AMPHENOL RF ENABLES THE INTERNET OF THINGS

Background

The Internet of Things (IoT) is delivering the promises of greater efficiency, improved production, enhanced and new services, and deeper levels of control and data acquisition for city planners, city managers, agriculture, manufacturing, and individuals.

The widespread availability of wireless, radio frequency (RF) based connectivity is fueling the growth and success of IoT solutions. Because IoT solutions typically rely on resources distributed over wide geographical areas for system operation, an RF-based infrastructure is ideal.
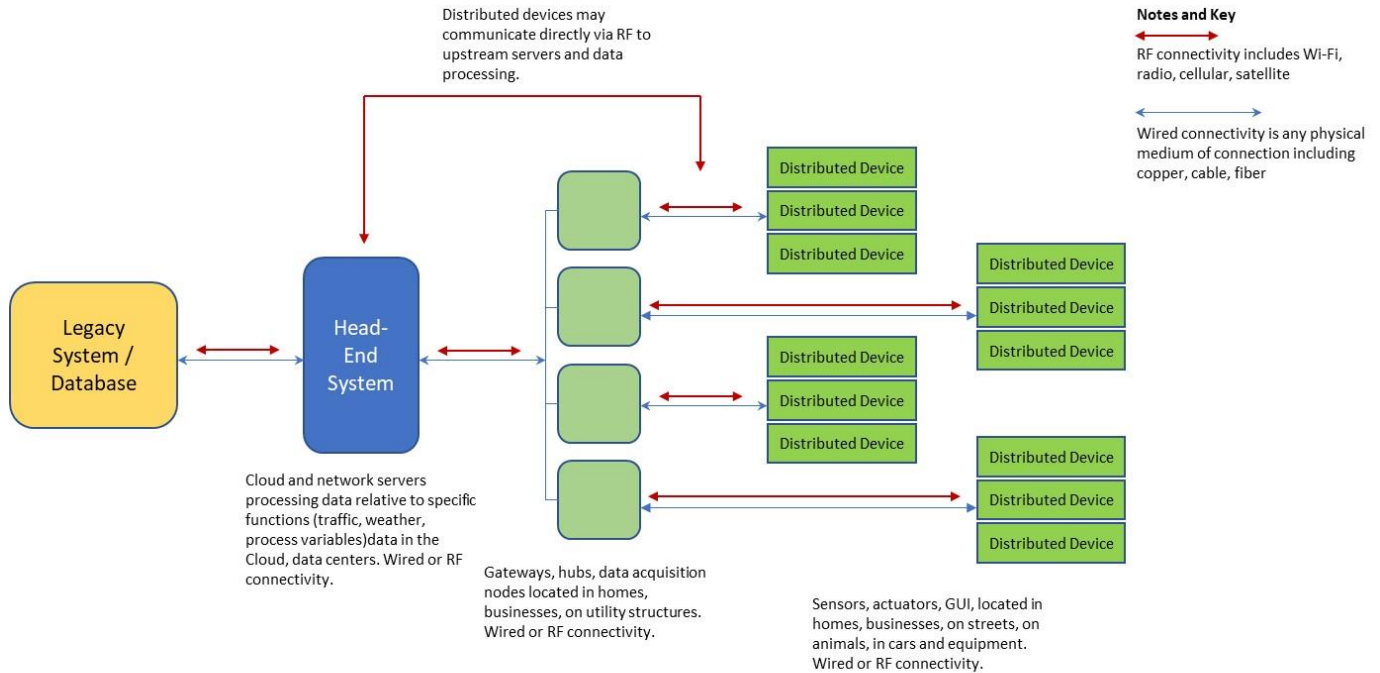
IoT solutions are being designed to deliver:
- Optimized use of existing infrastructure (managing traffic flow via coordinated signaling networks and connected vehicles)
- Energy management
- Efficient use of natural resources (subsurface moisture sensors controlling rates of irrigation with weather data integration)
- Decentralized access to legacy databases to facilitate self-service by stakeholders in various instances such as license renewal, and registration
- Street light management and maintenance
- Integration of AI for semi-autonomous operation of manufacturing, agricultural, and urban processes
- Acquisition of larger volumes of more detailed data to support continual process optimization.

An IoT solution architecture includes both software and hardware components. For the purposes of this paper, hardware will be the focus. Widely distributed hardware resources are used to provide the localized control, communication, and data acquisition capabilities required for effective operation. These resources can include:

- Existing Wi-Fi networks
- Smart or internet capable devices such as thermostats, traffic sensors, environmental monitors
- Hubs collecting input from several wireless and wired devices
- Additional devices required to manage the efficient flow of communications and commands including internet and other network servers

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Distributed devices may communicate directly via RF to upstream servers and data processing.

Legacy System / Database

Head-End System

Distributed Device

Cloud and network servers processing data relative to specific functions (traffic, weather, process variables)data in the Cloud, data centers. Wired or RF connectivity.

Gateways, hubs, data acquisition nodes located in homes, businesses, on utility structures. Wired or RF connectivity.

Sensors, actuators, GUI, located in homes, businesses, on streets, on animals, in cars and equipment. Wired or RF connectivity.

Simplified IoT Architecture & Connectivity

What challenges are IoT solution implementers facing?

Smart City IoT solutions are designed to improve utilization of capital investments including optimization of traffic flows on highways, light rail and public transportation management, provision of online services from existing systems, and so forth. Impediments to deploying Smart City IoT solutions can include:

- Establishing locations for the distributed devices
- Gathering the necessary permits required for co-location on or in existing utility infrastructure,
- Implementing the solution quickly and cost effectively
- Operating and maintaining the deployed solution

Smart Agriculture IoT solutions address water management, monitoring environmental variables relating to soil, plant health, water and heat stress of animals, monitoring animal health, managing livestock feeding on a per animal basis through RF tags, integration of weather data for crop management, links to commodity markets, and use of distributed or mobile devices. Smart Agriculture impediments can include:

- Distances between IoT hardware components
- Lack of existing utility infrastructure (poles, cell service, etc.)
- Harsh operating environments

Industry 4.0 might be considered more akin to Smart Ag than Smart Cities because of the harsh environments encountered in many situations and the potential for significant distances between hardware components. Consider, for example, mining, refining, and chemical production operations. These situations typically occupy sizeable areas and many of the process components are located outside. Structures for attaching wires may be widely separated or be unsuitable for direct attachment. IoT components can be exposed to the weather as well as dusty, caustic, or corrosive environments that can impact hardware life and functionality.

Regardless of the IoT application, RF provides an optimal solution in many, if not the majority of, cases. Wired solutions bring the following issues:

- Running additional wire (copper, fiber, or coax), on poles requires permits and permission from the host utility.
- Adding wires may necessitate a loading study to confirm the ability of the poles to handle the extra wire's weight, weight from icing on the new wire, and wind loading.
- Co-location on utility poles and other facilities typically incurs an ongoing, periodic fee.
- Underground wiring involves expensive excavation and repair of disrupted surfaces.
- When wiring breaks, it must be repaired by qualified crews. If it is underground, the cost and delay is significant.
- There may not be poles in Smart Ag solutions and underground is rarely practical.
- With Industry 4.0, space may not be available or readily accessible for installing or attaching wiring.

RF centered solutions are ideal for the following reasons:

- Fewer co-location requirements
- Easier to maintain – a failed unit can often be put back into service with a board replacement
- Provides architectural design flexibility – supports 100% wireless or hybrid approaches
- Creates the infrastructure for connecting mobile distributed devices carried on vehicles and farm equipment

Specify the perfect connector for optimal RF performance with Amphenol RF

More devices than ever before are being sold with a wireless connectivity capability. This additional capability is an acknowledgement of the flexibility RF provides and is a response to widespread availability of RF systems that provide access to the internet for cloud-based control and data analysis. This rapid growth can put engineers at a disadvantage if they do not have RF experience or have not had experience integrating RF capable components in their designs.

Amphenol RF engineers are a tremendous resource to engineers facing either of these situations. As the largest RF connector provider globally, Amphenol RF engineers can apply their unparalleled knowledge of connector optimization to your specific situation. This resource can guide engineers and specifiers in areas such as:

- Does the RF device's PCBA use through board or surface mount components? Which connector is best suited for the situation?

- Are the PCBA launch geometries (antipads, trace widths, and gaps) optimized to handle the project frequency?
- What type of antenna connection is preferred to meet initial cost requirements and ease of future maintenance?
- What type of data and command communication is required in terms of quality, packet size, and speed?
- Where will the RF device be mounted? In an enclosure? In a corrosive environment? In harsh weather environments?
- What are the RF frequency and quality requirements?
- Where are antennas mounted? Internally? Externally?
- What type and form factor of antenna is being used? How far is it from the RF Hardware?
- How many distributed devices will be connected to a single antenna? Is a multi-port connector or single connector more applicable?
- Can the design utilize pre-configured, off-the-shell assemblies or is a custom connector more beneficial?

Table 1 is taken from an article review written by Judith Sobotie[1] regarding the Padova, ITALY Smart City project. The table illustrates the complexity of a Smart City technical architecture in terms of integrating the various components into a properly functioning IoT solution. It lists communication options, data timing, packet sizes, and more. Amphenol RF engineers can aid in selecting the right connector for each layer in the solution.

TABLE I
SERVICES SPECIFICATION FOR THE PADOVA SMART CITY PROJECT

Service	Network type(s)	Traffic rate	Tolerable delay	Energy source	Feasibility
Structural health	802.15.4; WiFi and Ethernet	1 pkt every 10 min per device	30 min for data; 10 s for alarms	Mostly battery powered	1: easy to realize, but seismograph may be difficult to integrate
Waste management	WiFi; 3G and 4G	1 pkt every hour per device	30 min for data	Battery powered or energy harvesters	2: possible to realize, but requires smart garbage containers
Air quality monitoring	802.15.4; Bluetooth and WiFi	1 pkt every 30 min per device	5 min for data	Photovoltaic panels for each device	1: easy to realize, but greenhouse gas sensors may not be cost effective
Noise monitoring	802.15.4 and Ethernet	1 pkt every 10 min per device	5 min for data; 10 s for alarms	Battery powered or energy harvesters	2: the sound pattern detection scheme may be difficult to implement on constrained devices
Traffic congestion	802.15.4; Bluetooth and WiFi; Ethernet	1 pkt every 10 min per device	5 min for data	Battery powered or energy harvesters	3: requires the realization of both air quality and noise monitoring
City energy consumption	PLC and Ethernet	1 pkt every 10 min per device	5 min for data; tighter requirements for control	Mains powered	2: simple to realize, but requires authorization from energy operators
Smart parking	802.15.4 and Ethernet	On demand	1 min	Energy harvester	1: Smart parking systems are already available on the market and their integration should be simple
Smart lighting	802.15.4; WiFi and Ethernet	On demand	1 min	Mains powered	2: does not present major difficulties, but requires intervention on existing infrastructures
Automation and salubrity of public buildings	802.15.4; WiFi and Ethernet	1 pkt every 10 min for remote monitoring; 1 pck every 30" for in-loco control	5 min for remote monitoring, few seconds for in-loco control	Mains powered and battery powered	2: does not present major difficulties, but requires intervention on existing infrastructures

Table 1: Services Specification for the Padova City Project

Amphenol RF offers an extensive array of technical product and product application data in addition to its engineering capabilities. One example is the availability of ANSYS HFSS 3D component models (see Figure 1) for many Amphenol RF connectors. These free downloadable files allow engineers to test a PCB

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[1] http://www.etcs.ipfw.edu/~lin/CPET581-InternetOfThings/1-Lectures/2-5-2016-PaperPPT-slides/IoTResearchDirection_JS.pdf with her review being taken from the following source: A. Zanella, N. Bui, A. Castellani, L. Vangelista and M. Zorzi, "Internet of Things for Smart Cities", IEEE Internet of Things Journal, vol. 1, no. 1, pp. 22-32, 2014.

connector's performance in their PCBA design with an extremely high degree of accuracy. These files eliminate the need for building prototypes to determine performance, reducing both development costs and time.
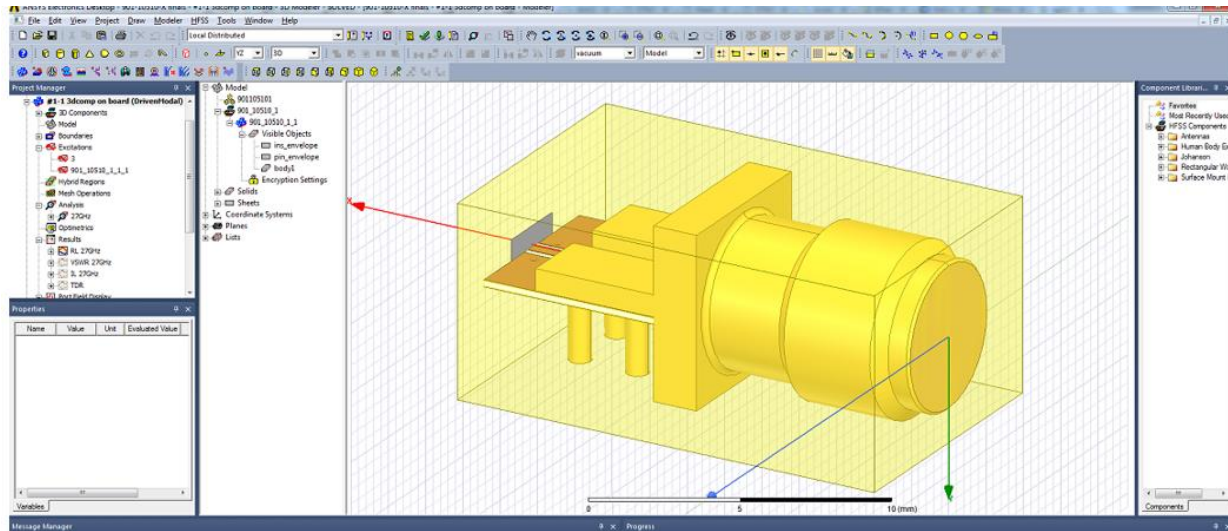

Figure 1: https://www.amphenolrf.com/ansys-hfss-3d-component-models

When it comes to implementing a RF-based solution, the quality of the connectors used will go a long way to determining how well the solution will perform. Regardless of the type required, a reliable, durable, high performance connector is a necessity for optimization of RF signal transmission. Proper connector specification and procurement is critical.

Examples of end use applications

Commercially available prefabricated wireless modules incorporating Amphenol RF connectors. These prefabricated modules are designed to provide engineers with compact, functional sources of wireless and RF connectivity including Wi-Fi, ZigBee, and Bluetooth. These modules are frequently part of reference designs engineers utilize to speed development of their own products. Engineers working tasked with building a wireless capable device may be unfamiliar with RF and wireless technology and optimizing its integration into their product. Amphenol RF engineers are an excellent resource to assist with the integration.

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RF connectors are designed into a PCBA assembly to facilitate connection of antennas, support the frequency and impedance of the solution, and protect against environmental conditions (IP67 or IP68 spec connectors).

AMMC	AMC	MMCX	MCX
6 GHz / 50 Ohm	6 GHz / 50 Ohm	6 GHz / 50 Ohm	6 GHz / 50 & 75 Ohm

SMA	TNC	N TYPE	FAKRA
26.5 GHz / 50 Ohm	11 GHz / 50 Ohm	11 GHz / 50 Ohm	4 GHz / 50 Ohm

Pre-configured cable assemblies are designed to provide affordable, proven antenna connectivity to antennas located outside the electronics case or inside larger hardware cabinets. They are also ideal for prototyping hardware designs.

AMC to AMC   SMA to AMC   IP67 SMA to AMC   IP67 TNC to AMC

Custom cable assemblies can be engineered and manufactured to solution specific requirements that existing, off-the-shelf alternatives cannot satisfy. Amphenol RF can manufacture cable assemblies that:
- Incorporate any connector configuration
- Use any cable type including ruggedized and armored
- Support hybrid RF/digital solutions
- Support ganged connectivity
- Comply with IP67 and IP68 protection

About Amphenol RF

Amphenol RF is the world's largest, most experienced producer of radio frequency (RF) connectors, coaxial adapters, and RF cable assemblies. Using its industry best engineering talent, Amphenol RF connectors employ the most advanced materials and production methods without compromising manufacturing efficiency and productivity. Amphenol RF connectors' role in the IoT ecosystem is fundamental to the proper functioning of IoT solutions by providing sound, reliable, durable, and high performance connection to antennas and delivery of the RF signal with minimal loss and distortion.

Innovation is a priority within every line and individual product engineered, manufactured, and sold by Amphenol RF. It is not enough to simply meet industry performance standards. Amphenol RF considers those the bare minimum and engineers its products to maximize both electrical and mechanical performance.

Additionally, Amphenol RF offers the broadest range of connectors in each category whether it be 75 ohm BNCs for superior data transfer in high-definition broadcast settings or SMPM products for high-frequency signal transmission in a micro-miniature package size. With this exceptional range and variety, an Amphenol RF connector can be matched to any application.

Specifying Amphenol RF connectors removes the risks of:
- Premature field failure
- Degradation in signal strength through connectors
- Performance impacts from poor IP67 and IP68 implementation
- Performance degradation from material and plating corrosion
- Product communication failure due to poor quality PCBA connectors

Every RF device has an antenna and nearly every antenna needs a connector. Amphenol RF connectors ensure optimal signal performance. *Amphenol RF Interconnection Solutions, Enabling IoT*.