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Space 4 Global IoT

New Space Economy

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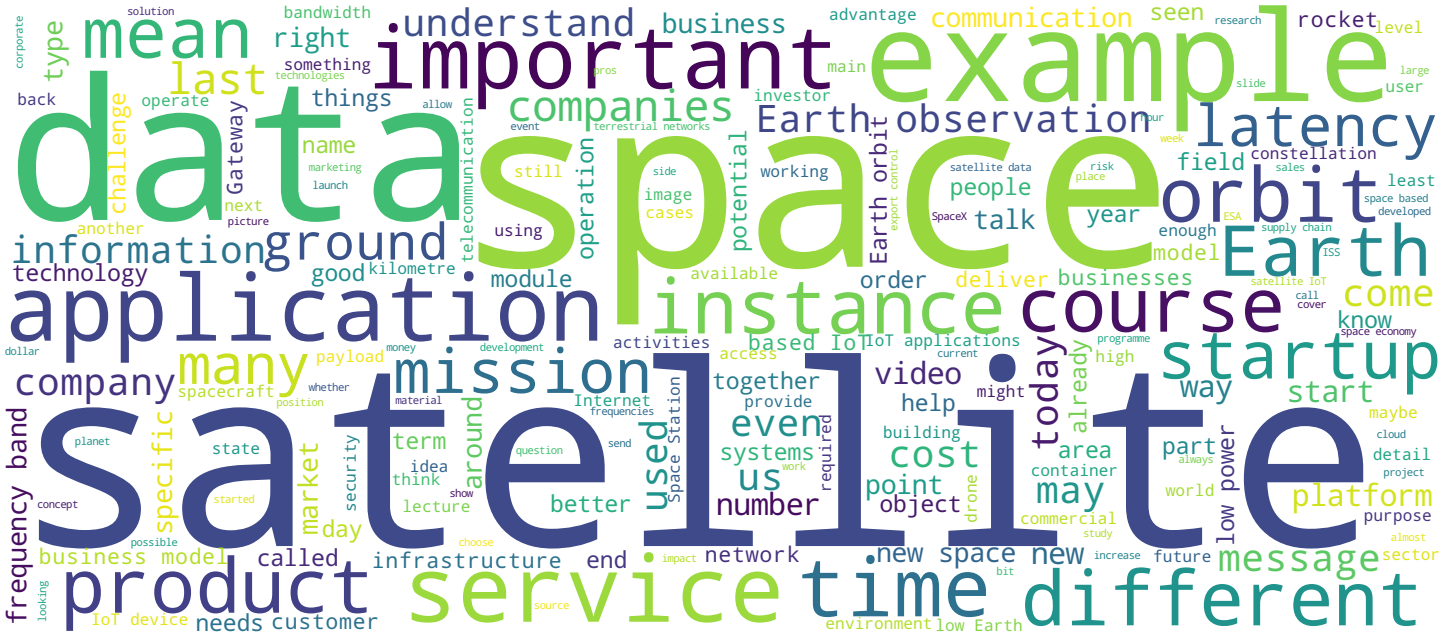

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Agenda

- What's IoT?
- Why is IoT important for businesses?
- Terrestrial vs space-based IoT
- Technology & Challenges
- Applications
- Summary

Hello. My name is Laurent Vieira de Mello, I'm the COO of Astrocast, and today I will run you through the world of space-based IoT services. The agenda for this video is the following. We will start by explaining what's IoT and why is it so important for businesses. Then we will compare terrestrial and space-based IoT solution, detail some of the technologies, and challenges of space based IoT and its applications, and we will conclude with a brief summary.

Notes

Summary

0m 05s

Image: Etsy

What's IoT?

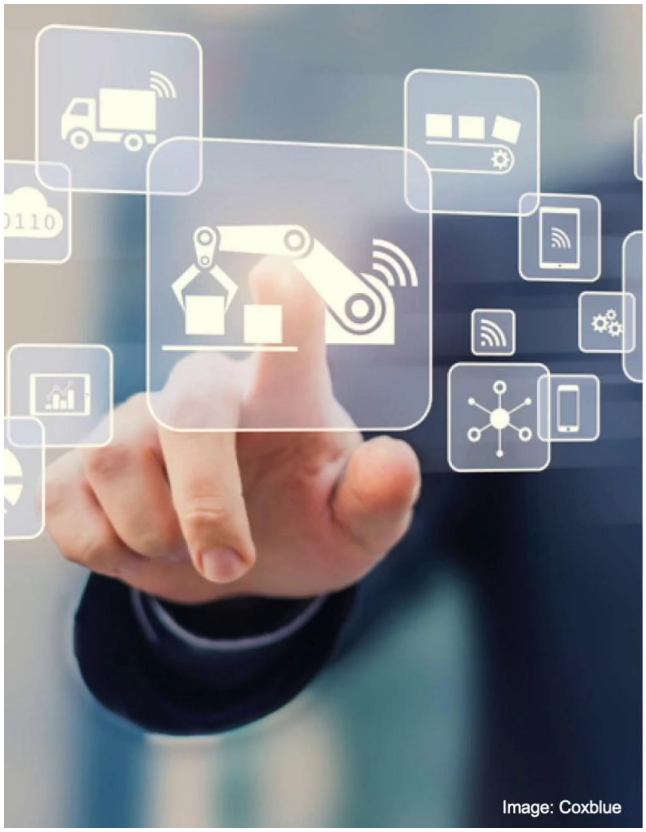
- "The **Internet of Things** (**IoT**) describes a network of physical objects ("things") that are embedded with sensors, software, and other technologies that are used for the purpose of connecting and exchanging data with other devices and systems over the internet"
- First concept of smart devices in 1982, with a modified Coca-Cola vending machine at Carnegie Mellon University
- In the consumer market, IoT technology is most synonymous with Smart Home (e.g. lighting, thermostats, home security)
- However there are much more professional applications in healthcare, transportation, energy, environmental, military, agriculture,…

So first of all, what is IoT? Definition of IoT is given here. The Internet of Things describes a network of physical objects, things, that are embedded with sensors, software, and other technologies that are used for the purpose of connecting, and exchanging data with other devices and systems over the Internet. The first concept of a smart device goes back in 1982. It was a Coca Cola vending machine, adapted by engineers from the Carnegie Mellon University in the US. And the machine was able to report its inventory, and tell whether loaded drinks were cold or not. Today, in the minds of consumers, IoT is mostly synonymous of smart homes, for instance, smart bulbs, connected thermostats, connected cameras, to name a few. However, there are much more applications for professionals in healthcare, transportation, energy, environmental, military, agriculture. And we will go into detail for some of these applications later on.

Notes

Summary

0m 38s



Why is IoT important for businesses?

Why is IoT important for businesses? Well, the simple fact of being able to monitor or run operations remotely, carries a lot of advantages for a company.

Notes

Summary

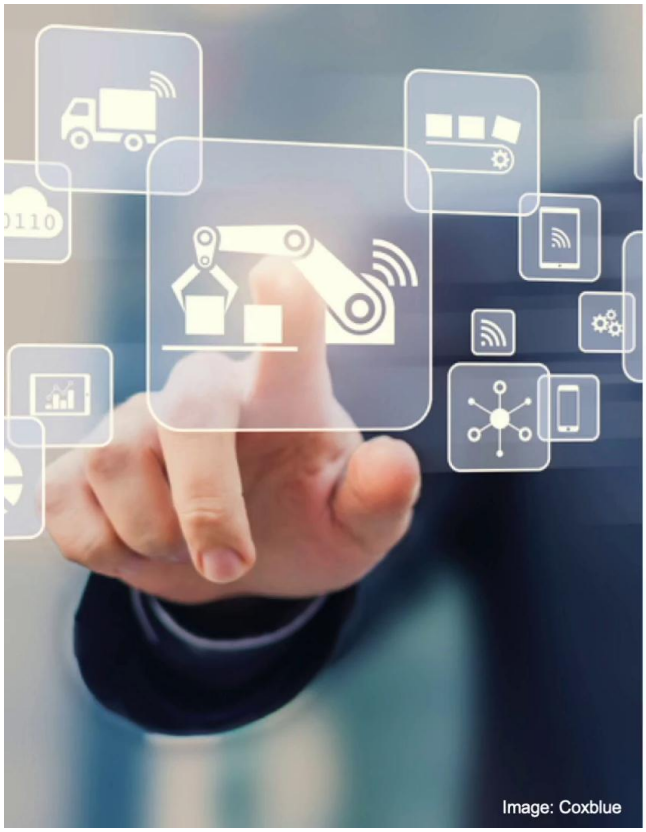
1m 44s

First, connected equipment in manufacturing, aviation, supply chain, agriculture and many other industries, is creating more data streams, and analytics potential. Meaning that companies can gain greater insights into their business operations, and how their customers use their products or services.

Notes

Summary

1m 56s



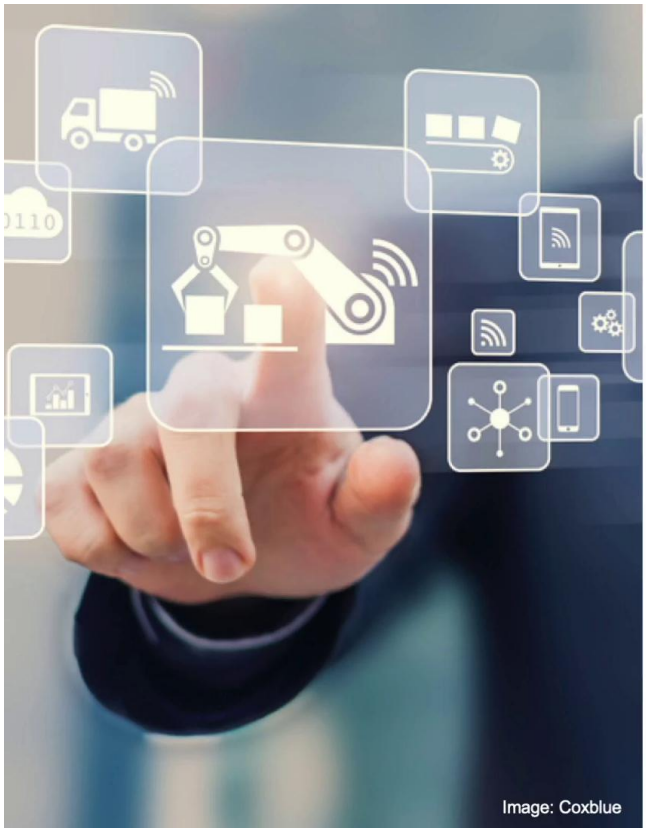
Why is IoT important for businesses?

Secondly, companies can reduce downtime, by predicting failures. This has a direct impact on productivity. Imagine the failure of one critical component in a power plant, causing days of downtime while the fault is being traced and fixed.

Notes

Summary

2m 16s



Why is IoT important for businesses?

Now imagine every part of that installation being represented in real time, in a digital twin, which would tell engineers that the component is going to fail weeks in advance and exactly where it is and how to replace it. As a result, the company can order the replacing component, and schedule a brief maintenance to replace it, with very limited impact on operations. That's a clear game changer.

Notes

Summary

2m 34s

Why is IoT important for businesses?

- Monitor and run operations remotely carries lots of advantages :
  - Improved business insights & customer experience
  - Efficiency & productivity gains (reduction of downtime)
  - Asset tracking & waste reduction
  - Instant access to data and insight from assets
  - New business models
- IoT becomes an integral part of everyday operations
- 5 billion connected devices by 2028 (Analysis Mason)

Companies can also track assets, being delivery tracks or small parts of a product. By doing so, they are able to efficiently track every component of this supply chain, to avoid losing them and optimise production. IoT also brings new business models. One can mention subscription based models, for instance, as for security cameras or data analytics to improve or tailor customer experience. For all these reasons, IoT technologies become more and more an integral part of company's everyday operations, and some analysis state that around 5 billion devices will be connected by 2028.

Notes

Summary

3m 00s

Terrestrial IoT

- Conventional terrestrial networks use radio stations, similarly to GSM, but optimized for small data transfer
  - Short range: Bluetooth mesh network, Wi-Fi, ZigBee,…
  - Medium range: LTE-Advanced, 5G,…
  - Long range (LPWANs): LoraWan, Sigfox, NB-IoT,…
- Problems with wider adoption:
  - Cellular systems cover 10% of the world's surface area and LPWANs only a fraction of this
  - Lack of interoperability between protocols

Image: Sigfox

Now let's talk about the architecture of IoT networks. There are a number of terrestrial networks that use radio stations, a bit like conventional cellular networks, but really optimised for transferring small amounts of data. These networks are split between three main categories: short, medium and long range. In short range, we can find the well known Bluetooth, Wi-Fi, ZigBee, medium range we have LTE or 5G, and long range LoraWan, Sigfox networks, for instance.

Notes

Summary

3m 43s

Terrestrial IoT

Image: Sigfox

Here under, you can see how Sigfox network works. Basically, objects would connect to antennas located on the ground, and these would relay the information to the Cloud, and the end user IT infrastructure.

Notes

Summary

4m 18s

Terrestrial IoT

- Conventional terrestrial networks use radio stations, similarly to GSM, but optimized for small data transfer
  - Short range: Bluetooth mesh network, Wi-Fi, ZigBee,…
  - Medium range: LTE-Advanced, 5G,…
  - Long range (LPWANs): LoraWan, Sigfox, NB-IoT,…
- Problems with wider adoption:
  - Cellular systems cover 10% of the world's surface area and LPWANs only a fraction of this
  - Lack of interoperability between protocols

Image: Sigfox

The problem with terrestrial solutions is that they only cover 10% of the world's surface, and LPWANs even a fraction of that. There is also a lack of interoperability between these networks, that make them hardly usable for global connectivity needs. That is when satellite based IoT comes into play.

Notes

Summary

4m 32s

Space-based IoT

- Using satellite connectivity used to be cost prohibitive because broadband constellations were not built for IoT applications
- The NewSpace approach enables low-cost service suitable for IoT applications
  - Use of off-the-shelf components and standard format satellites (CubeSats)
  - Access to space more affordable thanks to new launch providers and standardisation
- Today, LEO constellations enable global coverage at an affordable price

Image: Astrocast

Using satellite connectivity used to be cost prohibitive because conventional broadband constellations were not built for IoT applications, and it's specific needs that we will see later. The new space approach enables low cost service suitable for IoT applications by two means: first, the use of off-the-shelf components and standard satellites format, called CubeSats, and secondly, by having cheaper access to space, thanks to new launch providers and standardisation. Today, Low Earth Orbit constellations, mostly located at about 500-600 km altitude, enable global coverage at an affordable price. Typically, we are speaking about a few dollars per month, for a few kilobytes of data. It's not much, but it's enough to send valuable data, such as location, sensor data or even emergency signals.

Notes

Summary

4m 53s

Technology and challenges

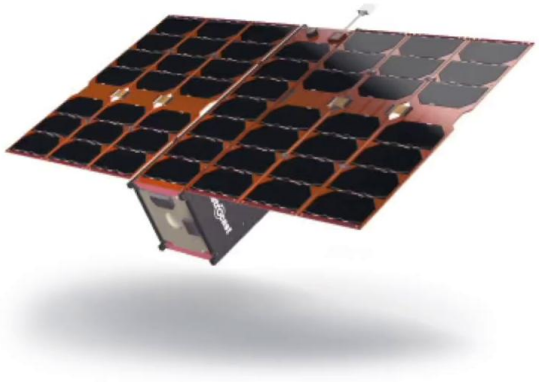


Image: Astrocast

- Important aspects for satellite IoT:
  - Radio frequency bands used for communication
  - Modules with low-power consumption and compact design
  - Security of communications
  - Reliability of service
  - Bidirectionality & OTA
  - Latency of messages
  - Direct-to-Orbit vs Gateway

What are some of the most important aspects when designing or selecting a satellite IoT service? Well, they're numerous: radio frequency bands used for communication is one, modules with low power consumption and compact design, security of communications, reliability of service, bidirectionality and Over-The-Air upgrades, latency of messages, and whether it's a Direct-to-Orbit or Gateway approach.

Notes

Summary

5m 52s

Technology and challenges

Image: Astrocast

We will go into more details for each of these points now, starting with the modules that connect the IoT device to the satellites. What's very important here is that it can last a very long time in the field, without the need to replace the battery. So low power is key. Size also matters because some applications, like animal tracking require very small trackers. These two parameters are influenced by multiple factors.

Notes

Summary

6m 26s

Technology and challenges

Image: Astrocast

- Security of communications
  - Encryption (hardware and software based)
  - Storage of data (cloud)
- Reliability of service
  - Service availability
  - Redundancy in satellites
  - Customer Support
- Bidirectionality & Over the air updates (OTA)
  - Allows customer to control/manage assets from afar
  - OTA allows remote asset firmware updates
- Latency of messages
  - Market segmentation
  - Heavily dependant on number of satellites and ground stations
  - Drives choice of antenna

Electronic components optimisation, if you have an ASIC, it's of course, much better, state of the art in low power electronics, wake up/sleep schedule, also called Ephemeris, the frequency band used, the communication protocol and whether the satellite sends acknowledgements at message reception, which avoids the module to send the same message multiple times, and saves battery, the antenna size, the smaller the better. Other important aspects in satellite IoT are: the security of communications, of course, it is very important that customer data is kept secure End-To-End, for that, we use encryption, both hardware and software based. The reliability of service is important as well. It comes with a good customer support, of course, but also redundancy within the satellites themselves. For instance, you may want to have two communication cards on board, in case one fails. Some constellations offer bidirectional communications that enable devices to send and receive crucial information like security patches or software updates. And finally, the latency of messages is crucial. Each application has its own needs in terms of latency. For instance, a glacier melting sensor might be fine with one message per day, while a vaccine tracking box will rather need a latency of a few hours.

Notes

Summary

6m 54s

Technology and challenges

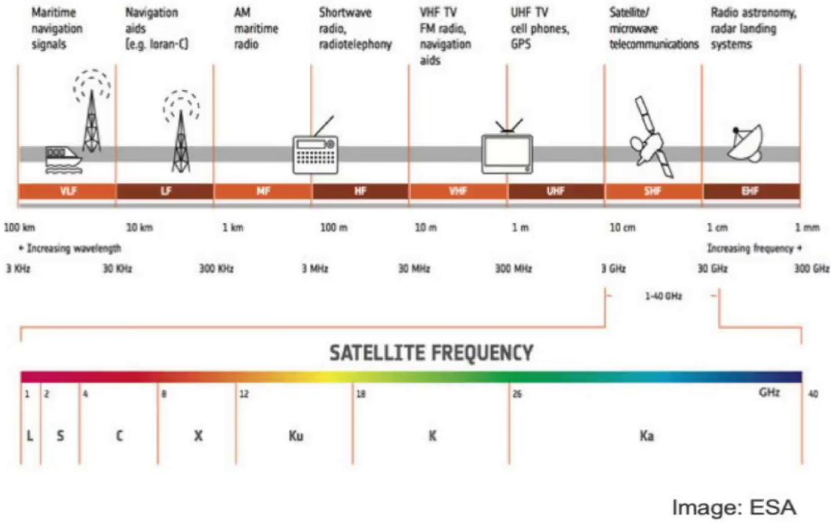


Image: ESA

Now, a few words on the radio frequency bands used for communications. Here we are not talking about the telemetry, and telecommand communications to operate the satellites, but we rather focus on the frequency band used to communicate between the IoT devices on the ground and the satellites. There's a wide variety of frequencies that are available, and they each have their pros and cons.

Notes

Summary

8m 26s

Technology and challenges

- Radio frequency bands are key
  - VHF (30MHz-300MHz): not suitable for very small devices and antennas
  - L-band (1-2GHz): small antennas, not subject to rain fade, best frequency band for IoT applications but hard to obtain
  - S-band (2-4GHz): very crowded band
- Market access
  - Some frequency bands require authorisation by each country where the service is offered
  - Rules are specific to each jurisdictions
- Some countries also require that you be registered as telecom operator

The main ones are VHF, a well known band for radio communications. It's easy to access, but not really suitable for very small devices, and antennas which are required for IoT applications. L-band, it enables small antennas and is not subject to rain fade. It's actually the best frequency band for IoT applications, but it's hard to obtain. The S-band is a very crowded band, also used for air traffic control, weather radar, and it's also the band that NASA uses to communicate with the ISS, for instance. That's for the frequencies. But once you have a frequency, you're still far from being able to operate the service. Most of the countries require to secure market access rights, and the rules are very different from one country to another.

Notes

Summary

8m 51s

Technology and challenges

Image: Astrocast

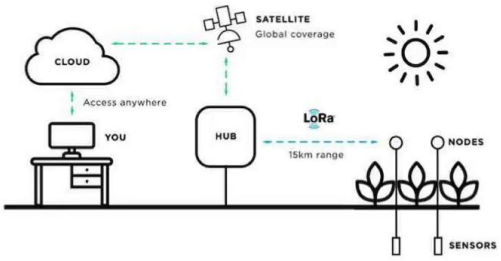


Image: Fleet

Last but not least, there are two different approaches to ground terminals. Either you have one module per IoT device or several IoT devices connected to a single module or Gateway. That would then send the data to the satellite. Each solution has its pros and cons.

Notes

Summary

9m 44s

Technology and challenges

Image: Astrocast

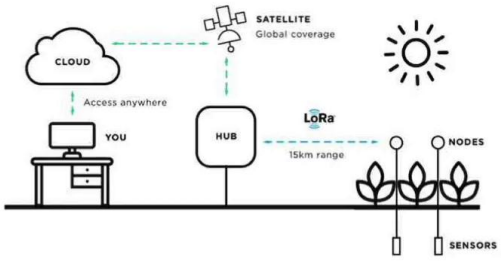


Image: Fleet

- Direct-to-Satellite vs Gateway
  - Pros:
    - Gateway location always optimized for sky view
    - Gateway can provide low-cost connectivity to a large number of devices within a short radius
    - Gateway can perform edge computing, therefore reducing need for bandwidth
  - Cons:
    - Gateway is a single point of failure, which requires maintenance. If it fails, the whole fleet of assets is disconnected
    - Assets movements are limited around the gateway (ca 15-20km in ideal conditions, can be as low as 1km in hilly environments). Hence not suitable for livestock tracking, transportation,…
    - Gateway can be a bottle neck if too many assets transmit at the same time
    - Requires a bigger source of power than individual modules

There are some advantages to a Gateway solution. For instance, the location is always optimised for sky view, a Gateway can provide low-cost connectivity to a large number of devices within a short radius, and it can perform edge computing, therefore reducing the need for bandwidth. However, a Gateway solution has also disadvantages: the Gateway is a single point of failure, which requires maintenance. If it fails, the whole fleet of assets is disconnected. Assets movements are limited around the Gateway, around 15 to 20 km in ideal conditions, but it can be as low as one kilometre in hilly areas. Hence, it's not suitable for livestock tracking or transportation. The Gateway can also be a bottleneck, if too many assets transmit at the same time. And last, but not least, it requires a bigger source of power than individual modules.

Notes

Summary

10m 03s

Technology and challenges

- Direct-to-Satellite vs Gateway
  - Pros:
    - Gateway location always optimized for sky view
    - Gateway can provide low-cost connectivity to a large number of devices within a short radius
    - Gateway can perform edge computing, therefore reducing need for bandwidth
  - Cons:
    - Gateway is a single point of failure, which requires maintenance. If it fails, the whole fleet of assets is disconnected
    - Assets movements are limited around the gateway (ca 15-20km in ideal conditions, can be as low as 1km in hilly environments). Hence not suitable for livestock tracking, transportation,…
    - Gateway can be a bottle neck if too many assets transmit at the same time
    - Requires a bigger source of power than individual modules

So based on that, customers have the choice and would choose the best option for their applications. And the applications are numerous.

Notes

Summary

11m 02s

Large number of applications

Image: Astrocast

All applications have their own requirements in terms of geography, message volume, frequency, and latency of messages. Here you see a global view of the verticals that use satellite IoT, and we will now study three specific use cases.

Notes

Summary

11m 11s

Use case – Asset tracking

The first use case is a logistics company that needs to track its containers across the globe. What is important here is to have a seamless tracking solution, whether the container is on land or loaded on a ship. The latency of messages is not essential, because the main goal is to avoid losing the container, not to know exactly its position in real time. A big challenge of this use case is to design the tracker so that it can always communicate even if the container is at the bottom of the pile.

Notes

Summary

11m 28s

Use case – Environmental research

In the context of climate change, researchers do several measures in remote places. The second use case is a University, for instance, that wants to perform regular measurements of temperature and humidity. In Antarctica. The geography is specific and the latency can be up to 24 hours. The data size is limited to some environmental parameters like humidity, pressure, temperature, etc. What is important here is a very low power consumption, and a ruggedised module that can withstand extreme conditions. The cost of data must be very low as well so that many sensors can be deployed in the field.

Notes

Summary

12m 05s

Use case – Humanitarian relief

The third use case is an NGO, active in different geographies that require humanitarian relief, mostly Africa and Asia. The goal is to monitor water tanks, to provide safe drinking water to populations, track vaccine delivery, or detect wildfires. You can see that in the first cases, a few messages per day is enough, while in the two latter, a low latency is required. What is very important as well for these remote places is a low power module that can last a long time in the field. And because terrestrial networks might be down or dysfunctional after a humanitarian disaster, a reliable satellite network becomes crucial.

Notes

Summary

12m 53s

Summary

- IoT is not new but has gained lots of momentum in the last years due to the 4th industrial revolution
- IoT brings efficiency and productivity gains to businesses
- NewSpace approach to satellite connectivity brings the best of both worlds: global coverage at (almost) the cost of terrestrial networks
- Different technology approaches exist today with their pros/cons, enabling customers to chose the best option depending on their applications

As a summary to this video, we've seen that IoT is not new but has gained lots of momentum in the last years due to the fourth industrial revolution. Iot brings efficiency and productivity gains to businesses. The new space approach to satellite connectivity, brings the best of both worlds. Global coverage at almost the cost of terrestrial networks. We've seen finally, that different technologies exist today with their pros and cons, enabling customers to choose the best option depending on their applications. So that was a very quick overview. I hope you enjoyed this video, and that you feel interested to dig more into the subject. Thank you.

Notes

Summary

13m 39s