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Emerging Harsh Environment Concerns in Cloud and IoT Infrastructures

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The expanding Cloud-based, IoT-oriented RF landscape, and the explosion in application spaces served, poses an expanding risk in base-station deployments and other aspects of the RF hardware infrastructure.

The continued expansion in the availability of advanced technological solutions to new and legacy applications has created an evolutional and disruptive development environment. Every aspect of the modern marketplace and society is being impacted by automation in ways both expected and unforeseen. The Cloud and IoT are empowering society in a great many ways, from online task collaboration to remote working and telepresence (Figure 1).

This evolutionary migration to a more information-enabled ecosystem is placing strong pressure on the electronic design and development community to create both the advanced devices with the high levels of functionality and connectivity desired by the consumer, and the hardware-based infrastructures required to support them.

Our Cloudy World

Our emerging Cloud-enabled, Internet of Things (IoT) oriented society involves every participating member of that society to be able to fully function within it, wirelessly, seamlessly, and everywhere. This forces service providers to deploy systems in extremely marginal places in order to serve the users in those locations, regardless of the deployment logistics.

By definition, any outdoor electronic system deployment must take into account a baseline level of environmental durability. Even a vending kiosk under a gazebo will encounter a significant number of environmental conditions, even if they only involve humidity, temperature swings, and foreign objects. Another significant factor is that people are extremely active, and take their activities into the most hostile physical environments available, in the most remote locations.

RF Base Stations, by design, are critical infrastructure elements, without which this modern Cloud-based device ecosystem cannot function. This means that Base Stations must be deployed in places that are subject to extreme environmental challenges. Many emerging applications, such as Telematics for supply-chain and fleet management, require RF capability in the most remote and harsh locations.

Harsh Environment Realities

When it comes to environmental conditions and addressing/mitigating them, it is important not only to categorize all potential hazards, but also to consider how the hazards as well as the risks can leverage or compound each other, both for ill and for good. Some environmental mitigation efforts will have a positive impact on other aspects of the design, while other mitigation efforts will place burdens on other subsystems that must be addressed.

Water is the most obvious and prevalent hazard presented to any electronics-based system deployed outdoors. At the lowest level, this risk manifests itself as humid conditions making water condense within the enclosure, and at the highest level the Base Station could be completely immersed in snow, mud, or water due to bad weather. Water is also one of the most hostile contaminants that can be present in an electronic system, as its deleterious effects linger long after the initial exposure.

Figure 1: The Cloud and IoT are empowering society in a great many ways

Figure 2

The biggest problem with water mitigation efforts is that a sealed enclosure cannot vent heat easily, a serious problem in a current-based electronic system. Power amplification circuits are not only dangerous in operation, they are extremely dangerous under marginal operating conditions. Any water-mitigation effort must take thermal management into consideration, or it will create significant deployment issues in the field.

External environmental hazards are those that are not expected from nature, but may be present. The best example of this can be found in industrial environments, where conditions may be more extreme due to processes or situations present. For example, the Base Station could be deployed in an area where snow runoff from a facility roof could bury it under certain conditions, or it could be places where hot/damp/dirty exhaust from machinery could be blowing upon it, exacerbating existing environmental conditions. The best way to address this issue is to very thoroughly plan and scout the deployment location to avoid unexpected hazards.

Dust and debris can arrive within the enclosure via a variety of mechanisms. Just as water mitigation methods can cause peripheral issues with thermal management, dust filtration can also place demands upon the airflow within the enclosure, complicating matters. Other debris can enter via cable connection points and ingress vias, operation and service openings, and battery/fuel/power openings in the packaging. Mitigation issues are similar to that of dust- and waterproofing when it comes to thermal management.

Vibration and Shock are not a primary concern when it comes to a stationary deployment like a Base Station, but they can be depending on the location involved. For example, there could be a vibration hazard from nearby equipment, or even the building itself. This falls under the external environmental hazard category, as it can also be potentially mitigated by a simple location change or shock-absorbing mounting if needed. Vehicle/cart/robot impacts and collisions are a similar issue, and must also be addressed with proper deployment-site management.

Vermin are a very real problem when it comes to Base Stations deployed outdoors. This is due to the natural pressure for creatures to occupy enclosed spaces indoors, enhanced by the warmth generated by operating electronics. Once inside, vermin can destroy a Base Station by chewing through wires and other components, and fouling the circuits with waste and hair. Water- and dust-proofing measures will mitigate vermin incursion to a degree, but any rubber or plastic parts can be gnawed or dug through. The best mitigation practices involve deployment site management and regular maintenance visits to Base Stations in risk areas.

Preventing poor performance

By properly planning your Base Station deployment, you can address many of these issues simultaneously. Addressing thermal management with active or passive cooling, with fins or heat pipes, can ease the impact of dust and water protection. Another way to handle thermal issues is to design the Base Station with full power derating in mind, and overengineer the system to cope with high temperature loads.

Internal hardware can be ruggedized to address environmental challenges, by doing things like applying a conformal coating for both thermal and vibration issues. Conformal coating can increase overall durability, while also protecting from outside contaminants and dirt. Potting, or completely covering the board with a putty or gel can both absorb shock and keep vermin off of the circuitry.

One of the most overlooked aspects of harsh-environment resistance is also directly related to system performance, and that's the cabling and connections. Not only are they the critical link between everything in the Base Station, they must be able to perform in the presence of environmental hazards. In many cases the I/O and battery-connection points are the only openings in an enclosure, other than for cooling, in a Base Station.

Figure 3: The right cables and connectors must be able to perform in the presence of environmental hazards.

In any Base Station deployed outdoors, secure and waterproof electrical connections are vital. Assembly and maintenance of cables and connectors are critical, as this is another area where design impacts performance. Poor connector termination haptics can increase user error, causing an improper connection, which bypasses all of the intended thermal and environmental resistance.

This means any solution that uses cabling for power and/or data connection must address dust and moisture ingress, as well as vibration, shock, and even vermin, regardless of the final environment the Base Station is intended to operate in. The right cables and connectors will provide a baseline level of ruggedness, as the shells and gaskets involved are able to handle multiple insertions and potential hard use.

Looking Forward

Environmental issues, unless proactively addressed, can accumulate to the point of catastrophic systems failure in a Base Station deployment. Thermal threats to operation can come from a variety of sources, from accumulated waste heat, to improperly managed external thermal loading, to heat from failure states like motor seizures and short circuits. Being able to address every kind of thermal threat to the system involved insures reliability, performance, and safety.

- Cloud continues to grow
- New infrastructure deployments
- Proper setup is important

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