ICOM®

IP Advanced Radio System: **White Paper**

Transceiver + IP Network

Wireless LAN
A Transformative Technology
Comes to Radio

Wireless LAN
A Transformative Technology
Comes to Radio

Transceiver + *IP Network*

Highlights:

- Connectivity Needs
- Fueling Growth
- How WLAN Works
- When to Employ an IP-Based Radio System
- The IP100 Radio System
- Advantages of the IP100 Radio System
- A Revolution in Radio

It's been less than 20 years since former Apple chairman Steve Jobs shocked a MacWorld audience by picking up a laptop computer and walking a few steps across a stage. The crowd roared because of what was missing: wires. To rousing cheers Jobs playfully passed a Hula Hoop around the clunky machine and grinned like the magician he was.

Today, the number of mobile devices and connections exceeds 7 billion. The data carried last year over those devices was 30 times that of all the Internet traffic recorded in 2000. Predictions are that mobile traffic will grow nearly tenfold by 2019.

The foundation for this transformative growth is the wireless local area network, a technology used today almost without notice by millions of home computer users, coffee-shop patrons and hotel guests. Wireless networks have transformed workplace computing and fueled the explosive growth of tablet computers.

Now, having pulled the cords from computers, WLAN technology is ready to take the two-way radio online. Internet Protocol radio systems have a number of distinct advantages over traditional RF systems and can literally take radio where it has never been before. But adoption will depend on understanding, among the people who buy radios and the people who sell them.

Connectivity Needs Fueling Growth

Wireless LAN traces its beginnings to the 1990s, when it emerged as a niche application that was soon adopted by home users. Business users followed. In 2013, the number of enterprise WLANs grew by 20 percent as 13.2 million access points were sold. ABI Research has predicted that by 2019 that annual total will be 25 million. The reason for the optimism is the desire for the same levels of connectivity already enjoyed by home users. That need is not going anywhere. It is future proof.

Wireless networks are already in place in many businesses; and if not, they are easy to construct. The management and maintenance of these networks can usually be accomplished by IT managers, though some systems may require outside help because of their added complexity with respect to infrastructure and architecture. The infrastructure needed for a wireless network varies by the size of the business.

Icom America Inc.

While most home networks perform well with a single wireless router, large enterprise systems require many access points. The controller, which includes DHCP server functions, allows all these access points to be tied to each other. That connectivity allows users to "roam" as they do with their cell phones.

Costs of these systems vary based on a number of factors, including the number of access points required, their location, and the presence of concrete and metal that impair AP signals. But generally an IP-based two-radio system is much less expensive than building out an RF system. And system design is expanded with IP, giving organizations capabilities they could only wish for with RF.

How WLAN Works

A WLAN system includes an access point, a station, and a wireless medium. If there is more than one AP, both a main AP controller and distribution system (typically an Ethernet network) are required.

Distribution System

Access Point   Wireless   Station
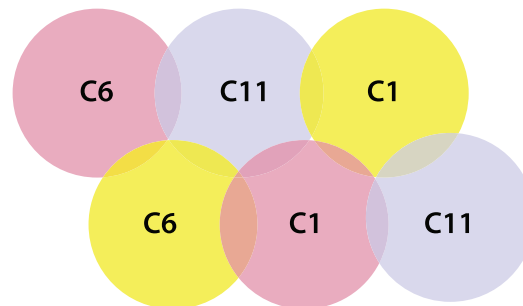   Medium
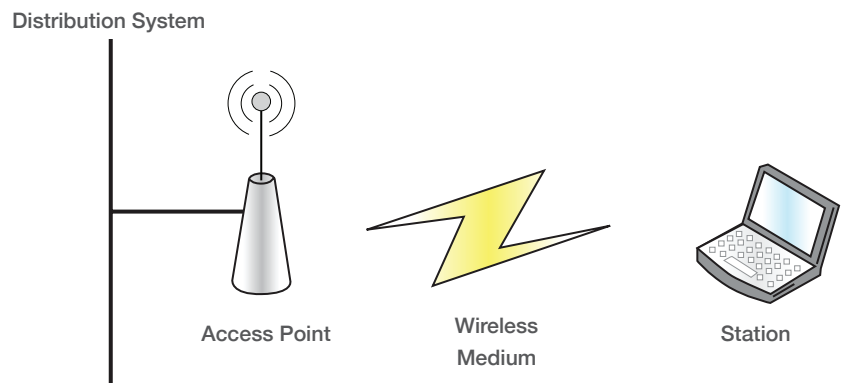
WLANs use the RF spectrum to carry information just as smartphones and two-way radios do. Just like these other technologies, WLANs operate on either of two frequency ranges, the 2.4 GHz and 5 GHz bands. Each band has a number of channels: 2.4 GHz has 14 channels while 5 GHz has 24 channels. (In the US, the FCC limits the use of some of these channels.) These channels provide the physical media to carry the information, just as an Ethernet cable or two-way radio channel does.

In the 2.4 GHz band, the channel spacing is 5 MHz and the bandwidth is 22 MHz. The potential of overlap should be considered when establishing the channels for each access point. That is why channels 1, 6 and 11 are the most common channels used. They are the only non-overlapping channels which, if strategically placed, could be reused to provide coverage throughout the system.

Icom America Inc.

The 5 GHz band has 24 non-overlapping channels. However, the middle of the band may experience interference from other external systems. So, the bottom four and top five channels are most often selected for WLAN use.

These channels operate at very high speeds, allowing a lot of data to be transmitted in short periods of time. This is accomplished by digitizing the data and packetizing it into small frames of information that are shared in bursts. In between the burst the channel is unused and open for other stations to send their data burst. They use a protocol called CSMA/CA or Carrier Sense Multiple Access with Collision Avoidance to control media access. Imagine a polite dinner-party conversation. The air is the carrier and the people around the table are the multiples wanting to participate in the conversation with each not wanting to interrupt the others. How they do it is to listen, make sure no one else is talking, wait a bit, and then talk. If someone else does the same at the same instant, they both stop and wait before trying again. That is essentially what WLAN stations do.
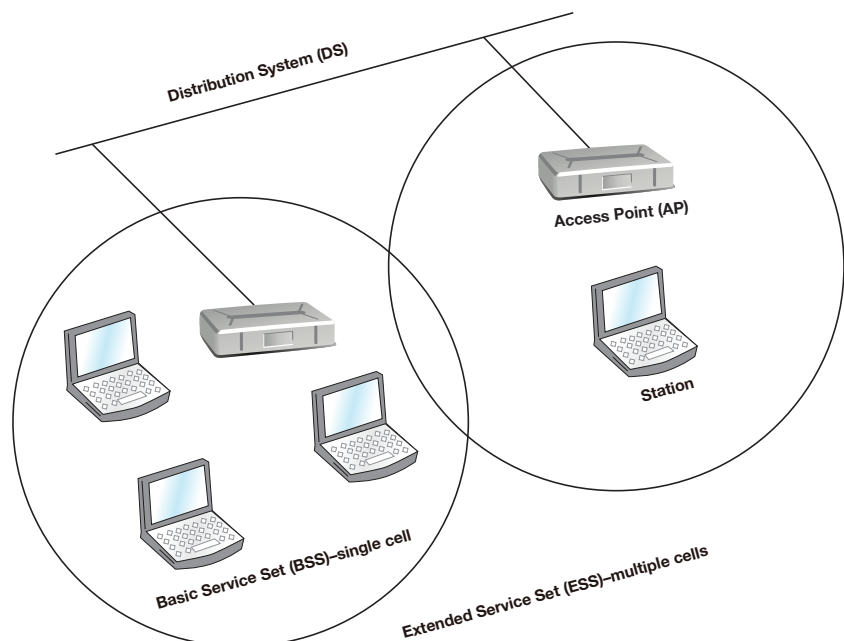
The more stations trying to transmit the more difficult this becomes. And the larger the frames being transmitted, the longer a station has to wait before trying to access the AP. Thus, congestion and frame size tend to increase jitter in voice transmissions. Setting QoS does help alleviate this.

Once the station has gained access to the wireless media and has sent a properly formed frame to the AP, the AP then inspects the frame to determine whether or not it belongs on, or is affiliated with, the WLAN. The station can associate with an AP based on the SSID. The controller or main AP sends out the SSIDs for which it is configured to accept; and the station, upon seeing its SSID, requests to be associated with the AP. If there is more than one AP on the distributed system, as the station moves out of the range of the AP, it disassociates from the first AP and re-associates with the new AP. The station determines when to initiate this transition based on RSSI. In a distributed system, the APs share their affiliation list so a station is only associated with a single AP at a time. This is how the AP knows where to send the data when one station wishes to communicate with another.

Icom America Inc.

Since the AP transmits the SSID in the clear allowing stations to determine if their network is available, it provides no access security. Authentication is introduced to provide that extra layer of access security. This is done using WEP, WPA, or WPA2. So the SSID is like the address to the building, and authentication is the key that lets visitors in. For authentication to work, the station and the AP need to have a common key. WEP is the least secure as it uses a static key. WPA (TKIP) using a temporary key has much better encryption than WEP. WPA2 has encryption that is nearly impossible to crack (AES)but can use TKIP for interoperability with WPA.

Once affiliated and authenticated on the AP, the station can communicate with the other stations using that AP. When only one AP is used it is called a Basic Service Set (BSS). If there is more than one AP connected together through a distribution system, typically Ethernet, the two or more APs form an Extended Service Set (ESS). With multiple APs in the ESS it is possible to have some APs with different SSIDs than the others. The station would only find the APs with the SSID to which it is configured.

The system can have other features enabled, such as DHCP and QoS. DHCP allows the system to assign IP addresses to the stations, making it easier for the system administrator to allocate and manage the addresses. QoS, Quality of Service, is another feature that must be implemented systemwide. QoS gives multiple layers of priority to the frames sent out by the station. This is good for voice traffic that is time-sensitive. Setting QoS will give priority to the voice frames transmitted as they are sent through the distributed system. DiffServ and VLAN are two ways to increase QoS.

Distribution System (DS)

Access Point (AP)

Station

Basic Service Set (BSS)–single cell

Extended Service Set (ESS)–multiple cells

Icom America Inc.

Consider the practical operation of a WLAN system, starting with a single BSS AP with little or no traffic. This system can affiliate many stations if they don't attempt to gain access in the same instant. Once on the system, if they don't transmit anything, all is well. But if a station (a computer) begins to stream video, the bandwidth usage goes up dramatically. This still may be fine if the bandwidth of the WLAN exceeds that of the streaming video. There will be enough empty space between frames to allow others access. However, when all stations begin to transmit data, be it file transfers, video or voice, the capability limitations show. The AP must manage the traffic from all the multiple sources, which puts an increasing demand on the processor. In a case when 100 stations are affiliated to a single AP and they all start to communicate to one another, some will not be able to get access even if the overall bandwidth is not exceeded. Another AP is needed. Similarly, if a station is affiliated on one AP then roams to another busy AP, it may not be able to associate to the new AP quickly due to the load. The impact of this is minimized by the fact the APs communicate status to each other, which aides in the roaming process.

When to Employ an IP-Based Radio System

Wireless networks make possible a whole new approach two-way radio communications. These IP devices use the Internet that many businesses already have. Systems are quick to install, easy to operate, and very secure. They can be managed by IT personnel who are very comfortable with the technology. No licenses or frequency coordination is required. Perhaps most importantly, they are much less costly than traditional RF and land mobile systems. There are six scenarios in which IP-based radio systems are especially attractive to customers:

No RF coverage in the building. Many buildings, because of their design, don't allow the use of traditional RF. Everyone has been to a building where they lose cell coverage in an elevator. Concrete and steel, the enemies of traditional radio, are not a problem for IP-based systems.

Reserve Rare LM Spectrum. FCC licensed spectrum is hard to get. If you have it, it needs to be used for the most critical functions. An IP-based solution can be used for routine communications.

No budget for a new RF system. Expenses remain a constant concern, especially the capital outlays that radio systems require. Part of that expense is time. A traditional system can take months, even years, to evolve and install. An IP-based system can be up and running in half a day.

Existing LMR is not upgradable or supported. Very often a legacy land mobile radio product can't be upgraded and is at the end of life. This creates the opportunity to build a business case for converting to a system that offers better capabilities and coverage.

Icom America Inc.

Costs of maintaining an existing RF system are too high. Many customers have spent significant sums maintaining RF systems and can't continue to add repeaters, hardware and equipment. The costs of maintaining an IP-based system is miniscule compared to land mobile radio.

Cellular plan or recurring costs are too high. Issuing cellular phones to employees raises a number of issues. Perhaps the most worrisome is the fact that carriers can dictate pricing, especially to smaller customers. An IP system removes that dependence, which, as every cell phone owner knows, can be frustrating.

The IP100 Radio System

Icom America's IP100 radio system is the first product on the market to allow for radio communications over an existing wireless network. It can make possible site-to-site communication regardless of distance or geographic location. It can be used in almost any environment or industry, and implemented and maintained at much less expense than cell phones or traditional radios.

The system's core components include the IP1000C, the controller/server. This is an embedded GUI that, just like a wireless router, is accessed using an IP address. It's where the configuration for the radios and network takes place. Managers log into it, set up the network, set up the radios, and that's it.

The AP-90M, Icom's compact WLAN access point, enables the use of both 5 and 2.4 GHz spectrum bands with a built-in high safety standard for encryption. The access point is equipped with various features, such as load balancing, packet filters, and support for the PoE function. The functionality of the system can be monitored with the use of RS-AP3 software. Adding access points can easily expand system coverage.

Icom's IP radio, the IP100H, is a compact yet powerful device. Measuring only 3.7 inches in length and weighing just 7.2 ounces, the IP100H is one of the smallest professional radios on the market. The IP100H is rated IP167 for submersion in water to 30 centimeters for 30 minutes. Its uncompressed, V57 audio is very similar to digital. The standard battery life is 27 hours. An available extended battery lasts 40 hours, which is unheard of in land mobile radio.

The 32-character display, complete with emojis, lets the user quickly identify the type of call based on the icon he or she is seeing: a telephone or a radio, an individual or group call. With a microphone or headset, users can work hands free and talk just as they would on a cell phone. The days of "Over" and "Stop" are gone.

Icom America Inc.

Advantages of the IP100 System

One of the very first organizations to adopt the IP100 System was a dental practice. The dentist wanted to communicate with his employees all around the office without having to walk – or shout – between rooms. The cost of the system was significantly lower than that of a traditional land mobile array: No repeaters, no licensing, and no frequency coordination. It was easy to use, asking of its users only those skills needed to operate a cell phone, so training was minimal. IP100 systems can use existing WLAN and IP infrastructure, and they can be managed and maintained by IT professionals who are already very familiar with the technology. Installation can be completed in a day.

Other benefits and savings:

- Individual, group and all calls
- Simplex push-to-talk with a full-duplex option
- Up to 1,100 radios; many simultaneous calls
- Reliable, clear voice quality
- Built-in diagnostics and range testing
- Easy to expand over different locations
- Coverage expandable by adding access points

The IP100 System is especially well suited to applications in which cost and architecture rule out traditional systems and users require simple radios and the ability to communicate in groups. Among them:

Hotels. Many already have plenty of experience with managing wireless networks and delivering Internet accessibility.

Manufacturing and warehousing. Facilities typically have telephony, require Internet or Internet connections to a server.

Hospitals. Doctors and nurses can easily talk using infrastructure, and in places where cell phone usage is often prohibited.

Security. Officers remain reachable any time, no matter where in a facility they may be.

Restaurants. Managers can talk to employees and also to colleagues at other locations if they need help or stock.

Retail stores and groceries. Many are well versed in traditional RF. The IP system offers improved coverage in stores and improved coordination between them.

Icom America Inc.

What about cell phones?

All of the attention given to the Bring Your Own Device trend obscures the fact that for many organizations issuing cell phones to lots of employees was never an appealing option. Communication is limited to one to one. Phones can be a distraction and are open to abuse. As anyone with a cracked phone screen knows, they are not sufficiently durable to stand up to tough work environments.

The biggest disadvantage of cell phones remains the recurring expense. Two-way radios are a one-time cost and can pay for themselves in a minimal period of time through improved efficiency. The IP100 System enjoys this and other traditional advantages of two-way radios then adds plenty more.

A Revolution in Radio

The IP100 System from Icom America is a product without peer. It is the first in the market to allow for radio communication over an existing wireless network. It offers site-to-site communication regardless of distance or geographic location. It is a complete system that can be used in almost any environment or industry. It is less expensive than traditional radio systems to purchase, implement and scale.

When customers see it, they ask why this approach hasn't been used before. When dealers understand it, they gain the ability to sell radio solutions to a whole new set of potential customers. The IP100 System already has been used to communicate in hospitals and warehouses, offices and restaurants, between Atlanta and San Francisco, and from cars rolling down the highway.

Where can we take it next?

Icom America Inc.