Space-based IoT: An Efficient Energy Usage Planner

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The Internet of Things (IoT) has become widespread in our daily lives as technology evolves. All of the electronic devices around us can be connected to the internet, including a pet camera or a pacemaker in a patient's body. These devices contain sensors that record and exchange data and work cooperatively to make our technological environment a better place, so they are all part of IoT. While the traditional IoT has unstable connectivity, a new space-based IoT (S-IoT) has emerged. In recent years, companies like SpaceX, Starlinks, and Amazon are establishing an S-IoT using nanosatellites around the Earth. S-IoT is an innovation that provides the next step in IoT because it not only resolves the unstable connectivity problem but also increases the efficiency of data processing and reduces energy costs by monitoring energy usage. I will explain how S-IoT constructs stable connectivity between devices and how it makes data processing more efficient, then I will introduce how S-IoT helps reduce energy consumption.

Efficient Data Processing

Nanosatellites of S-IoT have lower bandwidths that are struggling to accommodate the massive data transmission with millions of electronic devices on Earth. However, researchers have developed a new sampling-reconstruction (SR) algorithm that extracts the most amount of information out of limited data for managing the entire S-IoT. As the name suggests, this algorithm samples parts of the data from S-IoT and reconstructs other data through the space and time correlation deduced from the sample. (Fei et al., 2019) Thus, the massive data from S-IoT can be managed even with lower bandwidth.

Among all the information sent out from each electronic device as a node within an S-IoT, the researchers found a strong correlation exists between data from different periods on one node, and similarly, another correlation between data from neighboring nodes during the same period. From this pattern, the algorithm can cluster all the nodes and select a sample from each group. The algorithm is validated through a case study with real weather data. Beyond this study, the researchers believe that they can apply artificial intelligence and machine learning method to further strengthen the algorithm (Fei et al., 2019). As S-IoT is equipped with an efficient algorithm for

data processing, S-IoT now can help build a sustainable future by reducing energy consumption.

Stable Connectivity Between Devices

When too many people nearby use electronic devices together, data transmission between devices can be slow and erratic. Most people are annoyed because their device often takes a long time to respond when the connectivity is unstable. S-IoT can resolve connectivity problems by receiving data from devices on Earth using low-power protocols that can decode weak signals (Nandakumar, 2021). Because of the massive connectivity of electronic devices, S-IoT has to support data transmission with a random access scheme, which means any user can access any part of the data as simply as one another. Traditional random access limits the amount of data loaded each time. If we transmit too much data, data will break into fragments, causing data collision. One example of data collision is people who accidentally get kicked out of a Zoom meeting when they turn on their cameras. Researchers have proposed a new intelligent load control-based random access algorithm to prevent data collision (Fei et al., 2021).

Each electronic device makes up a node in the internet of things. The new algorithm sets up a threshold value similar to the size limit for an email attachment. If the data load does not exceed the threshold, the nanosatellites can afford the data transmission. If the data load passes the threshold value, the algorithm will send out a broadcast to all the electronic devices on Earth with a new parameter for controlling the load. For example, sometimes devices or websites will pop up with a reminder window showing “your internet connection is unstable.” Similarly, the electronic devices on Earth have sensors to receive the broadcast and decide when they will send out the next signal based on the new parameter (Fei et al., 2021). Thus, all the data transmission between Earth and S-IoT can be stable and avoid collisions.

Reduce Energy Consumption

Heating, ventilation, and air conditioning (HVAC) devices are central to our daily lives, but their energy efficiency tends to decrease as we used them for a long time. Most people experience an increase in their electricity bill over time because their HVAC devices are worn out. However, with current S-IoT technology, a new energy management system (EMS) is developed. Most HVAC devices contain sensors that deliver energy usage data to facility

managers. Then the facility managers can identify the devices that consume more energy and provide an optimal plan for energy consumption (Al-Ali et al., 2017).

The EMS is widely applied in smart homes. The system contains sensors, controllers, and servers that work cooperatively. The sensor can not only measure the temperature and humidity but also calculate the energy consumption of one device based on AC measurements. The controller for getting data from the device is designed to be compact and high-speed. There are several servers located in the system. One storage server for handling large amounts of data, one engine server for making decisions based on energy consumption, and one webserver for transmitting data to get monthly reports. Currently, this system is under prior user testing among the Arab Gulf countries since the HVAC devices contributed to 60% of energy consumption in those countries (Al-Ali et al., 2017).

Challenges

Although S-IoT promotes energy sustainability, there are challenges to popularizing S-IoT. One is the short lifetime of all the nanosatellites. Most of the nanosatellites have a lifetime of two years, and they must be supported by infrastructure on Earth to keep monitoring the status of each nanosatellite. In the future, we can build nanosatellites with a longer lifetime to support S-IoT. Other challenges include avoiding space junk and low connectivity in bad weather, while there is ongoing research from NASA to tackle these challenges (Nandakumar, 2021).

Conclusion

Despite the challenges mentioned above, S-IoT is still a promising technology that provides efficient data processing and stable connectivity between electronic devices. Based on these two features, it facilitates a sustainable future in energy consumption. To develop S-IoT is to create a brighter future for us where all electronic devices are connected efficiently and stably with low energy consumption. Therefore, we can communicate with each other easily, and better tackle future environmental issues with S-IoT technology.

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