The Rise of Autonomous Device Networks
What drives IoT business models?

FROST & SULLIVAN

A Frost & Sullivan Whitepaper For

WIREPAS
Things connected – Naturally

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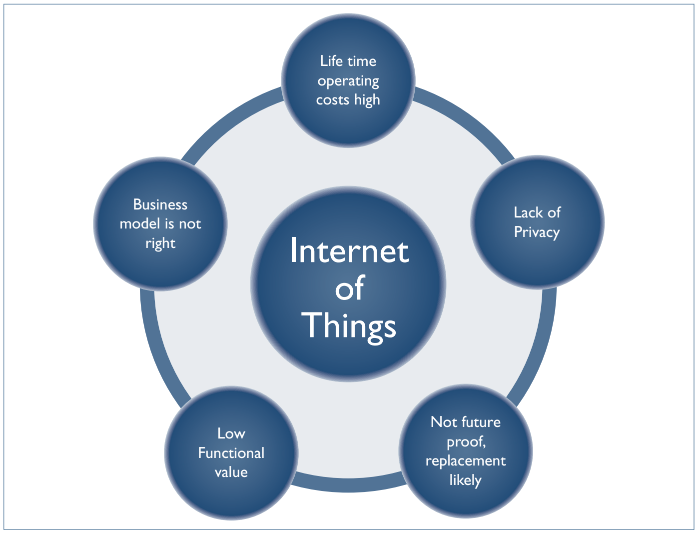
1. Introduction

In 1965, Gordon Moore, co-founder of Intel, articulated a prediction that revolutionized the electronics industry and illuminated the path towards the current era of digital transformation. Now known as Moore's Law, this breakthrough observation found that the number of transistors per square inch on integrated circuits had doubled every year since their invention, a pattern that would continue into the foreseeable future. Moore's Law, still relevant today, became a springboard for the innovation behind microprocessors. The ability to integrate microprocessors into virtually any small object - via a cost-efficient process - has launched an era in which every-day "things" can be connected. In fact, research finds that by 2020, more than 50 billion devices will be connected [6]. That is nearly 7 connected devices for every human on the planet, giving rise to the vision of a fully connected world referred to as the Internet of Things (IoT).



The IoT can be defined as a network of interconnected objects that are uniquely addressable based on a set of standard communication protocols, helping create smart networks composed of devices communicating with one another. But connecting these innumerable devices poses a significant challenge. It is often stated that a common monolithic connectivity solution will form the basis for a "massive IoT." Indeed, many reasons exist for driving a single solution. Most common among them is economies of scale for the connectivity providers; however, business requirements vary considerably from one application to another, and a common monolithic solution circumvents end-user experience, leading to a loss in customer value. That said, the question will surely arise: "Is this solution providing value even?" [7]. A common monolithic connectivity solution is also considered as "the right way" to enable Big Data, a revolutionary step for mankind. A subsequent question arises, however, as to whether the connectivity layer itself will lead to the existence of Big Data and enable new services. Does this imply that the systems are unwilling or unable to share information at a higher abstraction level between clouds?

In this paper, Frost & Sullivan and Wirepas challenge the assertion that a common monolithic connectivity solution rightly forms the basis for IoT by examining factors influencing the choice of a connectivity solution. The discussion addresses how business models should drive development of technical solutions, and not the other way around. Finally, the paper examines selected IoT applications across various degrees of maturity such as Smart Cities, Smart Meters, logistics, asset tracking, and the Industrial Internet, highlighting the key business requirements for a successful transition into the world of connected things, processes and people.

2. What drives choice of connectivity solution?

The number and breadth of objects that can be connected to the Internet has been growing exponentially every day, spanning items such as simple disposable tags to more sophisticated devices such as manufacturing plant machinery. This expansive range of connected devices equally drives diversity in applications and services, including both international connectivity providers and local cloud services, the latter of which is desired to support a stand-alone operation. The huge diversity in applications and services logically demands diversity in business concepts too. In effect, we can infer that it is practically impossible for a single operational format of connectivity to suit all applications.

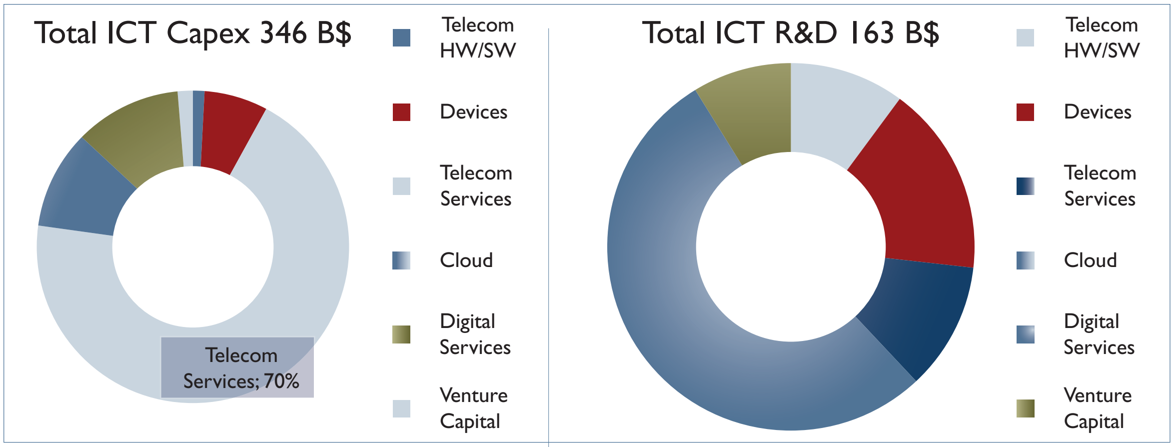
In the logistics space, for instance, a huge difference distinguishes scale from device density. During the delivery process, sensor density is very high in warehouses, whereas range is high during transport. The requirements of a connectivity solution, therefore, vary between scale and device density. Similarly, robustness of operation is another key metric affecting choice of a connectivity solution, which varies across applications. In some applications, connection outage is critical, whereas in others, this is not of critical importance. Depending on the type of service, a single point of failure, like unavailability of wireless network services, may result in serious consequences for a city enterprise, whereas for global enterprises, failure at a single point may not pose a serious threat.

Ultimately, the choice of a connectivity solution varies from one application to another. This choice is also dependent on two other important factors: cost consideration and business operation requirements.

2.1 Cost Consideration

In recent years, there has been a growing discussion on the capital outlay required for IoT devices. According to the World Economic Forum, the overall global investment for information and communication technology (ICT) is a more than $500 billion. And more importantly, nearly 50% of this investment is related to telecom services. The research findings also indicate that nearly 25% of the telecom investment is allotted for spectrum costs. However, it should also be noted that the telecom capital expenditure (CAPEX) figure does not include equipment or network infrastructure costs, which is approximately 14% of total estimated investment. Although there has been sufficient progress in optimising capital investment surrounding network infrastructure, the operational costs surrounding connected devices has not been addressed with equal fervour. Considering that the typical life for the autonomous operation of a connected device is nearly 10 years, the operational costs is a huge frontier for recurring expenditure that places a significant burden on the end-user of a connected enterprise.

Some of the typical activities surrounding maintenance of connected devices include remote management, over-the-air (OTA) software upgrades, status monitoring, and so on. Such maintenance activities cannot be performed on a single site visit as the number of nodes in a system is quite high. Therefore, connectivity solutions have a major role to play while estimating lifetime costs for a connected business. Consequently, the availability of solutions that can help reduce the aforementioned costs is poised to grow in demand and also enable development of more use cases in the future.



ICT CAPEX and R&D costs [4]

How can connectivity costs be cut to a fraction of what they are today?

Connecting billions of sensors and devices to a wide area network (WAN) is a costly proposition. In order to overcome this challenge, the industry has currently developed new radios, which have multiplied system capacity while significantly reducing hardware prices. On the same hand, the price for personal connectivity has not witnessed a reduction. Nonetheless, the business model has evolved from consumption-based to a monthly-fee-based model because with the increasing number of connections, the consumption-based model leads to billing complexity. The monthly-fee-based model provides a better billing alternative, but it does not aid in reducing the cost to the consumer.

One alternative for reducing the cost of connectivity is to use a de-centralized and self-organising device network. Device networks operate in a direct node-to-node communication mode without the need for network infrastructure. This type of network is connected to a back-end Internet system using gateway nodes, where traffic from hundreds of independent nodes converges. The typical ratio between a gateway node and an independent network node is 1:500. Moreover, each node is autonomous, enabling them to dynamically change their neighbour nodes in case of potential modifications in network structure or any other form of interference occurrence. The network's self-organising ability also enables it to adapt to the environment and route data to gateway nodes with utmost efficiency. In addition to these capabilities, a back-end connection to the network can also be facilitated using wide area cellular (requires sufficient data rates), Wi-Fi, or even a traditional Ethernet connection.

There a number of ways to achieve reduction in connectivity costs. Some of these ways are indicated below:

- Limited use of wide area connectivity in last-mile connection.
- Autonomous device-to-device communication on license-free bands.
- De-centralised operation where every device has autonomy to make decisions on how to connect into a device network.
- Freedom to select different technologies for back end connection and ease-of-use to build local networks with desired capabilities.

2.2 Business Operation Requirements

In the pursuit of building a business founded on connectivity, availing flexibility between different connectivity technologies is of critical significance. Apart from connectivity costs, the choice of a specific connectivity solution is determined by the following attributes:

- **System scalability:** Does the deployment of nodes require advanced planning?
- **Connection layer adaptability:** How does the system behave when new nodes are added or removed?
- **Autonomous operation:** Will a single point failure lead to major economic implications?
- **Stand-alone operation and local data processing:** Is there a requirement for sup porting stand-alone operation and local data processing?

If the answer to these questions is an overwhelming yes, then a de-centralized autonomous device network becomes the standard choice for connectivity. This is because a de-centralized design does not require advanced planning, and nodes can be added automatically to the system on an ad-hoc basis. Hence achieving scalability is possible without disrupting operation. Additionally, this also provides increased flexibility in the connectivity layer as there is very minimal need for operational planning. Thus the decentralised design, by nature, protects the network against a single point of failure. Even in case of a failure in the back-end system, the autonomous device network will continue to operate without any disruption. And last but not the least, such network architecture enables applications to process data locally, without the need for external back-end facilities and facilitate stand-alone operation.

From a service standpoint, there is a growing interdependency between developing services and deploying them on field. With regard to connectivity in specific, the availability of sufficient signal quality is of utmost significance and forms the basis for all service provisions. The services in case of a wide area technology, rests squarely on the connectivity provider. However, in case of autonomous device networks, every node is part of an extended network and the service provider has the direct capability to control service quality and determine overall end-user experience.

The application back-end forms a very critical part of overall service quality. The question is simple: is the application operated from the system of the service provider or is it hosted on the system of a cloud-service provider? These two possibilities are relevant and useful in the context of specific business applications and there is no one single connectivity method that can suit all environments. However, a connectivity method that can help users adapt to different service operation strategies hold an edge over those that are strictly limited in terms of service strategies.

Moving from services, the other critical attribute that determines choice of a connectivity solution is time-to-market. Long standardisation lead times result in elaborate and complex development cycles, taking into account multiple requirements including overhead versus actual need for a given application. Standards play a pivotal role in enabling users use a common connectivity platform for serving multiple applications globally.

In effect, we find that there a number of requirements, that need to be taken into consideration before implementing and building a business founded on connectivity. Each of these business requirements exerts an influence in determining the appropriate connectivity solution. This further reiterates that a single common solution for connectivity is neither realistic nor efficient for a connected enterprise of the 21st century.

3. Large scale IoT Applications

In this section, we analyse key applications and deduce how connectivity solutions drive business maturity. Given below are examples of specific applications and possible use cases from a connectivity standpoint.

3.1 Smart Cities

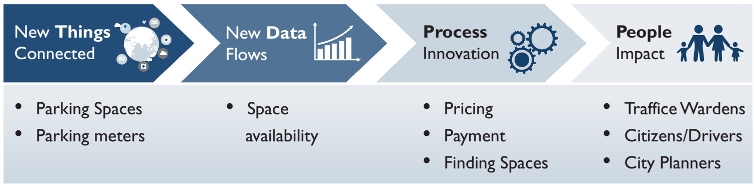
Urbanization is perhaps the biggest Mega Trend of the next few decades. The World Economic Forum estimates that over 55% of the world population will live in urban areas by 2025, which is close to 1 billion people more than the population today [1]. Cities are struggling to improve efficiency, optimise expenditure, mitigate traffic congestion, lower energy consumption, reduce wastage, and improve citizen health and ultimately support the creation of a safer environment. At the same time, we also see an equal or even a more intense focus on rapid urbanisation globally. These two seemingly contradicting objectives call for a number of innovative steps, including the choice and implementation of connectivity technology.

Within the broad construct of Smart Cities reflected earlier, we now narrow our focus on some specific applications where wireless technology is likely to be used and also explore the possibility of the most pertinent connectivity solution that can be adopted in each case.

- **Smart lighting,** considered synonymous with energy saving, can be achieved in multiple ways. New designs can introduce additional functionality such as increased local illumination control and fault reporting, among others. Even though smart lighting is often used as an example, massive deployments are yet to be realised on a global scale. Deployments are likely to happen once the current installations reach their end of life so that investments can be shared over multiple years.

- **Smart Traffic** addresses the challenges associated with growing traffic load in urban areas, enabling real-time control of traffic. With technological evolution in wireless connectivity and battery operation, it will be much cheaper and faster to deploy smart traffic solutions in the future.

- **Smart parking** is a concept that will relay information about available parking spots in advance. Parking sensors are simple and easy to install, with the purpose of informing the back-end application on parking availability. The smart parking application can be further expanded to develop additional services such as assisting users with the geographic location of their parked car. This service is valuable in shopping malls where parking areas are huge and people easily forget where they parked their cars. For smart parking, the connectivity solution must be local and the backend application should have the capability to expand as a city-wide service. In case there is a failure of the back-end system or the wide area system, local services cannot be interrupted



- **Smart building** and infrastructure monitoring of heating, ventilation, and air conditioning (HVAC) is a very important trend under the smart cities vision. The growing size of large constructions, such as sky scrapers and shopping complexes require well thought out solutions to optimize pedestrian traffic and safety. Emerging needs include advanced elevator control for managing crowd flow, regulating and managing traffic between the parking area and the building, and basic monitoring and control of any temporary event. Even in case of a restricted building area, monitoring and managing such actions are highly efficient only when the overall control exists locally.

3.1.1 Smart City Drivers

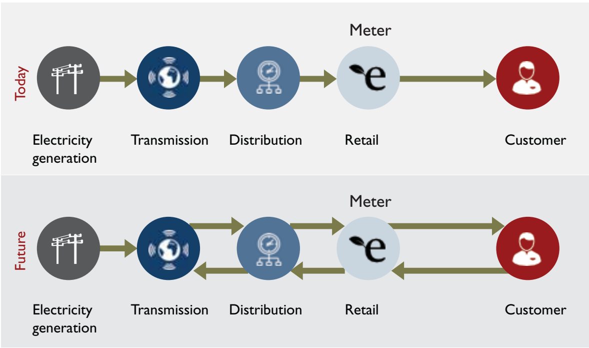
The modernisation of city infrastructure to improve efficiency and serve growing population needs in urban areas is a mega trend that is gaining mileage across all global economies. Within the multiple subsets of applications that form the vision for Smart Cities, connectivity plays a very critical role in creating and fulfilling the smart city vision effectively. The design of each application determines the type of connectivity solution, that can be either centralised or de-centralised in overall architecture. The nature of data requirements is another key factor that is critical for all applications. While data integrity is critical for all applications, the need for data privacy holds greater priority for specific applications. Taking these multiple factors into account, it is clear that a connectivity solution of a single kind will be insufficient to meet the needs of service modernisation.

3.2 Smart Meters

Since the introduction of remote electricity meters 10 to 15 years ago, the capabilities of these devices have evolved significantly. Furthermore, the role of remote metering is expected to grow in relevance with the increasing use of smart grids.

The functionality of electricity meters, though considered quite stable, is undergoing sweeping changes. New requirements, some originating from regulations and others from new business initiatives, are founded on the provision of two-way communication capability between the meter and utilities.

In recent years, initiatives to save natural resources, energy, and water, have led to newer requirements for critical infrastructure such as electricity grids and the water supply system. In smart grids, distributed energy production creates a new operating environment, where electricity meters have become a measurement node for critical parameters of distribution systems.



Energy grid infrastructure is massive, and each part of the system evolves at its own pace. Hence, every part needs to operate autonomously. In the system maintenance space, partitioning of the energy grid is supported, so inevitably these practical factors drive choice of connectivity technologies. "The Electricity Grid of the Future," a recent case study by Groupe Speciale Mobile Association (GSMA), reinforces this notion by concluding that the whole grid is not likely to be managed with a single communication layer. It is more economical and reliable to partition the communication layer based on system functionality. In case of communication issues, a single point of failure is mitigated, and parts of the system can then sustain operation.

The smart grid architecture is composed of a number of different systems, starting from power generation, substation, power transmission, power distribution and smart meters. These seemingly seperate units communicate with each other through a number of connectivity solutions, including local area network (LAN), wide area network (WAN), field area network (FAN), besides others.

Water meters are integral to monitoring fresh water infrastructure and enabling more efficient leakage detection. Global urbanization is leading to the concentration of fresh water consumption in urban areas. But fresh water wells cannot keep up with the pace of urbanization, and it is highly likely that water consumption in the future will become extremely regulated. These regulations will be determined by existing water reserves as witnessed in the case of California in The United States of America. Connected water meter grids are thus likely to form a very critical part of state water regulation in urban areas in the future

3.2.1. Smart Meter Drivers

Increasing regulations surrounding power generation and consumption are driving the case for Smart electricity meters globally. The increasing contribution of renewable power to the overall energy mix will further bolster the demand for efficient smart grids in the future. This trend will further expand functionality of smart metering equipment, considering that it has evolved to become an important sensor within the overall network operation.

Frost & Sullivan anticipates that similar functionality will be built around the water supply system in the future. Today, most consumers treat water as an unlimited resource, but within the next decade, pervasive limitations on water consumption per household may well become a reality. Hence, to prepare for this eventuality, water utilities need to pay attention to two-way communication.

Meter installation, then, is critical for reliable connectivity. Wide area solutions offer good outdoor coverage but pose challenges in basements where a majority of meters are installed. A de-centralized device network solution can solve this connectivity challenge efficiently and provide the opportunity for scaling to newer needs and functions.

3.3 Logistics, Retail Operations

Logistics companies have already started digitizing their business operations. The most revolutionary invention has been connected scanners that monitor material flows in and out of warehouses. Inside warehouses, connected things enable a new level of optimisation in operations [6]. In the delivery chain, goods can be monitored better and damages resulting from accidents can be prevented well in advance. Delivery errors and delays can also be further prevented. Another dimension to connected things in logistics is the capability of people and asset tracking. This improves employee safety in case of emergency and reduces idle traffic scenarios within the warehouse.

Retail warehouses can benefit in similar ways to their logistics counterparts, but connected things can significantly enable a new consumer shopping experience. One instance of a feature emerging through connectivity is the growing use of information screens and beacons to display content directly on customers' smartphones. This connection enables the retailer to deliver on-site personalized information to the consumer. To have the desired impact, the amount of beacons and the amount of information displayed needs to be high. In addition, the displayed content should also be changed regularly.

Additionally, the beacons can also act as an effective local advertising solution and connecting beacons into a common system also helps to improve content information management.

3.3.1 Logistics and Retail Drivers

The business of logistics operation is extremely cost sensitive. The high investment in logistic applications is justified only if they drive high value to customers. Continuous monitoring of sensitive goods, medicines, and equipment are some examples of investment-intensive logistic scenarios. In this regard, implementing a de-centralised device network can offer significant benefits. In particular, a de-centralized device network system can scale from a solution of high unit density to one of high range seamlessly. This is owing to the provision of flexible gateway connections (in house gateway vs. mobile gateway) and the capacity to autonomously connect to the best gateway node in each case. A de-centralized and self-configuring connectivity solution is optimal in locations where large quantities of things are located in a relatively small area. Additionally, this solution is battery operated and includes no recurrent connectivity costs.

In logistics, typically, the operating time of sensors is longer than that of individual parcel delivery time. If an autonomous device network is used, one can re-use this solution multiple times. The autonomous device network also offers two-way communication capability, enabling efficient monitoring of parcel-level goods. Radio frequency identification (RFID)-based solutions, for example, cannot offer the same capability. Lastly, flexibility in terms of back-end technology is also an important character of an efficient logistics system. An autonomous device network can use an Ethernet-based gateway solution and is easy to integrate with an RFID network. This solution can also support a wireless, cellular-based gateway solution that is ideal during transportation as it can also effectively handle challenges associated with international roaming.

3.4 Industrial Internet

Now that the Industrial Internet is widely recognized as set to have a profound economic and social impact across the world, it has become one of the main agendas for the World Economic Forum, which has concluded that multiple steps will be involved in the evolution, with timelines left wide open [2].

Near-term opportunities, nevertheless, exist in the areas of improved efficiency (assets and people), operational cost reduction, and improved productivity, as well as preventive maintenance and remote unmanned operation to improve safety. The demand for high performance (in terms of reliability and latency) drives the deployment of such new ideas. Each industrial sector needs adaptation for their assets and operations, while at the same time not sacrificing operational security, profitability, and safety.

With a longer time frame, it is expected that new business models are likely to be developed where production, distribution, and customers share information assets, enabling the growth of existing and the birth of new services. Production based on products-as-a-service (PaaS) or pay-per-use business models, among others, may emerge from the Industrial Internet. However, the common denominator today is that no one has a clear picture of what is likely to happen. Indeed, this is currently a trial and error period, which therefore requires flexible designs for modification at a later date. In later phases, the Industrial Internet will enable completely new business models such as new service models, pay-per-use models, software-based services, and data monetization, to name but a few.

3.4.1 Industrial Internet Drivers

The Industrial Internet is a broad subject; different industry sectors have hugely different technology assets. In other words, each industry and company will need to make a proper assessment of how to prepare for future business models. It is apparent, however, that each sector or company requires an optimized solution to match its particular business transformation strategy, wherein the connectivity solution has to fit its business objectives rather than the other way round. The sensitivity of connectivity outage may be critical for some applications, for instance, and the solution will need redundancy to avoid a single point of failure. For others, the local network connection or Intranet, may be critical to enable robustness of information availability.

Within the Industrial Internet paradigm, an autonomous device network offers significant benefits. Of course, its applicability depends on the application and Frost & Sullivan and Wirepas is not proposing this to be the only solution, yet many applications can benefit from the following advantages:

- An enterprise of connected things can autonomously develop its business because every device has the ability to route data, which also extends the network coverage.
- In remote locations where there is negligible wide area solution coverage, an autonomous device network solution can be deployed. Hence, this connectivity solution is not restricted by location.
- It is resilient to single point of failure because of multi-gateway support. In case a gateway does not work, nodes/devices start routing traffic to other gateways, autonomously.
- In critical business cases, information can be processed locally within the production facility as the back-end is connected using Ethernet. With wide area solutions, the data is by default delivered via connectivity service providers' systems, and a multi-level chain of trust is required.
- Autonomous operation enables easy scaling without heavy pre-planning. New equipment can be installed in the coverage area, connecting them automatically to the system.

3.5 Asset Tracking

Tracking physical assets, either by scanning barcode labels attached to the assets or by using GPS or RFID tags designed to broadcast their location is increasingly becoming central to many businesses. Not only location but also tracking status of physical assets and people within a given area such as warehouses, yards, hospitals, and production facilities is ushering in an era of high productivity. The continuous tracking and monitoring of assets, tools, and personnel helps various industries reduce their lead-time, wastage, labour cost, and losses thereby helping achieve quicker return on investment (ROI) and add value to their businesses. A number of verticals are benefiting from asset tracking such as healthcare, manufacturing, transportation, logistics, aerospace, and defence.

In the manufacturing industry, asset tracking is being used for optimizing profitability through expediting inventory management, reducing theft and loss of assets and tools, limiting waiting time in production, mitigating inefficient quality control, and eliminating excessive man power expenditure.

4. Requirements Summary

Having reviewed how the needs of different applications drive the choice for a connectivity solution, be it single monolithic connectivity or a de-centralized device network, the report will now offer a summary of the requirements that stem out of typical IoT enterprises. Further, the benefits of a de-centralized network for each of these individual requirements are outlined, showing that autonomy in a connectivity solution is a critical ingredient for business success.

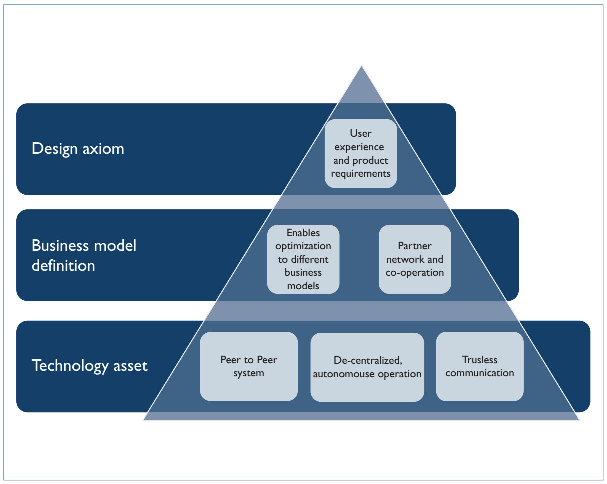
1. Reduced dependency on connectivity service providers
    - As systems are designed for autonomous, de-centralized operation, self-configuring systems enable applications without wide area systems.
2. Connectivity cost per device
    - A de-centralized device network operation offers a solution to cut connectivity cost by one to several hundreds, when compared to a monthly fee per connection service.
3. Deployment efficiency and speed of a self-configuring system
    - Network planning is time consuming and necessary before deployment commences. The business model and service application may be under planning as well, so this complicates and prolongs the time before actual service launch.
    - Once the node is powered, the system can scan and configure itself, without requiring any on-site support.
4. Scaling with the business
    - Unit density is an important quantity. The density of devices may vary significantly even in the same use case, between 10's and 100's of thousands in a relatively small area. Scaling allows flexibility and adaptability per application.
    - New functionality is possible during the lifetime of operation.
5. On-site system support
    - Back-end connection outside local facilities is not required. Besides the network is resilient to potential service breaks from external back-end connection.

6. Device life-time
    - Low-power consumption enables multiple years of operation in a battery-powered case.
    - Firmware OTA will introduce new features and prevent on-site visits.
7. Payload capabilities
    - Payload needs to be 2-way, sufficient in capacity for enabling configuration and control from a remote system.
8. Latency adaptation per use case
    - Agile system allows devices to be configured to power-saving or low-latency modes.
9. Mobility support
    - Dynamic environment changes and neighbour modifications are supported, like change in environment, addition of new nodes, etc.
10. End-to-end security
    - Secure communication that is fraud resilient is a fundamental need for any service in the future.

The table below maps the given requirements' sensitivity for selected applications.

		Autonomy, need for 3rd party delivering connectivity	Payload	Latency	Installation time / number of units	Life time / battery life	Unit density, (e.g., 50m x 50m area)	Mobility	Security	OPEX/ CAPEX constraints
Metering	electricity	Medium/High	Medium	important	High	Low	Low/Medium	Low	High	High
	water	High	Low	Low/Median	High	High	Low/Medium	Low	High	High
	gas	High	Low	Low	High	High	Low/Medium	Low	High	High
Lighting		High	Low	High	Medium	Low	Medium	Low	Medium	High
Logistics		High	Low	Low/Medium	High	High	High	High	Medium	High
Asset tracking		High	Low	High	High	High	High	High	High	High
Industrial Internet		Hign	Medium/ High	High	Medium/Low	High	High	Medium	High	Medium/High

5. Conclusion



The best connectivity solution for a given application or use case varies considerably. This paper has highlighted applications wherein a de-centralized and autonomous device network can bring unique benefits in comparison to a monolithic wide area solution. However, it has to be noted that the wide area approach to connectivity is also relevant and effective for many other business applications. Perhaps the most important parameter to consider when making the choice for a given connectivity technology is the need for scalability. If scalability is critical to the success of a business, then a de-centralized autonomous device network should become the automatic choice as it provides significant advantages over a wide area solution.

Based on the analysis in this white paper, we can summarise that a de-centralized network topology is ideally suited for smart cities, smart metering, logistics, retail, and some specific use cases of Industrial Internet. In this regard, the most important need for a connectivity solution is to add value to the customer and provide an agile and adaptive solution that enables efficiency. Frost & Sullivan concludes that a positive business case requires maintenance and operation costs to be competitive throughout the service lifetime. In many applications, the autonomous network not only provides customer value but also enables them to maximise their potential. However, we are also aware that a single connectivity solution cannot be relevant to the hugely diverse applications that constitute the paradigm of a connected enterprise.

In this paper, we have used the term "de-centralized device network" instead of "Massive IoT" with a specific purpose. In the widespread discussion on connectivity, it becomes critical to address the difference in connectivity topologies and IoT. From an operational standpoint, the seat of intelligence in a connected enterprise is not of primary concern. Whether it is centralised somewhere deep in the system or located in an anonymous location, real value for autonomous device networks can only be achieved through a decentralised intelligence framework.

6. References

[1] World economic forum; Global risk 2015

[2] World economic forum: Industrial Internet of Things: Unleashing the Potential of Connected Products and Services, Accenture 2015

[3] World economic forum: the future of electricity; Attracting investments to build tomorrow's electricity sector, 2015

[4] World economic forum: Delivering digital infrastructure: Advancing internet economy, 2014

[6] Internet of Things in Logistics; A collaborative report by DHL and Cisco on implications and use cases for the logistics industry, 2015

[7] Device democracy, Saving the future of the Internet of Things, 2015, IBM

[8] The electricity grid of the future, Jan 2016, GSMA

About Wirepas

Wirepas is focused on providing the most reliable, optimized, scalable and easy to use device connectivity for its customers. Wirepas Connectivity is a de-centralized radio communications protocol that can be used in any device, with any radio chip and on any radio band. With Wirepas Connectivity there is no need for traditional repeaters because every wireless device is a smart router of the network. The connected devices form the network - easy as that.

The technology can be used in several large-scale IoT applications such as smart metering, asset tracking, logistics, and environmental sensoring. Wirepas offers the connectivity for Original Equipment Manufacturers (OEMs), System Integrator (SI), Radio Hardware Manufacturers, Telecom Operators and End Customers.

Wirepas has its headquarters in Tampere, Finland and offices in Brazil, France, South Korea and the United States.

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