INDOOR SMALL CELLS: AGGREGATION AND BACKHAUL

ENHANCE QUALITY OF EXPERIENCE AND STREAMLINE OPERATIONS

APPLICATION NOTE

ABSTRACT

Mobile technologies and devices are increasingly important within all enterprises, driven by the proliferation of mobile devices (such as smart phones, tablets and laptops) which are replacing traditional wired technologies. There is also a growing trend towards end users bringing their personal devices to work (BYOD). Supporting this increased traffic within building sites is challenging when a connectivity service is based on limited macro cell capacity and/or coverage.

Alcatel-Lucent has developed its IP/Ethernet Small Cell In-Building Aggregation and Backhaul solution to assist in addressing this situation. The solution provides backhauling and aggregation capability for small cells deployed in buildings of various types and configurations. The Alcatel-Lucent solution offers the flexibility, scalability and simplified operations required to enhance the mobile subscriber's experience. It facilitates the rapid delivery of increased mobile capacity and coverage with the appropriate quality of service.

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INTRODUCTION

Deploying high-quality mobile voice and data services within a building can be challenging when service is based on limited macro cell capacity and/or coverage with marginal penetration to the building's interior. Increasingly, large corporate clients are approaching their Mobile Network Operators (MNOs) and requesting better in-building service coverage and infrastructure. Network operators are responding since they are strongly motivated to maintain high quality service for their corporate clients. The preferred deployment model that is emerging is based on customer located equipment (CLE). Network operators are installing a suite of managed CLEs, including radio access points (the small cells), and the aggregation and backhaul infrastructure to facilitate in-building networking and backhaul transport across the WAN.

Small cells are low-powered wireless access points that operate in licensed (3G/4G) and unlicensed (Wi-Fi®) spectrum providing the required quality for in-building wireless service. In-building small cell wireless service is utilized by network operators to increase capacity (offload the macro cell network), improve depth of coverage, improve the user experience, and deliver value-added services.

Alcatel-Lucent's design experience for in-building small cell deployments has determined that numerous small cells are often required in order to meet the demands on the wireless service. The typical density of small cells within a given building strongly supports an in-building IP/Ethernet aggregation and backhaul network. It is important to ensure that the small cell in-building aggregation and backhaul network supports the following principal requirements:

- **Simplicity**: Simplified operations are required to minimize total cost of ownership (TCO) and easily facilitate network deployment. A standardized approach to in-building transport network provisioning and turn-up is required, regardless of access options or location. The need for site visits must be minimized. End-to-end visibility and control of elements at every location is needed for streamlined OAM, with surgical, remote troubleshooting. It is crucial that the network proactively indicate when key performance indications (KPIs) are out of bounds and service layer agreements (SLAs) are not being met.
- **Flexibility**: Deployment of in-building small cells brings the need to exploit the closest, most cost-effective access medium that can meet the quality of service (QoS) requirements. This will result in a great diversity of backhaul transport access options, driving a requirement for flexible solutions that can operate consistently over microwave, xDSL, Ethernet, CWDM or GPON.
- **Scalability**: The transport network must scale to support increasing numbers of small cells and climbing traffic levels. High performance IP/Ethernet switching and routing solutions are needed for extremely scalable and reliable network architectures and topologies.
- **Resiliency**: Network resiliency is crucial to supporting the subscriber's quality of experience (QoE). In particular, as more in-building small cell locations home in on higher capacity head-end systems, failure recovery mechanisms become more critical to limit the breadth of impact when the systems become unavailable.

- **Quality of service**: MNOs must be able to provide appropriate access to network resources, such as link bandwidth, for multiple traffic streams including OAM, telemetry, streaming video, and VoIP, especially when networks are operated at high utilization levels.
- **Synchronization**: Maintaining synchronization has always been a requirement in networks generally, and particularly in the mobile domain. This is equally true for in-building small cell deployments. The in-building transport network must provide accurate and resilient frequency and phase where access to external synchronization sources to each small cell is unavailable or prohibitively expensive.

A correctly specified and engineered IP/Ethernet network can efficiently support these requirements for small cell in-building aggregation and backhaul. . In fact, a correctly-selected and implemented IP/Ethernet in-building transport network can be a real strategic business differentiator for MNOs. The Alcatel-Lucent IP/Ethernet Small Cell In-Building Aggregation and Backhaul solution is designed to meet these requirements and to provide a solid business foundation for efficient growth.

ALCATEL-LUCENT IP/ETHERNET SMALL CELL IN-BUILDING AGGREGATION AND BACKHAUL SOLUTION

Solution overview

The Alcatel-Lucent IP/Ethernet Small Cell In-Building Aggregation and Backhaul solution architecture addresses a number of typical small cell use cases. These use cases accommodate different building classes categorized as either large, medium or small.

Large and medium locations will typically have two stages of aggregation. An example of such a location is an office tower that requires small cells to be deployed on multiple floors. It is cost prohibitive to run direct Ethernet cabling from each small cell to the cell site gateway router that is probably located on the ground floor. It is recommended that the first stage of aggregation take place on each floor. The first stage of aggregation is Ethernet based, and all Ethernet interfaces from the small cells situated on that floor are aggregated into a single Ethernet interface destined towards the second stage of aggregation. The second stage of aggregation is IP based, and all IP interfaces from the small cells situated on all floors are aggregated into a single IP interface destined towards the backhaul transport network.

Small locations may only require one stage of aggregation as they generally have fewer small cells. In this case, the Ethernet aggregation stage may not be required and access points can connect directly to the cell site gateway router. An example of such a location is an enterprise office that can be served by four to five wireless access points.

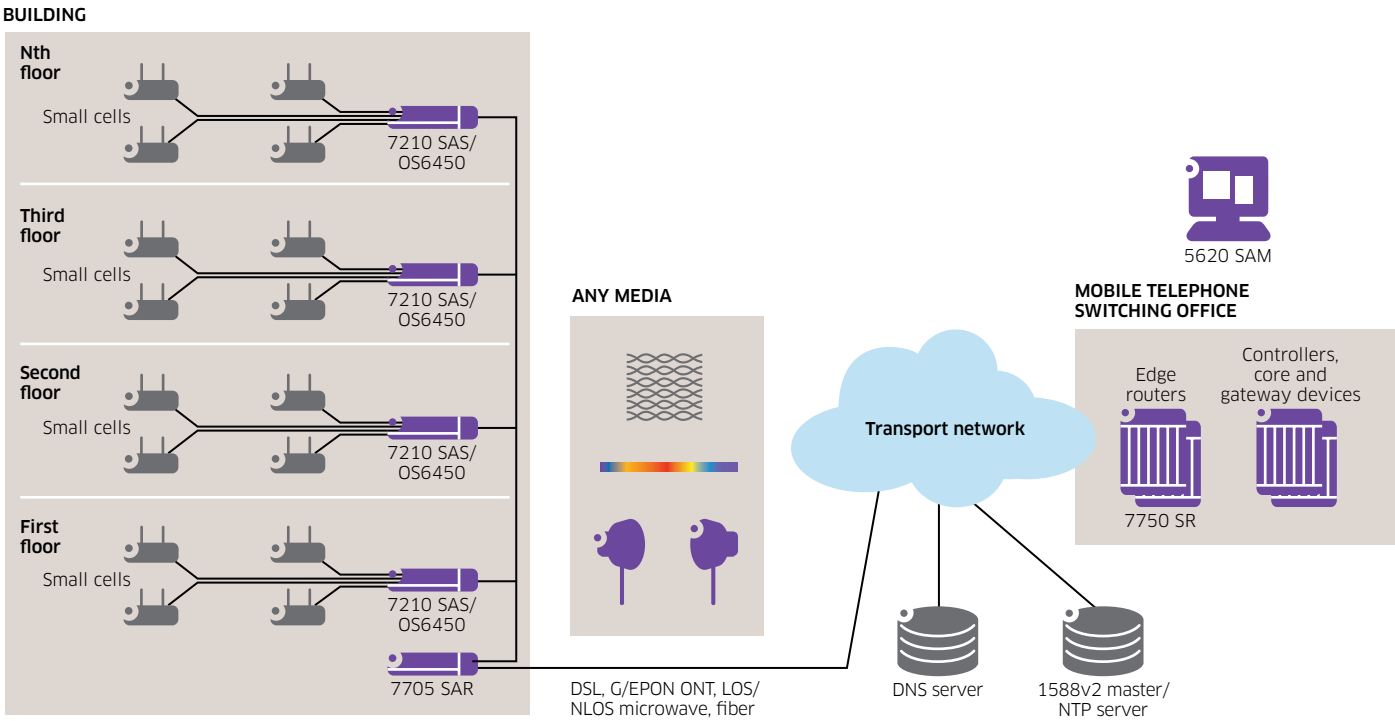
First stage aggregation devices are deployed on each floor in large and medium locations. The Alcatel-Lucent 7210 Service Access Switch (SAS) or OmniSwitch 6450 devices fulfill this function, providing Ethernet aggregation and switching for all of the small cells on a given floor. The 7210 SAS or OmniSwitch 6450 interfaces with the Layer 2/Layer 3 gateway router, the Alcatel-Lucent 7705 Service Aggregation Router (SAR).

The 7705 SAR fulfills the role of cell site gateway router providing the second stage aggregation and is deployed at each in-building location. The 7705 SAR is the next hop IP gateway for all small cells in a given location. The 7705 SAR interfaces with the public fixed transport network or the service provider's fixed transport network infrastructure, and supports Layer 2 Ethernet (VLANs), Layer 2.5 (MPLS) and Layer 3 IP connectivity to facilitate maximum deployment flexibility.

In the mobile telephone switching office (MTSO), the Alcatel-Lucent 7750 Service Router (SR) provides the aggregation head-end function and completes the hand-off to the Radio Access Network (RAN) controllers and other core devices. The 7750 SR provides comprehensive resiliency and massive, proven scaling for any networking paradigm.

The Alcatel-Lucent 5620 Service Aware Manager (SAM) provides Fault, Configuration, Accounting, Performance and Security (FCAPS) management across the elements of the solution. The solution is complemented by the expertise of Alcatel-Lucent Professional Services.

Figure 1. Alcatel-Lucent IP/Ethernet Small Cell In-Building Aggregation and Backhaul solution



Key solution attributes

The Alcatel-Lucent IP/Ethernet Small Cell In-Building Aggregation and Backhaul solution leads the industry in its ability to deliver simplified, flexible and scalable aggregation and transport. It ensures the resiliency, QoS and network synchronization required to support the evolution towards small cells.

Simplicity of operations

Keeping operational costs low has a major impact on the TCO of a network. With emerging heterogeneous networks, managed elements will be deployed in huge numbers. It is therefore vitally important that operators be able to achieve remote turn up and troubleshooting with minimal site access and few site visits. The 5620 SAM is the overarching management entity for the Alcatel-Lucent IP/Ethernet Small Cell In-Building Aggregation and Backhaul solution. The 5620 SAM provides end-to-end management with flow through service provisioning, performance management (statistics), inventory management, and fault management.

Alcatel-Lucent recognizes the importance of ensuring that network impairment QoS metrics, such as delay, jitter and loss, are not impacting the small cell KPIs. For this reason, MNOs can monitor the backhaul transport network QoS metrics with the 5620 SAM in conjunction with the embedded OAM functionality in the 7705 SAR, the 7210 SAS and OmniSwitch 6450. At the service layer, the implemented functionality from specification Y.1731 provides OAM support for delay, jitter and loss measurements. At the Ethernet layer, IEEE 802.3ah EFM support is provided, and at the IP layer, a wide variety of options is available including TWAMP. Furthermore, the Alcatel-Lucent 5620 Service Assurance Agent (SAA) can be used to minimize operator workload by proactively probing the delay, jitter and loss that each service experiences periodically, so that issues are discovered before SLAs are impacted. An available Dynamic Host Configuration Protocol (DHCP) server capability on the 7705 SAR simplifies and distributes IP address management,

Flexibility of deployment

There is a great variety of backhaul installation options for in-building small cell locations and a range of uplink media that can be used, depending on availability, suitability and cost. As a result, operational flexibility is a key attribute of any backhaul transport deployment.

Backhaul transmission media flexibility

A powerful aspect of the 7705 SAR family is the ability to provide a consistent networking and operational capability over a wide range of physical media types. Due to the extensive and ubiquitous nature of backhaul transport networks, varied media types are often encountered, at a range of cost points, throughout the network. The flexibility to select the most cost-effective backhaul medium available in a particular site from the egress of the building towards the MTSO — while meeting service requirements — is a key competitive advantage.

Some carriers may choose initially to deploy microwave backhaul to expedite the provision of coverage. This microwave equipment may stay in place, or be enhanced with higher capacity systems as the technology evolves. Alternatively, as fiber is made available at a particular location, it may take the place of microwave, creating an opportunity for re-deployment of the microwave equipment. This operation can be carried out with no impact to the networking layer or to ongoing operations. The 7705 SAR products can leverage the appropriate transmission medium and any underlying network infrastructure for backhaul transport that reaches deeper into the aggregation network.

Networking and topology flexibility

The Alcatel-Lucent IP/Ethernet Small Cell In-Building Aggregation and Backhaul solution supports a rich suite of Layer 2 (Ethernet), Layer 2.5, (MPLS) and Layer 3 (IP) switching and routing capabilities to allow the most appropriate and efficient networking technology to be deployed. The availability of network address translation (NAT) on the 7705 SAR enables the economical usage of a scarce public IP address space. This is particularly important where a Layer 3 business Internet service is used as backhaul infrastructure.

Platform Flexibility

The Alcatel-Lucent IP/Ethernet Small Cell In-Building Aggregation and Backhaul solution offers a range of product variants with different form factors and capacities for the Layer 2/Layer 3 Gateway Router (7705 SAR) and the Layer 2 Switch (7210 SAS or OmniSwitch 6450). This allows the ideal device to be selected for a specific deployment.

Scalability

As mobile backhaul networks are extended to accommodate an underlay of small cells, both indoor and outdoor, there will be additional scaling requirements in a number of dimensions. The number of cell sites to be supported in a single backhaul network will expand by an order of magnitude in the coming years. Some of the largest backhaul networks may see expansion from tens of thousands of cell sites to potentially hundreds of thousands of sites. Each one of these sites will also see an increase over time in the amount of bandwidth required, which in turn will drive the requirement for increased bandwidth back into the metro aggregation and transport network.

The 7750 SR provides a highly reliable head-end aggregation and concentration point for thousands of small cell and/or macro cell sites over any intermediate transport. The 7750 SR, with its revolutionary FP3 network processor, provides comprehensive resiliency and massive, proven scaling for many thousands of cell sites. The 7750 SR supports high-density 10, 40 and 100 Gb/s interfaces, ensuring ample capacity for future growth requirements.

Resiliency

Networking resiliency is built into the Alcatel-Lucent product portfolio: it is part of the foundational architecture of the SR OS software. The solution brings a strong suite of traffic engineering and resiliency capabilities via functions such as control and switch fabric redundancy, Fast Reroute and redundant MPLS pseudowires that can ensure reliability from the in-building small cell location to the MTSO across both leased and self-built transport backhaul environments.

The 7705 SAR supports Bidirectional Forwarding Detection (BFD) with 10 millisecond timers that will detect and re-converge small cell traffic to minimize service disruption in the event of network failures. Ten millisecond BFD is available on the 7705 SAR in a highly scalable fashion.

Platform options for completely passively cooled 7705 SAR platforms add to reliability and resiliency for the overall solution and also have a positive impact on overall power consumption.

End-to-end QoS

It is critical to be able to control and maintain QoS for packet traffic. Not all types of traffic have the same set of requirements. Voice traffic, in particular, requires low delay and low jitter (delay variation), as well as low packet loss. Data traffic often has less stringent delay requirements but may be very sensitive to packet loss, as packet loss can seriously constrain application processing. To offer the required treatment throughout the network, traffic flows with different requirements are identified at the wireless access point and are marked in-line with the appropriate QoS metrics.

The Alcatel-Lucent IP/Ethernet Small Cell In-Building Aggregation and Backhaul solution uses extensive traffic management policies to ensure fairness. Detailed classification and hierarchical scheduling options include: queue type-based, weighted round robin, or strict priority and profiled scheduling. Multi-tier policing is also available to differentiate and prioritize individual services and flows. With the solution, operators can differentiate multiple traffic streams, which enable them to meet the different QoS needs of various traffic types including OAM, synchronization, site telemetry, streaming video, VoIP and bulk data.

The 7705 SAR in particular has the ability to buffer and shape traffic in order to absorb up to 100 ms of traffic bursts and improve effective application throughput and network utilization. This helps operators deliver an optimal QoE for mobile subscribers while minimizing user retransmissions. Traffic management on the 7705 SAR has been modeled after the traffic management mechanisms of the 7750 SR. The network processor based architecture of the 7705 SAR allows for considerable flexibility and evolution of traffic handling mechanisms. While QoS must be properly applied at the small cell and gateway separately, the in-building transport network must also ensure that when traffic flows from the small cell to gateway, a consistent QoE is maintained. Operators need to deliver an appropriate QoE for subscribers regardless of the access location in the heterogeneous network.

Maintaining synchronization

In-building small cell wireless access points may rely on the in-building transport network to deliver a stable synchronization reference from which to derive radio frequencies and to ensure reliable subscriber handover between cells. LTE Advanced features will increase the importance of synchronization, including frequency, phase, and time of day (ToD). The Alcatel-Lucent IP/Ethernet Small Cell In-Building Aggregation and Backhaul solution supports network-based 1588v2 Grand Master Clock, Boundary Clock, Transparent Clock, and Ordinary Clock for frequency, phase and ToD. The support of a fully distributed 1588v2 Grand Master Clock ensures that accurate frequency and phase timing can be achieved for in-building small cell locations. Accurate and high performance 1588v2 timing is accomplished by a combination of built-in architectural features, efficiently tuned algorithms, and powerful QoS mechanisms to minimize the delay experienced by synchronization traffic.

Management of the synchronization infrastructure is a key differentiating capability. The 5620 SAM provides tools for managing synchronization, providing centralized synchronization path visualization, proactive monitoring, and alarm correlation to allow rapid discovery, and correction of, synchronization impairments.

CONCLUSION

With its comprehensive portfolio of backhaul products and professional services, Alcatel-Lucent brings the solutions and specialist expertise to assist service providers in preparing their backhaul network to support the evolution towards in-building small cell deployments.

Alcatel-Lucent's IP/Ethernet Small Cell In-Building Aggregation and Backhaul solution offers:

- The **flexibility** to deliver any mobile service over any access with support for 3G, LTE and Wi-Fi services with appropriate SLAs; choice of fiber, copper or microwave access; and backhaul equipment optimized for indoor and outdoor small cell locations
- The **scalability** to support in-building small cell locations at higher densities and bandwidths; IP/MPLS for highly scalable and reliable backhaul network architectures and topologies
- **Simplified deployment and operations** through a consistent approach to cell site backhaul provisioning regardless of access or location; end-to-end visibility and control to every cell site (indoor and outdoor) for streamlined OAM; and professional services to help plan, optimize and deploy small cell backhaul networks

The Alcatel-Lucent IP/Ethernet Small Cell In-Building Aggregation and Backhaul solution offers the flexibility, scalability and simplified operations required to enhance the mobile subscriber's experience by facilitating the rapid delivery of increased mobile capacity and coverage with the appropriate quality of service.

APPENDIX

For further product information, see:
Alcatel-Lucent 5620 Service Aware Manager
Alcatel-Lucent 7210 Services Access Switch
Alcatel-Lucent OmniSwitch 6450
Alcatel-Lucent 7705 Service Aware Router
Alcatel-Lucent 7750 Service Router
Alcatel-Lucent Service Router Operating System
FP3 Network Processor

ACRONYMS

5620 SAM	Alcatel-Lucent 5620 Service Aware Manager
5620 SAA	Alcatel-Lucent 5620 Service Assurance Agent
7210 SAS	Alcatel-Lucent 7210 Service Access Switch
7705 SAR	Alcatel-Lucent 7705 Service Aggregation Router
7750 SR	Alcatel-Lucent 7750 Service Router
BFD	Bidirectional Forwarding Detection
BYOD	bring your own device
CLE	customer located equipment
CWDM	Coarse Wavelength Division Multiplexing
DHCP	Dynamic Host Configuration Protocol

DSL	Digital Subscriber Line
EFM	Ethernet First Mile
FCAPS	Fault, Configuration, Accounting, Performance and Security
GPON	Gigabit-capable Passive Optical Network
KPI	key performance indicator
LOS	line of sight
LTE	Long Term Evolution
MNO	Mobile Network Operator
MTSO	Mobile Telephone Switching Office
NAT	Network address translation
NLOS	non line of sight
OAM	operations, administration and management
OS6450	Alcatel-Lucent OmniSwitch 6450
QoE	quality of experience
QoS	quality of service
RAN	Radio Access Network
SLA	service level agreement
SR OS	Alcatel-Lucent Service Router Operating System
TCO	total cost of ownership
ToD	time of day
TWAMP	Two-Way Active Measurement Protocol
VLAN	virtual local area network

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