Big Data Goes Satellite

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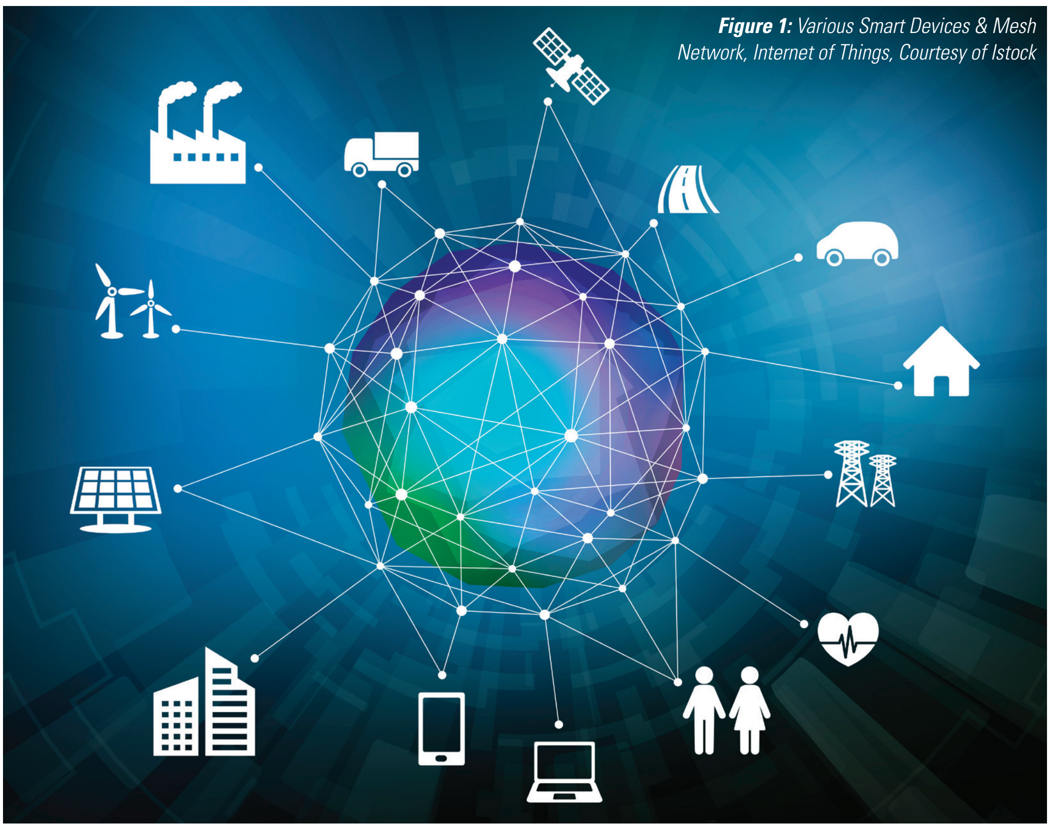

Figure 1: *Various Smart Devices & Mesh Network, Internet of Things, Courtesy of Istock*

The World of Today is Digital

We live in a digital world. For almost a decade, the number of devices connected to the Internet has outnumbered the number of humans on Earth. Today, the devices outnumber the world population growth by a factor of three and, by 2020, will reach 50 billion units, according to Cisco Systems[1]. The overall economic benefit, according to Cisco, will lead to $19 trillion in profits and cost savings. Looking back, telecommunications companies quickly moved from providing simple connectivity via email and Web browsing to enabling a networked

[1] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/409774/14-1230-internet-of-things-review.pdf

economy that fostered human collaboration via e-commerce and digital supply chain management to drive increased business process efficiencies. Enhanced software, storage/memory and mobile networking capabilities accelerated the industry forward, allowing applications to be moved into the cloud to create an enhanced immersive experience of digital interactions including social media to people on the move. The miniaturization of sensors carried this a step further, allowing the autonomous digitization of data and processes, adding connectivity to objects and machines to enable new services and experiences. This new connectivity of Machine to Machine (M2M) is called the Internet of Things (IoT) and is providing previously unrecognized insights that organizations globally can leverage to enhance their products. A huge challenge remains for connectivity companies to build out networks to reliably gather this "golden" data from the most remote sites and proactively act upon it.

From the Cloud into the Fog

Cloud computing allows memory and detailed processing to be distributed throughout a network and allows remote sites to exchange data with the centralized sites through an access network. To operate effectively, a reliable link from the remote sites to a centralized site is required to maximize productivity. With "Big Data" getting bigger by the day, there is an accelerating need to analyze data with different levels of responsiveness, from real-time for immediate decision making and action to non-real-time for longer term analysis, optimization and course correction. This requires a distributed architecture of IoT data brokers, each of which selects and forwards data as required to a destination. Fog computing provides for a decentralized computing infrastructure that distributes computation and analysis in the most efficient and logical location between the data source and the cloud. Fog computing distributes data management through the system and closer to the edge of the network. However, many challenges arise when gathering this data, including the sheer mass of data to be sent from remote sites, the availability of bandwidth in areas that are typically very remote, the low reliability of links in these areas and the overall real-time management of the network supporting this accessibility.

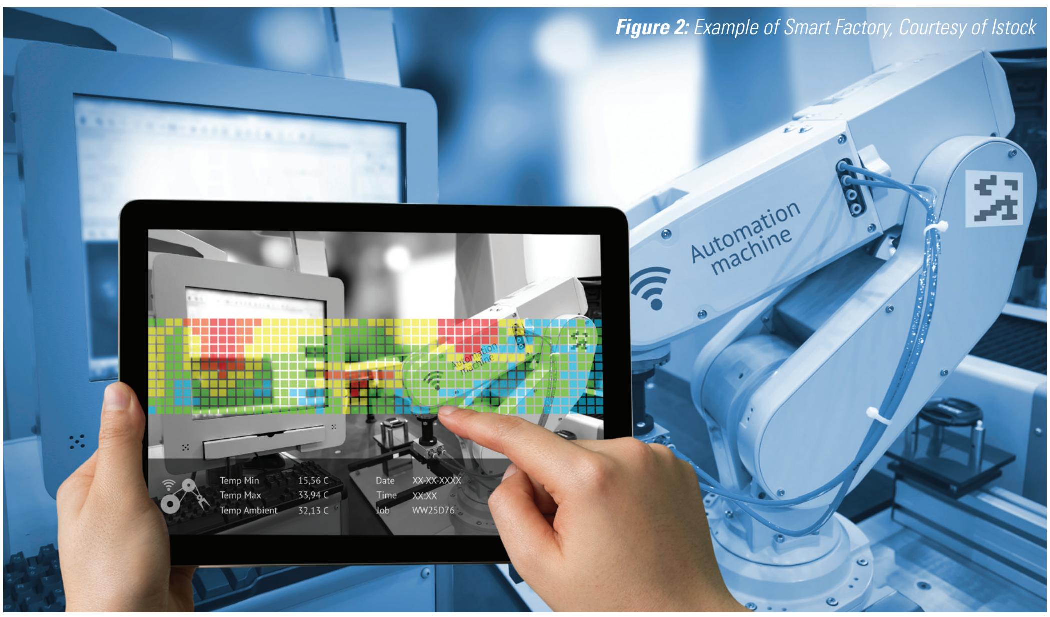

Figure 2: *Example of Smart Factory, Courtesy of Istock*

Benefits of a Robust IoT Infrastructure

Before we tackle the many challenges in getting to the data, let's focus on the array of benefits that the analysis of this mass of information can provide. The benefits of leveraging satellite connectivity within an IoT network differ by industries. Below are examples:

Figure 3: *Coal Mining Operation, Courtesy of Fotolia*

Transportation / Maritime

- On-board automation provides operational condition logging, allows immediate issue remedy and reduces staffing requirements
- Real-time on-board data trending allows leisure companies to provide highest level of individually tailored passenger service
- Detailed data trending provides service providers and equipment manufacturers insights to improve products and customer experience

Oil & Gas

- Increased situational awareness improves remote decision making and profitability
- Real-time equipment status maximizes up-time, increases employee productivity and safety
- Analysis of non-real-time data highlights trends, improves processes and increases efficiency

Utilities

- Extension of the smart gird to any remote location offers increased awareness and efficiencies
- Advanced Metering Infrastructure provides real-time billing data and reduces truck rolls
- Distribution automation increases reliability and quality throughout distribution grid

Military and Civil Government

- First responder equipment and vehicle insights allow optimal performance during emergencies
- Connectivity and monitoring during humanitarian crises provides security and increases responsiveness
- Increased remote awareness improves anti-terrorism, customs, immigration, border patrol processes and effectiveness

Mining

- Increased automation lowers operating costs by reducing required workforce per site
- Need for immediate remote geophysical data analysis increases per-site bandwidth requirements
- Critical real-time information reduces on-site risks, extends life of equipment and increases efficiency

The Major Challenge is Getting to the Data

The primary challenges to properly accessing and being able to intelligently leverage the data are:

- Providing the throughputs required to transmit data back to the central site
- Finding enough bandwidth and equipment in remote areas
- Reliably transmitting mixed data flows in a currently high lossy environment

Historically for satellite communications, outbound to inbound asymmetry ratios were in the 10:1 to 100:1 range, meaning remote sites typically required from ten to one hundred times more download speeds than upload speeds. While this ratio continues to decrease, the IoT over satellite sector will have the most accelerated decrease, likely requiring more inbound throughputs than outbound in the long-term. Terrabytes of data will be generated hourly and will need to be distributed immediately into the fog and on to the cloud to be analyzed and processed accordingly.

As arrays of sensors continue to be deployed to remote locations, the second challenge will be accessing enough terrestrial bandwidth to support the throughput demand of the aggregation of these units. Often terrestrial telecommunications companies have not been able to assimilate business cases to scale their higher throughput networks into the remote areas, and even when remote demands increase, are slow to react.

This lack of infrastructure leads to reliability issues from both link and equipment perspectives. Many times, antiquated low bandwidth hardware with limited traffic handling capabilities will be used as long as possible with minimal periodic maintenance in remote areas to minimize costs. This outdated terrestrial equipment cannot support the robust IoT networks.

Is LEO, MEO or GEO the Solution??

Northern Sky Research projects the overall IoT over satellite market to grow from annual revenues of $1.4B in 2016 to $2.9B in 2026[2]. The Asian market is second only to North America in these projections with an anticipated $440M being generated per year. With this growth potential in mind, a common question that arises is which earth orbit provides the best fit for IoT over satellite.

***Figure 4:** Looking at Oil Distillation, Courtesy of Shuttersock*

[2] Northern Sky Research M2M and IoT via Satellite, 8th Edition, September 2017

To date, most IoT solutions (real-time and non-real-time applications) have required only low throughputs and have benefited from low cost ground equipment and the response times that LEO constellations.

The advent of High Throughput Satellite (HTS) options at the GEO orbit has significantly increased the addressable market for IoT over satellite. In particular, higher throughput IoT applications that require strong Quality of Service (QoS) mechanisms and do not fit, cost-wise, into a usage-based model can now cost effectively be supported via satellite. These HTS designs through frequency reuse have significantly improved satellite communications economics.

The combination of OPEX and CAPEX savings at GEO has significantly increased the addressable market for satellite communications in general, particularly as it pertains to IoT applications via increased throughputs. Additionally, the wholesale pricing models that are readily available with GEO options allow service providers to offer differentiated services within this market while removing the worry of end users of billing unpredictability and unexpected overcharges based on traffic flows. While the economics of connecting a single or handful of sensors to a satellite will remain challenging, the aggregation of thousands or tens of thousands of devices and the insertion of a GEO satellite connection in the proper position within a Cloud/Fog network can be quite cost economical.

The Real Focus of the Solution…Quality of Experience

To meet the challenges of accessing the "golden" remote data and properly distributing it to the fog or the cloud, it is important to focus on the QoE that a satellite solution can provide. The QoE is the expected level of service that an end user can anticipate through the satellite network's QoS.

Five Factors Driving Cost Effectiveness

Any satellite network solution that supports the aggregation and delivery of IoT data must be cost effective due to the solution's size and scope. The five main factors that drive cost effectiveness are:

Figure 5: *Growing Profits, Courtesy of Fotolia*

Future-proof design: Implementing solutions with headroom for additional IoT data processing and throughput as the number of sensors per aggregation site grows avoids potential costly remote overhauls or upgrades.

Dynamic resource allocation: A demand-based bandwidth sharing mechanism that intelligently assigns spacecraft resources gracefully allows the OPEX to be shared across a network.

Maximum resource efficiency: The use of powerful coding and modulation plus intelligent bi-directional adaptive coding modulation (ACM) ensures each individual remote connection is optimized.

Minimal site intervention: Real-time network health insight allows issues to be avoided before degraded performance or outages occur, which is key to maximizing service profitability.

Scalable Growth Paths: A satellite network solution that allows for a staged implementation for IoT networks provides minimal up-front costs with moderate CAPEX requirements as the number of re motes and sensor data grows.

First, remote sites that aggregate 100s or 1000s of sensors will require high inbound throughput capabilities to allow this data to be transmitted to the proper location in the fog or cloud before buffers are flushed. As data flows will likely consist of small IP packets, a satellite platform with strong packet processing, compression techniques and high throughput capabilities are a must to ensure data flows are not throttled.

But, sheer throughputs will not be enough to tackle the IoT network data. The device aggregation flows will require a proper level of latency and jitter on the link to ensure protocol performance. Shared access techniques must be leveraged to ensure cost effectiveness, but not all bandwidth sharing mechanisms provide the same level of application performance. Care must be taken to select a dynamically allocated bandwidth technique that provides as close to a Single Channel per Carrier (SCPC) performance level as possible.

The same links that connect these remote sensors will likely also support other forms of data flows and the sensors themselves will likely not generate a homogeneous stream of data. Therefore, a strong traffic shaping mechanism is required to ensure different levels of priority and timeliness for the flows. This requires a deep packet inspection of each IP packet along with classification, compression and queuing at high data rates.

Link availability and reliability will be key as sensor and aggregation device buffers will likely be small and unable to store a great deal of data before being flushed. An unavailable or unreliable link will render the lost data useless and would minimize the effectiveness of the distribution network.

Lastly, connectivity costs will always be an issue and it is imperative that the network rollout be cost effective over the long term. The satellite network must provide bi-directional link adaptation to ensure links remain up during adverse weather conditions, pass the most important data first, and also that the transmission medium utilization is maximized during clear sky conditions, not being hindered by other remote sites.

Are You Prepared to Leverage the Insights of IoT?

End users are looking to partner with satellite service providers that are building out robust networks that will allow them to realize the economic and service level benefits of IoT. Today's terrestrial networks simply cannot be scaled quickly enough into the remote region of "golden" data. LEO options of today provide usage-based narrowband connections for low rate services but are no longer the only satellite option for IoT connectivity. Innovations in the GEO space in both the air and on the ground have made available cost effective, reliable and high throughput solutions that meet the unique demands of the IoT aggregation arena. Service providers looking to take advantage of this Big Data wave must be careful to select the proper ground equipment platform. Incorrect platform selections will reduce overall network performance or cost-effectiveness… perhaps both. So, are you ready?

Steve Good *is Senior Vice President, Premium Enterprise for Comtech EF Data where he leads the strategic and market development direction for the premium enterprise market. He previously held senior positions with Intelsat, Verestar, Viacast and Hughes Network Systems. He holds BSEE, MSEE MBA and a MSCpE degrees.*