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Technical Article Release

Emerging Cloud-Computing-Oriented Communications Architectures Drive New Fiber-Optic Communications Applications

By Warren Miller

The insatiable demand for increased communication bandwidth is driving the development of new network structures and associated cloud computing architectures. These emerging networks will allow for much more flexible allocation of cloud computing resources, but only if high-speed communications backbones, using fiber optic transmission, continue to grow in reach and scope. Two new options for emerging wireless network structures — a distributed heterogeneous architecture and a centralized homogeneous architecture — will both provide new opportunities for cloud-computing architectures.

Emerging Centralized and Decentralized Network Architectures

The centralized or homogeneous approach to communications network architecture leverage uses a high-speed optical interconnect between the remote radio head and a centralized server (Fig. 1). Centralized baseband processing is moved from the remote radio head and can be located tens of kilometers away by using fiber-optic links that support standard communications protocols (CPRI, for example). Baseband processing can be done on standard server hardware, which reduces the development and deployment costs of the baseband functions. Standard server hardware also makes it easier to deploy software updates and to more easily scale capacity. The use of standard servers makes it possible for carriers to move some cloud-computing-related processing and storage functions closer to the consumer, providing new features and revenue sources. In this architecture it might be possible for the user's key cloud applications and data to be located in the closest central server to reduce latency and improve quality of service.

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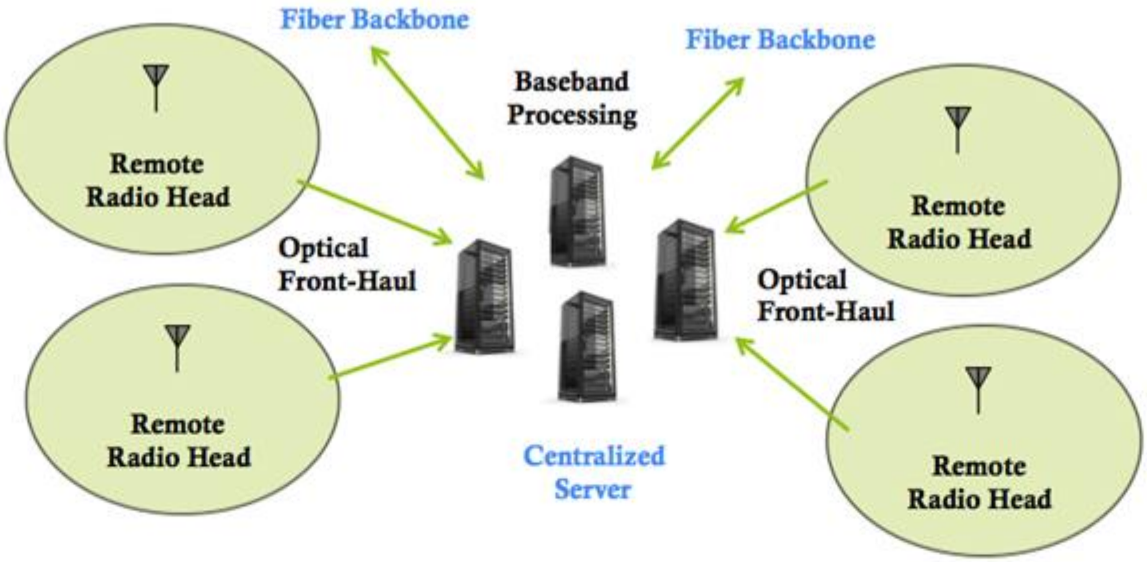

Figure 1: *Centralized network architecture*

The centralized servers will need to connect to the network backbone to satisfy the communications requirements from multiple coverage areas and to connect to other server clusters. High-speed communications between clusters will help to balance processing and storage requirements depending on the number of users in each area. Server-to-server connections will allow load balancing so that deployed computing and storage resources — the more costly elements of the system — are used efficiently.

The small-cell approach (Fig. 2) uses several different types of cells to provide different coverage ranges. Macro cells cover the largest range, more than 30 kilometers, while smaller micro and pico cells cover from 2 kilometers to 200 meters. Each of these cells has a natural coverage area, from several city blocks or a large complex, down to a single building. The smallest femto cells might cover a single small business. These heterogeneous cells combine both the radio front-end and the baseband back-end functions in an integrated and small footprint. In fact, the footprint requirements are so small that they can be easily deployed on a rooftop or within a building's existing service cabinet. This eliminates the need for installing a big expensive tower and makes it much easier to deploy additional capacity.

Rapidly growing areas can be quickly added to an existing system to cover a shadow area not able to be served by a large tower. Smaller coverage areas need not use high-speed fiber to connect to the network, but will provide additional traffic that needs to be consolidated and connected to a fiber-optic backbone. These consolidation points could use the centralized server, from the homogeneous network example (illustrated in Fig. 1) as a convenient source of needed connectivity, processing power and storage. Any cloud-based applications located on the centralized server could also be provided to appropriate small cell users, further leveraging the installed infrastructure.

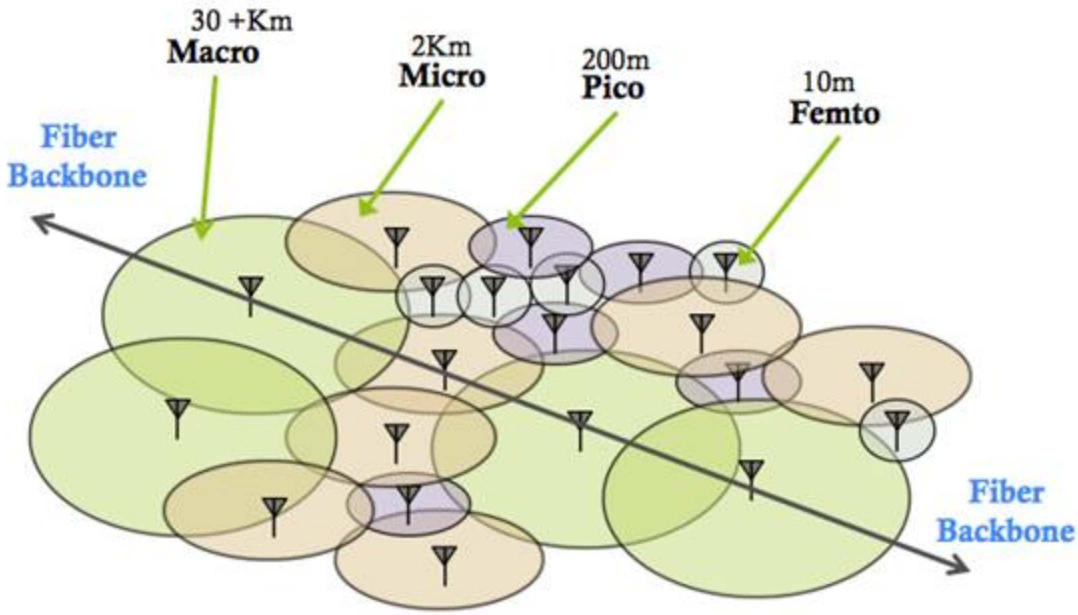

Figure 2: *Small-cell network architecture*

Most likely, the emerging network architecture will be a mix, using both the centralized and the small-cell structures. Centralized servers will connect to remote radio heads in areas with established and unobstructed coverage, while small cells will be deployed in coverage shadows and areas that need expanded coverage, but don't yet require a centralized facility. Small cells may also have associated cloud server capability when deployed in a campus, office building or other high traffic areas. These local cloud servers could be extensions of remote cloud services and reduce traffic during heavy traffic periods.

A New Cloud-Computing Architecture

The traditional cloud-computing architecture is typically thought of as using a massive server farm located a significant distance away, maybe even on a different continent, from the user. These farms are located where there is plentiful power, a large amount of water for cooling and connections to multiple very high-speed communications backbones. These backbones are the bottleneck to the overall system and use the highest bandwidth available, usually in the 40-gigabit range and moving toward 100 gigabits as it becomes more available. Clearly the perfect mix of power, water and connectivity is difficult to find and even with economies of scale can be very expensive to deploy. A more distributed system with a multitude of smaller server installations can help move computation and storage closer to the user, breaking the communications bottleneck. The overall network then begins to look more like a mesh, with a large number of smaller servers at the connection points to provide the baseband processing, data storage, cloud computing and communications functions. Communications bandwidth becomes less of a bottleneck since data and computation can now be located where it is needed, not where it’s convenient for the provider.

The distributed approach will require significant overall bandwidth, just spread across a larger portion of the network. In fact, total system bandwidth requirements will go up as users can more easily find and use cloud-based services. These new services, more easily deployable on standard hardware platforms, will thus drive additional data communications requirements. The use of 40-gigabit, 100-gigabit and even-higher-capacity networks will proliferate to serve this growth in demand. The ability for users to have their key applications and data "follow them" through the cloud to a more local and more cost-effective deployment will also increase bandwidth requirements. Data will naturally flow throughout the network to optimize bandwidth, storage, power, cost and convenience, depending on the level of service plan the user has. Thus the communications grid becomes much like the smart power grid with “peak times” and “off times” when data transfers can be had on a budget.

The Use of Fiber Communications in the New Network Architecture

Fiber-optic communications will be pervasive in these new architectures as bandwidth requirements expand. In the centralized system with remote radio heads, at the very outer edge of the communications mesh, fiber optic communications can be used to satisfy the requirements for robust and medium-distance connectivity. Optical modules that support CPRI, like the example from Finisar shown on the left side of Fig. 3 below, will be used between remote radio heads and centralized baseband servers, as previously illustrated in Fig. 1. Speeds in the 1-gigabit-per-second range will typically be sufficient for these applications. Centralized servers will use higher speed modules to connect to the optical fiber backbone of the outside mesh, perhaps using 10 Gigabit Ethernet modules like the example from Finisar shown in the middle of Fig. 3. Speeds in the 10 to 40-gigabit range will typically be found in these areas. Emerging backbone applications that aggregate the heaviest communications traffic will use even higher bandwidth modules, such as the 100 Gigabit Ethernet module from Finisar shown on the right side of Fig. 3 below.

Figure 3: *Optical module examples from Finisar: FTLF8526P3BNL, FTLX1612M3BCL, FTL410QE2C.*

Summary

The evolution to a more heterogeneous and distributed wireless infrastructure is underway and evolving rapidly. As new distributed network architectures emerge to deliver more data with higher quality to users, opportunities to deliver new cloud-based services will expand communications bandwidth requirements. Optical modules will be used to tie together the multitude of distributed elements that make up the emerging network. The result will be more localized storage, computation and communications resources needed for a smarter communications grid.