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The Role of Connectivity in Next Generation Wireless Networks

ADC KRONE

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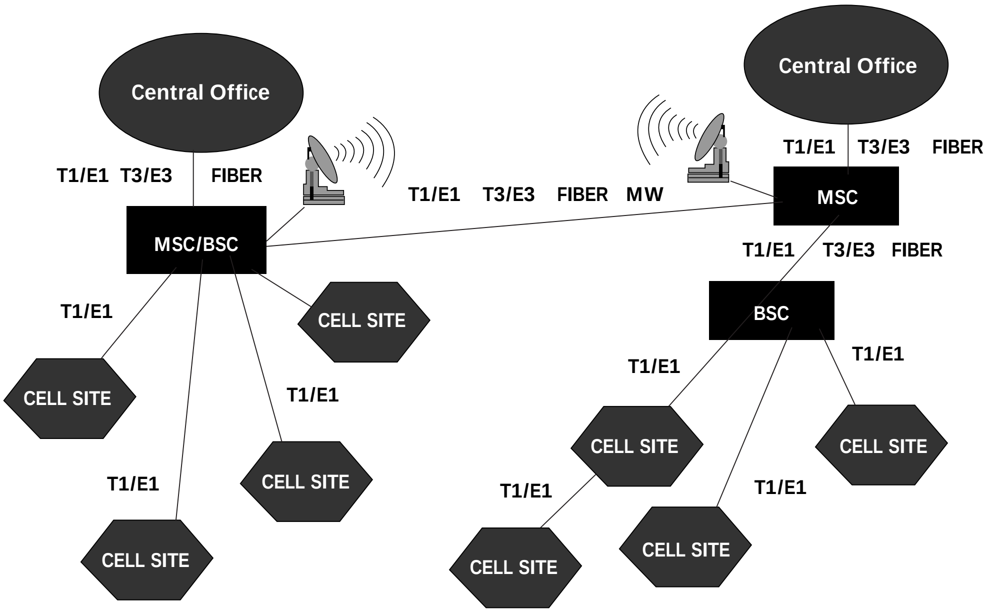
Next Generation Wireless Networks

What does the wired portion of a next generation wireless network look like? The better question is this—what does the wired portion of a next generation wireless network look like at specific points in time: one year, three years, seven years from now, and so on into the future? That question is hard to answer because migration to next generation networks is an evolutionary process.

Evolution is more than change. It is constant change. For wireless service providers, evolution implies a stepwise process of network migration, a process driven more by subscriber demand and operational efficiency than by a "build-it and they will come" strategy. In today's business climate, progression to next generation networks is driven by several factors.

- **Improve quality of service.** Subscribers have higher expectations for wireless services. Quality means better coverage, fewer dropped calls, and transparent billing and roaming. Quality also means higher speeds to support new spectrum-hungry data, video, and multimedia service offerings. With churn rates as high as 30% in recent years and evidence that suggests higher speed wireless data subscribers will generate more than three times the revenue of voice-only subscribers, quality of service clearly drives earnings.
- **Improve operational efficiency.** Service providers face high fees for 3G licenses, mandates for 3G service availability, and limited handset availability that delays deployment of advanced services. Still, one of the biggest items in the budget is network operations. As the network grows and becomes more complex, wireless service providers must improve operational efficiencies. Areas such as service monitoring, troubleshooting, fault isolation, and repair must help to reduce costs.
- **Increase revenue.** The promise of next generation networks is to reduce churn, earn new subscribers, and increase average revenue per user (ARPU) with new services. Mobile web, video conferencing, streaming video, gaming, telemedicine—the list of potential new wireless applications is almost endless. Earning new revenue requires a flexible, future-proof network architecture that can quickly and easily change to capture subscribers as applications move from potential to reality.

There are multiple paths to next generation services. For example: GSM to GPRS to EDGE to W-CDMA; CDMA to 1xRTT to 3xRTT; or TDMA to IS-136 to EDGE to W-CDMA. Each iterative step to successive modulation techniques drives software and hardware changes at cell sites, base station controller sites (BSC)/radio network controller sites (RNC), and mobile switching centre sites (MSC)/media gateways. Still, does anyone really believe that the 2 Mbps speed of 3G—the current target for most build-outs—will satisfy the wireless bandwidth appetites of consumers and business subscribers? Absolutely not. Already, major wireless RF equipment vendors are experimenting with 4G modulation techniques that can deliver 100 Mbps service as early as 2010—extending still further the horizon for evolution of wireless networks.



MSC: MOBILE SWITCH CENTER
BSC: BASE STATION CONTROLLER
BST: BASE STATION TRANSCEIVER

Wireless network advancements are similar in many respects—migrate from circuit to packet, increase network speeds, and make better use of radio spectrum. Yet emerging wireless networks are much more than new radios and handsets. Next generation wireless networks require more cell sites and smaller coverage areas to accommodate higher data rates. This means a substantial investment in the wired portion of the network, the wireless access infrastructure—more cell sites, more BSCs/RNCs, and larger/more MSCs/media gateways to handle increased traffic. In addition, T1/E1 pipes become STS3/STM-1 pipes, and copper cables are replaced with fibre cables carrying even higher bandwidth. Eventually, increased data rates and always-on service requires many more micro sites—small, remote transceivers that transport RF signals over existing metro fibre rings, increasing further the use of fibre cables in the wireless access infrastructure (see Base Station Hotels, page 5). This build-out of wireless access infrastructure introduces operational and financial risks to service providers—risks easily managed, however, with proper connectivity solutions.

Evolving Networks Create New Risks

As the wired portion of the infrastructure grows, migration to higher speed, packet-based networks have significant implications for both the cost and performance of the network—all of which translate into new risks for wireless service providers. These risks include the following:

- **Operational risks.** Driven by the need for smaller coverage areas, wireless networks are growing larger and more complex. Hundreds of new cell sites, dozens of new BSCs/RNCs, and highly dense MSCs/media gateways introduce more potential points of failure. The work of troubleshooting, maintenance, and upgrades grows. Add in reconfigurations, network element migration, and network consolidations, and the efficiency of network operations can quickly degrade—impacting service and increasing operations costs.

- **Financial risks.** Inordinate maintenance costs alone can depress earnings. Yet there is financial risk on the revenue side of the ledger, too. As bandwidth increases, the value of service interruptions is magnified. Outages are more costly. Time to repair and restoration is more critical. With more players in the value chain—content providers, content aggregators, application service providers, mobile virtual network operators—the ability to clearly identify fault is essential. Unobtrusive monitoring and upgrades now carry more weight—because there are more services and more dollars at risk.

Of course, the ultimate risk in evolving networks is the potential for poor quality of service that increases churn, reduces revenue, and raises cost per subscriber.

The Role of Connectivity in Wireless Network Migrations

Circuit to Packet Migration	Connectivity Solution
The introduction of new network elements (soft switches, media gateways, call servers, and voice-enabled routers) present new interfaces, port counts, and higher speed terminations. These network devices also require new interfaces, such as Ethernet, into BSC and MSC environments.	Connectivity provides a flexible physical layer platform for port count matching, interface and media conversion, and cable management. High performance connectorisation at the seams improves reliability and ensures improved QoS.
Electrical to Optical Migration	**Connectivity Solution**
Introducing network elements (optical cross connects, metro optical transport platforms, long-haul DWDM systems) with all optical interfaces creates higher fibre cable counts and more termination points at network elements.	Connectivity provides a flexible physical layer platform for port count matching, interface and media conversion, and cable management. Managing increased fibre cable counts is accomplished with high density, high performance connectorisation, termination, and cable management. Multifunction panels enable migration to media converters, modular O/E inputs and outputs, and O/E repeaters.

Connectivity Reduces the Risk of Network Evolutions

The most overused and under delivered concept in next generation glossy brochures is “seamless.” In the wired portion of the network, the seamless wireless network is like the paperless office. It sounds great. Achieving it is another issue altogether.

In the wired portion of wireless network architecture, seams are everywhere. Seams are where cell sites meet BSCs/RNCs and BSCs/RNCs meet MSCs/media gateways. Seams are found in optical/electrical conversion or in collocation and network sharing. Seams are hand-off points to local operating companies, Internet Service Providers, and even competitors. Seams are where the physical layer intersects with active equipment or portions of a network owned and managed by another entity. Seams were in the network 10 years ago. Seams are there today. And seams are part of next generation network design, too.

Proper management of seams in the wired portion of wireless networks, the wireless access infrastructure, is the setting for connectivity solutions. From a service provider’s perspective, seams are desirable. Seams are where the work of conducting reconfigurations, performing maintenance and loop qualification, restoring and turning-up service, facilitating upgrades, and providing a fall back position for equipment and cable failures occurs. Seams provide access for monitoring network health and for establishing boundaries between networks for billing and roaming.

Connectivity Checklist for Next Generation Wireless Network Deployment

- Complete management of cables for network elements—bend radius protection, ample storage, protection of cables on and off frame, easy-to-follow routing paths.
- Quick and accurate circuit and jumper identification with visual indicators at both ends of copper and fibre cross-connects. Good labeling and connection designation.
- Plenty of room for jumper (cross-connect) storage and management.
- High quality, low insertion loss fibre connectors.
- Non-intrusive monitoring capabilities.
- Full access to Tx and Rx signals at all times at the distribution frame.
- Copper patch cords are polarised to prevent +/- wire reversals, ensuring correct patching at all times.
- Reliable cable and jumper connection methodology.
- Reliable and high life cycle contacts.
- Platform flexibility.
- Superior fibre connector access for ease of cleaning and maintenance.
- Scalable for future growth.

Connectivity at the seams provides flexibility that helps improve operational efficiency, increase quality of service, and reduce the risks of network evolutions. Specifically, connectivity includes these functions at all seams in the wired portion of the network:

- **Termination.** Protected, modular termination for twisted pair, coax and fibre circuits that enables rerouting of traffic, non-intrusive upgrades, and test access.
- **Patching.** Ensures that any cable can be removed and installed without degrading service or disrupting adjacent cables. Enables temporary circuit rerouting during outages or upgrades.
- **Access for monitoring and testing.** Provides non-intrusive test points in the network—either local or remote—that allow technicians to measure the health of circuits, gather data on network performance, and catch problems and implement solutions before subscribers feel the impact.
- **Cable management.** Protect bend radius of cables, provide safe storage for excess cables, enable clear circuit identification, and enforce a systematic cable routing scheme. These all avoid service affecting damage to copper and fibre cables and drive operational efficiency.

Whether the project is leveraging the existing plant or migrating to next generation capability, the objectives are the same: minimise operational costs, increase reliability, and maximise revenue. These are the direct benefits of wireless networks that employ superior connectivity solutions.

Proper connectivity makes networks highly reliable, flexible, and less expensive to maintain. With an advanced connectivity system, maintenance hours and intervals are reduced. Circuit availability and bandwidth increase. Failures in electronics and facilities are often transparent to subscribers. Transition to new services and network upgrades are non-intrusive. All of which improves quality of service and reduces churn. And all of which reduces the operational and financial risk in the migration of wireless networks to next generation architecture.

Base Station Hotels

Digitised optical RF transport is a technology used to transport RF signals over fibre. In use since 1992, D-HFR converts an entire section of the RF spectrum to a digital bit stream, transporting the digital bit stream over a fibre cable, and reconstructing the RF signal at full bandwidth at the other end of the link.

In next generation networks, coverage areas will be much smaller, requiring numerous new cell sites. In metro areas, wireless capacity is centralised in a base station hotel where base radio capacity is extended digitally over fibre cable to high traffic or poor coverage areas and broadcasted with small remote units. This approach to increasing coverage and capacity minimises zoning and physical location issues of constructing traditional cell sites.

Compared to the costs and zoning constraints of constructing countless new cell sites, a base station hotel—with small remote units and antennas linked to the hotel that each handles hundreds of calls—conserves capital and lowers operating costs. Time to market is shortened, too. The average time to construct a new cell can be as long as 24 months. However, remote pole mounted antennas linked by fibre to the base station hotel can be operational in just 90 days.

Another factor that makes base station hotels using digitised optical RF transport so attractive in next generation networks is the ability to leverage existing CATV and MAN fibre rings. These fibre rings can be tapped by such methods as Dense Wavelength Division Multiplexing (DWDM) or Coarse Wavelength Division Multiplexing (CWDM), using unused wavelengths in fibre rings to connect remote antennas to base station hotels. With base station hotels, service providers are able to leverage existing spectrum, reduce operational costs by tapping existing fibre rings, and greatly expand coverage and capacity—at a fraction of the cost of deploying new cell sites.

Maximising the benefits of base station hotels also optimises the use of fibre in wireless networks. Connectivity ensures reliable connections, proper bend radius protection, circuit access, and protected cable management for base station hotels.

What is the Cost of Connectivity?

Connectivity typically accounts for between 1% and 10% of the upfront costs of a network deployment. This is a small price to pay as compared to the alternative—a network where performance and reliability problems gradually enter into the system and where operations costs escalate. As expected, these problems in the wireless access infrastructure are almost always traced to poor bend radius protection, inadequate cable storage, restricted circuit access for repair and maintenance, cable congestion, poor rerouting options, and other weaknesses in the network.

The cost of connectivity is small because the alternative is a high maintenance, high cost proposition that is characterised by longer service interruptions, operational inefficiencies, and frustrated subscribers. Here are two examples showing the hidden costs of wireless infrastructures built without connectivity:

1. Dozens of DS1 facilities may connect remote cell sites with a MSC/media gateway or BSC/RNC. Without the ability to remote test, circuit qualification requires a technician at each end of each circuit. Man-hours and maintenance costs are compounded with leased DS1s, which often require multiple sessions to complete the qualification process. In addition, truck rolls for "no trouble found" conditions and undetected troubles outside the wireless access portion of the network hinder operational efficiency.

2. During initial installation of a fibre distribution system, relatively few patch cords are installed in the routing path to and from the optical distribution frame (ODF). The small number of fibres, combined with the natural stiffness of fibre cable and partially filled cable routing paths, ensures proper bend radius protection. However, as more fibres are added to the system, the weight of additional fibres in routing paths can cause macrobends on the original installed fibre cables. Fibres that have worked fine for years suddenly show increased attenuation, poor performance, and a shorter service life. Troubleshooting, truck rolls, and service-disrupting repairs all become unnecessary costs. Higher cost of operations, decreased network reliability, and increased churn all contribute to lower earnings.

As these examples show, higher maintenance costs are only one part of the equation. Equally important is quality of service. Without connectivity solutions, service providers are perpetually behind the competition in terms of provisioning, performance, and availability of new services. The newest network elements neither contribute revenue nor reduce costs if subscribers can't get the services they want.

Another cost of connectivity is the upfront purchase of connectivity products. Superior connectivity products should be highly functional, reliable and designed to minimise technician time. Purchasing connectivity equipment is a long-term proposition—once you buy, you are faced with managing and maintaining the equipment for years. Network operations remains a large part of the budget. Equipping the operations staff with proper connectivity solutions reduces the cost of network maintenance and increases network availability for subscribers.

With any network solution, there is no free lunch and you get what you pay for. While a connectivity component may carry an attractive price tag, the total cost of ownership for that component could far exceed the cost of owning a technologically superior and highly functional product.

Preserving the Function of Connectivity in the Network

Occasionally, network element vendors advocate elimination of physical connectivity and cable management solutions, claiming everything you need is "in there". For example, digital cross connect systems (DCS) were originally positioned this way. Yet it was quickly apparent that hardwiring network elements to DCS equipment made rerouting and integration of new network elements difficult and expensive. Suppose a MSC has six network elements and six DCS—one DCS for each network element. Routing a circuit from network element #1 to network element #6 could mean routing the circuit through six DCS—using expensive DCS ports for a simple reconfiguration. With proper connectivity, the circuit is routed from DCS #1 to DCS #6 with a digital signal cross connect (DSX) panel, opening DCS ports for more important network functions.

In addition, a hardwired DCS environment makes identifying and isolating problems in real time impossible, causing unneeded service interruptions and delays in restoration. Without connectivity surrounding DCS equipment, the result is increased operational costs and lost revenue.

It is important to note that DCS adds significant operational efficiencies for service providers. However, maximising the benefits of DCS or any network element requires that the function of connectivity remain intact. These functions—including modular termination, patching, access for monitoring and testing, and end-to-end cable management—ensure that everything from routine maintenance to outages in the network are transparent to subscribers.

Combining functionality in network elements has always been a trend in communications hardware—and it will be the trend for next generation solutions, too. Yet even as certain functions collapse into network elements, new network elements arrive with new functionality. In these more complex networks there are still physical seams to manage. Without proper connectivity surrounding these network elements, troubleshooting, maintenance, and rearrangements occur in the backplane of network elements—introducing enormous operational and financial risk to the business.

Will connectivity functions ever be completely rolled into network elements? Maybe. Yet no matter where connectivity functions reside, termination, patching, access, demarcation, and cable management solutions are critical to the operational efficiency of wireless service providers—especially as networks progress to next generation capabilities. As networks include new network elements and higher bandwidth pipes, the function of connectivity remains more important than ever. Without connectivity, the operational and financial risks to the business soar. These risks make the function of connectivity in next generation networks more critical than ever.

Conclusion – Build it Right the First Time

Migration to next generation wireless networks is an evolutionary process. Wholesale replacement of all network elements is not feasible due to financial constraints and the protection of existing services revenue.

With the increased bit rates of next generation modulation techniques, wireless coverage areas are shrinking. Next generation architecture therefore means more than just new radios and handsets. Next generation architecture requires a larger and more complex wireless access infrastructure that includes many more cell sites, more BSCs/RNCs, and larger MSCs/media gateways—all connected by higher bandwidth cables.

The building and expansion of the wired portion of the wireless network presents new operational and financial risks for service providers. However, expansion of the wireless access infrastructure also presents an opportunity for wireless service providers—an opportunity to improve operational efficiency, reduce operational costs, and improve quality of service even while network migration continues to 3G and beyond.

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The opportunity lies at the seams of the network. In wireless access infrastructures, seams are good. Seams are where the critical connectivity functions of termination, patching, monitoring, testing, and cable management occurs. Careful management of the seams translates into tangible benefits for service providers that reduce the risk of network evolutions. Even as network elements change, connectivity ensures accurate fault isolation and problem resolution. The inherent flexibility of connectivity speeds time to repair, reduces time to turn-up, and shortens time to revenue — all of which increases performance and availability of assets. Most important, as an integral part of operations practices, connectivity allows carriers to scale network operations by leveraging the workforce around a common set of methods and practices at the seams of the network. Proper connectivity provides a platform to improve operations efficiency and services availability — even in the middle of constant change.

In the end, it is the function of connectivity that makes a wireless network more reliable and cost effective to operate. That's because as the network grows more complex, as new network elements are installed, as new radios and cell sites are brought online, as problem circuits are rerouted — no matter the evolution and change in the network, connectivity ensures that impact on subscribers is minimal.

Note: ADC KRONE provides products and services that support multiple requirements of wireless service providers. In addition to connectivity solutions for the access infrastructure, ADC KRONE offers professional services that range from network and inventory audit to commissioning and integration. Also available are product solutions including tower top amplifiers, indoor wireless coverage solutions and digital hybrid fibre radio solutions.

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