THE GROWING NEED FOR MULTI-FUNCTION RF SENSORS

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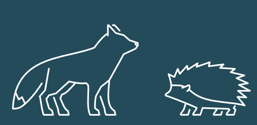
Fox or Hedgehog?

THE PARABLE OF THE FOX AND THE HEDGEHOG IS OFTEN SUMMARIZED AS "A FOX KNOWS MANY THINGS, BUT A HEDGEHOG KNOWS ONE BIG THING"[1].

This phrase has been used as a framework for evaluating alternatives and strategies in a variety of arenas. Notable examples of this framework include James Collins' book Good to Great; Why Some Companies Make the Leap... and Others Don't (spoiler: Mr. Collins suggests hedgehog companies fare better) and Nate Silver's book The Signal and the Noise, where the fox mindset is argued to produce better judgement.

Here we apply the same thought process to the topic of Radio Frequency (RF) systems that support the growing demand for sensor data to enable smart cities. These sensors are critical to a variety of new technologies, from drone integration in the national airspace to real time spectrum monitoring for optimal communications with smart devices. Should we have a suite of highly specialized sensors, each performing a narrow function? Or should we strive for flexible and programmable sensors that can be reconfigured to provide many functions?

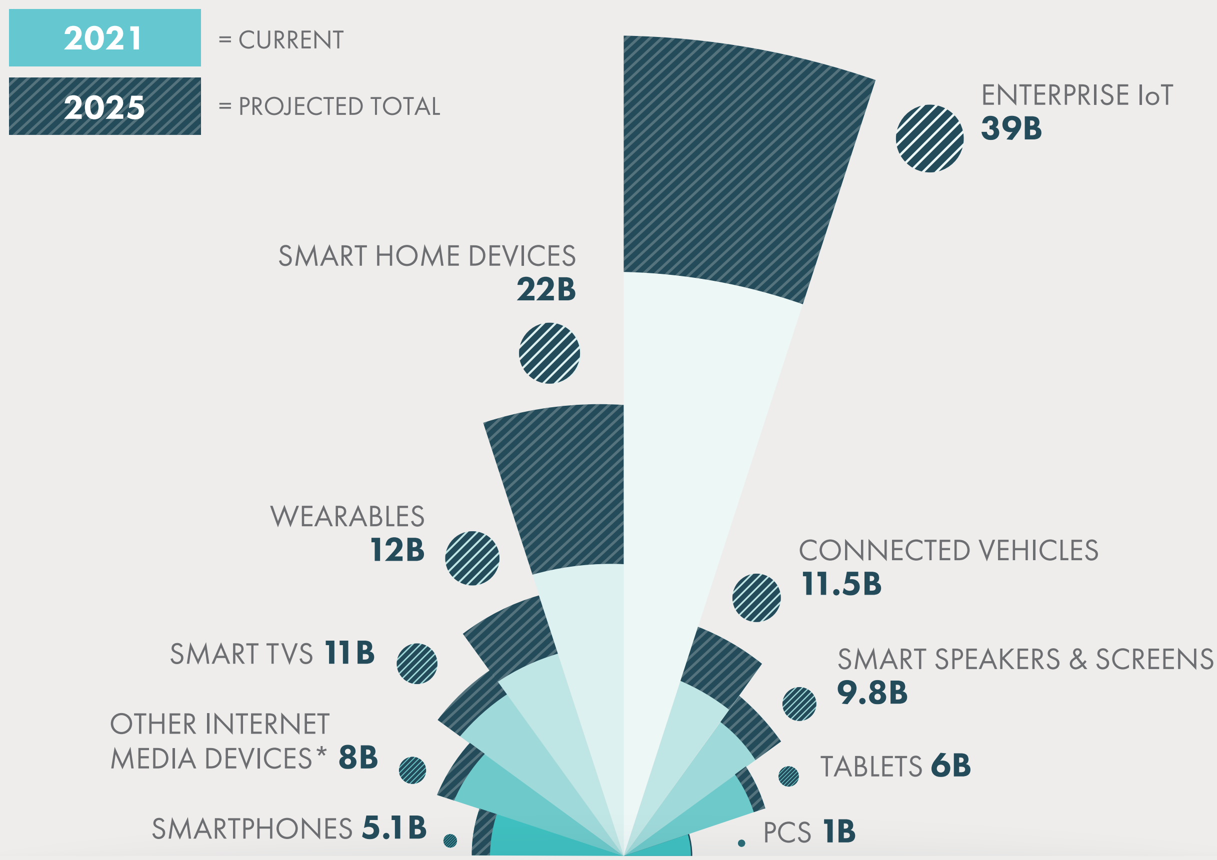
While there will always be a need for both single-use optimized and software definable sensors, the trends of increased speed in technology deployment and a dynamic RF environment dictate that designing and deploying sensors with multiple programmable functions should take top priority.



Industry Trends

There are several other industry trends that drive the need for multi-function devices, the first of which is the rising number of sensors and limited locations to install them. These sensors (which contain a mix of wired, wireless, indoor, and outdoor) include internet connected vehicles, smart phones requiring infrastructure, drones, etc. For this discussion, we are primarily concerned with outdoor wireless sensors.

PROJECTED RISE IN SMART DEVICES

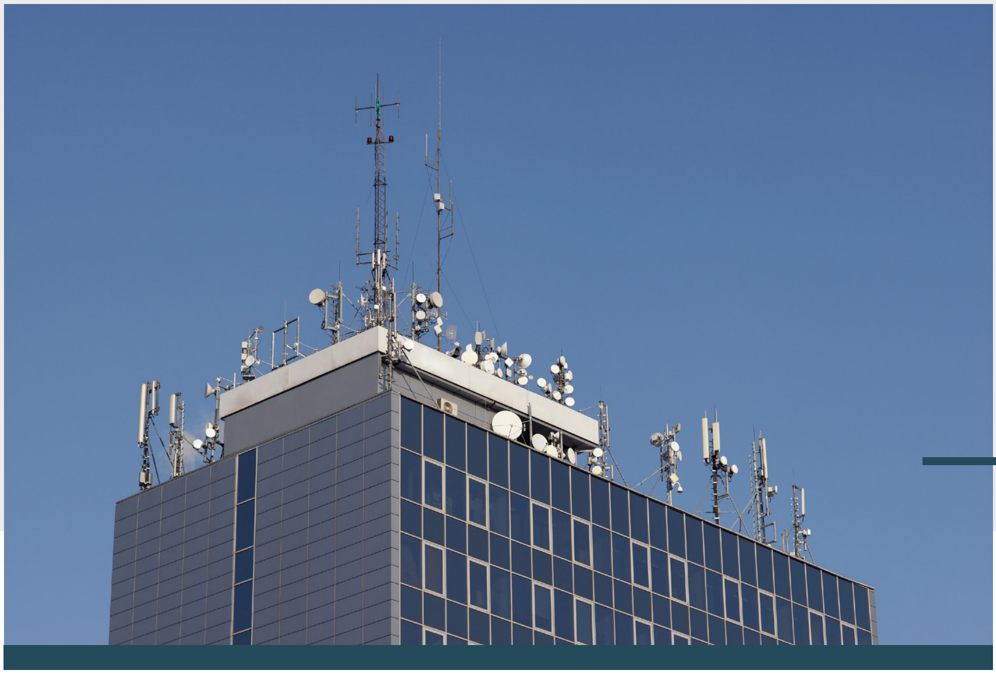


GLOBAL CONNECTED AND IoT DEVICE INSTALLED BASE FORECAST

*Includes Audio Systems, BD Players, DMA, Game Consoles, Digital Camera, E-readers, PMP, Portable Game Consoles, NAS, STB and DVR.
**The Internet of Things (IoT) is the interconnection of embedded devices within the existing internet infrastructure. Typically, IoT is expected to offer advanced connectivity of devices, systems, and services that goes beyond machine-to-machine communications (M2M) and covers a variety of protocols, domains, and applications. Includes M2M, LPLA and LPWA. Not all devices will communicate with a WAN, but be part of a Mesh networks etc.

Figure 1. Source - Strategy Analytics research services, May 2019: IoT strategies, Connected Home Devices, Connected Computing Devices, Wireless Smartphone Strategies, Wearable Device Ecosystem, Smart Home Strategies

This lack of sufficient installation locations is increasingly common in urban areas where rooftops, utility towers, and other high points are blanketed for sensors supporting 5G communications, point to point communications, security systems, etc.



Besides the lack of physical space to mount additional sensors, this crowding exacerbates the second trend of increasing congestion and re-allocation of RF spectrum. Spectral congestion has been continually on the rise with no end in sight.

Figure 2. Multiple sensors crowding building rooftop as physical space becomes more limited

Over the past two decades there have been numerous spectrum re-allocations and sell offs[2]. This reallocation means that static sensors with fixed frequency operation and limited configurability may find themselves unable to operate due to changing assignments or new interference sources that they were not designed to mitigate.

A similar trade between optimization for a given function (hedgehog) and adaptability (fox) is faced by electronic system designers choosing between deploying flexible programmable hardware such as Field Programmable Gate Arrays (FPGAs) or application specific integrated circuits (ASICs) to realize system function. ASICs are superior to FPGAs in both production cost (in high volume) and in power efficiency for a given capability. However, the design cycle time and development cost on an ASIC is substantially larger than an FPGA and if functionality needs to change due to new requirements of the system, the ASIC must re-start that cycle. In this trade the system complexity plays a huge role in determining the optimal design solution. As system complexity increases, the need to tune, reconfigure, and optimize grows. A "perfect" solution becomes more difficult to obtain, making the costly and time consuming ASIC design cycle less attractive. For this reason, complex solutions have seen a rise in using programmable logic in implementation. There are multiple efforts within industry and the government, such as the Electronics Resurgence Initiative, to try and marry the best of both custom and programmable functions.

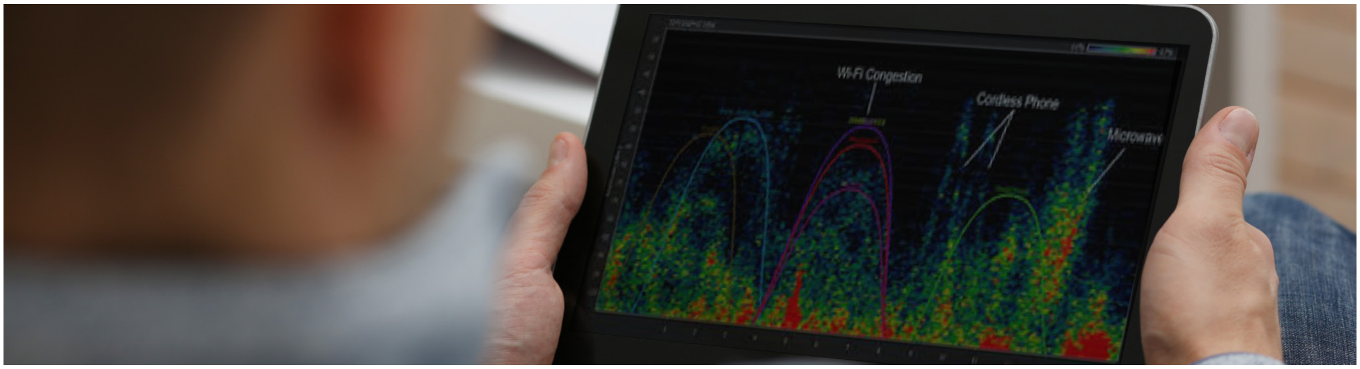


Figure 3. Source - lairdconnect.com

Enabling Technologies

TECHNOLOGY ADVANCEMENTS MAKE MULTI-FUNCTION RF SENSORS MORE ATTAINABLE THAN EVER. A FEW SPECIFIC EXAMPLES INCLUDE:

1

Commercially available high performance software-defined radios (SDR) and multi-channel RF System on Chip (RFSOC) devices. These devices come with abundant processing resources built in, allowing for the functionality to be tailored by use case. The fundamental RF characteristics (operating frequency, bandwidth, signal duration, etc) can be rapidly reconfigured and tuned during runtime which allows the same sensor to perform multiple functions.

2

Tunable RF filters for dynamic spectrum selection. As previously mentioned, the RF spectrum is congested and dynamic. Interference from signals in adjacent frequency channels is a limiter of performance for any RF sensor, making filters an important part of co-site interference mitigation. Switchable banks of fixed filters have been used for years to allow frequency selectivity of an RF system. However, as the number of uses increases and spectrum is re-allocated to different users, the ability to tune RF filters without changing hardware allows for increased agility.

3

Improved computing power. Increases in computing power allow functionality that was once relegated to hardware or ASICs can now be done in software. This computing may be co-located with the sensor or in one of the existing cloud computing services.

4

Data as a Service (DaaS). Most end users of sensor data are not themselves sensor experts (think of the police officer operating his or her radar gun). The rising popularity of sensor DaaS allows multi-function systems to be re-configured and updated in the background, without user involvement.

These technologies can be combined into a flexible and extensible sensor: **MARRYING A GENERIC AND WIDEBAND RF FRONT END TO A TUNABLE AND RE-CONFIGURABLE RECEIVE AND PROCESSING PATH**

Example Use Cases

As cities evolve into "smart cities", so too must the sensors and infrastructure enabling these capabilities evolve. By deploying configurable and multi-function sensors as part of this infrastructure investment, a multitude of use cases emerges:

Safe drone integration into the national airspace for delivery, search and rescue, inspection, etc.

Spectral "weather maps" that monitor real-time spectrum usage information to maximum channel utilization for wireless devices.

Autonomous vehicles (ground and air) receiving real-time information regarding weather, traffic, accidents, and emergencies for optimal routing of traffic.

Enhanced security around critical infrastructure

ILLUSTRATION OF SMART DEVICE APPLICATIONS

Figure 4. As cities evolve into the use of smart technologies, sensors are supporting an increasing number of devices

Contact Us

Unlocking the potential of smart cities in a safe and cost effective manner requires the development and deployment of a multitude of RF sensors. In order to maintain performance and add additional uses in an ever more crowded and congested environment these sensors must be software configurable and adaptable.

Inquiries

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References

[1] https://en.wikipedia.org/wiki/The_Hedgehog_and_the_Fox

[2] https://www.fcc.gov/auctions-summary

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