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A Tale of Two SONs: Unraveling D-SON and C-SON

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Self-Organizing Networks have the potential to rapidly and simultaneously transform network economics and improve customer experience. Two variants of SON – Centralized and Decentralized – focus on different approaches. Network operators need to be aware of their capabilities and consider where each provides the best optimization support.

SON Systems automate the configuration and optimization of wireless networks to help operators maximize deployed RF and spectrum capacity, simplify Radia Access Network (RAN) management and improve customer experience, all while reducing network OPEX. Complexity and costs associated with network management have been steadily increasing for several years as the number of network parameters to be monitored and 'tuned' has grown exponentially both for the Radia Network Controllers (RNC)/Base stations in 3G networks and for the eNobeB/MME in LTE/4G networks.

Already in 3G networks, it has become useful to automate the optimization of many RF, Controller and Antenna parameters. More recently, SON has become essential as HetNets, small cells and LTE escalate the complexity of RF planning with spectrum re-farming, HetNets and multiple cell types – macro, micro, pico, femto etc. – overlaid in the same or adjacent frequencies. The huge torrents of live network event data that are thrown off by modern HetNets cannot feasibly be processed by human network engineers in the timescales required to manage and optimize these fast- growing mobile broadband networks. RAN automation using SON must become an integral part of making these networks operational.

Three functions of SON

Major infrastructure vendors now offer SON solutions – for instance NSN describes SON's three functions:

- **Self-configuration** – for automated setup and configuration with neighboring cells exchanging parameters as needed.
- **Self-optimization** – for real-time intelligence and parameter modification including brokering handovers and balancing loads among neighboring cells.
- **Self-healing** – to cope with service impacting failure detection and recovery.

Self-configuration based on Automatic Neighbor Relation (ANR) is one of the most deployed SON feature among network operators. SON provides dynamic plug-and-play configuration of newly-deployed RAN elements.

Self-optimization capabilities include optimization of coverage, capacity, handover, and interference. Load balancing is part of the self-optimization functionality, enabling SON systems to identify cells that are experiencing congestion and transfer the traffic load to other cells that have bandwidth. Coverage and capacity optimization enable scheduled correction of bottlenecks in dynamic environments both daily and seasonally.

Finally, self-healing capabilities enable automatic detection and removal of failures.

In announcing its recent deployment of SON for SingTel's WCDMA network, Nicholas Seow, President and Country Manager of Ericsson Singapore noted, "Network complexity has reached the stage at which self-configuring, self-optimizing and self-healing functions are now indispensable for running a modern mobile network. Multiple standards and an expanding ecosystem of equipment providers need the automation of as much network planning, design, build and optimization as possible."

Centralized SON (C-SON) is now being deployed for Automated Neighbor Recognition (ANR), cell configuration, power control, interference and load management at the network operations center. This is *OSS Level SON* emerged first for 3G networks as 3GPP introduced a number of Self Organizing Networks (SON) standards starting with Release 8 in 2008 and expanded them in Release 9 with use cases in 2010/11. C-SON provides a centralized architecture where the optimization algorithms reside in the network

management system or a central SON server that manages all edge radio nodes. It can potentially orchestrate the behavior of radio network equipment across an entire network of multi-vendor and multi-technology environments. C-SON can take into consideration data from all nodes in the network to identify and address network-wide issues. And since the control of all SON functions is done centrally, these interactions can easily be coordinated and managed using a variety of resolution techniques.

C-SON solutions generally recommend optimization alternatives that network operations can accept or ignore. Once accepted, these 'Open-loop' solutions can be implemented in minutes and kept in place for hours or days. As operators gain confidence, these may become automated 'Closed Loop' solutions. Although 'Closed Loop' C-SON systems – where the system automatically completes tasks without human intervention – have proven to be successful in many instances, operators often prefer to include some level of human supervision of SON recommendations, particularly in the early days of an implementation. This is known as 'supervised mode' and is a useful step to building confidence and trust of Network Operations Control Center (NOCC) personnel in the deployment of a fully automated SON system. When operators see for themselves the impact of C-SON and become confident of its reliability, stability and capabilities, they can move quickly to the fully closed-loop, automatic mode, ensuring that the economic and customer experience benefits of SON are captured as rapidly as possible.

Three Vendors that are leaders in developing C-SON solutions are: Celcite (acquired by AMDOCS), Ingenia Telecom and Intucell (acquired by Cisco). Arieso (acquired by JDSU) focuses on customer centric 'location aware' SON and Reverb is best known for its Antenna optimization capabilities.

C-SON solutions can be more robust against network instabilities caused by the concurrent operation of SON functions with conflicting objectives because control is centralized. However, centralized systems may respond too slowly in the emerging world of small cells that experience very transitory traffic loads.

Distributed SON (D-SON) offers another approach to SON with real time automation and 'embedded' RF control at the edge. This is *Element Level SON* whose functions are distributed among elements at the edge of the network, typically the ENodeB's to rapidly configure the physical cell identity, transmission frequency and power. D-SON functionality is therefore designed for near real-time response in seconds or milliseconds and therefore supports more frequent and more localized changes than C-SON.

D-SON algorithms run in individual network edge nodes and exchange information directly with one another locally. Each node can initiate SON processes and provide optimization decisions independently or in co-ordination with other nodes. This architecture makes the SON functions highly dynamic and enables the network to adapt to local changes more rapidly.

Initially this decentralized architecture was very vendor-specific and did not allow for easy coordination among equipment from different infrastructure vendors - so a supervisory layer - like a C-SON - was still needed to coordinate the different instances of D-SON across a much broader scope and scale.

Two vendors are now, however, bringing D-SON into the SON mainstream as small cells and HetNets require the millisecond response times of D-SON.

Qualcomm has long focused on small cell technologies to allow simple plug-and-play deployment and increase network capacity by over 1000x of today's macro networks - now referred to as 'Neighborhood Small Cells' (NSC). Based on earlier work for femtocell automation, Qualcomm has proposed a suite of self-organizing network features for NSC called *UltraSON Open™*. This currently enables 3G dense small cell deployments to automatically provide indoor and outdoor coverage. In parallel *UltraSON Private™* "helps traditional restricted access small cell operate robustly with the existing macro-small cell network." UltraSON Private is now being commercialized on Qualcomm FSM chipsets.

Another new D-SON approach recently won the best enabling technology award at the Small Cell Forum in June 2013: that was *eSON™* from AirHop.

AirHop's eSON™ technology brings SON to the edge network elements for both 3G ***and*** 4G/LTE networks and can be viewed as '**the PC revolution for RF networking**' since it offers both open component configuration and a client server approach for the following:

- **Self-configuration to support distributed, real-time inter-cell coordination** capabilities and allow neighboring base stations to communicate with each other so as to dynamically manage inter-cell interference, optimize frequency reuse, data throughput, and QoS during live operations.
- **Direct inter-node communication and coordination** to establish neighboring base station topology and inter-base station communications via a unified application-level software platform. [Note: This can address the need for co-ordination mentioned above.]
- **Active real-time interference management** based on coordination among the neighboring cells.
- **Enhanced Radio Resource Management** (eRRM™) based on distributed algorithms and coordination among the cells. It optimizes frequency reuse, data throughput and QoS performance across the neighboring cells.

AirHop's eSON can be transparently deployed for small cells in any existing macro network regardless of the infrastructure supplier and has already been adopted by five major chipset vendors including TI, Freescale and picoChip.

With these major advances for small cells and transparent HetNets, it looks as if D-SON is here to stay.

Summary

Overall, SON offers an automated, mechanized solution that simplifies the control of complex network behaviors by analyzing the terabytes of data being generated from multi-vendor, multi-technology, multi-layered heterogeneous network (HetNet) infrastructures. SON systems are becoming a necessity for future mobile network operations to automatically configure, optimize, and heal network issues with minimal human intervention.

It goes without saying that SON implementations should be built to allow extensions offering a platform that can incorporate new optimization ideas and advanced use cases. Scalability, with respect to the number of cells and applied network load is crucial as is the flexibility to support a variety of different equipment vendor implementations and operator-specific policies. As mobile networks become more complex it is increasingly important to have a SON architecture that is robust under rapidly changing circumstances with defense mechanisms to minimize outages.

C-SON and D-SON must learn to co-exist. Some vendors are already promoting '*Hybrid SON*' that meets the needs of both OSS automation and real time millisecond configuration. It is becoming clear that both approaches are needed if SON is to fulfill its potential to transform the economics of network operations and improve customer experience at the same time.