LANCOM Tech paper

Hierarchical switch infrastructures

When setting up the logical architecture of a company network, especially with regard to the LAN infrastructure, it is vital to make in-depth considerations of the individual data paths and, separately, the efficient and secure transport of data. The result of this a hierarchical structure of a company LAN that implements the various functions and tasks of the network devices, in particular for the switches that are so important for distributing data traffic.

This tech paper introduces the different hierarchy levels of an enterprise LAN and shows how different sized and complex enterprise networks, starting from small environments up to very large enterprise networks, can be built from the lowest access layer of the respective end devices, through the bundling aggregation or distribution layer, up to the core or top of the network.

Three-layer network design (“three-tier model”)

A tried, tested and widely accepted basic architecture in the understanding and construction of modern LAN network architectures is the three-layer network design. But to help with a better understanding of the three-layer model, we should first explain some terms and the layers used in this model.

Access switches

The access layer connects the clients to the network. This includes, for example, access points, PCs, IP telephones, networked machines or IoT sensors. Switches on the access layer generally feature large numbers of ports and distribute the network to the connected clients. They can also be used as a power supply for the end devices. For this to work, the switch and the end devices have to support Power over Ethernet (PoE).

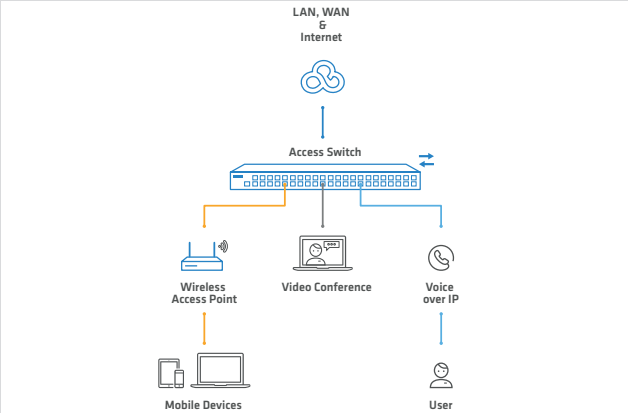

Fig. 1: Access switches on the application layer

Aggregation switches

The term “aggregation layer” refers to the hierarchical layer that collects (aggregates) the uplinks from the access layer below it. In the uplink direction, i.e. upwards in the hierarchy, and depending on the deployment scenario, the aggregation switches are used to connect with high bandwidths (10G / 25G / 40G / 100G) to the core switches (“three-tier scenarios”, see below). In smaller scenarios, these switches can additionally perform the task of the core (“two-tier scenario”, see below). Typically performed on the aggregation layer are L3 tasks such as DHCP server functions, i.e. IP address management or the predefinition of network routes across one or more network segments, which takes a great load off of the router or, if applicable, the firewall. Operating redundant aggregation switches (stacking) increases the reliability of the aggregation layer, and connecting the relevant access switches to two different network nodes in the aggregation layer ensures an extremely high level of reliability (HA – high availability) for near-to uninterrupted network operations.

See also Tech paper Design guide for hierarchical switch networks with redundancy.

Core switches

The core switch forms the top layer and, in the three-layer model, this is the backbone of the network. With its high throughput, it mainly handles non-blocking switching tasks on layer 2 (the data-link layer) and routing tasks on layer 3 (the network layer). This switch is mainly used in data centers and features very high performance and maximum data throughput. It's principal function is to forward data packets as efficiently and latency-free as possible, either from distribution layers (e.g. WAN, DMZ), from the data-center LAN, or between aggregation switches via the central distributor core switch (packet forwarding).

How the layers are named

To better understand the terms access, aggregation and core switch, which will be explained in more detail later, we should mention that the various manufacturers each use different names. For example, the term "aggregation switch" refers to the layer used to network the access switches on the access layer used by the end users. From the other perspective, the switches on the top layer have the task of distributing from the core layer to the access layer, and are therefore referred to by some manufacturers as "distribution switches". So a lot depends on the nomenclature of the particular manufacturer. LANCOM has decided on the term "aggregation switches" on the second layer, as this term most accurately reflects the task of linking the core and access layers.

These layers form the three-tier model

The lowest tier is the access layer, which connects all of the end devices such as PCs, laptops, servers, and wireless devices. The switches on this access layer then connect upwards to the next tier, i.e. the aggregation layer. In "three-tier scenarios", the aggregation switches connect the access layer with the core layer or, in smaller two-tier networks, they actually form the top layer of the network hierarchy (i.e. a "collapsed backbone"), see figure 3.

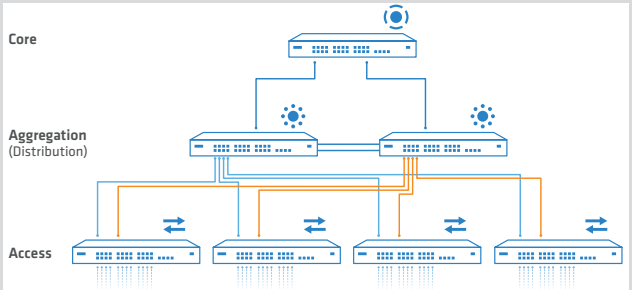

Fig. 2: Hierarchical LAN structure based on a three-tier model

Three-tier design

In very large scenarios, such as on larger company or university campuses, the core switch forms the top layer and the aggregation switches form the intermediary layer between the core and access layers. This is known as a three-tier design.

Two-tier design

Core switches are highly expensive and are mostly used for large-scale networks and data centers. Smaller to medium-sized scenarios generally manage with a single device or stack that combines the core and aggregation layers into one (known as a "collapsed backbone"). In these cases, the aggregation switch combines the functions of the top core layer of the network topology with the tasks of the aggregation layer.

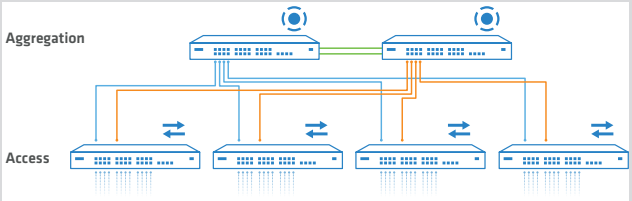

Fig. 3: Hierarchical LAN structure based on a two-tier model

The right network topology for any scenario

We at LANCOM offer a complete range of offerings for campus switching, so allowing our partners to implement network scenarios with different network requirements and sizes. The current portfolio of LANCOM aggregation and access switches, and the option of combining them to meet any requirement, opens up a wide variety of scenarios that can be implemented, ranging from smaller (SME) to medium-sized (ME) scenarios and even up to large enterprise (LE) networks.

Smaller scenarios (small enterprise (SE) networks)

Small LAN environments, such as at a chain-store branch, usually feature only a few end devices, e.g. two to three access points, three to four cash registers and the office computer of the branch manager. Sufficient for this scenario is usually a single access switch operated directly at the WAN gateway. However, even in these traditionally smaller environments, progress in digitalization is leading to a rapidly growing numbers of network users and end devices that need to be networked. Even in these supposedly small environments, the use of an aggregation switch can quickly become necessary especially if numerous distributed company buildings (e.g. another office building, a warehouse, gates) or remote peripheral elements (e.g. barriers, displays, cameras) need to be integrated into the network. These smaller, distributed networks are the ideal backdrop for a cost-effective solution such as the entry-level aggregation switch LANCOM XS-5110F. With its 8 fiber-optic SFP+ ports and 2 additional multi-Gigabit (10/5/2.5/1G) Ethernet ports, this switch is the ideal upper-layer instance for connecting additional access switches or NAS/server components. To support these scenarios, the SFP+ ports 7 and 8 can be defined as stacking ports in the software settings. A stack can consist of up to eight aggregation switches. This ensures a high level of scalability and the possibility of increasing the number of ports.

Medium scenarios (mid-sized enterprise (ME) networks)

Medium-sized local area networks, such as those required by medium-sized companies, authorities, administrations or schools, cannot be implemented without the use of an aggregation layer. Reasons for this may be the geographically distributed company buildings, larger building complexes with several floors, or in-house (often redundant) data centers. Depending on the size, complexity and extent, at least one or even several aggregation switches may be necessary. This is where LANCOM offers the XS-5116Q, a 10G stackable, managed fiber aggregation switch for medium-sized, distributed networks. The XS-5116QF is a high-performance device with a total of 14 SFP+ ports (10G), 2 of which are designed as multi-Gigabit Ethernet combo ports, for medium-sized networks and non-blocking network operation. Two 40G uplink ports (QSFP+) can be used for a broadband uplink to the core layer or to a data-center LAN. However, this model is recommended for a "collapsed core" scenario, i.e. a two-tier network design with 10G uplink to the router and/or data storage. Thanks to the implemented stacking function, up to eight switches of this model can be used for high availability (HA), redundant scenarios in business-critical environments. Power supply units that can be hot-swapped during operation offer a further increase to reliability. With this model, too, the two QSFP+ ports can be redefined in software as stacking ports. Since this is standard Ethernet technology using standard media types, it is also possible to combine far-distant network nodes into a stack with the help of tried-and-tested fiber GBIC modules.

Large-enterprise scenario (LE) networks

The LANCOM XS-6128QF, the largest model of the 10G stackable managed fiber-aggregation switches, enables the implementation of large, decentralized enterprise networks with virtualized applications. This model has consistently been optimized for operational efficiency and reliability and, like the LANCOM switches mentioned earlier, it is engineered to feature exclusively industry-standard ports

and is free of any proprietary interfaces. With a total of 20 SFP+ ports (10G), 4 of which are multi-Gigabit Ethernet combo ports, this aggregation switch operates as a high-performance distribution platform for large numbers of lower-layer access switches. Four dedicated SFP-DD (50G) backplane stacking ports provide a non-blocking/ wirespeed connection between all of the devices in a stack. LANCOM offers SFP-DD-DAC50 stacking cables in 1 m and 2.5 m lengths. It is also possible to use SFP28 25G modules, which can connect decentralized, i.e. distant locations with half the bandwidth. This model supports stacks with up to eight switches and thus up to eight times the port capacity, and that with up to 224 uplink / downlink ports. A massive backhaul capacity is available either via 2 QSFP+ (40G) or 4 SFP28 (25G) high-speed uplink ports. These combo uplink ports provide great flexibility when connecting to the upper-layer core switch with either 25G or 40G. It is even possible to set up a high-performance connection to a data center by using LACP to bundle the four SFP28 (25G) ports to form a 100G connection. Two redundant power supply units and a fan system can be swapped out during operations, which maximizes high availability. Since the uplink/ downlink ports are based on standard Ethernet technology using standard media types, it is easy to combine far-distant network nodes by using tried-and-tested fiber GBIC modules. The switch offers basic L3 features and currently under development are dynamic routing functions.

This portfolio of aggregation switches and the equally extensive range of access switches makes LANCOM extremely well positioned to implement practically any application. We can cater for all network scenarios in the small & medium enterprise segment, including retail networks, production LANs, logistics centers, office towers, or campuses.

Wirespeed system architecture and available uplink and downlink bandwidths

Regardless of the classification into SMB or enterprise segment, parameters such as the blocking ratio between uplink and downlink ports are elementary for the design of the network. Some of these planning parameters are presented below.

Wirespeed system architecture of the switches

All LANCOM switch models are engineered to have a non-blocking system architecture. What that means is that the switch has sufficient internal resources to handle maximum transfer rates from all of the ports. In brief, LANCOM aggregation and access switches can process all connected clients at “wirespeed” and without any bandwidth limitations.

Uplink blocking factor

The available bandwidth between the switch layers (access – aggregation – core) is defined by the capacity of the uplink ports. The individual uplink ports can be bundled by link aggregation (LACP protocol). This increases the available uplink capacity in stages and thus reduces the blocking factor (sum of downlink to uplink capacity).

Stacking blocking factor

If several switches are operated as a stack, the blocking factor between these stack-member switches is defined by the downlink capacity to the stacking capacity. Stacking makes use of uplink ports or, if available, dedicated stacking ports. The blocking factor is reduced by an increase in the port capacity of the stacking ports. A non-blocking stacking capacity is said to exist when the sum of the downlink capacity is covered by the sum of the stacking capacity.

Redundancy concept

In particular for the higher quality LANCOM switch models, a consistent redundancy concept plays an important role. This ensures the highest levels of reliability and optimal network availability.

Redundant power supplies

"Hot-swappable" PSUs allow the switches to be exchanged and operated without interruption if a power supply unit is defective. For this reason, the two aggregation switches XS-5116QF and XS-6128QF are equipped with a slot for a second power supply unit. If one of the two power supply units should fail, the defective power supply unit can be replaced while the affected switch continues to work. This redundancy concept is maintained right through to the access layer: The LANCOM GS-3152XSP can also be equipped with a second PSU, which doubles the PoE power output of the switch and thus ensures that all connected PoE end devices receive sufficient power.

The right combination for every scenario

We have so far discussed the limiting conditions of setting up various network scenarios based on the three-tier model as well as the basics for port expansion, creating redundancy, and the different stacking topologies. The various combinations of the three LANCOM aggregation switch models and also the various LANCOM access switch models offer us a large number of possible network designs and made-to-measure application scenarios.

See also Tech paper Design guide for hierarchical switch networks with redundancy.

Summary

The descriptions of the scenarios selected here aim to shows the variety of options available with the new LANCOM aggregation switches and their different levels of performance. The intelligent combination of these LANCOM devices with the high-performance and cost-effective access switches from LANCOM means that there are almost no limits on the possible applications—in particular for medium-sized companies. This paper deliberately focused on calculations that allow for maximum redundancy. Operating without redundancy of course increases the number of available ports, but LANCOM does not recommend this to its customers. Since every network exists under its own unique conditions, the application examples considered here cannot claim to be exhaustive and are no substitute for individual network planning, which has to be tailored to the customer's particular needs. Ideally you should include our design recommendations at the planning stage in order to ensure high availability and to minimize costly downtimes.

In particular when selecting the access switches, which this paper only mentions in passing, there are many other parameters to take into account apart from just the number of ports. This includes, for example, the total power demand for PoE (Power over Ethernet), the manageability or L3 features of the respective switching family, high availability requirements (fail-safe) from redundant power supplies, uplink speed, and the distance to the aggregation switch (Ethernet-standard copper cable reaches 100m, fiber-optics achieve kilometers of range) among others.

The extensive LANCOM switch portfolio offers made-to-measure solutions for the particular requirements of your infrastructure.

Are you planning to set up or expand your network with LANCOM switches?

Experienced LANCOM technicians and the specialists from our system partners will help you with the planning, construction, and operation of a needs-based, high-performance, and future-proof LANCOM network design.

Do you have any questions about our switches, or are you looking for a LANCOM sales partner?

Please give us a call:

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