
Video Conferencing	Full	Symmetrical	Medium to High
Audio or Video Streaming	Half duplex/Simplex	Highly Asymmetrical	Medium to very High

In light of the characteristics of most data communication sessions, transactions at Layer 1 and 2 are bursty and transient, but as the chart above shows, there are exceptions. Significantly, it is in the non-bursty categories where the greatest growth in demand for mobile network bandwidth is.

The fundamental philosophy behind the Inter-RAN Spectrum Optimizer (I-RSO) is to pool aggregate RF resources in a given service area. The assumption is that participating MNOs will not relinquish the spectrum they've been previously licensed. Accordingly, those subscribers loyal to a given MNO would not be expected to make any changes with regards to the relationship with their MNO. In fact, from a business and customer relationship perspective, introducing the I-RSO would be transparent to the user – other than the improvements in RAN performance. The average user is likely to attribute the improvements to their 'home' MNO.

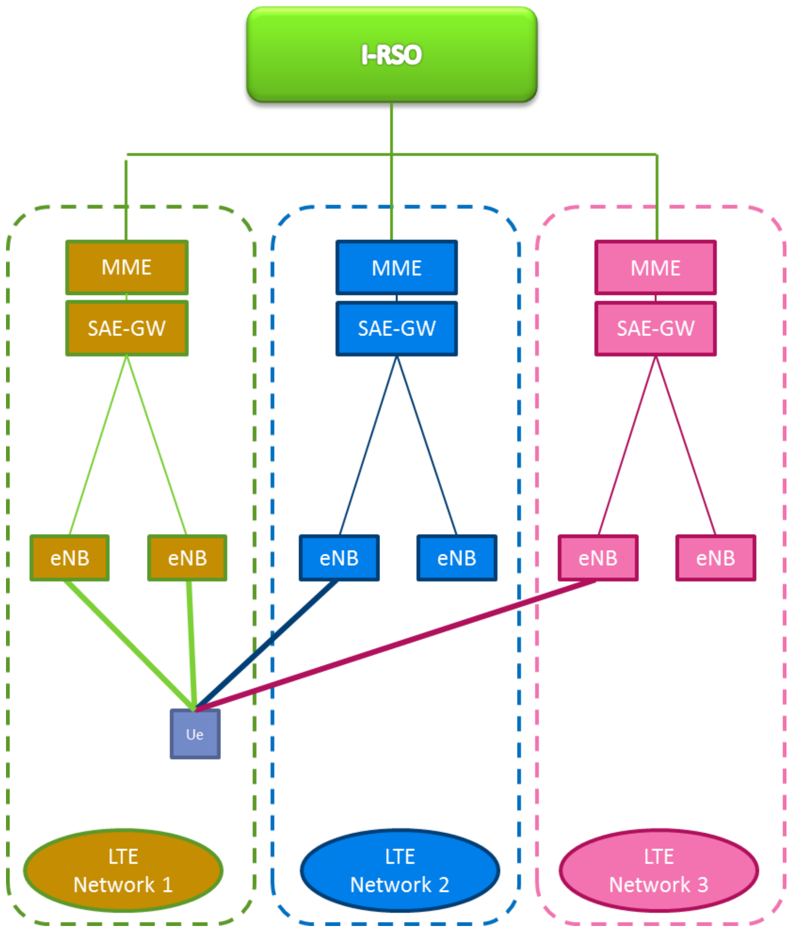
RANs As They Currently Operate

The diagram below depicts three disparate LTE networks in a given service area with a user (Ue) on the brown network confined by the RAN resources on his/her most favorable cell/sector. The Ue is in a high-demand data session and experiencing poor performance because of limited bandwidth on the RAN. At this same moment, there is spare RAN capacity on the neighboring brown network cell, but there is also spare RAN capacity on the networks his/her home network competes against.

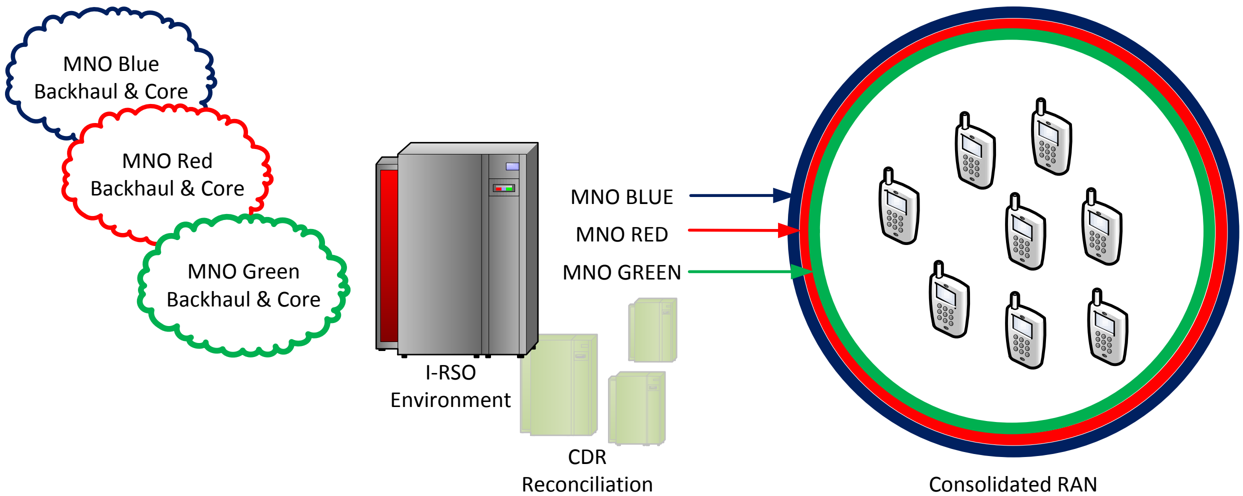


Optimizing RAN Utilization with I-RSO

The diagram below depicts the same Ue, along with the same three disparate LTE networks (previous page). This time, however, bandwidth is aggregated from the blue and pink network. The Ue also benefits from an additional channel on its home network.



The diagram below depicts I-RSO relationships at a high level.



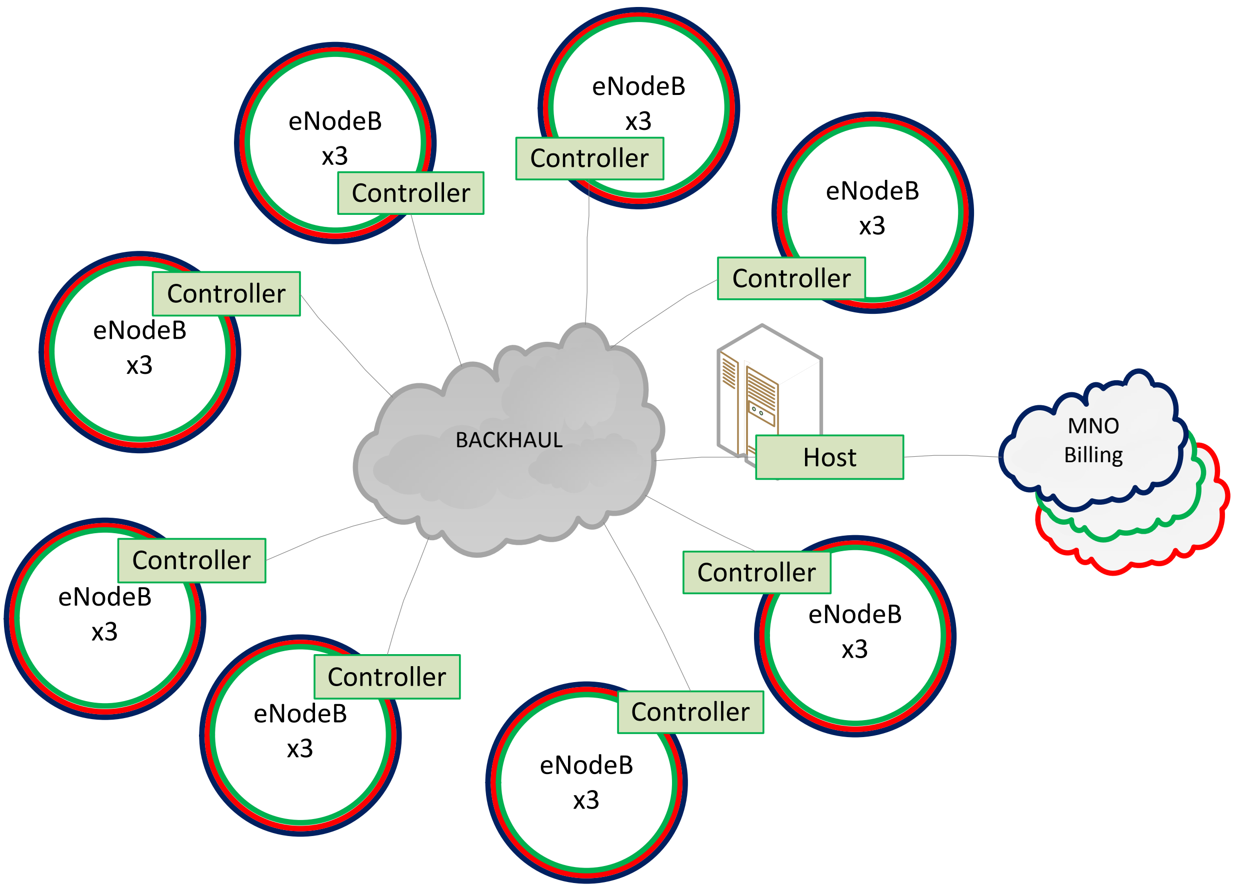
I-RSO Components

The I-RSO consists of two basic components:

1. Session Host

2. Session Controller

As can be seen below, there is a one-to-many relationship between the Host (centralized), and the Controller (distributed).



Note: LTE/SAE (Long Term Evolution/System Architecture Evolution) base stations are being used for demonstration purposes. The I-RSO is RAN technology agnostic, however – meaning that a combination of disparate radio access standards (e.g.: HSPA, HSPA+, White Spaces, Wi-Fi) could be bonded at a given instant, in a given location.

Session Controller Functions

Located at the RAN edge, the Session Controller is connected to all participating eNodeBs in a given serving area (i.e.: cell/sector). In this example, MNO Blue, MNO Red and MNO Green are participants. The Session Controller's role is to constantly and instantaneously evaluate aggregate RF resource supply and demand for its cell/sector. Based on business and operational rules preloaded from the I-RSO Host, the Session Controller allocates RF resources appropriately.

These activities are of extreme time sensitivity in light of the highly dynamic nature of RF resource supply and demand in data communications applications.

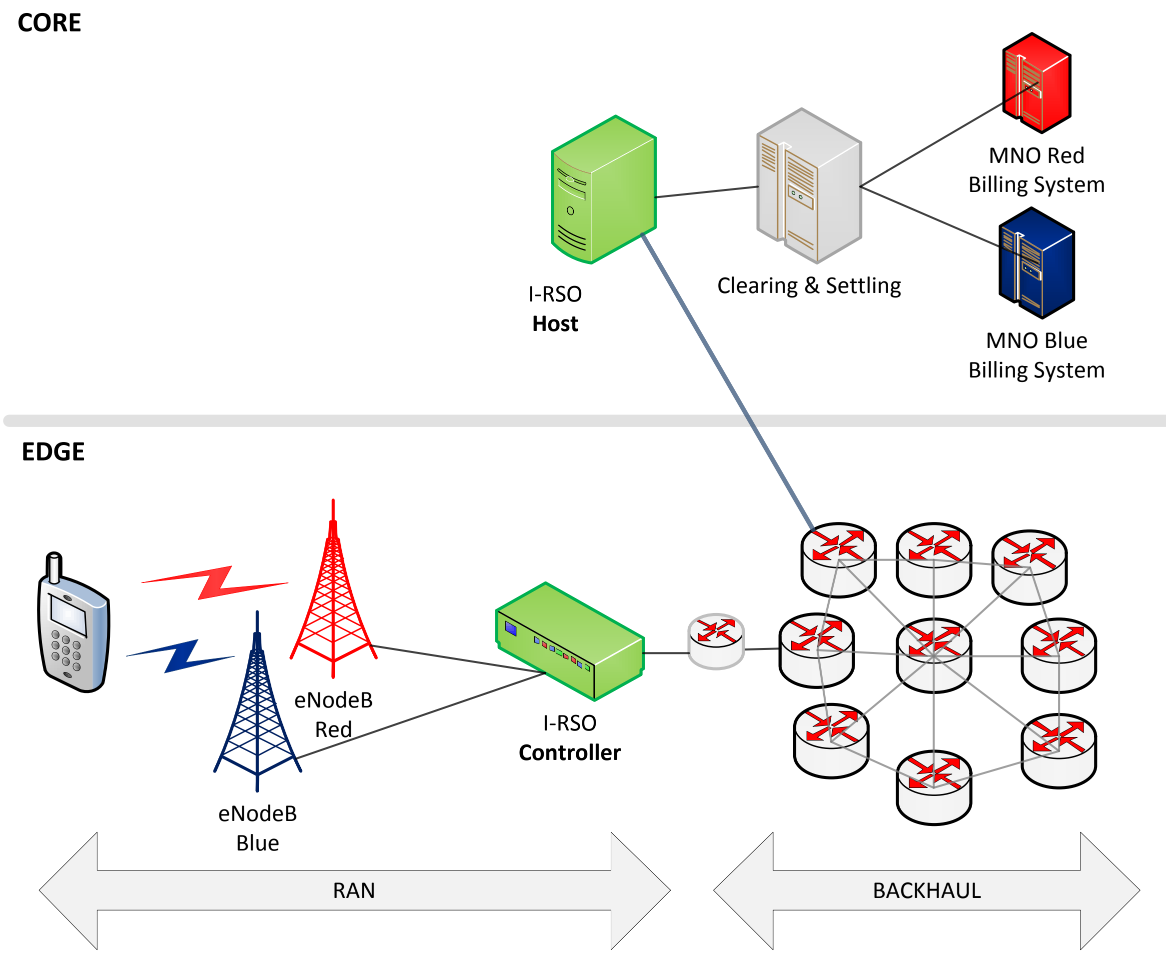
A less time sensitive, yet critical function is the Session Controller's other role of delivering Charging Data Records (CDR) to the Session Host (next section).

Session Host Functions

The Session Host is the operational management and administrative foundation of the I-RSO. Roles include:

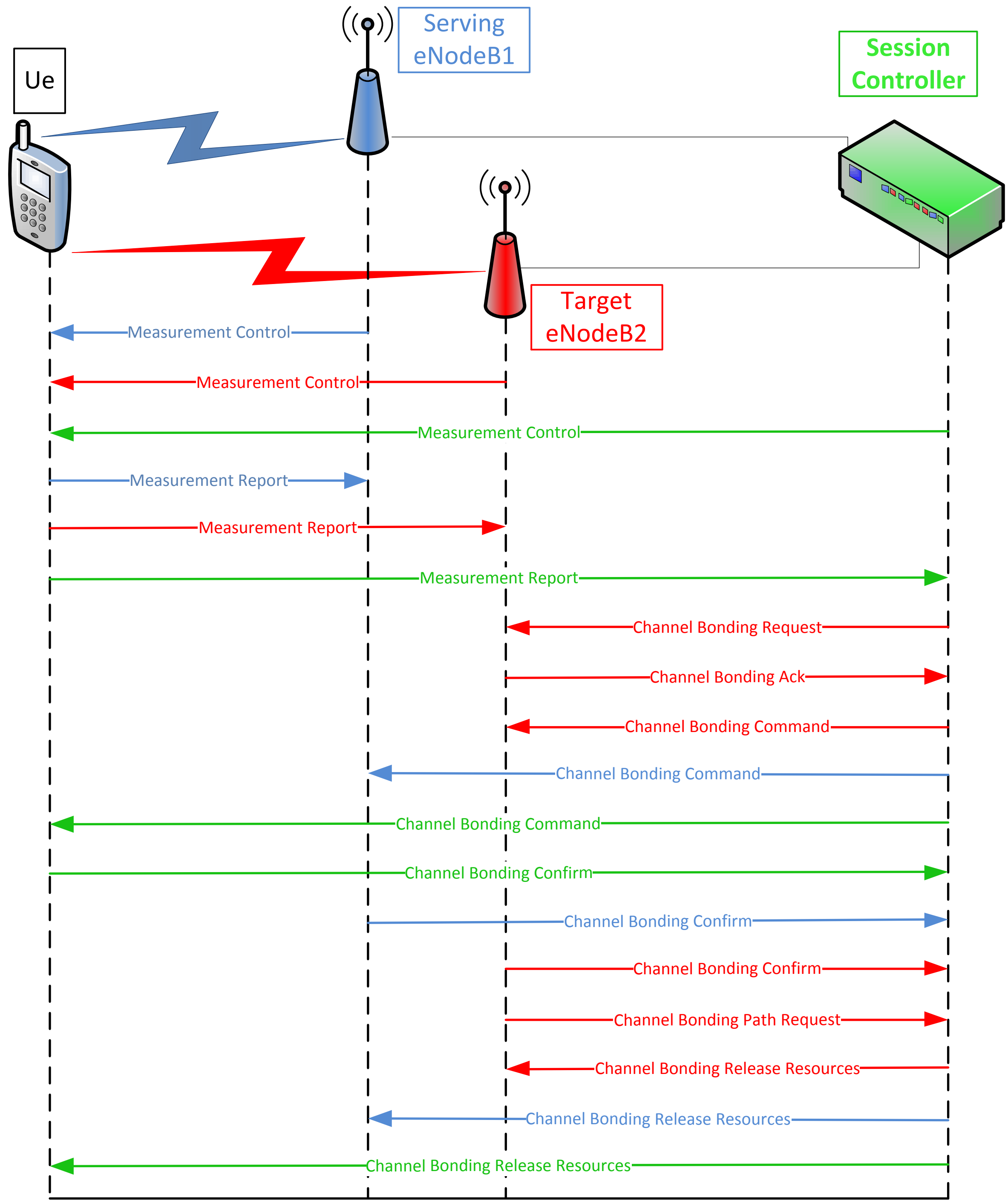
1. Storage and loading of operating parameters to all participating Session Controllers.
2. O & M environment in support of Session Controllers, along with the Host itself.
3. Database of CDRs delivered from all associated Session Controllers.
4. CDR reconciliation engine to ensure RAN usage reporting is delivered accurately to the appropriate MNO billing environment.

Implementation Model, Single Location, Two Participating MNOs



The Controller operates at the RAN edge of all participating MNOs. Operational parameters are loaded locally on all participating eNodeBs (radio base stations). The I-RSO Controller constantly evaluates spectrum supply and demand on each eNodeB. It is the instantaneousness of RAN resource allocation that makes it necessary to deploy the I-RSO Controller at the network edge.

Controller Message Flow



I-RSO Controller Channel Selection Criteria

Criteria for binding channels on disparate RANs in a given location will first be dependent on criteria with the RAN technology standard. Typical parameters include but are not limited to Reference Signal Received power, Reference Signal Received quality, Signal to Interference Noise Ratio etc.

The algorithm associated with I-RSO Controller decision-making is under development and regarded as out of scope of this provisional patent application.

Conclusion

From a business model perspective, there is a compelling precedent for this type of relationship where competitors pool their resources to improve their collective performance. In the early 1980s, Automatic Teller Machines (ATM) began to appear in Canada. The hardware was expensive as were the recurring costs for communications facilities back to the bank's data center. In order for the general public to adopt this new approach to banking, the belief was that ATM penetration had to be much higher than any one financial institution could single handedly deploy. In response, Interac was formed as a cooperative network to support cross-bank ATM usage by member financial institutions. To this day, this cooperative works very well and has proven to be the foundation for other advances not directly related to the ATM network.

A more germane precedent is the Internet itself. As a 'network of networks', infrastructure supporting the Internet is incalculably enormous and complex, and by its very nature, openly shared. The end user's relationship with the Internet is largely defined by his/her relationship with their ISP, even though the 'invisible' networks that make up the Internet are an essential part of the Internet experience. This cooperative approach to resource sharing amongst numerous network operators may prove prescient for RAN pooling.

TERMS & ACRONYMS

Backhaul	Interconnection of telecommunication network elements internal to the network and not directly touching the customer
CDR	Charging Data Record
eNodeB	Intelligent Radio Base Station in compliance with the LTE standard
HSPA	High Speed Packet Access
I-RSO	Inter-RAN Spectrum Optimizer
LTE	Long Term Evolution
MNO	Mobile Network Operator
RAN	Radio Access Network
SAE	System Architecture Evolution
Wi-Fi	Wireless LAN
UMTS	Universal Mobile Telecommunications System