SERVICE MANAGEMENT IN NEXT GENERATION HETEROGENEOUS WIRELESS NETWORKS - A SOLUTION APPROACH

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Manoj Nair
Mukund Krishnaswamy Veeraraghavan

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Today's cellular wireless networks involve a wide array of emerging network technologies—such as LTE Advanced, software defined networking, heterogeneous networks, and fixed-mobile converged networks - which are rapidly advancing along the development curve from standardization, to adoption, trial, and ultimately deployment.

For wireless operators, the impact of these new technologies represents a paradigm shift from the way the services have traditionally been offered, operated, and managed. Since this shift poses challenges with respect to controlling the data tsunami and complex signaling, operators are hard-pressed to find advanced technologies that give them tighter, integrated control over their deployed infrastructure and service elements.

Operators are also on the lookout for solutions that differentiate their offerings through better quality of service resulting in an enhanced customer experience. Service management, which is crucial to delivering a better customer experience, is particularly challenging because of the complexities introduced by next generation network technologies and the limitations of existing and legacy network monitoring solutions.

In this paper, we critically evaluate the service management challenges operators can encounter in tackling these next-generation heterogeneous networks and offers operators new insights, strategies and recommendations. This paper also evaluates how standards bodies are moving to address these challenges and presents our point of view on the available approaches for operators, especially the 3GPP proposed telecommunications management framework, with an emphasis on service management. This paper also highlights the need for a direct interface between the service management layer and southbound interfaces, looks closely at non-3GPP integration and makes suggestions to help operators manage the converged Heterogeneous Network (HetNet) ecosystem.

Introduction

Heterogeneous Networks (HetNet) refer to a complex eco system of radio cells with varying coverage ranges and technologies that interoperate to deliver the required capacity and coverage. Post LTE, they are the next wave of enhancements expected to be rolled out across the globe by communication service providers (CSPs). The primary objective of heterogeneous networks is to improve coverage and capacity over traditional cell deployment models like macro, micro, or picocells.

Because LTE service is widely available worldwide and the handset eco system is evolving rapidly to keep pace with high speed network technologies, end users will expect all their service to work seamlessly, with high availability, reliability, and other quality standards, across different technologies.

For CSPs, HetNet ensures that their services are always available to subscribers and an advanced service management solution ensures that all the services are managed efficiently and optimal service levels are maintained. It is of paramount importance that for seamless, highly available, guaranteed quality of services, service management of Heterogeneous Network should be treated as a focus area for CSPs.

Heterogeneous Network Characteristics

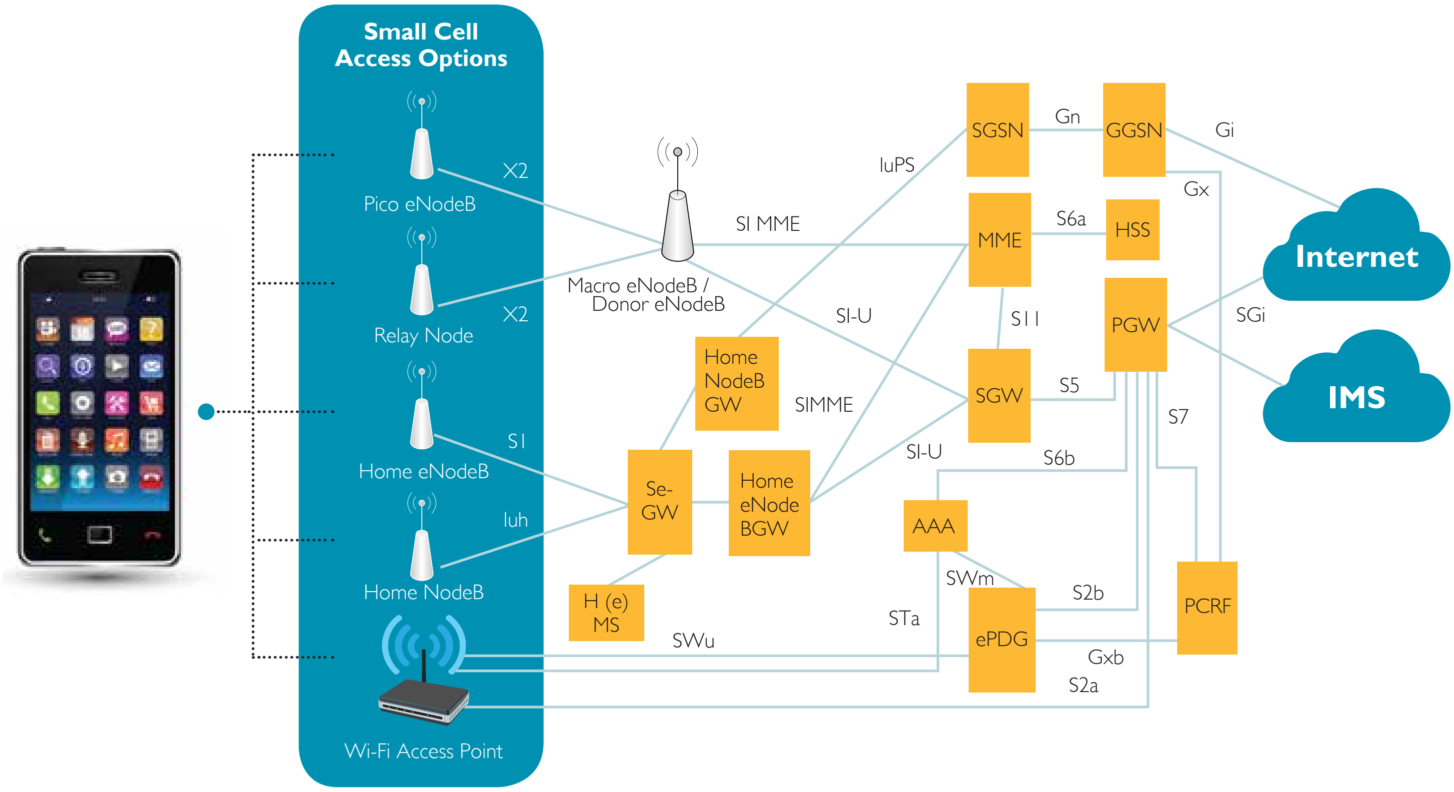

Figure 1: Heterogeneous Network Functional View

The access components in heterogeneous networks consist of Home NodeB, Home eNodeB and corresponding gateways that interconnect the NodeBs with the operator core. Here are a few unique characteristics of heterogeneous networks:

1. Architectural Changes

In HetNet, there are 5 basic access mechanisms that are defined by the 3GPP standard. This includes pico cells, relay nodes, Wi-Fi access nodes, Home NodeB and Home eNodeB. The Home NodeB and Home eNodeB are connected to the core network through the security gateways and Home eNodeB gateways. For the Home eNodeBs, since the X2 interface used primarily for interference control is optional, there is a dependency on the OAM (operations, administration, and maintenance) and SON (self-organizing network) functions to carry out the optimizations. For the Wi-Fi access, there is a trusted and non-trusted model. In the trusted model, the UE (user equipment) is transparently switched to the Wi-Fi network since the access points will be trusted and verified by the operator core. But with the non-trusted model, the user equipment needs to establish a secure IPSEC connectivity with the core over a Proxy Mobile IP tunnel after authenticating the credentials with an AAA server through the packet data gateway. In relay node option, as the name indicates, donor eNodeB coverage is extended through the use of relays over a wireless backhaul. These architectural changes subsequently impact the call flow and eventually impact the traditional management architectures, functionalities, and management system development road maps. There's now a different level of classification for small cells that's popularly called metro cells, which are deployed indoors or outdoors. They have a higher processing capacity and are typically managed by the CSPs to enhance capacity and coverage of the macro cells.

2. Self-Organizing Networks (SON)

Self-Organizing Networks primarily consist of three mechanisms—self-optimization, self-healing, and self-configuration—which are components of an automated service assurance system. In a network ecosystem like HetNet, it's essential to leverage SON because traditional monitoring and management might not be efficient and could lead to high operational expenditures. For traditional service management solutions, SON will be an enabler that impacts operational procedures implemented by these solutions.

3. Flexibility

One notable advantage of HetNet is the flexibility it offers in terms of using multiple radio access technologies like 3G, LTE, Wi-Fi or traffic rerouting/offloading options related to LIPA (Local IP Access), SIPTO (Selected IP Traffic Offload) with or without mobile operator support. With multiple access options available, 3GPP also offers a mobile IP based network address assignment, which provides flexibility to seamlessly switch from one access mechanism to another while ensuring session mobility. This is going to impact service management systems since the service can flow through any of the available access mechanisms. Until the operator has visibility into all the supported access options, there will be gaps in determining service quality.

4. Deployment Model

With the heterogeneous network, multiple deployment options are possible. Among the emerging deployment options are Femto as a Service (FaaS) and Small Cell as a Service (SCaaS) where the access terminals and antennae systems are owned by a hosting provider (Home (e)NodeB Hosting Party) and multiple mobile operators leverage the access infrastructure built by these hosting providers. Similar characteristics exist in deployments having Distributed Antennae System (DAS) owned by a hosting party or the building infrastructure provider, which is shared by multiple CSPs. RAN (radio access networks) sharing, or Mobile Operator Core Network (MOCN) sharing, is another area that will greatly impact management because the RAN infrastructure will be shared by multiple operators, and collecting and distributing performance and fault metrics will involve additional overheads. Typically in these types of shared infrastructures, the SON may not work as effectively because the optimizations carried out for one operator may not function properly for others. Phantom cells, currently in the research stage, is another type of deployment model where the control and bearer follow different paths – i.e. the control path is handled by a macro cell and the bearer path is handled by a small cell. The choice of deployment model varies, depending on each operator's business requirements. The deployment model also impacts management frameworks since multiple usage scenarios will need to be monitored and measured.

Service Management of Heterogeneous Networks - Challenges

Service Modeling

In service management, service modeling is a critical activity which defines association metrics for a service at a high level. Three main types of associations are defined – services to resources mapping, service performance metrics to resource performance metrics, and resource level alarms/notifications to service level alarms/notifications.

Mapping services to resources depends on the inventory management system. With the introduction of heterogeneous networks, many access nodes need to be accounted for by the inventory management system in terms of their physical and logical information. It's also essential to have an automated reconciliation mechanism that can discover configuration changes and update the inventory.

When mapping service to resource metrics, it may not be that challenging to define the metrics, but four fundamental factors need to be considered to handle the flood of performance data—latency, performance data size, collection frequency, and capacity. Since HetNet supports a parent-child cell model, where one macro or micro cell acts as an aggregator for multiple small cells, it's essential to define the aggregated performance metrics, which need to be mapped to the service metrics that enable overall service performance assessment.

For mapping between service alarms/notifications and resource alarms/notifications, one challenge is the reporting of small cell level faults to the network operations center and the subsequent impact assessment on service, such as when a local power outage switches the small cells in the region to back up power. In service modeling, the alarms need to be carefully chosen and designed to avoid alarm flood and alarm filtering rules at the resource layer so that service impact is assessed without imposing a load on the management infrastructure.

SON Capabilities

One critical impact on service management resulting from the introduction of SON will be the self-healing mechanism. In the current SON, the self-healing mechanism is oriented towards resource level problem identification and rectifying problems like cell outage, coverage holes, etc. The efficiency of the self-healing depends on how quickly and accurately problems are detected and fixed, which, in turn, depends on the vendor products and corresponding element management systems.

Like self-healing, self-optimization and self-configuration will also impact service management systems. Self-optimization detects optimization issues and works with configuration modules to fine-tune end device parameters. Some of these optimization issues include handover thresholds, power settings, antennae parameters, neighbor lists, cell identity parameters, and tracking area association. Since this is done dynamically, until the inventory system gets updates on such configuration changes, there will be data mismatches that impact service models and data aggregation mechanisms in the service management systems.

Another challenge with enabling SON is that the legacy 2G/3G portion of the network will continue to be managed manually while the small cells will be monitored and controlled through automated SON functions. This creates additional operational overheads, especially in service scenarios involving mobility across different mobile technologies and cell variants. It will also be operationally challenging to maintain separate procedures and systems for the management of the legacy and small cell RANs.

On Demand Management

In 3GPP specification 32.835—pertaining to HetNet management—one of the critical requirements is on-demand management, which is context-specific management of the deployed infrastructure. The majority of Common-Off-The-Shelf (COTS) OSS components, especially those marketed in the service assurance space, have limited flexibility in terms of defining management contexts. This limits the operations team from implementing custom management use cases and often this leads to heavy dependency on the network vendor or managed service partner.

Management of Converged Network

With respect to HetNet, one particularly interesting use case, "Femto Access Management," (described in 3GPP specification 32.833), describes a combination of fixed and mobile access elements in a residential deployment scenario, which provides connectivity to the operator's mobile core network. The femto network is deployed to provide a convenient, high-quality connection to the mobile core when the mobile user tries to access the services from home. Here the service management system should have the intelligence to determine the access mechanism used by the end user when he connects from home or outside, or seamlessly moves into a femto connection zone. To enable this, a separate set of resource metrics and the corresponding service dependency need to be ascertained as part of the service modeling activity.

Integration of 3GPP RAN with Non-3GPP RAN

One advantage of HetNet is the seamless mobility it offers across various access technologies. One exception is when an access node controlled by a partner operator gets connected to the primary operator mobile core, which is quite possible in non-3GPP access mechanisms, such as HetNet-supported Wi-Fi and WiMAX. When the user switches from 3GPP to Wi-Fi access, the control layer messaging may switch over to the ePDG, assuming a non-trusted Wi-Fi access. The service management layer needs to have visibility across both Wi-Fi and 3GPP access layers, with information on the mobility parameters, to identify the sessions that are switched from one technology to another. Similarly, the session quality of service also needs to be measured regardless of the access technology being used.

Recommendations and Implementation Approach

This section looks at service management, specifically service assurance of heterogeneous networks, from an end user's point of view.

Architectural Recommendations

Assuming that the majority of brownfield CSPs across the globe have a base network/resource management architecture in place, more are now moving to the next stage in telecommunication network management—from resource level management to service level management. While the TMForum Business Process Framework and associated process areas can be used as a reference for defining the service management architecture, there are equally important frameworks like TOGAF and the relatively new 3GPP management architecture. Since TOGAF defines the enterprise architecture, which is broader in nature, it's relevant to consider the more focused 3GPP proposed management architecture and its implications for HetNet service management.

As shown in Figure 2, 3GPP 32 series specifications prioritize information management through the use of information models rather than network elements as physical resources. The advantage of this management architecture is that it's vendor agnostic and it emphasizes functional elements and the management of information.

This architecture relies on three standardized components:

1. **Network Resource Model:** The management information inside network elements that need to be managed.
2. **Interface Model:** The management information exchange between the network resources and management systems.
3. **Common Data Model:** the common data that can be used by the network resource and interface models.

These three models are represented by integration reference points, which consist of:

- A generic logical model called information service, and
- Specific implementation models called solution sets

Northbound and southbound interaction between the entities is carried out through interface N, which has associated generic information and implementation specific solution sets defined using interface model specifications.

The only options currently available from a service management point of view are subscription management (3GPP 32.17x) and user data convergence (3GPP 32.181/182). Some use cases, like TCP optimization, Location/Proximity detection, media broadcast, and Service Session Tracing, may require direct interaction by the services layer with the resources. Per the 3GPP architecture defined above, this requires that the functionality of the network manager be extended to serve service specific management requirements.

Also, service sessions, especially those involving Home eNodeB, pass through the security and Home eNodeB gateways (GWs) on the RAN side. In this case, the management systems for Home eNodeBs and respective gateways may be from a single vendor or from separate third-party vendors. Interacting with multiple vendor elements will impose additional overhead because the management interfaces and SON specific algorithms utilized by each vendor may be different.

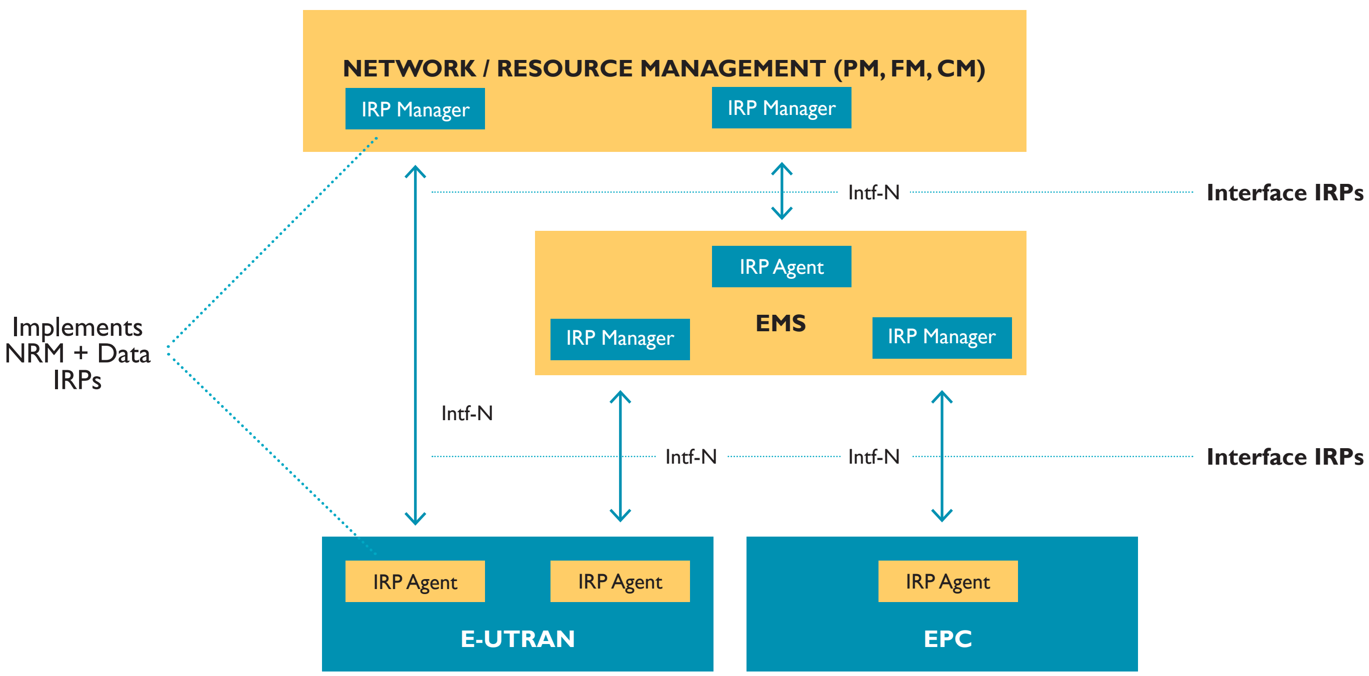

Figure 2: 3GPP Telecommunications Management Model

Figure 3 shows a possible alternative for incorporating service management requirements in the 3GPP network management architecture.

In the proposed model in Figure 3, IRP Managers at the resource management layer have pass-through functions that are explicitly implemented through the respective IRPs. This enables northbound management systems to directly execute service-specific management commands without depending on the product vendor or lower layer umbrella management systems. This model also enables on demand management because the operations team can carry out custom management activities without having to depend on the product vendors.

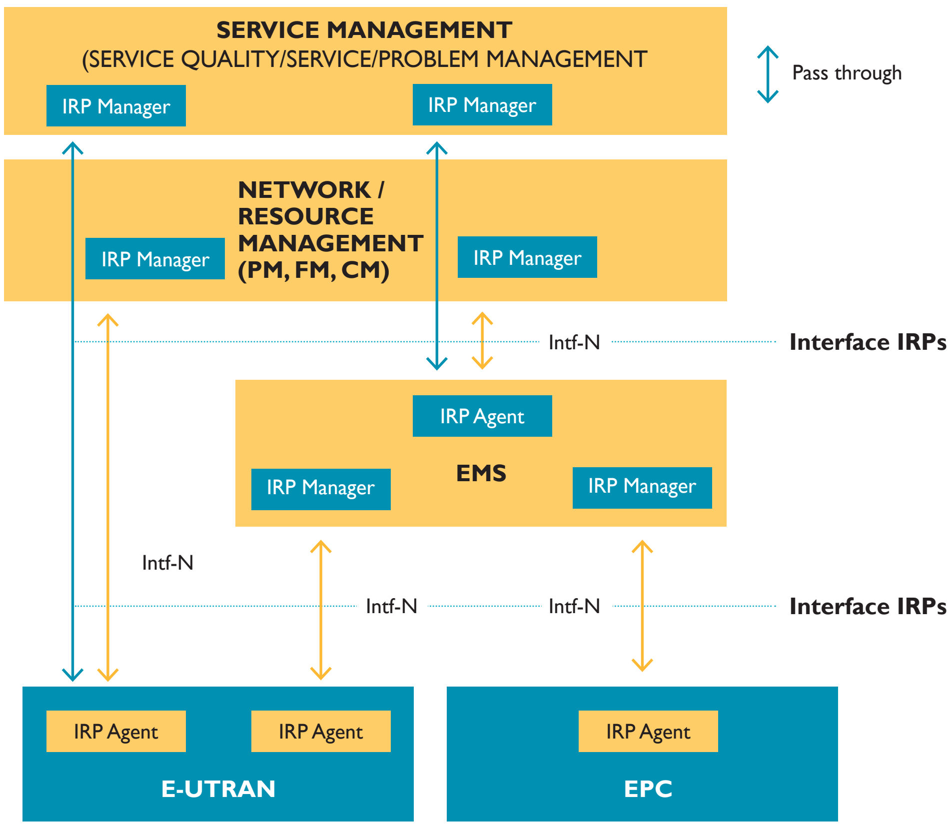

Figure 3: Suggested Telecommunications Management Model

Service Modeling Considerations

Service modeling involves aggregating service level information from different resources and creating an end-to-end view of the service in terms of performance, problems and dependencies. Service models depend on the network deployment architecture and end-to-end call flows. For this reason, only generic entities in the service model are standardized. For example, 3GPP standardizes:

- Network resource models, which define the management information in a resource that can be aggregated at a service level based on the network deployment model
- Key performance indicators for various network technologies and network segments, which can be aggregated to get service level performance metrics

While TMForum GB923 facilitates wireless service measurements, heterogeneous networks require new service model definitions because services sent over HetNet can flow through multiple paths, regardless of the radio access technology or radio network deployment models involved. In addition, the sessions may originate in the primary operator network and terminate in an untrusted network, which may impede the operations team from measuring end-to-end service quality.

Figure 4 shows a view of the service model with HetNet as the underlying access mechanism, including data service to HetNet resource mapping and data service performance to HetNet resource performance.

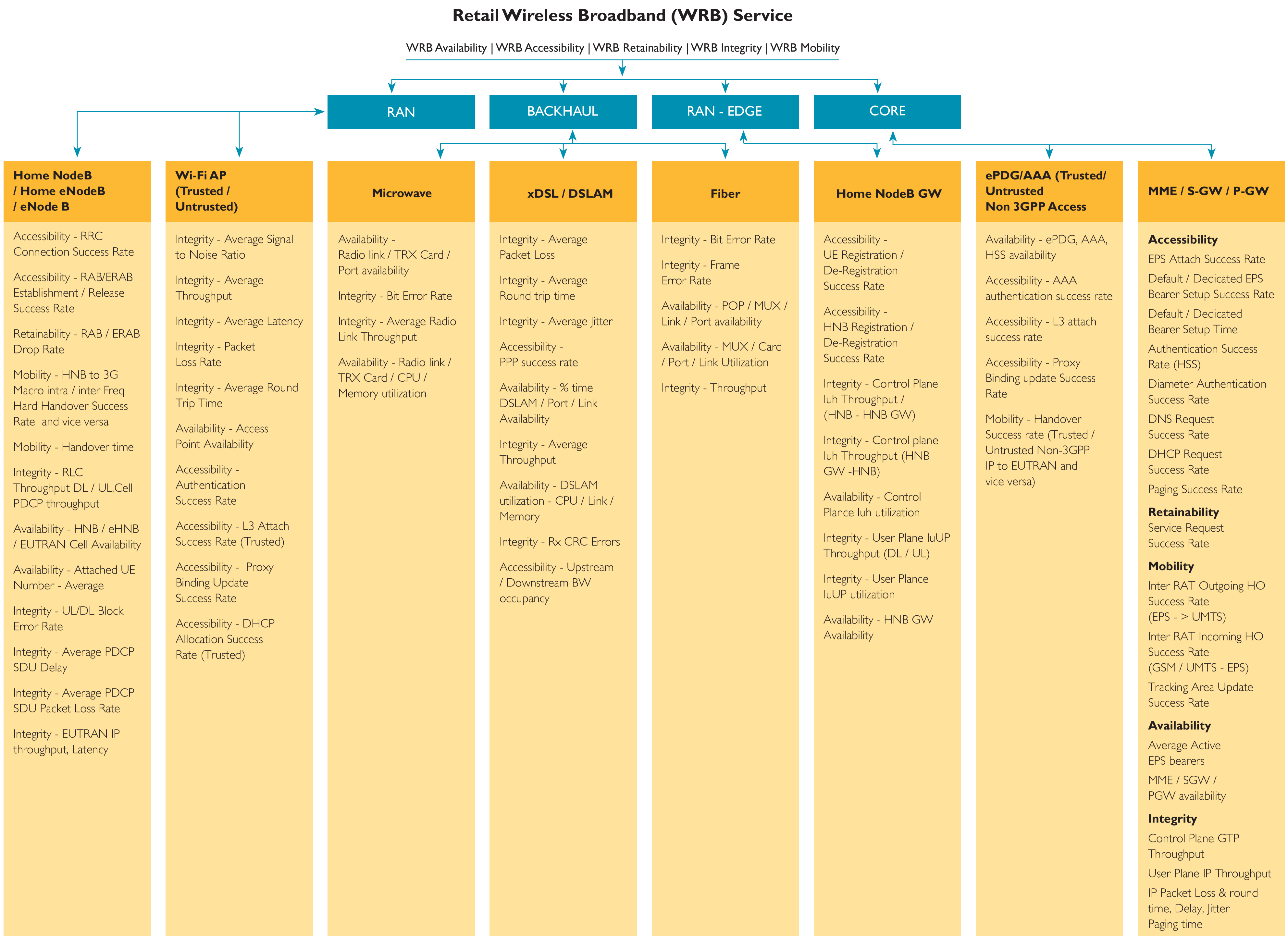

Figure 4: Sample Service Model for HetNet

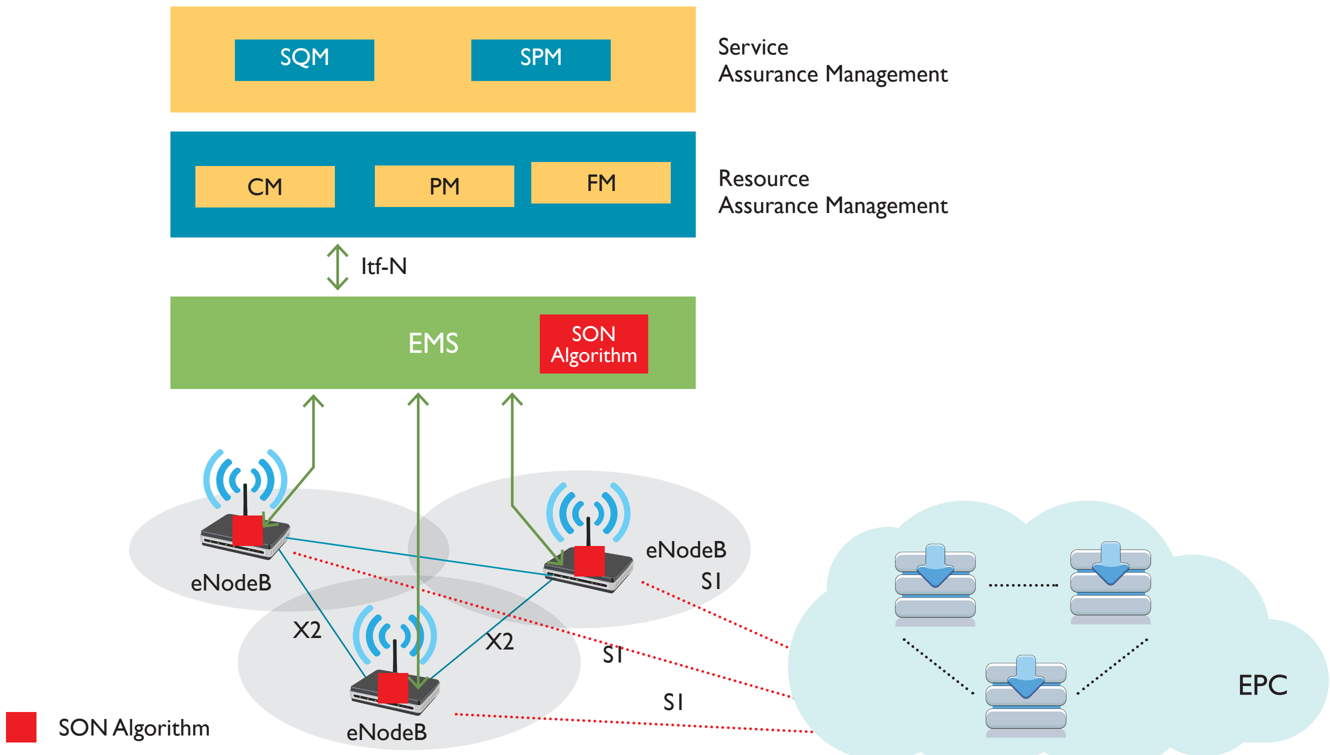

Figure 5: SON Functional Model

SON Considerations

Like the 3GPP SON specifications (32.500), there can be 3 different implementation models for SON:

- Centralized, where the SON algorithm resides in the EMS and/or NMS
- Distributed, where the SON algorithm resides in the network element
- Hybrid, a combination of the two

Using the three models above, the overall functional architecture for resource and service management looks as shown in Figure 5.

Three aspects need to be addressed in the Figure 5 for heterogeneous networks:

1) As per 3GPP specification 32.571, there are two types of interfaces between the Home eNodeB and management systems—the interface between the Home eNodeB and Element Management System, and the interface between the Element Management System and Network management systems. The majority of SON control functions reside in the Element Management Systems, and the management interaction between the EMS and Home eNodeBs is carried out through the TR069 protocol. This model requires the northbound management systems to have a tight coupling with the element management systems, which may lead to product dependencies. The recommended approach is to have a pass through mechanism in the EMS that can directly invoke the SON functions or TR-069 interfaces from northbound management layers.

2) From a service management point of view, it's desirable to trigger SON algorithms based on the KPIs, KQIs or patterns observed by the resource and service management layers, or to enable traces, session logging or specific parameter monitoring on an as-needed basis. This is a convenient way of implementing the on demand management feature described earlier. Combined with the recommendations above, extending the SON and management capability beyond the EMS/NMS makes the overall management framework more efficient since critical, time-consuming algorithmic computations can be offloaded to upper layer management systems, which can enhance the SON rules.

3) In the case of Home eNodeB, it's optional to have a Home eNodeB GW, which extends connectivity to the core network. And where the Home eNodeB GW is absent, the Home eNodeB acts as a typical eNodeB in a EUTRAN system, with or without SON functionality. But if the SON function is absent in the EMS and the Home eNode B, it's logical to place it in the resource management/network management layer. In this event, the recommended approach is to have the northbound interface from EMS opened up to execute SON actions passively through the EMS.

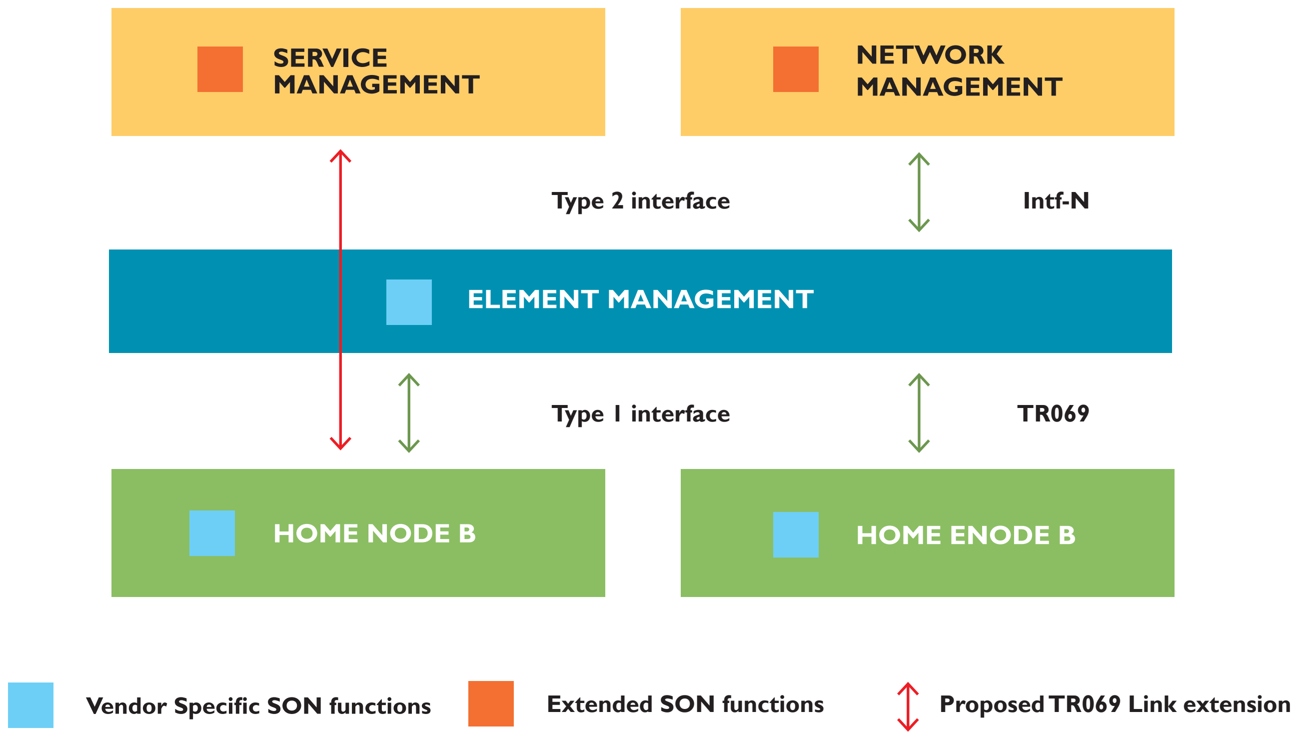

Figure 6: Suggested SON Model

The recommended logical model for HetNet management is illustrated in the Figure 6.

Business Process Considerations

It's essential to understand the HetNet management capabilities supported by access along with the connectivity and possible interactions of end-user network elements with core network elements. Procedures need to be defined to validate and audit management and operational capabilities. Critical procedures for HetNet include:

- Validation of end-to-end service over the HetNet infrastructure
- SON capabilities (self- optimization, self-healing and self-configuration)
- Mobility procedures in/between different small cell models

When validating SON functionalities, it's essential to ensure the interoperability of SON functions with other OSS components like inventory, provisioning systems, and fault/performance management systems so the right information is synchronized with legacy networks and 2G/3G OSS systems. It's also essential to define the metrics for operations efficiency measurement, especially for SON functions, i.e., determining how quickly and accurately the SON function identifies the pattern and takes corrective actions based on rules.

In terms of operations readiness, it's important to build the adaptation mechanisms required for data management while introducing the heterogeneous network infrastructure. This may be required in LTE small cell element management systems, partner element management systems, and existing OSS systems to accommodate the metrics and aggregations introduced by small cells.

While service modeling is a build phase activity, it's essential to define processes for benchmarking quality metrics. The evaluation of operations readiness should include defining processes to continually set benchmarks based on capacity and service offerings. For HetNet, this means defining procedures to measure the small cell performance thresholds and criteria for triggering the SON functions. It might also include defining the rules for the patterns to be monitored, analysis to be carried out, and the actions to be taken by each SON function.

Resource and service inventory management processes are also impacted by the introduction of HetNet. While defining service models, including service-resource mapping, is a build-phase activity, it's also important to define standard operating procedures to collect inventory details from HetNet elements on a continuous basis. This requires defining end-to-end procedures for element introduction, change management, configuration management, and inventory update related to these activities. It's also essential to fix loose ends in the process flow, especially those related to site commissioning, inventory updates, configuration and change management. This is extremely relevant in the context of the SON introduction, especially the self-configuration and self-optimization components, because the automated configuration or optimization mechanisms modify the network parameters that need to be captured as part of the inventory.

As procedures are defined for collecting the quality metrics and fault notifications from HetNet access nodes, there will be process level impacts on resource data collection and distribution. This is the case whether the data is distributed across different hierarchical levels in an aggregated form from gateway elements or directly.

Since the HetNet will be a multi-operator, multi-vendor eco system, it's also important to define supplier/partner management systems, especially the supplier/partner interface for problems and performance related issues. Other obvious process changes, especially in the fault and performance management layers, have not been described in detail because they are similar to what's currently being done in traditional management systems.

Conclusion

This paper identifies the challenges and considerations that arise when operators migrate to a HetNet based service delivery environment. While some of our recommendations are yet to be evaluated in terms of establishing best practices, Wipro believes that migrating to heterogeneous networks will ultimately benefit end users and simplify the overall network management processes.

We understand the many operational challenges presented by HetNet and believes that it's imperative that vendors of management products collaborate with service providers to establish a set of use cases and management system fundamentals for HetNet—which can subsequently influence the evolving standardization process.

About the Author

Manoj Nair has over 14 years of experience in the IT/Telecom Services space. He is currently handling role of a senior consultant in Wipro Telecom Network Services. In past he has undertaken large consultancy roles for equipment vendors and Cellular service providers in the areas like NGN migration, Network optimization, Application & Data Service Optimization. He also played role of Architect for R&D projects in different technology domains like IN, Optical Network NMS/EMS , Common Information Model, Enterprise Communication Networks, Unified Communication and Service Assurance. He was also involved in developing strategies and solutions in the area of customer experience management for tier 1 wireless operator in NA.

Mukund Krishnaswamy Veeraraghavan has more than 21 years of experience in Telecom and IT domain, handling leadership roles in cross functional areas such as sales, presales, delivery and program management of large projects. He is currently a senior consultant in service management practice, in Global Media and Telecom BU, Wipro, responsible for providing solution in engineering, operation and consultancy around service design, service fulfillment, assurance and planning for telco service provider's requirements. He has master's degree in Electrical Engineering from Wayne state Detroit, and is a certified PMP.

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