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OPTIMIZATION OF LONG RANGE WIDE AREA NETWORK DEVICE SPREADING FACTORS BASED ON PREDICTED LOCATION

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ABSTRACT

Techniques are described herein for optimizing Long Range (LoRa) network reliability and device power efficiency. LoRa device physical layer settings may be adjusted based on the Radio Frequency (RF) environment in which the device is expected to be located during the device's next network transmission.

DETAILED DESCRIPTION

Long Range Wide Area Networks (LoRaWANs) are composed of potentially hundreds or even thousands of devices in a constrained region competing for time slices and spectrum for transmitting their data to base stations (typically gateways). The LoRa physical layer relies on a proprietary chirp spread spectrum modulation technique and features a variable Spreading Factor (SPF) which controls the length of time between chirp transmissions and consequently the final data rate for the link between the LoRa device and the base station. Smaller SPF values result in shorter transmit duty cycles for a LoRa transmitter and consequently less power consumption, but at the cost of the Signal-to-Noise Ratio (SNR) and increased risk of message loss. Larger SPFs transmit the same amount of data in a longer chirp, which consumes more power but increases the SNR and reduces the risk of data loss.

The LoRaWAN protocol includes a provision for Adaptive Data Rates (ADR) which permit the network server to adjust the SPFs of the ensemble of devices in a geographic region to optimize the balance of device power efficiency as a function of data loss risk. In general, ADR algorithms seek to keep SPFs small so long as the SNR or Received Signal Strength Indicator (RSSI) is acceptable. Typically, larger distances between the device and base station, and any physical obstacles therebetween, can lead to signal loss and drive the need to increase SPF and power consumption by LoRa devices to ensure their messages are delivered reliably. In open areas, distance is a reasonable metric

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for setting SPF, but in any urban or "cluttered" area factors such as blocked "line of sight" or Fresnel losses predominate transmission losses. These types of losses are not necessarily easily predicted or accommodated in LoRaWAN ADR schemes and may vary over time.

LoRaWAN sensors typically transmit small amounts of data within a period of minutes, hours, or potentially days. Gateway location is critical to successful reception of the message. Proper RF transmission settings on the device (e.g., SPF) based on the environment of the device may determine when it transmits its next message. For devices at rest, the environment may change as a result of new elements appearing between the device and gateway(s), thereby blocking or impeding the RF transmission. For devices in motion, the environment could be entirely different based on physical location of the device when it transmits next.

Accordingly, techniques are described herein to cause the network server to track both the current location of a LoRa device and also a motion vector which can be used to predict the location of the device when it transmits next. The network server maintains a history of LoRa device locations, SPF, and RSSI/SNR for a region to be used to predict the RF environment for the device when it transmits next. The network server may also direct the device to adjust its SPF after a transmission to optimize the SPF for the next transmission based on the RF environment the device will most likely encounter when it transmits next.

For devices in motion (e.g., devices attached to a shipping container on a flatbed truck on a roadway) the location of the device could be very different when it transmits again after a period of even minutes. Depending on the location, the SPF may require optimization to ensure the transmission succeeds. For locations in which the device is stationary but elements are moving around the device (e.g., a freight yard), cyclic patterns of RF interference may be identified and those patterns used to optimize device RF settings for future transmissions.

The LoRaWAN for Class A devices follows an Aloha protocol and as such a base station cannot proactively reach a device and adjust settings. ADR can only be adjusted in a downlink window from the base station to a device that opens one and two seconds after a successful transmission from the device to the base station. Any adjustment to the SPF must be made at that time, potentially well in advance of the time at which the next transmission will occur. For Class A devices, the transmit period is fixed and changing the time between transmissions is not governed by ADR. A device may transmit a message every ten minutes or every hour under its own internal clock, unsynchronized with any other element in the LoRaWAN network. Thus, Time-Division Multiplexing (TDM) based optimization is not possible. Additional complexity arises for devices which transmit on a non-periodic basis, such as when a value changes, or for devices that are moving in a non-uniform fashion (e.g., a truck encountering traffic congestion). This can be addressed by statistically modelling the transmission timing and location uncertainty of a device over time and using estimates with associated standard deviations to choose ADR settings that are optimal given the greater uncertainty of the device location at the time of the next transmission.

In summary, techniques are described herein for optimizing Long Range (LoRa) network reliability and device power efficiency. LoRa device physical layer settings may be adjusted based on the RF environment in which the device is expected to be located during the device's next network transmission.